Issue 127 / Autumn 2022

# PN
# Physiology News

## Climate Change Special Issue:
*Tackling the greatest health threat facing humanity*

The Physiological Society

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Welcome to the Autumn 2022 edition of *Physiology News*

## Introduction



## News and Views



## Features



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**Cover image:** Bushfires in Australia

# Nominate your **outstanding** physiologists today!

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# The perils of climate change: How physiology can save lives in our changing world

*Dr Keith Siew*

Scientific Editor, *Physiology News*

If you go to your medicine cabinet, fish out your old school glass thermometer and wrap the mercury reservoir of that thermometer in damp cotton… Then congratulations… You have just created a terrifyingly simple model of human thermoregulation, a device capable of measuring the "wet-bulb temperature". Something you can expect to hear more of in the coming years.

The concept is straightforward. When humidity is low, the wet-bulb's temperature remains lower than that of the ambient air through the shedding of heat by evaporation; similar to that of sweat evaporating from our skin. However, as humidity is rising (and no, the barometer is not getting low… before you go getting any ideas) the ability to shed heat reduces and eventually at 100% relative humidity the air becomes saturated with water vapour and the wet-bulb temperature will match that of the ambient air. This is the scary point at which no amount of sweating will cool you down.

Even for a young fit healthy individual a wet-bulb temperature of 32°C would render them unable to carry out most normal outdoor activities. At only a few degrees higher we hit the theoretical survivability threshold of 35°C, where even with an endless supply of water and stripped to bare skin, one cannot survive more than a handful of hours at best. Originally climate models had projected the first occurrences of wet-bulb 35°C to emerge by the mid-21st century, but a close inspection of weather station data shows that several places on the planet have already hit this, albeit for brief moments in relatively unpopulated areas. However, extreme heat can put enormous stress on the cardiovascular system and even wet-bulb temperatures of 28°C have resulted in large amounts of excess deaths, for example in the 2003 European and 2010 Russian heatwaves.

And despite all this going on, it seems many have their heads buried in the sand. I don't know about you, but I'm certainly not appreciating the alarming frequency at which "life imitating art" is playing out in recent years (and unfortunately not the fun movies with happy endings). At first it was 2011's *Contagion*, which seemed another star-studded blockbuster with a far-fetched and surreal doomsday event, but upon a recent rewatch (yes, I'm a glutton for punishment) it was eerily prophetic of our own impending pandemic. The all-too-familiar lingo of social distancing, R0 values, political miscalculations and snake oil promises rang through with a stark emotional tone, which I had (unsurprisingly) not felt on my first watch.

A decade later, our screens were graced with *Don't Look Up*, a satirical and at times ridiculous post-Trumpian take on how we might respond to a ball of ice and rock on the apocalyptic scale, hurtling towards Earth. From this love-it-or-hate-it flick, one scene remains emblazoned on my mind, wherein the scientists breaking the news of our impending doom to the world are interviewed by news anchors insistent on putting a comic and positive spin on things. Twice now this exact scene has played out on British TV, except in this case the scientists aren't astrophysicists but meteorologists and climate scientists. I couldn't believe my eyes and ears; here was a meteorologist anticipating, many many excess deaths occurring as the UK soared to temperatures of 40°C, while the reporter berated him for being all doom and gloom, when she just wanted some good news and to feel good about the weather!

So, in response to this, we have chosen to focus this special issue on climate change and the role physiology has to play in our response to it. This includes a piece by Professor Hugh Montgomery who expertly lays out the path before us if we don't change course (see p.16), as well as a swathe of other articles covering recommendations from Professor Ollie Jay on how fan-based cooling may be beneficial or harmful (see p.29), to an argument for the intertwined nature of air pollution and climate change by Dr Michael Koehle (see p.26), and how taking advantage of our routes to school and work as an opportunity for physical activity could help combat climate change by Dr Julia Zakrzewski-Fruer (see p.23). Lastly, we have contributions from Dr Ana Bonell (see p.19) on the disproportionate impact of heat stress on women during pregnancy in subsistence farming communities, a striking piece on the professional versus personal contributions of scientists to climate change by Martin Farley (see p.13), and a piece by Professor Mike Tipton and Dr Gemma Milligan on how physiology may be well suited to come to the rescue (see p.40).

We hope that this issue will impress upon all our readers the challenges and serious perils that await us without swift meaningful action, but also to give you some hope that many lives can yet be saved, and that physiology can provide some means to assist our adaptation to our changing world and mitigate the damage.

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# The heart of our new strategy: Building a strong community of physiologists to advance science

*Professor David Paterson*

President,
The Physiological Society

Almost 150 years ago, on 31 March 1876, 19 men who had made – or would make – significant contributions to physiological research, teaching or writing met at John Burdon Sanderson's house in London. They discussed a Royal Commission, which had been established on the practice of subjecting live animals to experiments for scientific purposes and a proposal to form an association for 'promoting the advancement of physiology and facilitating the intercourse of physiologists'.

Within a few weeks, rules for such an association were agreed and an inaugural dinner was held at Criterion restaurant in Piccadilly. The Physiological Society was formed.

The Society's Minute Book from the time contains a list of Sanderson's guests – founders, with him, of The Physiological Society. Their names appear as follows: Wm. Sharpey, Tho. H Huxley, Michael Foster, Geo. H Lewes, Francis Galton, John Marshal [sic], G.M. Humphry, Fk. Wm. Pavy, T. Lauder Brunton, David Ferrier, P.H. Pye-Smith, Wm. H. Gaskell, J.G. McKendrick, E. Klein, E.A. Schäfer, Francis Darwin, Geo. J. Romanes and Gerald F. Yeo.

It is in the footsteps of these greats from our past that current members of The Society walk. While the world of 2022 looks very different to that of 1876, our core purpose as a community of physiologists who work together to support each other and advance the physiological sciences remains unchanged. Our members truly are our greatest strength. The aspect of my presidency I have enjoyed the most is meeting members and hearing their passion for physiology and The Society.

