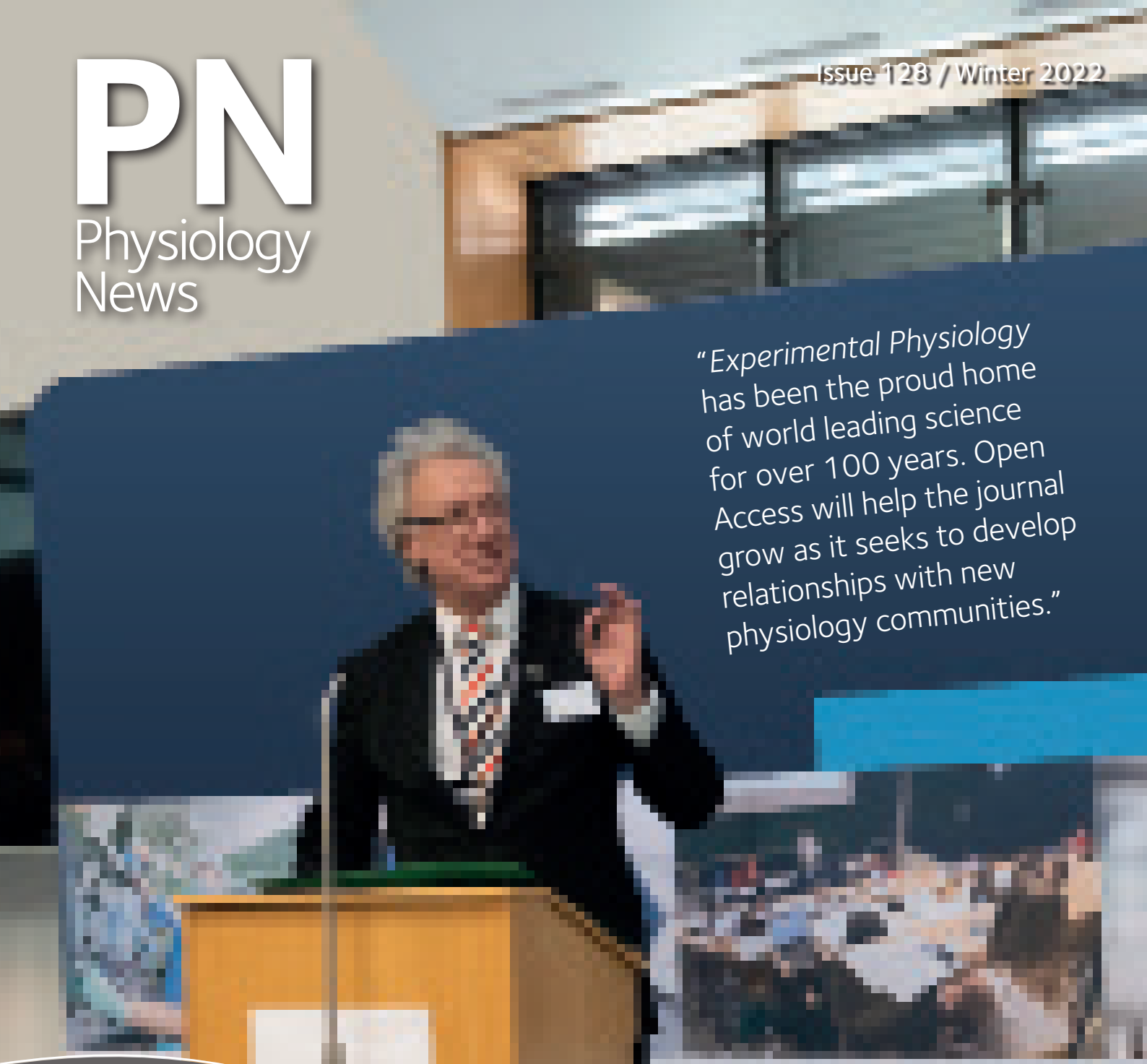
PN
Physiology News
Issue 128 / Winter 2022



"*Experimental Physiology* has been the proud home of world leading science for over 100 years. Open Access will help the journal grow as it seeks to develop relationships with new physiology communities."

President of
The Physiological Society,
Professor David Paterson

Moving to Open Access: *Experimental Physiology's Open Access future*

The Physiological Society

Contents

Welcome to the Winter 2022 edition of *Physiology News*

Introduction

News and Views

Features

Events

Membership

Cover image: President of The Physiological Society, Professor David Paterson, speaking at the launch of our policy report on physiology education and training in Parliament in June 2022

Physiology News

We welcome feedback on our membership magazine, or letters and suggestions for articles for publication, including book reviews, from our members.
Please email **magazine@physoc.org**.

Physiology News is one of the benefits of membership, along with reduced registration rates for our high-profile events, free online access to our leading journals, *The Journal of Physiology*, *Experimental Physiology* and *Physiological Reports*, and grants to help members take the next step in their careers. Membership offers you access to the largest network of physiologists in Europe.

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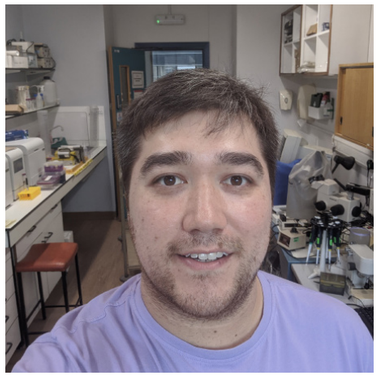

Sailing into 2023

Dr Keith Siew
Scientific Editor,
Physiology News

Welcome to the Winter issue of *Physiology News*, and what I hope will be another thought-provoking and stimulating issue of *PN* magazine for our readers.

In this issue we bring you Professor Angus Brown's recounting of the fascinating life of Peter Roget, a true polymath who despite a troubled life made innumerable contributions to both physiology and medicine, who in his spare time gifted the world the modern thesaurus (see p.20). We also have an essay from Eniola Awodiya on the interplay between genetics and physiological limitations in running speed (see p.27), as well as a discussion by Kyrstal English *et al.* on not just the similarities between hepatic stellate cells and astrocytes, but also their functional connections in regeneration and health of the brain and liver (p.24).

This time around we bring you a mini-collection of education-themed articles hot off the conference circuit at Europhysiology 2022 held in the lovely Copenhagen, Denmark this September. These were fascinating talks to attend and I'm thankful the authors have been willing to share their unique perspectives and experiences with us. Dr Paul Murphy reintroduces us to lessons from Claude Bernard and demonstrates how intertwining medical physiology and the dramatic arts can truly enrich the learning experience (see p.15). Professor Derek Scott recounts his use of popular culture in the classroom, and the highly entertaining and engaging use of Game of Thrones deaths (of which there is no short supply) to teach about pathophysiology and toxicology (see p.18). While, Kate Brown a 4th year medical student speaks about an often neglected subject in physiology and medical teachings – death. Something that at times seems taboo but is the grand ultimate physiological process, which we all must undergo, and her work opens the floor for a much-needed discussion on how we should be actively filling this gap in education and perhaps viewing death through a more physiological lens (see p.16).

And lastly, as 2022 draws to a close, and the new year approaches, I am reminded that it has been one of great change for many of us. Here at *PN* things are no different, and we are extremely grateful to Julia Turan for the solid ship she left us with, to Jane Shipley who helped navigate us through the choppy waters of transition, Alanna Orpen and Emily Wilde who have been a joy to work with, grow and learn from in this new collaboration, and now the wonderful Susan Patterson who helps steer our ship while Emily is on maternity leave (may I extend the congratulations from the whole *PN* editorial board and staff)!

But no ship can sail without its crew, and in our case, it is through the hard work and dedication of numerous volunteers who contribute to the commissioning, editing and long-term direction of *PN*. I have been very fortunate to be surrounded by colleagues who are creative and enthusiastic, diverse of background and thought, and most importantly fun to work with! However, all good things must come to an end. And so, I would like to dedicate this editorial to my colleagues and friends who are stepping down from the Editorial board, many of whom have been with me since the start of my tenure as Scientific Editor.

These are namely Dr Ronan Berg, Dr Derval O'Malley and Dr Philip Lewis who have been with us since PN111 and brought expertise in respiratory medicine, gut microbiome and chronobiology research. As well as Dr Havovi Chichger, Dr Michael Preedy and Dr Richard Hulse who joined with PN116 and have given us valuable insights into diverse areas of research in epithelium, pharmacology and neurophysiology. Your contributions over the last few years have been both immense and invaluable, we are all grateful and you will be missed. (I highly recommend you check out p.40 in the membership section to read some of their parting thoughts). I wish you all the very best of luck in all your future endeavours.

Looking forward to the future, I am excited for the injection of new ideas that comes with new *PN* editorial board members. In particular, I am pleased to announce we will be revisiting the Education Special Theme for PN130 in an aim to capture how radically the teaching landscape has changed since summer 2020 and share the exciting new innovations in the field with our readership. As always, we welcome suggestions for themes, articles and indeed letters to the editor from our readers. And with that, enjoy the well-earned holidays, Happy Near Year, and we'll see you in 2023!

Thank you to our community of members who have always inspired me during my Presidency, and farewell

Professor David Paterson
President,
The Physiological Society

As my term as the President of The Physiological Society draws to an end, I thought it would be timely to reflect on the progress we have made over the last two years.

When I began my Presidency I outlined how my tenure would be defined by three words: visibility, inclusivity and sustainability.

Visibility

In recent years the discipline of physiology has faced challenges around reducing recognition, as illustrated by the decline of physiology departments in the UK and the US. To respond to this, I have worked with the Board of Trustees and the Senior Management Team to raise the visibility of The Society within institutions as well as the discipline more broadly.

My term began during the height of the COVID-19 pandemic. COVID-19 highlighted the real-world relevance of physiological research, with the multi-organ disease showcasing the unique role that physiologists play in understanding how organ systems communicate in pathophysiological states.

The pandemic saw The Society adapt successfully to the online environment, supporting members and holding conferences to ensure physiologists were supported during this difficult period. This included our "Questions from the Frontline" initiative and our webinar on returning to the lab; such initiatives showcased how The Society can respond rapidly to changing circumstances.

The success of Questions and then Answers from the front line highlighted to Trustees the importance of physiologists and clinicians coming together to enrich one another's fields. Consequently, The Society's first ever clinical Trustee will join the Board in December.

As soon as lockdowns lifted, The Society hit the road to raise the visibility of physiology with senior leadership at institutions across the UK and Ireland, touring our Board meetings and roadshows to meet our members.

Whilst moving The Society forward is key to maintaining relevance, it is important to acknowledge our heritage and to build on this distinguished past. We launched The Society's Blue Plaque scheme last year, which honours outstanding physiologists who have contributed to the advancement of the discipline through their discoveries while leaving a legacy beyond their lifetime. By the end of this year, we will have established 15 Blue Plaques at institutions right across the UK and Republic of Ireland, including Sir Charles Sherrington at Liverpool and Oxford, Professor Mary Pickford in Edinburgh, Professor Henry Barcroft in Belfast, Professor

David and Professor Michael Gill (Trinity Institute of Neurosciences, Dublin, Ireland) at the blue plaque unveiling in Dublin to celebrate Gerald Francis Yeo

Gerald Francis Yeo in Dublin and Professor Thomas Graham Brown in Cardiff. The full list with photos of the plaques and unveiling ceremonies is on our website.

Our in-person President's Lectures have attracted significant attention, with NASA astronaut Jessica Meir giving 2021's and Sir Patrick Vallance delivering this year's. It has become an established high-profile opportunity to put physiology on the map raising the profile of the discipline with key stakeholders such as policymakers.

Physiology is a discovery science and is at the heart of tackling global challenges, therefore the work physiologists undertake in assembling physiological processes at the molecular, cellular, tissue and systems level of organisation has never been more important. Through an ongoing series of reports and projects we raise the visibility of physiology among policymakers, government, and funding organisations. This includes our recent report into physiology education, which found that physiology teaching delivers £22.6 billion to the UK economy every year and was launched at an event in Parliament where 100 physiologists met MPs and civil servants. We have also worked with Wellcome Trust and the Lancet Countdown for Health on a "Climate Change and Health Summit", supporting Wellcome in delivery of their new grant schemes in this area. Our most recent report, focused on healthy ageing and the workplace, was launched at the start of November in Parliament.

Blue plaque unveiled at Queen's University Belfast to celebrate Professor Henry Barcroft

Inclusivity

Our research communities must become more inclusive of a wider range of voices and perspectives and all of us involved in science have a responsibility to redouble efforts to promote diversity. Our new strategy has Equity, Diversity and Inclusion (EDI) at its heart, and our EDI Taskforce have worked with an expert consultant to develop our new EDI Roadmap. This Roadmap focuses on a 4-point plan with measurable KPIs that addresses the five biggest barriers to inclusion and diversity

- Lack of self-awareness
- Biased development opportunities
- Lack of role models
- Low cognitive diversity
- Fear of making mistakes

Sustainability

Our sustainability strand has been focused on the future of The Society and the discipline, as well as the health of the world in which we live.

David delivering his speech at the Physiology Education Policy report launch in Parliament

Dr Jessica Meir presented with her Honorary Member certificate by David Paterson at the Awards Ceremony and President's Lecture in November 2021

The environment in which The Society and our members operate is perhaps the most uncertain it has ever been. With Open Access leading to changes in our funding model and higher education systems under strain, we have been undertaking work to ensure The Society is sustainable for the future. The recent flip of *Experimental Physiology* to Open Access is an exciting step in the journal's 100-year history and shows our commitment to the Open Science agenda.

Finally, we have recently launched our new Sustainability Policy, which seeks to reduce The Society's impact on the environment but considering how we operate and manage our activities. The policy can be found here: physoc.org/about-us/board-of-trustees/governance-reference/the-physiological-societys-sustainability-policy/

Next steps

While as an organisation we have never stood still, the pace of change in the world around us is now greater than ever and demands a step change in how we operate to meet the challenges we will face.

It is for that reason that I am delighted that the Board has agreed The Society's new strategy to guide us through the next five years. For more about our new Strategy see the report from the Chief Executive.

I have thoroughly enjoyed my time as Society President. Throughout it all I have been inspired by our community of members; while the world of 2022 looks very different to that of when we were founded in 1876, our core purpose as a community of physiologists who work together to support each other and advance the physiological sciences remains unchanged. I look forward to continuing to be a champion and ambassador for The Physiological Society from "the back benches", as it continues to go from strength to strength under our new President, David Attwell FRS. Finally, I would like to thank the professional staff at The Society for their dedication and hard work. It has been a pleasure and an honour to work with you.

Professor Ole Peterson (Cardiff University), Dariel Burdass (CEO at The Physiological Society) and Professor David Paterson at the blue plaque unveiling at Cardiff University to celebrate Professor Thomas Graham Brown (1882 – 1965)

Exciting times as we launch our new strategy 2023–2027

Dariel Burdass

Chief Executive,
The Physiological Society

Over the past couple of years, under the Presidency of David Paterson, The Society has focused on re-engaging with its community and our wider network of stakeholders to increase the visibility of physiology through an inclusive approach so that we are sustainable for the future.

During the last year The Society has focused on developing its new strategy, which has been led by Andrew Mackenzie, Associate Director of Strategy and External Relations, who has overall responsibility for the formation of strategy within our organisation. The strategy process has involved working closely with Trustees, members, and staff to set our course for the next five years.

While it is important to note that the current strategy has served The Society well over the last five years and was ambitious and forward-thinking, our four distinctive but interconnecting strands tended to map onto the administrative departments we had set up for our own convenience rather than convey to the outside world a direction and objectives.

Good strategy	Bad strategy
Short	Long
Simple and concrete	Complex and abstract
Focused and directional	Aims to do too much
Action-orientated	Focuses on ambitions and goals
Coordinated effort	Long checklists
Takes culture into consideration	Anticipates rational and idealistic world
Flexible	Static

Strategy involves focus and, therefore, choice. And choice means setting aside some goals in favour of others. A good strategy will, by definition, not please everyone but will demonstrate how we will support physiology while providing that sense of community for members and a strong voice for our discipline through our publications, policy work, and conferences programme.

So, what does a good strategy look like?

Richard Rumelt, one of the world's foremost thinkers on strategy, noted in his book Good Strategy/Bad Strategy that:

"Good strategy recognizes the true nature of challenges and finds ways to overcome them. Bad strategy leaves you blind to your organization's challenges and chases unattainable goals without a workable plan."

"Good strategy is coherent action backed up by an argument, an effective mixture of thought and action with a basic underlying structure I call the kernel. A good strategy may consist of more than the kernel, but if the kernel is absent or misshapen, then there is a serious problem."

The strategy should therefore set the overall direction of The Society to ensure that we maximise potential both now and in the future. It should also provide the foundation for decision-making and resource allocation and describe a direction of travel towards an attainable end point so that we can all see how our activities are helping us to get there.

Rumelt's book offers three essential guideposts for good strategy:

- A Diagnosis
  A diagnosis defines the challenge in clear, simple terms. A good diagnosis distils a complex, often-overwhelming reality into a simpler story that people can act upon.
- A Guiding Policy
  A guiding policy is the broad approach to addressing the obstacles you've identified. It points you in a certain direction without dictating exactly what to do.
- Coherent Action
  Coherent actions are the ways to execute the guiding policy. These are a set of coordinated policies, resources, and manoeuvres that are aligned with and support each other.

Exemplified in the diagram below:

To thrive as a sustainable organisation, The Society needs to engage with its loyal members and also attract a continual supply of keen new members, whom we retain by involving them in activities that engage them and of which they feel part; members must be at the heart of The Society and are central to the success of the new strategy.

The new strategy is shown as a Strategy Map, which provides a visual framework for integrating strategic priorities across strategic pillars, sometimes referred to as "pillars of excellence". The strategic priorities are essential elements that provide structure and boundaries, and support the Mission and Vision. More importantly, they define the business model and allow measurable strategic outcomes (results) to be identified.

I, along with the Trustees, look forward to launching our new 2023–2027 strategy at the Member Forum on Friday 2 December.

The Society's Strategy 2023-2027

OUR PURPOSE

To support and inspire our community to advance the physiological sciences.

OUR VISION

A world in which physiological discovery leads to healthier lives.

OUR MISSION

- Increase the visibility of physiology as essential to tackling global challenges and act as a catalyst for the dissemination of knowledge.
- To champion equality, inclusion and diversity.
- To forge a sustainable future for The Society.

Strategic pillars

STRENGTHENING THE COMMUNITY:
The physiology community in the UK and Republic of Ireland will be stronger and more diverse.

SECURING THE FUTURE:
Physiology as a discipline is more secure, with research and teaching having increased funding and recognition.

IMPROVING HEALTH:
Physiology will have a greater influence in informing evidence and public policy.

Strategic principles

1. We will have a larger, more diverse community of members.
2. We will be essential to physiologists developing their career.
3. We will strengthen our links at key interfaces of physiology and between sectors.
4. We will play an influential role in shaping funding and public policy.
5. We will be a forward looking, sustainable society.

Policy engagement at the 2022 party conferences

Shania Pande

Policy Officer,
The Physiological Society

Labour Party conference

The Society's policy team headed to Liverpool, UK in September 2022 to kickstart this year's round of party conferences. The conference was filled with a quiet but confident view that Labour would win the UK's next general election among party members, parliamentarians and the media alike.

Tackling the climate crisis was central to the conference, with the conference slogan being "a fairer, greener Britain." Speaking on the main conference stage, Sir Kier Starmer pledged to launch Great British Energy, a publicly owned green energy company, within the first year of a Labour government. This follows on from Labour's 100% commitment to clean energy by the year 2030.

The Society's staff attended a fringe event with the Shadow Minister for Climate Change, Kerry McCarthy MP, and the Chair of the Business, Energy and Industrial Strategy select committee, Darren Jones MP, which discussed how behaviour change in individuals is key to achieving net zero. This relates to The Society's policy work in the area that encourages active travel and climate-friendly diets as a way to mitigate climate change. Both MPs will likely be stakeholders The Society will engage with as part of our climate change work next year.

