AGEACTION

“Changing Expectations of Life”

Monday 23 April 2007
The Sage Gateshead

A one day Conference funded by the EU FP6 Framework and hosted by Newcastle University’s Institute for Ageing and Health

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AGEACTION
‘Changing Expectations of Life’

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## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgements</td>
<td>1</td>
</tr>
<tr>
<td>Programme</td>
<td>2</td>
</tr>
<tr>
<td>Speaker Biographies</td>
<td>5</td>
</tr>
<tr>
<td>Sector Panel Biographies</td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td>14</td>
</tr>
<tr>
<td>Finance and Industry</td>
<td>17</td>
</tr>
<tr>
<td>Technology</td>
<td>19</td>
</tr>
<tr>
<td>Medicine</td>
<td>21</td>
</tr>
<tr>
<td>Social Science</td>
<td>23</td>
</tr>
<tr>
<td>The Aims and Scope of AGEACTION</td>
<td>25</td>
</tr>
<tr>
<td>Brief Summaries of the Sector Panel Reports</td>
<td></td>
</tr>
<tr>
<td>Social Science</td>
<td>35</td>
</tr>
<tr>
<td>Medicine</td>
<td>36</td>
</tr>
<tr>
<td>Biology</td>
<td>37</td>
</tr>
<tr>
<td>Technology</td>
<td>38</td>
</tr>
<tr>
<td>Finance and Industry</td>
<td>39</td>
</tr>
<tr>
<td>Full Reports of the Sector Panels</td>
<td></td>
</tr>
<tr>
<td>Social Science</td>
<td>41</td>
</tr>
<tr>
<td>Medicine</td>
<td>59</td>
</tr>
<tr>
<td>Biology</td>
<td>72</td>
</tr>
<tr>
<td>Technology</td>
<td>89</td>
</tr>
<tr>
<td>Finance and Industry</td>
<td>105</td>
</tr>
</tbody>
</table>
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Newcastle University
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Institute for Ageing and Health
Staff of the Institute for Ageing and Health provided additional support for the administration and registration of the Conference.

CELS
The Centre of Excellence for Life Science (CELS) provided additional support towards the hospitality and refreshments for the conference and will host a workshop on 24th April to develop further dialogue on Assistive Technologies.

Newcastle Science City
The Newcastle Science City Initiative, through the regional development agency One NorthEast, provided additional support towards the hospitality and refreshments for the conference.

Gateshead Metropolitan Borough Council and Newcastle City Council
We thank the Mayor of Gateshead and the Lord Mayor of Newcastle for their gracious support of the Conference and for their ongoing commitments to the wellbeing of older people within their communities.

The Silver Programme of The Sage Gateshead
Musical entertainment during the registration and informal reception on Sunday 22 April is provided by members of the Silver Programme of The Sage Gateshead, which aims to encourage the involvement of older people, from a range of backgrounds, in music based activity.

The Sage Gateshead
Staff of The Sage Gateshead.

Saville Audio Visual
Saville Audio Visual provided Audio Visual services.

Newcastle and Gateshead Convention Bureau
NewcastleGateshead Convention Bureau for Delegate hotel accommodation.

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Dawson & Sanderson, Whitley Bay for Delegate travel arrangements.

DB Consultancy
Conference services provided by DB Consultancy.
PROGRAMME
AGEACTION
“Changing Expectations of Life”
23 April 2007

09.00 Civic Welcome
   Mayor of Gateshead and the Lord Mayor of Newcastle

09.10 “Longevity: the big issue of our time”
   Tom Kirkwood, Newcastle University

09.30 “EU funding for ageing research”
   Patrik Kolar, Health Research, European Commission

09.45 “Active ageing around the world”
   Alex Kalache, World Health Organisation

10.00 Coffee

10.30 “Citizenship and society in an ageing Europe”
   James Vaupel, Max-Planck Institute for Demographic Research

11.00 Presentation and debate on report of Social Science Sector Panel
   Chaired by Sally Greengross, International Longevity Centre

11.30 “The medical challenges of longer life”
   Jean-Pierre Michel, European Academy for the Medicine of Age

12.00 Presentation and debate on report of Medicine Sector Panel
   Chaired by Alex Kalache, World Health Organisation

12.30 “Living in an ageing world: a challenge for the individual and society”
   Ursula Lehr, University of Heidelberg, formerly German Minister of Health

13.00 Lunch
AGEACTION

“Changing Expectations of Life”
23 April 2007

13.45 “Unlocking the potential of biological ageing research”
   *Linda Partridge, University College London*

14.15 Presentation and debate on report of Biology Sector Panel
   *Chaired by Nadia Rosenthal, European Molecular Biology Laboratory (Monterotondo)*

14.45 “Technologies to enhance older age”
   *William Mann, University of Florida*

15.15 Presentation and debate on report of Technology Sector Panel
   *Chaired by Wim Dekkers, Radboud University Nijmegen Medical Centre*

15.45 Tea

16.15 “Economic opportunities of increasing longevity”
   *Robert Diamond, Diametric Ltd*

16.45 Presentation and debate on report of Finance and Industry Sector Panel
   *Chaired by Stewart Sutherland, UK House of Lords Science and Technology Committee*

17.15 “Changing Expectations of Life: How to Make it Happen”
   Panel Debate with Wim Dekkers, Sally Greengross, Alex Kalache, Nadia Rosenthal, and Stewart Sutherland
   *Chaired by Tom Shakespeare, Policy Ethics and Life Sciences Institute*

18.00 Close
SPEAKER BIOGRAPHIES
Speaker Biographies

**Professor Tom Kirkwood** directs the Institute for Ageing and Health at Newcastle University. His research is on the science of ageing and longevity. He chaired the UK Foresight Task Force on ‘Healthcare and Older People’ and was Specialist Adviser to the House of Lords Science & Technology Select Committee inquiry on ageing. He has published numerous scientific papers and won several international prizes for his research. His books include the award-winning *Time of Our Lives: The Science of Human Ageing*, ‘Chance, Development and Ageing’ (with Caleb Finch) and ‘The End of Age’ based on his BBC Reith Lectures in 2001.

**Professor Alex Kalache** MD, has directed the WHO Global Programme on Ageing and Life Course since 1995. He earned a medical degree at the Federal University of Rio de Janeiro and a Master's Degree in Social Medicine at the University of London. He worked as a Lecturer at the Department of Public Health, University of Oxford, where he earned a PhD in Cancer Epidemiology. From 1984 to 1995, he was the Head of the London School of Hygiene and Tropical Medicine's Programme on Public Health Implications of Ageing and launched the first-ever Master's degree course on Health Promotion. He is a native of Rio de Janeiro.
Professor James Vaupel is member of both the U.S. National Academy of Science and the Max Planck Society of Germany. He is Director of the Max Planck Institute for Demographic Research in Rostock, Germany; his other positions include Director of the Duke Population Research Institute; Guest Professor of Demography at the Medical School of the University of Southern Denmark; and Visiting Professor at the London School of Economics. He studied mathematical statistics, business administration, and public policy at Harvard University and has written many articles and several books about demography and aging. He was a member of the U.S. National Advisory Council on Aging and received the Irene Taeuber Award for his accomplishments in demographic research and the IPSEN Foundation Prize for his research on longevity.

Baroness Sally Greengross is Chief Executive of the International Longevity Centre UK and co-chairs the Alliance for Health and the Future. Previously she was Director General of Age Concern England from 1987 until 2000. She has been a crossbench (independent) member of the British House of Lords since 2000, is a member of the Lords Social and Consumer Affairs sub-committee, and chairs two All-Party Parliamentary Groups: Corporate Social Responsibility; and Grandparents and Extended Kin. Other roles include being a Commissioner on the new Commission for Equality and Human Rights and President of the Pensions Policy Institute. Among many charity interests she is Patron of Beginnings, which encourages the employment of people with disabilities, and a board member of the Pfizer Foundation.
**Professor Jean-Pierre Michel** is Professor of Medicine at the University of Geneva and head of the geriatric ward of the Geneva University Hospitals. Additionally, he is Honorary Professor in Limoges (France), Beijing (Beijing), Montreal (Canada) and Visiting Professor at Newcastle University. Professor Michel co-founded the Geneva Interfaculty Gerontology Centre and the European Academy for Medicine of Aging, which trains the new leaders in this field. In 2006, he was elected in 2006 as member of the British Royal College of Physicians and Academic Director of the European Union Geriatric Medicine Society. He has published 170 professional and research papers and is editor of numerous books including the Oxford Textbook of Geriatric Medicine.

**Professor Ursula M Lehr** trained at the Universities of Frankfurt/Main and Bonn in psychology and philosophy gaining the rank of Full Professor of the University of Cologne, before becoming Professor of Psychology and Director of the Department of Psychology at the University of Bonn; and then Professor of Gerontology and Founding Director of the Institute of Gerontology of the University of Heidelberg. In addition to her academic career, Professor Lehr was from 1988-1991 Federal Minister of Youth, Family, Women and Health in the German Government and from 1990-1994 Member of the German Parliament (Deutscher Bundestag). Among her international honours she is Corresponding Member of the Austrian Academy of Sciences. She has many publications in developmental, lifespan, educational and social psychology, family studies and gerontology. Her book “Psychologie des Alterns” (1972, 11. Ed. 2006) is published in Italian, Netherlands, Spanish, Turkish and Japanese.
**Professor Linda Partridge** directs the Institute of Healthy Ageing at University College London. Her research is on ageing and age-related disease, for which she and her collaborators have recently been awarded a Wellcome Trust Strategic Award. She has chaired two funding initiatives for Research into Ageing at the Biotechnology and Biological Sciences Research Council. She was recently awarded a Help the Aged 'Living Legends' Award and has received many marks of recognition for her work including Fellowship of the Royal Society and the Fondation Ipsen Longevity Award.

**Professor Nadia Rosenthal** is Head of the European Molecular Biology Laboratory-Monterotondo Outstation, Rome and Professor of Cardiovascular Science, Imperial College London where she serves as Director of Science at the Harefield Heart Science Centre, Imperial College London. She previously directed a biomedical research laboratory at Harvard Medical School. She co-edited the definitive text *Heart Development*, was on the editorial staff at the New England Journal of Medicine, is a member of EMBO, and was awarded the Ferrari-Soave Prize in Cell Biology. She delivered the 2006 Howard Hughes Holiday Lectures on *Potent Biology: Stem Cells, Cloning and Regeneration*. Professor Rosenthal's research focuses on developmental genetics, the molecular biology of ageing and the role of stem cells in tissue regeneration.
Professor William Mann OTR PhD is Professor and Chair of Occupational Therapy and Director of the Ph.D. Program in Rehabilitation Science at the University of Florida. He also directs the National Older Drivers Research and Training Center, and has served as the Principal Investigator for the Rehabilitation Engineering Research Center (RERC) on Aging since 1991. Previously, he was a professor at the University at Buffalo for 25 years. His current work focuses on home monitoring and communications technologies (tele-health, tele-homecare), and older driver assessment and rehabilitation. He has authored more than 125 professional and scientific articles and four books, and served as founder and editor of the journal Technology and Disability from 1990 to 2000.

Professor Wim Dekkers MD PhD studied medicine and philosophy at the Radboud University Nijmegen. Until 1992 he worked part-time as a general practitioner. At the moment he is an associate professor ‘Philosophy of Medicine’ at the Department of Ethics, Philosophy and History of Medicine of the Radboud University Nijmegen Medical Centre. He is also a senior researcher at the Centre for Ethics of the same university. He is interested in philosophical and ethical aspects of palliative care, especially in conceptual and ethical questions relating to the care for persons with dementia and the chronically and terminally ill. He is editor-in-chief of Medicine, Health Care and Philosophy.
Robert Diamond is Founder and Chief Executive of analytical marketing consultancy Diametric. Founded in 2001, Diametric (www.diametric.biz) has grown rapidly to become an award-winning expert in the areas of marketing analysis, commercial strategy and customer loyalty. Current clients across the European, US and Asian markets include British Telecom, National Lottery, Coca Cola, GlaxoSmithKline, Reckitt Benckiser, Powergen, Woolworths and Unilever. Diametric is the third marketing consultancy that Robert has founded. Prior to setting up the company he was a European Board Director with the world’s largest direct marketing agency, Wunderman. He previously co-founded the New York-based Relationship Marketing consulting practice for Coopers & Lybrand Consulting (now part of IBM), following a career in brand management with Procter & Gamble and EMI Music.

Lord Sutherland of Houndwood KT FBA

Currently:

Provost of Gresham College
Adviser to Scottish Care and English Committee Care Association
President of Alzheimer Scotland

Previously:

Chairman Royal Commission on Long Term Care of the Elderly
Chairman of the House of Lords Science and Technology Committee’s Report into the Scientific Aspects of Ageing
Vice Chancellor University of London
Vice Chancellor University of Edinburgh
Tom Shakespeare is a medical sociologist with a particular interest in disability and in bioethics. He has researched and taught at the Universities of Cambridge, Sunderland, Leeds and Newcastle. He has published and broadcast widely, including seven books ranging from The Sexual Politics of Disability (1996) to Disability Rights and Wrongs (2006). He is an editor of the World Health Organisation's World Report on Disability and Rehabilitation. He has been active in the voluntary and cultural sector, and is currently chair of Arts Council North East and a member of the Arts Council of England.
SECTOR PANEL BIOGRAPHIES
Sector Panel Biographies

BIOLOGY

Professor Peter Csermely works at the Semmelweis University (Budapest, Hungary). His major fields of study are the links between aging, molecular chaperones (www.chaperone.sote.hu) and networks (www.weaklink.sote.hu). In 1995 he launched an initiative, which provides research opportunities for more than 10,000 gifted high school students (www.nyex.info). He wrote and edited ten books (including the *Weak Links* at Springer in 2006) and published two hundred research papers with a total citation over 2,500. Dr. Csermely is the past-president of Cell Stress Society International, an Ashoka Fellow, was a Fogarty and Howard Hughes Scholar and received the Descartes Award of the European Union for Science Communication.

Thomas von Zglinicki is Professor of Cellular Gerontology at the Institute for Ageing and Health, Newcastle University. He discovered the role of oxidative stress for telomere shortening and telomere-dependent cell replicative senescence. He wrote more than 120 scientific articles and edited two books on telomere and ageing biology.
Dr Stathis Gonos is Director of Research of the Department of “Molecular and Cellular Ageing” at the National Hellenic Research Foundation (Center of Excellence in Biology in Greece). The Department’s research focuses on the genetic and environmental factors linked to human ageing and longevity. He has published over 70 research articles and is author of several monographs and patents. He organized the 2nd EuroConference on “Biological Ageing” and the 12th International Association of Biomedical Gerontology Congress. He is Associate Editor of “Mechanisms of Ageing & Development” and Editorial Board member of “Aging Cell”, “Experimental Gerontology” and “Biogerontology”. Since 2004 he is Deputy National Representative of Greece in European Union in the thematic area “Genomics and Biotechnology for Health”.

Professor Eline Slagboom is head of the Molecular Epidemiology Section at the Leiden University Medical Centre. Her research is focused on genetic and molecular epidemiology of human ageing and longevity. Over the years she has been very successful in obtaining grants from diverse scientific foundations which allowed her to establish unique study cohorts of human subject that have attracted many scientists to the topic. She has published in high ranking journals over 90 papers on research into ageing. She is active in various EU programmes dedicated to studies into ageing and longevity and is section editor of Aging Cell.
Professor Ewa Sikora is head of Molecular Basis of Aging Laboratory at the Nencki Institute of Experimental Biology, Polish Academy of Sciences, Warsaw. Her research is on the science of ageing and longevity with particular interest in cellular senescence and cell death. She has initiated Polish Centenarians Studies. Recently, she has been involved in cancer and aging interface studies. She organized several national and international conferences on aging. She coordinates SSA FP6 on European Cancer and Aging Conference which will be held in Warsaw in 2007. She actively participates in many national events popularizing aging, longevity and cancer studies.
**FINANCE and INDUSTRY**

**Dr Frans van der Ouderaa** is a member of the Unilever Corporate Research Leadership Team with specific responsibility for the Corporate Biology programme based at Sharnbrook. This programme focuses on strategies for the applications of Human Genomics, in particular in the area of Healthy Ageing. Before his transfer to the U.K. in 1982 Dr Van der Ouderaa worked for Unilever in The Netherlands as a clinical biochemist working on PUFA metabolism. Within the UK he was initially at the Port Sunlight Laboratory where he led Unilever’s worldwide Oral Care Research. In 2000-2001 he was a member of the Board of Unilever’s diagnostics company Unipath responsible for R&D. He has served the UK Medical Research Council as a research board member.

**Tom Ross** is a former President of the Faculty of Actuaries in Scotland. He is Chairman of the Pensions Policy Institute, an organisation which he was instrumental in creating in 2001. The PPI’s mission is to conduct independent fact based research into retirement policy issues in the United Kingdom. His other activities include being chairman of the Trustee Boards of two pension funds, of Penta Capital Partners (a private equity management firm) and of the Edinburgh UK Tracker Trust (a listed investment trust), being the Senior Independent Director of the Royal London Mutual Insurance Society and being a member of the Code Committee of the Panel on Takeovers and Mergers.
Professor Claudio Franceschi MD is Professor of Immunology, University of Bologna and until recently Director of the Inderdepartmental Centre “L. Galvani”. From 1996-2005 he was Scientific Director of the Italian National Research Center on Aging (INRCA) at Ancona. He is Associate Editor of Aging Clin. Exp. Res, and member of the editorial boards of Exp. Gerontol., Mech. Ageing Devel., Ageing Res. Rev., Int. J. Immunopathol. Pharmacol. and Eur. J. Inflammation. Coordinator of the EU 6th FP Integrated Project “GEHA” (Genetics of Healthy Aging). He has published more than 450 peer reviewed papers mostly devoted to genetics and immunology of human aging and longevity.

Paul Garner is head of BT's Pervasive ICT Research Centre. A chartered physicist, Paul has produced many publications in the field of telecommunications. Paul was a member of the Foresight Task Force on Healthcare 2020 and a founding member of a large randomised controlled trial of telemedicine at the Royal Free Hospital. Between 2003 and 2006 Paul led the DTI Care in the Community virtual research Centre and was a member of the European Telecommunications Standards Institute specialist task force on Telecare. Paul is currently a member of the Royal Society study group on the impact of ICT in Healthcare.

Professor Stig W Omholt is professor in biology at the Norwegian University of Life Sciences. He is also director of the Centre for Integrative Genetics, a Norwegian core facility in functional genomics and systems biology. Omholt pioneered research on ageing in honeybees, which has now become a model system for understanding the life-history reasons underlying the observed ageing patterns in an advanced social structure. He is now engaged in understanding the evolutionary reasons for ageing in a broader context and the build-up of systems medicine with particular emphasis on making advanced mathematical representations of the ageing process in humans.
TECHNOLOGY

Professor Garth Johnson graduated in mechanical engineering before working as a research engineer in the machine tool industry. In 1971 he returned to Leeds University to study for a PhD in Bioengineering and he has been in this field ever since. After 7 years in the National Health Service, he was appointed Reader in Biomedical Engineering at Newcastle University in 1981 and then Professor of Rehabilitation Engineering in 1995. His main research interest is in the biomechanics of the upper limb with application both to implant design and to the problems of measuring neurological impairment. He has published 150 scientific papers and is a Fellow of the Royal Academy of Engineering and Founder member of the Society for Research in Rehabilitation.

Dr Kees Schep is leading a team of researchers at Philips Research in Aachen, Germany, working on solutions in the area of personal disease management and home healthcare. Before that he worked on the development of Blu-ray Disc for which he in 2004 was elected by MIT’s Technology Review on their Top-100 list of Young Innovators. He has a Ph.D. in physics from Delft University of Technology, published over 25 scientific papers, and was granted 10 US patents.

Peter Gore is the Managing Director of ADL Smartcare, a company dedicated to providing evidence-based tools to support the matching of people to technological solutions and to assessing the outcomes. He has been an expert adviser to the EC on matters of technology for older people and the disabled for many years, and has also monitored research projects for the EC as a Project Technical Assistant for some years. A founder member of the Yorks & Humber Regional Ageing Panel, he continues to collaborate with researchers, academics, industry and health & social care providers.
Dr Olivier Toussaint is Research Associate of the Fund for Scientific Research and affiliated with the University of Namur, Belgium. His group studies the biology of human ageing and nanotoxicology. He received several international scientific Prizes. He coordinated a European FP5 project on functional genomics, coordinates the FP6 Coordination Action ‘Link-Age’ (www.link-age.eu/) and participates in FP6 Integrated Projects. In 2004, he created Straticell (www.straticell.com), a company active internationally in chemical, cosmetics and pharmaceutical research. Straticell moved into its new in vitro toxicology facilities in February 2007. Straticell also participates in European projects.

Dr Richard Faragher is at the School of Pharmacy and Biomolecular Sciences at the University of Brighton. His research is on the link between cell senescence and organismal ageing with particular emphasis on the cell biology of Werner’s syndrome. In 2005 he became the first scientist to receive a Help the Aged award for his championship of older people and the use of research for their benefit. In 2002, he won the Royal Pharmaceutical Society medal for Outstanding Scientific Achievement for his work on Werner’s syndrome. He is a member of the BBSRC-Experimental Research on Ageing (ERA) committee, the Research Advisory Council of Research into Ageing and was Treasurer of the British Society for Research on Ageing (1999-2003). He Co-directs the SPARC programme, a UK government sponsored initiative to build national capacity for inter-disciplinary ageing research.

Professor Roger Orpwood is Director of the Bath Institute of Medical Engineering at Bath University, which develops disability and healthcare equipment. Originally a Neuropsychologist, he retrained as a Mechanical Engineer and worked in the aerospace industry as a designer. He has published widely in Medical Engineering, involving a wide range of technologies, and many new products have resulted from his work. His focus in the last eight years has been on assistive technology for people with dementia, with acclaimed developments in the use of smart homes and user-led approaches to engineering design.
**MEDICINE**

**Professor Dr Rudi G J Westendorp** qualified as a specialist in Internal Medicine and worked in intensive care before training as an epidemiologist. Since his appointment as Professor of Medicine, in particular research into ageing (2000) he combines both skills in trying to understand age related disorders and healthy longevity. He heads the department of Gerontology and Geriatrics that especially takes care of elderly people with multiple comorbid conditions in a clinical and outpatient setting. Within an European perspective he chairs "LifeSpan", an European Network of Excellence that bridges research on development with research on ageing and integrates disciplines that do not have a tradition of close interaction.

**Dr Gillian Butler-Browne** directs a team working on “Regeneration, Pathology and Therapy of human skeletal muscle” in the Myology Institut, Paris. This Institut is affiliated with Inserm, Université Pierre et Marie Curie and the Association Française contre les Myopathies.. She has always been interested in muscle biology and more recently has tried to apply this knowledge to understand the various factors which could be involved in the muscle wasting which accompanies normal human aging.

**Professor Eva Topinková** has worked in the field of geriatrics and gerontology since early 80s. Currently, she is Chair of Department of Geriatrics at Charles University in Prague, and Director of Training in Geriatrics at the Institute of Postgraduate Medical Education. Professor Topinková is Secretary General of the European Region of the International Association of Gerontology and Geriatrics. She served as an expert of European Commission for the 5th and 6th FP in the area of aging and disability and, more recently as an expert for the World Health Organisation. She is author or co-author of several textbooks and monographs and more than 200 professional and scientific publications.
**Professor Alexander Bürkle** is Chair of Molecular Toxicology at the Dept of Biology, University of Konstanz, Germany. His work is focused on the relevance of cellular stress resistance for the ageing process, in particular the resistance to DNA-damaging agents via DNA repair. He has served as a Departmental Chair at the University of Konstanz and is currently Member of the Executive Committee and Treasurer of the International Union of Toxicology.

**Professor Heinz D Osiewacz** directs a research group on Molecular Developmental Biology at the Johann Wolfgang Goethe-University in Frankfurt/Main, Germany. He has a long-standing interest in the molecular mechanisms of biological ageing. Currently he is coordinator of an EU Integrated Project seeking to unravel *The Role of Mitochondria in Conserved Mechanisms of Ageing.* He has published numerous scientific papers and edited a number of books including *Aging of Organisms, Model Systems in Aging* (with T Nyström), *Molecular and Cellular Gerontology* (with O. Touissaint, G. Lithgow, C. Brack). He received the *Sandoz Prize of Gerontology* (with K. Esser and colleagues) and the *René-Schubert-Prize.*
SOCIAL SCIENCE

**Professor Marja Jylhä**, MD, PhD, is Professor of Gerontology at the Tampere School of Public Health, University of Tampere and Director of the national graduate school Doctoral Programmes in Public Health. Her interests in research include health, disability and mortality in old age; social determinants of health; longevity and the oldest-old; and old age as a stage of life in the modern society. She is the Principal Investigator of Tampere Longitudinal Study on Ageing (TamELSA), and Co-PI of the Vitality 90+ Study. At present, she is also actively involved in the European Research Area in Ageing Research (ERA-AGE).

**Professor John Bond** is a social scientist with a background in sociology, social policy and social gerontology. He is Deputy Director of the Institute of Health and Society and a member of the Institute for Ageing and Health at Newcastle University. He specialises in researching the cultural and psychosocial aspects of ageing and contributing to clinical trials of interventions for older people and has published extensively on these and other research topics. Recent books include *Quality of Life and Older People* (2004, with Lynne Corner) and, published in 2007, the third edition of *Ageing in Society: European Perspectives on Gerontology* (edited by John Bond, Sheila Peace, Freya Dittmann-Kohli and Gerben Westerhof).