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 The Society has spent the last few months developing its new strategy to run from 2023. It is an ambitious strategy that builds on our successes, addresses challenges, and sets us on a course to grow stronger in the future.

We have seen over recent years the real success of reinvigorated engagement within institutions, and through schemes like our Blue Plaques and Member Roadshows are now regularly travelling across the UK and Ireland to meet with members. Our policy work has focused on making the case to decision-makers and funders on the role of physiology in tackling societal problems such as healthy ageing and climate change.

There are plenty of challenges ahead. Open Access, through Plan S, will transform the publishing environment and require us to change our approach. Greater competition for members means we must ensure we are offering our membership the support and services they need. Increasing scientific subspecialisation means we must continue to make the case for discipline relevance. Pressures on higher education institutions will demand we are agile and vocal in advocating for our members' interests within departments.

As the Chief Executive of UK Research and Innovation, Professor Ottoline Leyser, has stated, our current research system is too siloed, which "restricts career paths across roles, sectors and disciplines, reinforcing silos by reducing connectivity and the flow of people and ideas." In response, The Society must consider how to connect the broader scientific ecosystem by reaching out beyond academia into industry and clinical settings to support the full breadth of physiology.

This includes ensuring we are supporting our excellent physiology educators, who are working to inspire the next generation of physiologists, medics, healthcare scientists and many others.

Our journals are recognised as world leading with international reach, and our new strategy will improve the connections between them and our membership. The Society has huge breadth and depth across areas of the discipline, institutions, sectors, and countries. With over 60 countries represented in our membership, we are truly a global community. Many of the challenges facing physiologists are shared the world over, and a stronger global network will support physiology to thrive.

Physiologists building their career will continue to be time pressured and at the heart of The Society's mission should be that our conferences are viewed as "must not miss" events and our support and publications are essential to career and scientific advancement.

I am proud that we have had 60 Nobel Prize winners among our membership: we must ensure we are supporting the Nobel Prize-winning physiologists of tomorrow.

To achieve this, our new strategy will be focused on five overarching objectives that we will measure our delivery against, underpinned by The Society's Equity, Diversity, and Inclusion Roadmap.

By the end of 2027 we will:

- Have a larger, more engaged, and more diverse community of members.
- Be essential to physiologists building their career.
- Improve our relevance by strengthening our links at key interfaces of physiology and between sectors.
- Play an influential role in shaping funding and public policy.
- Be a forward-looking, sustainable society.

For almost 150 years we have been at the forefront of life sciences, but we must never assume our future position is guaranteed. As a discipline and as an organisation, we must be clear in our mission and adapt in order to achieve it. Being proud of our history and heritage while looking clearly to the future is at the core of our new strategy, and how we will work with our members, partners and the public to build a strong community of physiologists to advance science.

*The Society's new strategy will be launched at our Member Forum on Friday 2 December at the Royal Society in London. All members are invited to attend. Please visit our website for more information: physoc.org/2022memberforum.*


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# Climate change and how it has made me reflect on my running

*Dariel Burdass*

Chief Executive,
The Physiological Society

As I write this, the UK is sweltering under its first ever red warning for heat and seeing temperature records smashed everywhere. In this heat we know that exercise including running should not be undertaken but I hadn't considered the impact of air pollution, which is also affected by climate change.

I took up running when I hit 50 as I wanted a new and healthy challenge. I was fascinated with the simplicity, convenience, and freedom this form of exercise offered me, which I could also do outside. Having completed couch to 5 km (which I found an excellent way to get started), I signed up for a half marathon, purchased my first pair of running trainers and started to follow a training plan. What I love and continue to love about running is that it is the most basic human form of whole-body locomotive movement – you do not need fancy equipment, just your own body weight and two legs, to propel yourself forward. Also, it is never boring: you can run on your own or with friends, and every run is different as you can run on roads or trails, hills or flat, intervals or fartlek (a form of speed training). There is so much variety! And running, even leisure-time running, is associated with many reported health benefits; it promotes physical health by enhancing cardiovascular endurance, strengthening muscles, and building strong bones as a weight-bearing exercise. It also has an implication in lowering mental health burden (Garofolini and Taylor, 2019) (Jones and Carter, 2000) (Lee et al. 2017) (Markoti et al. 2020). What's not to love?

To fit running around work I do most of it on the roads across London, from Paddington to our HQ at Farringdon. I have many different routes that range from 6 km through to 15 km and all on flat to rolling terrain. I am fascinated by the architecture and the interesting places I pass on my urban adventures, and this keeps me motivated whatever the weather. I have always seen the positives of running but working at a Society that has a focus on climate change I have become more interested in the negative impact that climate change may have on my running and ultimately my health. In particular, I would like to know how air quality may affect my well-being and what I can do to lessen the impact of air pollution as much as possible.

## How climate change impacts the air we breathe: Air pollution and allergens

**Background – here's what I've learned:**
Climate change poses many risks to human health and represents a massive threat to respiratory health (D'Amato et al., 2014) by:

1. Directly promoting or aggravating respiratory diseases; or
2. Increasing exposure to risk factors for respiratory diseases.


Potential respiratory health effects of climate change. COPD: chronic obstructive pulmonary disease (D'Amato et al., 2014).

The main diseases of concern are asthma, rhinosinusitis, chronic obstructive pulmonary disease (COPD) and respiratory tract infections.

A staggering 91% of the world's population lives in places where air quality exceeds World Health Organization's (WHO) Air Quality Guidelines limits. With over 7 million premature deaths every year associated with exposure to air pollution, the WHO considers air pollution a major public health emergency (World Health Organization, 2022).

The annual economic burden of asthma and COPD on the NHS in the UK is estimated as £3 billion and £1.9 billion, respectively. In total, all lung conditions (including lung cancer) directly cost the NHS in the UK £11 billion annually (NHS England).