Conservative Party conference

In contrast to the cautious optimism of the Labour conference in Liverpool, the Conservative conference in Birmingham, UK opened amid growing discontent about the impact of the Budget on the perceptions and future electoral fortunes of the party. Early Monday morning, it was announced that the (then) Chancellor Kwasi Kwarteng had been forced to reverse the decision to remove the 45p tax band for those earning over £150,000 a year.

Given both the private, and at times public, unease of many Conservative MPs over the proposals outlined in the "mini-Budget" 10 days before, many that did not have roles in Government had decided not to travel to conference this year, some at less than 48 hours' notice. As such, the MPs were conspicuous by their absence, with the exception of those high-profile MPs that opposed the tax cut. For example, The Society staff attended a Q&A session with the new Health Secretary, Therese Coffey MP, that did not feature the Health Secretary. We did, however, attend a number of fringe sessions on issues such as retaining older workers in the workforce with panellists from the Centre for Ageing Better and Mumsnet and another focused on higher education with Baroness Justine Greening, John Stevenson MP and Pete Gibson MP about ensuring higher education was at the heart of "levelling up". This event was hosted by the National Centre for Universities and Business (NCUB), an organisation The Society has previously collaborated with as part of its *Translating Knowledge and Research into Impact* report.

As a result of this engagement, The Society has secured Carole Easton from the Centre for Ageing Better as a speaker at the launch of our report into the ageing workforce. We will also ensure that the language used throughout our policy reports aligns with the new Conservative government's prioritisation of attempting to stimulate economic growth and offer policy solutions with a physiology element that meet that ambition.

Reports of The Society's recent committee meetings

The purpose of these short updates is to keep you informed about the work of our committees. The following summaries detail the meetings of the past few months.

Policy Committee

The Policy Committee met virtually in September 2022 to discuss The Society's recent policy work and set out projects for 2023. The meeting was chaired by Professor Mike Tipton, University of Portsmouth, UK.

The Committee received an overview of the ongoing policy projects by the Policy Manager, which included the National Ageing Workforce Strategy report launch and the Parliamentary & Scientific Committee event on the mitigation of climate change. The Committee discussed The Society's *in vivo* work and identified key topics on which policy work in this area should focus. This includes the MRC's introduction of a requirement, which states that unless there is a strong justification for not doing so, both sexes should be used in the experimental designs in grant applications involving animals, and human and animal tissues and cells.

The Committee discussed the impact of The Society's policy work in strengthening relationships with key funding and health-related stakeholders, and helping members further their careers by linking The Society's policy and professional development work. The Committee noted that the impact of the policy work must reflect The Society's new strategy and its objectives.

The Committee discussed three areas of future policy projects: a project focusing on the Republic of Ireland, another looking at healthy ageing within the UK, and the third specifically focusing on physiological research and climate change mitigation.

Changing Landscapes

Dr Peter Kohl

Editor-in-Chief,
The Journal of Physiology

We are witnessing an explosion in the number of published research papers, rising from 1.02 million PubMed entries in 2011 to 1.78 million in 2021. The current number is equivalent to three PubMed papers every minute! One may be forgiven for mentioning, in this context, that the income that can be generated in industrial-scale academic publishing is mind-boggling. Globally, the sector has an estimated annual turnover of ~USD 28 billion (STM Global Brief, 2021), exceeding the music industry, which generates ~USD 26 billion p.a. (IFPI, 2022). Profit margins can be in the region of 40% (STM Global Brief, 2021) helped by voluntary contributions of us scientists who do the peer-reviewing,[1] as well as submitting otherwise funded research in the first place.

You may wonder where all that money goes. For society-owned not-for-profit journals, the answer is relatively straightforward: it is used to support the charitable aims of the academic owners. This means that societies, their journals, and their membership are "in the same boat, on the same sea, sailing the same breeze" (borrowing heavily from the Rolling Stones' *Between a rock and a hard place*, 1989).[2] Therefore, when we write, review, and refer for/to journals of The Physiological Society, we are supporting a good cause!

With this in mind, and to better reflect the latest developments in the field of physiology as a whole, *The Journal of Physiology* is working to strengthen its activities not only in the three core contributing domains neuroscience, exercise, and cardiovascular physiology (which collectively account for >60% of published research), but also in the so-called "smaller fields" across the entire spectrum of physiology. In addition, we will add hitherto underrepresented domains, namely "physiological omics", and "data science & modelling".

This undertaking is backed by a series of nearly 20 Special Issue topics that will be announced over the course of the next year, led by members and fellows of our marvellous Editorial Board. With regard to the two new scientific domains, above, I am delighted to welcome Jeannette Erdmann, Professor for Cardiogenetics at the University of Lübeck, Germany, and Natalia Trayanova, Murray B. Sachs Professor and Director of Computational Cardiology at Johns Hopkins University, US, as new Senior Editors at the journal. Both are international leaders and keen to encourage submissions that extend our scope of publications.

The final 2022 issue of *The Journal* will also see the launch of a new article category: Opinion. These will offer stimulating conceptual views on exciting new and/or controversial areas of physiology research, and they are hoped to help foster exchange across our community, ideally seeding new ideas for further research. The first Opinion will be by Denis Noble, Emeritus Professor of Physiology at Oxford, and long-term member of The Society (On 31 December 2022, Denis Noble will have been a member of The Society for 60 years. Congratulations, Denis!).

Tectonic changes are afoot at *Experimental Physiology* too. From January 2023, the journal will be fully Open Access. We wish the team, authors, and readers a productive journey on this exciting endeavour. Much to be learned.[3]

Let me finish by encouraging you to get in touch if you have suggestions for Special Issue topics, reviews, Opinion papers – or comments on how *The Journal* may serve you and The Physiological Society better.

With the best wishes for a peaceful 2023,
Peter Kohl

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IFPI (2022). *IFPI Global Music Report – State of the Industry*. Available online **at** https://www.ifpi.org/wp-content/uploads/2022/04/IFPI_Global_Music_Report_2022-State_of_the_Industry.pdf

STM Global Brief (2021). *Economics & Market Size*. Available online at https://www.stm-assoc.org/2022_08_24_STM_White_Report_a4_v15.pdf

Footnotes

1. Ideas for rather rigorous changes in peer review are being tested, such as by eLife: https://elifesciences.org/articles/83889 who propose "*Peer review without gate keeping*". No doubt, this would further increase throughput via the system. What this will mean for the balance of quantity and quality remains to be seen.
2. The rock-and-a-hard place setting from The Rolling Stones song fits current changes in our publishing landscape perfectly.
3. For those readers of *Physiology News* who are still trying to figure out implications of "Plan S", a research funders (incl. UKRI and Wellcome) backed a drive backed by research funders (including UKRI and Wellcome) to require scientists to publish outside journal paywalls, there is a helpful summary: https://www.nature.com/articles/d41586-021-00883-6. As an aside, the "S" in Plan S apparently stands for any of the following: "science, speed, solution, shock", https://www.nature.com/articles/d41586-018-06178-7, in case you wondered.

Inspired by space physiology: Shoot for the stars and believe in the beyond!

Professor Damian Bailey

Editor-in-Chief,
Experimental Physiology

"No one would have believed
In the last years of the nineteenth century
That human affairs were being watched
From the timeless worlds of space
No one could have dreamed that we were being scrutinized
As someone with a microscope studies creatures
That swarm and multiply in a drop of water
Few men even considered the possibility of life on other planets
And yet, across the gulf of space
Minds immeasurably superior to ours
Regarded this Earth with envious eyes
And slowly and surely, they drew their plans against us"

You're likely all too familiar with this opening verse taken from Jeff Wayne's musical version of "The War of the Worlds", first published by H.G. Wells in 1897 and later released by CBS records in 1978 (classified as progressive rock, no less). I was instantly hooked when I got my first taste as an 8-year-old. Narrated by Richard Burton who starred as the "journalist", that well-known Shakespearean actor whose mellifluous gravelly deep baritone voice, forged in the Welsh Valleys, was simply captivating. And as one of the earliest stories about mankind and aliens, the mélange of science, space and good triumphing over evil set my imagination alight, as Wells openly explored fictional extremes of natural selection.

That childhood spark, fuelled by a fascination for science, space and adventure, has stood the test of time. Some four decades later, an opportunity to perform physiological experiments with the French Space Agency to determine how the brain responds to the micro- (and hyper-) gravity of parabolic flight (Bailey *et al.*, 2020) combined with an appointment to Chair of the Life Sciences Working Group (LSWG) to the European Space Agency (ESA), and as a member of the Human Spaceflight and Exploration Science Advisory Committee (ESA) and Space Exploration Advisory Committee (UK Space Agency), helped fan those formative flames.

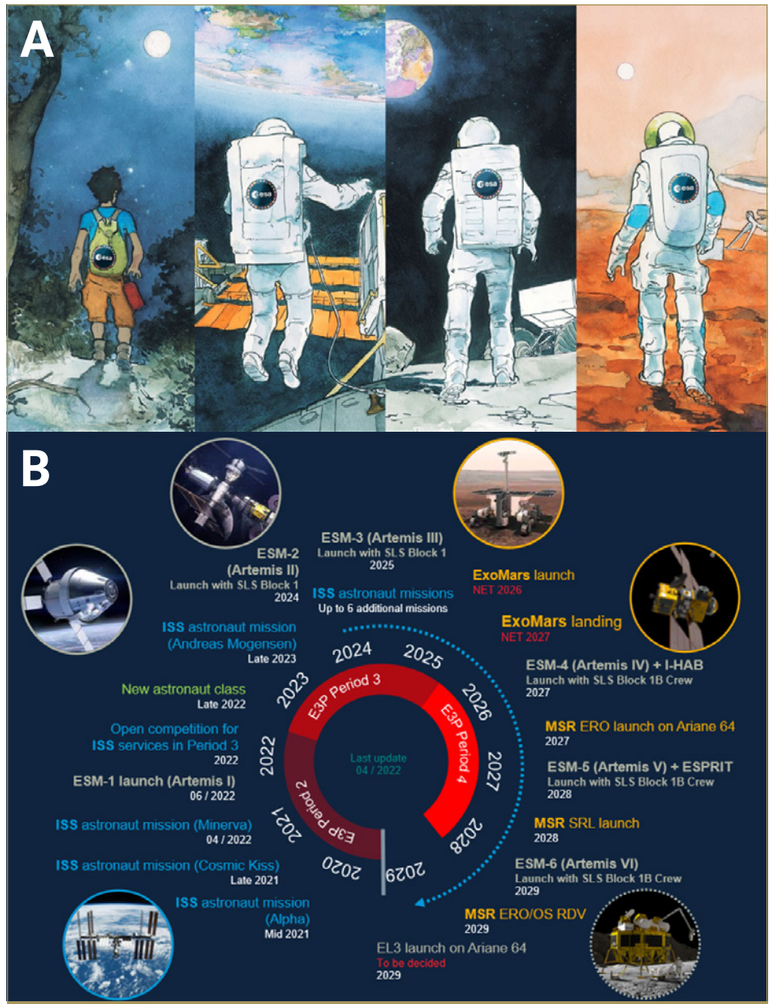

Figure 1. Visual (A) and programmatic (B) aspects of the Terrae Novae 2030+ Strategy. A. Artist's impression of the three destinations, low Earth orbit, Moon and Mars. Image copyright: Olivier Pâques, European Space Agency. B. Proposed timeline of the major milestones. EL3, European Large Logistic Lander; ESM, European Service Module, I-HAB, International Habitation Module; ESPRIT, European System Providing Refuelling, Infrastructure and Telecommunications; ERO, Earth Return Orbiter; SRL, Sample Return Lander; OS, Orbiting Sample; NET, not earlier than. Figure taken from ESA (2022).

Free falling

No words can describe the wonders of weightlessness during the "zero-g" phase of parabolic flight (albeit a meagre 25-30 s worth per parabola!), that fundamental constant that has helped shape our physiology since the dawn of time. The former physiologist-astronaut Dr James (Jim) Pawelczyk who flew aboard the 1998 NASA STS-90 Space Shuttle mission as a Payload Specialist and who described his experiences in an earlier issue of *Physiology News* (Pawelczyk, 2020), commented, "If you can imagine yourself falling but not feeling any wind, that is exactly the sensation you have of being in space". Fun freefall aside, it's the experience leading LSWG, the senior advisory body to the Director of Manned Spaceflight and Microgravity on all matters concerning life and physical science research in space, that has proven the most illuminating. I simply wasn't aware how omnipresent physiology truly is, not simply shackled to life here on Earth, but permeating "across the gulf of space", coined by Wells himself.

And the one duty that LSWG was tasked with that really "brought physiology home" involved providing specialist input into ESA's Human and Robotic Exploration Terrae Novae 2030+ Strategy Roadmap document (ESA, 2022). Its objectives are bold and ambitious, creating new opportunities in low Earth Orbit for a sustained European presence after the International Space Station. It enables the first European to explore the Moon's surface by 2030 ("boots on the Moon") as a step towards sustainable lunar exploration in the 2030s in preparation for the horizon goal of Europe contributing to the first historic human voyage to Mars (Fig.1A-B).

Exploring uncharted territories

And when it comes to extreme environments, for which *Experimental Physiology* has an established track record, space certainly sweeps the superlatives. Since the first human spaceflight by Yuri Gagarin aboard Vostok 1 on 12 April 1961, it has become increasingly clear that the extremes of gravitational shifts, ionising radiation, hypoxia, hypercapnia, celestial dust, decompression sickness, physical inactivity, malnutrition, and confinement pose unique physiological challenges that collectively threaten not only mission success but more importantly, human survival (Afshinnekoo *et al.*, 2020; Bailey *et al.*, 2021; Bailey and Carpenter, 2022). The ambition to push into unchartered territories culminating in a (wo)manned mission to Mars some ~55 to 400 million km from Earth (orbit dependent), has called into action an urgent need to provide deeper "phenotyping" of each of these risks and their integrated physiological impact. A safe return, above all, has to be our number one priority.

To that end, LSWG alongside ~300 specialists have since contributed to the formulation of sixteen "White Papers" reflecting the life/physical science communities' recommendations on fundamental research questions that warrant consideration within the scope of the Terrae Novae programme as well as enabling exploration and addressing terrestrial applications (ESA, no date). Stand-alone White Papers have been published for Human Physiology (ESA, 2021a) and Integrative and Countermeasures Approach (ESA, 2021b) themes that I encourage you to read and digest; so much food for thought and future experimentation! The latter White Paper is especially impactful since it prescribes a multidisciplinary translational approach to guide and inform the design/implementation of optimised countermeasures to mitigate the physiological risks posed by deep spaceflight (ESA, 2021b).

The promise of wonder and adventure

This exercise highlighted how ubiquitous physiology truly is, transcending numerous themes (Fig.2) forcing a reappraisal and newfound need to understand potential cross links, which has stimulated discussion and collaboration between other research disciplines that have traditionally operated *sui generis*. This was very exciting and a most rewarding experience, and the collaborations forged once again speak volumes to the "power of physiology" (Bailey, 2022).

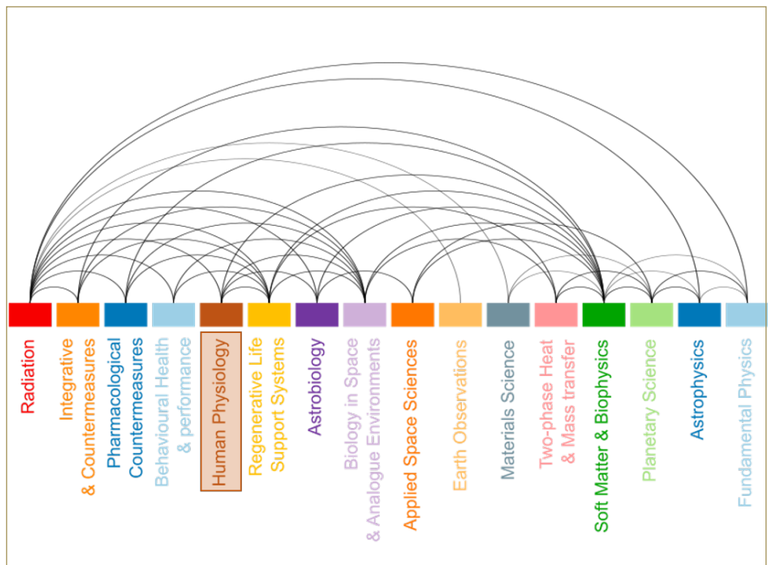

Figure 2. Human physiology "connectome" within the European Space Agency's SciSpacE programme. Note how the discipline of physiology connects and overlaps with others, highlighting its interdisciplinary impact. Figure adapted from ESA (2021a).

And to our younger generation of physiologists, do not fall foul of the same blinkered approach that P.S. Buck, who in his novel *The Good Earth* openly admitted to, "Like Confucius of old, I am so absorbed in the wonder of Earth and the life upon it that I cannot think of heaven and angels" (Buck, 1931). Space physiology has never been more alive, relevant and adventurous, begging answers to some of the most challenging questions that could also help shed unique insight into our understanding, treatment and prevention of terrestrial diseases, notwithstanding the technological advances. Shoot for the stars and believe in the beyond!

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Experimental Physiology's Open Access future

From January 2023, *Experimental Physiology* will be fully Open Access.

Since it was established in 1908, *Experimental Physiology* has published research articles that report novel insights into homeostatic and adaptive responses in health, as well as those that further our understanding of pathophysiological mechanisms in disease.

From 18 October 2022, any article submitted and accepted for publication in *Experimental Physiology* will be published Open Access under the terms of a Creative Commons Attribution licence (CC BY). These articles will be accessible by anyone, anywhere. This change will benefit the journal's global readership and authors, and The Society anticipates those publishing in *Experimental Physiology* will see increased downloads and citations of their research, increasing its visibility, reach and impact.

All accepted articles will be subject to an Article Publication Charge (APC), to cover the cost of publishing. Many authors will have these fees covered by transitional agreements made between their institutions and our publisher, Wiley, but The Society is pleased to be able to offer a number of waivers to ensure that payment is not a barrier to publication.

The transition to Open Access further illustrates *Experimental Physiology*'s continued commitment to the principles of the Open Science movement. For more information, please read the frequently asked questions.

Experimental Physiology is part of The Physiological Society's family of journals, including also the *Journal of Physiology* and *Physiological Reports*.

Commenting on the announcement, President of The Physiological Society, Professor David Paterson said:
"This is a momentous occasion for The Physiological Society. Experiment Physiology has been the proud home of innovative, world-leading science for over 100 years and this is the most significant change to its publishing model in its history. It represents a fantastic opportunity for research in Experimental Physiology to reach as wide an audience as possible."

Editor-in-Chief of *Experimental Physiology* Professor Damian Bailey said:
"I, along with the Editorial Board, am energised by the opportunity this provides for Experimental Physiology to continue to grow, diversify and further connect the physiological community it serves. Both authors and readers of the journal will benefit from this historic change. Experimental Physiology's mission remains constant and we look to physiologists across the world to join us in this enterprise, by submitting manuscripts and contributing to reviews."

Chair of The Physiological Society's Publications Committee Professor Paul McLoughlin said:
"We are very pleased to be able to make this historic announcement. This move will help us strengthen Experimental Physiology's links with existing and emerging physiological research communities."

Vice President of Open Research at Wiley Kathryn Sharples said:
"Wiley is committed to a future in which more and more of the world's research is open and available to make the biggest impact. We are very excited that Experimental Physiology is moving to a fully Open Access model and look forward to continuing our partnership with The Physiological Society on this next phase of the journal's evolution".

Frequently asked questions

I submitted a manuscript to *Experimental Physiology* before 18 October 2022, which is currently out for review/under revision. Will I have to pay an APC if my article is accepted?
No. We will honour free publication for all articles submitted before 18 October 2022. If the article is accepted and assigned to a 2023 issue, these articles will all be published Open Access.

I was invited to submit a manuscript to *Experimental Physiology* by the Publications Office before 18 October 2022, but I have not yet submitted it. Will I have to pay for an APC if it is accepted?
No, content commissioned prior to 18 October 2022 will not be subject to an APC.

