

TRANSLATING UK KNOWLEDGE AND RESEARCH INTO IMPACT:

Physiology and knowledge exchange

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We are enormously grateful to the members of the Advisory Group who offered their time and expertise to ensure the success of the project.

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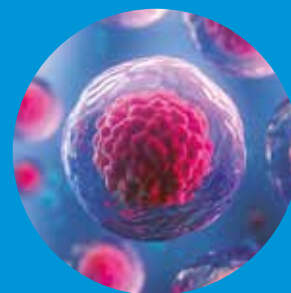
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WHAT IS PHYSIOLOGY?

Physiology is the science of life. It is the branch of biology that aims to understand the mechanisms of living things, from the basis of cell function at the ionic and molecular level to the integrated behaviour of the whole body and the influence of the external environment.



WHAT IS KNOWLEDGE EXCHANGE?

Knowledge exchange is the multiple interactions between higher education institutions and businesses, public services, charities, public engagement, communities, policymakers and government to create societal and economic benefit.



THE CONTRIBUTION OF KNOWLEDGE EXCHANGE TO SOCIETY AND THE ECONOMY

There is no doubt that research makes a huge contribution to society and the economy well beyond the laboratory. We welcome UKRI's *2020-21 Corporate Plan* which emphasises collaboration across disciplines and challenges, stating that 'the research and innovation system is complex and multidimensional and must be considered holistically'.¹ In order to ensure that the UK is best placed to lead the response to future challenges, now is the time to foster networks between universities, industry and the whole R&D ecosystem. By focusing investment on improving these partnerships, we will convene and catalyse the interdisciplinary networks essential to knowledge exchange to maximise its societal and economic benefit.

Physiology, as a key interdisciplinary science, is central to understanding the human body in health and disease. Producing this report in the midst of the COVID-19 pandemic, where clinicians and physiologists have worked closely together to battle this novel virus, makes the importance of this exchange of knowledge clearer than ever.

It is to the credit of this project's Advisory Group, the academics across the country who provided case studies and the knowledge exchange professionals in higher education institutions across the UK who contributed institutional data, that we have been able to reflect the breadth of physiology and provide a snapshot of the UK's physiology-related knowledge exchange.

It has been a real privilege for The Physiological Society and The National Centre for Universities and Business (NCUB) to be involved in co-creating a project as innovative and unique as this. This project highlights the value that learned societies bring to civil society beyond the benefits they offer their membership.

The project demonstrates a new way of benchmarking a specific discipline against previous national approaches to understanding knowledge exchange among the academic community. It showcases the variety and value of knowledge exchange, as well as highlighting the need to ensure that universities and businesses alike recognise the importance of – and nurture – collaboration across sectors.

COVID-19 has wreaked havoc on the academic system, impacting on every aspect of an institution's life, and we are extremely grateful to all the members of our Advisory Group, the academics and the institutions who have contributed to this report.



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CO-CHAIR FOREWORD



It has been a real privilege for us both to chair this project and meet with such a variety of people committed to promoting and improving the UK's knowledge exchange.



The COVID-19 pandemic, combined with the United Kingdom ending its membership of the European Union, has brought into sharp focus the symbiotic relationship between activities related to physiology and the wider national economy. This builds on previous work linking health, wellness and resilience in ageing outlined in The Society's 2019 report *Growing Older, Better* and its 2020 project looking at the impact of COVID-19 on older people.

This project has also demonstrated how crucial it is to bring a diverse group of senior academics, knowledge exchange professionals, civil servants, industry representatives and policy experts together from across the nation to showcase the best in UK knowledge exchange for the global community. It has been equally important to ensure that we have heard from physiologists at different stages of their careers to explore the extent to which perceptions about knowledge exchange are formed (and challenged where necessary) and demonstrate the real-world impact that physiology has.

We would like to take this opportunity to thank everyone who participated in the project, particularly the members of the Advisory Group, those institutions that provided data on their physiology-related knowledge exchange outputs and the members who responded to the survey on their experience of knowledge exchange. These have been the central strands of this project's success, and we look forward to seeing the report being used as a template for other discipline-specific analyses and as a benchmark to see The Society's progress in this area.



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EXECUTIVE SUMMARY

Physiology is the science of life, and research in physiology helps us to understand how the body works in health, what goes wrong in disease, and how it responds and adapts to the challenges of everyday life.

Knowledge exchange (KE) describes the multiple interactions between higher education institutions and businesses, public services, charities, public engagement, communities, policymakers and government to create societal and economic benefit.

This report aims to shine a spotlight on the specific contributions to knowledge exchange made by physiology; we provide estimates of the level of physiology-related knowledge exchange and explore the activities and motivations of physiologists working with partners beyond higher education. On the basis of the report's findings, a series of recommendations had been made for government, institutions and The Physiological Society (The Society) aimed at maximising the contribution of physiology and addressing knowledge exchange barriers.

First, we set out to establish the magnitude of physiology's contribution to ongoing knowledge exchange activity. We discovered that of the institutions that participated in this project, an average of 11% of their overall KE activity – as reported to the

Higher Education Business and Community Interaction Survey (HE-BCI) – is related to physiology. Institutions were asked to provide estimates of knowledge exchange that was directly related to physiology as well as where it was an element of broader – interdisciplinary – knowledge exchange. The table below outlines physiology-related KE as a percentage of total knowledge exchange at those institutions that provided HE-BCI data.

Second, we sought to review the type of knowledge exchange activity carried out by physiologists. To achieve this, we built on the approach developed by Hughes *et al.*² with the National Centre for Universities and Business (NCUB) and surveyed physiologists across the UK. We found that physiologists are very active across the spectrum of knowledge exchange activities. Over half of respondents have produced joint publications with external partners in the last 3 years. Over 60% of respondents have engaged in brainstorming or external lectures outside of higher education, and nearly the same proportion have taken their knowledge and skills directly into schools.

Income (£000s)	Collaborative Research	Consultancy	Contract Research	Facilities and Equipment Related	CPD and Continuing Education	IPR Income
Total HE-BCI	342,998	46,702	471,097	48,483	125,006	72,471
Of which physiology	38,055	7,411	61,977	7,849	4,559	4,806
Of which physiology %	11%	16%	13%	16%	4%	7%

This collaboration is seldom exclusively driven by financial gain. Physiologists are motivated to engage in knowledge exchange because it provides new insights into their research (55%) and furthers their institution's mission (44%) far more than because it provides the potential for personal income (13%).

However, physiologists report (53%) that it is a challenge to balance their wider workload in order to engage further with public and private organisations in demand of their knowledge and skills. There is some difficulty in identifying the best partners to work with (34%), and this report makes recommendations to improve this. Cultural differences between academia and external partners, however, were not a particular concern (6%).

“We found that physiologists are very active across the spectrum of knowledge exchange activities. Over half of respondents have produced joint publications with external partners in the last 3 years.”

Technology transfer is a subset of knowledge exchange, which includes some of the more formal and more traditionally understood interactions such as licensing patented inventions and the creation of new enterprises – spin-offs – from academic discoveries. Again, we see that physiologists compare favourably with the wider picture of UK technology transfer, although it is to be expected that a lower proportion of individuals report these activities. Around 8% of physiologists report patenting an invention compared with 6% of the wider group surveyed in 2015; 4% of our respondents had licensed research outputs to a company compared with 3% in the Hughes 2015 survey sample.

Excitingly, nearly 60% of physiologists report that knowledge exchange activity has led directly to new research projects – a similar proportion to that seen in the Hughes 2015 survey. However, several other categories (such as reputation enhancement and improving teaching material) show that physiologists



perceive fewer immediate benefits than other disciplines, which merits further investigation.

Throughout the report, we highlight a range of case studies in order to showcase how the knowledge exchange carried out by physiologists benefits and improves health, life and wealth in the UK and beyond.

RECOMMENDATIONS

The knowledge exchange ecosystem depends on interactions between the **research community** (including academics and learned societies etc.), **institutions** (including senior leadership and knowledge exchange professionals) and **partners across the economy and society**. This is set within an **innovation context** that is shaped by overarching policies such as funding models and government priorities. This report aims to maximise the contribution of physiology to knowledge exchange and address barriers by making 12 recommendations across the 4 elements of the ecosystem.

Make the UK the best place in the world to conduct, commercialise and benefit from healthy ageing research

Innovation context

1 The UK Government, through the Department for Business, Energy & Industrial Strategy, the Department for International Trade and UK Research and Innovation (UKRI), should invest in establishing a Global Coordinating Centre for Healthy Ageing Research and Development to focus on identifying world-class productive knowledge exchange between academia and public and private sectors to meet the objectives of the Industrial Strategy Healthy Ageing Grand Challenge.

This will ensure the UK becomes the international partner of choice for academic discovery through to the commercialisation of the innovative new products and services that will flow. This will fully realise the benefits from the UK's world-leading physiology research into the mechanisms underpinning ageing and knowledge exchange in the area. It will promote opportunities for physiologists to engage with global networks to address shared challenges, attract further investment and talent, and increase productivity in the UK health economy.

Innovation context

2 The UK Government and devolved administrations should increase investment for knowledge exchange between now and 2024 through Higher Education Innovation Fund (HEIF) allocations and devolved equivalents in other parts of the UK, in line with the commitment to increase R&D funding.

Research community

3 The Physiological Society should work with the Centre for Ageing Better, a recognised Cabinet Office "What Works Centre", to place physiological research at the heart of the evidence base for public health policy around ageing.

Place knowledge exchange at the heart of the research and innovation ecosystem

Research community and knowledge exchange partners

4 **The Physiological Society** should work in partnership with PraxisAuril, the National Centre for Universities and Business (NCUB) and the National Co-ordinating Centre for Public Engagement (NCCPE) to establish a network of physiologist Knowledge Exchange Academic Champions across the UK, with co-chairs drawn from industry and academia. The champion in each higher education institution will promote knowledge exchange opportunities, liaise with central knowledge exchange support, and tackle the barriers faced by physiologists when engaging in knowledge exchange. The network champions will share good practice and lessons learned for developing relationships with external partners.

Knowledge exchange partners

5 **The Physiological Society** will work with PraxisAuril and the National Co-ordinating Centre for Public Engagement (NCCPE) to demonstrate the benefits of working with physiologists and develop a range of online resources for physiologists to showcase knowledge exchange activity and impact.

Innovation context

6 **UKRI** should foster cross-council translational funding, building on successful schemes such as the Biotechnology and Biological Sciences Research Council's (BBSRC) Follow-on Funding Scheme, the Medical Research Council's (MRC) Biomedical Catalyst, and Innovate UK's Healthy Ageing Trailblazers.

Innovation context

7 **UKRI** should continue to fund the UK's world-leading basic research base through periods of budgetary pressure. Successes in physiology and knowledge exchange stem from sustained investment in the UK's basic research base, and it is crucial that this funding remains in place.

Institutions

8 **Higher education institutions** should adopt the evidence-based model for analysing knowledge exchange financial data in this project to fully understand the interconnectivity of knowledge exchange activities in physiology and other disciplines. This will enable them to optimise ongoing activity, plan effectively, and offer dynamic incentives to further embed knowledge exchange in the reward and progression of all staff.



Support physiologists to overcome barriers to undertaking knowledge exchange activity

Research community

9 **The Physiological Society** should explore establishing Knowledge Exchange Fellowships along the lines of the UKRI model either, subject to funding being available, as a standalone programme to alleviate time barriers or working in conjunction with global initiatives such as the *Marie Skłodowska-Curie Actions* Research Fellowship Programme to enhance the mobility of UK academics and the benefits to their research profiles this brings.

Research community

10 **The Physiological Society** should develop knowledge exchange continuing professional development resources for physiologists, particularly focused on mentoring and upskilling early career researchers, and work with industry partners such as GlaxoSmithKline, AstraZeneca and Unilever to develop material that will help members identify where and when external partners can most benefit from physiology knowledge exchange.

Institutions

11 **Higher education institutions** should sign up to the principles of the Knowledge Exchange Concordat and use the development year to embed knowledge exchange into the culture of all institutions, ensuring that criteria around academic promotion and reward recognise successful knowledge exchange activities.

Institutions

12 **Higher education institutions** should ensure there is accessible professional knowledge exchange support available and increase take-up by academics. This can be achieved through focusing on alleviating the primary barriers to knowledge exchange of time pressure and partnership building. They should provide support and training to academics for conducting knowledge exchange activities such as growing new enterprises and activities.



CASE STUDY

IMPROVING HYDRATION IN OLDER PEOPLE

Dr Nidia Rodriguez-Sanchez, University of Stirling

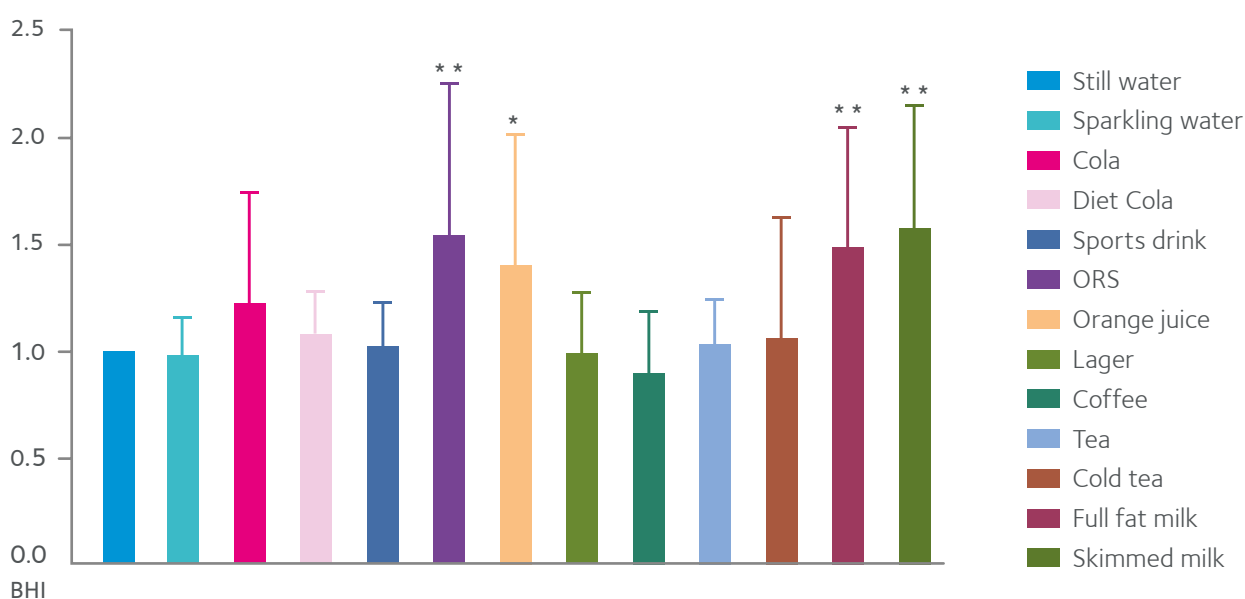
Hydration status has an impact upon physical health, cognitive performance and patient outcomes following admission to hospital in all life stages and particularly in older adults.

In ageing, several physiological and behavioural changes predispose older adults to dehydration. Inadequate fluid intake and subsequent dehydration are associated with increased risk of falls and infections, and are a frequent cause of hospital admission. These consequences negatively affect older adults' lifestyles and the global economy, considering that the population aged 65+ is growing faster than that of all other age groups. Understanding the physiology of water balance in the general population and in older adults has a positive impact on the development of strategies

and recommendations for reducing the risk of low-intake dehydration in older adults and improving their quality of life.

As part of their research investigating the hydration potential of beverages, we developed the "beverage hydration index". This is a comparison of how much of a drink (different from water) is retained 2 hours after ingestion compared with the same amount of water.³ We completed a pilot study supported by The Food Train where we obtained information from 303 independently living Scottish older adults about their daily fluid intake. We observed that 26% of older female adult and 50% of older male adults did not meet the European Food Safety Authority (EFSA) daily fluid intake recommendations.

The Beverage Hydration Index (BHI) is a tool to identify the hydration potential of a drink

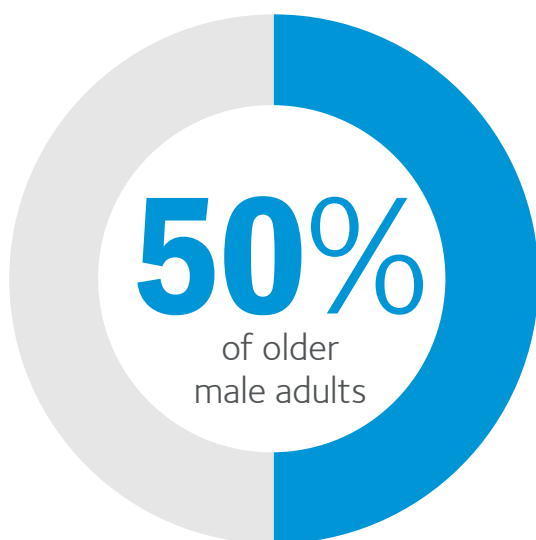
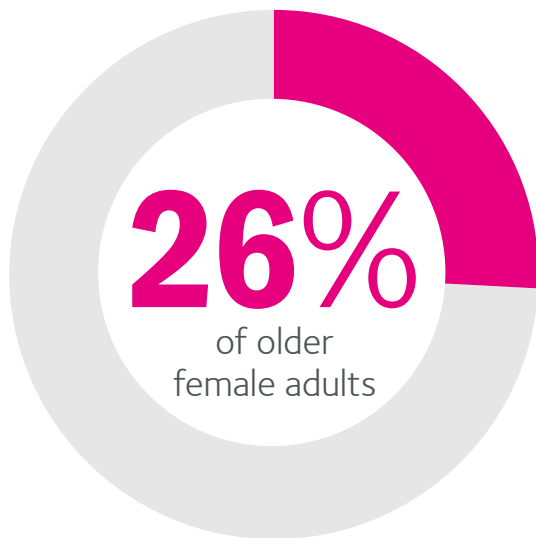


ORS - Oral Rehydration Solution

*p < 0.05, **p < 0.01

Maughan *et al.*

Am J Clin Nutr, 2016



did not meet the European Food Safety Authority (EFSA) daily fluid intake recommendations.