**Air pollution**
According to the National Climate Assessment, climate change will affect human health by increasing ground-level ozone and/or particulate matter air pollution in some locations (Centers for Disease Control and Prevention). When the temperatures are higher and there is more sunlight, the chemical reactions involving nitrogen oxides and volatile organic compounds speed up, creating more ground-level ozone. Breathing ozone irritates the lungs and the rest of the respiratory system, leading to shortness of breath. It can also cause inflammation and make the lungs more susceptible to other triggers of inflammation, such as pollen and mould spores, sometimes leading to infections. Rising temperatures intensify drought, causing dust and wildfires to fill the air with particle pollution at ground level. Air pollution also accelerates climate change.

**Allergens**
Climate changes affect allergenic plants and pollen distribution worldwide. These changes in temperatures cause an increase in the concentration of pollen in the air, the strength of airborne allergens and an increase in allergy symptoms (Asthma and Allergy Foundation of America). Climate change also causes some allergen-producing plants to move into new

Encouragingly, the British Heart Foundation reports that for most people, the benefits of being physically active outweigh the risks of breathing in polluted air.

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areas, and winds can carry pollen and mould spores many miles to new geographical areas.

**What this means for my running**
Little seems to be known about the balance between the health benefits of physical activity weighed against the potential harmful effects of increased exposure to air pollution during outdoor physical activity. However, a recent article published in the *European Heart Journal* (Rae Kim et al., 2021) found there is a sliding scale when it comes to pollution, exercise, and risk of cardiovascular diseases (CVD). The researchers determined that individuals living in areas with low to moderate levels of air pollution who reduced their physical activity levels increased their risk for CVD. On the other hand, individuals living in areas with high levels of air pollution who increase their levels of physical activity may adversely affect their cardiovascular health.

Encouragingly, the British Heart Foundation[12] reports that for most people, the benefits of being physically active outweigh the risks of breathing in polluted air. So, while I will check the air pollution level in the area I am running, I look forward to more research from our physiologists in this area and hope to see other physiologists on my runs across London For more information about the influence of air pollution on our health, read Dr Michael Koehle's article (p. 26-28). PS: I am the one often wearing *The Journal of Physiology* or *Experimental Physiology* baseball cap.

*If you are interested in respiratory physiology The Society in partnership with the British Pharmacological Society is running a Lung Summit on 21-22 November in London. Register now for "The Lung more than an organ of gas exchange" on our website.*

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# 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.*

## Conferences Committee

**April 2022**
Dr Catherine Hall (University of Sussex, UK) was welcomed as Chair, together with Professor Dan Martin (University of Plymouth) representing the clinical community and also Dr Jo Lewis (University of Cambridge) representing Metabolic Physiology.

The main agenda item centred on Society conferences and meetings for 2023 and beyond, and how these could best support physiology and physiologists, also engage the membership and their communities, particularly post-COVID-19 pandemic.

As part of The Society's commitment to equity, diversity and inclusion, an Events Code of Conduct was accepted. All attendees will agree to abide by this when they register to attend a Society conference or meeting.

Dr Karen Mifsud (University of Bristol, UK) was selected as the new Theme Lead for Neuroscience. Karen will take up the post immediately, joining Professor Charlotte Stagg (University of Oxford, UK) and Dr Laura Rich (University of Nottingham, UK). She will remain in position until 2026.

## Publications Committee

**April 2022**
The Publications Committee met in April 2022, chaired by Professor Paul McLoughlin. The Editorial Reports for *The Journal of Physiology (JP), Experimental Physiology (EP)* and *Physiological Reports* were presented. Both *JP* and *EP* had seen a decline in submissions, and The Committee discussed the possible causes and remedies of these declines. Online usage and social media followings of all three Society journals remained impressive.

New *JP* Editor-in-Chief, Professor Peter Kohl, outlined his vision for his term. He was keen to stimulate further contributions from both existing Board members and current Physiological Society members. He also called for strategic investment in targeted Board appointments.

Professor Mike Tipton, Editor-in-Chief of *EP*, highlighted the success of the Mid-Career Researcher Prize initiative. He believed that the introduction of this popular prize highlighted the importance of engaging a talented, enthusiastic, yet often overlooked demographic of the research population. Professor Tipton's tenure comes to an end in September 2022, and The Committee approved the formation of a recruitment panel to oversee the appointment process of his successor and ensure a smooth handover of the role.

The publishing landscape continues to change in the face of the Open Access movement, and it remains highly likely that *EP* will "flip" to Open Access in January 2023. This will provide the journal the opportunity to monetise its growth. While *JP* has no immediate plans to "flip", The Committee was cognisant of the potential effect on revenues that Open Access might have on The Journal, and consequently The Society.

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# How can our understanding of physiology help us mitigate and adapt to climate change?

*Shania Pande*

Policy Officer,
The Physiological Society

*In this article, Shania Pande, the Society's newest Policy Officer, explores the importance of physiological research in the response to climate change and sets the key priorities for public policy.*

Climate change is the world's biggest threat to health, according to the WHO (World Health Organization, 2021). Over five million deaths in a year are due to the direct impact of climate change such as heat, extreme weather, air pollution, and food insecurity. Together, these extreme weather events not only pose an immediate risk to life but also affect health and physical work capacity. The impact of climate change extends to beyond human health, as extreme weather can cause biodiversity loss and result in the collapse of ecosystems.

Physiology is central to the scientific response to climate change as it helps us understand the impact of a changing environment on health, diet and productivity. Further, physiology plays an important role in mitigating climate change by reducing greenhouse gas emissions and in adapting human and animal physiology to ensure the health of the planet as a whole. Thus, it is essential to understand the key areas where physiology can contribute to the development of responses to tackle climate change.

Recognising this, The Physiological Society brought together physiologists from across the world, along with organisations such as the Intergovernmental Panel on Climate Change (IPCC), Wellcome, and Lancet Countdown on Health and Climate Change to understand the key physiological research gaps relating to the mitigation and adaptation to our changing environment and set priorities for public policy. The resulting pamphlet *The Climate Emergency: Research Gaps and Policy Priorities* was published in July 2022.