As a reader, what are the benefits of Open Access?
Providing you have internet connection, you will be able to access all articles published in *Experimental Physiology*, regardless of where you live, or whether or not you are affiliated with a certain institution.

As an author, what are the benefits of Open Access?
Given there are no restrictions on who can access your work, your articles will be read, and cited, markedly more. This increases the visibility, reach and impact of your research.

How much will the APC be?
From 18 October 2022, the APC for research papers and review articles published in *Experimental Physiology* will be $2,800 (USD)/£2,150 (GBP)/€2350 (EUR). The APC for Short Communications and Case Reports will be £$1,400 (USD)/£1,075 (GBP)/€1,175 (EUR). Editorial matter and Registered Result Protocols will not require the payment of an APC.

What if I can't afford the APC?
We understand that an APC will be a barrier to publication for some authors. A considerable percentage of our existing author base work in institutions that have agreed deals with our publisher, Wiley, which cover these fees automatically. You can check whether your institution is covered online at Wiley Author Services.

If your institution is not covered, and you lack the funds to cover an APC, you should contact *Experimental Physiology's* Editorial Office prior to submission. The journal has a finite number of fee waivers we can apply to ensure those who cannot afford an APC are not barred from publication.

Please note that our publisher, Wiley, also offers automatic waivers and discounts to corresponding authors based in low- and lower middle-income countries. You can check if you are eligible online at Wiley Author Services.

I am part of a cross-institution collaboration, and looking to submit to *Experimental Physiology*. Some of these institutions are covered by Wiley deals, but some are not. Is there a policy relating to the payment of APCs here?
Yes, Wiley will use the corresponding author's institution/funder mandates in these instances.

What is a CC BY license?
Publishing under this license enables authors to retain copyright to their work. It is a Creative Commons attribution license that permits use, distribution and adaption of the original article in any medium, providing it is cited properly.

Does a flip to Open Access compromise the quality of accepted articles?
No! There will be no change to *Experimental Physiology*'s editorial policy or peer-review processes.

If you have any other questions, please email our Publications Office at: ephjournal@physoc.org.

Collection of education-themed articles from Europhysiology 2022 conference

Claude Bernard, playwright, and the value of the dramatic arts for physiology education

Dr Paul Murphy
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The young Claude Bernard, bored with life as a pharmacist's assistant in Lyon, France spent his free time watching plays at the Théâtre des Célestins, and was inspired to write a vaudeville comedy "La Rose du Rhône", which was performed to some acclaim but never published (Foster, 1899, p.7). Following his first theatrical success Bernard wrote a more ambitious historical play in five acts, initially framed as a tragedy but later changed into a prose drama. With play in hand he travelled to Paris to make his fortune where he was received by the eminent scholar Saint-Marc Girardin at the Sorbonne. Girardin noted that the play, *Arthur de Bretagne*, possessed real artistic merit but rather than encouraging Bernard to continue as a playwright he suggested that he pursue a career in medicine and write plays in his spare time: "'You have studied pharmacy', said he, 'study medicine, you will thereby much more surely gain a livelihood'" (Foster, 1899, p.9). And so the world lost a promising playwright but gained a physiologist who became a titan of medical science.

Mise-en-scène

Bernard famously developed the concept of *milieu intérieur* to describe the extracellular fluid forming the environment of cells in a multicellular organism. *Milieu intérieur* or the internal environment cannot be fully understood or meaningfully separated from *milieu extérieur* or the external environment. For example, a human being has to breathe in air, which is processed by the lungs and oxygen is then distributed to the bloodstream. The field of epigenetics focuses on how an individual's behaviours and interaction with their environment can lead to changes that affect the way their genes function.

The consumption of food, the transfer of knowledge in the process of communication and every other aspect of human behaviour involves the social interaction between an individual and their environment. Indeed, all scientific knowledge is an outcome of the social interaction between individuals. In stagecraft the technical term for external environment, as Bernard knew well, is *mise-en-scène* or the stage setting, and the scenery and properties of a stage production. The technical term for the interaction between individuals on stage is drama, from the Greek noun δρᾶμα meaning deed, or action, derived from the verb δρᾶν meaning to do, act, or perform (OED online).

Delivering a winning performance

Simulation-based education (SBE) (Nestel *et al.*, 2018) is traditionally manikin-centred but there has been movement in recent years towards a more person-centred emphasis, particularly regarding the involvement of simulated patients (SPs) (Nestel and Bearman, 2015) who perform the role of the patient in training sessions. The kind of training SPs receive varies widely depending on the country and institution in which they work.

Over much of the last decade I have designed and delivered SBE with staff in social work, and healthcare disciplines including medicine, nursing, midwifery, psychology, psychiatry and most recently physiology, and pharmacy. The collaborative education often involves drama students performing as SPs, and a common finding that emerges from both staff and student feedback is that the drama students provide high-fidelity performances that are comparable and often indistinguishable from real patients (Walsh and Murphy, 2017).

The power of role play

Person-centred engagement is often consigned to communications courses, which make up a small percentage of the curricula of most healthcare disciplines. The overwhelming focus is on teaching students subject-specific technical knowledge and skills, with the content in communications courses often referred to as non-technical skills. The deficit model description of communication skills as non-technical is problematic and leads to the derogation of skills, which are nonetheless essential to effective healthcare (Murphy *et al.*, 2019).

In a recent collaborative educational initiative I worked with colleagues in the physiology education team at Queen's University Belfast to address this issue focusing on a case centred around a 34-year-old woman experiencing idiopathic premature menopause. The role of the woman was performed by drama students and the role of the doctor was performed by second-year medical students. The aim was to take physiology education off the page and onto the veritable stage where students interacted in a live, high-fidelity SBE scenario.

Why healthcare should embrace the arts

In the feedback questionnaire the medical students reported that the live simulation really contextualised physiology, and that they found the experience challenging, engaging, and authentic, and more realistic than family placement or a very scripted OSCE examination. The drama students found the simulation worthwhile in contributing to the education of medical students as future healthcare professionals, and gained value from acting in a situation that very few students of the dramatic arts have the opportunity to experience. The takeaway for physiologists and healthcare educators more generally is to imagine an alternative reality where Claude Bernard, rather than abandoning the dramatic arts for medical science, sought to combine them in order to enliven and enhance physiology education.

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We need to talk about death

Katie Brown

Fourth-year medical student, University of Aberdeen, UK

There are few certainties in life – but one is that it will unequivocally end in death. Indiscriminate of gender, race, wealth or virtue, death is an inevitability certain to all. However, death is not merely an event. Death is a process – a process that has a universal outcome, at least in the physiological sense, but which is itself unique to every human life. However, the fundamental biological mechanisms underlying the process of death are almost entirely invariably consistent. Furthermore, these mechanisms may be simply explained by consideration of some central principles of physiology – a foundational bioscience subject in healthcare education – such as those proposed by Michael and McFarland (2020) to be the "core concepts of physiology". Physiology teaching resources, such as textbooks, so often contain lengthy descriptions of conception, birth and development, but absolutely nothing about the natural events that occur at the other end of life. Moreover, whilst there is evidence to suggest that palliative and end-of-life care teaching has become more prevalent across healthcare curricula (Walker *et al.*, 2016), the extent to which the process of death itself and the applicable underlying physiological mechanisms are explored in educational programmes is much more limited. If we as scientists and healthcare professionals are not willing to teach or discuss the subject of death, why would we expect students to understand what happens at the end of life?

Why is death omitted from the conversation?

All physiology textbooks include detailed descriptions of the processes of cell death, such as apoptosis and necrosis. However, there is a significant scientific void in the exploration, discussion and understanding of the physiological basis of the changes that the human body goes through at the end of life. Those caring for patients – no matter of profession, position or speciality – ought to have, as an absolute minimum, a basic appreciation of the physiology of dying – just as knowledge of cardiovascular, respiratory and reproductive physiology is an expectation of those such individuals working in healthcare (The Physiological Society, 2020). Death can occur suddenly and unexpectedly or may be a more insidious and gradual process. Irrespective of the trajectory of death (Fig.1), if the dying process is not recognised due to a lack of such education, preparation to manage the dying patient, and those dear to them, cannot be expected to be even close to adequate. This can consequently cause or contribute to a state of high distress for all those aforementioned. It is therefore critical that the clinical observations indicative of the dying phase of life or imminent death, and crucially over and above this, the biological processes that cause these changes to arise, are made known to all healthcare professionals.

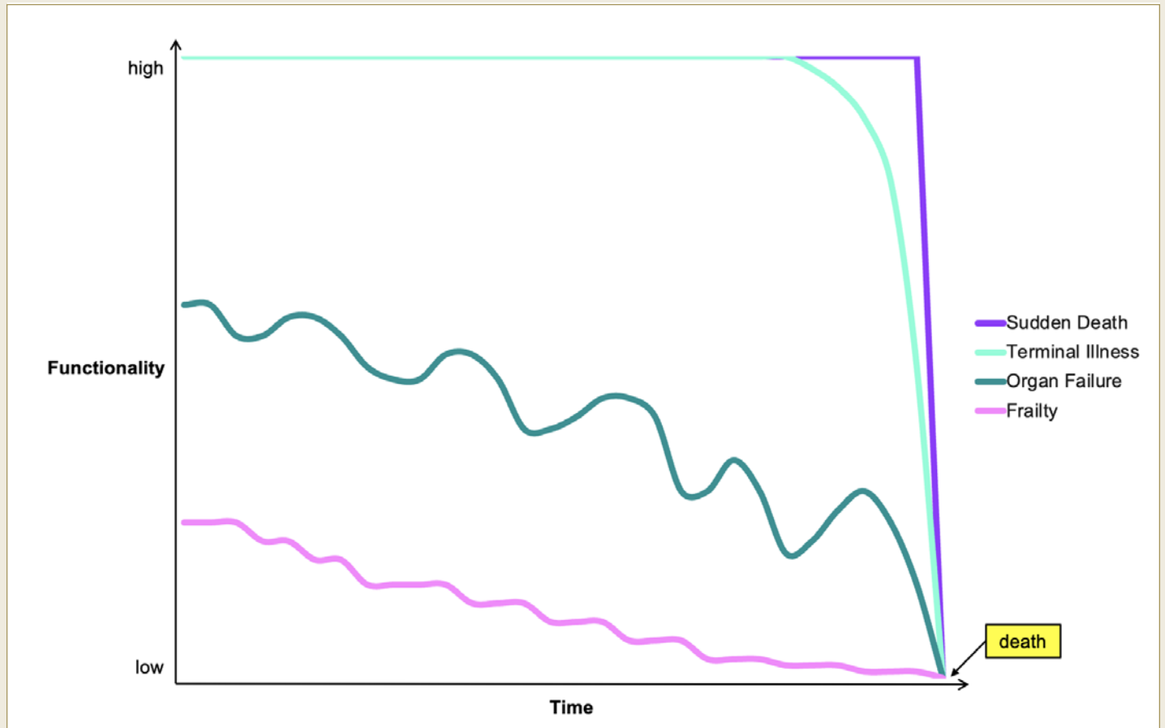

Figure 1. Graph showing trajectory of death

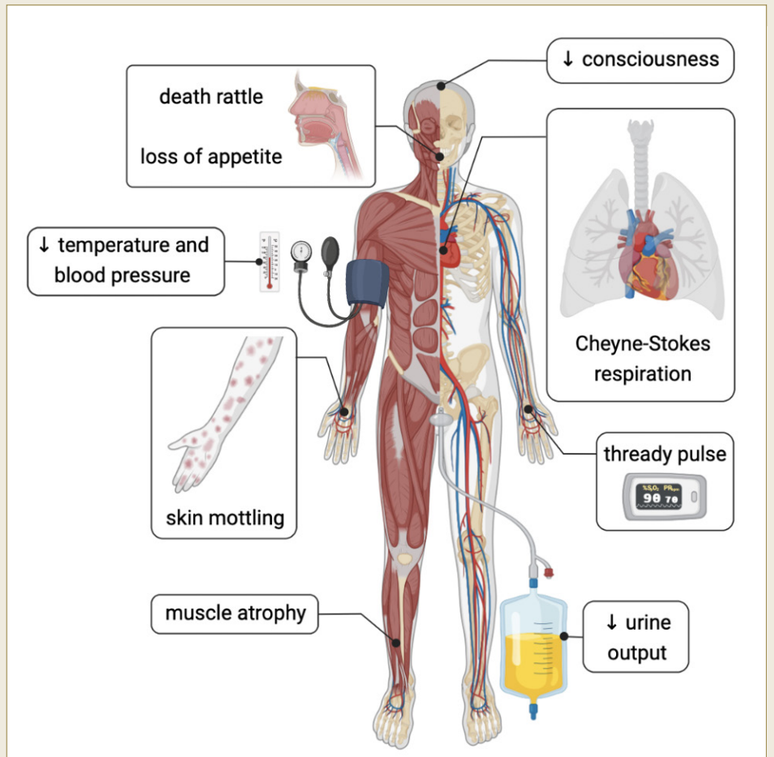

Figure 2. Illustration showing the medical signs characteristic of the dying process

The death rattle and understanding the dying phases

The medical signs characteristic of the dying process include Cheyne–Stokes respiration and the so-called "death rattle" (Hui *et al.*, 2014) – but these terms alone with no further description do very little to explain the changes that the dying human body is experiencing. Further noticeable alterations towards the end of life, as detailed by Minett and Ginesi (2020), include increased somnolence, mottling of the skin and reduced ability to maintain consciousness. The dying process, and the synonymous clinical observations (Fig.2), although unique to each and every individual, can be attributed to a much more finite range of physiological mechanisms, such as inadequate circulation or respiration, irreversible metabolic disturbance and loss of organ function. A grasp of these such biochemical and physical processes can shed light onto why apnoeic breathing, dysphagia and agitation occur at the end of life and, crucially, why death is happening. Such understanding can, in turn, facilitate the conversations with those close to the dying, which even the most experienced healthcare professionals can struggle to face at times. A clear, calm and honest explanation of what is happening to their loved one and what can be expected to be seen can, time and again, alleviate anxiety and distress – as described anecdotally by the prominent palliative care physician Dr Kathryn Mannix, in her critically acclaimed forthright memoir *With the End in Mind: How to Live and Die Well* (2018).

Buried six feet under – a problem for healthcare education

Discussion about death, in the educational, healthcare and day-to-day setting is necessary and relevant to all – now more so than ever. In January of this year, the *Report of the Lancet Commission on the Value of Death* was published, in which it was advocated that education about death "*be integral, substantial and mandatory in the curriculum of every health and social care student*" and continued throughout professional practice (Sallnow *et al.*, 2022). Several healthcare curricula guidance publications or benchmark statements issue recommendations or requirements of the expected standards of physiology teaching and understanding. A comprehensive appreciation of physiological processes "across the lifespan" (College of Operating Department Practitioners, 2018; College of Paramedics, 2019) is often stipulated. Some resources further clarify the accepted constitutive phases of the continuum of life, including the publication by The Physiological Society, *Physiological Objectives for Medical Students* (2020), identifying "foetal, neonatal, childhood, adolescence and adulthood" as the distinctive stages of human life. However, none of the documents examined considered death as such a part of life, nor specified a necessity for an understanding of the biological mechanisms underlying dying and death. Surely this is a glaring omission in the education and practice of our healthcare science and professionals of the moment and of the future who care for our dying, dead and bereaved? The discussion has to start somewhere – but without reconsideration of the content of current healthcare and physiology education programmes and attitudes towards the delivery of teaching about death, this subject matter will continue to be buried six feet under. We simply cannot afford to allow this to happen – we need to talk about death.

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News and Views

Using Game of Thrones to teach physiology

Professor Derek Scott
University of Aberdeen, Scotland, UK

How many of us remember during pandemic lockdowns, desperately trying to come up with new and exciting online tutorials that would engage students whilst encouraging them to problem-solve and use their imagination? Easier said than done. My own creativity was starting to run somewhat dry – that is until my lockdown binge-watching came to the rescue. I had finally managed to catch up on all episodes of Game of Thrones from beginning to end and realised that poisons were a recurring theme in the series. Why not use that as the topic of an upcoming tutorial? Given that many people assume that Aberdeen is the equivalent of Winterfell, I decided to give it a try.

Fictional characters help students understand physiological concepts

Previous work by Berg and Polvsing (2016), Fitzgerald (2018) and Brown *et al.* (2017) have all shown the worth of using fictional characters to help students expand and demonstrate their understanding of complex biomedical concepts. I wanted memorable topics where students would actively participate and apply what they had learned in classes – I had previously used Berg and Polvsing's article about Darth Vader with great success! Given the popularity of Game of Thrones, we tried to use different storylines to get the students to work out how the fictional poisons/drugs depicted might affect physiological functions. My hope was that even some of the less interactive students might find this unusual enough to contribute more during these online classes.

What's your poison?

We trialled this approach with students studying a neurophysiology and neuropharmacology module. Many poisons (both fictional and real) target mechanisms and processes that are commonly discussed in courses relating to neuroscience, physiology and pharmacology. Our idea was to flip the classroom during synchronous, online hour-long tutorial sessions and encourage students to apply the knowledge that they already had and use it in novel ways to solve problems. Students (n = 80) did not have to be aware of the content of the television programme, but they could access free video clips on platforms such as YouTube if they wanted to. Students were given some basic scenarios (See Fig.1) to think about. We provided some ideas to get them started (see Fig.2), but the students had to do the rest. These tutorials allowed students to demonstrate not only their mastery of discipline-specific knowledge, but also the wider graduate attributes of imagination, problem-solving, lateral thinking, and originality.

Character	Features	Topics to explore
Cersei Lannister	Delivers poison by a kiss to Tyene Sand. We are told the poison is called "The Long Farewell". Symptoms include bleeding from the nose, blurred visionand nausea.	Why doesn't Cersei die if she has the poison on her lips? What can we tell about the drug if it can be transferred lip to lip? Why might it take a long time to have an affect? What processes do you think the drug might be acting upon?
Olenna Tyrell	Given poison by Cersie Lannister. Drinks it in wine. We are told there will be no pain or horrible side-effects. Dies relatively quickly.	Does this drug sound like anything we have discussed in the course? What mechanisms might this drug be acting upon if it causes death with no pain/distress?
Joffrey Baratheon	Poisoned at own wedding in his drink with something called "The Strangler". Problems breathing, starts to b eed and skin goes purple. Acts within minutes.	What mechanisms that control breathing might this drug be targetting? Why are blood vessels involved? How might we try and reverse such a poison?

Figure 1. Typical tutorial scenarios for students to consider

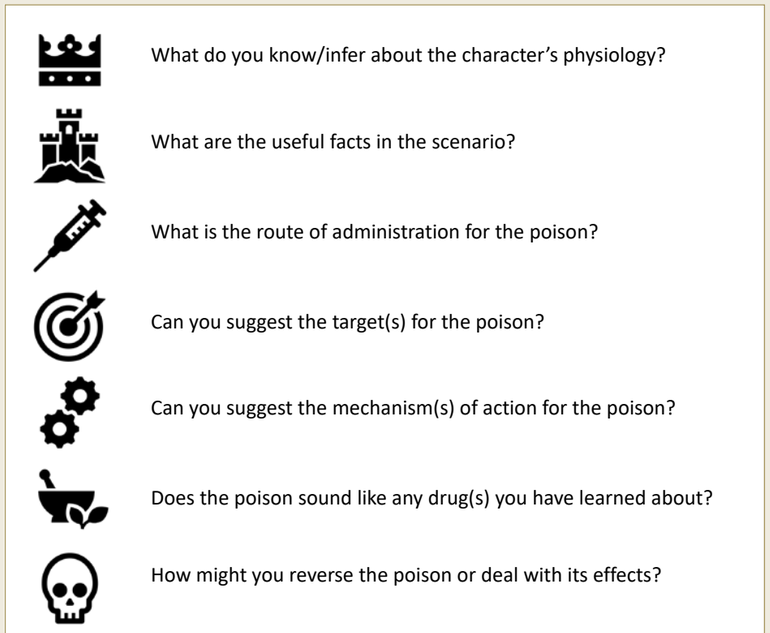

Figure 2. Things to think about when considering the scenario

The story so far

Other traditional tutorials in the course that focused on real-life physiological or pharmacological problems (n=11) had an average of 52 comments in the online chat. The comments usually came from the same 7 or 8 students. The Game of Thrones tutorials (I only planned one but ended up doing three on this theme due to student demand) had an average of 203 comments in the online chat, with comments from at least separate 60 students contributing per session. Tutor perceptions were that students were much better at demonstrating their mastery of the discipline-specific material when asked about it in this fictional context, compared to 'dry' questions that related to everyday pharmacology or physiology problems. Tutors thought the increased engagement was great but 'exhausting'. There were a far greater number of follow-up questions via email from individual students (minimum n = 43) after the sessions took place when compared to the other traditional problem-solving tutorials (tutors reported an average of three after such events).