From the analysis of the volume and choice of beverages, we observed that the difference between those meeting and those not meeting the EFSA recommendation could be attributed to differences in water ingestion. In particular, water intake during the mid-morning and early-afternoon was lower in those not meeting the guidelines. We are very interested in continuing to work with the older population, investigating the most appropriate drink strategies for improving their hydration status and health outcomes and therefore having a positive impact on their quality of life.



“

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CHAPTER

1

INTRODUCTION

By collaborating and co-creating programmes we can generate ideas and explore issues in an inclusive way to reach multi-dimensional solutions that will enhance the very fabric of our society.

Knowledge exchange is at the heart of realising the value of the UK's world-leading research and development and higher education. Without it, British ingenuity would not have been translated into the products and services we enjoy today. In addition to tangible benefits, it is also crucial for inspiring the next innovation and the next generation of researchers. In the same way the *Bond Review*⁴ noted that “*Mathematical tools and techniques lie at the heart of numerous industries, ranging from financial services to the special effects and computer-generated imagery (CGI) used in the film industry*”. The case studies in this report demonstrate how physiology is fundamental to the life sciences. Among the higher education institutions that responded as part of this project, an average of 11% of their overall knowledge exchange activity is related to physiology.

The UK Government rightly included research and development (R&D) in its 2017 Industrial Strategy⁵ and laid out its thinking further in the 2020 UK Research and Development Roadmap.⁶ The data gathered for this report – both from academic activity and financial metrics – provide great insight into the value of physiological research and teaching to UK knowledge exchange, giving insight into the discipline's contribution to the broader UK economy. The approach we applied has not been attempted before, and our findings represent a useful picture of the benefits that flow from physiology, allowing identification of opportunities to build on physiology's success and tackle barriers to knowledge exchange.

Through this report The Physiological Society will seek to leverage the knowledge and skills of its membership to fully engage with UK Research and Innovation (UKRI)'s 2020-21 Corporate Plan, which states that “*by collaborating and co-creating programmes we can generate ideas and explore issues in an inclusive way to reach multi-dimensional solutions that will enhance the very fabric of our society*”.⁷

1.1 What is physiology?

Physiology is the science of life. It is the branch of biology that aims to understand the mechanisms of living things, from the basis of cell function at the ionic and molecular level to the integrated behaviour of the whole body and the influence of the external environment. Research in physiology helps us to understand how the body works in health throughout the life course and how it responds and adapts to the challenges of everyday life; it also helps us to determine what goes wrong in disease, facilitating the development of new treatments and guidelines for maintaining human and animal health. The emphasis on integrating molecular, cellular, systems and whole-body function is what distinguishes physiology from the other life sciences.

As highlighted in The Physiological Society's recent reports *Growing Older, Better*⁸ and *A National COVID-19 Resilience Programme: Improving the health and wellbeing of older people during the pandemic*,⁹ the integrative nature of physiology means that it has a broad reach when it comes to the types of knowledge exchange activities physiologists undertake. The different areas of society that are impacted by physiological insights are also very broad, covering traditional areas such as testing and diagnostics through to non-traditional areas such as legal advice and elite sport.

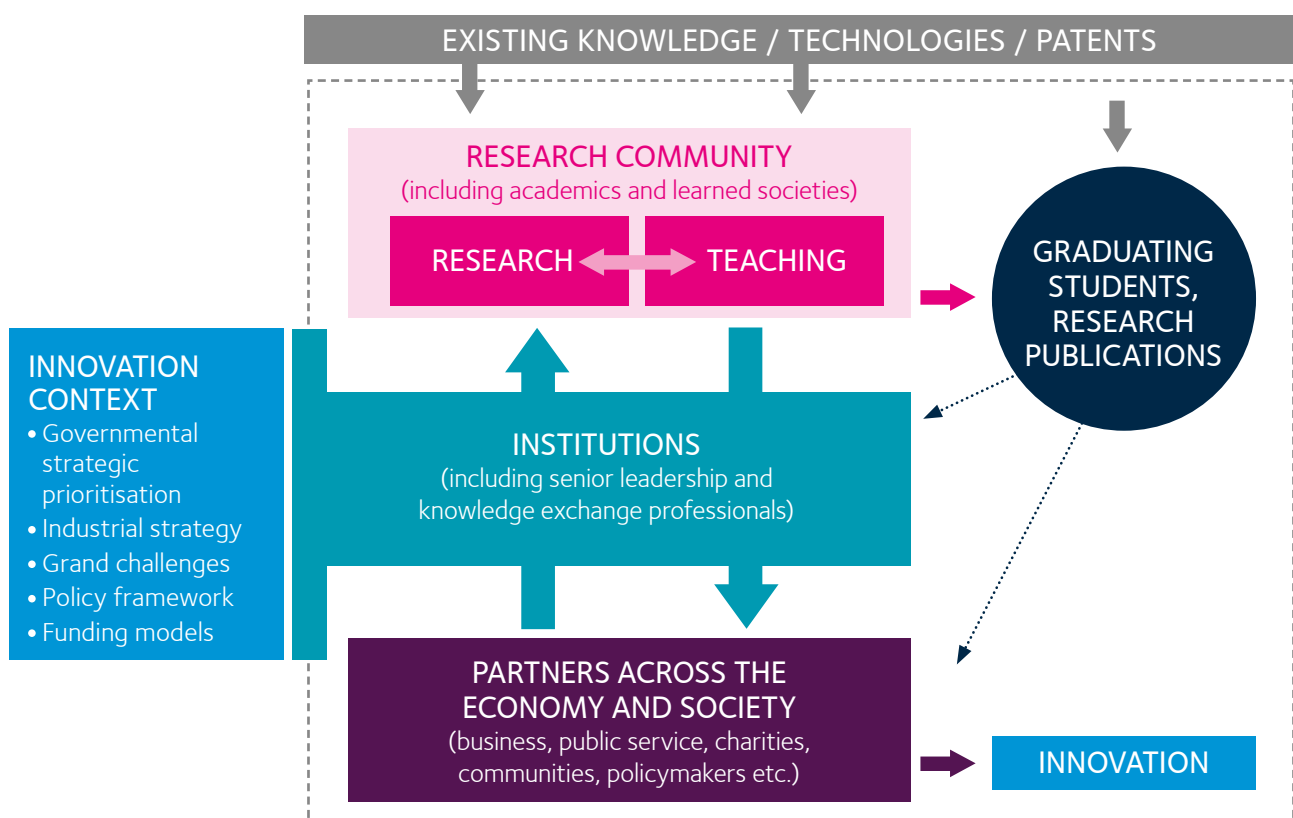
1.2 What is knowledge exchange?

Knowledge exchange is the multiple interactions between higher education institutions and businesses, public services, charities, public engagement, communities, policymakers and government to create societal and economic benefit. These interactions include joint research and development projects, consultancy, training and setting up new companies. Knowledge exchange is critical to a world-leading higher education system¹⁰ and R&D sector. For business, knowledge exchange activity supports competition, innovation and productivity, with universities offering their wealth of knowledge and expertise.

Figure 1 outlines the knowledge exchange ecosystem, which depends on interactions between the research community, knowledge exchange professionals within institutions and the knowledge exchange partners. This is set within an innovation context that is shaped by overarching policies such as funding models and government priorities, articulated through mechanisms such as the Industrial Strategy. As well as resulting in innovation, knowledge exchange also benefits the traditional outputs of higher education, such as the student experience and research publications.

As Figure 1 demonstrates, the knowledge exchange ecosystem is complex and this report outlines recommendations for each of the primary actors involved.

Figure 1 Overview of stakeholders involved in knowledge exchange (adapted from Public and Corporate Economic consultants)



As knowledge exchange becomes more embedded and productive, UKRI is working with partners across the UK, including the NCUB, Universities UK, GuildHE and PraxisAuril, to develop the Knowledge Exchange Framework (KEF) and Concordat, which aims to “increase efficiency and effectiveness in the use of public funding for knowledge exchange and to further a culture of continuous improvement in universities. It will allow universities to better understand and improve their own performance, as well as provide businesses and other users with more information to help them access the world-class knowledge and expertise embedded in English Higher Education Providers.”¹¹

The UK Government’s “Industrial Strategy: building a Britain fit for the future”¹² puts effective knowledge exchange at the centre of UK ambitions to build on the five foundations of productivity – Ideas, People, Infrastructure, Business Environment and Place. This project aims to help the recently launched Knowledge Exchange Concordat to support higher education institutions, and their staff and students, to develop clear and ambitious strategic objectives for their knowledge exchange activities.

CASE STUDY

DISCIPLINARY DIFFERENCES IN KNOWLEDGE EXCHANGE

Tamsin Mann, PraxisAuril

PraxisAuril is the UK’s network for knowledge exchange practitioners. Our training and development programme is skills-based, focusing on the tools, techniques and knowledge that are required for the day-to-day job of engagement, collaboration and commercialisation.

For PraxisAuril, being involved in this kind of “deep dive” activity is valuable because it helps us to see different modes of knowledge exchange and where new approaches to training might be needed. Sometimes this will be about involving new stakeholders in existing training, so that the context for application is clear, but might extend to creating a new product as was the case with our Arts, Humanities and Social Sciences special interest group (AHSS SIG). It is also an opportunity for PraxisAuril members to think about a particular disciplinary space and reflect on how they can create more engagement in their own institutions or in partnership with others where there is complimentary expertise. KE has tremendous benefits for academics and students alike and for a professional society it helps to demonstrate relevance and, hopefully, attract investment through collaboration as well as students for the next generation of professionals.



CASE STUDY

BUILDING A MULTILATERAL KNOWLEDGE EXCHANGE NETWORK TO MEET THE CHALLENGES OF AN AGEING SOCIETY

Dr Beverley Vaughan, UK SPINE

Average lifespan has risen rapidly in the developed world, but the number of years lived in good health – healthspan – has not risen at the same rate. This means that most of us can expect a long period of ill health at the end of our lives. As well as large detrimental effects on quality of life for those affected, this also places a large care burden on families and healthcare services.

UK SPINE aims to improve health in old age by accelerating the development of new drugs that target the underlying mechanisms of ageing.

UK SPINE is now working with over 50 universities, businesses, charities and patient groups to create a strong geroscience knowledge exchange environment. We provide infrastructure that accelerates cross-institution and cross-sector collaborations, resulting in the creation of knowledge, tools and new therapeutic development pathways in geroscience. Our interaction with investors, businesses and the NHS enables us to exploit these outputs, and UK SPINE is beginning to create conditions that will translate these outputs into new products, jobs and accelerated clinical adoption. Most importantly, our efforts with a widening range of stakeholders will ensure that these new medicines will be safe, effective and affordable.

We are running over 30 translational research projects, with project leads ranging across career stages from postdoctoral researchers to globally recognised research leaders. Our rapid deployment of funding and unique framework agreement enable researchers to collaborate across institutions, facilitating the rapid transfer of data and materials between institutions. This allows us to rapidly identify candidate targets and biomarkers and prioritise them for further development.

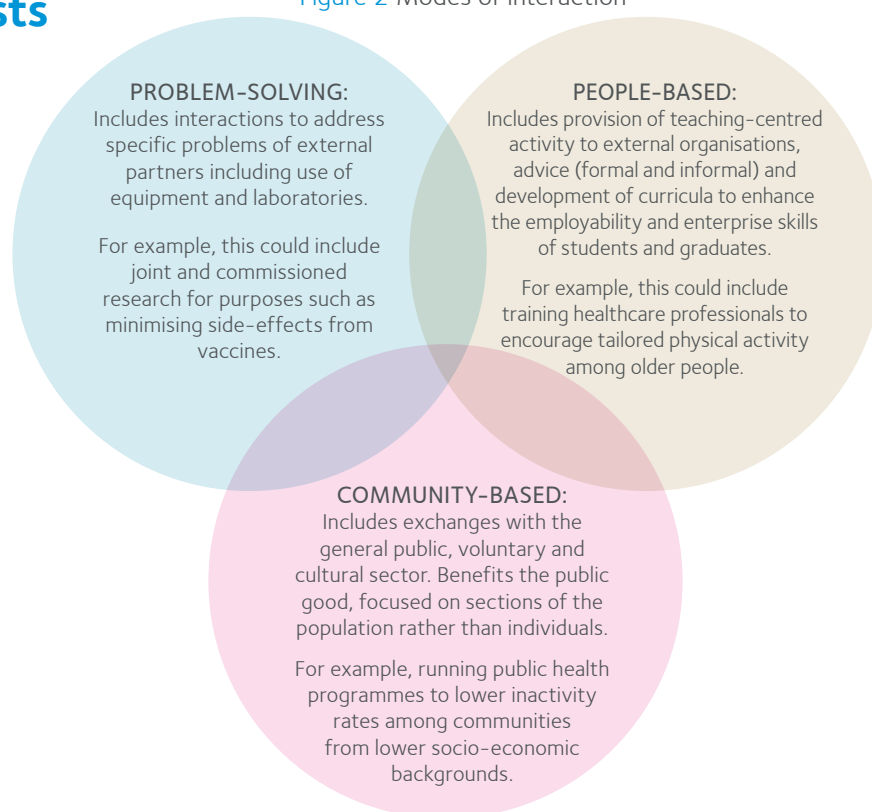


1.3 How do physiologists engage in knowledge exchange activity?

Physiologists study every aspect of the way human and animal bodies work and physiological research provides the foundation for many biological and clinical sciences, including medicine and veterinary science.

The knowledge, skills and experience of physiologists can be used in a variety of communities and sectors, from healthcare through to unexpected areas such as patent law, and address a variety of problems through a wide range of engagement activities. These modes of interactions can be grouped into three categories: people-based, problem-solving and community-based.

Figure 2 Modes of interaction



1.4 What knowledge exchange activities do physiologists undertake?

Knowledge exchange activities are classified in a number of different ways.

Figure 3 highlights the most relevant classifications for physiology.

Facilities and equipment refers to the specialist physical resources of an institution such as clinical testing facilities, super computers or hypoxic chambers. External partners seek to access these facilities from institutions where it is cost-effective to do so, which can often lead to building relationships.

Continuing Professional Development (CPD) and Continuing Education (CE) involves institutions offering specific, sometimes bespoke, education focused on particular economic sectors or partners. It often refers to upskilling people who have already qualified but are seeking to progress in their field and keep up to date with the most effective practice.

Intellectual Property Rights (IPR) refers to income from licensing inventions and design innovations to external partners. In the example of a new drug, it may be the compound itself that is protected, the specific manner of manufacture or both. Significant income may then be derived from overseas as licences may be granted to different partners covering different parts of the globe.

Collaborative research is where one or more institutions gain both public funding and a material contribution from one or more non-higher-education organisations. For example, UKRI providing matched funding as institutions work with industry to develop and produce vaccines.

Contract research is usually a more direct transaction than collaborative research, where the external partner will cover the full economic cost of the research and gain most of the output. It will be novel research usually focused on a specific problem such as drug testing and repurposing or medical diagnostics.

Consultancy is the innovative application of existing knowledge. While no new knowledge is created, consultancy may see innovative interdisciplinary and cross-sector work. This might include veterinarians who have developed a specific vaccine but need a delivery method that may have been produced for unrelated human conditions.