**Professor Bernard Jeune** directs the Ageing Research Center at the University of Southern Denmark. His research is on the epidemiology of ageing and longevity, especially on the oldest-old. He was member of the Danish Research Agency's Steering Group for the strategic foresight on the ageing society 2030, and coauthor of the Danish report 'The Ageing Society 2030' (2006). He has published numerous scientific papers and book chapters. His books include 'Living longer' (Copenhagen 2002). Together with James W. Vaupel he has edited the series of 'Odense Monographs on Population Ageing', including 'Exceptional longevity'.
Professor Dorly J H Deeg PhD is a professor of epidemiology of aging in the Institute for Research in Extramural Medicine and the Department of Psychiatry, VU University Medical Centre, Amsterdam, the Netherlands. She is the scientific director of the ongoing, interdisciplinary Longitudinal Aging Study Amsterdam (LASA). Publications focus on public health and ageing, including studies of longevity, chronic conditions, functional limitations, cognitive impairment, depression, personal competence, social support, and methodology of longitudinal research. Current interests include cross-national comparison and time trends. Prof. Deeg is editor-in-chief of the European Journal of Ageing, and chair of the Netherlands Association of Gerontology.
THE
AIMS AND
SCOPE OF
AGEACTION
Changing Expectations of Life

Tom Kirkwood
AgeAction Co-ordinator

Introduction
The primary purpose of the AgeAction conference and of the EU FP6 Specific Support Action, of which it is part, is to bring about a substantial change in the perception within Europe of what is without doubt one of the greatest changes to affect the population of this continent in the last two hundred years. It is a change which is long overdue for recognition, but it is only in the last two decades that some of the most startling aspects of change have become apparent. Even now they are not nearly as widely appreciated as they should be.

The change is, of course, the increase in life expectancy. To set this change in context, we can assert with considerable confidence that it is likely to be at least as sweeping in its impact on our lives as climate change, the emergence of global terrorism, and many of the other issues that command our daily attention. Yet unlike other challenges of our time, the increase in longevity is a change that, although dangerous if we ignore it, is the product of quite extraordinary success and has the potential to contribute to even greater successes in the future.

Our goal is to help policymakers, research scientists, industries and the public at large to see this success for what it is and to realise the opportunities that it brings, as well as the challenges. To do this, we believe that it is necessary to create and exploit much greater interaction between scientific research that is beginning to throw light on what actually drives the eventual ageing of our bodies and other areas of activity, in medicine, social science, technology, finance and industry.

Nothing happens without money and a part of the ambition of AgeAction is to see funding for research on ageing within Europe increase by at least tenfold within the next 10 years. But we are not arguing for a handout. The case for investing in ageing can, we believe, make itself without special pleading, once it is understood what is involved and what is at stake. Our lengthening lives have enormous societal and commercial potential. We need to make the transition from seeing population ageing as merely an inconvenient by-product of our success in preventing people dying before their time and focusing on how to make the most from our hard-won extra years of life.

Background
Life expectancy has increased steadily across most of Europe since around 1800, prior to which date the average length of life had probably changed rather little since the days of the Roman Empire. From 1800 onwards, however, life expectancy has shown a remarkably uniform rise, at least in the countries that benefited from the technological advances that grew out of the
industrial revolution. Although considerable poverty and squalor existed still, the gradual trend towards improved sanitation, cleaner drinking water and improved housing led to a steady decline in the rates of mortality due to infectious disease, which had previously caused particularly severe losses among infants but which also generated deaths across the life course.

In time, the control of infection was advanced through development of vaccines and, from the mid-20th century, by the discovery and general use of antibiotics. From the time that antibiotic use became widespread during the 1950s and 1960s, the death rates in the early and middle years of life dropped to be so low that although death from infection can still occur, there was no room for significant further increase in life expectancy as a result of further reducing mortality rates during the early and middle years of life. Since the prevailing view of the ageing process was then that the human life span had a fixed upper limit, imposed by an essentially immutable process of senescence, the demographic forecasts continued, up until the 1970s and 1980s, to project an imminent slowing and cessation of the trend towards increased longevity.

As the statistics show, however, populations failed to do as demographers expected. Life expectancy showed no sign of slowing its remarkably constant rate of increase, of around 2 years per decade. This continuing increase is no longer due to declining early mortality but, instead, results from dramatic declines in the death rates of those aged 75 years and above. Part of the cause for this improvement in late-life survival is undoubtedly due to improvements in medical care, but a large part also appears to be due to the fact that in today’s Europe older citizens are reaching advanced old age in unprecedented bodily health. In effect, the nature of old age itself appears to be undergoing a quiet, yet profound transformation, despite the fact that the increased number of older people has led to much higher prevalence of age-associated conditions such as Alzheimer’s disease, osteoporosis, macular degeneration, and so on.

Enter the new biology of ageing
At the same time that population ageing has been transforming the previous age-mix of European societies, a series of important advances in our biological understanding of the ageing process has revealed that ageing is indeed more malleable than used to be thought. From the late 1970s onwards, the idea that ageing is due to some fixed biological programme for senescence and death has come to be seen as false. The current consensus is that ageing is driven by the lifelong, gradual accumulation of a broad variety of molecular faults in the cells and tissues that make up our bodies.

Further work has confirmed that, as has long been believed, there is a tendency for a genetic predisposition to above or below average longevity to run in families. Genes have been estimated to account for about a quarter of what determines length of life for the typical individual. However, the way in which genes exercise this influence on longevity comes not from controlling some kind of clock-like timing mechanism but rather from influencing the activity of the key cellular maintenance systems, such as DNA repair and antioxidant defence. Genes also appear to influence important features of our metabolism, such as how the body handles cholesterol, which in turn has an
impact on the age-related accumulation of damage within the cardiovascular system.

Since genes do not programme the ageing process in a strict, clock-driven sense, there is plenty of scope for non-genetic factors to affect how fast or slowly the burden of molecular and cellular damage builds up during our lives. The first, very important implication of this new appreciation of ageing is that it underscores the life course nature of how our bodies age. The damage that will determine our health, vitality and level of independence in later life has been accumulating since we were in the womb. Indeed there is emerging evidence that some of the more important kinds of damage have their origins very early in our development. This means that research on the biology of ageing concerns not only those who are old already but is equally relevant to children of all ages.

Biological research on ageing is one of the newest branches of the life sciences yet already it is making a major impact in the best scientific journals and there are signs that the field is at last beginning to attract significant numbers of the brightest young researchers. This is a trend that needs to be actively encouraged and supported. As yet, the number of basic scientists working in the field of ageing research around the world is still tiny in comparison with longer established areas such as cancer research, immunology and human genetics. The urgency of building research capacity in ageing is so great that the process cannot simply be left to follow the slow trend whereby the handful of established research leaders train just a few new early-career researchers, and so on. The complexity of biological ageing is such that there is great scope for established specialists in other branches of the biological and biomedical sciences to be able to re-orient their research towards challenges of ageing, provided that adequate training and funding incentives are put in place.

An important catalyst of the recent advances in basic research on ageing has been the development of high resolution and high throughput analytic procedures, which have the power to analyse the fine-scale and often heterogeneous molecular processes responsible for age-related cellular and functional decline. Because ageing is intrinsically multi-faceted, there is also particular opportunity for the recent advances in ‘systems-biology’ research to make a crucial contribution. Whereas the last few decades of research have seen a trend that has been increasingly reductionist in nature – analysing individual components and pathways in ever narrower focus – the essence of the systems-biology approach is to generate a higher level understanding of how the components and pathways fit together and interact as a functional whole. This requires a new intensity of engagement between the biological sciences and other disciplines such as mathematics, statistics, bioinformatics, engineering and computing.

The medical challenge
Closely allied to the biological research agenda is the need to develop medicine for healthy ageing. Age brings increasing vulnerability to a wide range of medical conditions and indeed in today’s hospitals, apart from the
specific diseases of childhood and a relatively small range of other clinical conditions, the great majority of medical problems are ones for which age is a significant, and often the most important, risk factor.

Although there has been longstanding debate about the relationship between age-related diseases and what some call ‘normal’ ageing (i.e. ageing that is seen when individuals with specific diseases are excluded from consideration), it is becoming clearer all the time that the most likely avenue of progress toward understanding and intervening in age-related diseases will be to identify precisely why the aged cell or tissue is intrinsically more vulnerable to pathology.

The current understanding of intrinsic ageing is that it is due to the progressive accumulation of molecular and cellular defects. However, if we look at the equivalent understanding of neurodegenerative diseases, osteoarthritis, muscle wasting (sarcopenia), and even cancer, we find that an almost equivalent situation exists. The damage that leads to the accumulation in the aged brain of the amyloid plaques and neurofibrillary tangles, which are associated with Alzheimer’s disease, appears to be so intimately associated with the intrinsic processes of brain ageing that we probably cannot understand the one without understanding the other.

The branch of medicine that has most directly addressed the challenge of ageing has been geriatrics. Geriatricians have long dealt with the distinctive spectrum of health problems affecting the very old. As we come, however, to a deeper understanding of the many links between intrinsic ageing and age-related frailty, disability and disease, it seems likely, indeed imperative, that a better integrated medicine of ageing will be developed that moves beyond simply seeing ageing as the ultimate cause of medical failure. We have seen increasing recognition in recent years of the value of focusing greater attention to end-of-life issues such as improved palliative care and recognition of the importance of ‘living wills’ – advanced directives for those wishing to have some say over how they will be treated should ageing rob them of active autonomy over their affairs. For a long time, medicine has been concerned chiefly with stopping people from dying. Now that we are entering an era in which most of us will survive to ages when we shall need to cope with a range of conditions requiring medical attention, it is high time to focus fresh attention on to how medicine can best address questions of maintenance of independence and quality of life in old age.

The social context
In many European countries, the realm of the social scientists has been quite far removed from that of the biologist and doctor. Social scientists, often with good cause, question the application of the ‘medical model’ to the range of issues encountered by older people. The points of interchange between social and biological scientists have been even more infrequent. However, when we confront the changing expectations of life in today’s Europe it makes little sense for the biologist to ignore the social perspective, and vice versa. Human beings are social animals – our social interactions are influenced by the state of our bodies, and our bodies are subject to the effects of our social context.
One of the immediate challenges requiring engagement between social scientists and other disciplines is to understand how much of the 75% of that which determines length of life from a non-genetic standpoint can be modulated from a societal perspective. Part of this spectrum of factors will include nutrition, which is part biological but also, to a very significant extent, socially modulated. Part is related to lifestyle, including exercise, where the same inter-connection between biology and social science must be addressed. Part is also related to education, to housing, to employment status and the nature of work. The nexus of connections is extensive and urgently needs to be explored. It is a stark fact that length of life is positively correlated with socioeconomic status, with those at the bottom of the social scale suffering a disadvantage of 5-10 years less expectation of life.

The social sciences are also the locus for exploration of attitudes to ageing and the psychology surrounding our journey through the life course. The range of problem attitudes to ageing is legion. These include fatalism (the belief that ageing is fixed and cannot be altered), denial (the pretence, until it is too late, that one is immortal), negative stereotyping (the pervasive scourge of overt and covert ageism), tunnel vision (the inability to see alternative ways of addressing the challenges), and fantasy (the delusion, fuelled by popular imagination and an ever-eager media, that a ‘cure for ageing’ will soon be found). It is sometimes fondly believed that when it comes to matters concerning ageing, old people are the fount of all knowledge and wisdom. The truth, of course, is very different. Older citizens have experience of what it means to be old and some of them can put this experience to outstanding use. For others, however, old age is, as Trotsky once remarked, the most surprising thing that can happen. Many older people are confused by the experience of being old, have had little or no useful preparation for this state, and many have simply carried ageist prejudices formed in youth into their own old age. To find oneself the object of one’s own negative prejudice is an unhappy state indeed, but one which appears far from uncommon.

Integration of different age groups within European societies has suffered from the rapid pace of change over the last century, with each successive generation facing challenges and opportunities different from those of their parents and grandparents. To counter this potential disconnection of the generations, it is important to promote the inclusion of every generation, including the old equally with younger people, in all societal, social and political activities and to resist the tendency to categorise people according to their age, particularly on matters where age itself is not an issue. A common tendency is to worry that a new focusing of additional resources on older people will be disadvantageous to the young, thereby reinforcing the idea that generations are in some sense in competition with each other. The truth is that today’s young Europeans will, for the most part, attain old age. Therefore, investments to create a society that redresses the present adverse balance, which disadvantages older Europeans, will create benefits that today’s young can expect to enjoy in their turn.
The potential of technology

One of the greatest changes to alter our lives over the last twenty-five years has been the sequence of breakthroughs in technology, and particularly communications technology. It requires a conscious effort to remember a world without the mobile phone and the internet. Yet both these innovations became widely available only ten years ago. Although very recent trends have seen significant growth in internet use by older users (so-called silver surfers), internet and mobile phone technology is largely driven by the imperatives of the youth market. This is a pity, because these technologies have so much to offer the older person whose life may be becoming gradually more restricted as a result of physical and cognitive impairments.

With ageing comes increased vulnerability to a range of disabilities and functional impairments. Yet disability is not an intrinsic state of incapacity but tends far more often to represent the failure of our environment adequately to meet our needs. Often a relatively simple modification of the environment can remove what was previously an insuperable obstacle, an obvious example being, for a wheelchair user, the provision of a ramp and a door wide enough to take a wheelchair. For a person with arthritis of the hand, use of a conventional mobile phone may be impossible, so such a person is disabled with respect to making telephone calls while on the move. However, simple technological solutions exist, at least in principle, for this problem.

The development and widespread application of technologies to change the expectations and functional abilities of Europe’s older citizens is such an obvious priority that it is truly remarkable that the advances to date have been so modest. Perhaps this comes out of a lack of understanding of the issues, and a traditional approach to design that assumes if the designer can use their product, so can everyone else. There has certainly been valuable development of, for example, alarm systems (for frail or isolated older people), motorised scooters (that assist transport for those who might otherwise remain housebound) and hearing aids. However, these are but minor developments compared to what might have been done. The true nature of not only the need but also the opportunity remains to be generally appreciated. This failure is not necessarily a reflection on technology companies themselves but represents a wider societal problem.

Technology, properly developed and applied, will liberate large numbers of older people from entirely unnecessary social isolation and enforced dependency. The result, even if the technology solutions were funded entirely from state resources, would be savings in the need for high-dependency support services that would easily repay the investment. However, there is no need to see the future provision of technology solutions as requiring state support. The market opportunities for companies are enormous already and growing every year, though these are currently exploited by a very small group of specialist companies within very niche areas. The position across Europe is as yet dominated by thousands of imaginative small businesses, with little access to mainstream markets, and only a very few examples of more mainstream companies starting to explore the possibilities. The larger potential
for the benefits of technology in ageing is little known, and even less exploited.

It is hard to escape the impression that what is holding back further developments is nothing less than a pervasive lack of imagination, propelled by equally pervasive ageism. Perhaps it also derives from a perception that older people represent a small niche market with limited disposable income and narrowed interests that fall outside of mainstream activity. Of course, nothing could not be further from the truth, but the current tendency of businesses and media to focus on the priorities of the young means that the opportunities are insufficiently realised. In the fullness of time this perception is bound to change as increasing numbers of older people challenge the prevailing negative stereotypes. In order to accelerate this change, there is a clear role for policies to initiate programmes specifically designed to stimulate the growth of some beacon developments that may help to show the way.

**Finance and industry**

There is a widespread but profoundly mistaken view that in economic terms, the increase in longevity is simply a burden that must be shouldered, if and when society can afford to do so, as exemplified by a headline in a prominent financial newspaper stating “the bad news is that we are living even longer”. This profoundly gloomy assessment has been challenged by economic assessments of the crude economic value to societies of the increase in life expectancy. For example, one recent analysis has claimed that “the economic value of the increase in longevity over the last 100 years is about as large as the value of measured growth in non-health goods and services” (W. Nordhaus in *The American Journal of Economics and Sociology* 2005; vol 64: pp 367-392). While such analyses are subject to important caveats, they firmly establish that the fact we are living longer is indubitably a good thing, unqualified by worries about the fiscal challenges that today’s European governments must address.

The problem of getting industry to engage proactively with the challenges of population ageing derives in part from the attitudinal problem just mentioned. There are early signs that some of the more enlightened companies have recognised the market forces that will make it sensible to develop business ventures addressing the growing numbers of older people. Nevertheless, a recent report by the UK House of Lords Science and Technology Select Committee on ‘Ageing: Scientific Aspects’ expressed surprise at the current failure of industry to see what is so clearly on the horizon.

There are obvious opportunities for the traditional health-related industries in addressing the challenges of ageing. The pharmaceutical industry, for example, is already investing heavily in new drugs aimed at treating neurodegenerative diseases, osteoporosis, and similar conditions. Nevertheless, it remains true that most of this effort is focused so far on treating end-stage pathology and there is little sign to date that research scientists in these industries have made serious connection with the emerging understanding of the underlying biological mechanisms of ageing. It is probably in the latter direction that the greatest promise is ultimately to be
found, since early intervention against degenerative conditions is more likely to be successful than trying to intervene when the damage has already reached an advanced state. Such a realignment of targets for drug treatments may, however, require a concomitant adjustment in the regulatory procedures by which drugs are tested and approved. To license a drug that is to be given for early-stage presentation of an age-related condition raise issues around the ethics of medicating someone who is not yet seriously ill and around the duration of the necessary clinical trials.

Important progress may be made in the relatively near future with the development of improved biomarkers of ageing. Such biomarkers are needed not only to help understand the underlying pathobiology of intrinsic ageing and age-related disease but also to make it possible more quickly to determine whether or not a proposed intervention is having an effect.

In addition to the recognised biomedical industries, there are likely to be major opportunities for businesses offering nutritional, personal care and lifestyle products and services that will promote health and well being. These will be developed not only through the existing manufacturers but also though novel offerings in the retail and service contexts. The provision of care is likely to become an increasingly important feature in the Europe of the not very distant future, and we can anticipate major opportunities for novel businesses to emerge in this area, alongside the growth of existing components of the care-provision industries. The attraction of these developments is that there will be significant growth in business related to Europe’s ageing population, while at the same time successful products and services will actually be extending the period of independent living and enhancing quality of life. It is thus quite easy to anticipate win-win outcomes for companies, individuals and states, but only if the right moves are made quickly. This may require strategic policy incentives and some pump-priming investment.

In the area of finance, the overriding issue, to which much attention has already been given, is the provision of pensions. When pensions were first introduced across several European states, around a century ago, life expectancy was some 25 or more years less than it is today. The average period of time over which the average worker could expect to draw a pension was minus 10-15 years. Today the expectation is for plus 10-15 years, so it is small wonder that the systems are under strain. Indeed, it is a remarkable sign of the growth in the European economies that we have reached our current position without crisis occurring much sooner. We now see the beginnings of adjustment in pensionable age. It is obvious that with the combination of increasing life expectancy and static or declining birth rates that either retirement ages must be deferred or pensions become relatively less in monetary terms. However, there has been remarkably little attempt made so far to connect the planning of future pension and retirement policies with what we are learning about the science of human ageing. Making the appropriate adjustments will not be easy but it is likely to be more of a science and less a matter of guesswork if we can engineer better links between the financial planning sector, both public and private, and the other disciplines that are addressing the problem of our changing expectations of life.
BRIEF SUMMARIES OF THE SECTOR PANEL REPORTS
SOCIAL SCIENCE

The report firstly discusses how ageing, longevity and health in older age are affected by the social world and vice versa, secondly summarises the state-of-the-art of (European) research that cross-cuts the biological and the social sciences, and thirdly suggests opportunities for new research in Europe in areas where the biological and social sciences interact. The term “social science” includes, among others: anthropology; demography; economics; epidemiology; geography; health services research; history; political science; psychology, and sociology. The ultimate purpose of the proposed research is a better understanding of ageing processes, the improvement of quality of life in older age, and a balanced development of European societies.

An outline of the interaction between biological and social aspects of ageing emphasises the importance of the distinction between population ageing and individual ageing. Both are affected by social factors, and their study adds to our understanding of ageing across time and space. The report continues by discussing long-term and recent population trends in life expectancy and mortality, and the possible explanations for these trends. The same is done for health outcomes in older age other than mortality, although the population trends are necessarily limited to more recent periods, due to the availability of data. Separate consideration is given to interaction between genetic and environmental factors in ageing, including the recent interest in epigenetics (modification to the pattern of how genes are expressed, which may be induced by factors such as nutrition).

The observed heterogeneity of population ageing trends across European countries is likely to be best understood by combining biological and social scientific insights. Next, the report turns to ageing at the individual level. Evidence from several European studies is discussed that implicates the heterogeneity and even inequality within the ageing populations, and shows how social class, social engagement, lifestyle and psychological mechanisms operate to influence individual life spans and health in older age. The meaning attached to ‘age’ and ‘ageing’ receives particular attention, and it is shown that the way these terms are understood has profound effects on the organisation of society and the self-perception of individuals. We also discuss the negative impacts of age discrimination and segregation, and the necessity for the ageing societies to integrate old people better into societal activities.

The final message is that greater inputs into in different fields of ageing research and particularly greater interaction between biology and the social sciences will be essential if understandings about ageing are to have maximum impact on ageing policy within Europe. Therefore, the strengths and challenges of the current situation of multi- and interdisciplinary research in Europe are described, resulting in several suggestions for the future. These suggestions pertain to several levels: researchers, students, universities, funding agencies, and the national, cross-national and European decision makers. Most importantly, it is suggested to create established research environments for ageing research, support research training, and improve financial possibilities for multidisciplinary and interdisciplinary research on ageing.
MEDICINE

Traditional health research has focused on risk factors that cause people to develop disease and die early. This has contributed to the increases in life span. Societies are now confronted with an increased fraction of their citizens living long enough to suffer from age-related diseases, often with the complications of multiple medical problems. However, there is great variation in the way that different individuals experience the ageing process. Some of 60-year olds appear to have a biological age of 80, but some at age 80 years seem as if they were aged only 60. The key question now is to understand why individuals age at such a different pace. To fully understand the causes of this variation in ageing trajectories necessitates a detailed knowledge of the underlying mechanisms. This is timely as recent advances in understanding ageing of experimental models are beginning to provide the promise of previously unforeseen breakthroughs. Acquiring a better understanding of the interplay of genes, nutrition, lifestyle and environment chance will be crucial if Europe is to maximise the benefits of increased longevity by keeping people healthier for longer.

New, powerful technologies and the development of biological markers of ageing are likely to result in the identification of determinants of a healthy ageing trajectory. A key challenge in bringing this about will be to bridge the biological and medical research domains, which traditionally have been separated by important differences in their conceptual approaches. One of the main needs is to develop and apply a multi-disciplinary approach to unravel the ageing process. This will require the building of teams that can cover the full range of challenges that arise not only within the laboratory clinic but also within the daily lives of older people across society. Our report identifies major structural issues, in terms of the organisation of professional groups with research interests in ageing and of the development of training with the European medical and biological curricula, which urgently need to be addressed.

Among the hurdles which definitely need to be overcome is the outdated but still powerful tradition of holding both scientific research into ageing and the medical care of geriatric patients in low esteem, compared with other branches of biomedical research. This derives from the ambivalence of society towards its older citizens and the widespread negative stereotypes which too often pass unchallenged. The ultimate prospect for the required new medicine of old will be for senior citizens to remain active for longer, to consume fewer healthcare resources and to contribute for longer to the economy.
BIOLOGY

Age is the most important risk factor for many debilitating diseases, such as cancer, cardiovascular disease, stroke, type II diabetes, immune disorders, senile dementia and neurodegenerative diseases. Increasing our biological understanding of the ageing process can therefore be expected to deliver the knowledge base from which novel strategies and businesses can be developed to meet the challenges of population ageing.

Ageing research has become established in Europe only over the last two decades. An important stimulus has been EU support for collaborative programmes on biology of ageing. At the national level, several European countries have seen the establishment of the first research centres on ageing. These developments have proved the possibility of beginning to understand intrinsic ageing process and led to important discoveries including identification of candidate compounds that delay some aspects of the ageing process. This progress needs to be expanded in order to deliver a coherent scientific understanding as it occurs in humans and other animal species that will result in:

- A deep understanding of the mechanisms of ageing;
- Biomarkers of ageing;
- Identification of longevity assurance genes;
- Identification of how environmental effects are generated;
- Development of successful healthy ageing strategies;
- Extension of healthy human life expectancy;
- Improved links of biogerontology to other disciplines and the industry.

By comparison with the US, European funding for research on biology of ageing is a much lower fraction of the research spending of health overall. The report argues the case to increase proportional spending on ageing research across Europe to match the US level within the next 5-10 years. This would allow Europe to achieve urgent goals:

Creating adequate critical mass at a national scale by:
1. Construction of national focused research networks
2. Establishment of National Centres of Excellence/Institutes of Ageing
3. Training and education at the national level

Capacity building at the European level by:
4. Networking within the EU
5. Establishment of European Centres of Excellence
6. International education

Developing the synergistic links of ageing research by:
7. Increased overlap between research on ageing and age-related diseases
8. Stronger relations to the industry
9. Better communication strategies for the public

European ageing research is at a critical position. The proposed changes will propel European research on the intrinsic biology of ageing into the internationally competitive position that be necessary to improve health span and result in successful economic exploitation of a range of major opportunities.
TECHNOLOGY

The progressive decline in the functional capacity of many different organs and systems is an inevitable consequence of advancing biological age. Taking into account the very great variability in the rate of decline, it is suggested that there are three categories of individuals in which it is appropriate to consider the use of technology:

*Informed* – where advancing technical developments are used are used to provide feedback, e.g. through the production of novel biosensors, on critical body functions and general state of health in relation to intrinsic ageing;

*Supported* – where a range of technologies, e.g. improved joint replacements, hearing aids, etc, provide the capacity to maintain almost complete independence in spite of some functional decline; and

*Dependent* – where functional decline is further advanced, so that independence can no longer be assured, through the provision of autonomous ‘smart’ homes and other assistive devices that help to maintain as much social engagement, quality of life, and freedom from the need for expensive and intrusive social and medical support, as is possible.