We were delighted that more of the students seemed to be engaging with the material and thinking about whether the science would be possible or not. We stressed that these were not real situations, and the drugs or poisons were fictional, therefore there may not be one correct answer. My students sometimes struggle to accept the concept of ambiguity and these tutorials allowed us to highlight that we don't always know the 'right' answer, but we can use our knowledge of fundamental physiology to help us narrow down the possibilities.

The plot thickens

We've continued using these scenarios this academic year when we returned to face-to-face teaching, and their popularity has continued. Our students have already started working on their own fictional characters/scenarios in their own time to explore how valid the science might be. We've had discussions ranging from the poisons used in Agatha Christie novels, to what exactly was in Snow White's apple! It may sound bizarre, but this approach can be engaging for both students and tutors. Why not try it yourself? And if anyone asks who you got the idea from, tell them. I want them to know it was me....

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Peter Mark Roget:

Polymath extraordinaire

Hana Beswick-Jones

Amy J Hopper

Dr Angus M Brown

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The development of mental illness can condemn the sufferer to a life of solitude, frustration, and thwarted ambitions. Even those who manage to cope with their affliction tend to suffer prolonged periods of inactivity and hopelessness, characterised by reduced productivity. Peter Mark Roget, however, author of the eponymous *Thesaurus*, was able to channel his mental illness to constructive ends, his inquisitive nature directed to searching for a sense of order, which was evident in his diverse occupations as physician, physiologist, mathematician, and author. As such Roget can be considered a positive role model, an example of an individual who prevailed in the face of the considerable challenges that accompany a diagnosis of mental illness. His best-known work, the ubiquitous *Thesaurus*, changed the world, and as we celebrate 170 years since its publication, it remains an essential and treasured tool for novice and experienced writers alike.

Childhood

Early events in Roget's life shaped his personality. Born in London on 18 January 1779, he was 6 months old when his parents, Catherine Romilly and Jean Roget, travelled to Switzerland in the vain hope of treating his father's tuberculosis. Roget was left in the care of his maternal grandfather, Peter Romilly, a prosperous jeweller and one-time neighbour of the Mozart family during their stay in London in 1764, Romilly attending concerts given by the 8-year-old prodigy. Rogets's father died in 1783, soon after his return from the continent, an event that had a devastating effect on his mother, who recalled her life as perfect happiness prior to her husband's death. The mores of the day dictated young widows with limited financial means had little chance of remarrying and she was condemned to a life of widowhood. Catherine was unable to receive counsel for her grief, her solitude compounding her heartache, leading to depression and a listlessness that compelled her to move with Roget and his younger sister, Annette, several times a year. Such rootlessness instilled in Roget a sense of instability and inability to form attachments with his peers. A teacher commented to his mother that "I am still surprised he hasn't found a friend to enliven his activities." Catherine's mother had been subject to schizophrenia-like symptoms, ascribed to the early deaths of six of her children, and the family tree (Fig.1) illustrates how mental illness (diagnosed retrospectively from contemporary accounts of symptoms and behaviour) haunted the family through four generations. Catherine would measure her life against her son's achievements, becoming overbearing and interfering. The more she smothered Peter the more he recoiled and retreated, developing into a classic loner. When he was 8 years old, he began compiling lists, starting with "Dates of Death", in which he noted the passing of friends and family members, a list he updated until he was 78 years old. One of Roget's schoolteachers was a Swiss preacher, Etienne Dumont, who encouraged Roget's fascination with words and astronomy, his interest in Roget inspiring the boy to immerse himself in these subjects. These academic pursuits would prove pivotal to Roget's future achievements, his interest in words embracing astronomy, geometry, and algebra, with Roget considering mathmatics as a pure language, which has rigid rules for describing abstract concepts (Kendall, 2008).

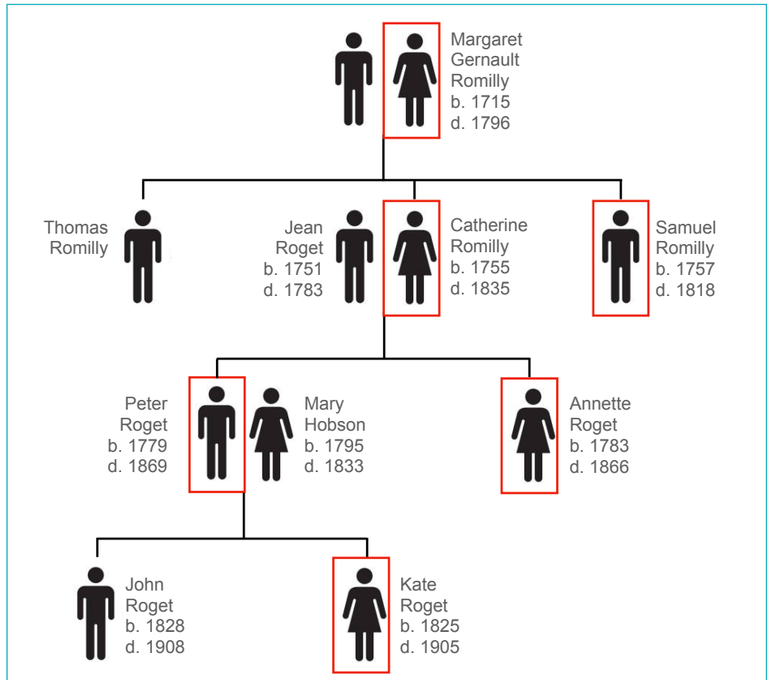

Figure 1. A tree of Peter Roget's immediate family, those who suffered serious mental illness enclosed by a red border.

Psychologists assert that between the ages of 8 and 12 is when children invent paracosms, imaginary private worlds. The importance of these worlds is that they allow children to ignore the stresses and uncertainty of the real world, and instead inhabit a world of their own devising, where they feel comfortable, secure, and at ease. Children tend to sustain an interest in these paracosms their entire lives, and such was the case with Roget. He created a paracosm that involved a search for order that was achieved by cataloguing objects, his total immersion in this venture dissipating his feelings of anxiety. He proceeded to make Latin word lists, the nascent form of his *Thesaurus*, and this cataloguing mania continued into his adult life. The *Thesaurus* is an obvious example, but his physiology textbook *Bridgewater Treatise Vol 5* was an enormous review of contemporary information organised according to comparative anatomy and physiology.

Medical and scientific career

In 1793, at the tender age of 14, Roget travelled to Edinburgh, accompanied by his mother and sister, to study medicine. One of his lecturers, Dugald Stewart, considered appropriate use of words paramount and the imperfections of language planted the seed for Roget to make a systematic attempt to tidy up word usage. Stewart inspired Roget to become a scholar and he passed his exams, his dissertation on classification of the laws of chemical affinity. In 1798, he travelled to Derby where he met Erasmus Darwin, Humphrey Davy and Thomas Beddoes. He moved to Clifton, Bristol, to work in the Pneumatic Institute founded by Beddoes, an eminent physician, who championed the use of gases such as oxygen, carbon dioxide and nitrous oxide to treat tuberculosis. Roget was one of the first to sample nitrous oxide as a recreational drug – it was not to his liking (Wright, 2001). In 1800 Roget returned to London to train in anatomy. In 1802 Roget acted as guardian to the two teenage sons of a local industrialist and accompanied them on their grand tour of Europe. The timing of this trip could not have been worse as the tenuous peace between Britain and France was shattered with the failure of the Peace of Amiens, and Napoleon began imprisoning British nationals resident in France. Roget and his charges fled to Switzerland and were lucky to escape. In 1803 Roget returned to England and in 1804 took up the position of physician in Manchester at the city infirmary, where he helped found the medical school. However, Manchester, at the heart of the Industrial Revolution, was filthy, and Roget became despondent, channelling his depression into his lists. In 1806 Roget gave his first lectures on physiology. He realised there was a systematic arrangement of physiology, which he divided into four functions: mechanical, respiratory, nervous, and reproductive. In his first lecture he discussed mechanical functions, which he further divided into five subclasses: mechanical properties of cellular texture, chemical composition of cellular substance, membranous connections, provisions for the defence of the body, and muscular action (Snell, 1974). Roget maintained his interest in physiology and in 1809 he moved to London where he lived for the rest of his life. He became an independent physician but realised a path to success lay in association with learned societies and institutions. In 1809 he was licensed by the Royal College of Physicians, joined the New Medical and Chirurgical Society of London (renamed the Royal Society of Medicine in 1907), and later became secretary of the Royal Society for 21 years. The Royal Institution appointed him Professor of Comparative Physiology in 1812, followed by appointment as the first Fullerian Professor of Physiology. Roget's studies in physiology are too numerous to describe here, but a detailed account can be found in an excellent review (Kruger and Finger, 2013). His most famous paper was on optics, in which he described retinal after-effects as an explanation for an optical illusion created by rotating spoked wheels (Roget, 1825). His most impressive academic work was his contribution to *The Bridgewater Treatises*; *Animal and Vegetable Physiology Considered with Reference to Natural Theology* published in 1834 as Vol 5 in the series. The Treatises were sponsored by the 8th Earl of Bridgewater and devoted to illustrating the power of God. Roget used design in nature as evident from comparative anatomy as proof of the existence of God. This enormous work was 600 pages in length and categorised not only Roget's work on areas of physiology, but also other relevant contemporary work. However, in 1846 Robert Grant, Professor of Comparative Anatomy and Zoology at the University of London, wrote a letter to *The Lancet* claiming Roget had plagiarised some of his ideas for the Treatise (Grant, 1846). Roget's reputation was tarnished, with *The Lancet* dubbing him "a literary pilferer". Roget retired as secretary of the Royal Society in 1847 a wounded man. He refused to apologise or concede any wrongdoing and found himself at the age of 70 with boundless energy and time on his hands.

Class 1 — Abstract Relations

I. Existence (1-8)
II. Relation (9-24)
III. Quantity (25-57)
IV. Order (58-83)
V. Number (84-105)
VI. Time (106-139)
VII. Change (140-152)
VIII. Causation (153-179)

Class 2 — Space

I. Generally (180-191)
II. Dimensions (192-239)
III. Form (240-263)
IV. Motion (264-315)

Class 3 — Matter

I. Generally (316-320)
II. Inorganic (321-356)
III. Organic (357-449)

Class 4 — Intellect

(1) **Formation**
I. Operations (450-454)
II. Precursory conditions (455-466)
III. Materials for reasoning (467-475)
IV. Reasoning processes (476-479)
V. Result of reasoning (480-504)
VI. Extension of thought (505-513)
VII. Creative thought (514-515)

(2) **Communication**
I. Nature of Ideas (516-524)
II. Modes of Communication (525-549)
III. Means of Communicating (550-599)

Class 5 — Volition

(1) **Individual**
I. General Volition (600-657)
II. Properties (658-679)
III. Voluntary Action (680-703)
IV. Antagonisms (704-728)
V. Results (729-736)

(2) **Intersocial**
I. General (737-759)
II. Special (760-767)
III. Conditional (768-774)
IV. Possessive Relations (775-819)

Class 6 — Affections

I. Affections in General (820-826)
II. Personal Affections (827-887)
III. Sympathetic Actions (888-921)
IV. Moral Affections (922-975)
V. Religious (976-1000)

Figure 2. The classification system present in Roget's original 1852 *Thesaurus*, encompassing six classes with associated sections comprising 1,000 concepts.

Thesaurus

It was while in Manchester in 1805 that Roget produced his initial thesaurus, entitled *Collection of English Synonyms Classified and Arranged*, which contained 15,000 words. Roget was not the first to create a book of synonyms. In 1718 French monk Abbé Gabriel Girard produced one in French, his motive that he considered speech the force that held society together, and that clear thinking depended on the ability to express oneself clearly. He grouped words together that expressed common ideas and wrote a few paragraphs on the appropriate use of each synonym. There were 295 such articles. In 1776 Englishman John Trusler translated Girard's book into English. About 30 years later Hester Piozzi published a thesaurus, which consisted of 310 articles. It was not systematic and devoid of academic rigour; Roget was unimpressed and considered it lacked cohesion, conflicting with his belief that words were crucial tools that promoted the progress of human knowledge. Roget was influenced by John Horne Tooke, who argued in his 1786 book that all words could be traced back to nouns and verbs. Tooke inspired Roget to think systematically about how to organise words in his thesaurus. Roget's embryonic thesaurus was not published, but he used it regularly to express himself more lucidly.

At around the time of his retirement from the Royal Society, interest in Piozzi's work was rekindled, which acted as an incentive for Roget to update his *Thesaurus*, which he commenced in 1849 and published in 1852. As he stated in the preface, "I had often during the long interval found this little collection, scanty and imperfect as it was, of much use to me in literary composition, and often contemplated its extension and improvement; but a sense of the magnitude of the task, amidst a multitude of other avocations, deterred me from the attempt." For those who are used to a thesaurus comprising solely an alphabetical index of key words and their synonyms, the Roget *Thesaurus* is a revelation, its classification template a model of utility. Roget devised six classes, the framework around which his *Thesaurus* was constructed. The first three classes encompass the external world and the last three concern the internal world (Fig.2).

- Abstract relations
- Space
- Matter
- Intellect
- Volition
- Affections

There is a logical progression from abstract concepts, through the material universe to mankind, followed by what he considered mankind's highest achievements, morality, and religion in the class of Affections or Emotion. The brilliance and insight of his classification ensured that the layout of the *Thesaurus* has survived for 170 years with only minor modifications. The classification may be viewed as a tree with the six main branches (classes) further divided into smaller branches and twigs until it comprised 1,000 concepts. Roget's view of the *Thesaurus* is concisely summarised in the first paragraph of the introduction to the original 1852 edition: "The idea being given, to find the word, or words, by which that idea may be most firstly and aptly expressed. For this purpose the word and phrase of the language are here classed, not according to their sound or their orthography, but strictly according to their *signification*". He further claimed "there are words and phrases sufficient to satisfy the most exacting writers and the most diverse tastes." It was only as an afterthought that Roget added an index that listed words in alphabetical order with their associated synonyms, the form of thesaurus with which most people are familiar.

The Slide Rule

Perhaps Roget's most unexpected achievement was in the field of mathematics, since it did not follow the ordering of objects that defined his other work. He was acquainted with William Haydn Wollaston, who invented the chemical slide rule in 1814 to aid with calculations involving chemical proportions (Gotlib, 2012). Roget worked to modify the slide rule to allow calculations of powers and roots and realised this could be achieved by applying the laws of logarithms via the development of the log log scale (Fig. 3) (Roget, 1814). This operation conformed with the intention of the logarithm's inventor, John Napier, that multiplication was converted into addition. Roget's insight was to logarithmically transform the factor twice as follows:

To calculate $6.7^{1.2}$

take the *ln* of this expression

$ln(6.7)^{1.2}$

Apply the 3rd law of logarithms: $ln(a)^b = b\ ln(a)$, thus

$1.2\ ln(6.7)$

take the *ln* of this expression, apply 1st law of logarithms: $ln(a \times b) = ln(a) + ln(b)$

$ln(1.2) + ln(ln(6.7))$ (Steps 1 and 2 in Fig.3C)

$0.182 + ln(1.90)$ (Step 3 in Fig.3C)

The power calculation becomes addition of logarithmically transformed numbers

$0.182 + 0.642 = 0.824$

Then carry out the inverse transformation twice, such that

$e^{0.824} = 2.27$ (Step 4 in Fig.3C)

$e^{2.27} = 9.77$ (Step 5 in Fig.3C)

Thus $6.7^{1.2} = 9.77$

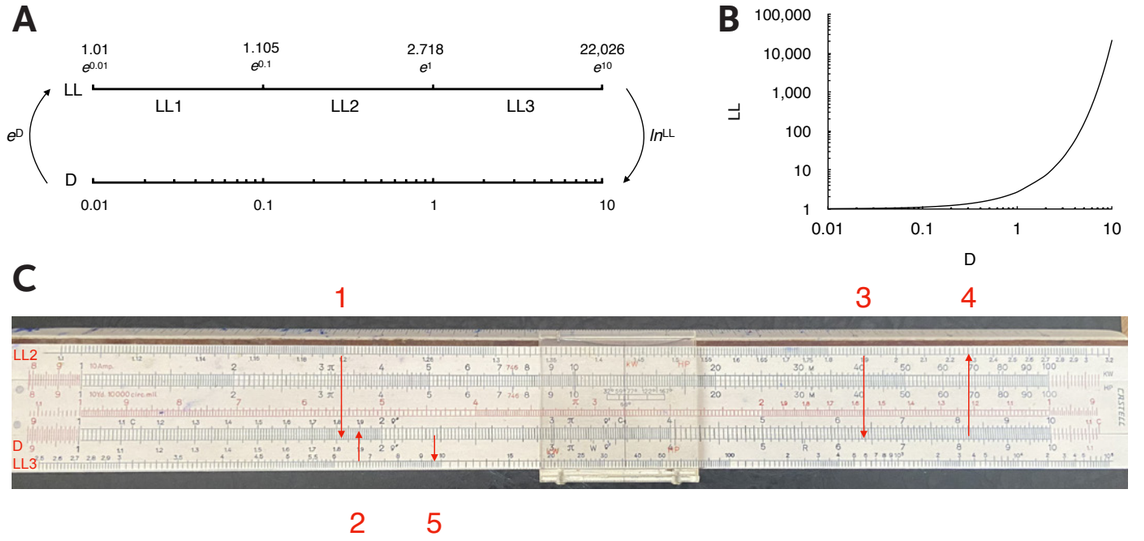

Figure 3. The log log slide rule invented by Roget in 1814. A. The D and LL scales devised by Roget are based on the inverse relationship between *ln* and *e*, where $ln^e(x) = y$ equates to $e^y = x$. The D scale is continuous from 0.01 to 10, but for practical purposes the corresponding LL scale is divided into three separate scales on the slide rule (LL1 – LL3), according to the logarithmic progression of the D scale from 0.01 to 10, three orders of magnitude. The LL scale is e^D and the D scale is ln^{LL}. Although the D scale extends from 0.01 to 10, it is represented as only one scale on the slide rule, from 1 to 10, thus when transforming from the LL2 scale to the D scale, the result must be divided by 10, etc. B. The relationship between the D and LL scales displayed graphically. C. Image of a slide rule illustrating the sequence required to carry out the power calculation described in the text. The fathers of all three authors used slide rules in their respective professions; that illustrated belongs to AMB's father.

This process is displayed graphically in Fig.3C. In 1814 Wollaston presented Roget's paper on the slide rule to the Royal Society, and Roget was elected Fellow in 1815.

Later life

In 1824 Roget married Mary Hobson, producing two children, Kate (b. 1825) and John (b.1826). In 1833 Mary died, and to alleviate his depression and occupy his mind Roget commenced work on his *Bridgewater Treatise*. His daughter Kate began to display symptoms of mental instability in 1849, when she was 23, her erratic behaviour a source of constant worry for Roget, who resorted to isolating her from any contact with friends, presuming that his means of dealing with his illness by shutting out the world would also help her. It seemed to work, and Kate returned to her family. Although she never descended to such depths again, she remained unmarried and dedicated herself to supporting Roget's work, caring for him in his old age. He died in 1869 at the age of 90. Although Roget periodically sank into depressions, most notably while in Manchester in 1805, after the suicide of his uncle Sir Samuel Romilly in 1818, and upon the death of his wife in 1833, he always prospered professionally.