CHAPTER

2

PHYSIOLOGY'S CONTRIBUTION TO KNOWLEDGE EXCHANGE

2.1 Understanding the growth in the UK's knowledge exchange landscape

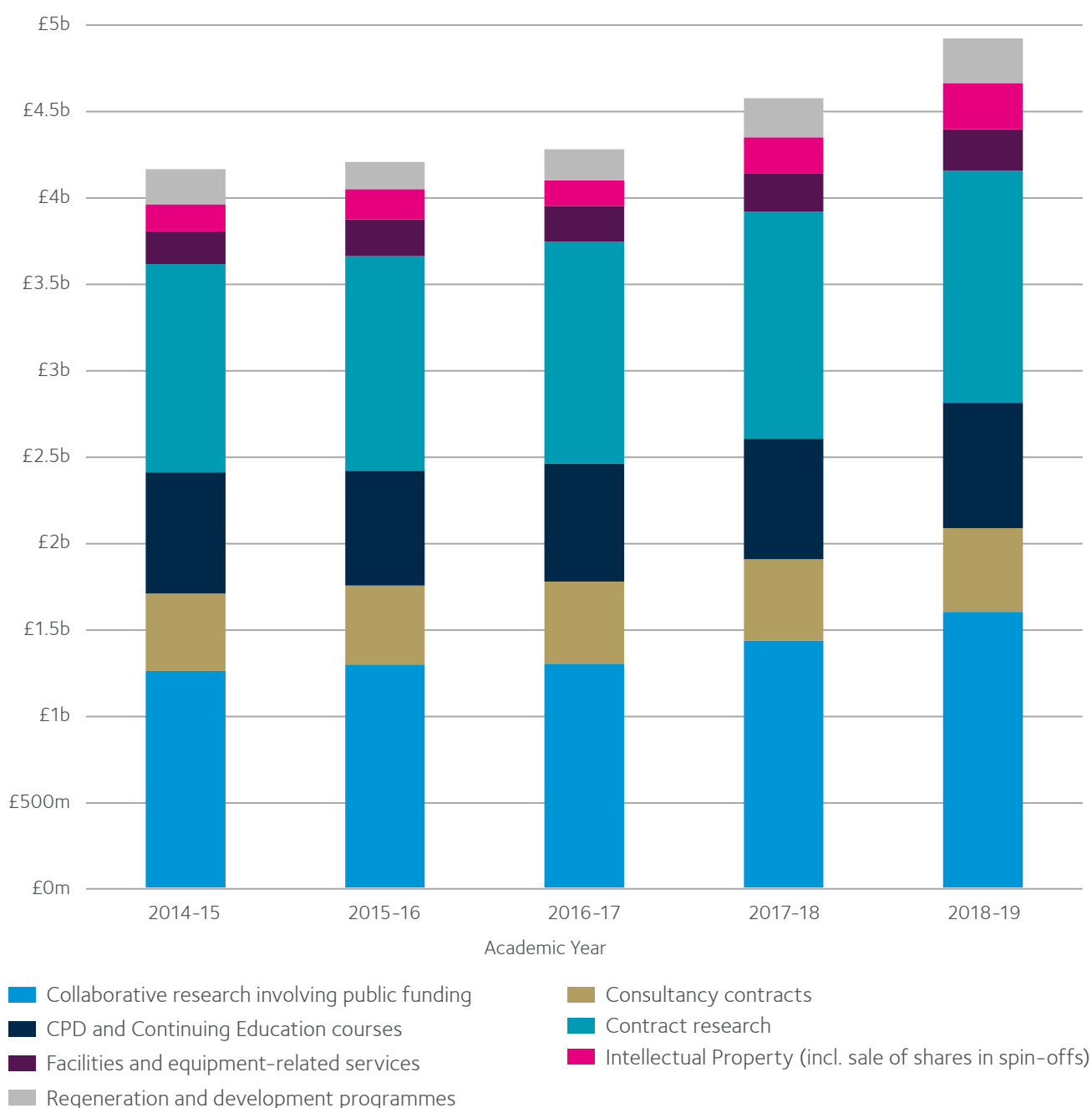
In order to understand physiology's contribution to knowledge exchange in financial terms, we must first examine how the UK Government records knowledge exchange interactions at a sector level.

The annual Higher Education Business and Community Interaction Survey (HE-BCI) is now in its 20th year and

represents the most complete record of knowledge exchange in the UK.¹³ Figure 4 shows the main financial indicators and the increases year-on-year from academic year 2014–15 to 2018–19. The growth of knowledge exchange income outpaced the overall economy over the 5 year period outlined above.

As knowledge exchange income overall increased year-on-year for the last five consecutive years, The Society sought to develop a model that would capture physiology's contribution to this landscape.

Figure 4 Total UK knowledge exchange cash terms income 2014–2019¹⁴ (based on HE-BCI survey data)



CASE STUDY

DEVELOPING A NEW INTERNATIONAL LIGHTING STANDARD

Professors Robert Lucas and Timothy Brown,
University of Manchester

Professors Robert Lucas and Timothy Brown are interested in understanding how visual signals are communicated and processed within the brain to control not just visual perception but also the timing of our body clock, which can lead to subconscious changes in physiology and behaviour such as alertness, mood and cognitive performance. Inappropriate light exposure (such as night-shift work) can therefore compromise health, wellbeing and performance by disrupting biological rhythms and patterns of sleep. Their research has revealed the importance of a new photoreceptor as the main origin of such non-visual effects. They have established a novel method for quantifying these effects and demonstrated the application of this approach for predicting meaningful biological effects of lighting in real-world applications. Through working with key stakeholders, this has led to the development of a new International Lighting Standard (CIE S 026/E:2018) and consensus guidelines that account for these non-visual effects of light, which have been adopted by the lighting industry and regulatory policymakers to ensure healthy lighting.



2.2 Quantifying physiology's contribution to knowledge exchange activity

While all UK institutions submit data to the HE-BCI survey, there is no requirement to report data by academic discipline. Hence, our request to estimate the proportion of their HE-BCI return that related to physiology was something of a novel challenge and only requested of institutions identified by members of The Physiological Society as most active in the discipline.

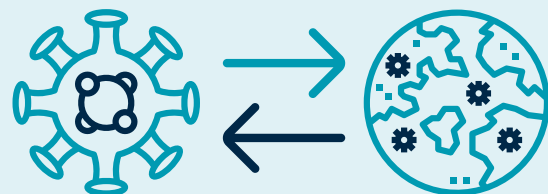
Physiology HE-BCI data methodologies

We are immensely grateful to all the institutions that have invested considerable time and effort to provide us with estimates of their physiology-related knowledge exchange. There is a diverse range of practice in terms of how data and reporting are embedded, and we encouraged institutions to approach the task using their best judgement and a degree of expert estimation. Some identified specific departments/units that were most active in physiology while others looked at data from individual academics. Most institutions noted that some activity could be wholly linked to physiology, with further activity drawing on a number of disciplines including physiology. We have used the broader definition and included both direct and indirect physiology-related knowledge exchange on the basis that while much of the value flows from a wider range of subjects, all of what we display was – in some part – dependent on physiology. This is intended to put the economic and social contribution of physiology directly in the spotlight and demonstrate its contribution alone and as a fundamental, integrative and interdisciplinary science. Regeneration income is a HE-BCI category but was excluded from the process on the basis that it tends to be made up from (large) public funding schemes such as the European Regional Development Fund (EDRF), which would likely entail substantially more for institutions to analyse potentially less robust in terms of the physiology-related elements given the activity is less directly user-inspired.

Impact of COVID-19 on developing project evidence

Our approach was agreed just as the UK moved to combat the spread of COVID-19; the resulting lockdown and remote working added substantially to the complexity of the task. Of course, physiologists have been at the forefront of the global search for effective treatments for COVID-19. This may have limited the time available to provide fully complete estimates, but as the report's case studies outline, has also provided a timely reminder of the contribution that physiology makes to global health and wellbeing.

We therefore wish to stress that these data are not meant to be a complete record of the precise levels of physiology-related knowledge exchange. More, we see them as the beginning of a conversation to highlight the role physiology plays – directly and indirectly – in improving quality of life and economic growth across the UK and beyond in order assist institutions and government in developing knowledge exchange strategy.



While the process has been challenging, we have worked to support both knowledge exchange teams and physiologists in building relationships and have had very positive feedback. There is now a greater understanding of what each side can bring to effective knowledge exchange, with both knowledge exchange teams and physiologists reporting that they expect to continue working more closely as a result of this project. Further work with partners (particularly PraxisAuril) will be required to embed this understanding by providing guidance to knowledge exchange teams as to where they might draw more on the knowledge and skills of physiologists. This will occur in parallel with work by The Physiological Society and others to highlight the support infrastructure available to promote not only knowledge exchange but the concomitant benefits to research and teaching also.

CASE STUDY

DEVELOPING A NATIONAL COVID-19 SYMPTOM STUDY APP

Dr Claire Steves, King's College London

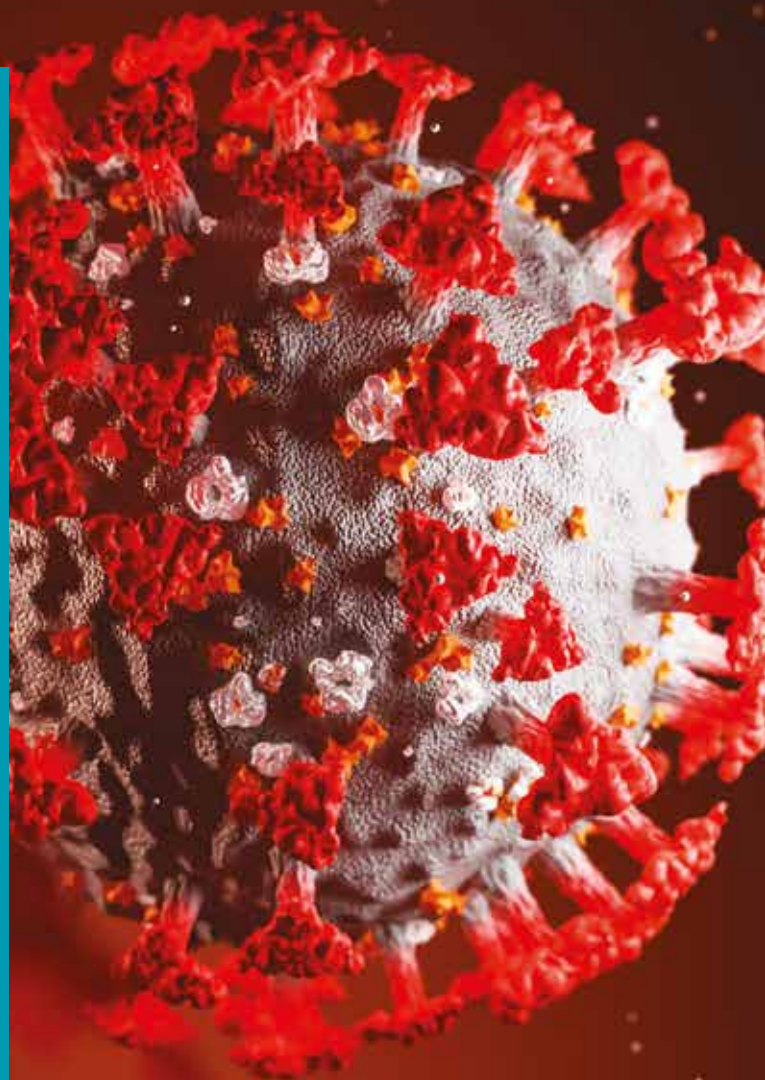
Developed by researchers at King's College London and healthcare science company ZOE, the COVID Symptom Study App has been used to log symptoms by over 4 million people across the UK, with over 10 million individual reports so far. Members of the public are using the app to track their daily health whether they are healthy or showing potential COVID-19 symptoms. It is also being used by healthcare and hospital workers nationwide so their increased risk can be recorded.

The researchers have developed a statistical model that analyses millions of COVID Symptom Study data points, including those of thousands of people who have had tests for COVID-19, in order to predict which combination of symptoms indicate that someone is likely to test positive. This model is then applied to the UK population aged 20–69 and to regions of the country, accounting for age and gender differences, to provide maps over time. The most predictive individual symptoms, in order of importance, are lack of taste & smell, fatigue, shortness of breath, fever and persistent cough. The model estimates that 3.5% of these app users would be positive if tested.

Although many COVID-19 symptom tracking apps have been developed and released and offer critical public health insights, they are often not tailored for the type of scalable longitudinal data capture that epidemiologists need for performing comprehensive, well-powered investigations. To meet this challenge, this group of researchers established a multinational collaboration, the COronavirus Pandemic Epidemiology (COPE) Consortium, comprising leading investigators from several large clinical and epidemiological cohort studies.

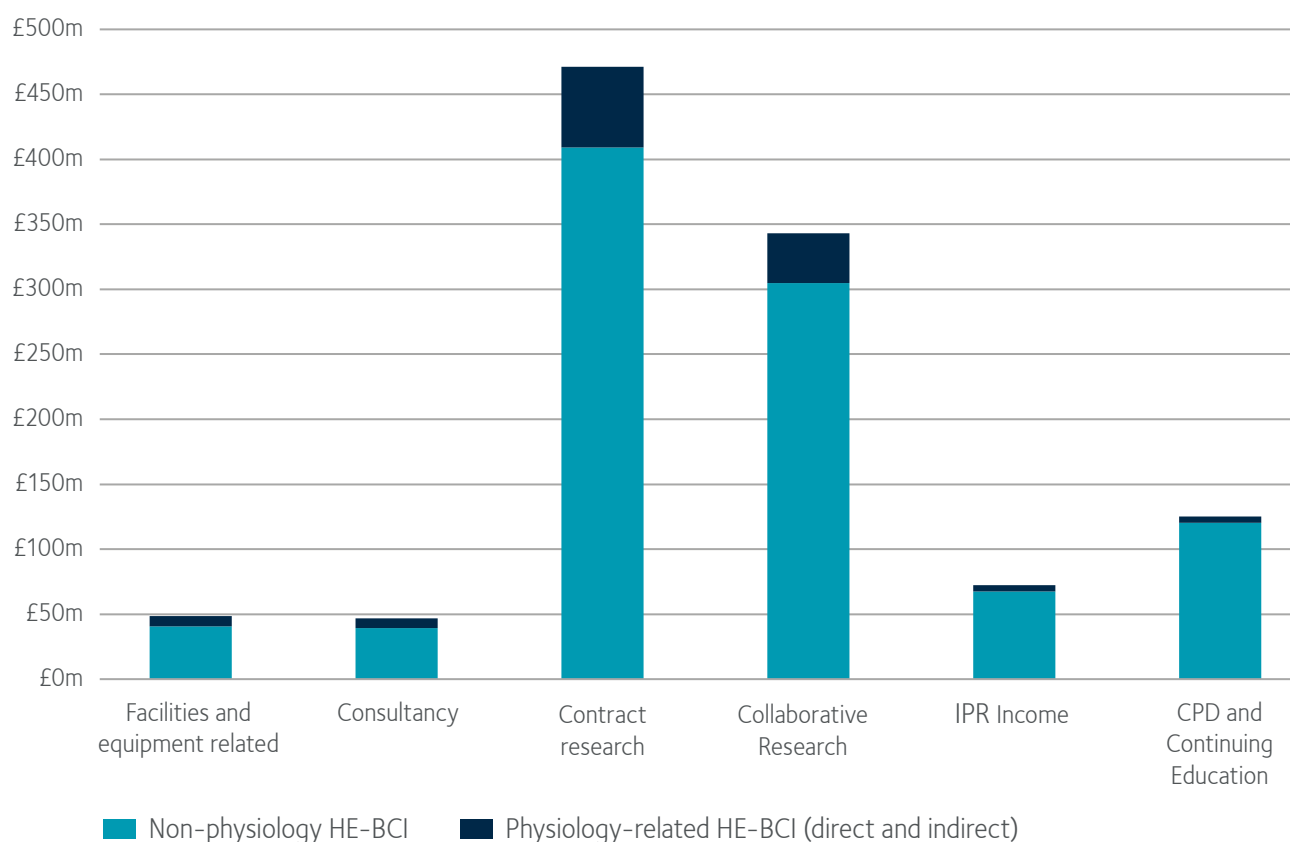
COPE brings together a multidisciplinary team of scientists with expertise in big data research and translational epidemiology to interrogate the COVID-19 pandemic in the largest and most diverse patient population assembled to date.

As a result, the researchers say that their app initiative offers critical proof-of-concept for the repurposing of existing approaches to enable rapidly scalable epidemiologic data collection and analysis, which is critical for a data-driven response to this public health challenge.



The COVID Symptom Study App has been used to log symptoms by **over 4 million** people across the UK, with **over 10 million** individual reports so far.

Figure 5 Sum of all responding institutions' physiology-related knowledge exchange income in 2018-19



Income (£000s)	Collaborative Research	Consultancy	Contract Research	Facilities and Equipment Related	CPD and Continuing Education	IPR Income
Total HE-BCI	342,998	46,702	471,097	48,483	125,006	72,471
Of which physiology	38,055	7,411	61,977	7,849	4,559	4,806
Of which physiology %	11%	16%	13%	16%	4%	7%

Figure 5 shows the total knowledge exchange metrics of responding institutions selected specifically for being active in physiology, covering institutions from across the UK, and the proportion of this activity they have estimated to stem (directly and indirectly) from physiology. The data is for the academic year 2018-19.

Consultancy and facilities income are the highest reported proportion of physiology-related knowledge exchange income, with both at around 16%. This is a substantial amount, demonstrating the perceived value external partners see when working with UK physiologists, while also being a significant source of

income for institutions. It should be stressed that respondents were asked to err on the side of including activity that was related to physiology so we could provide a more complete picture. The proportion of HE-BCI indicators drawn solely from physiology is likely to be lower, but such a strict approach would reduce the usefulness of this exercise because of the fundamental role of physiological insight. We would expect any follow-up to this survey to provide clearer guidance on how to define physiology and advice on splitting activity between being directly or indirectly drawn from physiology, but this was not possible here owing

to the scope of this project. Institutions that were able to provide a breakdown of income by partner report that the majority (~63%) of income comes from noncommercial partners, with large business and small- and medium-sized enterprises representing around 22% and 14%, respectively.