At the informed and supported levels, appropriate inclusive design is of paramount importance and has the ability to lift people from the supported category. Similarly, the use of technology to support the selection of the most appropriate supporting device can provide impressive functional benefit and, at the same time, reduce the wastage of inappropriate supply.

At the dependent level, autonomous smart homes have the potential to increase independence and maintain a safe environment. The full potential of this approach will only be realised with the development of new sensors and computer systems for the appropriate interpretation of the data acquired. Advanced communication systems are also required to allow isolated older people to have realistic interaction with friends and relatives.

In each of these areas there are major opportunities for technologists to engage in entirely new branches of research and to forge close links with research in the biological, social and medical domains. Europe offers a strong research environment for such technology development in view of both the strength and diversity of technology research, development and commercialisation and in the richness offered by the variety of impacts of increasing life expectancy in the different European populations.
FINANCE AND INDUSTRY

The changes that are occurring in the demographic structure of populations across Europe are having major effects in nearly all domains of finance and industry. Although therer is widespread tendency to see the economic aspects of population ageing chiefly in terms of negatives – the ‘burden’ of increased numbers of older citizens – there are strong indications, backed up by economic arguments, that the gains in life expectancy have been a highly significant contributor to the improvements in GDP. For the U.S., for example, authoritative estimates are that the increase in longevity over the past century has added $3.2 trillion to GDP annually. It is expected that when a proper realisation of the changing expectations of life is made, market dynamics and productivity will go through profound changes in the near future.

Our vision for industry is threefold: (i) to contribute to sustainable improvements in quality of life of people; (ii) to help individuals to prevent disability, frailty and deteriorations in physical and mental health; and (iii) to offer people routes and products to cope better with potential issues that might otherwise have a negative influence on financial and functional independence. We emphasise that the opportunities for business in this context are very extensive, with scope in particular for innovations in financial services, consumer goods and information technologies.

Ageing research in the EU at present is relatively poorly funded and structured. In order to capitalise properly on the opportunity represented by the improvements in longevity, we argue that there needs to be a virtual European Ageing Institute that will effectively combine work across: (a) biogerontology (focusing on the underlying causes and mechanisms of ageing and how these feed in to age-related frailty, disability and disease); (b) socio-economic aspects and behaviourial of ageing (in order to understand the origins of socioeconomic gradients in health and the barriers to uptake of lifestyle and other changes that might support healthier ageing), and as (c) studies of the ‘healthy phenotype’ (in order to understand the factors that sustain health, independence and quality of life at older ages). The latter area in particular has so far relatively little emphasis in programmes across European countries but has great potential to lead to the germination of new products and services.
FULL REPORTS OF THE SECTOR PANELS
SOCIAL SCIENCE

Panel Members: Marja Jylhä (Chair), John Bond (Vice-Chair), Dorly Deeg, Bernard Jeune

Introduction
Human life expectancy is increasing world-wide (United Nations, 2003), due mainly to improvements in living conditions, hygiene and health care. Across European populations, changes in life expectancy as well as in fertility rates have transformed the demographic profiles over the course of the 20th century from the population “pyramid” to the “bell-shaped” and later the “urn-shaped” population distribution. A recent development, beginning only a few decades ago, is the rapid decline in old-age mortality, resulting in increasing longevity and a rapidly growing number of nonagenarians and centenarians. This phenomenon, labelled an ‘ageing revolution’ (Kirkwood, 1999), has been widely conceived as a social and political problem (McIntyre, 1977) as reflected in the political rhetoric of apocalyptic demography. The increases in life expectancy have a considerable impact on individuals and on the cultural, economic, political and social landscapes in which we live.

In this review, we argue that increasing life expectancy is one of the great achievements of our societies, that it is clearly a consequence of successful human intervention, and that research can help societies to promote healthy longevity, and to adjust to and take advantage of the changing age structures. Here, social science has a major role. By social sciences, we refer to a range of disciplines that impact on “the social” including: anthropology, demography, economics, epidemiology, geography, health services research, history, political science, psychology, and sociology. We are convinced that both stronger social science on ageing, and greater interaction between biology and the social sciences will be essential if understandings about ageing are to have maximum impact on ageing policy within Europe. First, it is now clear that the biological processes of ageing, even if inevitable as such, are malleable, not only by targeted biological and medical interventions, but primarily by the social environments in which we live. Second, the meanings of ageing and the quality of life of old people are essentially produced and modified by our cultural understanding and social decisions. Third, the consequences of the ageing of populations to society are greatly dependent on the measures and decisions taken by these societies themselves.

The purposes of this review are:
• to examine understanding of ageing from the perspective of the social sciences, and the issues where social science and biology should work together;
• to discuss the major social factors that influence healthy longevity;
• to suggest measures that will help our societies to face the challenges of changing age structures; and
• to examine the role of research, particularly that of social science research, in these processes.
The processes behind increasing life expectancy

The increase in life expectancy throughout Europe during the 1900s has been so rapid that it seems obvious that the main causes for this historical change must be environmental rather than genetic (Christensen et al., 2006). However, within given birth cohorts there are still large variations in life expectancy, and it is still unclear to what extent the variation is related to genes, environmental factors, interaction between genes and environmental factors, or epigenetic or stochastic processes. It is important to stress that both life expectancy at the population level, and the life span and health of an individual, are dependent on a complex interplay between genes, environment and chance.

The most extreme measure of the continuing increase of life expectancy in most ‘low-mortality’ countries is based on trends in annual records of life expectancy (Oeppen and Vaupel, 2002). Thus, female life expectancy in the record-holding countries has risen for 160 years at a steady pace of almost 3 months per year – from 45 years among women in 1840 in Sweden (the record-holding country then) to 85 years among women in Japan (the record-holder today). Record life expectancy has also risen linearly for men, although more slowly so that life expectancy in the record-holding countries has increased on average by 2.5 years per decade for more than a century. If this trend continues record life expectancy will reach 100 years before the end of the present century. Although rapid progress can be followed by a slower rise, stagnation, or even a fall, as observed in recent years in some European countries (Jacobsen et al., 2002, Jacobsen et al., 2004, Janssen et al., 2004), life expectancy does not appear to be approaching a limit, and can be expected to increase further in the future (see below). Linked to the increase in life expectancy is an increase in maximum life span (Jeune and Vaupel, 1995, Kannisto, 1996, Vaupel et al., 1998, Wilmoth, 2000).

The observed change in life expectancy has occurred at different rates and has had multiple causes in the course of the 160 year period (Vaupel and Romo, 2003). In the early 1800s, it was mainly the result of decreases in child mortality, but in the late 1900s (1960 onwards), increasing life expectancy reflected the decline in premature mortality among middle-aged and younger older people. A closer look at this development suggests that different causes have been acting in the different periods, each with their own effect. Oeppen and Vaupel (2002) argued that the continuous increase in life expectancy could be explained by “a regular stream of continuing progress” such as advances in income, nutrition, education, sanitation, and medicine varying over age, period, cohort, place, and disease.

In his seminal analysis of the decline of mortality in England and Wales from 1848 to 1971, McKeown (1976) found that about three quarters of this decline was due to the reduction in mortality of infectious diseases, mainly the airborne diseases, including respiratory tuberculosis, and that this reduction was a result, by and large, of improved living conditions, especially nutrition and sanitation, and only modestly of medical care (such as obstetrical care and surgery). In an analysis of the declining mortality in the Netherlands in the period 1875 to 1970, Mackenbach (1996) confirmed that most of the decline in mortality was due to a reduction in mortality from infectious diseases. But
contrary to McKeown and in line with Szreter (1988), Mackenbach (1996) also suggested that prior to the introduction of antibiotics other public health and medical interventions had had an effect. Bunker (2001) estimated that medicine contributed to at least 5 years of the about 30 years of increase in life expectancy that has occurred since 1900, and to half of the increase in life expectancy since 1950, i.e. 3-4 years of gain in life expectancy. Furthermore, several studies (Mackenbach et al., 1999, Mackenbach et al., 1988, Bronnum-Hansen et al., 2006) indicate that prevention of diseases in the circulatory systems and cancer would result in the highest gains in life expectancy. Based on data from the MONICA-project among middle-aged populations in Europe (Tunstall-Pedoe et al., 1999, Kuulasmaa et al., 2000), it has been estimated that two thirds of changes in coronary heart disease mortality can be attributed to a decline of risk factors which influence the incidence and one third to treatments which influence the case-fatality of coronary heart diseases. As more than half of ‘oldest-old’ die of diseases in the circulatory system, the mortality decline of these diseases must have had a substantial impact on the recent increase of the maximum life span (Jeune, 2006).

Population trends in other health outcomes
Life expectancy is a powerful and objective indicator, but it does not tell us much about the health of those who are alive and how their lives come to an end. As medical science presently seems to be better at managing chronic diseases than at curing or preventing them, decreasing mortality could be accompanied by poorer health. Indeed, there is ample evidence of an increase in the prevalence of chronic diseases in the past twenty years (Freedman and Martin, 2000, Fleming et al., 2005). This increase may partly be explained by earlier diagnosis and improved medical treatment. As a result, persons with a chronic disease may live longer with their disease. In addition, persons with a chronic disease may have fewer disabilities because their disease is diagnosed at an earlier stage or because improved medical care and increased use of assistive devices have reduced its deleterious effects (Wolf et al., 2005). There is evidence from European studies that specific chronic diseases have become less disabling during the past twenty years (Deeg et al., 1994, Robine et al., 1998).

Functional ability of individuals can be described in many ways, e.g. as measured performance, as self-reported disability, or as disability-free life expectancy, an indicator that combines mortality and disability. Disability is usually defined as the inability to carry out tasks of daily living. It is an established powerful indicator of health status at older age and a good predictor of future outcomes (Guralnik et al., 1996). The recent evidence on population trends in disability shows different results across countries and periods (Robine and Michel, 2004), but most studies show a decline in prevalence of ‘less severe’ disability since the 1980’s (Freedman et al., 2004). The majority of these studies have been conducted in the United States (Freedman et al., 2002, Manton et al., 2006). In European countries, both decreases and increases in disability have been reported (Sagardui-Villamor et al., 2005, Martelin et al 2005, Parker et al., 2005). There are hardly any data indicating improvement at age 80 or above, but due to small and often selected samples, the evidence for the ‘oldest-old’ is weaker than for younger age
groups. It is important to realise that disability is not a characteristic of a separate individual and his/her physical status, but reflects the relationship between an individual and her environment. This conceptualisation implies that disability can be prevented not only by rehabilitating individuals but also by improving their environments.

Across European countries, there is variation in the observed prevalence of disability, even for disability in activities of daily living (ADL disability). Although the few available studies show slightly different patterns, ADL disability is estimated to be highest in Italy and Spain, and lowest in Finland (Pluijm et al., 2005, Van den Brink et al., 2003). A north-south gradient in Europe is also found in hand-grip strength, which is a strong predictor of disability and mortality (Jeune et al., 2006). The north-south gradient may be explained by socio-economic as well as cultural differences. In Mediterranean countries, only a small minority of older people have completed elementary education, whereas this is true for the majority of older people in northern countries. Differences in the prevalence of disability may also stem from differences in the meaning of disability and the availability of family help. Self-reported disability may be greater when help is available within the family, which is the norm in Mediterranean countries, as opposed to northern countries. Despite the variations in the prevalence of disability, its ability to predict mortality and its association with objective, performance-based disability scores are very similar across countries (Noale et al., 2005, Van den Brink et al., 2003).

For self-rated health, which has been shown to be a good predictor of mortality, disability and cognitive impairment (Bond et al., 2006), no north-south gradient can be observed. However older people in Eastern Europe rate their health as ‘worse’ than older people in Western Europe (Appels et al., 1996, Bardage et al., 2005, Carlson, 1998). There is less information on trends for self-rated health than for disability, but again, results from individual countries indicate both improvement and deterioration (Spiers et al., 1996, Crimmins, 2004, Aromaa and Koskinen, 2002, Wilhelmson et al., 2002).

In conclusion, there is no single way of ageing in Europe. The data show cross-European differences in nearly all indicators of health among the various older populations. In addition, shifts over time in levels and determinants of health, encompassing cohort and period effects, seem heterogeneous. However, this heterogeneity should not be seen as an obstacle, but as an advantage for further exploration of critical factors that influence health as people age.

**Longevity and health - the interaction between genetics and environment**

A Danish twin study has found that about 25% of the variation in life span is determined by genetic differences (Herskind et al., 1996). This has been confirmed in a recent analysis of more than 20,000 twins born in the Nordic countries which also showed that the genetic impact on life span increases after the age of 60 (Hjelmborg, 2006). Another 25% of the variation in life span might be due to non-genetic factors that are fixed at the age of 30, and
the other half might be due to environmental factors occurring after the age of 30 (Vaupel et al., 1998).

Rare mutations may either cause serious diseases early in life or exceptional longevity, both with large effects on individual life span. However, their impact on the variation in life expectancy at the population level is very small (Christensen et al., 2006). The impact of genes on life expectancy may instead involve many common genetic variants with moderate or small effects. However, so far, only the effect of the apolipoprotein E (APOE) polymorphism on longevity has been found consistently in various populations, including those from several European countries. The APOE4-allele frequency varies considerably between adult populations with a north-south gradient in Europe. However, whatever the level is (e.g. high in Finland, low in Italy), the frequency among centenarians is about half of the frequency among adults. Suggested associations between many other putative candidate genes and longevity which have been observed in only one or two populations have not been confirmed in other populations, suggesting either that they are statistical artefacts or not generally relevant.

The recent increase in interest in epigenetics – the study of heritable changes in gene expression that do not involve coding sequence modifications – draws attention to the role of environmental and nutritional effects on the way genes are organised and transcribed, and on the ensuing phenotypes (Feil, 2006). A Spanish twin study showed that although monozygotic twins are epigenetically indistinguishable during the early years of life, they exhibit remarkable differences in gene-expression at older ages (Fraga et al., 2005).

In all, considering that the genetic impact on life span is moderate and probably involves hundreds of genes with small effects, that these effects are the results of a multitude of interactions with environmental factors which varies among different birth-cohorts and populations, that several environmental factors, including life style and medical care, independently influence life span, and that epigenetic and stochastic processes also influence life span, there may be multiple ways to achieve very old age. It is therefore important to note that studies of interactions between putative candidate genes and important environmental factors such as nutrition, smoking, fitness, obesity and stress-resistance are as yet very scarce. Further European research on such interactions is likely to be very rewarding.

**Social determinants and the problem of inequality**

Improvements in life expectancy and health do not concern all people equally, but are characterised by heterogeneity and inequality. Life expectancy at birth varies by 9 years between European countries. Women live longer than men in all European countries by 4 to 8 years, resulting in one man for 7 to 8 women in the oldest age groups. A growing body of evidence shows positive effects of exercise and non-smoking and adherence to a beneficial diet (e.g. Mediterranean) on survival time even in old age (Ferrucci et al., 1999, Knoops et al., 2004). Even though obesity is only weakly associated with life expectancy, it is strongly associated with an increase in disability (Jenkins, 2004). Also, social ties and social participation have unique effects on survival
time at older ages (Penninx et al., 1997, Maier and Klumb, 2005, Rasulo et al., 2005).

Social inequality prevails between older and younger age groups, and within the older population. The income differences between generations vary from one country to another, but in many countries poverty is more common among older people than among others. Within all European countries for which data are available, there is a gradient showing lower mortality and longer life expectancy to be associated with higher socioeconomic position or higher educational level, resulting in a variation of 5-10 years in life expectancy (Jylhä and Luukkaala, 2006). Even in very old age, the remaining life expectancy varies by several years across social classes and educational levels (Martelin et al., 1998, Bronnum-Hansen et al., 2006).

Disability trends also vary with socio-economic status (Ebrahim et al., 2004). While disability in population groups with higher education is declining over time, this is not always the case in population groups with lower education, even in the United States (Crimmins and Saito, 2001). In a recent study, low education in mid-life was one of the three strongest predictors for failure to survive until the age of 85 (Willcox et al 2006). It is known that people in lower social classes are usually more likely to smoke, consume excessive amounts of alcohol, eat unhealthy food, and not practice physical exercise. There is also evidence that people in lower socio-economic groups participate less in social networks, receive less social support and express more pessimistic expectations (Stansfield and Marmot, 1992, Marmot, 1999). The essential feature in socio-economic differences is that not only is there a difference between the “poor” or particularly deprived groups and others, but there is also a gradient across the scale. It is the position in the hierarchy and the extent of ‘material’ differences over the scale – the relative deprivation (Runciman, 1966) – rather than the absolute wealth or level of education that matters. It is a major challenge to research to improve understanding of the processes that mediate the experience of inequality and biological processes.

In part, social inequality in health can be attributed to worse physical living conditions, poorer access to medical care, more unhealthy life styles and unfavourable psychosocial conditions among lower social classes (Koster et al., 2006). In total, however, social class differences in health cannot be explained by individual variables or their combinations only, as they result from global differences in the possibilities of need-satisfaction, both material and non-material. Rising levels of education are likely to influence health behaviours in general, but less likely to diminish differences between the social groups, if inequalities in other spheres of life prevail.

Bunker (2001) estimated for the UK that the total elimination of social inequality would result in a gain of life expectancy of about 3 years (persons in the highest social class live on average 9 years longer than those from the lowest social class), about 2 years if everyone assumed the physical activities of the fittest, about 1.5 years if every smoker quit smoking (6 years for the quarter of the persons who cease to smoke), and 0.5 year if overweight and obese individuals would return to normal weight.
The problem with the promotion of healthy lifestyles is that the effectiveness of health education is known to be weakest among those in lower social classes and with the least healthy lifestyles. People with poor general control over their lives are seldom in a position radically to change their lifestyles. Therefore, measures that instead of putting demands directly on individuals attempt to influence the environment and support healthy choices are more efficient, such as pricing policies, availability of healthy food, creating living environments that encourage walking and exercise, or legislation against smoking.

In conclusion, with the possibilities for improvements in healthy lifestyles, including healthy nutrition, the possibilities of healthier environments and better social support, and the substantial advances in medical interventions and assistive devices which can be expected in the future, it seems likely, although not certain, that life expectancy will continue to increase in the future, and that healthy life expectancy may increase even more. However, continued effort to understand the social and biological mechanisms driving improvements in life expectancy, and their interplay, is needed.

The meanings of age in society
Increases in life expectancy and lifespan have the potential to change the way individuals and societies think about human ageing and ‘old age’. From a biological perspective human ageing is a continuous process that starts early in life rather than a distinct phase beginning in middle or late life (Westendorp and Kirkwood, 2007). This concept of a continuous process is in contrast to the common stereotype of ageing, dominant in Western cultures, reflected in everyday life, popular culture and policy rhetoric that presents old age as a distinct, “different”, stage of life, characterized by greying hair, waning muscular strength, reduced vitality, reduced intelligence, and increasing dependency.

The understanding provided by the life course perspective in social gerontology is that ageing is an individualised and unique process that involves changes in many aspects of people’s lives, both positive and negative, and not just declining health and vitality. The life course perspective reminds us that both youth and old age are normal stages of life, not permanent characteristics of certain individuals. The social perspective also emphasizes that the meanings of age are socially constructed. The position of older people is dependent on social decisions, and varies between cultures and across periods of time.

Chronological age has been used in public policy for demarcating between ‘older people’ and others in society. Hence old age is represented as a social problem to be solved (“apocalyptic demography”; see Robertson, 1997). Early public-policy discourse perceived older people as in need of financial, medical and social support. More recent public-policy discourse has focused on the increasing demands of ageing populations on the social protection systems. This alarmist discourse has reinforced the development of negative stereotypes of ageing and institutionalised ageism. Another effect of this discourse is the increasing emphasis of contemporary public policy on individual
responsibility for illness. This has led to blaming older people for the largely social problems of population ageing and also for the biological processes not in their own control.

The representation of later life in the media and the arts reflects the negative attitudes of society toward older people. Images of ageing reflect the public’s perception that ageing is a bodily affair and are reinforced by society’s preoccupation with health, illness and mortality. Recently, the emerging concept of ‘Third Age’ has been used to create a sharp distinction between the often idealized positive images of the freedom and wealth in early years of retirement (Gilleard and Higgs, 2000), and the frailty and helplessness of the ‘Fourth Age’. These negative images are likely to create fear of ageing and injure the self-images of older people (Jolanki, 2004).

Ageism, defined as a systematic stereotyping of and discrimination against people because they are old (Butler, 1969), not only influences the lives of older people but also has negative impacts on society as a whole, by preventing it from taking advantage of the full contribution of older citizens. Characteristic to ageism are discourses where older people are viewed as “others”, people different from “ordinary people”, and as objects of measures and decisions rather than active agents themselves. This is evident also in research where perspectives and logical framework of old people are seldom discussed.

However, it is very clear that an ageing society would benefit from avoiding age segregation and age-based definitions where they are not justified, from attending to the voice of old people themselves, and from integrating them as much as possible into all activities of the society (Hagestad and Uhlenberg, 2005). A recent Danish report (Danish Research Agency and The Danish Council for Strategic Research, 2006) emphasized the importance of moving from an age-constructed to an age-integrated society.

**Increasing heterogeneity among older populations**

The increase in life expectancy influences each society in several ways, some of them positive, some creating new challenges. The impacts on both individuals and society have been observed in the nature of social relations and family life, leisure and cultural life, and in the provision of social protection, particularly in health and social services. Not enough is known of the quality and contents of these changes, however, because research to date has concentrated almost exclusively on the economic and policy dimensions of work, retirement and care.

With the ageing of populations, social diversity among older people, already quite remarkable, will increase further particularly as the ‘baby-boomer’ generations are likely to approach later life in ways differing from earlier generations. With the lengthening of life span, the distinction between the Third Age, characterised by reasonable health and good functional status, and the Fourth Age, with increasing likelihood of frailty, disability and cognitive impairment, will probably increase. It will be crucial to develop ways to increase the integration of older people, particularly those in the Third Age, both in employment and social activities.
Age stereotypes as reflected in popular and policy discourses fail to recognise the heterogeneity of older populations within Europe and across the rest of the globe. They fail to recognise the diversity of experience of individual men and women from different social and cultural groups, different generational cohorts and in different European countries. In addition to increasing life expectancy and life span, changes in cultural, economic, political and social life are leading to increased diversity. A significant change has been in the nature of social relations across the life span, including later life (see Askham et al., 2007 for a review). In line with changes in societal attitudes toward ‘marriage’ and family life, family relationships are no longer seen as the only significant social relations in later life. Friendships and ‘non-traditional’ partnerships are becoming more frequent and the importance of the traditional extended family is weakening. Older women continue to play a major role in providing care and support to both older and younger generations, but recent generations of older men are increasing their participation in caring activities, particularly in relation to the care of life-long partners. The majority of older people across Europe now live alone or with their partners (Peace et al., 2007a) and an increasing minority are growing older in countries where they neither grew up nor spent their working lives (Peace et al., 2007b). The new characteristics of family life and the new types of changing social relationships within and between generations are likely greatly to change the expectations of future life in old age (Lowenstein, 2005). However until now, there has been little research in Europe on these topics.

It is in the interest of present and future societies to encourage the independence, full inclusion in social life and participation of both healthy and more or less disabled older people. Here, good environmental planning, prosthetic home environments and modern technology can play a major role. Technology, medicine and social science are all needed in the attempts to produce useful, feasible, easy-to-use, and ethically acceptable technological solutions to the challenges of old age.

The role of research in “Changing expectations of life” - strengths and challenges in the present European research environment

To face the challenges of its ageing populations, Europe needs more research on ageing and old age, both in social science, biology, medicine and other fields. Many research questions can be addressed in the field of one discipline, but accumulating evidence suggests that to improve the understanding of human ageing, different disciplines must work together. In Europe, an increasing number of research institutes and universities have developed projects that bring together different disciplines, particularly biological sciences and social sciences, to improve our understanding of the process of ageing in humans, and the implications of the ageing of populations to society.

These programs can be characterized as multidisciplinary or even interdisciplinary. By “multidisciplinary” we refer to collaboration between disciplines where several disciplines contribute to a project or programme of research often using the methodological orientation of the dominant discipline with little attempt to integrate different disciplinary perspectives. By “interdisciplinary” we refer to a situation where the collaboration between the
disciplines creates new, integrated approaches that may involve epistemological, methodological and theoretical pluralism. These terms are sometimes used interchangeably and also the terms cross-disciplinary and transdisciplinary are also sometimes used to describe the different levels of collaboration between disciplines.

The EU 5th Framework Programme of Research provided a vehicle for multidisciplinary research by the key action “The Ageing Population and its Disabilities”, but in the 6th and 7th Framework Programs the themes on ageing do not have an appropriate funding mechanism that would encourage multidisciplinary or interdisciplinary research. The European Forum for Population Ageing Research and the ongoing European Research Area on Ageing (ERA-AGE), aiming to promote the development of a European strategy for research in ageing, both emphasise the importance of multidisciplinary approaches. In the US, the label of “biodemography” has been adopted to describe the emerging field of research that seeks to integrate approaches and findings from biology, demography, epidemiology, and social science (Wachter and Finch, 1997, Finch et al., 2001), significantly supported by the U.S. National Institute on Aging.

