

Biology of Ageing Research in the UK, Barriers to Translation and How to Overcome Them

Paper for the Office for Strategic Coordination of Health Research (OSCHR)

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Background

- After an inquiry into Ageing, the House of Lords Science and Technology Committee 2021 [recommended](#) “UK Research and Innovation should commit to funding further research into the biological processes underlying ageing as a priority, in particular to address gaps in understanding the relevance of ageing hallmarks to humans. Research to identify accurate biomarkers of ageing in humans should also be prioritised, to support studies to improve health span”.
- Partly as a response, the [MRC and BBSRC funded](#) 11 UK Ageing Networks over 3 years (cost approx £3m)
- The Chief Medical Officer’s 2023 annual report was “[Health in an Ageing Society](#)”, on the challenges of keeping people healthy with age. It had a final section dedicated to the biology of ageing produced with help from the Royal Society
- As Chair of the BSRA, I was asked by Lord Kakkar, member of the House of Lords Committee and Chair of the OSCHR to present a paper to the OSCHR, focussing on the barriers to translation of ageing research and recommendations to overcome them.
- As preparation, we spoke to more than 40 people (Jon Houseley interviewing those from the Babraham Institute). They included many researchers in the field of the biology of ageing but also clinicians, funders, investors and industrialists with an interest in the field (A list in the appendix). Each conversation was insightful.

Executive Summary

There is a long history of research into the biology of ageing in the UK. In recent decades, the discovery of molecular and genetic factors that influence ageing, particularly in model organisms, has given rise to the prospect that ageing can be slowed in humans by pharmaceutical means. This prospect is embodied in the geroscience hypothesis – that interventions targeting the underlying biological mechanisms of aging could prevent or delay the onset of multiple diseases and hence research and drug development in this area will be more effective than similar efforts for single diseases. Researchers in the ageing field have long argued that funding for this research needs to be increased dramatically because the outcomes would be unusually valuable for society and the potential for economic benefit is vast. While there have been various initiatives by funding bodies in the area over the last 20 years, the required increase in funding has not been supported by the government, and there have not been strong calls for it from scientists in other fields, the medical profession,

medical research charities or the general public. One issue is that over-hyped claims expressed by some scientists, entrepreneurs and influencers, mostly from outside the UK, has called the credibility of the field into question. UK researchers in the field can address this challenge. They need to be clear about what we do and do not yet know about the biology of ageing. They need to outline clearly the steps by which the science of ageing would be translated into keeping people healthy for longer. They need to work with those researching ways to prevent specific diseases. They need to engage with clinicians and drug developers in these areas, with education and training working in both directions. There are several barriers to translation at different levels, but I am confident that solutions can be found. The recommendations are summarised here:

1. Funding schemes specific for research on the biology of ageing at the scale and time frames required for useful research. This research should include basic research but with translational applications in mind.
2. Focus researchers into teams that work on specific areas of the biology of ageing to ensure resources are most efficiently used, yet making sure a broad range of areas is supported, allowing for new ideas.
3. Establishing a national service/centre for working with ethics boards and the Home Office to ensure better mouse experiments while maintaining welfare.
4. Use the biology of ageing to inform primary and secondary prevention strategies for single diseases, by working with researchers, clinicians, charities and industry in those fields.
5. Provide mechanisms for the researchers in the biology of ageing to engage with external stakeholders, including the general public, in honest discussions.
6. Reexamine the regulations for clinical trials, particularly for trials aimed at the prevention of disease. In trials focused on a single disease endpoint, biomarkers relating to other diseases should be monitored at the same time.
7. Training of basic researchers to understand the needs of industry and clinicians.
8. Training of clinical and industrial researchers in the biology of ageing.

Together these changes will increase the capacity for research on ageing within the UK, leading to greater success and ultimately economic and societal impact.