Contract research assumes that a substantial proportion of the immediate benefits will flow to the external partner, who will have paid the full economic cost for the work undertaken. Respondents estimate that around 13% of their contract research involves physiology. Collaborative research, however, as defined under the HE-BCI, includes a substantial amount of public (grant) funding along with cash and in-kind contributions from the external partner. **Institutions report that around 11% of their collaborative research activity is reliant in some part on physiology.**

These collaborations may often be more substantial in both time and risk than seen with contract research and will likely share benefits between the institutions and the external partners.

Consultancy is defined as academics applying existing knowledge to new problems, i.e. not undertaking novel research but perhaps seeing further – unexpected – impact from previous work.

Around 16% of overall consultancy income is reported to draw on knowledge and understanding from physiology, although the median figure is lower at 12%. An example of the indirect impact of physiology provided during this exercise is the law school of an institution drawing on expertise from the physiology department as part of the advice it provided to support one party engaged in a legal dispute. While physiology represented a minority of the overall value in terms of time it was pivotal to the outcome and was therefore included in the overall data.

Where consultancy represents non-academic partners accessing knowledge, universities and colleges often have specific facilities and equipment that can be of great benefit, such as pathology labs and other advanced testing/development capabilities, as has recently been seen in the fight against COVID-19. This is also an area where Sport and Exercise Science academics and departments report a significant degree of engagement, such as training environments for elite athletes as well as physiotherapy and treatment accessed by local communities and

Special Educational Needs and Disabilities groups. From the estimated data we have received, **around 16% of income for specialist facilities and equipment is linked to physiology-related units/departments.**

Continuing professional development (CPD) and continuing education data is included in knowledge exchange metrics to demonstrate the vital channel where knowledge and education are accessed by individuals throughout their careers as opposed to during formal under/postgraduate study.

The reported proportion of knowledge exchange income from CPD/continuing education linked to physiology is lower than the other indicators mentioned above at around 4%,

although institutions reported that there were particular challenges to estimating these data. Indeed, the majority of income returned comes from one institution, which plays a substantial role delivering post-qualification training for nursing staff, the majority of which is underpinned by physiology.

Income from intellectual property rights (IPR) such as licensing patents linked to physiology was reported at around 7% of the total knowledge exchange income,

although, again, respondents noted that these estimates were difficult to provide given that there is often a reasonable period of time that passes between discovery/invention and successful licensing. Several respondents were not able to provide estimates for this indicator, and it is the least significant in terms of total value.

Institutions report that a significant proportion of their physiology-related knowledge exchange comes from overseas, although it was not possible to provide specific figures for this exercise given the administrative time required to produce the initial estimates included in this report. Mapping global demand for physiology research carried out in the UK will provide critical opportunities to make progress against the UK's global research ambitions, for example establishing a Global Coordinating Centre for Healthy Ageing Research and Development to focus on identifying world-class productive knowledge exchange between academia, and public and private sectors.



CASE STUDY

CLINICAL EATING DISORDERS IN ELITE ATHLETES

Loughborough University

Disordered eating and clinical eating disorders are 10 times more prevalent in athletes than in non-athletes. Disordered eating can compromise an athlete's health and performance, causing increased risks of injury and infection, reduced concentration and coordination, and impaired recovery from intense exercise. In addition, eating disorders have one of the highest mortality rates of any mental health condition.

The National Institute for Health and Care Excellence (NICE) guidelines highlight that early intervention is essential for expediting recovery from disordered eating. However, despite the high prevalence of eating problems among athletes, this is not an area typically covered in sports coaching accreditation courses. We have developed resources and training to support sports professionals with this process.

Our screening tools to detect athletes at risk of disordered eating have been shared widely with several national governing bodies and Sport and Exercise Medicine practitioners. They have also been published in handbooks for practitioners – including the Clinical Handbook of Complex and Atypical Eating Disorders and Sport Psychiatry.

Our training has been attended by over 150 participants from organisations such as Scottish Athletics, Sport England and Sport Wales – as part of their CPD for coaches and sports professionals. They have reported improved knowledge and confidence around identifying disordered eating in athletes, and in understanding the negative impact on performance and health. This has empowered them to discuss eating concerns with their athletes, helping them to address any issues as they arise. Mental health charities are signposting to our online programme. Additional content – now freely available online – was developed with the NSPCC's Child Protection in Sport Unit.

The training has helped to reduce stigma around mental health issues among sports professionals, helping them to nurture positive and inclusive training environments.

Following the successful delivery of a workshop at the UK Coaching Research Conference 2020, a partnership with UK Coaching is currently in development to provide our training more widely to all UK coaches.

CHAPTER

3

**HOW PHYSIOLOGISTS
CONDUCT KNOWLEDGE
EXCHANGE**

The previous chapter provides a snapshot of the economic value of physiology knowledge exchange income. For the second part of the project, physiologists were surveyed to gain a greater understanding of the types of knowledge exchange activity they undertake and the associated barriers and enablers such as strategy, infrastructure and incentives.

The survey was designed to capture a broad range of knowledge exchange-related activity rather than to focus narrowly on commercialisation with private-sector partners. Knowledge from physiologists can be used in a variety of communities and sectors, and address a variety of problems through a wide range of engagement activities. As outlined in section 1.3, these modes of interactions have been grouped into three

categories relating to different users and beneficiaries: people-based, problem-solving and community-based.

It should be noted, however, that the categories outlined are not mutually exclusive and that any knowledge exchange activity could include one or all of the categories.

This survey provides valuable insight demonstrating that physiologists work with a broad range of external partners from the commercialisation of research to health and wellbeing programmes delivered in schools and communities across the UK. In parallel with the survey, qualitative data to provide context for the results was gathered from a range of individual interviews with physiologists and knowledge exchange professions.

Figure 6 Modes of interactions: Categories relating to different users and beneficiaries

MODES OF INTERACTIONS		
PROBLEM-SOLVING	PEOPLE-BASED	COMMUNITY-BASED
Setting up physical facilities	Employee training	Lectures for the community
Joint publications	Student placements	Performing arts and related cultural activities
Hosting of personnel	Curriculum development	Museums and art galleries
External secondment	Attending conferences	Heritage and tourism activities
Joint research	Standard-setting forums	Social enterprises
Contract research	Network participation	Community-based sports
Consultancy services	Sitting on advisory boards	Public exhibitions
Research consortia	Giving invited lectures	School projects
Informal advice	Enterprise education	
Prototyping and testing		

This survey provides valuable insight demonstrating that physiologists work with a broad range of external partners from the commercialisation of research to health and wellbeing programmes delivered in schools and communities across the UK.



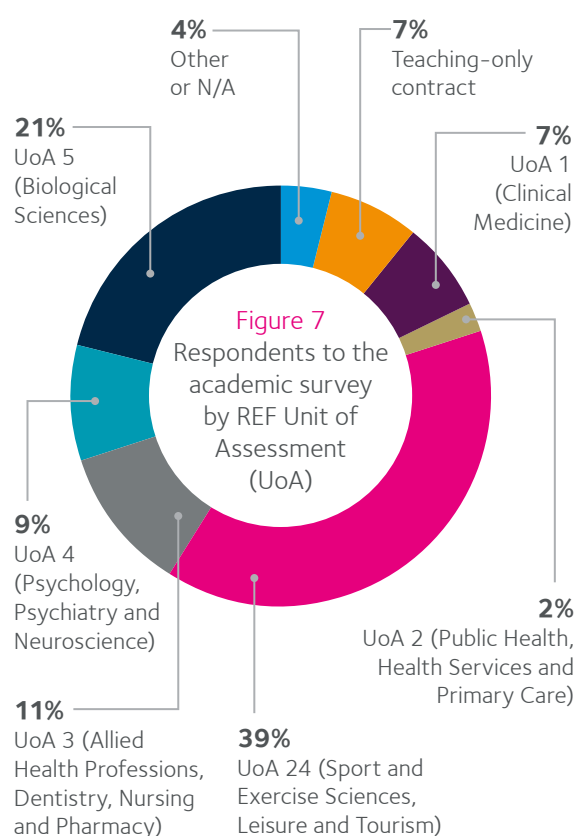
Academic survey methodology

Members of The Physiological Society and other physiologists were surveyed over the summer of 2020. Responses were received from 230 individuals, the overwhelming majority of whom were active in UK higher education. The survey was adapted from that developed in 2015 by Hughes *et al.* with NCUB,¹⁵ published in 2016, which updated the analysis of the largest ever survey of UK academic engagement with external organisations undertaken by the Centre for Business Research in 2008/9. The original Hughes *et al.* 2015 web-based survey attracted over 22,000 responses and together with the 2015 responses these are the two largest research and knowledge exchange surveys of a national Higher Education System ever completed. The results make a substantial contribution to the understanding of knowledge exchange activities in the UK beyond those assumed from institutional income metrics. In particular, they challenge assumptions about the motivation of academics and demonstrate the positive links between knowledge exchange and wider teaching and research.

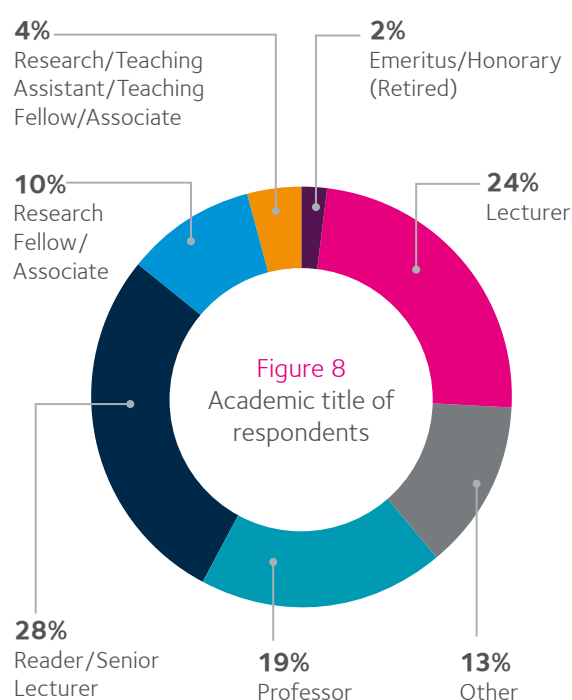
This project's survey tool was simplified from the original Hughes 2015 version to reduce burden while maintaining core data for comparison. Where data are directly compared between surveys, we advise that care should be taken given the 5 year gap between the two exercises. For context, total UK knowledge exchange income increased by around 18% from 2014–15 to 2018–19, suggesting that, were the Hughes 2015 survey to be re-run, activity would also have increased. In addition, respondents were asked to list all the barriers and then prioritise the top three barriers in order to highlight the most significant. Comparisons are made against the overall Hughes 2015 total as well as the subset of respondents active in health sciences (which is most likely to include physiology-related activity).

Further, our survey was conducted while the majority of respondents were undergoing disruption due to COVID-19, which added further challenges to dissemination and data collection.

Figure 7 shows that, of the 230 responses we received, the largest single group reported Unit of Assessment 24 (Sport and Exercise Science, Leisure and Tourism) as their primary research discipline. This may be a result of the survey methodology as the British Association of Sport and Exercise Sciences (BASES) supported The Society substantially by communicating the survey to its members. Future analysis with a larger sample is recommended where responding numbers can be compared with the Higher Education Statistics Authority (HESA) staff, which details the total number of staff working in all academic cost centres. Overall, proportions are reasonably in line with expectations. 'Other or N/A' includes academics based outside the UK and non-academic physiologists.



In Figure 8 there is a reasonably broad distribution of academic roles reported by respondents. Lecturers, Senior Lecturers and Readers make up just over half of the sample while a fifth are Professors. 'Other' includes a number of postgraduates and some from outside academia (including further education and school staff).



3.1 Problem-solving interactions

Problem-solving modes of interaction address specific problems of external partners, for example this could include joint and commissioned research for the purpose of minimising side-effects from vaccines.

Figure 9 shows the proportion of respondents who have engaged in problem-solving with external partners, split into commercial partners (small- and medium-sized enterprises and large business) and non-commercial partners (including charities and public and third sectors, amongst others). Overall, physiologists are more active in almost every indicator than those surveyed for Hughes 2015, which demonstrates the demand from external partners, especially non-commercial partners such as the NHS, for physiology-related knowledge. It should be noted that this may also be due in part to the self-selecting sample phenomenon as it is assumed that those more active in knowledge exchange were more likely to commit time to completing this survey.

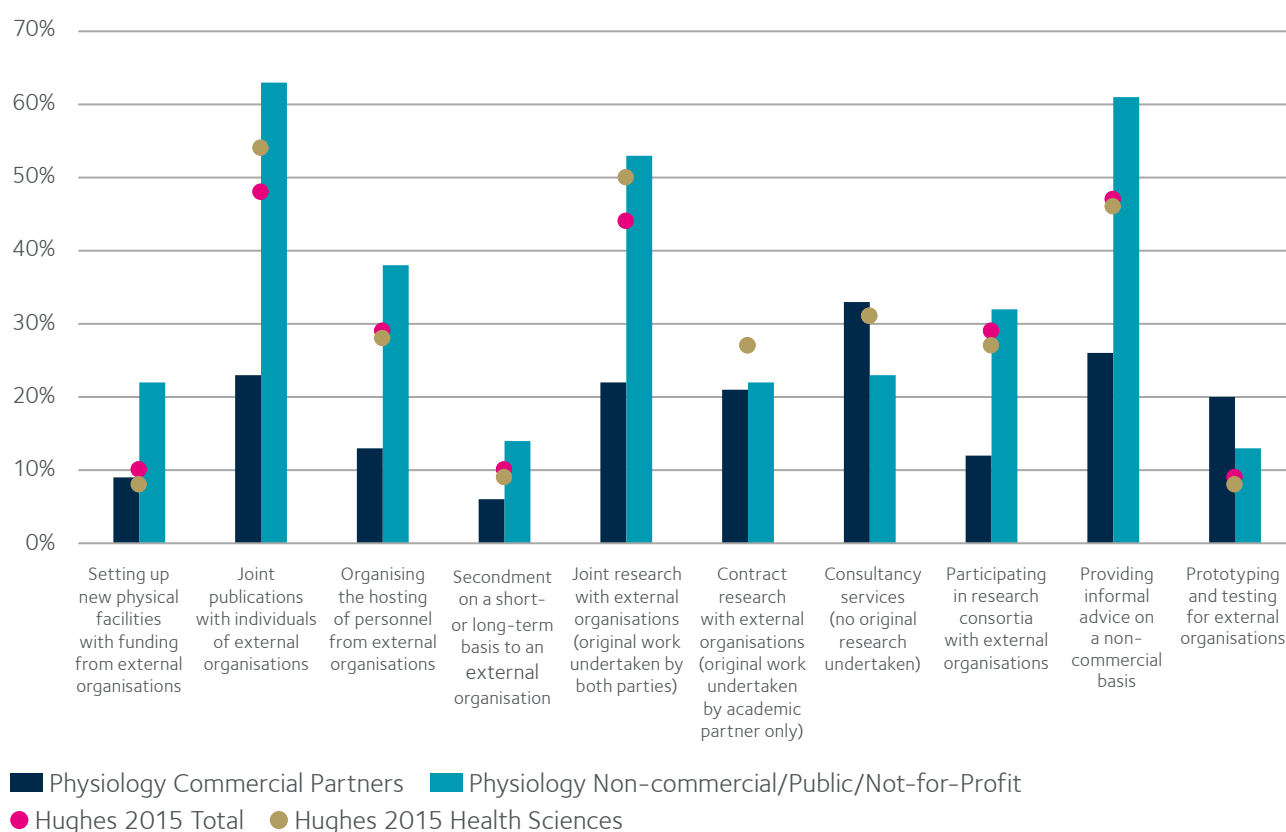
In particular, a greater proportion of physiologists have worked with non-commercial partners (such as charities, and governmental and non-governmental

organisations) than the wider academic body surveyed in 2015, especially in terms of joint publications and research, events and pro bono advice. However, commercial partners were more likely to seek physiological knowledge and expertise via formal consultancy and prototyping (testing new products/processes) activity than non-commercial partners.

It is difficult to generalise across the range of interactions covered by these data, but it might be assumed that the physiologists who responded to our survey are more likely to interact with other charities or public bodies on a non-commercial basis than with private-sector partners, perhaps because of the prevalence of health research. Further, the UK's large public health sector makes it likely that many physiological interactions will be non-commercial where similar activity elsewhere might be on a commercial basis (in the US for example). There is a good degree of correlation with the previous Hughes 2015 academic survey and among how respondents approached each survey despite five years having passed.

These data will be of particular interest to policymakers and funders given that they suggest a high level of external demand for physiology, especially from non-commercial partners.