Integrating biological and social science is possibly the most challenging form of interdisciplinary collaboration. Both fields, of course, are heterogeneous themselves, and usually they differ not only by their main topic of study but also by deeper characteristics: there are differences in the ways to define the object of research, in the understanding of the role of the researcher, in the criteria for high quality in research, and in the publishing traditions. These differences should not discourage researchers from different fields from working together. On the contrary, being aware of them should create better possibilities to collaboration. However, a considerable amount of time, work, persistence, and resources are needed to develop multidisciplinary or interdisciplinary research environments, and the present research and funding structures in Europe do not adequately support this work.

First, funding structures are usually organized according to disciplinary logic; this is true both for national and European sources. In these structures ageing research in general, and interdisciplinary research in particular, tend to be understood as non-mainstream research, being of generally lower priority and harder to evaluate in terms of quality. Therefore, there are very few established research environments in the field, and most of the existing groups or institutes, even the most prominent, are vulnerable to lack of continuity of funding.

Second, interdisciplinary studies on ageing in human populations usually require a longitudinal design, and at present national nor European sources are generally reluctant to commit long-term support for projects that last for more than 4-6 years, let alone several decades.

Third, it is difficult to recruit young researchers into the field. The situation of young researchers is weak because, due to the problems described above, their prospects for future careers are uncertain. Also, there is no established
systematic research training in multidisciplinary ageing research in any European country.

These structural and financial barriers prevent Europe from taking advantage of the unique strengths that it might otherwise deliver as a research environment e.g. in comparison to the US. Advantages include comprehensive and high quality population registers and census data, and high frequency of consent of people in most countries to participate in research studies. Further European strengths include strong traditions in demographic, epidemiological and social research, as well as long-standing traditions in theoretical and empirical research on well-being, quality of life and social institutions. Last but not least, the genetic and cultural diversity in Europe, within the common framework of the EU, provides rich possibilities for major comparative population studies.

Suggestions for the future
First of all, closer collaboration between the research funders, the scientific community and the political decision makers is needed to convince our societies of the opportunities and benefits of ageing research.

The status of ageing research in European universities needs to be more firmly established than it is at present. This is true for social, biological and clinical sciences. Permanent or at least long-term institutes are needed to create structures for interdisciplinary research environments. Ageing should be included in University curricula in biology, medicine, behavioural and social science and other relevant disciplines.

Simply put, ageing research needs more funding, both on the national, cross-national and European level. Funding organizations should create special practices for reviewing and funding in multidisciplinary and interdisciplinary areas such as ageing. In the present situation, targeted funding and flexible rules are needed that also make longitudinal research possible. Where governments narrow down their focus from the broad issues of ageing to health care issues, new ways should be found to invite an increasing number of private funders into the field.

The scarcity of young researchers is a great problem. Collaborative multidisciplinary doctoral and post doctoral courses could help bring a new generation of senior researchers into the field. The Future Leaders in Ageing Research (FLARE) organized by the ERA-AGE provides a modest but important example.

In the long run, Europe would benefit from more stable structures on ageing research and research funding on the European level. In the United States, the National Institute on Aging is a policymaker, funder and research institute; in Europe, no single body is responsible even for one of these activities. A European Institute on Ageing may be a feasible long-term goal, but to be successful it requires both a very strong mandate from the member countries and sufficient funding.
The European Union should and could play an important role in strengthening ageing research, and in putting the results of ageing research to use. The EU should provide frameworks for the collaboration between researchers, funders, and users of research, and support cross-national funding programs for research and research training. A targeted multidisciplinary European program for ageing research, encouraging integration between different basic disciplines, could serve as a strong driver for the whole field.

Conclusions and recommendations

In low-mortality countries, life expectancy has increased continuously for 150 years, and for the last 50 years mainly because of the declines in late life mortality. In addition to decreasing fertility this has lead to major changes in age structures in most European countries. The increasing life expectancy is a result of the social development both through better living conditions and also through developing prevention and medical care. The differences in the length of life and health status within one cohort are, however, determined by genetic factors, environment, and the complex interplay between these two. In Europe, life expectancy, health status and quality of life of older people vary between the countries and inside one country. In addition to health care and disease management, diminishing inequality and efficient health promotion are needed to continue the increase in life expectancy and healthy longevity.

In many ways, older populations are even more heterogeneous than younger age groups. At present, the rapid changes in our societies are changing the situation and role of older people. The negative stereotyping and discrimination against older people not only influence their lives but have a negative impact on society as a whole. It is in the interests of societies with ageing populations to avoid age discrimination and segregation, and integrate older people as much as possible in all the activities in the society. Chronological age should not be a barrier to full social participation in later life.

Scientific research is needed to understand the ageing processes and help Europe face the challenges of population ageing. To this enterprise, different disciplines, such as biology, social science, psychology, technological science and medicine have contributions to make. For better understanding of human ageing, however, multidisciplinary and interdisciplinary approaches, bringing together social sciences and biological sciences, are of vital importance. At present, neither funding nor infrastructures of ageing research are strong enough for Europe to take full advantage of the potential capacity of research. Therefore, Europe could greatly benefit from stronger support for ageing research in general and for multidisciplinary research in particular.

In summary we recommend the following:

- Because ageing societies need the contribution of their older members and older people are entitled to full citizenship and participation, the manifestations of ageism should be rooted out from public discourses and social life, and age integration should be adopted as a leading principle.
- Social inequality in old age, as at younger ages, should be recognized as a major problem and political measures should be taken to diminish it.
• Older people, healthy and disabled, should be encouraged to engage in social participation and activity.
• Environmental planning, easy transportation, prosthetic living environments and feasible, ethically approved technical solutions should be developed to support independence, activity and quality of life of older people.
• Healthy life styles should be promoted and supported in all stages of life, including old age. In addition to health education and other messages directed to individuals, measures and actions are needed from industry, environmental planners and public policy.
• Research on different areas of ageing should be supported more generously than at present, more established research environments should be built, and opportunities for multidisciplinary research on ageing should be improved.

References


adults: results from the Longitudinal Aging Study Amsterdam', *BMC Public Health*, 6, (Oct 5), pp. 244.


MEDICINE

Panel Members: Rudi Westendorp (Chair), Alexander Bürkle (Vice-Chair), Gillian Butler-Browne, Heinz Osiewacz, Eva Topinkova.

Introduction
The principal objective of AgeAction is to realise the full potential of ageing research in Europe. An important element of this involves creating greater synergy between the biological and medical research domains. At present, these two areas are separated by enormous conceptual differences. The medical research domain in ageing is traditionally populated chiefly by geriatricians, old-age psychiatrists and the relevant professions allied to medicine (physiotherapists, psychologists, etc) caring for elderly people in failing health. These professionals mainly have a problem-oriented focus. As a result, they tend to treat the symptoms of old age such as falls, dementia and delirium, rather than tackling their root causes. Biogerontologists on the other hand, study the biological basis for ageing. They are motivated by questions like: Why do people and other organisms age? How does ageing occur? And, most importantly, can we avoid its negative consequences? These researchers focus much far more on understanding underpinning mechanisms and, to some extent, on prevention.

Given these differences in orientation, each of the two fields attracts a particular type of researcher. One aims to treat (or, more often, manage) health problems of older people while the other wants to understand the mechanisms by which these problems occur. They have no tradition of working to a common goal, even though they are actually working on the same issue. Geriatricians and gerontologists are often member of different learned societies, or separate sections within a society for research into ageing. Some indication of the relative sizes of these societies is given in Appendix 1. This notion of these two strands of research into ageing being pursued simultaneously but in an unconnected fashion offers some hope that the gap between the two fields can be bridged, but what is it that might be gained by bringing them together?

Added value in bridging the gap
Human life expectancy is steadily increasing but the end of life is still accompanied by an increasing vulnerability to disease and disability. The medical sciences have primarily targeted processes that affect health in the so-called ‘productive years.’ Therefore it comes as no surprise that at present only little is known about the biological processes that cause humans to grow old and develop age-related diseases and disabilities in old age. This relative ignorance can be alluded to as the ‘knowledge shadow’. Moreover, diseases and disabilities in old age are often poorly defined, which is why there is only limited evidence on how they should be treated. This ignorance is all the more surprising when it is realised that for most of these conditions, age is the biggest risk factor. The chance of getting ill steadily increases over the lifespan. Nevertheless, experimental models have already shown that the
ageing process is far more amenable to intervention than most people are aware. If gerontologists and geriatricians could work together fully to understand the ageing process, it becomes far more likely that they will develop interventions to protect old people from disease and preserve their functional capacities. For instance, it is increasingly being recognized that inflammation plays a major role in the occurrence of adverse events at an early and late age. On the one hand, inflammation is a key mechanism to fight infection and to stay alive; on the other hand, it contributes to a wide variety of the chronic diseases of old age. Inflammation is, for example, clearly implicated in atherosclerosis, dementia and muscle weakness (sarcopenia). There is therefore both a challenge and an opportunity to intervene in these inflammatory processes but as yet the ways to do so and the resulting benefits are far from clear.

Another example of the potential added-value of joining the biological and medical domains comes from the discovery that several of the regulatory mechanisms of the ageing process appear to be evolutionary conserved. For example, the insulin growth factor pathway is found in organisms ranging across the species spectrum from yeast to mammals. It is a priority to determine whether such pathways, whose effects on ageing can be rapidly assessed in model organisms such as yeast, nematode worms and fruitflies, are equally relevant for the health trajectory of human ageing. Crucially then, the available data from model organisms can serve as candidate mechanisms of longevity in human populations and vice versa. An elaboration of this translational research is presented in Appendix 2. If it can be demonstrated that a fundamental mechanism, such as insulin signalling, is conserved in humans and animal models, and if we can reveal how such a mechanism affects the rate of ageing, then beneficial interventions in life-style, dietary intake, medication, or otherwise can be developed more quickly. The result might be to increase the length of disease- and disability-free life expectancy. Furthermore, as some of these interventions are most effective when applied at relatively young age, we need markers that can monitor their effect on body function throughout the life course. From harnessing the lessons from fundamental biological ageing research, the result might be senior citizens who remain active for longer, consume fewer healthcare resources, and contribute to the economy.

The key goal of this combined approach to ageing research is to identify the factors that can keep people live healthier for longer. Ageing results from the lifelong accumulation of subtle defects, caused by a great number of biological and environmental risk factors. This is a gradual process that starts early in life. The damage accumulated over time eventually leads to deterioration of the tissues and organs as well as functional impairment of the body. To a certain extent, this process can be counteracted by maintenance and repair factors that slow down the rate of the accumulation and keep the body healthy. It stands to reason then that, even if risk factors are present, boosting maintenance factors may render a person less likely to develop age-related disease. Conversely, if a person is exposed to adverse factors that exacerbate the accumulation of cellular damage, such as poor nutrition and stress, then early onset of age-related diseases is more probable.
Traditional medical research has focused on risk factors that cause people to die earlier, smoking being the classic example. Once the link between tobacco and lung cancer was established, health promotion agencies launched campaigns to make people stop smoking. Until now though, two aspects of cancer have hardly been addressed. Firstly, why is it that 80% of smokers do not develop lung cancer? Smoking is clearly a risk factor, but apparently it is insufficient to cause cancer on its own. A majority of smokers seem to be able to cope with the toxic agents in tobacco, which is why they do not develop the disease. The second question that has largely been ignored is: Why do some non-smokers develop cancer? Smoking is not a necessary cause of lung cancer either, so what are the factors that affect a person’s likelihood of developing the disease?

Geriatricians tend to point to smoking as a risk factor in developing lung cancer, whilst gerontologists are more concerned about the maintenance factors that affect an individual’s susceptibility to the disease. Separately, neither is enough to explain the onset of cancer in a particular individual. The best way to account for age-related disease is to combine information from both angles and study the interplay between risk factors on the one hand and maintenance factors on the other. Such a union will not only be scientifically desirable but also can come at a time when European health systems are shifting more and more towards prevention and the early detection of diseases. Diagnostics, screening and imaging are expected to play an increasing role in medical practice. By applying gerontological discoveries about the cell and molecular changes that underlie ageing in developing new technologies that can be applied to monitor the rate of decline in body function, it becomes feasible to anticipate the development of novel diagnostics and ‘personalised’ intervention strategies for enhanced maintenance and repair of the body.

**Lack of an existing framework for collaboration**

Despite the clear benefits of closer collaboration between geriatricians and gerontologists, there are very few institutions where both work together. The reasons for this may lie in the subtle messages that both groups give off. Geriatricians have to cope with negative connotations. Old people are generally presented as sad, frail, deserving of compassion and lacking in economic value. This societal view contributes to the discrepancy between the demographically driven need for care and the relative scarcity of chairs in geriatrics, especially in medical schools (see Appendix 3). In addition, people working in the field often see themselves as advocates fighting for people who are unable to fight for themselves. Gerontologists are able to sell a much more positive story. Their research is aimed to help people live healthily for longer by mitigating the loss of resilience with age or even by avoiding old age entirely. Few gerontologists have professional contact with older people and it is striking that a subset of biological ageing researchers focus their aims on pioneering the prospects for life extension, without evidencing much regard for the biomedical challenges of later life.

Given the differences in orientation of the two groups, it is challenging to devise organisational structure that can effectively combine the different frames of reference (although a few examples are beginning to emerge). Yet
without the moderating influence of the other, both fields are in danger of overselling their messages. Gerontologists are currently more successful in gaining attention, both in terms of media reporting as well as from a financial point of view, because their apparent promise of a longer, healthier life is more acceptable to a society that still struggles to come satisfactorily to terms with the realities of the ageing process. However, those researchers who emphasise life extension as a research goal may be playing a risky strategy, since their tendency to over-promise may weaken the credibility of the field as a whole, both in the eyes of other scientists and of the public, many of whom already have to deal with the immediate realities of the ageing process. They also encounter ethical and social issues about the desirability and practicality of extreme longevity. On the other hand, many gerontologists stress that the main goal is not to achieve immortality but to prevent or postpone age-related disease. This positive message is in itself scientifically challenging, since research capacity is still small, but it has an enormous potential for economical impact as it may not only reduce health care consumption but also allow European citizens to participate in society for longer.

Geriatricians face similar problems in terms of presentation. They can exploit their image as champions of the old and frail and gain short-term political and financial attention to their cause, but they too are in danger of overselling themselves. Their message is largely based on negative sentiments and people quickly become accustomed to the gloomy prospects of old age. Moreover, geriatricians have to defend themselves against prejudice that increasing life expectancy is the major cause of the dramatic increase in health care consumption, an argument that after careful study appears to be unjust.

Lack of a critical mass of research
Another issue that a combined approach has to contend with is the fact that there is as yet an insufficient critical mass of research into ageing. The overwhelming burden of disease occurs in old age, but this has not been the main focus of research. This contrasts sharply with the intensive efforts invested into research on cancer and coronary heart disease. By comparison, the majority of diseases of old age have hardly been studied at all, the exceptions being Alzheimer disease and other associated neurodegenerative diseases. Examples here include loss of muscle strength, osteoarthritis, falls, vision loss, hearing impairment, heart failure and depression. Even the studies into cancer and coronary heart disease have mainly focused on the middle-aged men, with women being studied to a far lesser extent. Why is this? The answer probably lies once again in people’s negative view of old age. The elderly are seen as a burden to society with little economic value. They, in general, have low esteem, dress and talk differently, do not set the public agenda and are thus marginalised in society.

The impact of this negative image has important consequences for medicine. Research into age-related disease is very much in need of young talent yet it is difficult to draw people to a field that has little prestige. This is surprising since bringing together risk and maintenance factors in one unified approach could form the basis for a knowledge domain in which research can thrive and prosper. In the past, other fields have come together and started a whole new
line of research activities. The close interactions between mathematicians and radiologists have given rise to breakthroughs such as computerized tomography and magnetic resonance imaging, both crowned with a Nobel prize. These techniques have become routine in hospitals worldwide and allowed for major improvements of diagnostic and therapeutic strategies. The current European Integrated Projects and Networks of Excellence for research into ageing within Europe could pave such a way. However, although the budget for basic research to unravel the basis of ageing by the EC has increased substantially, support is far behind that in the US (see Appendix 4).

The challenge then is to promote the value of a joint approach and the opportunities for developing new ideas and tools. A campaign is needed to overcome the negative image of older people and their health and to highlight what can be achieved.

**Lack of scientific knowledge embedded in clinical practice**

Even where research has produced valuable knowledge about ageing, very little of it is yet embedded in clinical practice. This is partly because geriatricians think that ageing is inevitable and that nothing can be done about it. They argue that we all have to die some time and the best course of action is to keep people comfortable until the end comes. As a result they concentrate on treating the complications of old age and recommend avoiding risk factors like smoking. What they fail to recognise is that people age at different rates. Some 60-year olds have a biological age of 80 years and some 80-year olds have a biological age of 60 years.

This narrow view of the ageing process means that most clinicians ignore prevention, even to the extent that some characterize those who propagate a pro-active attitude as being unrealistic. This is perhaps why there has been very little research into increasing old people’s resistance to disease. A proper understanding of the biology of healthy ageing however, and of human ageing in particular, has an enormous potential for developing the means to prevent or postpone important age-related diseases, thereby allowing individuals to live more healthily for longer. This strategy has been proven to be successful, since over the last 150 years average human life expectancy has increased linearly with 2 years per decade, while the increase in the maximum age at death has even accelerated. These achievements have occurred together with major improvements in the socio-economic, educational and hygiene standards as well as in the medical sector. The relative contribution of the various environmental changes is difficult to define. It does show, however, that the prospect of a longer, disability-free life expectancy is more attainable than the public, politicians, and most scientists tend to think.

Even when geriatricians do adopt preventive measures, they tend to copy strategies used in young and middle-aged people. For example, there has been very little research into preventing cardiovascular disease in old age, despite the fact that we know already that the risk factors in old and middle age are different. Nevertheless, the elderly are encouraged to lower their blood pressure and reduce their cholesterol levels just like middle-aged people. No one asks if this is truly beneficial in old age, yet the (limited) evidence
available shows that it is not. What gerontologists and geriatricians therefore need to do is understand how cells and tissues age and become more vulnerable to disease. With a comprehensive picture of the ageing process, they can develop new insights and interventions.

**Future success**
The broad aim must be to strengthen substantially the various strategies that are presently being exploited within the life sciences and health care organisations. Since one of the main principles is to apply a multidisciplinary approach to the problem of ageing, there is a clear need for consortia that cover the range from the research laboratory to patients in hospitals, clinics and general practice surgeries, and to society. First, the strategy should be to combine the various expertises necessary to develop, test and evaluate interventions as well as implementation for older patients. European health systems are shifting more and more towards prevention and the early detection of diseases. Diagnostics, screening and imaging will play a larger role in daily medical practice. New technologies can be applied to monitor the rate of decline in body functions and to provide assistance with interventions. Second, treatments need to be better tuned to the individual’s specific abilities for maintenance and repair of his/her body. New diagnostics and ‘personalised’ intervention strategies will have to be developed that lead not only to evidence-based advice on healthy behaviour (including nutrition, physical activity) and medical “check-ups” (including imaging, blood-tests), but also to advise appliances for the work, leisure and home environments. Third, with the ageing societies in mind, infrastructures have to be adapted to facilitate active living of older people. Newly developed interventions have to be evaluated with respect to their (cost) effectiveness and acceptance. The consortia will thus have to take the lead in assuring implementation of proven effective interventions in the population at large.

**Recommendations for action**
- To understand in detail how calendar age acts as the biggest biological risk factor for the occurrence disease and disabilities.
- To support clinically oriented research initiatives on the as yet poorly characterised diseases and disabilities of older people.
- To study why it is difficult to consider an organisational structure combining gerontology and geriatrics and work to overcome the obstacles.
- To stimulate education and research into the biology of ageing within the life sciences and the medical schools.
- To identify effective strategies that attracting young scientists, doctors and other health professionals to enter the fields of gerontology and geriatrics.
- To allocate funds for translational strategies from the biological sciences to medical research that will specifically benefit older people.
- To appoint chairs in gerontology and geriatrics within each academic medical centre in Europe.
- To explain to the general public that the ageing process and its consequences have proven not to be much more malleable than is generally assumed.
Appendix 1. Membership of European Societies for Research into Ageing
Since its foundation in 1950, the International Association of Gerontology and Geriatrics (IAGG; www.iagg.com.br) has emphasized the importance of biological, clinical and social gerontology. Currently IAGG-European Region sections exist in these three areas and function under the IAGG umbrella to support research, education and clinical practice in their respective fields of interest. An overview of the IAGG-European Region member societies is given in Table 1.

On the websites of most member societies, however, only their total membership is listed and differentiation between the numbers of individual members working in either clinical geriatrics or biological gerontology is not possible. One exception is the UK, with three separate societies focusing on geriatrics, psychosocial gerontology and biological gerontology, respectively. The situation in Germany also gives some insight into membership structure: The German Society of Gerontology and Geriatrics (DGGG) consists of four sections: experimental gerontology; geriatric medicine; social and behavioural gerontology; and social gerontology and care for the elderly. The section of experimental gerontology is by far the smallest. All other societies in European states seem to focus more or less exclusively on Geriatrics, and this is certainly the case for the Irish, Greek, French and Italian societies.

Although the head counts of the societies for gerontology/geriatrics in Europe look impressive, there is a massive under-representation of biological gerontologists. Only in very few cases have there been successful attempts to bring together geriatricians, biological and social gerontologist in a single organisation, such as the British Council for Ageing (www.bcageing.org.uk/) or the German Society of Gerontology and Geriatrics.
Table 1. Breakdown of member societies of the International Association of Gerontology and Geriatrics European Region.

<table>
<thead>
<tr>
<th>Country</th>
<th>Society name</th>
<th>Total membership</th>
<th>Members active in biological gerontology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albania</td>
<td>Albanian Association of Gerontology and Geriatrics</td>
<td>60</td>
<td>Very few if any</td>
</tr>
<tr>
<td>Austria</td>
<td>Austrian Society of Geriatrics and Gerontology</td>
<td>380</td>
<td>Very few if any</td>
</tr>
<tr>
<td>Belgium</td>
<td>Belgian Society for Gerontology and Geriatrics</td>
<td>500</td>
<td>Unknown</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>Bulgarian Association on Ageing</td>
<td>50</td>
<td>Unknown</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Czech Society of Gerontology and Geriatrics</td>
<td>418</td>
<td>Unknown</td>
</tr>
<tr>
<td>Denmark</td>
<td>Danish Gerontological Society</td>
<td>648</td>
<td>Unknown</td>
</tr>
<tr>
<td>Estonia</td>
<td>Estonian Association of Geriatrics and Gerontology</td>
<td>162</td>
<td>Unknown</td>
</tr>
<tr>
<td>Finland</td>
<td>Societas Gerontologica Fennica , and The Finnish Society for Growth and Ageing Research</td>
<td>250</td>
<td>Very few</td>
</tr>
<tr>
<td>France</td>
<td>Société Française de Gériatrie et Gérontologie</td>
<td>3,010</td>
<td>Very few if any</td>
</tr>
<tr>
<td>Georgia</td>
<td>Georgian Gerontology and Geriatrics Society</td>
<td>50</td>
<td>Unknown</td>
</tr>
<tr>
<td>Germany</td>
<td>German Society of Gerontology and Geriatrics</td>
<td>1,100</td>
<td>65</td>
</tr>
<tr>
<td>Germany</td>
<td>German Society of Ageing Research (DGfA)</td>
<td>105</td>
<td>79</td>
</tr>
<tr>
<td>Greece</td>
<td>Hellenic Association of Gerontology and Geriatrics</td>
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<td>Unknown</td>
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<tr>
<td>Ireland</td>
<td>Irish Gerontological Society</td>
<td>349</td>
<td>Very few if any</td>
</tr>
<tr>
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<td>565</td>
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</tr>
<tr>
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<td>1,565</td>
<td>Very few if any</td>
</tr>
<tr>
<td>Country</td>
<td>Association Name</td>
<td>Members</td>
<td>Unknown Members</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>---------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Luxembourg</td>
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<td>Unknown</td>
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<td>Malta</td>
<td>Maltese Association of Gerontology and Geriatrics (MAGG)</td>
<td>86</td>
<td>Unknown</td>
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<td>The Netherlands</td>
<td>Netherlands Society of Gerontology</td>
<td>244</td>
<td>Very few if any</td>
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<tr>
<td>Norway</td>
<td>Norwegian Gerontological Society</td>
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<td>Unknown</td>
</tr>
<tr>
<td>Poland</td>
<td>Polish Society of Gerontology</td>
<td>330</td>
<td>Unknown</td>
</tr>
<tr>
<td>Portugal</td>
<td>Sociedade Portuguesa de Geriatria e Gerontologia</td>
<td>81</td>
<td>Unknown</td>
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<tr>
<td>Romania</td>
<td>Romanian Society of Gerontology and Geriatrics</td>
<td>200</td>
<td>Unknown</td>
</tr>
<tr>
<td>Russia</td>
<td>Gerontological Society of the Russian Academy of Sciences</td>
<td>1,510</td>
<td>Unknown</td>
</tr>
<tr>
<td>Serbia</td>
<td>Gerontological Society of Serbia</td>
<td>50</td>
<td>Unknown</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>Slovak Society of Gerontology and Geriatrics</td>
<td>248</td>
<td>Unknown</td>
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<tr>
<td>Slovenia</td>
<td>Gerontological Association of Slovenia</td>
<td>270</td>
<td>Unknown</td>
</tr>
<tr>
<td>Spain</td>
<td>Spanish Society of Geriatrics and Gerontology</td>
<td>2,400</td>
<td>Unknown</td>
</tr>
<tr>
<td>Spain</td>
<td>Spanish Society of Geriatric Medicine</td>
<td>193</td>
<td>Unknown</td>
</tr>
<tr>
<td>Sweden</td>
<td>Swedish Gerontological Society</td>
<td>330</td>
<td>Unknown</td>
</tr>
<tr>
<td>Switzerland</td>
<td>Swiss Society of Gerontology SGG-SSG</td>
<td>1,000</td>
<td>Unknown</td>
</tr>
<tr>
<td>Turkey</td>
<td>Geriatrics Society Turkey</td>
<td>125</td>
<td>Unknown</td>
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<tr>
<td>Ukraine</td>
<td>The Ukrainian Gerontology and Geriatrics Society</td>
<td>250</td>
<td>Unknown</td>
</tr>
<tr>
<td>UK</td>
<td>British Geriatrics Society (BGS)</td>
<td>2,300</td>
<td>Very few if any</td>
</tr>
<tr>
<td>UK</td>
<td>British Society of Gerontology (BSG)</td>
<td>445</td>
<td>Very few if any</td>
</tr>
<tr>
<td>UK</td>
<td>British Society of Research on Ageing (BSRA)</td>
<td>150</td>
<td>Vast majority</td>
</tr>
</tbody>
</table>
Appendix 2. Added value of translational research

The gap between basic biological research on ageing and clinical medical applications aiming at preservation of human health is difficult to bridge. However, the discovery that single mutations in the evolutionarily conserved insulin/IGF-1 signalling (IIS) pathway were able to extend the life span of a nematode worm several-fold has greatly fuelled research into this area. Especially so, since soon after this discovery it was show that mutations that down regulate the IIS pathway were also able to prolong the life span of the fruit fly and the mouse, thus making the gap for translation of these results to humans considerably smaller. In the worm, down-regulation of the IIS pathway occurs in response to adverse environmental conditions, such as food shortage. Its main function is to co-ordinately adapt various aspects of the worm’s physiology so that priorities are changed from growth and reproduction to mere survival until conditions become favourable again. Paradoxically however, in man, lower IIS activities have thus far been related to increased incidences of several age related diseases. For example, the decreased production of GH/IGF-1 with age (also known as somatopause) has been associated with loss of muscle mass, increased adiposity, reduced bone mineral density and cognitive decline. One explanation for this paradox is that man is fundamentally different from other species. Recently however, the same paradox was observed within a single species: mice exhibiting accelerated ageing due to deficiency in DNA repair elicit the same response as in wild type mice undergoing caloric restriction, an intervention known to prolong their life span considerably. The picture that now emerges is that down-regulation of IIS is an ancient survival response that can occur both in response to sudden external stresses (such as food shortage) as well as in response to chronic internal stresses (such as the accumulation of damage with ageing). In translating these results to humans, the decline in GH/IGF-1 levels with age may be an adaptive response aimed to prolong survival, and doubts may be raised about the efficacy of GH supplementation trials in elderly, which are being advocated by some as potential anti-ageing strategy.