Biology of Ageing Research in the UK

Research in the biology of ageing is distributed widely. A [recent analysis](#) of the membership of the British Society for Research on Ageing showed 56 UK institutions with at least one member and 33 with at least 2. There are a number of centres with more than 10 members. Over the last 20 years alumni from successful centres of excellence have moved to other institutions in the country to set up their research. This is not a comprehensive picture but broadly speaking, biological ageing research in the UK mostly has the following backgrounds:

Theoretical research

Historically, the UK has been strong in this field, for example from Peter Medawar and John Maynard Smith at UCL in the 1950s/60s. Tom Kirkwood, then in London, proposed the disposable soma theory in 1977. This work influenced several people around the country. He moved to Manchester and then to Newcastle, establishing research centres focused on ageing.

Model organisms

Research in yeast, nematode worms (*C. elegans*), flies (*Drosophila melanogaster*) and mice has shown that there are genes that influence ageing that are conserved across species and identification of these genes (initially in the US, in the 1990s) turned attention to molecular mechanism. At UCL, work by Linda Partridge, Sally Leivers and David Gems, starting in the late 1990s in *Drosophila* and *C. elegans* led to the formation of the Institute of Healthy Ageing, which has produced a lot of research in the field and a lot of researchers, many of whom have formed their own research groups at other institutions around the UK. Linda Partridge is a co-author of the highly influential Hallmarks of Ageing paper.

Cell senescence

The UK has a strong track record in cancer research and specifically in the study of cell division. Many human cells when cultured *in vitro* only divide a certain number of times before entering a permanent non-dividing state – called senescence. This mechanism is seen as important for tumour suppression but it has also been shown that arrested senescent cells *in vivo* can be harmful and can contribute to ageing. The UK has expertise in studying cell senescence, including Lynne Cox at Oxford University, Lorna Harries at Exeter University and previously Richard Faragher, Brighton University and David Kipling, Cardiff University.

Immune system and ageing

Ageing of the immune system is an important aspect of human ageing. The UK has built on its expertise in immunology and in particular Arne Akbar, UCL and Janet Lord, University of Birmingham have pioneered work in this aspect of ageing. Several alumni from their groups have set up their own research and in Birmingham they have established the Department of Inflammation and Ageing.

Musculoskeletal research/exercise physiology

Work from Malcolm Jackson and Anne McArdle at the University of Liverpool has centred on muscle and oxidative stress. This work has also been connected with work on how muscle deteriorates with age and how diet and exercise can interfere with it. There are several researchers in this field across the country.

Babraham Institute

This long established BBSRC-funded research institute in Cambridge has moved its remit in the last decade to focus on various aspects the biology of ageing. It has involved present researchers moving their research more towards ageing and recruitment of new group leaders in the field. We spoke to several people here.

Relevant Organisations

British Society for Research on Ageing

The [BSRA](#) began around 1939 as a club for researchers studying the biology of ageing – the oldest in the world. Since then, it has continued to be run by researchers in the field. It has organised 73 annual scientific meetings, which bring researchers in the biology of ageing from different disciplines together as well as bringing in international speakers. It has a reciprocal arrangement with the American Association of Ageing (AGE) and sends the best early career speaker to the AGE meeting and vice versa, and the societies' members are invited to each other's meetings. The BSRA has charitable status, is a member of the Association of Medical Research Charities and uses donations to fund research in the biology of ageing at a low level (<£100,000 per year). It also engages in the public understanding of science and advocates for more resources directed to the field. It has ambitions to grow and has grown its membership and awareness substantially in the last few years.

The UK Ageing Networks

The MRC and BBSRC funded 11 networks for three years with the aim to build capacity in the area, make new connections within and outside the field, to include clinicians, industry, funders, and the public. The budget was £3m, which allowed funding for small pump-priming grants, organising of events, and trips abroad to build international collaborations. Each of the 11 networks had a different theme, representing different approaches and applications of ageing research. The BSRA has brought all the networks together as satellite meetings at the beginning of their 2023 and 2024 Annual meetings, which have been the only whole network meetings. The networks have had varied success, dependent on their leadership and engagement of each network and the large number of networks made it difficult for there to be coordinated leadership of all of them. The future of these networks is unknown, but their members have been encouraged to join the BSRA, if they are not already members.

UKAgeNet

This [network](#) was set up in November 2023 and is run from the University of Sheffield by Ilaria Bellantuono and Alan Walker. It aims to bring researchers in the biology of ageing with those in the social sciences researching how ageing affects society and how best to support an ageing population. It aims to advocate for more funding for research.