Figure 9 Problem-solving interactions



CASE STUDY

HOLLAND & BARRETT COLLABORATION

Loughborough University

It is estimated that more than 60% of adults in the UK are overweight or obese and physical inactivity costs the NHS around £1 billion per year. The availability of smart devices and the increased trend towards having a healthy lifestyle are driving growth of the global online health and fitness market. COVID-19 lockdowns have fuelled an exponential increase in downloads of health and fitness apps. While much of the online content is good, there is often a blanket approach to exercise physiology and its interdependence with nutrition is overlooked.

In 2018, Holland & Barrett approached Loughborough University's Performance Sport Team to cut through this crowded marketplace. Translating the holistic approach and evidence-based research Loughborough has used to help decades of Olympic champions, the partnership has culminated in a multi-layered, personal fitness and nutrition digital programme to enable the general public to achieve personal goals and sustain a healthier lifestyle.

The team provided exercise and nutrition plans to create programmes suitable for any ability (very sedentary to very active), using a combination of

over 350 individually filmed exercises and over 600 recipes produced in collaboration with Michelin-starred chefs and the University's performance nutrition lead. The collaboration also provided invaluable internships for Loughborough's Exercise Physiology Master's students to input into the exercise programmes.

Machine learning is at the heart of the new app, Oro, which launched this Autumn as a free service and a premium monthly subscription. It offers a varied combination of workouts and meal plans bespoke to the individual's body, cultural and lifestyle preferences, and goals. The app constantly learns from the user's behaviour and preferences to become more tailored and effective over time – designed to be a sustainable solution, not a quick fix.

True to Loughborough's sporting pedigree, a further ambition is that Oro levels the playing field by ensuring that its expertise reaches promising grass roots athletes, particularly those competing in sports where funding is scarce and personalised exercise physiology and nutrition support is not available.

Photo: Loughborough University



3.2 People-based interactions

People-based modes of interactions include provision of teaching-centred activity to external organisations, advice (formal and informal) and development of curricula to enhance the employability and enterprise skills of students and graduates. For example, this could include training healthcare professionals to encourage tailored physical activity among older people.

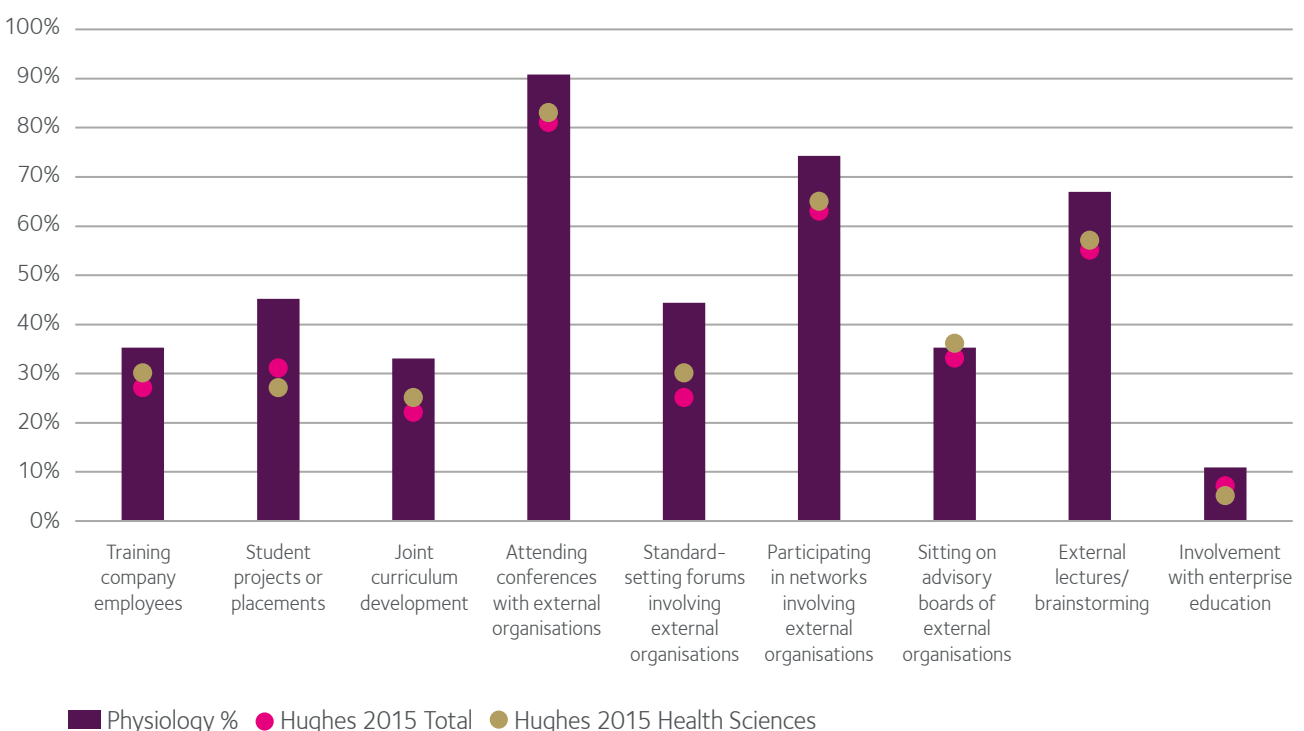
When looking specifically at people-based interactions (Figure 10), physiologists appear to be very active across all indicators and are generally more engaged than those who responded to the Hughes 2015 survey. This is likely to be due in part to the continued development of knowledge exchange over the 5 years since the Hughes 2015 survey but also demonstrates that any gap between the engagement of physiologists and other academics since 2015 has been closed or exceeded in many areas of people-based interactions. Placements and curriculum development demonstrate the value that knowledge exchange provides directly to students, making them more enterprising and employable by ensuring that they are provided with the knowledge and skills needed by employers.

The high proportions of physiologists attending conferences with non-academics, networking and thought-leadership are good examples of the porous

nature of UK higher education where knowledge is exchanged through various formal and informal channels. While the time and resources invested in these activities can be taken as a useful proxy for the perceived value – people do not spend their limited time where no potential value is perceived – it is very difficult to measure the context and trace the impact of individual interactions such as networking at a conference. The majority of work to date has been focused on formal interactions such as contract research and consultancy as these more robustly influence policy and funding. However, academics, industry and policymakers agree that networking is likely to lead directly to these types of beneficial interactions as noted by the UK Innovation Research Centre, “*knowledge exchange reported by business includes technology transfer... [and] also more widespread mechanisms which include people-based, problem solving and community interactions*”;¹⁶ so the activity is considered worthwhile even if no specific indicators currently exist.

It appears there are more opportunities to improve teaching practice through knowledge exchange activities such as attending conferences and networking or brainstorming with external partners than was reported under problem-solving. The Physiological Society will look to provide support and advice to physiologists to better prepare them to take up positions on advisory boards and funding panels.

Figure 10 People-based interactions



CASE STUDY

LIFE SCIENCES GRADUATE SKILLS WORKSHOPS

Dr Iain Rowe, University of Glasgow (formerly at Robert Gordon University)

Back in 2014, the Glasgow Economic Leadership (GEL) Life Sciences Skills Theme group developed an action plan focusing on graduate employability – in response to industry concerns over the modest knowledge graduates in physiology, pharmacology and biomedical sciences had of the Scottish Life Sciences sectors. A workshop approach was utilised where future physiology and biomedical science graduates could identify with the diversity of roles and careers within the Scottish science sectors and which exposed them to relevant industry knowledge targeted and focused in relation to future job opportunities with different employers in Glasgow, Edinburgh, Dundee and Aberdeen.

This model has been rolled out in Aberdeen over the last 2 years with a good mix of student attendance from both Robert Gordon University and Aberdeen University – predominantly from undergraduate final year students from courses including physiology, life

sciences, neuroscience, immunology and genetics. Feedback from students was very positive, with the majority stating after each workshop that they had learned ‘a lot’ and felt ‘better informed about their career opportunities’. This prompted students to take the next steps and ‘Search for intern positions in related fields to quickly apply my new knowledge’, ‘Find out more about the commercial aspects of Life Sciences’, ‘Get a LinkedIn account and connect with the speakers on LinkedIn’, ‘Be more active in applying for jobs and try to think more broadly about niche markets’.

The workshop will be running again this year, and the entrepreneurship and enterprise education aspects are key, particularly in a city such as Aberdeen transitioning from its previous focus and success in oil-related employment to growing and sustaining a vibrant life sciences community with physiology as one of the key players.

Photo: Robert Gordon University



3.3 Community-based interactions

Community-based interactions include exchanges with the general public, voluntary and cultural sector, which benefits the public good, or focus on sections of the population rather than individuals. For example, running public health programmes to lower inactivity rates among communities from lower socio-economic backgrounds.

Figure 11 displays responses for community-based knowledge exchange. The evidence suggests that survey respondents are more active than those in other academic disciplines, especially in public engagement, school projects and community sports. This is likely to be caused by the public interest in issues best addressed by physiologists such as healthier living through diet and exercise as well as more specific contexts such as ageing and obesity. Sport and Exercise Science (SES) academics account for around half of the responses in these activities, which are central to effectively embedding knowledge for healthy living for all age groups in the UK and beyond, but this demonstrates that non-SES physiologists also have an important role to play in sharing the latest evidence and science with the public as part of their knowledge exchange activities.

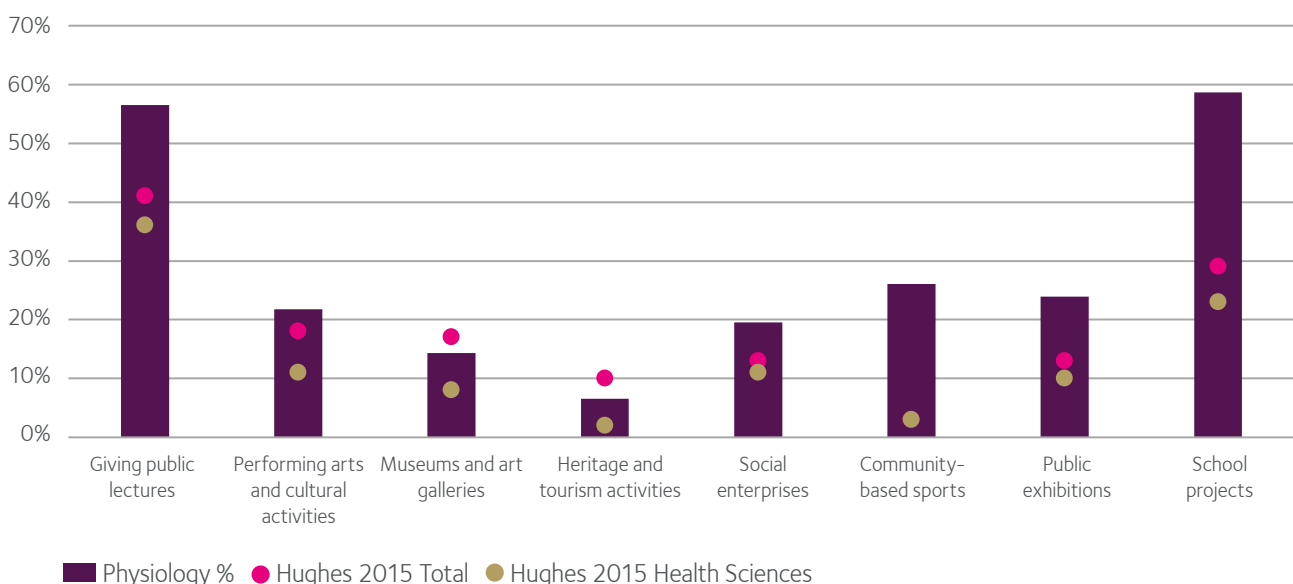
Physiologists appear relatively active in forming social enterprises too, with those from the Biological Sciences REF Unit of Assessment being the second most active group after Sport and Exercise scientists. It seems reasonable that there are relatively fewer physiologists engaged with museums and heritage by comparison

with the wider Hughes 2015 survey, given it includes a high number of respondents from Arts & Humanities.

Community-based activity may not be traditionally understood as generating the financial revenue seen with some problem-solving or people-based activities but is clearly seen as valuable by both academics and the general public given the investment of time in these knowledge exchange activities by both groups (and the impact of knowledge exchange on research and teaching as noted in chapter 4). Interviews with Early Career Researchers (ECRs) in particular revealed a desire to engage with the public and see the impact of physiology beyond academia. As well as underpinning excellence in teaching and research, such programmes also demonstrate the wider value of public investment in higher education by directly engaging with communities, for example helping schools draw on the latest research to enhance their exercise and wellbeing programmes or understand why COVID-19 has differing effects on different groups. An example of this type of work already being undertaken by The Physiological Society is its recent report, *A National Covid-19 Resilience Programme*, which has focused on providing up-to-date physiological and clinical evidence to help older people live healthier, more independent lives during the COVID-19 pandemic.¹⁷

These activities were also highlighted by non-academic staff at higher education institutions as good opportunities for universities that rely predominantly on students from local catchment areas to encourage the next generation of undergraduates to be engaged by the discipline and the university as a whole.

Figure 11 Community-based interactions





CASE STUDY

UPDATING NATIONAL PHYSICAL ACTIVITY GUIDELINES FOR OLDER PEOPLE

Dr Gladys Onambélé-Pearson,
Manchester Metropolitan University

Dr Gladys Onambélé-Pearson's research on habitual sedentary behaviour and bone health¹⁸ underpinned the key shift in emphasis in the updated UK Chief Medical Officers' (CMOs) Physical Activity Guidelines, published September 2019. The revised guidelines emphasise that '*any activity (even light) is better than none*' and highlight the risks associated with prolonged sedentary periods, irrespective of overall activity. Following publication of the reiterated guidelines, the CMOs reiterated a clear message about physical activity: 'If physical activity were a drug, we would refer to it as a miracle cure, due to the great many illnesses it can prevent and help treat.' This message demonstrates the importance of these guidelines. In England, 15 million people are living with one or more long-term health conditions that negatively impact quality of life and inactivity is responsible for one in six avoidable deaths, costing the country an estimated £7.4 billion a year.

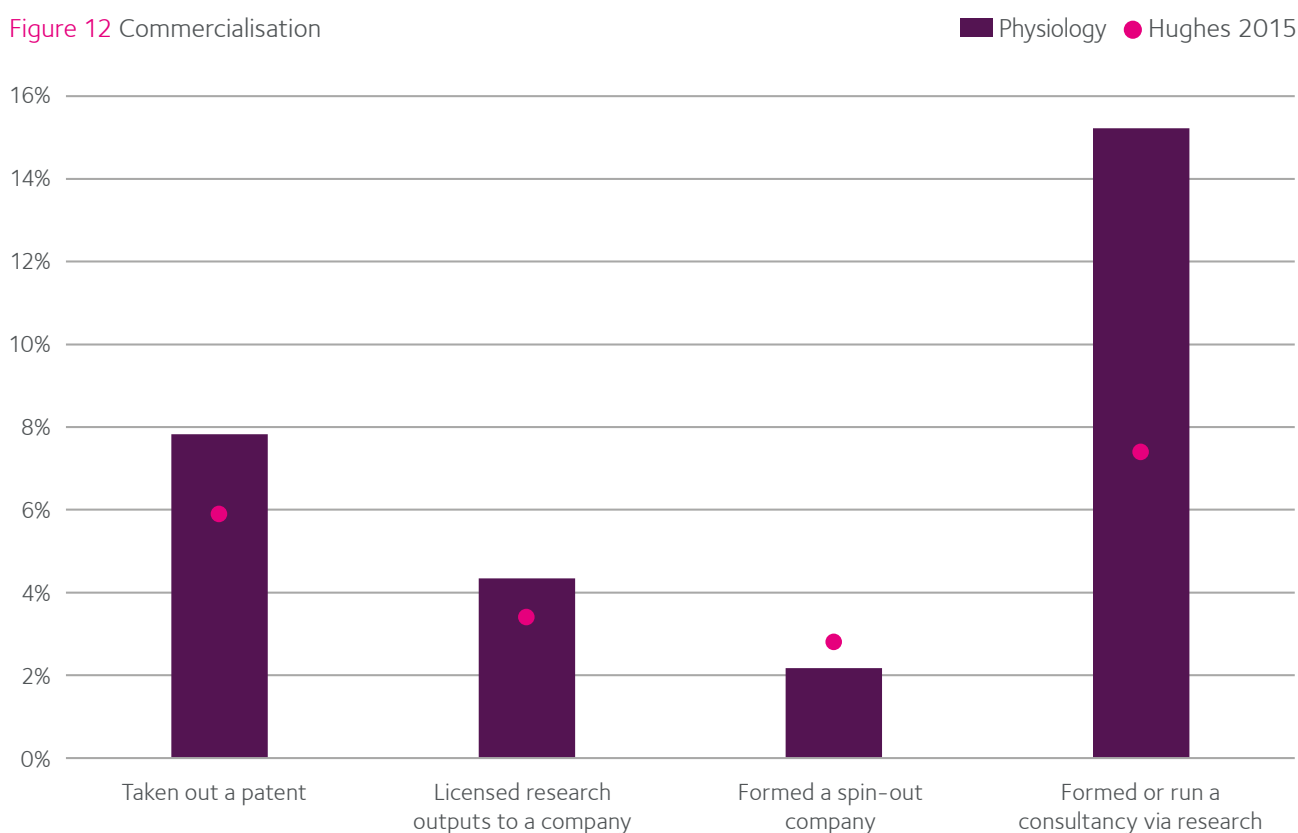
The UK physical guidelines are the primary resource for informing the public, health professionals (Public Health England and Sport England) and government policy/strategies (i.e. prevention green paper). According to NHS Digital, downloads of the 2019 update reached 73,000 views in just 11 months of publication, compared with 60,000 per year on average for the 2011 guidelines; evidence of the reach and significance of these guidelines for UK public health. Survey data suggest that approximately 40% of UK GPs (approximately 18,000 according to the General Practice Workforce dashboard) know about the guidelines and use them to inform their medical practice.