## Key research gaps

Physiological research is key to the development of responses to climate change, yet there remains a paucity of evidence in this area. Research gaps include using thermal physiology to help humans feel comfortable at (or in) warmer temperatures without relying on air-conditioning mechanisms, developing sustainable diets that meet nutritional requirements, and encouraging active travel. There is also a need to focus on vulnerable populations such as older people, pregnant people, those with co-morbidities and people with a low socio-economic status to minimise the impact of extreme weather events on people that are most severely affected.

The multifaceted impact of climate change requires interdisciplinary collaboration between physiologists and other research areas such as sustainable urban development and public health to develop responses to counter its effects. These could include greening cities with trees, community parks, and rooftop gardens to keep us cooler amid rising temperatures.

## Priorities for public policy

The policy response to climate change requires an interdisciplinary approach. Physiology by nature is an interdisciplinary science; it provides the interface between physical and life sciences and therefore forms an important part of the solutions. Government strategies should harness physiological research when developing public health guidelines to address climate change. Some priorities for the UK Government to consider include developing policies and safe working practices for different extreme environments, introducing effective early warning systems ahead of extreme weather events and developing sustainable proteins and alternative diets that meet the required nutritional standards. Further, the Government should work with other nations to develop local strategies and ensure that the gap between high-, middle- and low-income countries is not widened by policies to address climate change.

The Physiological Society brought together physiologists from across the world, along with other organisations, to understand the key physiological research gaps relating to the mitigation and adaptation to our changing environment and set priorities for public policy.

Given the importance of physiology in mitigating and adapting to climate change, The Physiological Society will continue to work with other climate-focused organisations to push national governments to prioritise human health and ensure it is at the forefront of agreements resulting from COP27.

*The Physiological Society's report "The Climate Emergency: Research Gaps and Policy Priorities" and further information about our policy work surrounding climate change can be found at: physoc.org/climatechange*

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# Zero – One – Two

*Dr Peter Kohl*

Editor-in-Chief,
*The Journal of Physiology*

If ever there was any doubt, Uriah Heep's Lady in Black[1] made quite clear: *there is no strength in numbers – have no such misconception!* With that in mind, please forgive me for throwing a few of them up into the air nonetheless.

Let's start with 'ZERO'.

That is the number of responses my last column in *Physiology News* (PN) triggered. I would like to renew my invitation to you, the reader of PN, to not hesitate writing to me *via* pkohl@physoc.org to share your thoughts about *The Journal of Physiology* (*JP*). It is your journal, and its future is being shaped as we speak, by you – the present generation of physiologists.

A second number I would like to mention is 'ONE'.

That is the number of papers[2] we can credit for the recent rise in the Impact Factor of *JP* from 5.18 (for 2020) to 6.23 (2021). This increase, welcome as it may be, illustrates the fickle nature of Impact Factors, and the extent to which the publishing of "guidelines" or "consensus statements" can sway a cohort-parameter that is still used by many institutions – erroneously! – to assess the quality of individual researchers' output.

Looking at the citation rates to this one item in *JP*, we can confidently predict that there will be a further small rise in Impact Factor next year. With equal confidence, we can predict a drop the year after, when it leaves the assessment window for Impact Factor calculation. That is – unless...

Which finally brings me to 'TWO'.

You have two options of supporting the journal, the standing of your area of research, and the financial return to The Physiological Society from *JP* publishing activities. They are not mutually exclusive.

First and foremost – please send your best work for peer review by *JP*. In my previous PN column I highlighted that currently *JP* receives on average *one paper per member of The Society every 20 years*. This is not sustainable for a Society-owned journal. Also, we should remember that Open Access is bound to become a reality for us by 2025. This means that income from *JP* for The Society will be driven solely by the number of papers published – with authors required to pay for the pleasure. This will affect value judgements. Unless we make a big step forward in raising the appeal of *JP*, also in the eyes of those institutions who use ill-suited parameters for individual academic evaluations, between now and then, we may regret it. *JP* needs your best work!

Second – please help us in communicating the amazing content of *JP* by reading and citing relevant papers. Of course, the ARRIVE guidelines[2] are of major importance for reporting animal research, and accordingly they were published in several professional journals in parallel. Their version in *JP* attracted 796 citations in 2021, with the knock-on effects on journal metadata mentioned above. The Physiological Society has ~3,500 members. I am sure each of you knows of original research papers and/or reviews in *JP* that are at least as relevant for your work as guidelines may be. Let's cite them, to give credit where credit is due, to convey the value of *JP*, and to celebrate science.

The first meeting of the newly formed *JP* Editorial Board was held in person in London in July

On this note, celebrating science is at the heart of a number of initiatives that the Editorial Board discussed at its recent July 2022 meeting in London, which are hoped to bring *JP* closer to its authors and readers around the world. They include the identification of Regional Editors who will represent the journal in those parts of the world where great physiology research is conducted, though often without finding its way to *JP*. We are also planning to expand *JP* subject coverage, to include more data science and modelling, as well as physiological "omics". These, and many other exciting topics, will be featured in an extensive series of Special Issues, which will be announced over the next 10-15 months. On the editorial side, we are striving to speed up peer review turn-around, and we will simplify the types of editorial decisions to be more in line with current expectations (accept, acceptable with minor revisions, potentially acceptable after major revisions, reject). We will further introduce a new article type for comments and opinions regarding current and/or controversial issues in physiology – but more on that in due course.

For me, it was the first Board meeting I had the pleasure of chairing, and so I would like to conclude with another line from Uriah Heep: *my labour is no easier, but now I know I'm not alone...*

With the best wishes,

Peter Kohl

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1. Chances are, this 'classic of rock' doesn't mean anything to you, unless retired. Worthwhile listening to nonetheless; the lyrics are pretty deep and current...