Industry (UK)

Most industry in this sector is based in the US. It is known that several large pharmaceutical companies are interested in this area. For example Abbvie has a collaboration with the Alphabet company Calico in the US, and Pfizer and Novartis have shown interest in this area. There are very few companies in the UK working on developing therapies to slow ageing. Here are those we know about:

[Altos Labs](#)- a US biotech company founded with \$3bn investment to work primarily on epigenetic reprogramming, with sites in San Francisco, San Diego and Cambridge, UK.

[Samsara Therapeutics](#) – a company based in Oxford working on modulators of autophagy to combat neurodegenerative diseases, back by Apollo Ventures, a VC dedicated to the field.

[Senisca](#) – a spinout of Exeter University led by Lorna Harries – working on RNA splicing and cell senescence

[Shift Bioscience](#) – working on partial epigenetic reprogramming, based in Cambridge, led by Daniel Ives

[Five Alarm Bio](#) – a startup based in Cambridge working on harnessing cellular responses to stress to slow ageing (I am an unpaid adviser).

Barriers to translation

The view of researchers

Consider a researcher in the biology of ageing who makes a discovery in the lab - maybe in biochemistry, cell biology or in a small model organism for ageing like the yeast *S. cerevisiae*, the nematode worm *C. elegans* or the fruit fly *Drosophila melanogaster*. The steps to translate that discovery to human health, and the barriers to them, might be as follows:

Experiments in mice

Preclinical investigations in a mammalian model are usually essential before interventions can be tested in humans, particularly if they involve a new drug or validation of target using genetic means. Mice have a short lifespan compared to other mammals (2-3 years), though that is still a long timeframe in relation to other studies. Ageing is very difficult to measure using *in vitro* cell methods. The only way to do it is to use primary human cells, usually fibroblasts and assess the number of cell divisions. These experiments are time consuming (around a year) and prone to variability because the donor for every experiment is different (including their age).

For ageing experiments in mice, the regulatory and financial barriers mean that very few such studies are carried out in the UK. The barriers include:

- The need for stringent toxicity studies before ageing experiments can begin.
- The pressure to reduce sample sizes, which diminishes the statistical power of the experiment, as variability between individuals increases with age.
- The need to cull mice when they show signs of ill health (eg a weight loss of 15%)
- The need to write a detailed report to the Home Office whenever a mouse dies during the experiment (which is time-consuming).
- Difficulty in getting approval to study aged mice over 24 months old.
- Several scientists have told me that they turn to performing experiments overseas instead. At least one scientist has taken up a position in Germany, putting pressure on his family, in part to carry out experiments in mice.

Experiments in mice take time (4-5 years because the experiments need ethical approval, breeding, preparation and sample analysis) and can cost a lot of money (£1-3 million pounds per study) making them unsuitable for most applications to UKRI responsive mode research panels (usually BBSRC or sometimes MRC). They also require facilities with experience of conducting ageing studies, for which there are only a few in the UK. For those that want to study mice that have already been aged, they can be difficult to source or take a long time to develop. The MRC funded an Ageing Cluster of the National Mouse Genetics Network, led by Profs Khaled and Greaves (I sit on the

SAB), but the funding of £3 million is only enough to fund a project that provides a baseline of mouse ageing, namely taking multiple organ samples across the lifecourse, which are banked and available to others in the UK.

Clinical Trials

Compounds that are successful in slowing ageing in mice need to be next tested in humans. Some interventions such as dietary changes do not require testing in mammalian models. Researchers pursuing clinical studies have said that it is difficult to get approval for a clinical study to study aspects of ageing and they first need to perform a pilot study with small numbers of participants. The numbers involved in many clinical studies are too small to account for the natural variation between individuals intrinsic to ageing and thus are underpowered for most interventions. These small studies often do not have strong enough outcomes to support a larger and more meaningful study. Thus, they seem to be a bad use of resources and a barrier to translation. Obtaining funding and approval for larger studies is very challenging.