It is interesting to note that in 1860, at the age of 81, Roget attended the famous debate on evolution at the University of Oxford,

Figure 4. Peter Mark Roget in 1867 aged 88.

attended by Charles Darwin, whose *Origin of the Species* had been published the previous year. As a result of the debate the scientific community relegated God's importance in science, an event that distressed Roget and his interest in science began to dwindle (Fig. 4).

Roget's *Thesaurus* had 28 printings in his lifetime, and after his death his son John assumed editorial responsibilities, followed by Roget's grandson Samuel, who sold the copyright in 1952. The *Thesaurus* has lost 10 concepts since its original publication, but the proliferation in vocabulary has dramatically increased the number of words.

In recognition of Roget's paracosm, we note an impressive list of his friends and associates: Erasmus Darwin, Michael Faraday, Humphrey Davy, James Watt, Charles Dickens, Edward Jenner, William Herschel, Thomas Young, Thomas Huxley, Charles Babbage.

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Astrocytes and hepatic stellate cells (HSCs): Stars of tissue regeneration

Astrocytes and HSCs in tissue regeneration

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Hepatic stellate cells (HSCs) in the liver and astrocytes in the brain have much more in common than just their beautiful star-shaped appearance. In this feature, we highlight the intriguing parallels between these cells that populate two very different organs: the liver and the brain. Both cell types contribute to maintaining a blood–tissue barrier and transdifferentiate to a myofibroblast phenotype in response to injury to regenerate damaged tissue. This adaptive response can become maladaptive with continued or chronic injury, leading to fibrosis that eventually disrupts the ability of the organ to function normally. Glial fibrillary acidic protein (GFAP) is one known marker for the activation of both HSCs and astrocytes, further highlighting functional similarities in their response to cellular damage between the two cells. Liver health and brain health are functionally connected in ways that go beyond the analogies between these two cell types.

HSCs are the guardians of liver health

The liver is a key organ that controls digestion, toxin removal, retinoid (vitamin A) storage and metabolism, and the synthesis of the mediators of the coagulation cascade. It is well established that the liver can regenerate, and hepatic stellate cells (HSCs) drive the process of liver regeneration. HSCs are a representation of mesenchymal stem cells that make up 5%–8% of the cells in the liver (Higashi *et al.*, 2017). They are located in the space of Disse (perisinusoidal space), located between the hepatocytes and the tubular sinusoids that allow blood flow. HSCs possess extensions that wrap around the sinusoids and facilitate communication with sinusoidal endothelial cells, hepatic epithelial cells, hepatocytes, and Kupffer cells (resident liver macrophages) (Wake, 2006).

HSCs are normally quiescent, and control sinusoidal tone and blood flow, hepatocyte proliferation, angiogenesis and maintenance of the extracellular matrix (ECM). They undergo activation in response to acute injury, upregulating smooth muscle α-actin and transdifferentiating into myofibroblasts (Kitto and Henderson, 2021). Chronic damage such as that caused by alcohol impacts hepatocyte mitochondria, causing cell death and also activating the conversion of HSCs to myofibroblasts.

Like astrocytes, HSCs show increased expression of glial fibrillary acidic protein (GFAP) during the process of transdifferentiation. GFAP is part of both HSC and astrocyte intermediary fibre systems that acts as a "command centre" for responding to cellular stress (Hol and Pekny, 2015). During chronic injury, various factors are released by HSCs including transforming growth factor beta (TGF-β), collagen (type I, III, and IV) and other ECM proteins (Kitto and Henderson, 2021). Repeated or chronic injury leads to sustained increase in expression of ECM components, resulting in scarring (Higashi *et al.*, 2017). In the case of acute injury, the ECM "scar" has the opportunity to resolve and regenerate, but in chronic injury (e.g. alcoholic liver disease, non-alcoholic fatty liver disease, untreated hepatitis) the scar becomes dense and fibrotic (Fig.1). The pathologic scar creates a barrier against the circulation of growth factors, creating a poor environment for hepatocyte proliferation. The vascular network also undergoes scarring leading to irregular blood flow and prevention of necessary nourishment (i.e. Hepatocyte Growth Factor [HGF]). Eventually, the fibrotic scarring forms fibrotic nodules, where extensive fibrotic tissue creates visible raised tissue, resulting in cirrhosis that can be detected on a CT scan.

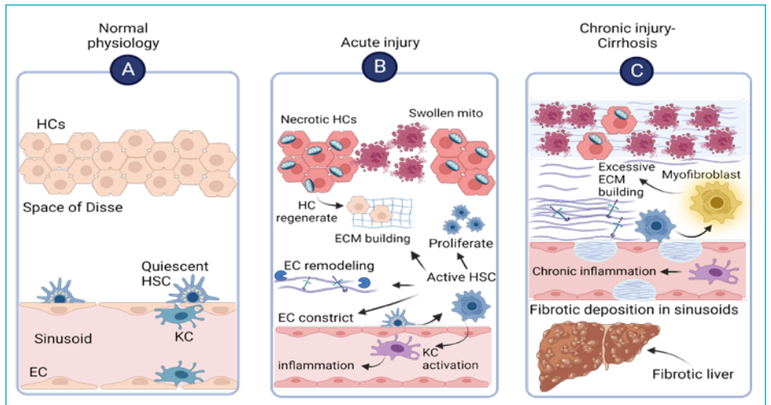

Figure 1. **1A illustrates the liver parenchyma in normal physiology.** HC = Hepatocyte cell, EC= Endothelial cell, KC= Kupffer cell. During this state the HSCs are quiescent and store retinoids. **1B illustrates the liver parenchyma under acute injury** (i.e. hepatitis, alcohol binging) as indicated by the damaged HCs (colour change to red) and swollen mitochondria. Under acute injury HSCs become active, lose retinoid storage and become less directly attached to sinusoids. Active HSCs promote regeneration through ECM building to allow a scaffold for new HCs, EC remodelling to breakdown damaged ECs (i.e. Pacman-like degradation enzymes) and continue producing new ECs, cause EC constriction, which leads to constricted sinusoid, and KC activation, which leads to downstream inflammatory cascades. **1C shows the chronic effects of chronic injury** (i.e. untreated hepatitis, alcohol abuse) as indicated by further hepatic damage as indicated by the multiple necrotic HCs. The activated HSCs transdifferentiate into myofibroblasts leading to further ECM deposition causing fibrosis within the space of Disse and around the HCs. Sinusoids also suffer from fibrotic deposition causing further flow restriction. KCs continue with chronic inflammation. This overall leads to a fibrotic liver. Created with BioRender.com

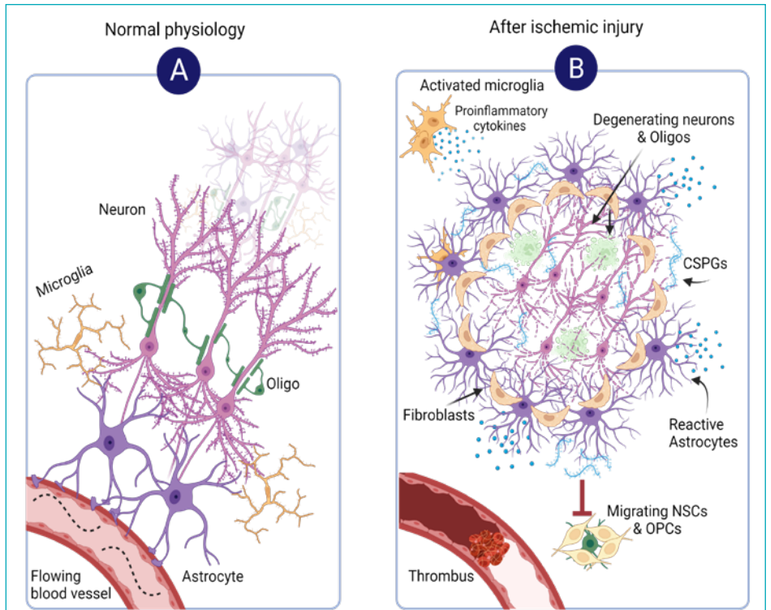

Figure 2. **2A illustrates normal physiology where astrocytes communicate with the vasculature** and allow crosstalk for neurons, oligodendrocytes (Oligo), and the surveying microglia. **2B shows the development of the glial scar after ischaemic stroke via a thrombus leading to dying neurons and oligodendrocytes.** Astrocytes become reactive and secrete pro-inflammatory cytokines plus proteoglycans like CSPGs, which brings forward perivascular fibroblasts. Both begin to circle the damaged, necrotic cells. Microglia also become activated and secrete pro-inflammatory cytokines leading to a pro-inflammatory cascade. Migrating NSCs and OPCs are rejected. Created with BioRender.com

With cirrhosis, liver function is decreased and the patient experiences symptoms that include coagulopathy with an associated risk of ischaemic infarction, malnutrition, and increase in blood toxin (e.g. ammonia) concentration. Excess ammonia can lead to systemic effects, with the brain being one of the most sensitive to this toxin. Liver dysfunction is one of the major causes of toxic encephalopathy.

Astrocytes are the guardians of brain health

Astrocytes are glial cells that originate from neural stem cells (NSCs) in the central nervous system (CNS). They are the most abundant cell type in the CNS, making up 20%–40% of glial cells, which constitute close to 90% of the cells in the CNS. Astrocytes are found throughout the brain, especially around blood vessels of the brain and the spinal cord (English *et al.*, 2020). Like HSCs, astrocytes use long cell processes for communication and nutrient transport between cells, including neurons, other glial cells, and vascular epithelial cells. Astrocytes provide physical and chemical support for neuronal growth from stem cell to maturity, synaptic maturation, and neurotransmitter regulation including protection against neurotransmitter toxicity, vascular tone regulation, metabolic regulation via ammonia metabolism, and protection from foreign pathogens and drugs as part of the blood brain barrier (English *et al.*, 2020).

Like the liver, the brain has the ability for cellular repair and regeneration, mediated by the astrocytes in the CNS. In response to damage, such as that caused by stroke and toxins, astrocytes donate their mitochondria to damaged neurons for cellular repair (English *et al.*, 2020) and release factors like Olig2 to promote oligodendrocyte precursor cell (OPC) development into mature oligodendrocytes (Weber *et al.*, 2021). Astrocytes can act as NSCs and mature cortical astrocytes can

undergo "reprogramming" to NSCs in the presence of injury (e.g. experimental ablation) (Gonzalez-Perez and Quiñones-Hinojosa, 2012). Finally, similar to HSCs, astrocytes create a scar called "glial scar" in response to injury.

On sensing injury, astrocytes become reactive and begin to express GFAP, a cytoskeletal intermediate filament (IF) (English *et al.*, 2020). This is accompanied by cytokine (i.e. TGF-α, Il-6) release from astrocytes, and also from other glial cells and neurons. Reactive astrocytes and perivascular fibroblasts proliferate and surround the cellular lesion using elongated processes to form a glial scar (Fig.2). The glial scar is a physical and functional wall around the necrotic brain tissue, serving to wall off toxic necrotic induced pro-inflammatory cytokines (English *et al.*, 2020). Generally, this impacts function that the specific area of the brain controls (e.g. a cerebellum infarct would impact motor control). As the glial scar persists, it becomes a double-edged sword, not only preventing the spread of necrosis-induced mediators from dying cells, but also inhibiting regeneration and recovery of neuronal synapses and function (Aktas *et al.*, 2007; English, 2020; Yang *et al.*, 2020). The inhibition is driven by the production of ECM components such as chondroitin sulfate proteoglycans (CSPGs), which actively repel neuronal axon growth as well as OPC maturation (Yang *et al.*, 2020). Even if the glial scar did not impede neural stem cell migration and differentiation, this does not necessarily mean that the new neuron would differentiate into the correct neuron population or have appropriate synaptic strength necessary for survival as the environmental cues for this process are missing. Using NSC transplantation as therapy for acute (<7 days) ischaemic infarcts has had mixed success. Though NSCs travel to neuronal circuits and can integrate into the circuitry they do not survive for long, and it is unknown if they possess the appropriate cellular phenotype that existing neurons do (Baker *et al.*, 2019).

The importance of liver function in brain health

HSCs and astrocytes are the stars of liver and brain health, each playing a key role in cellular/tissue repair. They are, however, also functionally connected in less obvious ways. Specifically, the systemic consequences of liver disease have a devastating impact on brain health. This connection is exemplified by the higher incidence of hepatic encephalopathy (HE) and stroke in patients with liver cirrhosis.

HE is a neuropsychiatric syndrome that is the result of brain dysfunction and is caused by alcoholic liver disease (Fig.3). The incidence of HE in alcohol-induced cirrhosis is roughly 45%–50%. The processing of alcohol in the liver produces highly toxic chemicals like ammonia, triggering inflammation that leads to liver cell death. Excessive amounts of ammonia overwhelm astrocytic metabolism leading to dysfunction and glutamate toxicity, causing neuronal damage and/or death.

Cirrhosis can also cause coagulopathy, hypoperfusion, impaired glucose metabolism, and dyslipidaemia, all shown to be risk factors for stroke. The incidence of stroke, both haemorrhagic and ischaemic, is increased in patients with liver disease.

Conclusions

HSCs and astrocytes resemble each other in both structure and function. Their cellular features reflect the analogous functional roles they play in the liver and brain. Importantly, liver disease takes a heavy toll on organs other than the liver. The brain is particularly sensitive to the systemic effects of liver disease, and liver disease should be included as a differential diagnosis for patients with mental confusion and behavioural changes.

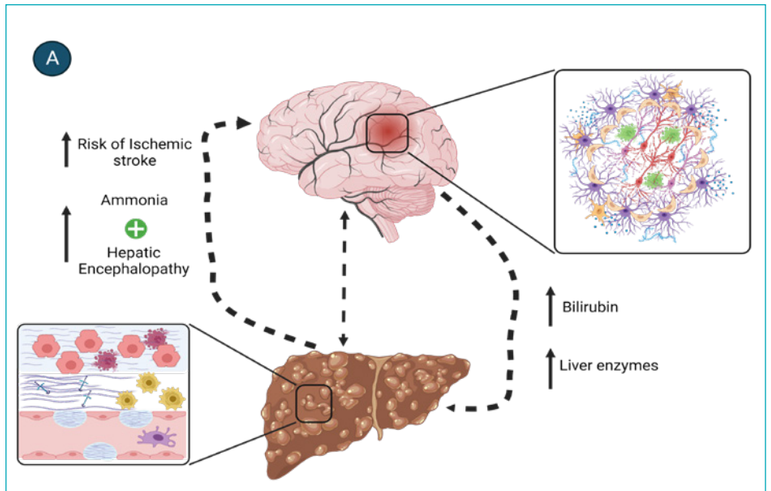

Figure 3. **Hepatic-Neurological Connection during injury 3A** shows a basic overview of the connection between the liver and brain during cirrhosis or ischemic injury. During cirrhosis there is an increased risk of ischemic stroke due to underlying coagulopathy, increase in ammonia, and hepatic encephalopathy due to high ammonia within the brain. During ischemic infarct, there is an acute increase in bilirubin and liver enzymes.

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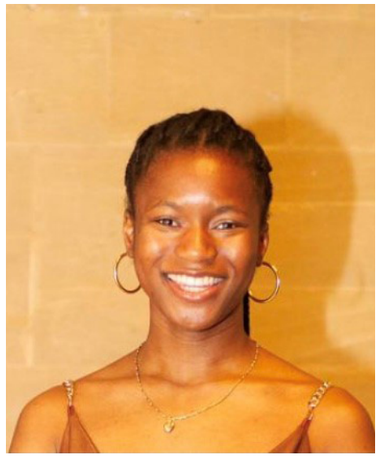
What can be said for the genetic component of speed and physiological limit?

Are we born to run?



Eniola Awodiya

Medical Student at University of Oxford, UK

In physics, speed (or velocity, v) is the time (t) taken to cover a fixed distance (d): v = d/t. The selective breeding of racehorses indicates a genetic component of speed. Research of skeletal muscle fibre types indicates that a speed-favouring predominant fast twitch (type IIa and IIb) muscle fibre type ratio is also, at least in part, genetically determined. To what extent genetic factors can influence speed is unknown, nor is it clear what physiological limits of speed are. Despite incomplete understanding of what a given person (or animal) may be capable of in terms of performance, detection of doping practices in sport is moving toward using artificial intelligence alongside biological data to identify individuals who are outliers and potentially doping. Therefore, improved understanding of performance-associated variables (i.e. genetics and other determinants of limits) could refine methods of doping investigation and prevent mud being thrown that may stick and damage careers.

Evidence for a genetic basis of speed

MSTN gene in horses

Since the mid-1700s, thoroughbred racehorse breeding has involved careful identification of, and selection for, traits predisposing to improved performance over one of five recognised distance categories – an early indication of a genetic basis of speed (Bower *et al.*, 2012). More recently, genome-wide-association studies (GWAS) found a variant of the MSTN gene (C-allele) to be predictive of sprint performance in racehorse populations (Binns *et al.*, 2010). MSTN encodes a transforming-growth-factor β molecule, expressed in skeletal muscle as a negative regulator of muscle mass. However, GWAS intrinsically assume allele frequencies are similar in randomly mated groups and racehorses – including those randomly selected in experimental protocols – are highly related. Indeed, some 95% of all thoroughbred racehorses are sired by common ancestor *Darley Arabian.*

Selection pressures for this gene may also be compatible with a genetic basis of speed (Bower *et al.*, 2012). To find potential sources for this C-allele, one study sampled standard-bred horses in regions mapping those selected for in thoroughbred founder lines. It had a frequency ranging between 0 and 0.5 in Eurasian populations and up to 0.90 in the infamous sprinter, the Quarterhorse. Given that the Quarterhorse has undergone intense selection for speed from the mid-1800s (~100 years after the thoroughbred), its high frequency of the C-allele indicates that population-specific selection pressures are significant. These findings begin to point towards a genetic basis of speed; however, no causal relationship can be assumed.

Asian – 25%
Caucasian – 18%
Ethiopian – 11%
Jamaican – 3%
African American – 3%
Kenyans – 1%
Nigerians – 1%

Table 1. Approximate XX genotype prevalence by ethnicity

ACTN3 protein in humans

Alpha-actinins are found at Z-discs and cross-link actin filaments of adjacent sarcomeres (Chan *et al.*, 2008). α-actinin-3 (ACTN3) is exclusively expressed in fast glycolytic muscle fibres. Homozygosity for a common polymorphism results in total deficiency of the ACNT3 gene (XX). This XX genotype – present in ~1 billion individuals worldwide – has a detrimental effect on speed and power performance, favouring endurance (Yang *et al.*, 2003). A lower incidence of ACTN3-deficiency in Australian sprint and power athletes compared to the general population (Fig.1) has been identified and the finding reproduced in Elite Finnish athletes (Yang *et al.*, 2003; Niemi and Majamaa, 2005). Ethnicity appears relevant here, with different frequencies of the XX genotype observed in different ethnicity strata (Table 1) (Yang *et al.*, 2003). These findings from large linkage and observational datasets indicate yet another genetic component of speed in ACTN3 (but aforementioned limitations are applicable here).

A proposed molecular mechanism for these findings may strengthen the argument for a genetic basis of speed. The mechanism involves ACNT3 and calcineurin, known to induce the type 1, oxidative, slow-twitch phenotype in skeletal muscle remodelling (Delling *et al.*, 2000). After 4 weeks of endurance training, ACNT3-KO mice (analogous to human ACTN3XX) presented with greater endurance and faster recovery from fatigue alongside concurrent increases in calcineurin compared to WT mice (Seto *et al.*, 2013). Competitive binding of ACTN2 for regulatory molecule calsarcin-2 leads to increased release of calcineurin from baseline calsarcin-2 inhibition in the absence of ACTN3. However, this is not observed in humans. No difference in $\dot{V}O_{2peak}$ was observed between human ACTN3XX and ACTN3RR genotypes following a 4 week endurance training protocol (Papadimitriou *et al.*, 2019). Of course, murine muscle has a much higher percentage of fast-twitch fibres compared with human muscle, potentially creating an over-represented effect of pathway-induced fibre-type switching. Additionally, there is a lack of diversity in the human study to indicate that the findings are externally valid.