References:
Appendix 3. Chairs of Geriatrics and Gerontology in European Medical Schools

According to a recent survey among 31 European countries, performed by European Union Geriatric Medicine Society (EUGMS) in 2006, geriatrics exists as an independent (distinct) medical a speciality in fifteen (48%), exists as a sub-speciality mostly within internal medicine in 11 (36%), whereas in about 5 out of the 31 (16%) countries it is not recognized at all (see fig 1). This has distinct negative consequences for how the field is practiced. Low prestige and self esteem also cause difficulties in recruiting qualified academic staff and a paucity of potential chairs. This situation is mirrored in the rather low percentage of Medical Schools who have appointed Chairs of Geriatrics, Biology of Ageing or Social Gerontology (see fig 2). Out of 286 Medical Schools surveyed, 130 (45.5 %) had appointed a Chair of Geriatrics, 15 (5.2 %) a Chair of Psychogeriatrics and 12 (4.2 %) a Chair of Biology of Aging. This clear shortage of chairs in Geriatrics and Gerontology indicates that a significant proportion of European medical students will graduate without being exposed to any formal education in gerontology and geriatrics. Furthermore, an even smaller percentage of medical schools have developed PhD study programmes in gerontology and the scale of gerontological research being performed is not sufficient for a firm development of the science of gerontology. Again, the situation is very heterogeneous around Europe, signalling opportunities for improvement.

This situation has been criticised and many initiatives aiming to improve the situation have started at a local, national and regional level. However, the majority of innovative approaches have supported geriatric medicine rather than gerontology: e.g. development of “geriatric curriculum”, “teach the teachers”, both initiatives of the European Academy for Medicine of Ageing (EAMA), an establishment of the UEMS- Geriatric Medicine Section (www.uemsgeriatricmedicine.org). Other activities of EAMA include harmonization of post- and undergraduate training, foundation of European Union Geriatric Medicine Society (www.eugms.org).

Reference:
Figure 1. Recognition of geriatrics within European states.

**Geriatrics recognized as a medical speciality or sub speciality** (31 countries)

**Speciality** (N = 15)
- Belgium
- Czech Rep
- Denmark
- Finland
- France
- Hungary
- Italy
- Lithuania
- Luxembourg
- Macedonia
- Malta
- The Netherlands
- Spain
- Sweden
- United Kingdom

**Sub-speciality** (N = 11)
- Bulgaria
- Iceland
- Ireland
- Germany*
- Norway
- Poland
- Serbia
- Slovakia
- Switzerland
- Turkey
- Ukraine

Figure 2. Prevalence of chairs of geriatrics in European medical schools.
Appendix 4. Budget development for ageing research in Europe and the US
Comparison of the budgets for ageing research of the EC (5th and 6th Framework Programme) and the US (NIA, Biology of Aging Program). The EC budget includes all specific projects related to basic biological ageing research. Additional support related to age-related research goes into some other, less specific programmes (e.g. Alzheimer research, Food research, etc). While overall financial support by the EC clearly is far behind support by the NIA in the US, the EC has significantly increased the budget for basic ageing research over the last six years.

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EU* (€ M)</td>
<td>2,574</td>
<td>3,599</td>
<td>5,739</td>
<td>4,694</td>
<td>8,396</td>
<td>12,291</td>
<td>17,848</td>
<td>6.94</td>
</tr>
<tr>
<td>US+ (€# M)</td>
<td>98,873</td>
<td>117,627</td>
<td>125,048</td>
<td>117,021</td>
<td>111,224</td>
<td>113,423</td>
<td>111,484</td>
<td>1.13</td>
</tr>
<tr>
<td>Ratio (%)</td>
<td>2.60</td>
<td>3.06</td>
<td>4.59</td>
<td>4.01</td>
<td>7.55</td>
<td>10.84</td>
<td>16.01</td>
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</tr>
</tbody>
</table>

* According to the budget information of the individual projects related to ageing research of the 5th and the 6th Framework Programme (Cordis)
BIOLOGY

Panel members: Peter Csermely (Chair), Thomas von Zglinicki, (Vice-Chair), Stathis Gonos, Ewa Sikora, Eline Slagboom

Introduction
Europe is already the oldest continent, in terms of the fraction of the population aged over 65, and it is currently ageing faster than other regions. The increase of the life expectancy brings both advantages and disadvantages. On one hand, many relatively healthy people can be found among the eldest, who enjoy reasonable physical and mental health and are actively engaged in society. On the other hand, age is the most important risk factor for many severe and debilitating human diseases, such as cancer, cardiovascular disease, stroke, type II diabetes, immune disorders, senile dementia and neurodegenerative diseases (1-4). This means that there is an increasing prevalence of age-related frailty, disability and disease, which is associated with poor quality of life and significant financial need for health and social care support. Moreover, in the current population there is anxiety about a growing trend towards increasing obesity and sedentary lifestyles, both of which can exacerbate the problems of ill health in the later decades of life and may actually counter the underlying trend towards increasing longevity.

The urgency of conducting biological ageing research in order to understand the underlying molecular, cellular and genetic factors that contribute both to healthy and unhealthy outcomes in ageing has never been greater. Furthermore, the advances that have been made in such research, both within the EU and elsewhere, has provided an evidence-based expectation that such research may be fruitful and lead to novel discoveries that can relatively soon be translated into health and quality-of-life benefits for Europe’s older citizens. For this to happen, however, there needs to be a greatly increased awareness of what such research can deliver and a serious commitment to developing the necessary infrastructure and capacity, in terms of highly trained researchers in biology of ageing, in order to tackle a challenge on this scale. The current numbers and funding of such scientific teams is entirely inadequate to deliver the necessary advance in time to achieve the benefits which need to be realised. The opportunities are there, although as yet not widely appreciated; however, failure to act early enough and boldly enough risks the outcome that increasing life expectancy will prove sadly costly in terms of lost quality of life and wasted economic and human potential.

What is biological gerontology?
Biological research on ageing combines research on human samples, computational, cellular and animal models with an array of sophisticated techniques in a ‘systems’ approach to:

- Achieve a coherent understanding of the cell and molecular basis of ageing, and of why aged cells are more vulnerable to pathology;
• Deliver an integrated knowledge of genomic, proteomic and metabolome profiling across the life course in a range of different species, in order to help identify targets for intervention;
• Identify biomarkers of ageing as basis for successful evaluation of interventions;
• Identify longevity assurance genes, understand and, if appropriate, identify possible routes to enhance their actions;
• Characterize interactions of genetic, epigenetic and environmental impacts on ageing, in order to understand the diversity of individual human ageing;
• Develop successful strategies to increase the likelihood of healthy ageing;
• Subject to securing sufficiently good quality of life, and due ethical consideration, to provide the knowledge that might contribute to extend human life expectancy.

Modern biogerontology has matured well beyond the traditional attitude ageing was seen as something that ‘just happened’. The inhibitions felt until quite recently by some, that ageing was just too complex for serious scientific study, have also melted away as a series of major advances, supported by some remarkable innovations in emerging technologies, has begun to reveal that the biology of ageing is no less tractable than other important biological challenges, such as the neurobiological basis of the human mind. Nevertheless, attitudes to biological ageing research are still to some extent constrained by the wide societal malaise about truly appreciating that ageing can now be seen in a much more positive way than used to be the case, even quite recently. Detailed knowledge of the biology of ageing is still narrowly contained within a relatively small number of teams and research centres, and the mass of biomedical researchers, like the population at large, still harbours some very ill-formed and very often fallacious notions about how the biology of ageing comes about. If only to help European citizens to break the constraints of negative thinking about ageing, it is essential that positive actions are taken. However, the eventual prize is much greater than that and there is no time to be lost.

**Some highlights of recent progress in biology of ageing**

Over the last two decades or so, there have been important advances in several areas of biological research on ageing and it would be impossible to summarise them in any kind of comprehensive way in the report. Instead, we briefly summarize some key highlights.

**Evolutionary basis of ageing**

A widely held misconception is that the biology of ageing is somehow programmed through the action of genes that have evolved specifically to cause ageing and death, perhaps a form of population control. The flaws in this logic have been clearly revealed in the now widely substantiated evolutionary understanding of ageing that recognises that there is no active genetic programme but that, instead, ageing results from limited genetic investments in the molecular and cellular mechanisms that support long-term survival. It is also recognised that genes may be favoured through natural selection if they provide an advantage to organisms in the early phases of life, even if the same genes lead to problems later. The essential implication of the
evolutionary theory of ageing is that there is greater malleability in the biological mechanisms than would be the case if ageing was under strict, programmatic control. This is consistent with the observation that the current drive to ever increasing life expectancy comes from the fact that people appear to reaching old age in better condition than was previously the case.

Genes and pathways
During the last two-three decades, considerable progress has been made in elucidating genes and pathways involved in the regulation of longevity in model organisms. Mechanisms of ageing have also been partially elucidated, which in some cases reveal process that are common across species, and in other cases reveal features that may be unique to humans.

Mechanisms of cell senescence
An early breakthrough in the understanding of molecular mechanisms of ageing came in the early 1990’s when senescent fibroblasts were shown unable to induce the expression of c-fos, the member of AP1 transcription factor necessary for cell proliferation (5). This was followed by an important discovery that senescent cells produce p21 protein, the cyclin-dependent kinase (Cdk) inhibitor (6) and that the shortening of telomeres is an important cause of cellular senescence (7). We now know that the Hayflick limit (the limitation on the ability of normal human cells to proliferate in culture) is caused by two overlapping pathways: (i) the erosion of telomeres, which elicits a p53-dependent DNA damage response, and (ii) stress induced expression of another Cdk-inhibitor, p16 protein and pRB response. The role of cell senescence in the ageing of organisms remains to be explained, which is especially true for the recently discussed issue of whether and how cell senescence might act as an anticancer defence mechanism (8). Attention is now turning to the hard but vital questions about cellular senescence of stem cells and their contribution to normal homeostasis, regenerative potential and ageing of the organism is also an unanswered question yet (9).

Nutritional effects on ageing
We have known for decades that in many animal models ageing and longevity are affected by dietary restriction. Dietary restriction extends both the mean and the maximum life span in many, but not all species, and delays the onset of age-related diseases such as cancer, diabetes, kidney failure, etc. Studies carried out recently revealed that dietary-restricted animals have lower insulin, glucose and IGF levels, several-fold decreased fat stores, enhanced immune capacity and better defences against free radical damage (10). Insulin/IGF-1 signalling pathway is involved in many functions related to metabolism, growth, and fertility in such animal models like nematodes, flies and mammalians. Using a genetic approach of mutant selection in nematode worms (C. elegans) or transgenic alteration in mice, it has been shown that while disruption of the insulin/IGF-1 receptor in nematodes and flies increases the life span, mammals with defects in the insulin signalling pathway are at risk for age-related diseases and increased mortality. This paradox can be explained by acquisition during evolution of more organs and more complicated metabolic pathways in mammalians, but it still awaits full elucidation (11).
The role of oxidative stress

The free radical theory of ageing, although controversial for many years, nowadays seems firmly established as an important contributor to the mechanisms of ageing. Oxidative stress arising from either the mitochondria or from other sources produces a wide spectrum of damage in the ageing cell. Proteins, membranes and DNA are all prone to irreparable damage through oxidative stress. By using transgenic mice and fruitflies it has been shown that enhancement of antioxidant defences can slow ageing and extend the life span. The complex role of free radicals in telomere-dependent senescence is now becoming increasingly evident (12-14). However, it should be noted that the intrinsic complexity of oxidative stress and the antioxidant defences necessitates a rigorous, systems-biology approach if it is to become possible to deliver effective antioxidant therapies to combat age-related diseases. Simply dietary supplementation with antioxidants has been found not to produce the expected benefits and when applied without proper understanding of the reaction flows within the intracellular network may actually do more harm than good. This is an area where further work is clearly a major priority.

Genetics of human longevity and healthy ageing

Animal studies have provided insights to identify candidate-genes possibly involved in the regulation of human life span. Several studies including those examining genetic polymorphisms that could affect human lifespan have been carried out recently in many groups around the world. Among the many candidate genes, only the role of the gene for apolipoprotein E (APOE) has so far been confirmed consistently (15). Human ageing seems to involve hundreds or thousands of genes, epigenetic and non-genetic factors, including environmental factors and simple chance (16). Moreover, ageing brings an unprecedented diversity in terms of genetic and phenotypic features of old subjects, which requires novel methodologies and approaches. The genetics of healthy ageing in humans is currently the subject of a large EU FP6 Integrated Project. This project is likely to advance knowledge considerably but significant further effort will be required to exploit the findings and to translate them into eventual benefit for older people.

Despite of the considerable progress, our knowledge is far from being complete in the rich field of the genetic background regulating life span and longevity as well as the metabolomic changes behind the remarkable effect of dietary restriction. We are at the very beginning of the elucidation of age-related proteomics, and the networks of hormonal regulation and immunity. The increase in the database-collection as well as analytical methods in systems biology will certainly prompt a rapid progress in these fields in the near future.

The above brief summary reinforces the previous assertion that important first steps are beginning to be made in unravelling the complexity of ageing. However, the size of the future challenge should not be underestimated. Using advanced techniques of microarray, proteome and metabolome analysis, comparative genomics and bioinformatics of the increasing number of available databases and data depositories, and making appropriate, ethical use of animal models will give an unprecedented richness of complex tools to
advance our knowledge and to tackle the formidable problem of the complexity and diversity of the ageing process. Major use will also need to be made of advanced mathematical and computational systems-biology approaches that can build effectively upon the emergence of unified concepts on ageing, such as the network theory (17,18).

**Current status of European research on the biology of ageing**

Ageing research only began to become established in Europe to any significant degree over the last two decades. The initial impetus derived from a few national programmes and particularly from support from EU framework programmes for Concerted Actions and other similar ventures. These projects helped to create an early network of European laboratories working on various aspects of the ageing process. The first such project, EURAGE, was a Concerted Action Programme (CAP) and, among other successes, enabled the operation of a central animal facility providing aged rodents to project partners; this however came to an end when the funding for EURAGE was terminated. A subsequent CAP, named MOLGERON, was established in 1995 and this provided the platform for several follow-up projects under Framework Programme 5. In FP6, there have been four major projects (Integrated Projects and/or Networks of Excellence) on biological ageing, namely: GEHA (www.geha.unibo.it) studying the genetic aspects of human ageing; MIMAGE (www.mimage.org) focusing on the function of mitochondria, PROTEOMAGE (www.proteomage.dk) addressing protein-protein interaction and protein maintenance during ageing, and LIFESPAN (www.nwo.nl/projecten.nsf/pages/2300132905) studying the links between early developmental events and late life patterns of ageing. Furthermore, a Concerted Action under FP-6, LINKAGE, (www.link-age.eu) is seeking to help identify and help implement common research strategies in order to generate critical mass and added value from European biogerontology research and to establish a framework that allows effective integration of research on different species to maximise the opportunities for synergy and interaction between researchers working on such species. Important as these initiatives are, and have been, the total volume of EU-funded research in ageing, and the numbers of experts so far trained in EU members states in biology of ageing, remains very small in comparison to other biomedical fields and in relation to the scale of the challenge. How to move to a more substantial position in both these respects is an important question that we believe needs urgently to be addressed.

In terms of funding within individual EU member states, research into the basic biology of aging in the UK is mainly funded by two public sector funding agencies, the Biotechnology and Biological Sciences Research Council (BBSRC) and the Medical Research Council (MRC), together with a number of private foundations, notably the Wellcome Trust, Help the Aged with its research arm Research into Ageing, and others. BBSRC and MRC together spent about 3.9% (about £29M) of their yearly allocation on basic ageing research in 2004. This is nearly twice as much as what was spent by them in 2002 and is a higher percentage than has been spent in the majority of other European countries. An important trigger for this faster growth was that BBSRC was early to launch two “ring-fenced” initiatives on Science of
Ageing (1998-2001) and Experimental Research into Ageing (2001-04), in which £9.15M was spent on a total of 49 grants. Active steps were taken in these initiatives to solicit applications from scientists with relevant skills but who had not yet worked on ageing and to foster scientific contacts between grantholders by organising yearly meetings. This proved to be an important step that helped to introduce a step-change in awareness of basic biological research in ageing within the UK and to draw strong new groups into the field.

Several European countries have seen the establishment of research centres on ageing, often as a result of local initiatives by individual universities but sometimes with state or regional funding. Examples include the Institute for Ageing and Health at Newcastle University, U.K. (www.ncl.ac.uk/iah/; presently the largest and fastest growing institution in Europe to combine basic research in biogerontology with research in clinical and social gerontology), the Italian National Centre of Ageing Research in Ancona (www.inrca.it; a multidisciplinary centre with state funding), the Institute for Biomedical Ageing Research in Innsbruck, Austria (www.iba.oeaw.ac.at; funded by the Austrian Academy of Science, which has the specific research goal to help to prevent age-related functional losses and diseases by analyzing ageing processes at a cellular level), and the Danish Centre for Molecular Gerontology at the Aarhus University (www.dcmg.dk, which focuses on the understanding the age-associated molecular biological mechanisms leading to genomic instability). Similar actions have also been initiated recently in few other European countries, for example, Germany.

EU and national funding has enabled several important discoveries in the biology of ageing, for instance the elucidation of conserved molecular mechanisms of ageing, such as telomere-initiated senescence (19), central role of proteasome (20) mitochondrial dysfunction (21) and details of premature ageing (22-25). The establishment of bio-banks from centenarians and long-lived siblings across Europe (the largest collection worldwide) made it possible to clone several age-related genes (26,27) and identify polymorphisms (28). Ongoing genetic scans (www.lumc.nl/1090/Programma's%20LUMC%202006/Molecular%20Epidemiology%20F1.html) are likely certainly lead to the identification of additional genetic markers (15). However, it must already be concluded here that European and national funding for basic biology of ageing is tiny as compared to the societal importance of the topic (see below).

Apart from these studies on basic research in biological ageing, European scientists are equally successful in identifying compounds that delay the rate of human ageing and exploiting their use by establishing ‘anti-ageing’ companies. These efforts include the identification of a cytokinin, kinetin, which delays the onset of several age-related changes in human skin fibroblasts (29), and its subsequent development as a component of numerous skin care cosmetic products, licensed by Senetek PLC (www.senetekplc.com), and the identification of an algae extract that activates the proteasome and delays the ageing of human keratinocytes (30). Several other compounds have been identified and are patent-protected on the basis of their potential healthy ageing properties. These include, ethanolamine (patent No: FR2821554) and...
4-oxo-retinol (patent No: DE10010814). However, the biological basis of their healthy ageing properties remains to be fully established.

All these examples may be regarded as a successful and promising start, which establishes adequate expertise and contact-networks for a rapid, further development of the field in the EU.

However, the recognition of the potential of basic research in ageing by politicians, media and the scientific community itself has so far lagged a long way behind not only the potential of the field, but also the needs of societies that are being dramatically increased as a consequence of demographic change. This is partly due to the extraordinary complexity of the topic, which precluded successful scientific approaches and definitions of realistic goals and objectives for a long time, seriously delaying the development of the field. However, with the appearance of new technologies, this is no longer a valid consideration.

As stressed earlier, age is the most important risk factor for many major diseases today. This means that effective intervention in the ageing process can potentially add enormously to healthy life expectancy, and it can do so in a much more cost-effective way. The technologies to achieve this are in place. A firm conclusion is that long-term future funding for basic and applied ageing research should at least match the present funding for research into the basic biology of tumours, dementia and cardiovascular disease. This does not mean that these conditions have become any less important; however a compelling argument can be made that investing in new science that addresses why the intrinsic ageing of cells renders these conditions more likely to arise may provide crucial new insights that might support the development of radically new drug targets and pathways for intervention. The reality, of course, is that there is a long way to go to deliver the research infrastructure that will be required to facilitate such results far away from this. Nevertheless, it is high time to begin the process and to commit the necessary resources that it can happen on a timescale commensurate with the challenge and opportunity. All EU member states have at least one large tumour biology research institute, as well as clinical research centres. The total European budget for research into age-related diseases including cancer, cardiovascular diseases, dementia and diabetes is hard to assess. Our best estimate of the spending for basic biological ageing research alone all over Europe, taking into account a wide variety of publicly available sources, is in the order of only 50M EUR/year in 2006. In the US, the current annual budget of the NIH is $ 29587M, while that of the National Institute on Aging is $1047M, or 3.66% of the NIH spending. Although most of the NIA budget funds research into individual age-related diseases, with a relatively small amount being spent on basic biology of ageing, there is a marked disparity on the two sides of the Atlantic ocean.

The lack of human capacity in European ageing research is also a source of major concern. Within the UK for example, there are about 10-fold fewer members of the British Society for Research on Ageing as compared to the British Association for Cancer Research, which is just one of British-based
cancer societies. It needs to be stressed in this respect, that the UK is the country in Europe that has had by far the most active funding of ageing research over the last decade.

Our stocktaking of the current status of ageing research in Europe clarifies two important points. Firstly, ageing research is very seriously under-funded in comparison to its relevance for human health at the moment. In fact, a ‘critical mass’ has not yet been achieved and a sustained development of the field in Europe is not ensured. Secondly, it might be speculated that classical research into age-related diseases already works much closer to ‘saturation density’ in terms of value for money. In other words, comparatively minor improvements of the funding situation in basic ageing research can be expected to lead to major breakthroughs in science.

Potential of European ageing research
The development of genomic, proteomic and metabolomic methods combined with the respective resources of databases and bioinformatics, as well as the successful establishment of European bio-banks, centres and networks of biogerontology has prepared the platform for attaining a new goal: developing basic ageing research within Europe to a level that can begin to realise its potential for the benefits of our ageing populations. Not only are there major targets to be reached in terms of providing the basis for enhanced quality of life and reduced health and social dependency, but there are also major prospects for engagement with the pharmaceutical and other industries (see report of the Finance and Industry Sector Panel) for wealth creation and growth of new European businesses. The enabling steps in reaching these goals will be to make substantive progress in key areas of the basic biology of ageing.