Raising investment/partnerships with companies

To progress translation, scientists are encouraged to protect their IP through patent applications and forming a spinout company, to gain investment to translate their findings. University technology transfer departments are keen to support these activities but often do not have sufficient knowledge and experience of the field to advise well on how best to achieve it. Many scientists have felt insufficiently supported by their technology transfer offices or have not received sufficient guidance in general about how to translate their work. There was one opinion that forming a company can sometimes prevent new research from being progressed, especially if the spinout company fails, which is a likely outcome.

Gaining investment in the ageing field is possible but challenging. Investors are wary of the area because of previous failures in the field and the general impression that the science in the area is not robust. Also, it is hard to fit into the normal biotech model as it often does not target a specific therapeutic area. Most pharma companies are organised by therapeutic area and the successful exit for most biotech companies is acquisition by a large pharma company. There was a view from one researcher that clinicians were actively preventing translation efforts in the biology of ageing.

Funding in general

Researchers have expressed that they have found it difficult to secure funding for ageing research and colleagues that sat on BBSRC panels said that ageing research was often not competitive with other applications. The length, breadth and subsequent cost of ageing research projects mean that it is difficult to compete with experimental plans in other fields of biology that were more mechanistic and appeared to be better value for money. There is uncertainty about obtaining funding from funders other than the BBSRC – For example the position of the MRC or Wellcome Trust on ageing research appears to change from time to time.

The view of clinicians

I spoke to a few clinicians who are supportive of research on the biology of ageing, so are unlikely to represent all clinicians. Their perspective was that most clinicians know very little about research in the biology of ageing. One opinion was that geriatricians, who seem the natural speciality to have an interest in ageing, were not engaged in research to the same extent as their colleagues in other disciplines. And those in other disciplines were focussed on their specific therapeutic area rather than underlying risk factors. In general, specialists are concerned about treating patients with advanced symptoms rather than preventing them, and so the biology of ageing is less relevant to their day-to-day challenges. The biology of ageing field is seen by some clinicians as dominated by “crazy” people and that as the research was chiefly being funded by the BBSRC it gave the impression that it was not relevant to the medical profession. There have been attempts to bring clinicians and researchers together – for example at Kings College London by Claire Steves, and she has had some success, but she came across reluctance from many clinicians to engage.

The view of funders, investors

I spoke to a few investors, charities in the field and representatives of BBSRC/MRC. Yuti and Lorna Chernajovsky were very passionate about translating findings from basic research. They considered that translation is seen as “a trade” and looked down upon by many academics, who also dominate decision making by the MRC and BBSRC. Basic scientists are for the most part not thinking deeply about translation. A US-based investor with experience in the field told me that the ageing field has suffered setbacks such as failed clinical trials for senolytics and homologues of the drug rapamycin. There are not enough success stories. Other factors, such as the dominance of Silicon Valley tech entrepreneurs, does not provide confidence from traditional biotech investors. The field is seen as fragmented, moving in multiple different directions. There is also uncertainty on the position of regulators, with ageing not considered an indication by the FDA, although they did approve the design of the TAME trial for metformin, which was based on the appearance of multiple morbidities. This trial has yet to be funded. Given the length of time required to develop a drug in this field, the 20 year life of a patent appears too short.

The view of industry

I spoke to Hal Barron, CEO of Altos Labs (and ex-CSO of GlaxoSmithKline). He offered the interesting analogy that academically funded science is like playing a game of poker where you have enough money for the ante but not enough to bet if you have a good hand. In other words, the funding is spread so thin that scientists that make promising discoveries, do not have sufficient resources to investigate it further and ultimately discover if it works in humans. At Altos Labs, they have made a \$3bn bet on one aspect of ageing – cellular reprogramming and recruited top scientists at two sites in California and in Cambridge UK. They work as a team and are prepared to accept outcomes if they fail as they develop their technology. It could be that the whole approach fails but they at least have enough resource to establish that.

A UK-based founder of a small startup company in the field of ageing was having trouble winning investment (around £2m) to continue his company’s drug development. He

tried and failed to get funding from Innovate UK, although he had been successful in the past for a project involving wound healing. He felt that a lot of Innovate UK funding went indirectly to academics. For mouse studies of ageing, he was planning to carry out the experiments in Italy because it was less expensive and easier to get regulatory approval. More than the experience of individual companies, the very small number of UK companies in this field is indicative of the considerable challenges.