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3.4 Routes to commercialisation

Figure 12 Commercialisation



Technology transfer and commercialisation are a subset of knowledge exchange and therefore perhaps relevant to a more limited range of activities and engagements. However, they can be a route for the most innovative and transformative ideas to reach the products and services used in daily life.

Results from our survey suggest that physiologists are relatively active and successful in commercialising their knowledge, although more in-depth work would allow for a clearer understanding of the factors supporting this.

Figure 12 shows that over the last 3 years, around 8% of physiologists who responded to our survey have taken out a patent compared with around 6% highlighted in the Hughes 2015 survey. Not all patents go on to be commercialised, but those that do may be licensed to a commercial partner where the university retains the rights to the invention but allows exclusive access for others to produce and monetise the product for either fixed or proportionate revenue.

In a smaller number of cases – usually where the technology has a clear market value, or few potential licensees are identified – a new company (spin-out)

may be formed. Again, the institution may decide to retain an equity stake in this new company or sell it outright. Roughly similar proportions of academics in both surveys report licensing research outputs while slightly more of those who responded to the Hughes 2015 survey reported forming a new company. Forming spin-outs in particular is a time- and resource-intensive practice, so a single snapshot of data may not provide the full picture.

Far more frequently, external partners look to academics to provide formal consultancy in order to bring innovation either to their products or the processes by which they are made. For example, pharmaceutical companies may reduce costs by finding more efficient ways of mass-producing products for which they already have control over the intellectual property. Around 15% of physiologists have engaged in research-based consultancy in the last 3 years, which compares favourably with the response rate of the Hughes 2015 survey (although this may in part be due to the wider range of academic disciplines surveyed – further work would be warranted to understand this observation).

CASE STUDY

FUNDAMENTAL BIOSCIENCES' CONTRIBUTION TO ADDRESSING AREAS OF UNMET NEED

Emily Boyce, Babraham Institute

Crescendo Biologics is a biopharmaceutical company developing potent, truly differentiated Humabody® therapeutics in oncology with a focus on innovative targeted T-cell approaches.

This next-generation antibody technology utilises a transgenic mouse system created using IP developed by Babraham Institute researchers to generate fully human antibody VH fragments suitable for a range of therapeutic purposes. The small size of the humanised antibodies increases their use as therapeutics.

Crescendo was spun out from the Institute in 2008 and raised £17.5 million in Series A Financing in December 2013. The company went on to enter into a deal in October 2016 with Takeda Pharmaceutical Company Limited, a pharmaceutical company focused on research and development in oncology, gastroenterology and central nervous system therapeutic areas plus vaccines. This deal was worth up to \$790m and in November 2019, Takeda exercised its option early to exclusively licence Humabodies directed to one of its oncology targets.

Crescendo's continued success highlights the contribution that fundamental bioscience makes to providing the foundation for technologies that mature to address areas of unmet clinical need.



3.5 Opportunities to grow knowledge exchange

This report has so far identified that a substantial amount of knowledge exchange in the UK relies on physiology. Physiological research is critically important for helping to address significant global issues.

UKRI's corporate plan notes the importance of growing knowledge exchange by improving connections across the broad ecosystem, by stating *"our role is to use the levers at our disposal in an integrated and coordinated way to support a diverse portfolio of outstanding research and innovation, and the people and infrastructure needed to deliver it; this will drive up prosperity, improve societal outcomes and support efficient, effective public services. We will work across sectors and places, and with government, industry, academia, civic society and the third sector to realise our vision and the ambitions of the Government's UK Research and Development Roadmap."*¹⁹

Given our ageing population and the UK Government's commitment to meeting the healthy ageing Grand Challenge as outlined in the Industrial Strategy, there is a particular opportunity to focus on research into healthy ageing and associated knowledge exchange activities.

With a post-Brexit requirement to make the UK the international R&D partner of choice, the UK should seek to ensure it is the best place in the world to conduct, commercialise and benefit from healthy ageing research.

To ensure continued investment in research in this area and benefit from opportunities for knowledge exchange growth, the Government should establish a Global Coordinating Centre for Healthy Ageing Research and Development. This will ensure that the UK plays a leading role in identifying and addressing the challenges of an ageing society: from attracting research investment in basic and applied sciences all the way through to the commercial opportunities that will flow from the research and innovation. This global collaboration will clearly contribute to the aims of the International Science and Innovation Strategy which seeks *"a new coherence and sharper focus to the UK's international research and innovation effort"*²⁰ as the UK redefines its relationship with the European Union and embeds the infrastructure required for the fourth industrial revolution.

Taking a lead role in the global ageing challenge will require commitment from a range of partners in Government and the academic sector, so it is imperative not only that research is prioritised so as to achieve the target of 2.4% of GDP invested in R&D but also that specific knowledge exchange investment is increased at a similar – if not increased – rate to ensure that UK industry and academic partners can capitalise on the research strengths and see them turned into social benefit and economic growth. To provide further foundational strength for these global interactions, The Physiological Society will enhance links with organisations such as the Centre for Ageing Better and the British Council where there is clear synergy through joining research strength to real world problems from local to international levels.



The UK Government's Ageing Society Grand Challenge Mission: Ensure that people can enjoy at least 5 extra healthy, independent years of life by 2035, while narrowing the gap between the experience of the richest and poorest.



CASE STUDY

COLLABORATION TO SUPPORT THE EXPANSION AND MODERNISATION OF TRAINING FACILITIES IN NANJING, CHINA

Associate Professor Adam Hawkey, Solent University

Based in Nanjing, China, The Wellbone Medical Technology Company specialises in traditional Chinese medicine and orthopaedic rehabilitation. In 2018, Wellbone began a collaboration with the Jiangsu Provincial Sports Bureau and the National Physical Fitness Monitoring Center as part of a wider 2030 National Strategy for Health. This initiative tasked Wellbone with developing a range of orthopaedic, sports, elderly and cardiac rehabilitation services for 80 million citizens across the Jiangsu Province. Despite the sports service industry in Jiangsu being estimated to be worth ¥175 billion yuan (~£20 billion), Wellbone identified a lack of expertise in the province relating to sport science and sports rehabilitation. UK universities are highly regarded in China for their work in this specialist discipline, and Solent University Southampton was approached to provide the required knowledge and expertise to facilitate the expansion and modernisation of training facilities and the development of physiological training programmes.

Following visits to Wellbone and the Jiangsu Sports Bureau, staff from Solent University were able to establish how physiological methods, both laboratory and field-based, used in the UK could complement

current, more traditional techniques practised throughout China. This facilitated a comprehensive review of current practices relating to:

- Physiological training for elite athletes;
- Rehabilitation provision for older people;
- Equipment and facilities used for physiological testing.

Such was the success of these initial interactions, Associate Professor Adam Hawkey (Strategic Lead for Knowledge Exchange at Solent University) was invited to deliver the keynote presentation at the Inaugural International Sports Research and Rehabilitation Seminar at the Olympic Sports Institute in Nanjing to a potential audience of >80 million people. Further knowledge exchange opportunities include the acquisition of specialised physiology equipment and training of local staff in its use – both for the assessment of athletes and the rehabilitation of older people. In the longer term, there is also an aspiration from Wellbone to utilise Solent specialists to raise the profile, value and significance of physiology. The ultimate aim is to develop a sport science culture in the Jiangsu Province.



Photo: Solent University Southampton

Recommendations to make the UK the best place in the world to conduct, commercialise and benefit from healthy ageing research

RECOMMENDATION 1

The UK Government, through the Department for Business, Energy & Industrial Strategy, the Department for International Trade and UK Research and Innovation (UKRI), should invest in establishing a Global Coordinating Centre for Healthy Ageing Research and Development to focus on identifying world-class productive knowledge exchange between academia and public and private sectors to meet the objectives of the Industrial Strategy Healthy Ageing Grand Challenge.

This will ensure the UK becomes the international partner of choice for academic discovery through to the commercialisation of the innovative new products and services that will flow. This will fully realise the benefits from the UK's world-leading physiology research into the mechanisms underpinning ageing and knowledge exchange in the area. It will promote opportunities for physiologists

to engage with global networks to address shared challenges, attract further investment and talent, and increase productivity in the UK health economy.

RECOMMENDATION 2

The UK Government and devolved administrations should increase investment for knowledge exchange between now and 2024 through Higher Education Innovation Fund (HEIF) allocations and devolved equivalents in other parts of the UK, in line with the commitment to increase R&D funding.

RECOMMENDATION 3

The Physiological Society should work with the Centre for Ageing Better, a recognised Cabinet Office "What Works Centre", to place physiological research at the heart of the evidence base for public health policy around ageing.

CHAPTER

4

IMPACT OF KNOWLEDGE EXCHANGE ON PHYSIOLOGY RESEARCH AND TEACHING



4.1 Impact on physiology research

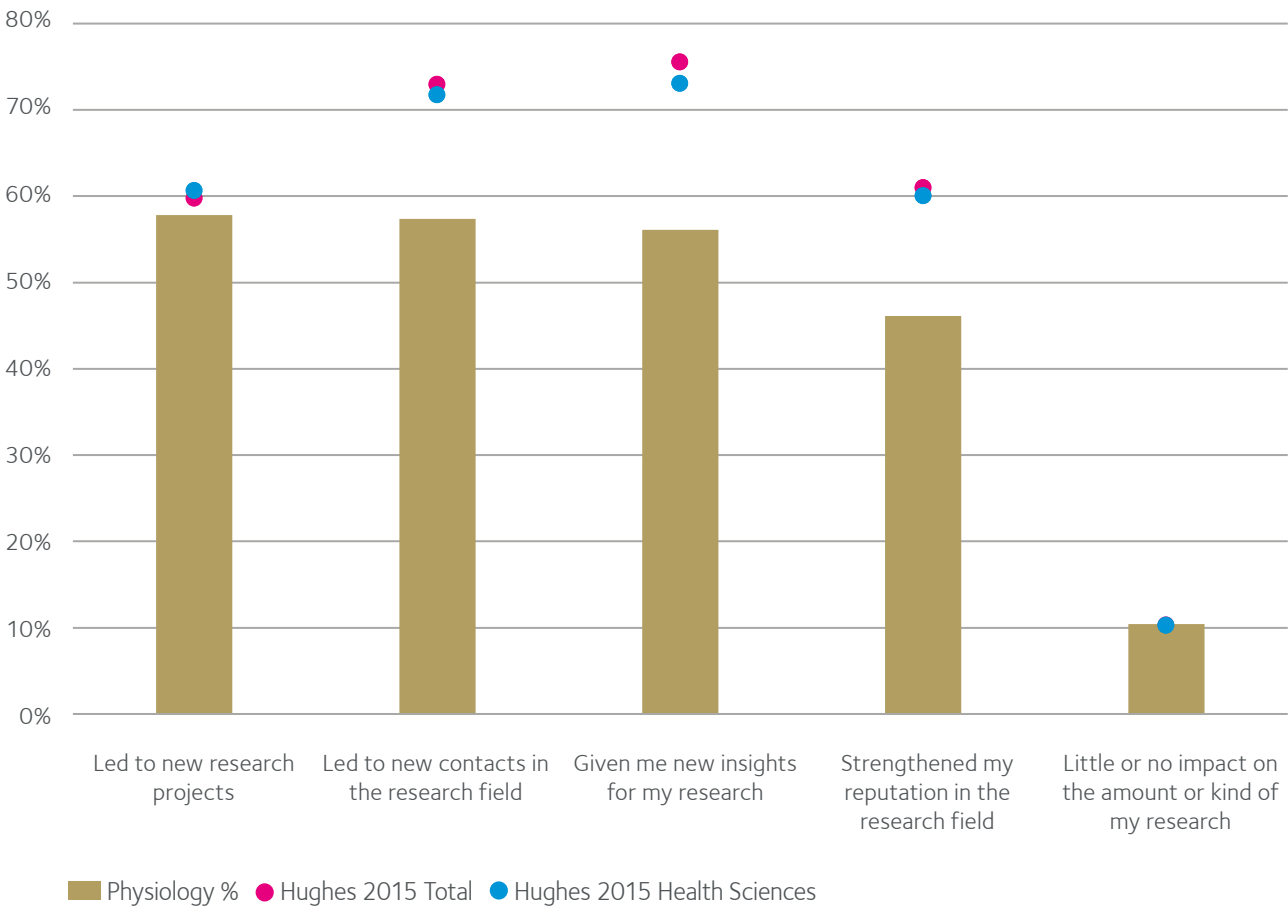
When asked about the impact of knowledge exchange activities on physiology research, only around 10% of respondents to our survey report little or no impact – very similar to the proportion reported in the Hughes 2015 survey (Figure 13).

Over half of respondents to our survey highlight new research projects as a result of knowledge exchange, again, a very similar proportion to that reported by

a wider selection of academics in 2015. Over half of survey respondents report new contacts and/or insights into their research with slightly fewer (around 46%) reporting improved reputation in the research field. These figures are somewhat lower than reported by the Hughes 2015 survey which, on the face of it, is a concern as it indicates that physiologists perhaps perceive lower benefits from knowledge exchange activity than those in other disciplines. However, this may be an effect of the simplified survey process and should be investigated further with physiologists and, if necessary, further practical steps identified to address this issue.

“Over half of survey respondents report new contacts and/or insights into their research with slightly fewer (around 46%) reporting improved reputation in the research field.”

Figure 13 Impact of knowledge exchange activity on research



CASE STUDY

**PHYSIOLOGY'S
IMPORTANCE FOR THE
PHARMACEUTICAL
INDUSTRY**

Dr Jacqueline Naylor, AstraZeneca

"Within the Cardiovascular and Renal Metabolism group at AstraZeneca, we aim to develop novel treatments that will improve the lives of patients by slowing and even reversing disease progression. This requires innovative and original science, integral to which is a close working relationship with academia. In order to make new medicines, we must first understand the disease. Academic research helps us identify novel targets and the role they play in patient physiology. We can then apply our own expertise to design new medicines to inhibit or potentiate these mechanisms by selecting from our significant toolbox of small molecules, biologics, modRNA or antisense oligonucleotides.

"By working closely with experts in the wider scientific field, we can determine important scientific aspects of our medicines, such as mechanism of action, in order to make improvements or limit side effects. In addition, we often consult scientific advisors with academic positions to inform our strategy, such as to identify areas of unmet medical need.

"The value of our academic partnerships is highly regarded and well recognised within AstraZeneca. We will frequently recruit scientists from an academic background, and it is possible to retain academic positions while employed with us. There are also partially or fully funded PhD and postdoctoral positions available at universities or within AstraZeneca.

"Combining our efforts and expertise across academia and AstraZeneca ultimately benefits patients by accelerating the rate at which we can deliver life-saving medicines."



“Combining our efforts and expertise across academia and AstraZeneca ultimately benefits patients by accelerating the rate at which we can deliver life-saving medicines.”