Coherent understanding of age-related changes by parallel profiling across species
Molecular research is at present performed in a rather species-restricted way to find the physiological age-related changes that reflect primary events in the ageing process. In the future, knowledge about the age-related changes occurring in cellular, experimental animal models and human studies of ageing needs to be better integrated. Profiles of gene expression changes, the proteome and the metabolome will be generated by using the new technologies available, which will allow the creation of a more complete, systems-level understanding of the ageing individual. Although such profiling is being studied extensively in human studies, pre-clinical age-related changes can only be detected in limited human biological material (skin, blood, urine) from healthy subjects. It is therefore highly relevant that simultaneous and systematic studies will be performed in animal and cellular systems and models. Cross-species comparisons of age-related changes under varying genetic and environmental interactions will provide vital information for the clustering of relevant molecular changes. Systems biology and bioinformatics approaches need to be applied on a much wider scale and, indeed, to be developed to a much higher level of integrative complexity in order to obtain coherent information about the biological events occurring at the DNA, RNA, proteome and metabolome level, about the networks of signalling pathways.
and functional interactions involved, in short, to understand the aging process in its complexity.

**Biomarkers of biological ageing**

Ageing research is now very much focused on life expectancy as the main phenotype. Consequently, we lack reliable biomarkers of biological ageing rate that can measure the rate of intrinsic biological ageing and predict the nature and timing of beneficial or adverse health events. Developing successful biomarkers of ageing is intensely challenging, as previous experience (e.g. the US NIA biomarker programme) has shown. The development of a more successful strategy for biomarker detection can only proceed through close integration of clinical studies in human population, fundamental laboratory science on mechanisms of ageing and high-level biostatistics.

**Identification of longevity assurance genes**

In different countries and EU consortia (e.g., GEHA) a wealth of population-based studies has been created to study which genes make the major contributions to late-life mortality and morbidity and which predispose to healthy ageing. Numerous population-based studies of elderly and control subjects, longitudinal studies of older people, and studies of familial longevity have been included and are being subjected to genome scans and candidate gene studies. Some genes appear to be mortality- or morbidity-related specifically in the human species, whereas other genes are expected to be associated to longevity across a variety of different species. Integration of the genetic findings with the results of biomarker research can be expected to elucidate the pathways causally contributing to ageing as a major risk factor of disease.

**Identification of epigenetic and environmental effects**

Whereas the genetic background of subjects and strains will certainly determine a few major factors influencing the lifespan, the contribution of epigenetic and environmental effects on the ageing rate must not be underestimated. Histone modifications (especially acetylation) and DNA methylation are mechanisms by which the genome represses or activates gene regions as a consequence of external stimuli. Many of the lifespan-regulating genes in animal models have been shown to be involved in histone acetylation. The human genome shows DNA-methylation changes with increasing age. Whether this phenomenon can be generalized and has major phenotypic consequences is not clear yet. It is clear, however, that we will not understand the action of genes in assuring longevity unless we have a better picture on their interactions with the environment.

**Development of successful healthy ageing strategies**

A major scientific question in the field is the identification of central regulators of the ageing process. Healthy ageing strategies are focused on finding such key points and investigating whether they can be modulated to retard the ageing process. Hormonal influence is an example of these control processes (exemplified by the dietary restriction-stimulated hormonal changes, or by the role of growth hormone retarding age-dependent changes in mice).
The protecting effects of stress-conditioning by mild stress, called hormesis, are providing another, more general mechanism for the exploration of healthy ageing strategies. Any healthy ageing strategy can be considered successful only if it retards ageing in the whole organism and promotes healthy ageing. This should be monitored by a decreased accumulation of age-related changes at the molecular and epigenetic level, which necessitates further the elucidation of adequate biomarkers of biological aging.

Development of links with the medicine of old age
Despite the fact that age is the biggest risk factor for many diseases of old age, the effective connections between biological ageing research, clinical translation and experimental medicine are severely under-developed (see also the report of the Medicine Sector Panel). To some extent this reflects the fact that within medicine itself, there is often a surprising lack of interconnection between geriatrics and other specialties, with the exception of old age psychiatry. Just as biogerontology needs to draw in experts from other relevant areas of the laboratory sciences, so geriatricians need to forge closer links with the clinical research being done on a wide range of age-related diseases. Indeed, it may well be that biogerontologists can help to catalyse such links by forming research collaborations not only with geriatricians, who have found little opportunity to date to exploit advanced molecular medicine, but also with clinical scientists addressing cardiovascular disease, immune system failure, osteoporosis and so on. To this end, attention needs to be given to establishing biological ageing research teams within the great majority of medical research centres.

Extension of healthy human life expectancy
Life expectancy in the EU has dramatically increased in the last two hundred years through improved nutrition, sanitation and medical treatment (75 years for men, 82 years for women). Healthy life expectancy, however, is still much lower (68 years for men, 73 years for women), and it is not clear whether it increases as fast as life expectancy. While disease-specific research areas will focus on physiological changes specific for the particular disease, ageing research focuses on the age of onset of common disease with the aim of postponing such disease and adding more healthy years to our lifespan. In this process, evidently, pathways will be identified that modify the onset of specific diseases. Since ageing is a risk factor for so many diseases, common factors will also be identified that increase sensitivity of disease in a more general way (like maintenance pathways controlling the quality of synthesized molecules and the accumulation of damage to macromolecules). In particular, research on subjects with familial longevity is expected to shed light on common pathways retarding the age of onset of disease conditions.

Since relevant age-related changes are expected to accumulate throughout life, a very promising line of research is one that aims to understand the links between early developmental conditions and late-life events. This is the focus of an EU consortium of research groups investigating the link between development and ageing in a spectrum of experimental animal models as well as humans (LIFESPAN).
Improving links between biogerontology, other disciplines and industry

Basic ageing research assists in understanding the ageing process in humans and especially its role as the major risk factor to common diseases. In human populations, biogerontology has the clear potential to combine with other important areas, such as the socio-economic status, nutrition, social behaviour and stress factors. This is especially important, since the main factors influencing human health will change from one cohort to another. It can be expected that increased weight and obesity will form major determinants of disease in the aged generations to come. Weight, just as ageing, is a major risk factor common to all age-related diseases.

The interdisciplinary EU networks of ageing research provide the flexibility to study the effect of new covariates (new modifying factors) of the gene-environmental interactions contributing to ageing and health. This is not only interesting from the perspective of human health policies but also from the industry perspective. If the ageing process of individuals can be monitored by biomarkers and understood in its major pathways, the pharmaceutical and biotech/diagnostics industry will be supported in their efforts to monitor the effects of medicines on the ageing process, as well as to generate personalized medicines for older people. The monitoring possibilities will also help the improvement of nutrition and personal health care by distinguishing the segmental effects of these products from their effects on the ageing of the organism as a whole.

A large number of consumer/personal care companies have already recognized the importance of specific measures, such as improved oral health benefits or improved diets contributing to the increase of life expectancy and healthy ageing. A better collaboration between biogerontology research and these companies may provide an example to extend the number of successful industrial implications of biological ageing research.

Conclusions

Biological ageing research has been strongly established in Europe, albeit on much too small a scale, over the last two decades. The EU gave important support for Concerted Action projects on biology of ageing, which increased the collaboration and trans-national, multi-disciplinary networking. At the national level, several European countries have seen the establishment of the first substantive research centres on ageing. These developments, together with dramatic advances in research methodology, have already led to several important discoveries including identification of candidate compounds that delay some aspects of the ageing process. It is now timely to develop the field in line to its potential importance for society in the 21st century. This is expected to result in a number of potential breakthroughs, which will not only help to understand the ageing process, but will also help to provide a healthier and more satisfactory life of the elderly. The expected development will result in the following deliveries:

- Coherent understanding of age-related changes by parallel genomic, proteomic and metabolome profiling across species;
- Biomarkers of ageing
- Identification of longevity assurance genes
• Identification of epigenetic and environmental effects
• Development of successful healthy ageing strategies
• Extension of healthy human life expectancy
• Improved links of biogerontology to other disciplines and the industry.

**Recommendations for action**

To realise the potential of biological ageing research within Europe will require the stabilisation, improvement and in many European countries the creation of a research infrastructure for biology of ageing that is commensurate to its societal importance within the next 5 – 10 years. This includes greatly increased levels of public spending on ageing research with several-fold increases even in those countries that do already support biological ageing research to some extent.

**Reaching critical mass at a national scale**

*Construction of national focused research networks:* A number of national funding agencies have programmes to support groups of researchers (usually 10-20 labs) working together on closely interrelated questions (for instance, “DFG Schwerpunktbereiche” – Priority Programmes – in Germany). Funding typically extends over 3 – 6 years at a level of 50 – 150 k€ per year and lab involved. The experience in the UK (two consecutive rounds of ‘ring-fenced’ funding for biological ageing research so far) shows that this is an excellent first step to open the field towards influx from related areas and to attract high-quality researchers. The establishment of similar programmes for research on ageing needs to be seen as an urgent priority for the research funding bodies in all member states.

*Establishment of National Centres of Excellence/Institutes of Ageing:* To allow sustainable development of the field, focused networks have to be complemented by stable research centres, which will be partially stabilised by intramural funding. National ageing research centres have been established in the US in 1974 and in Japan in 1995. Existing centres within Europe are without exception too small to sustain critical mass in ageing research in the longer term. Centres of sufficient size need to be established in all member states within the next few years. We see great opportunities here for new EU member states, who could use structural funds to generate highly competitive and attractive centres very fast, which would help to reverse brain drain.

*Training and education at the national level:* Gerontology, including biogerontology, needs to be firmly established as a relevant discipline in the medical and biological curricula. This requires the creation of respective chairs in those universities which do not have them yet (by far the majority) and of respective modules for undergraduate teaching. This further requires the integration of existing postgraduate programmes in (bio-)gerontology and the creation of new ones.

**Capacity building at the European level**

*Networking within the EU:* Ageing research has been part of the EU framework programmes 4 to 7, which was a major advance in the European field of aging research funding. However, in line with all other forms of
funding, EU support for ageing research was not sufficient to address the major public needs and expectations associated with demographic change. To make full use of recent developments in post-genomic technology, modern molecular genetics or systems biology, for example, large scale multinational networks are required more than ever.

European Centres of Excellence: To foster effectively top-quality research in ageing, a number (we suggest 4-6) multinational European Ageing Research Laboratories (EARL) need to be created, modelled on the successful European Molecular Biology Laboratories. These should provide a research-friendly and competitive environment each with its own focus that might range from population genetics to stem cells in ageing. We see here a promising opportunity for Article 169 funding.

International education: There is an urgent need for a highly flexible European funding for international education projects in ageing research in order to build new expertise and provide the research leaders of the future, particularly since the original cohort of scientific ‘pioneers’ is itself ageing. Those projects include
- Summer schools
- Short term focused visits for young scientists
- Marie Curie Fellowships in ageing
- EU PhD programs in ageing (in 3 different countries/places/disciplines)
- Meetings concentrating on the connection between areas
- Meetings raising the questionable, debatable, risky issues
- Meetings soliciting the discussions of young scientists
- Short-term, focused visits of senior personnel.
This program goes beyond current EU-supported initiatives (such as LINKAGE) both in scope, and integrity of multiple measures.

Synergies and links of ageing research
Increased overlap between ageing research and research on age-related diseases: Due to the large overlap in the focal points of the studies in biogerontology and age-related diseases, a special funding initiative is needed to foster the collaboration of these two areas. Additive, ‘inter-disciplinary communication grants’ should be formed to encourage successful scientists in ageing research to collaborate with leading labs on age-related diseases and vice versa.

Stronger relations to the industry: We need more substantial and better scientific background behind healthy ageing treatments and remedies. Biogerontology should develop and offer testing systems for healthy ageing medicaments and strategies, to test the effects of medicines, nutritional and health care products on the ageing process as well as to help the development of specific medicines, nutritional and health care products for the elderly people.
**Better communication strategies for the public:** Finally, scientists in the field of biogerontology need a special effort to collect the most successful arguments to convince the public of the potential, ambition and importance of biogerontology research. At present, coverage of the biology of ageing is unduly focused on sensational but scientifically questionable claims of imminent major life extension. Given the poor level of general understanding of the current status of biogerontology, it is not surprising that such a distorted and unbalanced representation has proved so easy for journalists and others to maintain. For the most part the distortion derives from innocent confusion of what really might be possible, although there are those in the life extension lobby who may have vested interests in fuelling this kind of coverage. It is high time that a concerted effort be made to engage journalists and key opinion formers in a better understanding of the real issues. It is striking for example, that the public will not tolerate wildly exaggerated claims in areas such as cancer and heart disease. Greater engagement between scientists and the public, through the medium of newspapers, radio and television, may also help society at large to move towards a more realistic and mature understanding of what it means to look forward to growing old in today’s Europe. Detailed discussion of the advances and limitations of biogerontology research will help to increase public understanding of the complexity of age-related issues. A deeper insight to the background will also help to change public opinion that aged people are not the burden of the society but a source of experience and wisdom.

**Potential future success of European ageing research**

Due to the technical and conceptual breakthrough and the major improvement of networking in the field, European ageing research has reached a critical ‘tipping point’, where future expansion is not only timely but should be attainable. Making a leap to the next level will enable us not only to understand but also to influence a process, which until recently has been regarded as an unalterable fate.

In the next 10 years, we anticipate that it will be possible to:
- bring a new generation of scientists to the field;
- generate extensive databases on the biological background of ageing;
- develop a list of coherent biomarkers of ageing;
- identify longevity assurance genes;
- establish national centres and a strong EU network of ageing research;
- achieve a deeper understanding of ageing research by the public; and
- provide an array of established links to the industry leading to novel nutritional and health-care products increasing life-expectancy and helping healthy ageing.

In the next 20 years, the above changes and measures will:
- lead to a breakthrough in our understanding of the ageing process;
- propel European ageing research into a world leading position;
- develop successful healthy ageing strategies; and
- lead to the development of compounds that delay several aspects of the ageing process.
In the next 50 years, the above progress will:

- lead to widespread personalized medication during ageing based on personal genomics, proteomics and the personal metabolome: a ‘molecular-self’ of elderly subjects, showing their life-history at the molecular level;
- significantly increase human life expectancy making the status of the ‘healthy centenarian’ achievable.

References

TECHNOLOGY

Panel Members: Garth R Johnson (Chair), Richard Faragher (Vice-Chair), Peter Gore, Roger Orpwood, Kees Schep, Olivier Toussaint

Introduction

The progressive decline in the functional capacity of many different organs and systems is an inevitable consequence of advancing biological age. However, because of the wide variation in genetic background and environmental conditions, there is a large person-to-person variation in the rate at which any given biological parameter declines. Such wide heterogeneity is a biological problem not unique to the ageing process - mapping an individual’s functional decline has many conceptual similarities with research currently being undertaken in pharmacogenomics. In this area, the ideal would be to provide a truly personalised medicine in which drug treatment regimes were optimised for a given individual. Practically, this is not possible, but it is entirely probable that the discipline will be able to segment the human population such that the best possible treatment strategy from a limited number available is deployed in support of a particular individual. The panel thinks that a similar approach is possible in the use of technologies to support healthy ageing.

The range of technologies considered by the panel is extremely broad, and it is difficult to find a specific example which could not be deployed helpfully to raise quality of life for older people. It is entirely possible that, in the end, the choices of which technologies to use in support of health in later life will be determined primarily by cost-benefit analysis at the point of delivery, rather than the intrinsic intractability of the problem that the technology is designed to solve. Thus, considered holistically, the “promise” of any given technological fix is very much a contested term requiring the input of other panels in a situation-dependent manner.

Technology can be applied in a number of ways in response to specific impairments or pathologies and it can be harnessed at three levels – monitoring the rate of decline, slowing that decline, and providing assistance at a certain level of decline. In some cases, there will be particular events such as stroke which may cause a step change in function. The monitoring approach may then be used to understand the rehabilitation phase and to interact directly with technological approaches to the rehabilitation process.

In order to be able to understand and influence these factors, it is necessary to provide a technological basis for data monitoring, modelling and interpretation for the maximum number of appropriate variables. People would be encouraged to maximise function and stretch boundaries within their safe margins – i.e play an active role in their personal ageing process. In this approach, technology should be seen primarily as an agent which assists in the delay of this progression and as “assistive” only when required in the later
stages. This idea is about maximising an individual’s potential and, if affected by an episode (e.g. stroke), regaining as much of that individual’s potential as possible, rather than aiming for some average value. This is only really possible where a person has ‘subscribed’ to being benchmarked. But this is also a great incentive for joining the benchmarking programme. It is very much about maintaining well-being within my capabilities. It doesn’t guarantee anything for me, but allows me to see where I am at, and what my lifestyle and other choices may/may not be doing to my longer term health prospects. I might also agree with my GP the boundaries around my personal measurements that may trigger a consultation. There is evidence that there are measurable indicators that might predict an adverse health event that are currently not recorded, and therefore we are possibly missing the preventative agenda in some areas.

The 2005 UK House of Lords Science and Technology Committee report on ‘Ageing: Scientific Aspects’ suggested that the factors that promote good health in ageing are as follows:

(a) Physical activity,
(b) Social role and function,
(c) Good nutrition,
(d) Absence of risk factors (alcohol/smoking)
(e) Good mental health and well being.

It is suggested that technology may have a role to play in all of these categories except, perhaps, (d). The major focus in this document will be (a) and (b).

**A framework for the application of technology**

Development in the understanding of the biological fundamentals of the ageing process opens up the possibility of using real, biology-related parameters to establish, on a personal level, safe boundaries for a variety of physiological variables. A framework based on this approach is shown in Figure 1 below.

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**Figure 1. Boundaries of technology support**
In Figure 1, the ideal (best outlook) biological process is shown. As the level of relevant biological and physical measures declines, there is a transition through the “three stages of ageing”:

- **Informed** (where there is a potential major benefit from controlling lifestyle in response to physiological feedback);
- **Supported** (where there is a need to use appropriate technologies to maximise independence); and
- **Dependent** (where independence relies upon the proactive support of technology).

In addition, there is a representation of how the ageing process may be accelerated by an adverse event, such as a stroke, causing a drop of status to dependence but with some return to the ideal line following rehabilitation. It is proposed that the applications of technology should be identified with these three stages.

Before going on to consider the applications of technology at the three levels, it is important to consider the importance of design approach across the whole spectrum. While those who are dependent upon technology are probably well defined, it is suggested that the boundary between informed and assisted is less clearly defined. The distinction is best examined in the light of definitions produced by the World Health Organisation (1976). Using these definitions, there are important distinctions between measures of impairment, handicap and disability.

As follows:

> “An impairment is any loss or abnormality of psychological, physiological or anatomical structure or function; a disability is any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being; a handicap is a disadvantage for a given individual, resulting from an impairment or a disability, that prevents the fulfilment of a role that is considered normal (depending on age, sex and social and cultural factors) for that individual.”

A similar approach can be taken to aspects of ageing and it is suggested that the diagram in Figure 1 is based primarily on measures of impairment.

**Handicap and the Importance of Design**

If we consider the concept of “handicap” then design becomes of paramount importance since appropriate design can maintain a person’s functional abilities. These aspects have been discussed by Keates and Clarkson (2000) using the concept of the “design cube” in which a “core” design can be further developed to take account of ability (see Figure 2).

These authors have then gone on to propose a 7-stage design approach, which places the initial emphasis on User-led design, in which the perceived needs of all potential users are taken into account. At the definition stage, aspects of perception, cognition and motor function are all taken into account. It is at this part of the process that there is the greatest opportunity to maintain function for older users. This approach brings with it the opportunity for designing the whole living environment in an inclusive manner so that
facilities are shared between children, middle age adults and the older population.

Figure 2. The Inclusive Design Cube (Keates and Clarkson)

Selection and matching of appropriate technology – making the best use of existing solutions.

While it is essential to search continuously for novel technological solutions to problems of ageing and disability using the approaches outlined above, there is a broad range of problems which can be solved satisfactorily by current technology, provided that it is appropriately selected. However, there is evidence from the UK that a high proportion of basic equipment (e.g. bathing and toilet aids, walking aids etc) remains largely unused because of inappropriate selection. In many cases this wrong allocation results from simple causes such as failing to take into account a person’s height or weight. In other cases, there may be a need for more detailed information, as yet undefined, influencing equipment selection. In the longer term, the systematic collection of these types of data can be used to inform the design processes highlighted above. This could potentially move much present day Assistive Technology into tomorrow’s Inclusive Design, reducing the cost and destigmatising as much as possible. We would also be able to define better what AT we need to develop, in contrast to the situation today where the ergonomic data widely available come from ‘healthy’ subjects, who by definition probably would not use AT.

This approach will maximise the usability of a particular device for users with a range of abilities/impairments. It is suggested that, while the approach is unlikely to move a person out of the “dependent” category, it has the potential to keep them at the “informed” level for longer.
Technology in the three stages of ageing

The remainder of this report will concentrate on the potential applications and benefits of technology within the three stages of ageing identified in Figure 1. The overall pattern of support is summarised in Table 1 below, which summarises the major technology needs to support an ageing population:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Devices</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informed</td>
<td>– Feedback of relevant physiological parameters</td>
<td>– Measurement devices and transducers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Wearable devices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– IT systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NB. In this phase it is very important that solutions are unobtrusive, and take little effort and/or time</td>
</tr>
<tr>
<td>Supported</td>
<td>– Biomechanical</td>
<td>– Total joint replacement</td>
</tr>
<tr>
<td></td>
<td>– Sensory</td>
<td>– Orthoses</td>
</tr>
<tr>
<td></td>
<td>– Mobility</td>
<td>– Incontinence support (clothing and devices)</td>
</tr>
<tr>
<td></td>
<td>– Rehabilitation</td>
<td>– Sensory devices – vision, hearing, etc</td>
</tr>
<tr>
<td></td>
<td>– Safety and security</td>
<td>– Interactive devices</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dependent</td>
<td>– Safety critical monitoring</td>
<td>– Smart homes</td>
</tr>
<tr>
<td></td>
<td>– Safety and security</td>
<td>– Intelligent systems</td>
</tr>
<tr>
<td></td>
<td>– Rehabilitation</td>
<td>– Advanced mobility devices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Haptic devices</td>
</tr>
</tbody>
</table>

Level 1 - Informed - the individual draws on a range of measured information relating to lifestyle and the ageing process

It could be argued that an appropriately delivered healthcare system will allow “informed ageing” from the cradle and modern developments in healthcare can be seen to move in that direction with the computerisation of medical records etc. Within the context of healthy ageing, the objective is to use a variety of technologies to enable a person to stay as close as possible to their personal “best ageing” line – i.e. to keep the rate of cellular ageing as close to the natural biological rate as possible. The proposed technology will have the ability to provide quantitative measures of health status, which can be compared against norms known to be compatible with healthy ageing. The excitement of this approach lies in the possibility to extend the personalised optimal range for a particular individual by making appropriate lifestyle changes. The factors to be monitored include the following: Blood pressure,
heart rate (as a function of time and exercise), gait, tremor, muscle mass, stress (e.g. skin conductivity), blood pressure, blood glucose etc – calling for novel minimally invasive sensors and developments such as smart clothing, together with data acquisition and internet databases to establish norms.

An example of this approach is the management of cardiovascular risk factors. The European Society of Cardiology publishes the SCORE (Systematic Coronary Risk Evaluation) Risk Charts, [http://www.escardio.org/initiatives/prevention/prevention-tools/SCORE-Risk-Charts.htm]. The SCORE Risk Charts indicate the 10 year risk of a fatal cardiovascular event, such as sudden cardiac arrest, myocardial infarction, or stroke. The tables are country-specific to reflect the different risk profile for different geographic locations. The risk factors include gender, age, cholesterol level, systolic blood pressure, and smoking status. The increased risk for a fatal cardiovascular event with age is an example of increased vulnerability with age. However, risk can vary greatly between individuals depending on other risk factors like cholesterol level, systolic blood pressure, and smoking status that are at least partly lifestyle (diet, activity) related and can be influenced by the person. This illustrates the informed stage of ageing where the person does not yet experience functional limitations but can still take action to stay as close as possible to the “best ageing” line.

Technology can play an important role in this phase. One example is the use of web-based IT tools that help to assess the risk of an individual, and in addition give advice in line with medical guidelines to reduce the risk factors by behavioural change and/or medication. An example of this is the HeartScore tool of the European Society of Cardiology. Technology can also help to play a role in measuring individual risk factors like cholesterol level and blood pressure. These technologies have become increasingly available for consumers. The approach is being explored in the MyHeart project funded by the IST programme of the European Union’s 6th framework.

At the Informed level, where the person is not yet experiencing functional limitations, it is a challenge to motivate people really to take action, and to continue to comply in the long run. Implications for the technology are that the monitoring should be as simple and unobtrusive as possible, taking little time and effort. The feedback of the results to the user should be easy to understand and should motivate the user to implement the required lifestyle changes, for example by integrating the risk management into daily life, showing progress over time, giving advice on lifestyle changes tailored to the personal status and preferences, and, preferably, making risk management fun. There is a need here for research to understand more about the psychological barriers to this approach – i.e. why is there a dichotomy between the emotional (reluctance to engage) and the rational (opportunity to benefit).

Also for other ageing-related conditions like diabetes or cancer, similar risk tables are available or in development. They are expected to improve over time, and to become better tailored to the individual.
A similar approach could be followed for general aspects of ageing. Already, popular television programmes and websites like try to give an indication of your “real” biological age and compare it to your birthday age. If a solid scientific basis can be given to such a popular concept (similar to the SCORE risk tables), technology can be developed to monitor real biological age according to the scientific guidelines and this can be a powerful tool to create awareness in a large fraction of the population and to drive action towards a healthy lifestyle that slows the ageing process.