Comparisons with other countries

The US is a leader in ageing research. The National Institute of Health has funded ageing extensively through the [National Institute on Aging](#), which includes a Division of Aging Biology, which makes up only a small proportion of the total funding (in 2020 it was \$229 million out of a total budget of \$3.9 billion). Most of the NIA funding goes to Alzheimer's disease studies. Individual PIs at US universities often have flexible funds that allow them to initiate large experiments quickly (e.g. in mice). Animal regulation is more amenable to experiments (Altos does more animal experiment in the US than the UK). The NIA funds the Intervention Testing Program, in which several compounds have been tested in mice across 3 labs. As well as government and charitably funded research, there have been billions of dollars invested in companies in this area. They have been able to carry out clinical trials.

As discussed above, it is often easier to carry out mouse experiments on ageing in European countries. Germany has invested heavily in the biology of ageing, especially via the [Max Planck Institute for the Biology of Ageing](#), which sits within the broader [Cologne Excellence Cluster for Aging and Aging-Associated Diseases](#). There is also the well-funded [Leibniz Institute on Aging](#).

The Saudi Arabian government established the [Hevolution Foundation](#) in 2021. It aims to fund research at \$1bn per year, although it has only spent \$400 million so far. It has funded a lot of research in the US but is currently focussed on investing in Saudi Arabia. Hevolution Senior VP for Research, Haya al-Saud said its success comes from government support and continuing to engage with the Saudi government. It is part of the Saudi Vision 2030, to invest away from oil, to support the challenges of an ageing society with issues of chronic disease, particularly diabetes.

Singapore has a rapidly ageing society and has recognised the importance of research in the area. It has invested in the biology of ageing through its universities and institutes, attracting prominent researchers from the rest of the world.

Cultural barriers

As described it was clear that many researchers in the biology of ageing have a very different view to those studying the biology of specific diseases and different to clinicians. Ageing researchers often express that their goal is to identify and validate interventions to slow human ageing without reference to disease, and subsequent implementation of these interventions will be sufficient to prevent diseases. While that is likely to be true, there is currently not enough resource to make that happen, particularly in the UK. However, there is a lot of effort directed to preventing specific diseases, even though this resource is considerably less than that focused on treating

diseases. With some exceptions, researchers in the biology of ageing do not engage with those involved with disease prevention.

There are also differences in the way that the general public views research on ageing compared to research on diseases. The ageing field has achieved a lot of publicity in recent years but the source is often US-based influencers and billionaires talking about huge increases in lifespan and immortality. These sources give an inaccurate picture of the progress of the field and make it appear to be a concern only of the super-rich. Under these circumstances it can be harder to gain support for more realistic advances, and on the goal of keeping people healthy (free from disease) for longer, rather than necessarily living longer.

There is only a very small amount of charitable funding available for the biology of ageing. The largest focused funder in the UK is the [Vivensa Foundation](#) (formerly the Dunhill Medical Trust) which gets its income from its endowment. The Wellcome Trust has funded substantial research on ageing. Other than the BSRA, there is no charity which the public can support to further the biology of ageing. The BSRA is increasing its fundraising activity and is launching a public engagement campaign to demonstrate how supporting ageing research benefits more than one disease area. There was a UK charity called Research into Ageing, which raised up to £1 million per year, which shows that it is possible to attract charitable funding in this area. Unfortunately, the charity merged with Age UK around 20 years ago and Age UK no longer funds research on the biology of ageing.

Communication

Doubts surrounding the biology of ageing can also be partly attributed to the researchers themselves. It is easy for scientists to exaggerate the importance of their finding, especially as that can lead to more prominent publications and more funding. For example, during the House of Lords enquiry, the promise of senolytics, which are drugs that kill senescent cells was hailed by many scientists giving evidence as a big breakthrough. It is too early to rule out this line of research but up until now, and after several trials, it has yet to have been as useful as proposed. There is much current excitement about cellular reprogramming and it is too early to say if that will produce a major breakthrough. The Hallmarks of Ageing is a concept based on the Hallmarks of Cancer, to make ageing research more accessible and broken down into various areas, all of which have been studied in the past, and are being studied. The concept has been successful in attracting attention and focussing research but it gives the impression that the biology of ageing is better understood than it is, and that further research on these particular areas of biology is all that is required. Three more hallmarks have been added since the initial paper, and it is likely that there are other aspects of biology that may be more important in ageing. Unfortunately, it allows researchers working on one of the hallmarks to claim they are researching the biology of ageing while only addressing the topic of ageing superficially. It also allows them to work on ageing without working on a system that displays ageing during the experiment or trial (eg a person or model organism).