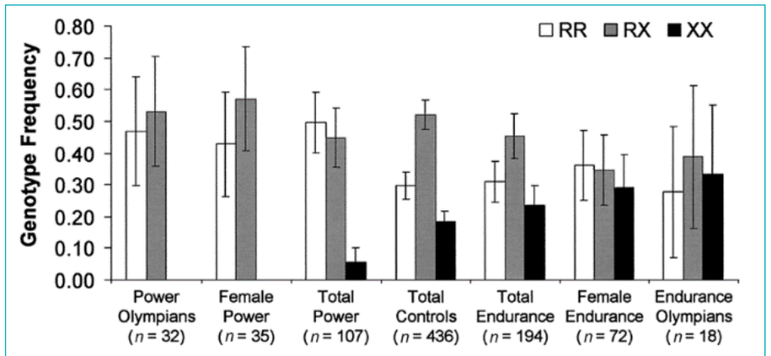


Figure 1. Primary data of ACTN3 genotype frequencies in controls, elite sprint/power athletes, and endurance athletes. Athletes compared with healthy Caucasian controls show a marked reduction in frequencies of ACTN3577XX genotypes (associated with α-actinin-3 deficiency). Error bars show 95% confidence intervals (*Yang et al., 2003*). Copyright © 2003 by The American Society of Human Genetics

Olympic trends do not support genetics being the most important determinant of speed

Despite selective breeding and genetic-based studies indicating a possible genetic basis of speed, data on Olympic 100 m performances throughout history suggests genetics are a non-essential factor for speed. Since the advent of Olympic races, there has been a steep downward trend in times recorded; that is to say, sprinters are getting faster (Fig.2). In contrast to thoroughbred racehorses, human speed has increased in one third of the time, with no selection and mating bias imposed. In a purely genetic model of speed, a constant plateau or much shallower gradient of change in speed at this stage of evolution should be revealed – of course, few, if any, would argue that training and nutrition practices do not come into play. This is not to say that genetic predisposition to larger gains from training or direct genetic contributions to speed do not provide an edge at the elite level. Clearly, to what extent genetics is a factor in speed requires more research to be determined.

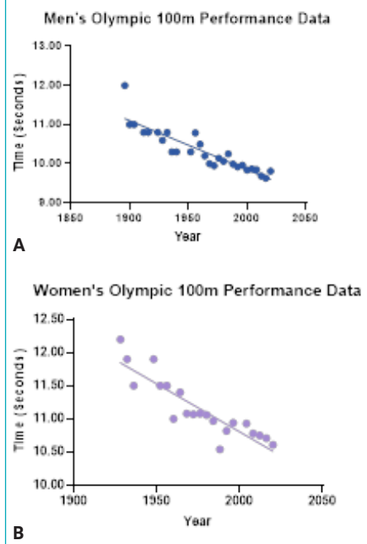


Figure 2. Raw data taken from Olympic website (www.olympics.com). Trends in 100 m Olympic times from 1896 (men's; A) and 1928 (women's; B) until the most recent in 2020. Lines of best fit are determind by linear regression.

Physiological limits of speed

Data trends allow an estimate for which year the infamous 9- and 10-second barrier for men's and women's races respectively, may break if improvements continue at this rate:

- Men's 9-second barrier: 2068
- Women's 10-second barrier: 2055

One important question is: what causes these barriers?

The force-velocity (F–V) relationship

Initially, determining force–velocity relationships involved timed (t) elbow flexion to spin various weights (F) at fixed ranges of motion (d) to infer the relationship was an inverse-linear one (Huxley, 1957). Refined protocols addressed needs for muscle isolation due to potential effects of antagonistic muscle groups and a new inverse-hyperbolic F–V relationship was inferred. Interestingly, amputee volunteers – as an example of *in vivo* isolated pectoralis muscle activity – presented similarly (Huxley, 1957).

This maps well onto sliding-filament theory (SFT) and provides a molecular explanation for limits in speed (Huxley, 1957). In SFT, the total tension in muscle is the sum of tension generated by all contraction sites within half of the sarcomere. Hence, an inverse F-V relationship can be observed because of an increase in non-bound actin and myosin filament pairs to form sufficient cross-bridges or because of an increased proportion of cross-bridges formed that cannot readily dissociate for the next cycle, thereby generating an opposing force.

The spring-stance model of running gait

The heralded spring-stance model of optimal running gait (Fig.3) involves (i) the stance phase where weight compresses limbs to store strain-energy in elastic tissues, before release via elastic recoil to accelerate the body, followed by (ii) the swing phase in which the opposite limb is repositioned to repeat the cycle on impact. The model has been tested in both high and low-velocity running, using a high-speed treadmill and $n = 7$ sprinters and non-sprinters (Weyand *et al.*, 2010). While both groups spend equal time repositioning limbs in swing phases of maximal-speed running – suggesting a passive mechanism of energy transfer model – differences were observed between stance phases. Fig.4 highlights this: the spring-stance model shows a symmetrical half-sine waveform on a vertical ground reaction force–time graph, depicting stored energy released in the reverse vector over time. While lower speeds and non-elite athletes mimicked this, sprinters at top speeds showed a consistent asymmetric waveform. This suggests faster athletes converged on a common mechanical solution for speed.

The elite sprinter applies a greater stance-averaged peak vertical force in a swifter contact phase than is typical for both the non-sprinter and the spring-stance model (Fig.5). Elite sprinters, rather than using recoil and passive propulsion, apply greater force in minimal contact times, aided by actively lifting the knee. Torque capabilities of knee and hip extensors and flexors also support this. Synchronised electromyography (EMG) activity indicates maximal hamstring activation just before ground contact and high eccentric hamstring peak torque ability as is necessary for maximal horizontal-force production. Further work supports this (Clark and Weyand, 2014).

One study used exaggerated models for speed parameters of ground reaction force (GRF), ground contact time (GCT) and horizontal force production (involving one-legged hopping, forward running, and backward running) (Weyand *et al.*, 2010). Although force applied in one-legged hopping was on average 30% greater than in forward running, velocity was reduced in comparison – highlighting the importance of aerial time in speed. Furthermore, force applied to the treadmill by extensor muscles in hopping gaits was on average 82% higher than that applied by identical muscle groups in sprinting gaits. The time course of a single electrical impulse to a human knee or ankle extensor is between 81 and 120 ms in young adult men (Weyand *et al.*, 2010). This is twice the time available in top speed running for GCF to be maximised.

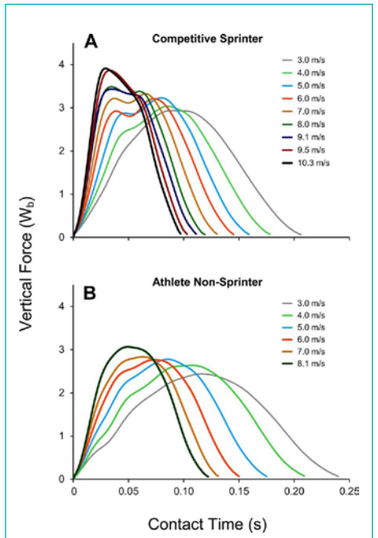


Figure 4. Primary data showing (A) a competitive sprinter's vertical force-contact time waveform over a range of speeds compared to (B) that of a non-sprinter. Spring-stance suggestive half-sine waveforms are at lower speeds in both athletes, with the competitive sprinter deviating from symmetrical waveforms more readily (Clark and Weyand, 2014).

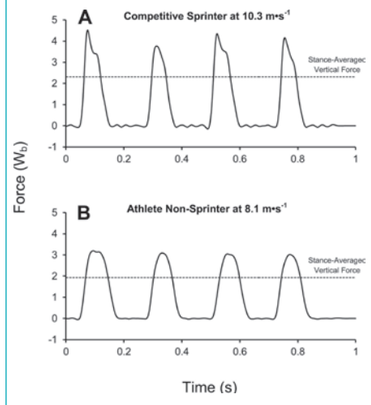


Figure 5. Primary data showing reaction force in the early part of the stance phase between (A) a competitive sprinter and (B) a non-sprinter athlete, at their respective top speeds (Clark and Weyand, 2014)

It appears that within human physiology, limits to speed lie in the trade-off made in generating GRF maximums within GCT minimums. However, much of this evidence arose from treadmill analysis of running gait where both sagittal foot-strike angle and knee flexion range are not strictly representative of overground running (Weyand *et al.*, 2010). Future work could benefit from overground running study replications.

In animal physiology, galloping behaviour as enabled by pronounced backbone bending increases foot-ground contact times and

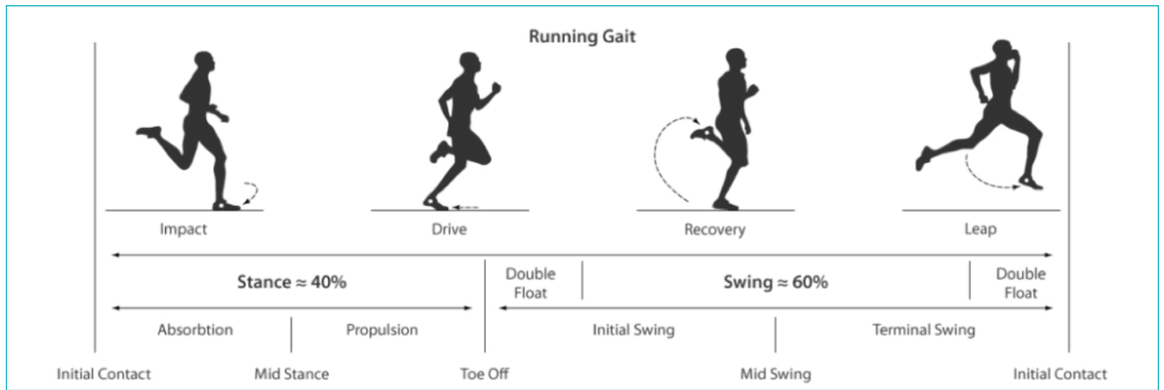


Figure 3. The spring-stance model of optimal running gait

lengths, thereby enabling a higher force production and application with no trade-off limitations in time wasted on the ground. Interestingly, this may suggest how the current fastest man in the world – Usain Bolt - claimed his title: his height allows a stride length of 2.77 m compared to averages of 1.52 m. According to this model, Bolt would have to make approximately 30 fewer strides than average within 100 m, and so 30 fewer ground force-ground contact time trade-offs, identified here as the limits of speed. This too may further suggest genetic contributions to speed with height phenotypes.

Implications

The World Anti-Doping Agency (WADA) monitors doping practices and refines detection techniques to overcome these. Genetics participate in speed, and alongside rising CRISPR-Cas9 technology, there have been attempts to utilise gene editing tools as means for gaining a competitive edge in horseracing. Further research into associated genes to generate screening profiles for known loci of interest may be beneficial in combatting this.

Similarly, there is potential to improve technological doping. Controversy surrounds *Nike Vaporfly* running trainers and *Nike Air Zoom Maxfly* sprint spikes – a form of "super spike" using foam padding just above spike plates. Given the importance of gait, foot strike and GCF in limiting speed, a shoe design overcoming this to maximise force output for the same fixed time is an obvious advantage. Potential for technologies to unfairly influence sport was recognised: the former of these trainers has since been banned by World Athletics in January 2020. However, it remains an open and exploitable factor worth highlighting, given what is now known.

An approach under development by WADA is an athlete-specific biological passport to track performance and known performance-associated variables, to create a personalised model from which outliers are clear. An interesting avenue for future research would be a computerised model of optimised human sprinting gait based on data findings, to predict limits of male and female speed more accurately. Although not absolute, it could supply a framework through which obvious outliers are highlighted for further investigation. Streamlining this (within rigorous ethical guidelines) to find predictive physical characteristics such as extensor muscle and limb lengths combined with known power measures such as the standing long jump, both of which inform sprint gait maximums, could aid closer athlete-specific observation.

Conclusions

Evidence has shown that there is a genetic basis of speed, with multiple GWAS suggesting their association. There is some evidence to suggest that this may be via influences on phenotypes associated with speed such as muscle fibre type. However, these data are is too limited to conclude that genetics is the sole or even most important determinant and trends in Olympic data further highlight this. Further work researching technological and performance kit advances of the last century could begin to quantify their input. Concerning limitations of speed, treadmill analysis of gait recommends a departure from the popular existing model, suggesting an alternative asymmetrical force application–time relationship selected for at higher velocities.

A collection of observing large cohorts of fast runners, comparing human physiology to fast animal counterparts, and investigating a molecular explanation cumulatively show that speed limits arise when GCF is limited as a factor of GCT. Moving forward, this posits exciting opportunities for personalised computer models to both track athlete potentials and profiles as an anti-doping strategy. Further work would need to expand gait findings to whole-body systems, and scale-up genome studies for this.

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The 100th anniversary of the Physiological Society of Japan (PSJ)

Reflecting on our history and looking ahead at the next century

Dr Yoshihiro Ishikawa

President of the PSJ

Professor Tadashi Isa

Conference Director of the 100th Anniversary Annual Meeting of the PSJ

The Physiological Society of Japan (PSJ) celebrated its 100th anniversary in 2022. The 100th Anniversary Congress with the theme of "Homeostasis for Sustainability – Toward the Next Century of Physiological Sciences" will be held in Kyoto on 14–16 March 2023.

The 100th Anniversary Congress, 2023 in Kyoto, Japan

The 100th Anniversary Congress will be held from Tuesday 14 March to Thursday 16 March 2023 at the Kyoto International Conference Center. At this memorial 100th meeting of the PSJ, we will look back over the 100-year history of physiology in Japan, and look forward to the next 100 years in anticipation of further development. Looking back over the past century, we can see that physiology has clearly contributed to the promotion of health in society. The most obvious marker of this is the extension of the healthy lifetime of humans. On the other hand, the COVID-19 pandemic, ongoing since 2020, has markedly changed human society and brought new issues to light for the field of physiology to address. In light of this, we must consider how physiology can contribute to the sustainability of our world, both for humans and for the natural environment. Therefore, the 100th Anniversary Congress will be themed "*Homeostasis for Sustainability – Toward the Next Century of Physiological Sciences*". Here, our message is "homeostasis, which is the fundamental concept of physiological science, should be the most critical for the future sustainability of our human life, society and environment of the earth and universe". The meeting will start with a memorial symposium, which brings together eminent presidents of international physiological societies to discuss the research and education of physiology for the next 100 years, and followed by a number of lectures and symposia covering a variety of life science fields, as well as poster sessions. The plenary lectures will be given by Shinya Yamanaka (Kyoto University, a Nobel Laureate), Svante Pääbo (Max Planck Institute for Evolutionary Anthropology) and Bente Klarlund Pedersen (University of Copenhagen). Please join us in Kyoto and experience the breadth of physiology. We are excited to welcome you with a superlative programme on this special occasion!

We will now take you back to the early 1900s, where our society's story begins. Here's how the PSJ was founded and has grown through the years.

Prehistory and establishment of the PSJ

The pioneering first conference on physiology in Japan was held in Tokyo in April 1902 as the second part of the first meeting of the Japanese Society of Physiology and Biomedical Chemistry. The sixth Congress of the Society was held in April 1922, and the decision was made to establish a separate physiological society.

History of the PSJ

The PSJ was founded in 1922 and the first meeting was held at the University of Tokyo on J10 July 1922 (Fig.1). At the first

第１列　向って左より、石川日出鶴丸、酒井卓造、藤田敏彦、生沼曹六、木下東作、天谷千松、石原誠、高安慎一、佐武安太郎、
第２列目には、黒田源次、越智眞逸、板垣政参、浦本政三郎、牧亮吉、大塚藤吉、久保盛徳、正路倫之助、
第３列には、勝義孝、操坦道、幸塚嘉一、西丸和義諸先生の姿が見える。

Figure 1. The 1st meeting of the PSJ at the University of Tokyo in 1922

meeting, 37 papers were presented as free communications. From the beginning, the society had a liberal spirit, which has continued to the present day. The Society's scientific meetings have been held annually except in 1944 and 1945 due to World War II. However, the activities of the PSJ were quickly revived after the end of the war. The aim of the PSJ is to promote research in the physiological sciences by providing free communications to members and by actively committing itself to the national and international scientific communities.

Contributions of the PSJ to the International Union of Physiological Sciences (IUPS)

The PSJ has been a member of the IUPS since its founding in 1953. The PSJ organised the 23rd IUPS World Congress 1965 in Tokyo (President: Genichi Kato, Keio University) and the 36th IUPS World Congress 2009 in Kyoto (President: Yasushi Miyashita, University of Tokyo; Fig.2). Masao Ito (1993 – 1997) and Akimichi Kaneko (2005 – 2009) served as Presidents of the IUPS. Yoshihisa Kurachi, with the recommendation of the PSJ, served as the First Vice President of the IUPS (2009 – 2013).

Current activities of the PSJ

The PSJ has a total of 2,591 members as of 18 January 2022. Most of the members belong to academic research institutions related to medical science, life science, health science, pharmaceutical science, and so on. The research activities of the PSJ members are mostly supported by grants from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) distributed by the Japan Society for Promotion of Sciences (JSPS). The JSPS also provides fellowships to graduate students and postdoctoral students, including those from foreign countries. Research grants are also provided by the Japan Agency for Medical Research and Development (AMED) and private foundations. A list of summaries of recent breakthrough papers published by PSJ members can be viewed at the "Science Topics" section of the PSJ website: http://int.physiology.jp/en/sciencetopics/

Important achievements

The PSJ has made achievements in various areas by the ongoing and tremendous efforts of individual PSJ members as described below.

The PSJ has established Society Awards to support young researchers and female researchers. These awards include the Promotion Award of the Physiological Society of Japan for Young Scientists and Hiroshi and Aya Irisawa Memorial Awards. The awardees have actively contributed to the progress of physiological sciences in Japan and worldwide.

The PSJ publishes two journals: *The Journal of the Physiological Sciences*, an international peer-reviewed journal published bimonthly in English, and *The Journal of The Physiological Society of Japan*, published quarterly in Japanese (Fig.3).

To provide opportunities to acquire a wide range of knowledge required for teaching physiology, the Education Committee of the PSJ has organised an educational lecture course in physiological science at the annual meetings. PSJ members who take part in the lecture course can earn points towards certification as a "Physiology Educator". Recently, 398 members were certified as "Physiology Educators" on 8 February 2022. The PSJ supports the Physiology Quiz in Japan, which college students run and participate in.

Figure 2. The 36th IUPS World Congress 2009 was held in Kyoto, Japan

International meetings

The IUPS World Congress was held twice in Japan, Tokyo in 1965 and 2009 in Kyoto. The 36th IUPS2009 in Kyoto was a successful meeting, with nearly 4,000 participants from around the world. The 9th FAOPS2019 in conjunction with the 96th annual meeting of the PSJ, was held in Kobe on 28–31 March 2019. Over 2,000 people participated in FAOPS2019, Kobe.

Annual meetings

The annual meetings of the PSJ have been held not only in Tokyo but also local areas of Japan at the end of the fiscal year (usually late March). All oral presentations, with some exceptions such as educational presentations, have been conducted in English since 2006 in order to be more welcoming to non-Japanese researchers from around the world. The annual meeting of the PSJ gives good opportunities to encourage international friendships and collaborations in each country.

International and domestic journals

The Journal of the Physiological Sciences (JPS) (formerly the *Japanese Journal of Physiology* [1950 – 2008]) publishes peer-reviewed original papers, reviews, etc. in English. The JPS, published by Springer Nature, became Open Access in 2020. High-quality papers have been published, and its most recent impact factor is 2.781 (2021 – 2022).

Find out more about the journal at: www.jps.biomedcentral.com

For PSJ members, *The Journal of the Physiological Society of Japan* is published quarterly in Japanese.