2. Updated ARRIVE guidelines for reporting animal research. https://physoc.onlinelibrary.wiley.com/doi/full/10.1113/JP280389




https://doi.org/10.36866/pn.127.10

Damian is an active skydiver, has represented his country both as a footballer and athlete, and remains a keen mountaineer having led numerous medical expeditions to the Himalayas, South America and Russia

# Looking forward to promoting the "power of physiology"


## *Professor Damian Bailey*

Editor-in-Chief,
*Experimental Physiology*


It is both an honour and privilege to introduce myself as the incoming Editor-in-Chief (14th in history) of *Experimental Physiology (EP),* one of the prestigious "flagship" journals under the auspices of The Physiological Society and the community it serves. In my predecessor Professor Mike Tipton's own words, he will shortly "stagger down the back straight and pass the baton on" to me, on 1 October 2022 (*Experimental Physiology*, 2022). On behalf of *EP*'s Editorial Board, its authors, reviewers, readers and publication staff, I would like to formally thank Professor Tipton for his tireless efforts and contributions that were an inspiration to us all. And for the record, there's been no staggering, I can assure you. That he managed to attract 32 papers alone as part of the Extreme environmental physiology: life at the limits meeting organised by The Physiological Society in September 2019, stands as a clear testament to his influence and leadership, his championing of whole-body integrative human physiology and perhaps his most endearing quality of all, a genuine commitment to inspire our next-generation physiologists. His tenure has seen *EP*'s research article submissions jump from 292 in 2016 to 484 in 2021, with accepted articles increasing from 95 to 128. I'd also like to thank The Physiological Society for the trust they have placed in my ability to lead *EP* over the next 3 years. I am excited about its future and fully committed to building on its impressive trajectory.

I'm especially excited given physiology's optimistic future, despite the usual rumblings that it is a discipline relegated to the past, slowly dying at the hands of molecular biology and high-throughput DNA sequencing (Wagner and Paterson, 2011; Lemoine and Pradeu, 2018). Physiological research provides the essential integrative links between genes and clinical care and will continue to transform our ability to detect, prevent and treat human disease. It is only strengthened by exchanges with other fields, including the various -omics disciplines from which it can take translational inspiration (Lenfant, 2003). However, beyond the conceptual, we face practical challenges given that its wide remit has led to a perceptual blurring of the lines regarding which sub-disciplines truly belong to physiology, reducing its visibility among educational institutions, policymakers and the public (Vaughan-Jones, 2016). Let's work together through *EP* to highlight the discipline's translational benefits so that physiology can be better supported and understood. This is best achieved through real-life examples (data) rather than simple table thumping. The translational gains in terms of understanding the pathophysiology and treatment of COVID-19 patients over the past three years stands recent testament to the "power" of integrated systems physiology. This was highlighted by Sir Patrick Vallance in his address to The Physiological Society (The Society, 2020), and *EP*'s very own Covid-19 special issue (Tipton *et al.*, 2022).

Having had the privilege of serving as a Senior Editor to *EP* for the past four years, I am patently aware of the responsibilities that the Editor-in-Chief role entails. I approach this with humble respect and an equal measure of excitement and trepidation. I am also

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> I want *Experimental Physiology* to address the big societal questions that really matter, with a focus on translational impact, not Impact Factor. I hope the research we publish will inform, if not indeed transform, change that can be measured and weighed

familiar with EP's colourful history, surviving a stormy birth some 114 years ago when it started out against all odds as the *Quarterly Journal of Experimental Physiology* under the leadership of Sir Edward Sharpey-Schafer (Editor-in-Chief for no less than 27 years) with the vociferous backing of Sir Charles Sherrington, among others of the physiology elite (Whitteridge, 1983). The journal has weathered many storms, financial, political and the inevitable academic – and has continued to flourish.

Yet despite its secure footing, *EP* now faces one of its biggest challenges as its transition to Open Access looms large on the horizon (The Society, 2019; Wiley, 2014). Like it or not, this change in publishing model is inevitable for the majority of publishers and journals to ensure compliance with funder mandates, and will fundamentally reshape how research is conducted, disseminated, communicated and assessed. We need to be ready for it.

And so to a brief note of my vision and aims – I shall purposely keep it high-level since I plan to solicit views from the Editorial Board and wider community as I take up my new role looking to further build said community, develop our brand, raise standards of scientific integrity, and shape physiology itself, in line with The Physiological Society's current and upcoming strategy. My vision for *EP* is for it to be recognised as the world's leading journal that publishes groundbreaking research in integrated translational physiology that challenges the boundaries of basic, applied and clinical research across the spectrum of health and disease. I want *EP* to address the big societal questions that really matter, with a focus on translational impact, not Impact Factor. I hope the research we publish will inform, if not indeed transform, change that can be measured and weighed. My primary aim will be to extend *EP*'s current reach and increase quality submissions as we transition to Open Access in January 2023, tapping into our collective networks of prestigious specialists working in allied disciplines while expanding clinical-scientist representation on our Editorial Board. We need to cast our creative net ever wider to help expand current communities while introducing new ones, broadening *EP*'s remit to include clinical (e.g. surgical, public health, big data epidemiological) and applied (e.g. exercise and elite sports, space biomedicine including industrial links with science technologists, environmental, comparative) physiology, to forge new partnerships with groups in Northern Europe (in particular Sweden, Denmark, Finland and Norway), South America, the Middle East and Asia. It is also important that we reflect and consolidate on those strategic initiatives that have proven successful (exercise and extreme physiology highlighted prior). We do not require revolutionary change; to the contrary, we require evolutionary tweaks. To paraphrase Professor Tipton, we need to keep the Daimler on the road and upgrade its sat-nav!

A brief albeit important final point. As a team, we cannot succeed without the understanding and support of some of the world's best researchers on our Editorial Board, including our referees who work at the coalface, making an indispensable contribution reviewing submissions. They are our secret sauce, the DNA of the journal's success, who give up their time selflessly for the love of the discipline and the journal!