We shall consider the future promise of new technologies at the level of “Informed ageing” under a number of headings:

**Sensor technologies:** advances in MEMS technologies will lead to further miniaturisation and wider availability of conventional sensors. In the short term, the development of a range of sensor technologies is anticipated where the wider commercial impact has already established such as RFID (for object identification and coarse location) and indoor/outdoor global positioning technologies. Improvements in motion, touch and pressure sensor technologies are likely to result in more ready integration in a wider range of everyday objects and infrastructure. Robust approaches to sensor fusion are likely to increase as the integration and remote (e.g. computer vision) and embedded (e.g. object located accelerometer) sensors become a practical reality. Next generation smart materials are also likely to emerge in which micro-nano technologies are integrated into both existing and new materials. As well as improving the physical properties, materials advances will lead to smart materials for personal wearable applications.

**Health and emotional monitoring technologies:** current health technology research (in MEMS and bioMEMS – Noury et al 2005) will lead to the development of non- or minimally invasive sensors for the continuous analysis of multiple health parameters including vital body signs and biochemical analytes. The primary function of such technologies is to provide real-time and real-world data for both chronic disease management and preventative monitoring. Additionally, both theoretical and technical advances in the measurement of the emotional state of users is also being actively pursued with a view to developing objective measures of pain, confusion, distress and other affective dispositions.

**Display systems:** advances in organic display technologies are likely to lead to wider deployment of displays in the everyday environment, as cheap low power and flexible display technologies are developed. Target application domains for future organic displays technologies include intelligent packaging, displays, signage and lighting systems, but advances in this area is likely to lead to the ubiquity of displays situated in our everyday environment and a shift away from the current emphasis of mobile computing applications on hand-held devices (i.e. mobile phones and PDAs).

**Pervasive computing:** truly ubiquitous high-bandwidth wireless network access will be a reality in the very near future and many of the anticipated advances in assistive technology assume such a context. Ubiquitous
networked systems will be supported by software and hardware infrastructures to enable the deployment and ad hoc collection of sensor data, security and trust in wireless and ad hoc systems, semantic service-driven computing provisions, and adaptive user interfaces.

**Level 2 – Supported** - the individual requires some support from items of assistive technology while still making use of the approach in 1 above. At this level, the person is already experiencing some functional limitations of the ageing process. However, the level of these limitations is not yet so severe that the person really depends on technology solutions to live an independent life. Furthermore, there will be many applications of technology with the power to improve health and lifestyle and reduce decline. After all, even the simple walking stick has the potential to reduce the rate of development of arthritis at the hip. At this level, there is a clear psychological barrier for people actually to use solutions that would help them, because of the stigma associated with them. Inclusive design plays a crucial role at this level to lower this barrier. It is useful here to consider the areas of Mobility, Self Care, Social interaction, Exercise, and Mental well-being.

(v) **Mobility:** All forms of mobility are of importance to independence. The opportunities for technology to support mobility of this group are probably as follows:

(i) Maintenance of joint and muscle function
(ii) Provision and use of appropriate walking aids - e.g sticks and crutches
(iii) Total joint replacement
(iv) Appropriate design of personal and public transport
(v) Good mobility and transport information systems

While all of these are relatively mature technologies, considerable design and development is required to provide the most effective support. There is a need for further research into aspects of exercise – there is evidence that endurance training can maintain muscle function but there is a need to develop the most appropriate methods of delivery (development of exercise machines, etc). Similarly, further studies are required on the design of walking aids and the biomechanics of assisted gait. Total joint replacement, particularly hip and knee, is at an advanced stage; however the demographic changes call for longer lasting joints in order to minimise the need for revision surgery. The median age group receiving total hip replacement is 70-79 – a group which is increasing in number (Malchau et al 2002). Similarly, the expectations of pain-free fitness add to the demand for low-wear joint replacements.

Priorities for vehicle design are improved physical access and sophisticated control systems to maximise the usefulness for older people. The priorities for public transport are improved accessibility and safety of vehicles, improvement communication and information services to users and improved safety at stations etc. While many of these may be aspects of development, there is, in particular, a need to take advantage of new pervasive computing approaches (e.g. EU ASK-IT Project).
Self care and personal hygiene: Incontinence is a major problem for significant numbers of older people. The major technological advances in recent years have focused largely on novel absorbent materials for garments which can be as near to normal as possible (Fader 2003). However, many problems remain, particularly in the design of catheters. The raised expectations of older people regarding fashion and clothing will further increase the demand for sophisticated solutions.

Social Interaction: Mobility is probably the most important aspect of social inclusion. When mobility is limited, then there is a need to use and develop appropriate internet approaches. The current reliance on traditional email and webservers is severely limited. There is a need to develop new interactive communication systems – the next generation of internet chat rooms and video conferencing. It is important to establish the correct balance between internet and real communication.

Communication is always vital to independence and so when travel for personal social interaction becomes more difficult, the use of other forms of communication becomes ever more important. The traditional telephone will remain a priority device for interaction. As older people become more and more familiar with technology, then internet-based instant message and speech systems will become increasingly popular. The opportunities for video communication will also increase. More exciting possibilities are provided by interactive and haptic systems – those which use touch in order to interact with a computer – which will allow, for instance, group games and competitions. There are real opportunities here for physically isolated people to be included in the design of services and products through ‘virtual participation’. The Smart Community Centre has the potential to combine real and virtual communication systems.

Research is also needed to evaluate the social dimension of these technologies – for instance, does virtual interaction really help or does it add to frustration and loneliness? Is there a need to select communication technology according to character type? Are there particular benefits of promoting communication between old and young? What is the best way to use website-based communication, and how can it be best used to promote the concept of a community base?

Exercise, fitness and therapy: The communication technologies referred to above are easily extended to provide exercise and therapy. Exercise is a vital component of healthy ageing. While the traditional forms, such as taking a walk, will be available to many, there will be a significant proportion who are unable to do this in all weather conditions. In many cases, forms of exercise – sport, dancing etc – may be available at community centres but haptic technologies can extend these possibilities. This becomes even more important for the provision of therapy after stroke or other neurological conditions. Recent studies (Lum et al 2006) are showing the benefits of robotic/haptic therapy after stroke. The required technology is reducing in cost and the computing facilities are already available. These technologies,
which have the potential to combine leisure, exercise and therapy activities, are seen as a major tool for minimising dependence.

**Mental wellbeing:** There is a need for cognitive exercise/games to maintain and promote maintenance of cognitive levels. There is, for example, some evidence that the playing of games and doing puzzles helps to maintain cognitive function. It is also essential to promote social integration. This can be at two levels – personal and virtual. Personal integration is likely to be dependent upon mobility (always a priority for technology). In some cases personal meetings may not be possible or indeed may not be wanted, so internet-based games (incorporating measures of cognitive and memory skills) are preferred. By encouraging mental agility through games, it is likely that (a) the activity would be free of stigma, and (b) it might be possible to encourage the interaction between different age groups – benefiting everyone.

**Issues of acceptability:** A key aspect of “Supported ageing” is the need for comprehensive feedback on aspects of health and lifestyle. Clearly there may be ethical issues here. Some people will feel that the use of sensors is excessive and personally invasive. While some of the necessary sensors can be completely non-invasive and incorporated into the home or into novel design of clothing materials, others will require either a visiting assessment at home or at a suitable centre. The potential here is very great and some possibilities for using sensors are as follows:

- Heart and circulation: Blood pressure; heart rate
- Respiratory: Peak volume; blood oxygen
- Musculoskeletal: Muscle mass/volume; bone density; strength; range and quality of movement.

While, in some cases, suitable non-intrusive and non-invasive devices exist (e.g. heart rate), there is a major requirement for novel sensors which can, wherever possible be attached to clothing or directly to the skin.

**Summary:** The “Supported ageing” category is likely to be the largest group of older people to benefit from advances in technology. Furthermore, the benefits of maintaining them above the threshold of dependence are large. Current technology has the ability to provide much of the necessary support; however, there is a need and potential demand for new technologies, particularly sensors, which can extend the support provided.

**Level 3 - Dependent**
At this level, there is a need for comprehensive support to ensure safety and the reliability of appropriate care. All of the necessary technology is now being incorporated into an autonomous or “smart” home, or some similar supported similar environment. It is important to emphasise that these approaches are not in any way inspired by Orwell’s novel “1984” but should be seen as technological extensions of personal care with the potential to increase independence while at the same time reducing the stress on carers.
An example of technology provided to people at this level is personal emergency response systems. In case people need help, for example after falling, they can press a button worn around the neck or wrist, and contact is made to a service centre that sends help. Contact to the service centre is by means of a two-way link via a telephone-like device with a powerful loudspeaker and a sensitive microphone. In this way, frail older people can continue to live in their own homes, which would not be possible otherwise. The technology should be easy to use, and should be robust so that it works under all circumstances. These types of solution are provided by companies like Tunstall in the UK (http://www.tunstall.co.uk) and Lifeline in the US (http://www.lifelinesys.com). Directions for future development include automatic and reliable detections of falling and detection of all sorts of other emergency situations by sensors either on the body or in the home (Sixsmith and Johnson (2004). Older people often suffer from chronic conditions like congestive heart failure, atrial fibrillation, asthma, chronic obstructive pulmonary disease, and diabetes. Many technology solutions exist and are being developed that help people live with these conditions. At this point we do not explore these further.

**Autonomous homes:** Current telemcare technology is demonstrating the value and benefit of using remote behaviour-sensing technology, but future developments will require the use of more autonomous living environments, where the home itself is able to respond to the user’s behaviour. Such homes will require a whole range of new sensors to monitor behaviour and interaction with the environment, and it is important that the development of these sensors is in response to an understanding of needs rather than being technology-led. Data processing of sensor output requires appropriate algorithms to be developed to make judgements about behaviour, and to initiate appropriate responses. Such algorithms will increasingly require the ability to learn and adapt to patterns of user behaviour, so that they respond to the particular needs and habits of the individual. Good personal carers, who may be paid professionals or family members, are effective because of their ability to empathise with how the user is feeling, and the emulation of such capabilities should be sought through the pattern recognising systems at the core of the adaptive processing of sensor data.

Autonomous homes will require the development of a series of support devices that can be called into play to provide support, such as automatic cooker and bath tap control, central home locking, medication presentation, etc. As a rule-of-thumb for the development of such support systems, it would be useful for the home to respond in a manner that emulates the behaviour of good personal carers. A key part of this support is the provision of prompts and reminders. There is a real need for work to look at the effectiveness of different means of communicating for such reminder support, including voice prompts and the use of screen based-systems such as avatars. Much of this equipment will be acting in an automatic fashion without the need for direct control on the part of the user. However, much will still require direct user interaction and there is an important need for work on intuitive user interfaces to provide control functions for such devices.
It is important to ensure that autonomous home installations are not just providing safe and secure environments, but also address issues that more directly impinge on the user’s quality of life. Such issues need very careful defining, with development work based on the understanding obtained, seeking solutions such as ensuring easy access to choices of music, support for reminiscence, and many other issues. One of the most important is to ensure social contact. Reduction of social isolation is particularly important for this group and technologies that can improve communication, provide virtual presence/visits, and provide a sense of belonging and social engagement are crucial.

A lot of data is going to be generated as a result of monitoring technology and there is a need for care in how these data are used. The primary role for such data is to provide information to enable support devices and systems to be activated. However, the data also have an important role in providing care professionals with insight into the life of the user and the effectiveness of the care plans in use. The data can be presented in the form of event timelines, but for professional care staff or supporting family or friends, some processing of these data would be needed to communicate to them fairly high-level judgements, such as whether the client is getting sufficient food, sleeping properly, or more general behavioural conclusions such as whether the client was feeling anxious, or showing signs of depression etc. An important issue for such monitoring is reliable fall detection, in conjunction with developments such as intelligent flooring to prevent excessive injury.

The links to care staff and systems outside the home would flag when interventions were needed, but the communication technology would be very similar to that required for other monitoring technologies such as telehealth applications and telerehab, and some convergence in thinking about its design and installation would make sense. As well as providing interaction with care and health providers, these links will also be important in providing access to other services such as shopping, paying bills etc, and for accessing information. As with other aspects requiring user-interaction, much thought needs to be given to making these interfaces as intuitive as possible, and not require any computer skills whatsoever. From an inclusive design point of view, this would of course mean the equipment would have much wider application. Remote food shopping in particular could be linked to dietary monitoring, with high-level selection based on meals rather than individual items of food.

The core of this work is technology research and development but there is a huge overlap with the skills and understanding that need to be provided by the social sciences and psychology. It is particularly important that the design and development process is a multi-disciplinary one, and is based on clear understanding of the user issues involved, and of the user’s interaction with support services. Many of the people in this category will have cognitive difficulties of one sort or another, ranging from mild memory problems to severe difficulties with understanding, and of course dementia. People with a mild to moderate dementia, with their memory problems, difficulty with learning new tasks, and general problems with executive functions, provide a
useful group to guide the development of support technology that is going to be suitable for people in this general category of need.

**Recommendations for action**

1. Need for routine use of inclusive design approach in widest possible range of settings
2. Maximise the accessibility of commonly used technology – e.g mobile phones, DVD recorders, computers/internet etc
3. Emphasis on the need to make the best possible use of existing technology by optimum matching of solutions to people
4. Implementation of supportive information technologies to empower people to monitor key health variables. This must be accompanied by social science research to understand the psychological barriers to acceptance.
5. Maximise the usability of the private car by the introduction of advanced control and guidance technologies
6. Maximise the usability of all forms of public transport to ensure the easiest social interaction between older people. This can be achieved by improvement of access, safety and comfort at stops and stations, improvement of information on times and routes, and maximising safety and comfort within the vehicle.
7. Implementation of robotic technologies to promote exercise and fitness and, where appropriate, to provide therapy
8. Research into use of advanced communication technologies – including robotic and haptic devices to allow the greatest possible interaction between older people and supportive agencies
9. Research into the use of multimedia communication systems to promote social interaction between people in isolated communities and to re-create the atmosphere of familiar meeting places
10. Underlining the importance of user-led design through encouragement of liaison between engineers, psychologists and social scientists to provide a better understanding of needs and the bases of good quality of life, how these needs could be met, and the development of new technology.
11. Establishment of a user’s forum organised to provide a resource for researchers and designers, both in academia and industry, to assist understanding, and to evaluate and guide the development of new technology.

**Conclusions**

This document provides an overview of the potential for technologies in relation to ageing and biological ageing research. While it is difficult to imagine any part of the field that could not benefit in some way from technology, it is proposed that the opportunities for technological support should be divided into three categories – Informed (technology provides information to support healthy living), Supported (technology provides the support necessary to maintain effective independence) and Dependent (technology makes it possible to live as independently as possible in the home or sheltered environment).
Within each of these categories, there is a need for improved inclusive design, novel physiological and physical sensors and sophisticated communication systems which can, in harmony, promote the greatest possible independence.

While in many cases the technical demands are clear, in others there is a need for more fundamental research in both technical and social aspects. There are currently many social barriers to the acceptance of technology which must be tackled head on. To some degree these will be overcome through the more general acceptance of, for instance smart homes systems, into more general use. However, in many cases, there is a need to understand the psychosocial aspects which can so easily slow down the uptake of new solutions. The real challenge will be to identify those technology directions that solve the major, currently unmet, needs of elderly people and thereby really help to improve their lives as well as minimising the cost to the taxpayer.

**Measures of success**

It is important to have criteria by which to measure success at different points in the future. It is suggested that these are as follows:

**10 Years:** Within the next 10 years, the majority of the technologies under development should be in use. There should be a general acceptance of the principles of inclusive design applied to the built environment, transport and consumer goods. The routine accessibility of public transport should be supported by the use of high level information systems on routes, real arrival times etc. Private cars should be designed to take into account the needs of the older driver using the support of sophisticated sensors and information systems. Autonomous smart homes will be an accepted part of housing provision as will the use of high level communication as an advance on current messenger systems. Smart clothing will become available for the measurement of simple physiological variables. The use of robotic systems for both exercise and therapy will begin to gain acceptance in both healthcare and the community.

**20 years:** Energy constraints will lead to further improvements in public transport which will lead to improvements in mobility to allow maximum interaction between older people. Smart clothes and sensor systems will become common and will have high levels of intelligence to improve user acceptance. These developments will allow health to be routinely automatically monitored, and interpreted to arrange assistance. High levels of intelligence allow increased support from autonomous smart homes without being excessively intrusive. The idea of a smart home becomes appealing to all sections of society reducing the stigma of assistive technology for older people. There will be reliable voice control of appliances and computers. Memory and reminiscence support will be available. There will be technical support for quality sleep.

**50 years:** While it is far more difficult to look this far ahead, we can be confident that intelligence will be built into all electronic items. Public transport will respond to individual needs and advance guidance systems will be routine for private cars. Smart homes will be commonplace for all – young and old alike – and “empathic” autonomous homes providing companionship,
compassion, as well as support will have been developed. In addition, robotic companions, councillors, advisors will have been developed to provide customised support systems. Social interaction will be achieved using advanced communication systems with immersion in virtual environments. Memory prostheses will be at an advanced stage of development and direct brain linkage will enhance sensory and motor abilities. Routine health monitoring will be achieved through the use of implanted bluetooth sensors (Dulay et al 2005).

References
European Society of Cardiology [http://www.escardio.org/initiatives/prevention/prevention-tools/HeartScore.htm].
Heartscore http://www.escardio.org/initiatives/prevention/prevention-tools/HeartScore.htm
Realage http://www.realage.com/
FINANCE AND INDUSTRY

Panel Members: Frans van der Ouderaa (Chair), Tom Ross (Vice-Chair), Paul Garner, Stig Omholt and Claudio Franceschi

Introduction
Over the past two centuries, human longevity has seen a most remarkable increase of three months per year (1). It is unlikely that genetic factors are a major factor in the changes observed (2, 3). Increases in life expectancy at the population level have probably resulted from improvements in productivity led by the industrial revolution, and from concomitant improvements in day-to-day living conditions and lifestyle (2). However in the context of wealth creation there is more to it than that; as recently suggested by Nordhaus (4). He has made a profound case that the improvements of health status over the 20th century as demonstrated by the improvements in lifespan, have been a highly significant, but generally unrecognised, contributor to economic welfare.

It is expected that by 2030 the 65+ age group in Western Europe and Japan will account for 50% of the population due to declining birth rates as well as the increase in average lifespan. The change in demographics will result in a shift in the ratio of people of 65 years and older and those in work; in the EU this ratio will rise from 0.38 in 2000 to 0.60 in 2050 (5). The OECD (5) forecasts that without changes in policy the reduction of people in the labour process may lead to a potential reduction in growth of GDP of 1.7%.

For industry there are major issues to consider. The availability of people for the labour process will diminish, in particular the availability of younger workers. This may potentially influence productivity. Another factor is the financing of pension and benefit systems for people in retirement. One recent development in this context is to extend the deployment of older workers in labour for longer.

The so-called ‘silver economy’ is likely to open up new market opportunities for marketing to the 50+ population group. A further consequence of the demographic change is that the age group of 15-35, who are now the chief target of a considerable fraction of marketing, will reduce significantly in number. Industry will need to develop strategies to connect more effectively with the 50+ population group than it does currently (6).

In addition to macro-economic considerations, the issue of quality of life of the individual needs to be recognised. In some countries, in particular Japan, healthy life expectancy has improved over the past decades more than overall life expectancy thereby reducing disability and morbidity (7). In other countries, such as the United Kingdom the gap between overall lifespan and healthy life expectancy has not improved (8). What is seen by many as the ‘Holy Grail’, i.e. to ‘live longer and die shorter’ (to quote J Grimley Evans) –
or in other words, maximising self perceived well being, functionality and health over the life course – is an important objective for society.

Quality of life and healthy longevity
Various definitions have been proposed for healthy longevity. Rowe and Kahn proposed a definition of “successful ageing” which is multidimensional, encompassing the avoidance of disease and disability, the maintenance of high physical and cognitive function, and sustained engagement in social and productive activities (9). Highly valued attributes in this context are: independence and self worth; related attributes such as physical and mental alertness; mobility; adequate vision and hearing; a safe environment; being optimistic about the future; and being able to set one’s own limits. Consequently many authors emphasize that successful or healthy ageing is more than absence of overt disabilities or disease and contains physical as well as mental well being.

In the main the principal attributes of healthy longevity are socio-economic, environmental, physiological and psychological (9), i.e.:

- Financial security
- Access to health care provision
- Physiological and lifestyle factors
  - Genetic predisposition
  - Diet and nutrition
  - Smoking
  - Stress
  - Physical activity
  - Grooming
- Social networks
- Sense of purpose
- Good luck (since many outcomes of ageing are affected by chance)

Most of the above factors can be influenced and could be regarded as a joint responsibility of society and the individual. Industry can play a significant role in providing people with products and services that can add value to people’s lives in the context of the above attributes. For instance, products to offer financial security, products that provide good individual health care, products that facilitate healthy diets and healthy lifestyles as well as prevent disabilities and illnesses, or products that help people to participate and engage in actual or virtual communities.

The pharmaceutical industry is involved in alleviation of disease at the individual level. Compounds such as statins, beta-blockers and blood pressure lowering agents contribute greatly to wellness, disease prevention and ultimately to retention of quality of life for longer.

Our vision for industry is to contribute to sustainable improvements in quality of life, achieve prevention of disability, frailty and deteriorations in physical and mental health, as well to offer people routes and products to cope with potential issues that could negatively influence quality of life. This includes
contributing to important attributes of emotional well being such as autonomy, a sense of self worth and acceptance, purpose in life, self development and positive relations with others (10).

Consequently the rationale for Industry to focus on the 50+ consumer is based on:

- The change in consumer demographics;
- The opportunity for Industry to help reduce diet and lifestyle-related chronic disease and improve healthy life span;
- Product and service opportunities focussed on the 50+ population group;
- The desire by the baby-boomer generation in particular, for products delivering health and other functional benefits ;
- A high degree of interest in health, this coupled to an unprecedented access by the 50+ consumer to health information.

Needs of the 50+ population

In order to assess the potential contribution from industry to healthy longevity we need to identify the needs, expectations and desires of older population groups. In this review we propose to look at three levels i.e. the level of the individual, the societal level and the level of the economy.

Before going into a more detailed analysis we need to consider the 50+ population group. Market research carried out suggests that this group is far from homogeneous. On the contrary, there are significant differences in outlook, attitudes, needs, values and behaviours among the over 50s (6). There are likely a number of dimensions that contribute to the heterogeneity:

- Birth cohort effects( for instance an interest in 1950’s and 1960’s music),
- Attitudes to ageing: most people of the younger age cohort of the over 50’s are in denial of ageing, they look forward, aspire to young attitudes and still want to make the most of life; other, older cohorts already strongly feel the effects of age, they are more reflective, which influences their outlook and behaviours
- Changes in biology and metabolism that require specific measures such as drugs, specific diets and lifestyle changes

The consequence of the above for industry is that brand values, product propositions and services as well as consumer communication cannot be assumed to be successfully applied homogeneously across the 50+ population group.

Needs, expectations and desires at the level of the individual

As mentioned above, autonomy and attributes such as positive relations, purpose in life and self acceptance are important for self perceived well being and healthy longevity. To achieve this, people need a sufficient level of financial security, including a level of insurance cover to cope with unexpected adversity. Autonomy and independence are also dependent on low levels of frailty both mentally and physically. Participation in community networks such as the Church, clubs and societies is a further key contributor to well being. Last, but not least, people should be able to access reliable and
independent advice, which could be in the context of health care, financial matters, etc.

**Needs at the level of society**
At the societal level one could identify needs that enable society to cope successfully with the increase in the population of the over 50’s. Some factors are the same as above; independence, financial security, proper health care provision and engagement with the community. In this context it is important that inter-generational issues are addressed in a manner that is seen to be fair. Society, in addition, needs to grapple with issues such as ageist attitudes and the ethics of longevity. Development of role models of ‘successful agers’ and incentives for individuals to engage in more healthy behaviours might be a productive route for governments and insurers to combine encouragement to improve quality of life with ultimately lower overall costs to society.

**Needs at the level of the economy**
A significant threat to the health of the economy is the change in proportion of people at work over people retired, as well as the cost of providing pensions of the now longer living individuals, in particular, in countries where pensions are not based on capital contributions. In view of the demographic changes, Vaupel and Loichinger (11) suggested postponement of the pensionable age through step by step reductions in the time spent at work over a period of 8-10 years. This would both increase the number of people at work as well as allow people to build up pensions over a longer period. This may require new institutes to train and prepare older people for (second) new careers later in life. The Finnish ‘workability’ model to extend active working life is an example of best practice in this context (12).

Another perspective on an ageing population is the likelihood of a shift to a higher proportion of service industries (2). This will need careful planning at the macro-economic level. In view of the spiralling health care costs of EU countries (13) and taking into account that the majority of costs are incurred in the last six months of life it is imperative that we find more effective prevention routes for morbid disease and disabilities.

**Business opportunities in the context of healthy ageing and research needs**
The scope for new business opportunities in the context of the ageing population is extensive and includes areas such as:

- Activities geared to provide nutrition and diets tailored to the specific needs of the 50+ age group;
- Businesses facilitating physical activity amongst this group;
- Novel services based on information and communication technologies specialising for the 50+ age group;
- Financial industries providing tailored advice regarding pensions, insurance and banking;
- Diagnostics to assess potential prevention plans and treatment needs at the level of the individual;
- The care industry to facilitate people to stay independent;
- Workplace innovations to allow people to stay in employment for longer;
• Assistive care technologies to assist people with loss of sensory faculties as well as other disabilities;
• Leisure and tourism (e.g. SAGA travel; specialist accommodation providers such as in Sun city);
• Culture and arts

In the context of this paper we shall mainly cover the first five of the above.