Please visit the PSJ website for more information: http://int.physiology.jp

A similar article has been published online at: IUPS.org

Figure 3. PSJ's membership journal *'The Journal of the Physiological Society of Japan'*


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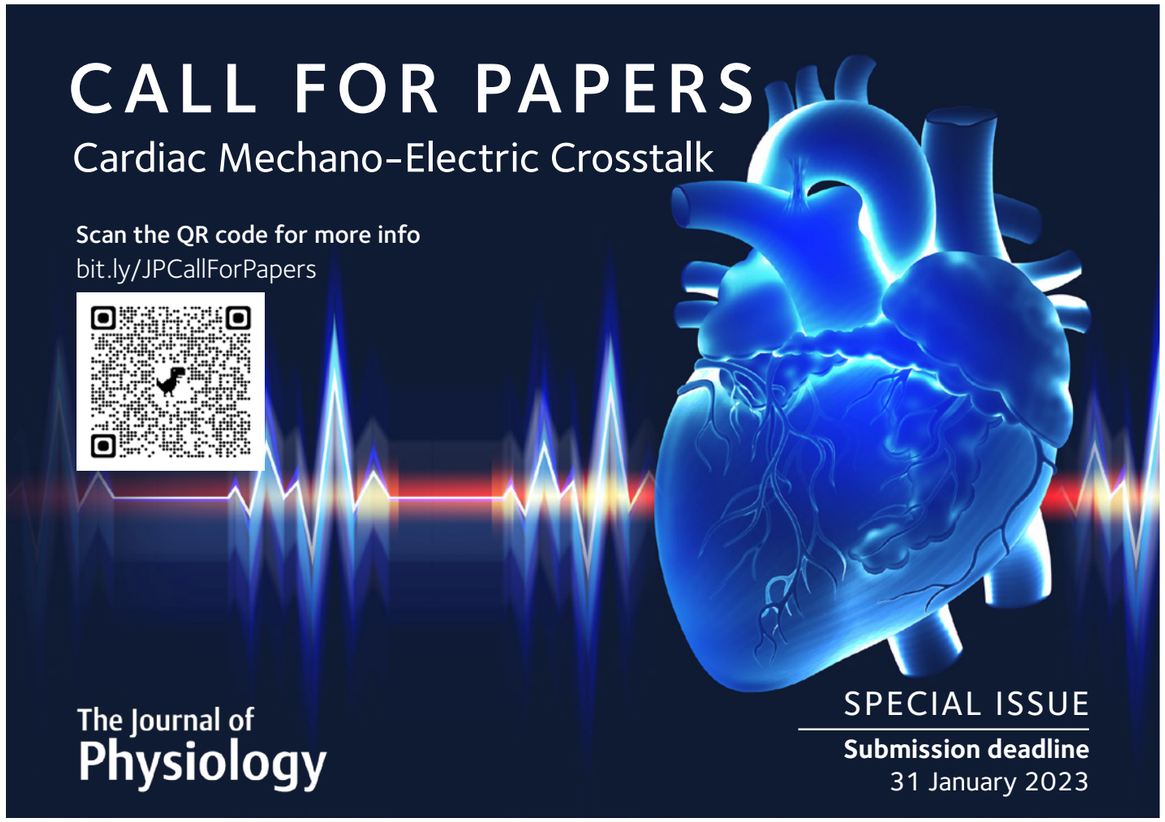
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Meeting Report

Europhysiology 2022

16 – 18 September, Copenhagen, Denmark

Sarah Bundock

Head of Events and Marketing, The Physiological Society

Over 1,200 physiologists from 57 countries joined The Society and its partner societies (The Scandinavian Physiological Society, The German Physiological Society, and the Federation of European Physiological Societies) in September in Copenhagen for Europhysiology 2022. The series is unique in that it brings together physiologists working across Europe.

Of the 1,205 that registered, 675 were early career researchers who shared their research at the 18 oral communication sessions and two vibrant poster sessions. Many members reported the posters as being a particular highlight of the conference.

Our Scandinavian colleagues were excellent hosts of the 2022 conference, and Copenhagen was a welcoming city. The Local Organizing Committee's thoughtful care and attention to the social programme meant that those attending could also experience local tourist attractions including a canal tour, and also the famous Tivoli Gardens. We were also warmly welcomed to the Copenhagen City Hall with its famous rådhuspandekager (Town Hall pancakes) at the welcome reception.

Thanks go to the Organizing Committee, and also the Scientific Programme Committee, chaired by Professor Helle Prætorius Øhrwald, Aarhus University, Denmark.

Three members of The Society share their highlights below.

Dr Catriona Cunningham

University of Aberdeen, UK

Europhysiology 2022 Poster Prize winner in Education & Teaching

This was the first time I have attended a Europhysiology conference and I was impressed by how well represented education and teaching were in the programme. It wasn't something I've seen at any other international conference.

One of my highlights was definitely the poster sessions. There was a very lively, friendly atmosphere and it was a great opportunity to meet other teaching-focused physiologists. I felt really welcomed by them and it was exciting to hear about a wide range of innovative approaches to teaching.

Another highlight was Professor Dee Silverthorn's Otto Hutter Physiology Teaching Prize Lecture on "Teaching in the Time of COVID – and Beyond". She shared her valuable insights into the challenges and opportunities of teaching during the pandemic or as she phrased it, the good, the bad and the ugly.

I also really enjoyed having the opportunity to hear about the latest physiology research. One session I found particularly fascinating was Professor Gero Miesenböck's lecture on using optogenetics to identify sleep-inducing neurons in *Drosophila*.

Overall, I thoroughly enjoyed Europhysiology 2022. I felt I had lots of great discussions and came away with several new ideas I want to introduce into my teaching. I'm really looking forward to Physiology 2023!

Dr Matthew Lee

University of Strathclyde, UK

Like many researchers during the COVID pandemic, I found it difficult to interact with online conferences. Not because the science was any less exciting, but because online events do not replicate the most important aspects of a conference – the social interaction, the networking and the poster sessions. So, after a two-year hiatus, I attended my first in-person conference at Europhysiology 2022 and it did not disappoint.

Europhysiology has the unique ability to bring together a considerable number of researchers from across Europe and beyond who have varying research interests but all with a shared focus on physiology. No matter where your research interests lie, you are guaranteed a session for you. Although my research focuses on vascular physiology, one of my highlights was the keynote lecture by Professor Bente Klarlund Pedersen where she discussed the benefit of prescribing exercise as a form of treatment in certain diseases.

As an early career researcher, it is always daunting to present to peers and experts. However, everyone at Europhysiology 2022 was very welcoming and friendly. I received excellent feedback and critique at the poster session, not only from experts in my field but also from researchers whose interests lie elsewhere. This was extremely beneficial as someone may ask a question you hadn't thought of or offers a piece of knowledge that is very helpful.

Europhysiology 2022 was held in Copenhagen and was the first time I had visited the city. Copenhagen is a fantastic city. Everyone is very friendly and laid-back, the infrastructure encourages exploration (mainly by bicycle), and the food is fabulous. I mean you can't really go wrong with an amusement park in the heart of the city!

Europhysiology series of conferences offers so much, especially for early career researchers. Anyone with an interest in physiology, should do their utmost to attend any future Europhysiology conferences.

Dr Luke Hughes,

Northumbria University, UK
Society Early Career Theme Lead for Human, Exercise and Environmental Physiology

Europhysiology 2022 was a brilliant conference that offered so many different opportunities for physiologists from around the world. The particular emphasis on early career researchers was an encouraging and beneficial aspect of the conference.

Unlike many other conferences I have attended, Europhysiology 2022 opened with a symposium focused on early career researchers and the speakers' experience of working within, and between, academia and industry. As someone who has stepped into both areas during the early stages of my career, I found it incredibly useful to hear from individuals who had moved from academia to industry, or vice versa, and the challenges and rewards they had experienced.

The conference had an excellent mix of human, cellular, and molecular physiology sessions. It was brilliant to have the opportunity to listen to presentations from several, award-winning, world leaders within the keynote lectures. The organised symposia were fantastic, and it was great to support some of my colleagues in the sessions they had organised.

One of the highlights of the conference for me was the chance to meet individuals from The Physiological Society, and network with researchers from different institutions.

Copenhagen was an awesome location for the conference, with plenty to do outside of the scientific programme. The craft beer and food at Warpigs was a definite highlight for me!

Meeting Preview

Innovation and Updates in Teaching and Student Education across Physiology and STEM in the UK and Ireland

Dr Charlotte Haigh, Dr Ruth Norman and Dr Chris Randall

University of Leeds, UK

We are looking forward to inviting members and non-members to our meeting "Innovation and updates in teaching and student education across Physiology and STEM in the UK and Ireland" taking place at the University of Leeds, UK on the 12-13 April 2023.

This meeting will focus on four key areas of student education that are being regularly discussed within higher education institutions across the UK and Ireland. These are: meeting the needs of a diverse student population; developing authentic assessment with useful feedback mechanisms; using core concepts in curriculum design; and developing global citizenship skills in students.

Coming out of the aftermath of the COVID pandemic, higher education is changing. There has been a lot of focus on forward thinking, taking on board what lessons have been learned. Many institutions are considering utilising the innovative parts of the rapid transition online, but continue to determine how we support learning of current and new students moving into higher education. Everyone is grappling with these ideas at the same time as thinking about future-proofing degree courses and developing student skills to enable them to become global citzens. Much of the sector is going through a redefinition of what they teach, the way in which they teach and the assessment associated. This meeting will allow academics to share best practice across Physiology and the wider STEM sector and generate ideas to shape future student education.

This will be appropriate for all members who have an interest in innovative education practice and are keen to listen and share. We will hear from experts in the four areas, with the keynotes being delivered in a workshop-style activity aiming to encourage the audience to implement some of the key ideas in their own practice. There will be a chance for attendees to showcase their scholarly work, from completed projects to research in progress, as well as generation of new ideas and support for cross-institution scholarly projects aiming to achieve wider impact. There will also be time in the programme for informal discussion and networking opportunities each day.

Leeds is a great location as it is central to the UK, easily accessible by train and air, with relatively cheap accomodation close to the university. In the evening there will be a chance to mingle and take in some of the hospitality that Leeds has to offer.

Whether you are an experienced educator or new to teaching, this meeting will provide opportunities to benefit you in your educational practice, including increasing the impact of your student education practice, publishing scholarly work and career progression in a scholarship role.

Please put the dates in your diary, and we look forward to a vibrant meeting in Leeds in April 2023.

Key dates

- Registration opens 1 December 2022
- Abstract submission period: 3 January – 3 February 2023
- Conference Attendance Award deadline: 28 February 2023
- Early bird registration deadline: 1 March 2023

www.physoc.org/events

Meeting Preview

Variability, Physiological Variability and Individual Responses: A Practical Research Workshop

Dr Jo Corbett

University of Portsmouth, UK

Dr Adam McDonnell

Jozef Stefan Institute, Ljubljana, Slovenia

When a group of individuals undergo an identical experimental intervention, they do not typically all respond in an identical manner or even in the same direction. Indeed, perhaps the one invariant amongst physiologists conducting research across the various domains is that the data that they collect will contain variability! If it did not have inter-individual variability, then '*n* = 1' would be the default experimental design rather than the exception.

Typically, an intervention is evaluated by comparing the average or mean. This we know is quite useful in describing the expected outcome, but it does not accurately describe the response of all of the individuals involved in the experimental group. Variability has historically been viewed by researchers as an inconvenience and so for many years the default approach to dealing with variability was a reductionist one, with data often condensed into "neat" reporting of summary measures of central tendency and dispersion. However, more recently there has been an increase in awareness that "variability" within the data itself is a rich source of information. The careful identification and quantification of individual variability has implications, not only for the optimisation of health interventions, but also for the determination of pathophysiological processes that can underpin the provision of personalised medicine. Caution should be applied, however, with regard to applying classification to the observed responses.

The evolution towards embracing variability within research data has led to a growing realisation that, to properly understand interindividual variability, an experiment must be designed in such a way that the "true" interindividual variation in the response may be titrated from the effects of the random within-subject variation. Such experimental designs need to strike a real-world balance between rigorous experimental designs and the practical realities of conducting these research studies. Once such an experiment has been conducted, the physiologist must then be equipped to present in a manner that displays this variability to the audience using appropriate data visualisation approaches, and subsequently that the interpretation of the variability within the data is clearly and accurately communicated to the scientific community. In order to provide scientists with the appropriate tools to conduct such research, The Physiological Society is hosting a workshop titled, "Variability, Physiological Variability and Individual Responses: A Practical Research Workshop".

This workshop on Tuesday 4 April 2023 in London will feature contributions from three discipline experts, allowing a greater amount of time for the presenters to expand on key points, give step-by-step guidance, and to provide practical "worked examples" of approaches to the assessment of variability covering a variety of experimental designs (their strengths and weaknesses), statistical methods and presentation and data interpretation. The afternoon session of this one-day workshop will host an interactive symposium for early career researchers to present their research, including data on individual variation.

Registration is open now and closes on 15 March 2023. Early career researchers can submit their work to be discussed from 1 December 2022. Find out more at physoc.org/events/variability-physiological-variability-and-individual-responses/

Speaker panel

- Professor Anne Hecksteden, Institute of Sport and Preventative Medicine, Saarland University, Germany
- Professor James Betts, University of Bath, UK
- Professor Stephen Senn, Statistical Research Consultant, UK

Sharing physiology stories with the community to unravel the mysteries of the body

Members reflect on their time serving on the Editorial Board for Physiology News

With one year ending and the dawn of the new year awaiting us on the horizon, it is the perfect time for reflection. As 2022 draws to a close, it marks a period of change for our Editorial Board. We must bid farewell to a few of our members who will sadly be stepping down after their years of dedication, working behind the scenes to shape and develop the captivating research, discoveries, and member stories we present to you every quarter.

We would like to say a huge thank you to Havovi Chichger, Ronan Berg, Dervla O'Malley, Philip Lewis and Michael Preedy. Before they finish their term and new members take up the baton, here are a few highlights they wish to share of their experience and time working on the magazine.

Dr Havovi Chichger

Anglia Ruskin University, UK

What inspired you to study physiology and pursue a career in it?
Understanding why things function the way they do and how we can study it. It is interesting to see how we can use this information and turn it into a way that helps public health, whether that is through treating disease, sport science or nutrition. It all comes from physiology.

What do you value most about being a member of The Society? Which member benefits have you found most useful over the years?
It is so great to be part of a collection of physiologists, whether they are anatomists, sports scientists, clinicians or cell biologists. Every time I attend a PPhysiological Society event (a meeting, workshop, committee or panel), I meet a different type of physiology enthusiast with a passion behind their membership and a physiology story to share!

What is your favourite *Physiology News* article?
That's a tough choice but it has to be the article in the Issue 123 September 2021 (Equity, Diversity and Inclusion Special Issue). We had a fantastic feature article called "Nothing about us without us" (https://doi.org/10.36866/pn.123.24) about how our current understanding of physiology does not take account of transgender health. This is not something that is often discussed or considered in the field and so I thought it was a really informative and an important article to bring the conversation to physiologists.

Dr Ronan Berg

University Hospital Righospitalet, Denmark

What inspired you to study physiology and pursue a career in it?
It was my inner detective that led me to study medicine. From the very beginning of my studies, my main interest was physiology, the science that seeks to uncover the mysteries of the body.

What excited you to be part of the Editorial Board?
I have always loved how *Physiology News* bridges the gap between in-depth physiological science and popular science. To me, *Physiology News* is the National Geographic of physiology. And I do love to communicate science myself as well, both to colleagues, students and to the general public. So, when I saw that opportunity to join the Editorial Board, I just knew I had to give it a chance. As with experimentation and teaching, I consider editorial work an integral and very important part of my work as a scientist. My term at *Physiology News* is now coming to an end, and it has been an incredibly inspiring experience. I will continue my efforts and apply what I have learned at *Physiology News* in my new role as Deputy Editor-in-Chief on the journal editorial team for The Society's *Experimental Physiology*.

Do you have any interesting anecdotes from your time serving on the Editorial Board?
I had the privilege of serving as guest editor on *Physiology News* Issue 117 "Space Physiology: To Mars and Beyond" (https://www.physoc.org/issue-numbers/winter-2020-issue-number-117/). The whole thing was just such a great experience. The authors were all so enthusiastic, and for a while it felt like we were indeed planning a trip to outer space. Being a bit of a control freak, I was involved in almost all steps of the completion of the issue, including very detailed instructions (I must have been so annoying!) to the Spanish artist Martin Sati who designed the cover art for us, cleverly juxtaposing biological organs and systems on a female astronaut on Mars. I was very proud when the issue was launched at NASA's Human Research Program conference in 2020.

What is your favourite *Physiology News* article?

I have quite a few favourites. From my own term on the Editorial Board, I think two outstanding articles are "Maintaining your attitude at altitude" (https://doi.org/10.36866/pn.111.24) by Joshua Tremblay and Michael Tymko, and "Ecophysiology and climate change" (https://doi.org/10.36866/pn.118.26) by L. Monica Trondrud and Alina Evans, Norwegian University of Life Sciences, Norway. Both articles elegantly communicate very complex science, while also showing the diverse careers and everyday lives of physiologists.

From the archives, I think John West's article on the avian lung is legendary: "Did evolution go the wrong path for the human lung?" (https://doi.org/10.36866/pn.65.17). Over the years, *Physiology News* has published a collection on the physiology of playing music. I particularly recommend reading Sheila Young's "A physiological study of Mozart's clarinet concerto" (*Physiology News* 19, pp. 28-29, 1995).

Dr Dervla O'Malley

University College Cork, Republic of Ireland

What inspired you to study physiology and pursue a career in it?
Having completed my undergraduate degree in Biomedical Sciences and not being completely sure where I wanted to go next in my career, I took a year out to explore the world and also try to figure out what my next steps should be. Having funded my travels with many uninspiring temping positions, I knew that job satisfaction was going to be critical to my long-term career happiness. I undertook a PhD in Neurophysiology and soon realised that a career aimed at figuring out "how" biological events happen, although frustrating at times, provided the practical and intellectual challenges that keep monotony at bay and ensure that I am happy to go to work each Monday. The most rewarding aspects of my career are having the independence to pursue interesting questions and the ability to share my curiosity with future physiologists.

Do you have any interesting anecdotes from your time serving on the Editorial Board?
Expecting to be the only Irish physiologist, I was happily surprised by the strong Irish links on the Editorial Board (even if many had expanded their geographical horizons beyond the Emerald Isle). To echo the sentiments of Professor David Paterson, President of the Physiological Society, it is encouraging to see that Irish physiologists continue to be at the heart of the Society.

What do you value most about being a member of The Society? Which member benefits have you found most useful over the years?
It is wonderful to join other physiologists from around the world, who share the passion and curiosity of trying to figure out how the body works. The Society has taken great strides in being open and inclusive, with the aim of making physiology flourish beyond the research labs and lecture halls.

What is your favourite *Physiology News* article?
During my tenure as an editor of *Physiology News*, the edition that I found most stimulating was Physiology News Issue 117 "Space Physiology: To Mars and Beyond" (https://www.physoc.org/issue-numbers/winter-2020-issue-number-117/). With articles that covered many of the physiological systems, this edition presented evidence of how malleable mammalian physiology is in the context of a dramatically altered environment. Life that has evolved under specific environmental and gravitational conditions are unprepared for the insults of space travel and yet, the evidence demonstrates physiological adaptation. This edition clearly demonstrated that if people are to survive and thrive on other planets, understanding the physiological impact of the challenges to be faced will be critical for success.

Dr Michael Preedy

Yale University School of Medicine, US

What inspired you to study physiology and pursue a career in it?
Keep this to yourself, but I'm not really a physiologist. Pharmacology was the trade I learned. But a pharmacologist must be a "jack of all trades," as Sir John Gaddum put it (1900 – 1965). And one cannot proceed very far in understanding how a drug affects a system without knowing a little something of how the system works in the first place.

What excited you to be part of the Editorial Board?
Essentially, to communicate science and gain practical experience in engaging audiences. It's too easy to disregard science communication because it's someone else's problem to deal with, not to mention the laziness of that attitude. It doesn't matter if you work at a university, a hospital, or in the private sector, if you're a scientist then you must shoulder some responsibility for ensuring that scientific content is communicated well.