Dr Jacqueline Naylor



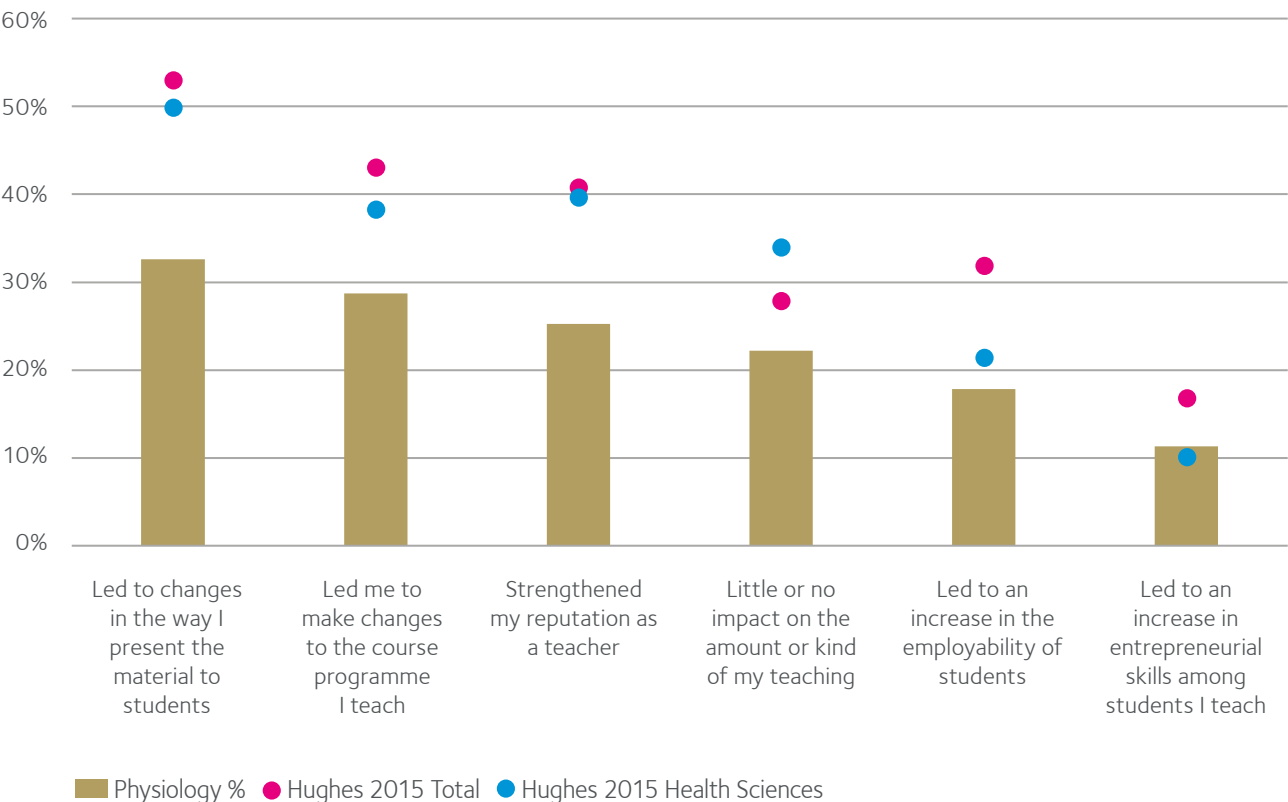
4.2 Impact on teaching

Overall, fewer physiologists report direct benefits to their teaching activity resulting from their knowledge exchange activity than in the Hughes 2015 survey, although the trend across different benefits appears to correlate (Figure 14). As noted in Figure 15 ‘Enablers’, respondents seem to perceive more benefits from knowledge exchange to their research activity than to their teaching. This may be due to a general emphasis of knowledge exchange activity in institutions being linked to research exploitation more than teaching.²¹ Further investigation is required to explain these results given that, as previously noted, our survey did not capture the same level of detail in terms of academic roles and the balance of time spent between research, teaching, knowledge exchange and other requirements.

The Society will discuss this further with its members and especially early career researchers as part of developing knowledge exchange CPD resources, particularly focused on mentoring and upskilling early career researchers. Indeed, Hughes *et al.* note, “The strongest impacts on teaching can be found for academics in the social sciences, engineering and materials science and arts and humanities”,²² which is likely to exclude the majority of physiologists, although there is still a notable difference between data reported here by physiologists and that by the Hughes 2015 subsection of academics working in health-related areas. Further investigation is required given that, as previously noted, our survey did not capture the same level of detail in terms of academic roles and the balance of time spent between research, teaching, knowledge exchange and other requirements.

“
Respondents seem to perceive more
benefits from knowledge exchange to their
research activity than to their teaching.”

Figure 14 Impact of knowledge exchange activity on teaching



CASE STUDY

BRINGING ANIMAL MODELS RESEARCH INTO SCHOOLS

Professor Andreas Prokop,
University of Manchester

Professor Andreas Prokop researches mechanisms of nervous system ageing and degeneration using the fruit fly *Drosophila melanogaster* as a model organism. During the course of his research, he and Fly Facility Manager Sanjai Patel began a schools outreach programme to showcase their research and soon realised that taking fly experiments into school biology lessons was an effective way to rekindle pupils' interest in science whilst teaching topics relevant to the curriculum. In 2015, they launched the droso4schools initiative and began a collaboration with teachers in two local education institutions. This resulted in the development of practical school biology lessons (for ages 11–18) using memorable experiments based on Prokop's research whilst conveying knowledge relevant to GCSE/A-level. Their lessons, resources and ideas are freely available online and are now being used to educate and inspire pupils on six continents, with follower initiatives having been launched in Nigeria, Latin America, Indonesia, Croatia and Turkey.



4.3 Placing knowledge exchange at the heart of physiology research and teaching

It was notable from our survey that the respondents have a lower perception of the impact of knowledge exchange on their research and teaching than those in other disciplines. While this could be – at least in part – a product of our simplified survey it is a concern that warrants further investigation. It should be understood that there are a range of ways that experience in knowledge exchange can enhance teaching and research, be it simply the inspiration for a new line of investigation or using ‘real-world’ examples to support teaching points. Opportunities to substantially update course structure may be infrequent but will be of fundamental importance in terms of ensuring graduates have the most up-to-date and relevant knowledge and skills.

The UKRI 2020–21 Corporate Plan sets out a welcome ambition to *“catalyse creativity and incentivise a diverse and inclusive system that builds on existing strengths, provides critical capability, fosters private and inward investment and creates new knowledge to enrich lives and build prosperity”*.

Everyone involved in the UK’s broad research and innovation ecosystem has an important role to play in improving interconnectivity to build a thriving system that connects discovery to prosperity and public good. To do this, knowledge exchange must be placed at the heart of the research and teaching ecosystems.

To encourage and embed this cross-fertilisation of people and ideas across all aspects of the system, The Physiological Society should work in partnership with NCCPE and NCUB to establish a network of physiologist Knowledge Exchange Academic Champions to promote knowledge exchange opportunities, with co-chairs drawn from industry and academia.

The diversity and autonomy of UK higher education institutions undeniably contributes to the excellent global reputation enjoyed by the sector. It is right that policymakers and funders respect this diversity of practice. However, it was clear from data gathered for this project that institutions having staff in physiology and related departments with a clear responsibility for knowledge exchange and external impact had a better understanding of both strategy and operational context.



CASE STUDY

PARTNERSHIP BETWEEN KING'S AND UNILEVER R&D

Dr Richard Siow, King's College London

Providing a centre of biological expertise and building on the Framework Agreement between King's and Unilever established in 2016, the Innovation Hub brings Unilever researchers and King's academics together in a shared space at Guy's Campus of King's to focus on research in the biology of healthy ageing. Unilever has funded research at King's with over £3 million since 2014 in a variety of areas, such as skin biology, regenerative medicine, cardiovascular science, nutrition and dentistry. The relationship has the ambition to scale up in the future to cover other areas of ageing research.

The King's champion for the Framework has been Dr Richard Siow, Director of Ageing Research at King's (ARK). Dr Siow's longstanding collaboration with Unilever R&D developed through joint BBSRC CASE studentships and an Innovate UK award. He

has undertaken a sabbatical period with Unilever involving close interactions with senior scientists at Unilever's global R&D Centres. One example of the success of this collaboration is a prestigious 3 year Knowledge Transfer Partnership (KTP) funded jointly by the Technology Strategy Board (TSB) and Unilever to investigate the actions of natural plant compounds on cardiovascular health.

An education element of the partnership was developed by Dr Siow through the joint King's–Unilever international summer schools on Diet and Healthy Ageing hosted at the Unilever Research Centre in Bangalore, India. This programme provided an opportunity for undergraduate and postgraduate students from India and the UK to attend talks by academics and Unilever scientists from both countries with support from the British Consulate in Bangalore.

Photo: King's College London



As such, institutions should consider adopting a similar structure as they seek to further embed knowledge exchange fully alongside teaching and research. Dedicated knowledge exchange teams also commented that this project had given them a clearer insight as to when approaches from potential external partners might better be addressed to physiologists rather than other life-science or medical colleagues. The Society will work further with PraxisAuril and the NCCPE to demonstrate to external partners the benefits of working with physiologists and develop a range of online resources for physiologists to showcase knowledge exchange activity and impact.

This project piloted a new approach for estimating the total amount of physiology-related knowledge

exchange undertaken by institutions as a proportion of the official statistics. This process was deemed to be valuable by responding institutions because, in many cases, they were able to use it to identify physiologists who carry out knowledge exchange activity, thereby strengthening the relationship between academics and professional knowledge exchange staff. Therefore, this report recommends that institutions consider developing similar processes – perhaps performing “deep dives” in particular disciplines – where there are perceived strengths or opportunities. This will provide more sophisticated understanding and allow better planning and resource allocation models while also providing compelling narrative and structural context that will enhance the knowledge exchange framework.

Recommendations to place knowledge exchange at the heart of the research and innovation ecosystem

RECOMMENDATION 4

The Physiological Society should work in partnership with PraxisAuril, the National Centre for Universities and Business (NCUB) and the National Co-ordinating Centre for Public Engagement (NCCPE) to establish a network of physiologist Knowledge Exchange Academic Champions across the UK, with co-chairs drawn from industry and academia. The champion in each higher education institution will promote knowledge exchange opportunities, liaise with central knowledge exchange support, and tackle the barriers faced by physiologists when engaging in knowledge exchange. The network champions will share good practice and lessons learned for developing relationships with external partners.

RECOMMENDATION 5

The Physiological Society will work with PraxisAuril and the National Co-ordinating Centre for Public Engagement (NCCPE) to demonstrate the benefits of working with physiologists and develop a range of online resources for physiologists to showcase knowledge exchange activity and impact.

RECOMMENDATION 6

UKRI should foster cross-council translational funding, building on successful schemes such as the Biotechnology and Biological Sciences Research Council's (BBSRC) Follow-on Funding Scheme, the Medical Research Council's (MRC) Biomedical Catalyst, and Innovate UK's Healthy Ageing Trailblazers.

RECOMMENDATION 7

UKRI should continue to fund the UK's world-leading basic research base through periods of budgetary pressure. Successes in physiology and knowledge exchange stem from sustained investment in the UK's basic research base, and it is crucial that this funding remains in place.

RECOMMENDATION 8

Higher education institutions should adopt the evidence-based model for analysing knowledge exchange financial data in this project to fully understand the interconnectivity of knowledge exchange activities in physiology and other disciplines. This will enable them to optimise ongoing activity, plan effectively, and offer dynamic incentives to further embed knowledge exchange in the reward and progression of all staff.

CHAPTER

5

KNOWLEDGE EXCHANGE BARRIERS AND ENABLERS

5.1 Enablers for knowledge exchange

In order to better understand the drivers for the types of knowledge exchange outlined in previous chapters, physiologists were asked for insight into what motivates them to engage with knowledge exchange and the barriers to further and continued engagement.

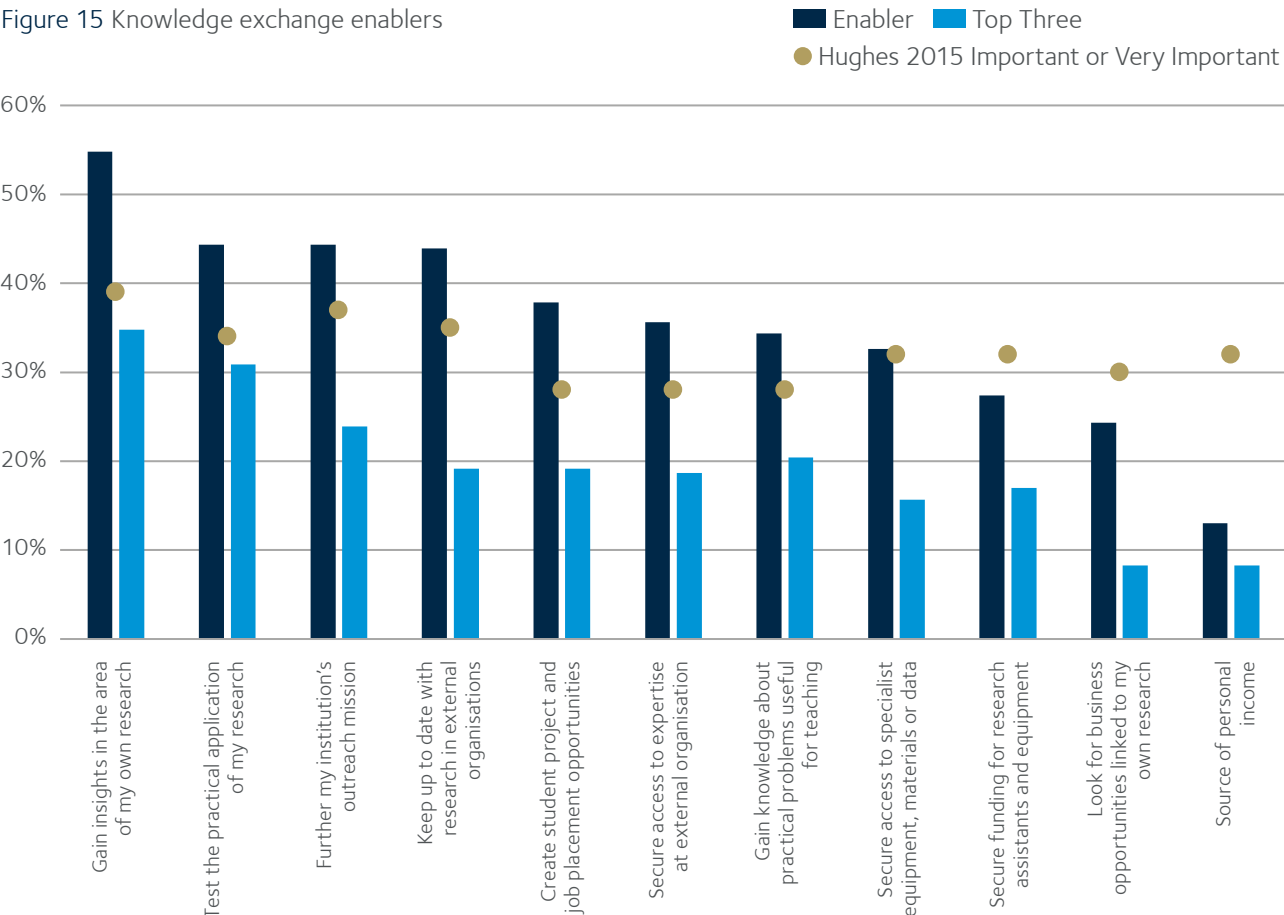
The proportion of physiologists responding to our survey who identified specific enabling factors, infrastructure or context that supports and motivates them to carry out knowledge exchange activity is shown in Figure 15. These data are vital for challenging the historic assumption held by some that academics primarily view working with external partners either as a source of revenue or – indeed – of limited value overall.

In line with the Hughes 2015 survey,²³ physiologists value knowledge exchange most for the positive contributions to their own research. This is both the most common response overall (55%) and most frequently prioritised when respondents were asked

to highlight the top three enablers (35%). Engaging in knowledge exchange as a source of personal income is the least cited enabler by a considerable margin at 13% (considerably lower than seen in the previous Hughes 2015 survey). Those physiologists who have been involved in the commercialisation of their research have spoken about the opportunity that this knowledge exchange activity brings for them to be directly involved with translating their science into real-world application rather than being driven by any financial return they are likely to receive.

Over 40% of respondents highlight the importance of engaging with external partners in terms of keeping up to date and/or testing practical applications. The fact that those UK institutions that receive dedicated knowledge exchange funding have embedded knowledge exchange as part of their core mission is equally important. Along with the increase in overall income for knowledge exchange activities, the 5 years since the Hughes 2015 survey have also seen continued investment in knowledge exchange infrastructure, incentives and funding, which is likely to have had a positive effect on responses to our survey.

Figure 15 Knowledge exchange enablers



CASE STUDY

MOVE: EMPOWERING PATIENTS LIVING WITH KIDNEY DISEASE TO INCREASE PHYSICAL ACTIVITY

Dr Jamie Macdonald and Dr Jennifer Cooney,
Bangor University

Chronic kidney disease affects 6% of the population. Treating patients living with chronic kidney disease consumes a disproportionately high NHS budget (approximately 3%) due to the high cost of renal replacement therapy (the treatment required for the most severely ill). One form of renal replacement therapy is haemodialysis. Health-related quality of life (HRQoL) remains poor in haemodialysis patients.

The physical components of HRQoL are directly influenced by underlying physiology. Enhancing the health and function of physiological systems is possible with interventions that increase physical activity. However, very few dialysis units choose to implement physical rehabilitation as an option for haemodialysis patients, despite patient and public involvement activities identifying that HRQoL should be targeted with alternative therapies to medication, including exercise.

Using information gathered from focus group discussions, the research literature and current exercise guidelines, we created MOVE (<http://move.bangor.ac.uk>), which builds on previous research completed by our group and our collaborators showing that increasing physical activity enhances functional capacity.

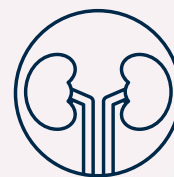
First, public and patient involvement activities were completed, including a series of focus group discussions for people living with stage 5 kidney disease and for health professionals from three renal units to determine the facilitators and barriers to implementing exercise as part of routine care. Second, research literature investigating physiological outcomes of exercise interventions in patients with chronic kidney disease were reviewed. Third, relevant information from existing guidelines on implementing exercise in chronic disease populations was extracted. MOVE provides knowledge and resources to help patients increase their physical activity and upskill health professionals to make exercise part of routine care for haemodialysis patients.