Career issues and Capacity

Several people have pointed out that the biology of ageing is a difficult field to establish an academic career in because of the shortage of sufficient funding and the length of experiments not keeping pace with the requirements to publish and obtain new grants. This lack of support results in fewer scientists pursuing the biology of ageing, which reduces the capacity of the UK to engage in this subject. Long term work in the subject is required to build the expertise and connections to funders, investors, clinicians and industrialists required for efficient translation.

Recommendations

1. Reforming funding for research on the biology of ageing

Problem: Insufficient ageing projects are funded through responsive mode routes. Ageing studies at the scale and time frames required are too long and expensive compared to equivalent studies in other fields. There are multiple approaches to ageing which means that supporting all approaches across many locations is expensive.

Recommendations: There should be funding streams specifically for ageing research, with expert leadership to make sure that a broad range of studies are supported and that the applications are truly focussed on ageing, and that while the research may be basic, the researchers have considered how to translate their findings if successful. The amount of funding available should be sufficient to enable studies powerful enough to determine whether the route taken has promise or not. There should be consistent funding (not just a few years) of ageing research that is both basic and translational. This approach is essential to increase capacity.

2. Focus and teamwork in specific areas

Problem: With the higher cost of ageing research compared to other branches of biomedical science, resources need to be used efficiently as possible. The UK is unlikely to afford to cover all areas with sufficient intensity. Yet, in a field with many unknowns, it needs sources of new ideas and thus cannot be too constricted. Focus needs to be able to accommodate these competing needs, and thus funding should also be available to explore completely new ideas. In the areas of focus, researchers should be incentivised to work in teams towards a shared goal, with the whole team rewarded, not just the principal investigator.

If there is an ageing-specific call, researchers from other disciplines find a way to adapt their research into ageing. This outcome can be beneficial because it brings in new ideas and approaches, and for example allowed Arne Akbar and Janet Lord to enter the field around 20 years ago. However, sometimes the adaptation is superficial, allowing researchers to continue their present work with a nod to ageing.

Recommendation: Establish strong leadership and expertise on grant panels/reviewers to ensure that promising research avenues are sufficiently funded, strong teams are brought together, new ideas are allowed to be tested, and proposals superficially about ageing are identified. It will need cross-education within teams: ie experts in the biology of ageing educating others in their teams and vice-versa, increasing overall capacity, something that was not explicitly included in the UK ageing networks.

3. Overcoming barriers to mouse experiments

Problem: Researchers find it hard to navigate Home Office legislation for experiments with mice and it often results in experiments being underpowered, limited to mice that are too young or experiments being terminated too early to show significant ageing. Thus, the benefits of the experiments are lowered, mice are not being used in a way that gives most value – resulting in more experiments, each with fewer benefits.

According to Sara Wells at the MRC Mary Lyons Centre, the legislation is not as specific as many researchers think. The barrier is being able to sufficiently argue the case for particular experiments to the local Ethics Board, which each animal facility has. Most researchers do not have much experience in dealing with these Boards. There is a major restriction that originates from the Home Office: once a licence has been used to do an experimental procedure on an animal, that animal cannot be transferred to a licence at another facility to do further experiments, and that includes mice that are more than 15 months old. This restriction prevents the use of facilities that are unique to specific sites (e.g. whole animal imaging), and movement of older mice.

Recommendations: Establishment of a national service involving experienced staff that guides researchers through the legislation and helps researchers to make the best arguments to local ethics boards. Discuss with the Home Office about more flexibility in transferring animals between different licences. An even better solution is to establish a national centre with the expertise and capability for ageing experiments in mice, with a local ethics board that understands the challenges. It is not necessary for principal investigators to be located in the same place as where the experiments are conducted. However, training on good practice and experimental design is required for participating scientists, increasing the UK base of expertise in this area.