What is your favourite *Physiology News* article?
Dr Sean Roe, Queen's University Belfast, UK wrote a compelling feature article on the legacy of Sir Gordon Morgan Holmes in the Winter Issue 124 discussing the far-reaching influence of Holmes' life and work on science worldwide (https://doi.org/10.36866/pn.124.32). Why? All I can do is encourage you to read it and you'll understand why it is a must-read for anyone.

Dr Philip Lewis

University Hospital of Cologne, Germany

What inspired you to study physiology and pursue a career in it?
A general interest in - and an aptitude for - understanding human biology led me from general science to physiology during my undergrad at University College Dublin, Ireland. Thereafter, and in addition to general interest, it was a case of the right people being around me at the right times who were inspirational and helped put me (and keep me) on this career route. This includes classmates, lecturers, project supervisors, postdoctoral colleagues, etc. I have been very lucky in this regard.

What excited you to be part of the Editorial Board?
Being part of the Editorial Board was a chance to experience another side of science, to meet new people, and to give something back to The Society that has helped me so much over the years. The extra workload involved seemed very manageable (which is also due to the way the board is run). The experience would look good on my CV (I was on fixed-term postdoctoral contracts at the time of application for the position). New experiences and meeting new people often lead to new opportunities (and they did). I did not see any downside (and there was none!).

What is your favourite *Physiology News* article?
It is impossible to select just one. It seems that every issue contains some material that I take note of for teaching. As guest editor for the "Chronobiology and Sleep Special Issue" a few years ago, I would recommend dipping into all the articles published in that issue (https://www.physoc.org/issue-numbers/physiology-news-113/). Over the years, the magazine has published many fascinating articles on comparative physiology, which even non-physiologists would find stimulating reads. I suggest browsing through past issues to see for yourself. Given that I currently work at an institute specialising in occupational and environmental medicine, a particularly relevant article that stayed with me is "Physiology to the Rescue" written by Professor Mike Tipton and Dr Gemma Milligan from the Climate Change Special Issue (https://www.physoc.org/magazine-articles/physiology-to-the-rescue/).

Many thanks to The Physiological Society and to the *Physiology News* Editorial Board for this excellent experience!

Dr Richard Hulse

Nottingham Trent University, UK

What inspired you to study physiology and pursue a career in it?
It has always been my ambition to investigate how an organism works. I was particularly drawn to neuroscience, eager to understand how neurons work and cause neurological disease. It is fascinating how neurons have the capability to adapt or alter during different stresses and the impact this has upon our ability to survive and function.

What do you value most about being a member of The Society?
As I have moved through academia The Physiological Society has supported me, from being a PhD student through to becoming an academic member of staff. I applied for my first grant funding through The Society's travel grant schemes, which enabled me to attend a variety of Society meetings. I gave my first oral presentation with The Society, who provided the initial opportunity to present my work to larger audiences. A story I always tell my students, as you can only improve your presenting and speaking skills with practise. Now I encourage our current generation of students to engage with The Physiological Society to take advantage of the opportunities provided and to benefit from their support. Being a member on the editorial board for Physiology News has enabled me to work more closely with The Society, increasing engagement with the current themes that are becoming more prominent in physiology and to showcase this work to a wider audience.

It is so great to be part of a collection of physiologists, whether they are anatomists, sports scientists, clinicians or cell biologists. Every time I attend a Physiological Society event, I meet a different type of physiology enthusiast with a passion behind their membership and a physiology story to share!

Enhancing your career with our professional development resources

In May 2022, we announced the awardees of a Research Springboard Studentship, a grant that provides undergraduate students the opportunity to undertake a research project supported by a supervisor.

Over the summer the students experienced the entire life-cycle of research, from writing a funding application to conducting and analysing research and report writing. Three of the awardees, Anne Marie O'Callaghan, Laura Gherman and Peter Panizza, discuss their projects and share how it has shaped their future career plans.

The call of regenerative medicine

Anne Marie O'Callaghan

My summer spent working in a leading Irish research laboratory has strengthened my interest in pursuing a PhD in neurophysiology. Delving into my own research project has awakened my curiosity in the field of neuro-regeneration, so I want to continue exploring this area as a postgraduate student.

My project aimed to assess the feasibility of delivering mRNA into neural cells using a non-viral vector i.e. nanoparticles made from biomaterials. Following spinal cord injury damaged neurons are unable to produce growth proteins in order to repair themselves and regrow. Delivering growth-associated genes directly into damaged neurons could therefore be key in treating cord injury. Genes can be delivered as mRNA, which is converted to protein once inside a cell.

For the naturally curious

Before completing this studentship, I saw research in academia as a very likely career path for myself. I thought that research was a fantastic way to explore a set question and therefore is very suited to someone like myself with a naturally curious mind and so was the perfect fit for me.

I was very excited by the field of regenerative medicine because the research seems so ground-breaking and revolutionary. I loved the thought of using cutting-edge techniques and developing new and efficient methods of improving health and quality of life.

I thought a researcher had to already have all of the skills and knowledge prior to beginning a research project. I did not realise how much a researcher learns day to day and how much training is required to become practiced in a specific laboratory technique. I discovered how collaborative research is and how important this collective effort is for the end result.

It was wonderful to meet people at distinct stages of their academia career progression. I learned so much about the different research positions and roles in a university lab setting and gained advice from a variety of experts about the career paths they have chosen.

Delving into the unknown

What surprised me the most during my studentship was the collaborative and social lab environment. I was always surrounded by other researchers, some working on vastly different projects.

As part of the spinal cord team I interacted with neuroscientists, bioengineers, material scientists and physiologists. From participating in weekly lab meetings to informal chats about our projects in the lab, I enjoyed the constant exposure to different ideas and points of view. I came to see how important collaboration is for good-quality research and how beneficial it is to always learn from fellow researchers.

I was given the independence and freedom to explore my project topic and gain ownership of my work. If something interested me, I was encouraged to investigate and follow it through. I found this so exciting and a stimulating way to work, as I was essentially delving into unknown territory and choosing how to lead the way.

I was recently invited back to present my findings at the weekly lab meeting, where I enjoyed hearing the team's feedback and engaging in stimulating conversation with them about my work.

What the future may hold

The studentship gave me hands-on practical experience in the lab, more than I ever would have received in college. I plan to undertake a PhD research project and follow it with a postdoctoral position. I would like to continue with regenerative medicine and neurophysiology for the long term as it is such a new area of research with limitless opportunities and possibilities heading into the future. However, other topics could capture my attention as I progress along this path, which I will be open to exploring so I could very well end up down a different path. Only time will tell.

Exploring the beauty of science's vast and ever-changing landscape

Laura Gherman

For a while now, completing a PhD to pursue a career in academia has been a path I saw myself following. After this summer, gaining a peek into the world of research has sealed that this is the journey I wish to continue.

I was involved in a project to understand long-term memory formation. The findings of this could highlight memory-relevant molecules that may be potential targets for therapeutic intervention into human disorders, such as those producing amnesia and compulsive behaviours. We investigated expression levels of genes that play a key role in memory formation, with a focus on genes encoding for proteins that detect a chemical messenger in the brain called serotonin.

A test of oneself

Scientific research is more than just about discovery and the betterment of humankind. I found that it is also about the betterment of the self. It can often test you, your perseverance and determination. By the nature of research, you will hit an obstacle, at which point you have to make a critical decision on how to progress: will you find a way around it, or is it time to start going down a new path?

My project demonstrated how crucial critical thinking, organisational skills and adaptability are in research. It highlighted the need to remain open-minded, and to be receptive to new ideas, even if they oppose your own. The beauty of science originates from its ever-changing nature and the infinite possibilities it offers, limited mostly by your creativity. However, with great creative freedom comes the great need for ambition and passion towards your project.

A lifestyle choice

One of the most fundamental points I came to realise during the project is that working in academia is more than just a career, it is often a lifestyle. There were days where I was so excited by my work that my mind was still buzzing once I had left the lab and failed to switch off even when I was at home, eager to get back and continue. However, not all days were like that, which is when the need for self-motivation, and as mentioned above, perseverance and determination arises.

For me, a life in academia is about succeeding in the face of the blends of thrills and turmoil it offers. I believe that I have the adaptability, resolve and tenacity to guide me through.

A glimpse into how much remains to be discovered

Peter Panizza

The project was an ideal opportunity for me to apply the concepts that I have learned throughout my undergraduate degree. Experimenting on skeletal muscle to investigate Duchenne muscular dystrophy, a fatal muscle-wasting disease affecting predominantly young males. A characteristic of the disease is mitochondrial dysfunction; however, the exact cause of this dysfunction remains unclear. It is hypothesised that the opening of a pore on the mitochondrial membrane may be a contributing factor to mitochondrial dysfunction in Duchenne muscular dystrophy.

To conduct original research in an area of physiology that I am extremely interested in gave me the chance to experience a career and contemplate the field I would like to follow. It also deepened my curiosity about physiology as it has given me a glimpse into how much remains for me to learn.

A fork in the road

Before commencing the studentship I had wanted to pursue a career in research. However, I was unsure whether I wanted to focus my research in neuroscience or physiology. After completing this studentship I decided that I would like to pursue a career in research focused on physiology, specifically skeletal muscle physiology.

A new perspective

Before conducting this project I had thought that life as a researcher was an isolated job. A job that required long hours working alone in a laboratory with little discussion between lab groups around the university. I had believed that the pace research could be conducted was simply up to the researcher and the number of hours they were willing to work. I had never considered the numerous factors that are completely uncontrollable could affect how quickly someone could carry out their work, such as waiting to use certain equipment and the ordering of reagents and the associated shipping times and delays.

Completing this project allowed me to understand that research is a highly collaborative job and has reinforced the importance of good communication skills. Problems are best tackled using the hive mind, so it is useful to ask others their opinion to gain alternative perspectives on a problem. I also learned that research requires large amounts of patience, whether it is long hours in the laboratory running an experiment or waiting to use a piece of equipment that is in high demand by others working in the same area.

Aspiration

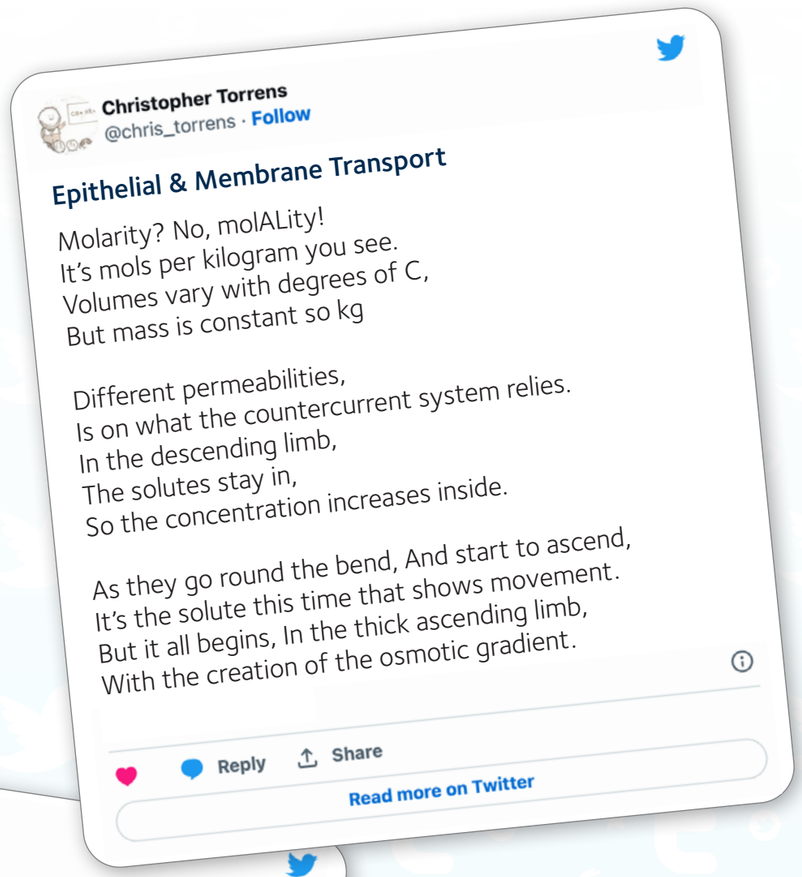
My goal from now is to continue pursuing a career in research. My ideal job would be one that allows me to work at a university and both teach/lecture while also carrying out research. The prospect of teaching while also doing research became most appealing to me after spending time among other academics at the University of Western Australia. The experience and talking to academics in this role was enlightening.

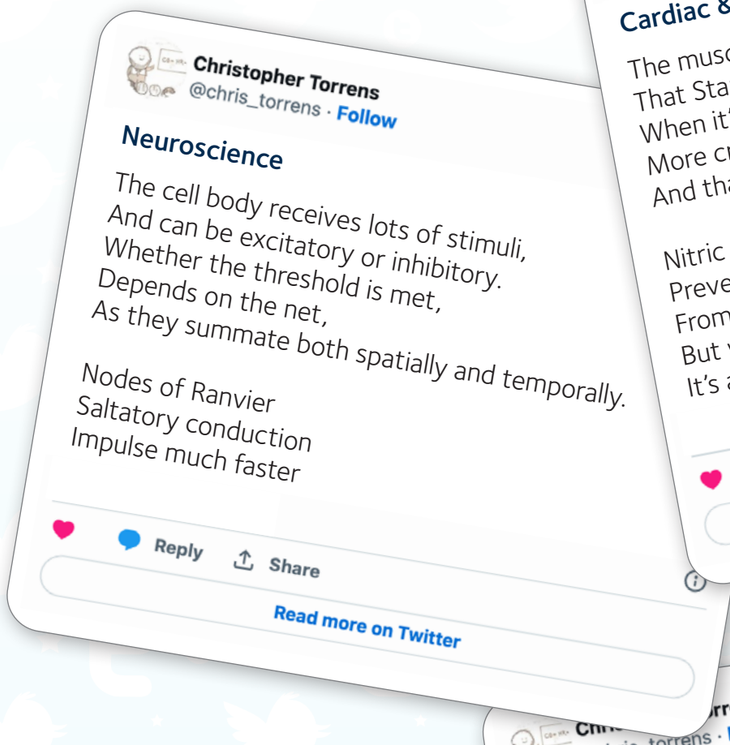
We are committed to supporting our members' professional development. Browse through our suite of webinars and resources produced in collaboration with expertise from across the physiological sciences at physoc.org/professional-development/

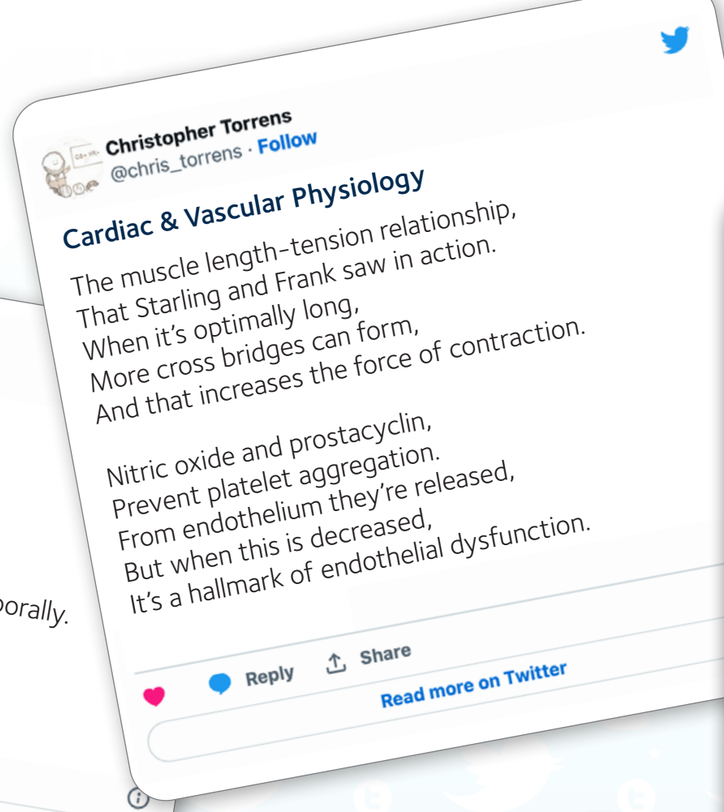
Adverse Physiology

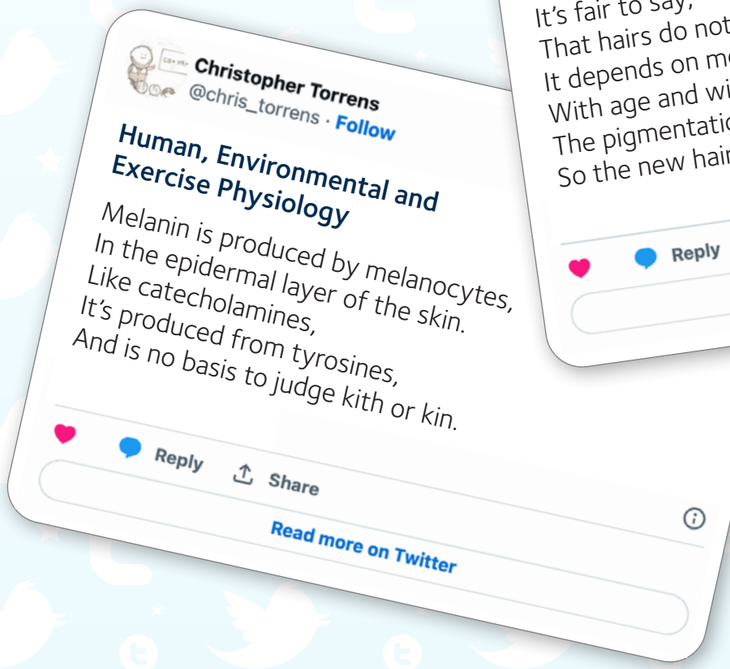
Dr Christopher Torrens
RCSI, Republic of Ireland

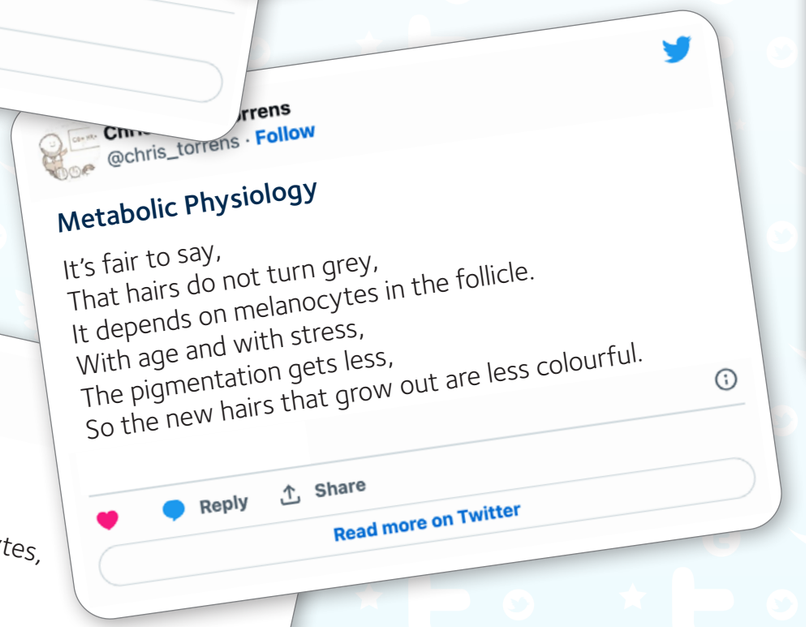
Back in Biology Week 2013, The Society held a competition for the best physiology-based poems. I created a twitter account (@chris_torrens) and posted a poem that sought to clear up the distinction between molarity and molality. The competition ended, my first entry was judged to have won and the die was cast. These are some of my personal favourites, beginning with that winning entry.











Physiology 2023

Enjoy a warm welcome with **first class science** and **unmissable networking opportunities** in the historic spa town of Harrogate.

10-12 July 2023 | Harrogate Convention Centre, Harrogate, UK

KEY DATES

Registration opens
3 January 2023

Abstract submission opens
1 March 2023

The Physiological Society

physoc.org/Physiology2023