We encourage you to join us in this enterprise, fuel the fire by submitting manuscripts and contributing to reviews. We will also be welcoming applications to join our Editorial Board in due course as we look to expand and diversify. We also welcome comments and suggestions that could improve the quality and visibility of the journal, your journal.

*Our special issue on heat stroke is soon to be published and is packed with fascinating insights and fundamental findings – keep a look out for further announcements.*

Experimental Physiology | The Physiological Society

IN CONVERSATION WITH

**Prof Damian Bailey**

Incoming Editor-in-Chief
*Experimental Physiology*

Professor of Physiology and Biochemistry
University of South Wales, UK

Watch Professor Damian Bailey's interview here: https://bit.ly/3CeZW9m

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# How sustainable can your laboratory be?

*Martin Farley*

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Pictured here are some exemplar criteria for the award levels Bronze, Silver, Gold, which laboratories are awarded depending on how many sustainability actions they take (UCL, UK)

If you work in a laboratory, chances are you are aware of the climate crisis. You likely even take actions at home to address this, such as through recycling or turning off the lights when not home. But did you know that your work in the laboratory likely dwarfs your impacts that you have at home? Laboratories require a lot of energy to maintain, and often require an equally significant number of materials, such as chemicals and single-use plastics. Any lab technician, scientist, or student will attest that lab work is resource intensive. Couple this with the fact that demand for such laboratories has increased in the past few decades, as the growth rate of spending in science continually outsizes the rate of global GDP growth (Unesco Science Report, 2021). There is a belief that the outcomes of science outweigh the impacts, but as the resources to conduct impactful science and the impacts of climate change increase, surely a balance must be struck?

If you work in a major academic institution or even some companies now, you may have a net-zero target in place. In the UK our largest funder (UKRI) has set the sector-leading target of 2040 (UK Research and Innovation, 2021). Wherever laboratories are present though, such a target can present a challenge. Can science even be done while achieving net zero? The truth is, we don't know, yet. But there is a lot we can do.

Energy consumption in laboratories is high for two main reasons: ventilation and equipment. Ventilation requirements can be significantly reduced through efficient design requirements, as well as by engaging staff on agreed hours of occupation. Equipment energy consumption is still a growing challenge, but we need to start with standards in how companies report the energy efficiency of their products. Currently there is little to no validation of reported efficiencies, making it extremely challenging for purchasers to even know if what they're selecting is efficient or not.

Beyond energy use are the greater environmental impacts associated with the consumption of chemicals, single-use plastics, gases, and materials required for modern science facilities. An estimated 2% of the world's plastic waste in 2014 originated from laboratories, and many suppliers today cannot produce enough consumables for the growing demand (Urbina et al., 2015). When we look at an institution like UCL, nearly half our energy is consumed by laboratory facilities, but that is just a small portion of our estimated overall carbon emissions (12%) (UCL, 2019a). This is due to the impacts of our supply chain and travel, which make up 87% of our carbon emissions. Here we see that while energy efficiency is important, the greatest impacts we can have are on our supply chains and travel methods. Understanding the impact of specific products is challenging, as most suppliers don't report on the embodied carbon required to manufacture goods. We must engage our suppliers to produce these figures, so we can set long-term targets and ensure sustainability is considered in purchasing.

More research is needed to fully quantify the impacts of science on the environment, and to enable us to conduct low-carbon science in the future. Time is not on our side though and action is needed immediately in all sectors to address the climate crisis now. To help drive this forward in science, at Sustainable UCL we have developed LEAF, short for the Laboratory Efficiency Assessment Framework (UCL, 2019b). LEAF is a tool that allows lab users to work towards a standard in sustainable lab operations, and contains actions around equipment, ventilation, single-use plastics, and more. Embedded within LEAF are calculators that allow users to estimate the financial savings they achieve, as well as the carbon emissions avoided. Uniquely LEAF blends sustainability with research quality and reproducibility, in recognition that reproducible science is that which represents the best use of the resources required. Piloted for 2 years before being launched in 2021, LEAF is the world's largest programme of its kind, now in over 1,200 labs enrolled from 72 institutions in 12 different countries and growing fast.

The uptake of LEAF and the reception amongst the scientific community has been truly inspiring, as well as the demand for more support in this area. It has validated the effort we have invested to create the platform and resources alongside LEAF. More work is needed though, as we need programmes like LEAF to become standardised. The entire sector needs to join efforts together to address this, from funders, to suppliers, to students, and all those who work around science.

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# Book Review: Life Before Birth: Challenges of Fetal Development by Peter Nathanielsz