4. Informing strategies to prevent disease

Problem: Researchers in the biology of ageing propose that slowing ageing will prevent, or at least slow the onset of disease, and yet there are insufficient interactions with those researching prevention of disease. Disease prevention is complex. There are various stages at which prevention can work. Primary prevention is targeted at the whole population. Secondary prevention identifies those with an elevated risk of disease and targets those

people. Once someone has the beginning of a disease, there are opportunities to prevent further development of the disease. However, as the disease develops the nature of it changes – the priorities are treatment of symptoms and saving lives, with prevention becoming less possible. Age-related diseases follow this path. Dementia for example is a disease in which when symptoms are observed it may be too late to prevent, and so applying findings from the biology of ageing is required earlier. For cancer, prevention is very different from what is needed to stop a late-stage tumour. Clinicians such as hospital specialists are very much focussed on the later stages of disease and not prevention. Likewise, pharmaceutical companies mostly focus on treating disease once it has developed substantially. Even in charities such as Cancer Research UK, there is internal tension between prevention and cure, with the latter being supported much more.

Recommendation: Researchers in the biology of ageing need to interact more with those working in prevention in specific disease areas. The Geroscience hypothesis would predict that an intervention that prevented one disease would also prevent other diseases. Cardiovascular is the area where prevention of disease has worked the best with standard tests for hypertension and high cholesterol identifying those at risk and drugs with known mechanism being used to control those risk factors. It has been shown that aggressive treatment of blood pressure in those with high cardiovascular risk reduces [the incidence of dementia](#). Similar results have been reported with cholesterol and statins. Controlling obesity via GLP-1 agonists reduced [the risk of cardiovascular disease](#). Researchers on ageing could work closely with disease-specific researchers, clinicians, charities and industry in those fields. A funding call from a consortium of charitable, industry and government funders would be a great mechanism to make that happen. Such partnerships would develop real world translatable strategies, build ties with clinicians, charities and industry, and improve credibility and public support for ageing research.

5. Engagement with stakeholders

Problem: The credibility of the biology of ageing has been questioned by many including key stakeholders such as clinicians, and the general public rarely hears from UK researchers in the field. Further understanding of the biology of ageing is required in order to facilitate translation.

Solution: Provide mechanisms for researchers in the biology of ageing to engage in honest discussions with various groups including the general public through events, such as workshops and using channels such as social media, print, radio and TV. It would require some resource towards this goal. This work can be supported by the BSRA and perhaps other organisations such as the Dunhill Medical Trust (Vivensa Foundation) or the Royal Society, which provides [training](#) for scientists in engagement and communication.

6. Clinical trials

Problem: Clinical trials in ageing and prevention of disease are hampered by negotiation of ethical regulations, the size and time required to see effects on ageing. Regulators do not consider ageing itself as an indication for endpoints, and so reasonable disease-associated biomarkers need to be established. This barrier prevents industrial investment in trials.

Recommendation. Convene a panel with sufficient expertise to reexamine the requirements for clinical trials, particularly in prevention of disease with the biology of ageing in mind. Trials need to be large enough and long enough for reasonable numbers of the at-risk group to develop the disease. These issues need to be discussed with the MHRA. In trials that are focused on a single disease, biomarkers relating to diseases in other therapeutic areas should be monitored at the same time to see if prevention of one condition prevents others. This has been shown in [the CANTOS trial](#) in which treatment of inflammation to prevent cardiovascular complications showed an unexpected decrease in lung cancer. Thus, trials that target to prevent one disease should monitor biomarkers in other therapeutic areas. Overall it requires clinical awareness of how one organ group can affect the function of another.

7. Training of researchers to understand the needs of industry and clinicians

Problem: Most scientists carrying out basic research in the biology of ageing only have a notion of what is required from their research in order for it to be translated. Yet this knowledge is essential to direct research in a way that makes it most useful. It requires an understanding of the end users of that research: namely those working in the prevention of disease, either as clinical researchers or in industry. The scientists most successful in translating their research have networks spanning several sectors.