**Health and lifestyle**

**The healthy phenotype:** Due to the increase in longevity new opportunities have emerged. In order for the EU to remain productive and internationally competitive its citizens must be healthy enough to remain engaged with social and occupational activities into older age, probably beyond the common retirement age of 65. The cohort of 50-75 years olds across the EU must be helped and encouraged to continue to make positive contributions to society for longer, for the benefit of society and for the wellbeing of the individual.

**Role of diet and physical activity in healthy longevity:** Magic bullets to influence the ageing process positively are unlikely to exist in the foreseeable future. Healthy longevity is therefore likely to result from a number of parallel routes:

**Dietary restriction**

Lifespan in experimental animals (the nematode worm *C. elegans*, the fruitfly *Drosophila*, rodents) can be significantly extended by diets with approximately 70% of the calories compared to the *ad libitum* situation, but with otherwise optimal levels of micro-nutrients. In dietary restricted rodents, the average lifespan is increased by around 40% (14). In non-primate monkeys, Tsuyoshi et al. (15) recently showed that gene expression in ‘old’, fully fed animals was greatly dissimilar from dietary restricted ‘old’ animals. Interestingly, dietary restricted animals displayed better sensitivity to the hormone insulin and expressed less inflammatory and neuroendocrine stress response genes. Some dispute whether dietary restriction will have effects on lifespan in humans of similar magnitude to rodents (16). Although dietary restriction as a method to extend longevity has had considerable public attention and in the U.S. is practised by members of the Caloric Restriction Society (http://www.calorierestriction.org/), one could speculate whether it is ever likely to be a significant consumer trend.

**Specific dietary routes**

To date direct evidence of the influence of diet and nutrition on lifespan and mortality in humans is very limited. However Robert Fogel’s meta-analysis suggests that a significant proportion of the increase in longevity of the past centuries can be ascribed to more food being available as well as to the quality of the diet (2). The gold standard of proof for the effects of diets and or nutrients on longevity, i.e. randomised controlled intervention trials (RCT), does not exist. Perhaps not as powerful as RCT’s, there are nevertheless some excellent observational longitudinal studies in which diet was studied in great detail. In one of those, the EPIC-Norfolk study, the most detailed food assessment instruments available to date were employed and consequently the study’s conclusions carry a lot of weight. It was found that plasma vitamin C
was inversely related to the risk of mortality and cardio-vascular disease. The quintile of the study population with the highest vitamin C level had as much as a 60% reduction in CVD risk compared to the lowest vitamin C group over the four year period between examinations (17). As the authors excluded supplement users from their analysis, they rationalised that the relationships between the health outcomes and vitamin C levels in plasma relate to the value of fruit and vegetable nutrition.

Another authoritative longitudinal study with diet as a main focus is the pan-European SENECA study which was carried forward as the HALE study (18). In these two studies smoking, physical activity and diet quality were independently assessed for their influence on mortality risk. The ‘favourable’ diet in this study was the so-called Mediterranean diet (i.e. a diet rich in fish, olive oil and fruit & vegetables). It was found that each of the three factors which were assessed influenced mortality independently. The combination of smoking, low physical activity and poor diet versus non-smoking, high physical activity and a good diet resulted in a nearly four-fold increase in risk of mortality over a nine year period in an 65+ year old cohort for the former compared to the latter (19). Hence, smoking cessation and the Mediterranean diet constitute another viable route towards healthy ageing.

Terry et al (20) recently found that cholesterol is a predictor of mortality and morbidity-free survival. Similarly, in a 39-year follow up study, Strandberg et al. (21) showed that serum cholesterol predicted mortality and physical functioning in healthy volunteers in a graded fashion. People with cholesterol at baseline of $\leq 5.0\text{mmol/L}$ had significantly lower mortality and better physical functioning than participants with higher levels. Cohen et al. (22) recently reported that moderate life-long reductions in LDL-cholesterol are associated with substantial reductions in the incidence of coronary events. In addition to treatment with cholesterol-lowering drugs (i.e. statins), dietary routes to cholesterol-lowering using plant sterol-esters have been recently proposed by Miettienen et al. (23) and Sierkstra et al. (24). These are now widely available commercially.

Notwithstanding the data from the aforementioned studies, it has to be reiterated that the gold standard of proof for the effects of diets, behavioural change and physical activity on longevity outcomes, i.e. the randomised controlled intervention trial (RCT), does not exist.

**Physical activity**

A specific mention should be made of the value of physical activity. As already mentioned above, the SENECA/HALE trial observed that physical activity improved the odds for healthy longevity, independent of smoking cessation and the Mediterranean diet. Ample evidence exist of moderate to high fitness favouring improved cardio-vascular health; recently Colcombe et al (25) further showed the value of physical fitness for improved cognitive health. Improved fitness also benefits the skeletal-muscular system as well as metabolism. Consequently, the value of moderate to high fitness in this population group cannot be overstated.
Factors relating to food choice in older populations
From a biological perspective, the 50+ population group cannot be regarded as homogenous. Up to 70-75 years of age, issues such as weight control, high cardiovascular risk, developing insulin resistance and onset of skeletal-muscular conditions are predominant. From age 70-75 the body loses weight and muscle mass and goes into negative energy and nitrogen balance, due most probably to a combination of physiological changes and social isolation (26). Weight loss becomes more of an issue and mental function may start to decline due to ineffective glycemic control (27).

There is a relatively slow loss of sensory acuity in the elderly. Olfaction has been shown to be more prone to losses in sensitivity than taste (28). Contrary to what is commonly assumed, a recent study has shown that, despite the losses in sensory sensitivity in 60-75 year olds, there is very little difference in food preferences between this group and a group of 9-33 year olds (29). Nevertheless, as mentioned above, due to a decrease in appetite and energy intake, older people do experience weight loss (30). Weight loss in this population group is related to poor outcomes (31). Matey et al. (32) reported in this context that in nursing home residents (>65 years of age) energy intake could be increased and weight loss could be reversed by flavour enhancement of foods.

Sheiham et al. (33) reported that dental status also affects body weight. Edentate people were reported to be significantly more likely to be underweight than people with 11 natural teeth or more. Older people with 20 or more teeth were likely to have a normal body mass index. In a further paper, Sheiham and Steele (34) reported on the relationship between dental status, the ability to eat certain foods and plasma vitamin concentrations. Perceived chewing ability increased with increasing numbers of natural teeth. Edentate people, particularly those living in institutions displayed very low levels of plasma vitamin C and A concentrations, suggestive of micro-nutrient intakes far below the recommended daily intake.

An opportunity for industry is to develop and market special diet and nutrition products as well as supplements to counteract the above negative trends. The potential size of the market would appear to be large, provided that the benefits of the products were underpinned by strong scientific evidence.

Novel information and communications technologies (ICT)
One of the most interesting developments in this area, pervasive computing, describes a vision of the future in which there will be a proliferation of tens or even hundreds of low cost miniature devices around our homes, and at work, will be able to sense their environment, intelligently process data and communicate autonomously. That vision will be enabled by the rapid advances in miniaturised electronics, increased computing power on a single chip, low power radio systems and the growing adoption of ‘always on’ communication services. The accompanying report by the Technology Sector Panel considers in more detail some of the likely developments; our focus here is on the connections with industry and finance.
Pervasive computing is being driven by new business models across a wide range of commercial and consumer sectors, underpinned by developments in technology including:

- Fixed and wireless broadband networks will be available everywhere, delivering high speed connectivity to anyone with an enabled ICT device, providing converged voice, video and data services in the home, office and street.
- Devices will announce their capabilities in a secure manner leading to automated service discovery, with adaptive interfaces, enabling consumers to enjoy new functional benefits without having to deal with the details of configuration.
- Printing electronics onto labels, packages and fabrics will facilitate embedded intelligence into more and more low cost items, to the point where they are disposable.

As the sensor and communications technologies become further commoditised and integrated with common entertainment and communication devices such as smart mobile phones, viable business models for pervasive computing applications will emerge. Already there is evidence that individuals with chronic disease can be supported in the management of their condition by personalised health information systems. Advances in information and communications technology coupled with easy-to-use devices to measure physiology has enabled patients to take more control of their condition, and when necessary to derive timely interventions from an authorised clinician. Combining ambient activity monitoring with physiology monitoring in real-time will further expand the range of needs that can be met by putting the physiological data into its activity-based context and thereby enhancing its value. The cost-benefit value of intelligent health monitoring systems that reduce the frequency of acute attacks and their associated consumption of expensive secondary and tertiary healthcare resources should be proven, with robust statistical significance, by the planned large scale demonstration systems in the UK over the next two to three years.

Pervasive computing technology combined with intelligent networked services could have a significant impact on health and social care, enabling smart personalised solutions tailored to the individual and focused on quality of life and wellbeing. Such solutions offer the promise of optimised care plans, integrated quality management of service provision and a movement to preventative care services. As the capability to integrate sensing technology into common devices like mobile phones develops, along with simple interaction between bespoke specialised sensing devices and the mobile phone it will become possible to “configure” smart services that can capture aspects of lifestyle of the general population. As long as the appropriate trust and privacy solutions are in place to deal with the potential negative implications of people monitoring, we can expect to see the sensing and communications technologies combining to provide an enabling environment for entrepreneurial new businesses which add value to the raw data. Such businesses would become self sustaining deriving revenue from end users who will be willing to pay for lifestyle enhancing smart services, some of which will include healthy ageing solutions.
**The economic opportunities of healthy ageing**

The economic value to individuals/society of healthy ageing: Murphy and Topel (35,36) make estimates, in the US context, of the value of improvements in health and life expectancy of men and women in the 20th century. Their approach to value is an economic one, based on people’s willingness to pay. For example, if people are willing to pay $500 for an airbag in a car, reducing the probability of dying in an accident in one year by 1 in 10,000, the value of a “statistical life year” is $500 x 10,000, or $5 million. Using this approach they estimate that the increase in longevity over the past century has a value of approx US$ 1.2 million for every citizen in the US. For the country as a whole, the annual value of increased longevity is US$ 3.2 trillion; the financial-economic benefits of the increases are therefore vast. Despite making many assumptions, and despite ignoring the beneficial effects of other, non medical factors, Murphy and Topel make a compelling case that the social benefit (in financial terms) of medical research and development, net of the cost of implementation and delivery, has been enormous. This is despite the considerable inefficiencies that they believe to be inherent in the implementation and delivery mechanisms.

It would be fascinating to see the results of similar research for European countries, perhaps with more refined methodologies. However it is already clear that investments in improving healthy longevity in Europe would be very highly valued by society. This, in turn, suggests that products and services that demonstrably achieve that end would be in great demand, with consequent benefits to employment and economic growth.

**The opportunities for growth in national output presented by healthy ageing**

Conventional wisdom seems to be that increased longevity, while good in itself, presents severe financial challenges. How can an economy support the rapid growth in economically inactive people? This conventional wisdom needs to be challenged, and Murphy and Topel’s work helps us to do that. As already mentioned, extra years of life are highly valued, so that relevant products and services that help achieve longer healthy life are likely to be in great demand. The Finnish experience of “Workability” (12) suggests that investments by government and industry could result in productivity improvements which in turn may be expected to lead to higher output. Moreover, is it right to assume that healthy older people want to be economically inactive? There is already some evidence in various EU countries (13) that the proportion of 60-70 year old people who are economically active has been increasing in recent years. It is easy to assume that this is due to economic necessity – inadequate retirement income – but this should be properly researched. Anecdotally, the reasons appear to go much wider than this.

Thus, it is persuasive to propose that improvements in the health and wellbeing of older people – particularly those in the “Third Age” of 55 to 75 – would result in significantly higher economic output through greater demand for goods and services and greater labour market participation. Research to test this proposition, perhaps by expanding the Workability experiment and extending it to other countries, would be very useful. Of course the new
services required to achieve healthier ageing – discussed elsewhere in these AgeAction reports – would themselves represent important contributions to economic growth.

The potential financial returns for business and the taxpayer: A major factor – perhaps the major factor – in the business boom of the past 20 years has been the coming of age of the IT revolution. Who would have believed, 20 years ago, that in a matter of two decades most people in the developed world (and many in emerging economies too) would have access to a personal computer and mobile telephony and to all of the information flowing from that. Could the next revolution be in the field of personalised health management?

Luce et al (37) extended the work of Murphy and Topel (35, 36) to estimate the return achieved on the additional spending on health in the United States between 1980 and 2000. They found that the overall return was between 55% and 94%.

Healthy ageing offers huge potential for science and technology businesses, but the exploitation of this potential will require substantial capital to finance the research and development and operational working capital required. At present, the world is awash with capital – for example large amounts of venture capital are being raised globally for the purpose of taking mature public companies into private ownership. We believe that the case can be made that such capital could be deployed profitably in future in new ventures created to exploit the healthy ageing revolution. Capital is extremely mobile, and when the conditions are right, which include the risks involved and the pay-off period, there would be no shortage of capital available.

We have already made the case that healthy ageing would stimulate demand for more (and new) products and services, as those who remain economically active for longer seek to spend their continuing income, and people would demand dietary and other products that will enhance their quality of life. The leisure and financial services sectors would be obvious beneficiaries. In a healthy ageing world, one can also visualise growth in partnerships between different businesses. An example that already exists is where a health insurer offers discounted memberships of health clubs owned by a leisure company to its policy holders. Similarly people are incentivised to use cholesterol lowering diet products by being offered lower health care insurance premiums as a reward. Such developments offer excellent opportunities to stimulate economic activity as well changes in behaviours.

Taxpayers too can benefit from healthy ageing. A recent UK study (38) described a series of examples where investments in preventative measures produced dramatic cost savings in medical and social care. For example, reducing the rate of institutionalisation by 1% per year could save £3.8 billion in 2031. Reducing age-specific dependency rates by 1% per year could lower public expenditure by £940 million in 2031.

On the other hand, increasing longevity is of concern to taxpayers who perceive “inevitable” increases in the cost of state pension systems, as the
proportion of older people increases. The response to this concern should be the prospect of increased economic activity among older people in a healthy ageing environment, as already discussed. This would seem to make a further compelling case for taxpayers (i.e. Governments) to invest in healthy ageing developments.

Adaptability of labour markets and retirement systems: In a world of healthy ageing, attitudes to work and retirement are likely to be very different from those that prevail today. Labour markets generally have the inherent flexibility to adapt to retraining for second or even third careers, extended career breaks, job sharing, part-time work accompanied by partial retirement income, home working and other aspects of flexibility that would seem to be important ingredients of extended working lives. Indeed, a number of these features are already happening in some countries.

Equally, the concept of retirement – ceasing all productive work and living off savings – is likely to change, so that it applies principally to the very old and those in poor health. State retirement systems tend to be less flexible and less easily changed than privately funded arrangements. Consequently, long-term planning to introduce new and more flexible state pensions, which are still seen as being fair, will be essential. Privately funded arrangements are much more adaptable to the more flexible requirements of a healthy-ageing world, although conditions attaching to accrued rights should be honoured.

Workability: A specific example of the aforementioned concepts is ‘workability’ (12). Finland has the oldest population in Europe and Ilmarinen’s group at the Finnish Institute of Occupational Health has pioneered ways to keep people longer productively at work. This research is evidence-based and called ‘workability’ (12). Across Europe, the numbers of people over 55 at work are increasing again (Finland +15%, The Netherlands +10%, EU +5%) and many countries are considering increases in the pensionable age to offset effects of low birth rates and the resulting effect on GDP of the proportion of people at work as compared to the number of those retired. However in order to keep 50+ people at work longer, a number of conditions need to be fulfilled. In the first place 50+ people need to be in good health, with the required competencies for the job. Secondly employers need to address management and leadership issues regarding employing older workers (e.g. discrimination). For instance, many industries do not currently provide training for people over 50. Thirdly, the workplace environment may need adaptation including more flexible working hours.

The Finnish experience suggests that ‘Workability’ investments by government and industry have a very high rate of return indeed in terms of better productivity, lower disability and reduced absence costs.

Pensions and Insurance Industries: Pension provision in European countries operates under a variety of structures. Generally, the state provides a base level of benefits, whose amount varies greatly from country to country. The UK has one of the least generous systems and Italy, for example, one of the most generous. These systems are almost always funded on the so-called “pay-
as-you-go” (PAYG) basis. That is, each year’s contributions go towards paying that year’s pensions, so that few reserves are built up.

Built on top of the state systems are private sector schemes, often arranged by employers or industry groups, but also provided through individual insurance or savings schemes. These “second tier” pensions are often funded in advance – that is, contributions are set aside in advance and pensions are paid from the accumulation of these funds, either directly to the pensioner from the fund or by the purchase of a lifetime annuity from an insurer when a participant retires. France is an exception, since second tier pensions are to a large extent organised on an industry basis and financed on PAYG lines. In that sense, the French second tier system is similar to many state systems. In Germany, much of the investment of the funds for second tier pensions is effectively in assets of the employer through the accumulation of balance sheet reserves, complemented by insolvency insurance. They are not PAYG, but the funding is internal rather than external.

The finances of State and other PAYG systems are clearly dependent on the balance between the numbers of working and retired citizens. A falling birth rate, or an increase in longevity, will lead to a need for increased contribution rates from workers, other things being equal. A combination of the two, which is what has happened in many European countries, and which is expected to continue, has major financial consequences which need urgent attention. Generally, the three options are higher contributions from workers, extended working lives or reductions in benefits in some combination. Sudden changes in any of these are likely to be politically and socially disruptive or, in the case of extending working lives, impractical. Long-term planning based on as reliable forecasts as possible is essential if acceptable solutions are to be found.

Thus far, the demographic projections which underpin estimates of the future financial requirements of PAYG schemes have been based on past statistical trends, with little input from those involved in biological and other areas of scientific research. Whether for this reason or not, estimates of future improvements in longevity have fallen well below the actual experience for many years (1). This has resulted in poor planning and a need for too sudden changes to systems, generally for the worse. Proposals for such changes have been highly unpopular and divisive, and have led to a loss of public confidence and trust in some state systems.

Whilst uncertainty will inevitably surround such projections, everything possible should be done to reduce these uncertainties and to understand the range of possible outcomes around central estimates. We strongly believe that encouraging a better understanding of the ageing process through biological and other research, and achieving a better understanding of the potential impact of that research amongst those actuaries, statisticians, demographers and others who are responsible for advising on these projections, would lead to more robust estimates and, ultimately, to more public confidence in state pension systems.
Pre-funded pension systems are, perhaps, somewhat less vulnerable to the shocks described above, but they are not immune. The large deficits in many UK pension funds, for example, are due in part to underestimates of the rate of future improvement in longevity of the scheme members. (These schemes provide a promised level of pension and, once awarded, this cannot be reduced to bring the assets and liabilities into balance). Greater than expected longevity improvements are also affecting those with defined contribution pensions (that is, where contributions are accumulated for each person and the proceeds are used to secure a lifetime annuity at retirement). For such individuals, the shortfall takes the form of much lower pensions than they had anticipated, as annuity rates have had to reflect increased longevity, with consequent disappointment and, in some cases, hardship.

Insurers too are concerned about the uncertainties surrounding future improvements in longevity. Most of them are far more vulnerable to annuity policy holders living longer than expected than they are to life assurance policy holders dying sooner than expected.

It follows that, in a similar vein to the comments above on PAYG schemes, biological and related research, and a better understanding of what it may be telling us, could make an important contribution towards improving the financial management of financial institutions, and towards better financial planning by individuals.

In summary, with good planning, labour markets and pensions systems should not be a barrier to progress towards healthy ageing societies.

**Research challenges**

**Organisation**

Industry would benefit from a more focused forum to address the challenges of the ageing population in Europe with products and services that improve the quality of life of people and give industry an opportunity to build competitive positions in this market. This could have a number of shapes, one of which might be a virtual Human Ageing Institute with a long term funding commitment similar to the European Molecular Biology Organization; this should direct ageing research across the Union and take a highly multi-disciplinary perspective combining:

- Mechanistic studies of the aetiology and mechanisms of the ageing process in humans in areas such as:
  - processes of cellular senescence and stem cell depletion;
  - understanding of DNA damage and repair;
  - processes of oxidative damage at the cellular and tissue level;
  - mitochondrial dysfunction as result of age;
  - biomarkers of the ageing process;
  - integration of biological processes as a result of ageing into the ‘systems biology’ approaches to understand human ageing; this should include development of powerful mathematical techniques to assimilate and handle big datasets and at the biological level for instance create the understanding of the interplay between the
body’s control systems such the brain, the neuroendocrine system and the immune system.

- Understanding the socio-economics of the ageing population in areas such as:
  - the value of longevity and prevention of morbidity to society;
  - occupational health aspects of an ageing workforce;
  - issues related to quality of life during life course transitions;
  - development of assistive technologies and intuitive IT tools that can be used by the elderly;
  - methodologies to achieve sustained behavioural change to improve autonomy, sense of purpose and perceived well being;
  - research into effective health services for the older generation.
- Studies of the ‘healthy phenotype’ including genetic aspects and the effect of early-life experiences as elaborated on below.

The overarching brief for such an Institute should be to develop powerful intervention strategies that, in the light of the high degree of malleability of the ageing process, could result in excellent ‘best practice’ to inform public health organisations as well as to inspire and inform industry to pursue new products and services.

The value of healthy ageing studies
In the field of human ageing, industry does not have the financial muscle to conduct decades of proprietary longitudinal studies. At the same time it is clear that to improve health of an ageing population, significantly powered long-term longitudinal cohort studies are required to understand mechanisms, risk factors, develop biomarkers and surrogate markers, assess psychological factors and associated behaviours in relationship to health outcomes. The EU could play an important role in facilitating such studies, and maybe more particularly, facilitate existing cohort studies in member states being brought together so that broader perspectives can be obtained from sharing best practice across the Union and research activities outside Europe. This could be a key role for the aforementioned Institute.

In this context, healthy ageing research in Europe should focus on early, reversible stages of pathological conditions in order to investigate prevention routes. Furthermore, many lifestyle-related chronic diseases (e.g. cardiovascular disease, type-2 diabetes, neurodegenerative disease) are now known to share common inflammatory and metabolic pathways; preventing the morbid, end stages of such conditions with lifestyle and diet routes is not only possible but also highly advantageous (39). Additionally, development of an integrated series of invasive and non-invasive markers, surrogate markers and diagnostic techniques at different levels of granularity – i.e. that could be used for specialist clinical research, clinical practice, or used in the home interfaced with dedicated IT supporting tools – should be part this agenda. A further input into ‘best practice’ that could be very powerful is the detailed investigation of healthy longevity phenotypes from a biological and behavioural perspective.
In the context of the healthy phenotype, a further focus should be the relationship between emotional well being and health. As mentioned above, human health is more than the absence of illness; positive health and well being contribute to functioning of multiple biological systems in the body and are known to influence health outcomes. It is important to understand the relationships between emotional well being and biology.

In spite of the advances in medical science, many older people struggle to deal with the effects of ageing. Progress in science and support with the activities of daily living have helped people to live longer but not necessarily to deal with growing older. New approaches and techniques must be developed to help the individual ameliorate the physiological and psychological impact of ageing (40).

Improvement in health status can be stimulated by small changes in every day life, largely related to diet, nutrition and exercise. The benefits of embracing healthy lifestyle options can accrue at any age; furthermore, research has shown that people who had relatively poor lifestyles until age 75 can still improve their longevity if they change to a healthier regime (41).

Whilst such observations are valuable, further research into what constitutes a healthy lifestyle throughout all stages of life is necessary in order for us to have a sound scientific basis for promoting healthy ageing for the forthcoming generations and to understand how to coach people through step changes in life such as retirement, bereavements etc. We must also recognise that the characteristics of ageing are themselves dynamic, for example the marked increase in asthma in our current younger population may feed through to new health issues in that cohort as it ages.

We therefore advocate significant EU-wide research to develop further our understanding of the processes associated with healthy ageing as opposed to research into controlling end-stage disease conditions. The healthy ageing research agenda should focus on prevention rather than cure, to complement the existing medical research agenda, which focuses on dealing with end-stage disease.

Finally, it cannot be overstated that the European research agenda should embrace a true interdisciplinary approach to ageing research combining biomedical, socio-economic, psychological and behavioural aspects into a ‘consumer-centric’ programme co-developed and co-owned with appropriate NGO’s representing the ageing community.

References
5. OECD; Live Longer, Work Longer, 2006
9. Rowe JW. Kahn RL.; Successful Aging, Pantheon Books, 1998
10. Ryff, C. D. Happiness is everything, or is it? Explorations on the meaning of psychological well being, J. Person. Soc. Psychol. 57; 1069-1081 (1989)
12. Ilmarinen, J; Towards a longer worklife! The Finnish Institute for Occupational Health, Helsinki, 2005
13. OECD, Health at a glance; 2005
24. SierkstraA, J., Westrate and G.W.Meijer. Spreads enriched with plants sterols, either esterified 4, 4-dimethylsterols or free desmethylsterols,


27. Convit, A. Links between cognitive impairment in insulin resistance: An explanatory model Neurobiol Aging S31-S35; 2005


34. Sheiham and Steele. Does the condition of the mouth and teeth affect the ability to eat certain foods, nutrient and dietary intake and nutritional status amongst older people. Public Health Nutrition 4 797-803. (2001)