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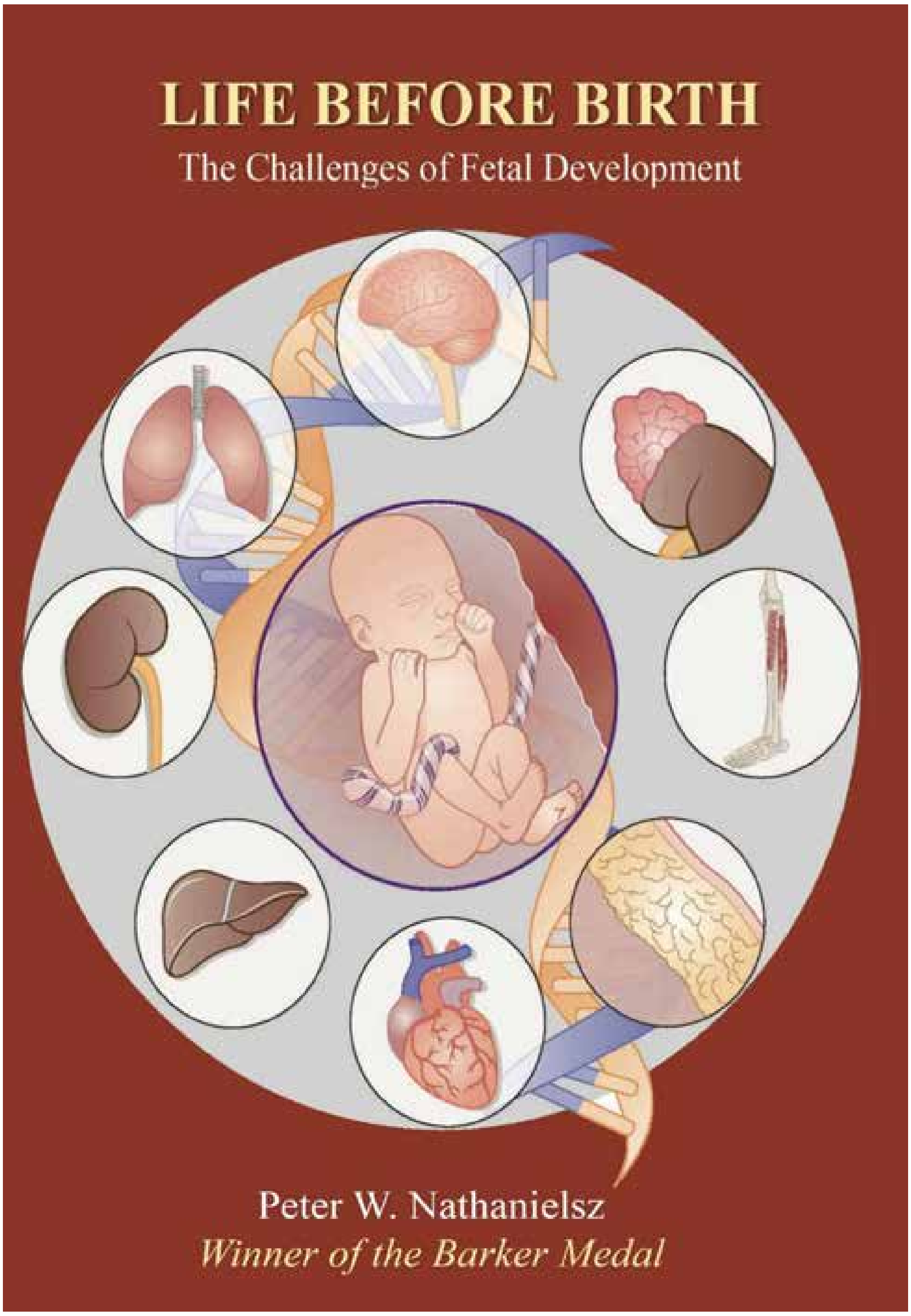


Aside from the engaging language and writing style, what puts this firmly in the category of popular science is the final chapter, written by Professor Lucilla Poston. It is an important final chapter that sets out the agenda of what we should do with this knowledge in a way that no textbook ever would (or should)

There is a familiar trope that there are only three certainties in life: death, taxes and overblown introductions to a book review or perhaps some other appropriate third option. This theme has its origins in the combination of Benjamin Franklin's observation that there are two certainties in life; "death and taxes" with the much older proverb with three certainties. That older proverb suggested that those certainties in life were *birth, death and change*. While this proverb clearly seeks to emphasise that nothing in life is set in stone, it clearly takes birth for granted as a certainty and considers this to be the starting point for life. I suppose this is not unreasonable. The proverb is certainly old, while as late as the 17th century the eminent embryologists and physiologists William Harvey and Marcello


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Malpighi were advocating preformationism – that organisms develop from miniature versions of themselves. The trials and tribulations of the life before birth were unknown then, but they are not now and they are brilliantly and comprehensibly presented by Professor Peter Nathanielsz, University of Wyoming, US in his book.

From the development of gametes through fertilisation, organ development, growth and maturation before and ultimately birth, this book packs a lot into its 300 odd pages. This timeline of growth and maturation gives the book some of its inherent structure, although in some respects it could be seen as a book of two halves. The first part addressing "normal" fetal growth and then, having given the reader enough background, the second part sets out to highlight the challenges and adaptations that can occur during development and the long-term consequences of these to the individual and society.

This structure works well. There are some who undoubtedly want the author's guiding hand to shepherd them through the material in an order as laid out. Each chapter builds on the last and occasionally digresses to some more general biology topics (such as genetics or cell communication) to provide context for the main thrust. For others though, perhaps a more cherry-picked approach is preferable, and maybe it is the placenta or the fetal cardiovascular system that specifically piques their interest. For those readers this works too, as each chapter stands alone and like every good textbook it is well integrated with references to the other chapters where more detail can be found.

In these first chapters, the author takes us from fertilisation to blastocyst formation, via a brief side swerve into cell biology. From there we learn about the development of organs: the placenta, the cardiovascular system, the GI tract and the brain and senses. In describing this last part the author recounts hearing Pasco Rakic present data on the development of the visual cortex; it is one of a few personal reflections that appear throughout and speak to the relatability of the text and the author's obvious enthusiasm for the subject. Some other highpoints in the first section are the sections on fetal circadian rhythm as well as the important issues around the effects of drugs and smoking on the developing fetus.

Having set up the normal in the first chapters and foreshadowed adverse environments in the chapter on smoking, the book shifts gear in the second half as it moves into the developmental programming chapters. These chapters offer a whistle-stop tour of the challenges to the fetus and of the concepts and methodologies of developmental programming. In the last 30 years there has been an explosion in research in this field and with it reviews, textbooks and other popular science books. It is wrong, however, to compare this book to those, as this is not a book about programming *per se*. This is, as it says, a book about life before birth, while much of the programming work is specifically interested in the consequences, and often quite long-term consequences, of perturbations to the fetal environment. What it does present is an excellent, well-referenced and easily readable series of chapters that give an important overview that fits with the scope of this book. From giving an overview of what programming is and the models that have been used to study it, the book also gives an overview of some of the research across different challenges (such as maternal hypoxia or obesity) and their impact on the various systems of the offspring (cardiovascular, metabolic etc).