Recommendation: Better education and networking should be provided through charities (BSRA), universities, government and industry. These interactions need to be valued to incentivise them, and could be linked to funding rounds. It is important for researchers to not just know about the eventual end users but to appreciate their challenges. Providing these opportunities would help build UK capacity in this area.

8. Training of clinical and industrial researchers in the biology of ageing

Problem: Most clinicians and clinical scientists know very little about the biology of ageing, providing a barrier to useful interactions.

Solution: Providing events to educate clinicians from all disciplines on the biology of ageing, including online events. They should be CPD accredited. It could be provided by the BSRA, government funders or other organisations. There should also be a concerted effort to include the biology of ageing in undergraduate medical degrees, particularly in institutions with strong research in the area.

Conclusions

There is great promise in using the biology of ageing to maintain health and keep people free of disease for longer. It will have huge economic and societal benefits in the UK with its ageing population and the technology and know-how could be applied to the rest of the world. The UK has great strength in this area. However, it is being held back by several factors outlined in this report. The recommendations here are designed not only to increase research output but to improve credibility and communication between the key sectors required to make the promise of translation happen. They will increase the long-term capacity in the UK for this form of research and make it more integrated with medical and pharmaceutical fields.

People consulted. In most cases, they were asked what they felt the barriers to translation were to them.

Paul Shiels, Professor of Geroscience, School of Cancer Sciences, University of Glasgow

Carly Welch, Senior Clinical Lecturer in Experimental Medicine, King's College London

Filipe Cabreiro, Professor of Microbiota in Aging, CECAD, University of Cologne

Colin Selman, Professor of Biogerontology, School of Molecular Biosciences, University of Glasgow

Niharika Duggal, Assistant Professor in Immunity and Ageing, University of Birmingham

Janet Lord, Professor of Immune Cell Biology, University of Birmingham

Richard Siow, Director of Ageing Research, King's College London

Jürg Bähler, Professor of Molecular Systems Biology, University College London

Ventak Reddy, Consultant Rheumatologist, Associate Professor, UCL

Claire Steves, Consultant Geriatrician, Professor of Ageing and Health, King's College London

Lynne Cox, Associate Professor of Biochemistry, University of Oxford

Lorna Chernajovsky, Chernajovsky Foundation, retired scientist and ex- Research into Ageing charity

Yuti Chernajovsky, Chernajovsky Foundation, retired scientist with success in translation

Hal Barron, Chief Scientific Officer, Altos Labs

William Bains, Chief Scientific Officer, Five Alarm Bio

Lorna Harries, Professor of Molecular Genetics, University of Exeter, CSO, Senisca

Arne Akbar, Professor of Immunology, University College London

Jyothi Devakumar, Investor, San Francisco

Alex Buchan, Investment Director, Northstar Ventures, Newcastle

Jon Houseley, Group Leader, Babraham Institute and BSRA Trustee

Len Stephens, Professor of Molecular Signalling, Babraham Institute

Phil Hawkins, Professor of Molecular Signalling, Babraham Institute

Gavin Kelsey, Senior Group Leader, Babraham Institute

Gavin Richardson, Professor of Cardiovascular Medicine, Newcastle University

James Edwards, Associate Professor, University of Oxford

Wahid Khaled, Professor of Tumour Initiation, Department of Pharmacology, University of Cambridge

Simon Barry, Executive Director, Oncology, AstraZeneca

Ilaria Bellantuono, Professor of Musculoskeletal Ageing, University of Sheffield

Peter Bloomfield, Director of Research, Macular Society

Sanjay Thakrar, Director of Research, Vivensa Foundation

Pedro Jacob, Grants Manager, Vivensa Foundation

David Doupe, Associate Professor, Department of Biosciences, Durham University

Liam Cassidy, Research Scientist, Altos Labs

Haya al-Saud, Senior Vice President of Research, Hevolution Foundation

Laura Greaves, Professor of Molecular Pathology, Newcastle University

Della David, Group Leader, Babraham Institute

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Lindsay Hall, Professor of Microbiome Research, University of Birmingham, and Quadram Institute

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Sara Wells, Director, Mary Lyons Centre, MRC Harwell