The MOVE resources are freely available and have been widely distributed, via printed booklets and a dedicated website, and are available in Welsh and Portuguese. Within 5 months of being released in 2018, the resources had been utilised in 79 renal units across the UK, Ireland, Portugal and the US. MOVE is recommended by kidney care charities and organisations including the British Renal Association and Kidney Care UK. The resources are also being incorporated into online rehabilitation platforms including Beam Feel Good, which is freely available for all patients in the UK living with chronic kidney disease.

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Chronic kidney disease affects 6% of the population. Treating patients living with chronic kidney disease consumes a disproportionately high NHS budget (approximately 3%) due to the high cost of renal replacement therapy.

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5.2 Barriers to knowledge exchange

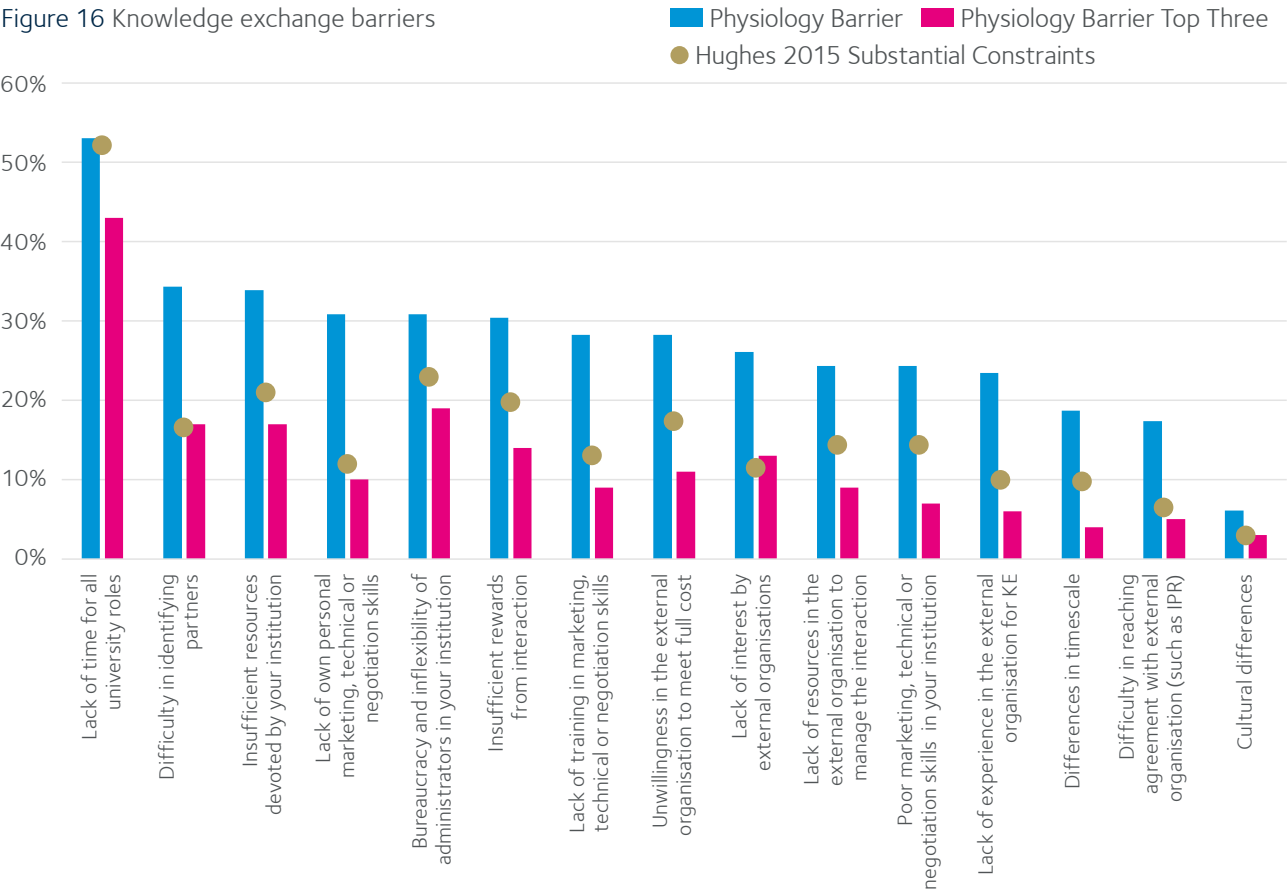
While the powerful effect of investment in knowledge exchange is clear – enabling academics to engage in mutually beneficial collaborations – barriers to further progress persist.²⁴ Chief among these are the lack of time to dedicate to knowledge exchange while managing other priorities such as teaching, research and administration. Physiologists are closely in line with the previous Hughes 2015 survey²⁵ in this regard, with a similar proportion (53%) acknowledging this barrier. **It is notable that lack of time is, by far, the most cited ‘top three’ barrier to further knowledge exchange (43%). Many of the barriers are discipline-blind, and The Physiological Society will support ongoing work by UKRI and others to overcome these constraints.** Higher education institutions should ensure that there is accessible professional knowledge exchange support available and increase take-up by academics focused on alleviating the primary barriers to knowledge exchange of time pressure and partnership building. They should provide support and training to academics for conducting knowledge exchange activities such as growing new enterprises and activities.

Further, timescales, contract negotiation and cultural differences – traditionally accepted barriers to knowledge exchange – are the least cited barriers, respectively, in both data sets. The UK has made

substantial increases in knowledge exchange funding over recent years, and increased investment between now and 2024 should continue in line with the commitment to increase R&D funding to ameliorate some of the time and resource issues.

Differences in the profile of responses between our survey and the Hughes 2015 work are perhaps due to the latter’s use of a five-point scale, meaning those who responded that factors were only partially constraining are not included here. Further analysis – perhaps in parallel with a future NCUB survey of businesses – will help further understand this issue. Given that the data suggest that identifying partners is a significant barrier to further knowledge exchange, The Physiological Society will seek to work with industrial partners such as GlaxoSmithKline, AstraZeneca and Unilever, as well as those in the public and charitable sectors, to develop material that will help members identify where and when external partners can most benefit from physiology knowledge exchange. NCUB’s partnership platform, Konfer, could be very useful in this regard. Where training or skills are a perceived barrier, PraxisAuril provides training for both knowledge exchange specialists and academics. For KE professionals, there is also the opportunity to achieve ‘Registered Technology Transfer Professional (RTTP) status through the Alliance of Technology Transfer Professionals (ATTP). The Physiological Society will seek to work with PraxisAuril to deliver specific programmes relevant to physiology in order to address the skills gap revealed by the data.

Figure 16 Knowledge exchange barriers



5.3 Tackling the barriers to knowledge exchange

The majority of the evidence presented in this report demonstrates the active role physiologists take in knowledge exchange through people and community engagement and problem-solving. However, some respondents – particularly early career researchers – expressed a desire to do more but were held back by a lack of appropriate support, resources or training.

In common with many academic disciplines, the most significant barrier to increasing levels of knowledge exchange is simply a lack of time. While academics, especially early career researchers, appreciate the value knowledge exchange brings, it should not come at the expense of other core activities such as teaching, research and administration. Focused knowledge exchange fellowships would potentially address these concerns by ensuring that academics have sufficient time and recognition to engage in innovative partnerships which will then, as the evidence suggests, further benefit their teaching and research activities rather than competing for time with them. UKRI support in this aspect would be welcome as it would provide further incentives for academics and institutions to take early stage risks in innovation on the basis that there will be funding for those projects that show genuine promise; this would further address the perceived “valley of death” where ideas that could bring about substantial economic and social benefit are not able to be developed sufficiently to attract the larger-scale, often private, finance required for some of the more potentially disruptive new products and services.

It was clear from discussion with knowledge exchange teams in institutions that their ability to support academics and identify and capitalise on collaboration opportunities has been greatly enhanced by sustained public investment in knowledge exchange infrastructure and good practice. This report recommends that The Physiological Society develops materials and resources both to assist knowledge exchange teams in assessing opportunities that would most benefit from involving physiologists and to support the continuing professional development of physiologists themselves.

Finally, the recommendation outlined in the previous chapter for The Physiological Society to work with the NCUB and NCCPE to invest in a network of knowledge exchange champions will also help to address knowledge exchange barriers. These champions will exemplify the benefits of collaboration beyond academia and provide advice and good practice to others looking to form and build wider collaborative relationships. This network should include physiologists from outside academia, including industry and health services, as they will be able to swiftly articulate where opportunities arise and support academic colleagues in addressing these opportunities and building strategic relationships.



CASE STUDY

**PRODUCING GUIDELINES
FOR EQUINE WATER
TREADMILL USE**

Hartpury University has made a considerable contribution to the evidence base regarding the physiology and biomechanics of water treadmill exercise for horses. We needed evidence to determine the suitability of the modality for various types of sport horses referred to our Therapy Centre for training and/or rehabilitation, with very different physiological and biomechanical demands. Our early work confirmed the aerobic, low-intensity nature of the exercise, and this combined with later work detailing the effects of water on gait patterns led to an evidence base supporting the use of the modality for dressage horses.

The Equine Therapy Centre offers a commercial water treadmill service providing exercise for sport horses and has an annual income of approximately £50k. The findings from our research have informed the training programmes of British, Irish and Italian Olympians across dressage and eventing within our own Equine Therapy Centre, with medal success in the London and Rio Olympics.

Recently, Hartpury University led on the production of guidelines for equine water treadmill use endorsed by the British Equestrian Federation. The guidelines came about as a result of discussions within an international group of vets, physiotherapists and commercial water treadmill providers to reach a consensus on exercise protocols. The research has been disseminated via British Equine Veterinary Association CPD events, a video abstract, invited talks and consultancy for individuals in the UK and abroad. The research and guidelines arising from this project are incorporated within Hartpury University's MSc Veterinary Physiotherapy programme, one of only two postgraduate programmes in the UK for Chartered Physiotherapists converting to Animal Practice. The research has been utilised to advise individual water treadmill users including leading National Hunt trainers, water treadmill manufacturers, rehabilitation centres, training venues and providers of water treadmill training.



CASE STUDY

BUILDING A PARTNERSHIP WITH THE ALL PARTY PARLIAMENTARY GROUP FOR LONGEVITY

Dr Richard Siow, King's College London

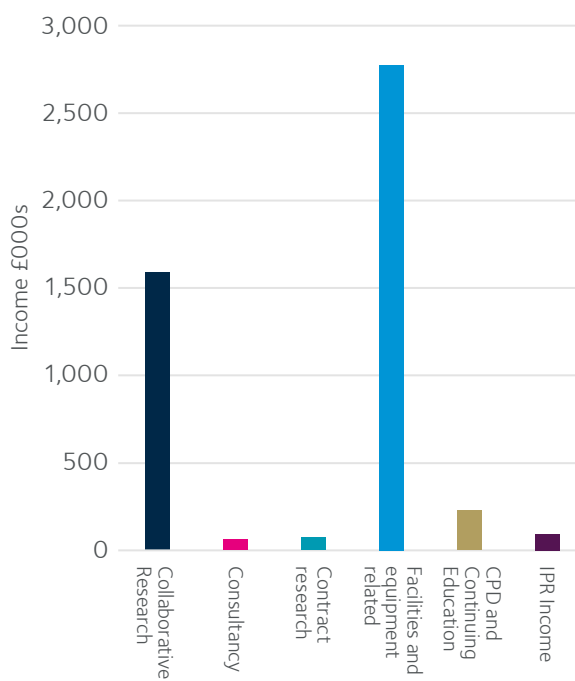
The All Party Parliamentary Group (APPG) for Longevity was established in March 2019 to address the scientific, technological and socio-economic issues relating to our ageing demographic and promote living younger, healthier and longer lives. Ageing Research at King's (ARK) was a founding academic partner and has contributed to several APPG for Longevity initiatives, including *The Health of the Nation: A Strategy for Healthier Longer Lives*, which was launched in February 2020 at an event hosted by ARK. The Rt Hon Matt Hancock MP, Secretary of State for Health and Social Care, spoke at the event and set out what the UK needs to do to meet the goal set by Government. ARK continues to play an integral role in the APPG for Longevity initiatives to develop a Business Coalition for a Healthier Nation and form an expert "Open Life Data" task group, both of which include parliamentarians, academics and key industry leaders to better inform government policy decisions.

The Babraham Institute and knowledge exchange

The Babraham Institute is an independent institute with charitable status. It receives strategic funding from BBSRC which funds their three core areas of research and therefore is not required to collect HE-BCI data. Their mission states that *'the Babraham Institute undertakes world-leading research into understanding the biology of how our bodies work, including what changes as we age and during disease. Their research is split into three programmes: Epigenetics, Signalling, and Lymphocyte Signalling, supported by strategic programme grants from the Biotechnology and Biological Sciences Research Council (BBSRC) and additional funding from research councils, the EU and charities.'* As such, they consider the overwhelming majority of their external interactions to be underpinned by physiology and have generously contributed the estimated metrics as shown in Figure 17.

While Babraham are active across all metrics, it is the collaborative research and their specialist facilities that are in the highest demand from external partners. This demonstrates not only that public investment has provided high-demand specialist facilities but also that their expertise is sought after and recognised.

Figure 17 The Babraham Institute – knowledge exchange income 2018-19



Recommendations to support physiologists to overcome barriers to undertaking knowledge exchange activity

RECOMMENDATION 9

The Physiological Society should explore establishing Knowledge Exchange Fellowships along the lines of the UKRI model either, subject to funding being available, as a standalone programme to alleviate time barriers or working in conjunction with global initiatives such as the *Marie Skłodowska-Curie Actions Research Fellowship Programme* to enhance the mobility of UK academics and the benefits to their research profiles this brings.

RECOMMENDATION 10

The Physiological Society should develop knowledge exchange continuing professional development resources for physiologists, particularly focused on mentoring and upskilling early career researchers, and work with industry partners such as GlaxoSmithKline, AstraZeneca and Unilever to develop material that will help members identify where and when external partners can most benefit from physiology knowledge exchange.

RECOMMENDATION 11

Higher education institutions should sign up to the principles of the Knowledge Exchange Concordat and use the development year to embed knowledge exchange into the culture of all institutions, ensuring that criteria around academic promotion and reward recognise successful knowledge exchange activities.

RECOMMENDATION 12

Higher education institutions should ensure there is accessible professional knowledge exchange support available and increase take-up by academics. This can be achieved through focusing on alleviating the primary barriers to knowledge exchange of time pressure and partnership building. They should provide support and training to academics for conducting knowledge exchange activities such as growing new enterprises and activities.

CHAPTER

6

CONCLUSIONS

This project set out to assess the impact that physiology makes to knowledge exchange. To this end, it can be said that physiology is a significant contributor to knowledge exchange income for those institutions that provided data, with an average of 11% knowledge exchange income related to physiology.

It was also noted that physiological knowledge exchange is an essential component of dealing with health challenges such as responding to COVID-19, as well as meeting the major societal challenges of the coming decades such as our ageing population. Fortunately, physiologists are active participants in knowledge exchange and see the value that it brings to future research, although more must be done to embed knowledge exchange to further teaching practices.

This project also identifies that barriers persist in ensuring the future of physiology's contribution to knowledge exchange in areas such as dedicated contracted time, identifying appropriate partners, and visibility of the discipline with those national organisations responsible for promoting knowledge exchange in institutions, industry and the not-for-profit sector.

This report outlines a series of recommendations that take advantage of the opportunities that exist to promote and expand physiological knowledge exchange to ensure that the UK is the best place in the world to conduct, commercialise and benefit from research, place knowledge exchange at the heart of the research and innovation ecosystem, and support academics to overcome barriers to undertaking knowledge exchange activity.

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23. Hughes *et al.* asked for responses on a five-point scale; the top two points for “important” and “very important” are summed and presented here for comparison.
24. Respondents were asked to indicate all barriers and enablers that they have experienced and indicate which were the top three in terms of significance.
25. Hughes *et al.* asked for responses on a five-point scale; the top two points for “constraining” and “very constraining” are summed and presented here for comparison.

APPENDICES

ABBREVIATIONS

ECR	Early Career Researcher
EFSA	European Food Safety Authority
ERDF	European Regional Development Fund
GCSE	General Certificate of Secondary Education
GP	General Practitioner
HE	Higher Education
HE-BCI	Higher Education Business and Community Interaction Survey
HEFCE	Higher Education Funding Council for England
HEIF	Higher Education Innovation Funding
HESA	Higher Education Statistics Authority
HRQoL	Health-related quality of life
IPR	Intellectual property rights
KE	Knowledge exchange
KEF	Knowledge Exchange Framework
KTP	Knowledge Transfer Partnership
modRNA	nucleoside-modified messenger RNA
MRC	Medical Research Council
NCCPE	National Co-ordinating Centre for Public Engagement
NCUB	National Centre for Universities and Business
NICE	National Institute for Health and Care Excellence
NSPCC	National Society for the Prevention of Cruelty to Children
R&D	Research and development
REF	Research Excellence Framework
RTTP	Registered Technology Transfer Professional
SES	Sport and Exercise Science
TSB	Technology Strategy Board
UKRI	UK Research and Innovation
UoA	Unit of Assessment



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