Aside from the engaging language and writing style, what puts this firmly in the category of popular science is the final chapter, written by Professor Lucilla Poston. It is an important final chapter that sets out the agenda of what we should do with this knowledge in a way that no textbook ever would (or should). We now know far more about fetal development and the importance of nutrition during pregnancy, and even before in the pre-conceptional period for both mothers and fathers, but how do we put this into use. Just as with Liggins' work with cortisol for promoting lung maturation in premature infants or Smithells' work with vitamins and folate for the prevention of neural tube defects, how do we take this understanding and turn it to addressing issues that still persist in antenatal care, such as spontaneous premature birth or poor placental function?

It turns out that birth is not really a certainty of life, but enjoying this book might well be one such certainty.

*To hear the latest pregnancy research, register for an exciting one-day meeting in London on 29 September "Environmental Impacts on Pregnancy and Offspring Outcomes: Lessons Learned and Avenues for Intervention". The meeting will explore how to mitigate the negative impacts of adverse environmental conditions on the lifelong health of the mother and child. For more information, visit physoc.org/pregnancyoutcomes*

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# Colossal changes in climate threaten our liveable future

## Catastrophe is on the horizon; we must act fast and hard to secure our survival

*Professor Hugh Montgomery*

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Climate change is the greatest threat facing humanity. From heatwaves, storms and rising sea levels to floods, droughts, and fires, our world is under attack from a climate of our own making. The downstream impacts of climate change on health are already being felt around the world. Our current trajectory commits us, within decades, to a mass extinction event to rival those in Earth's history. We have ignored the warnings. There is no time left. We must all act now.

### How did we get here? Ignorance is bliss

For over a century, we have been burning fossil fuels (namely oil, coal, and "natural" gas [mainly methane]) to generate the energy we need to heat and power our homes, cars and businesses. Use has increased exponentially over time. In 2019, 84% of the world's energy consumption needs were met by fossil fuels (BP, 2020), and low-carbon sources are merely supplementing escalating fossil fuel use, rather than displacing it. Despite a slight COVID-19 related dip in 2020, use increased in 2021 and continues to steeply rise. And we are paying the price. When fossil fuels are burned, large quantities of carbon dioxide ($CO_2$) are produced: 36 trillion kilograms last year alone (each kg representing over 500 litres of volume). Atmospheric concentrations are thus rising by 2.6 ppm each year. Carbon dioxide is a greenhouse gas (GHG), allowing shortwave solar radiation to pass through it, but trapping long-wave radiation from surface warming. Human activity (fossil fuel extraction, and our food system) also adds methane to the atmosphere, a GHG that is 93 times more powerful than $CO_2$ in its first 20 years (EDF, no date).

Since 1998, GHGs have trapped the energy equivalent of nearly 50 billion Hiroshima bombs in our oceans and gaseous atmosphere, and we continue to trap the equivalent of five more every second (Holmes, 2013). And this effect doesn't cease even when emissions do. One fifth of the $CO_2$ we release today will remain in our atmosphere, cooking us in 33,000 years, and 7% will still be in the atmosphere cooking us in 100,000 years.

During the last century we have been burning through fossil fuels, we have also been ignoring the warning signs that they are drivers of climate change. In 1896, a seminal paper by Swedish scientist Svante Arrhenius published in *Philosophical Magazine* first predicted that changes in atmospheric CO2 levels could substantially alter the surface temperature through the greenhouse effect (Arrhenius, 1896). Then, 27 years ago, in March 1995 the first United Nations Climate Change conference was held. Since then, member state representatives have met annually (bar 2020) at the Conference of the Parties (COP). Their warnings, and calls for action to limit emissions, have become ever more strident, as has the Intergovernmental Panel on Climate Change (IPCC) reports from the world's scientists. But all these warnings have been ignored. So, what does this mean for life on this planet?



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*Figure 1.* **Extreme weather events are becoming more frequent and more severe.** This map illustrates the statistical attribution of recent extreme weather events. Grey points indicate that we are uncertain of the cause, blue indicate no human influence. All the red labels and the majority of points, show human influence and statistically evidence that humans are the drivers of climate change. (Original interactive map by Rosamund Pearce for Carbon Brief (April 2020) https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world/)

## What's cooking?

Human activity has raised global mean surface temperatures by 1.1°C from pre-industrial levels. This sounds insignificant, until one considers the huge amount of energy required to do this. Add energy to an atmosphere, and you get weather. Rising temperatures increase concentrations of ground-level ozone and extend the pollen season, both damaging respiratory health. Together with altered rainfall patterns, warming increases exposure to vector-borne disease such as Dengue fever.

The more energy added, the more extreme weather events will occur, and the more extreme they will be. As a consequence, extreme weather events are becoming more frequent and more severe (Fig.1). As I write this, the UK is experiencing its hottest weather on record. For the first time in history, we saw temperatures climb to over 40°C. But records have been broken in the rest of Europe too, as well as in China, Japan, North and South America. Such heatwaves impact on crop production as well as the ability to work outside, and thus on food availability and health. Heat also causes excess cardiovascular deaths, especially in vulnerable populations such as the young, old, or infirm.

A hotter atmosphere can also hold more moisture, thus desiccating soil. Add heatwaves, and fires result, destroying homes, habitats and lives. Looking back at the past two years alone, we've seen escalating fires in the Amazon, Angola, Australia, California, Canada, Colorado, The Congo, Indonesia, Greece, Italy and Spain. Particulates from these fires impact human cardiorespiratory health, and may also increase the risk of other diseases such as cancers and dementia.

## Floods

Rising temperatures (Fig.2) also have devastating effects on our sea levels. Extreme weather events (low pressure) also cause extreme transient rises, with flooding augmented by associated dense rainfall. Ocean heating leads to thermal expansion and thus a rise in sea levels, as does melting of land ice, and this is accelerating. Alarming temperatures were recently recorded at the Poles. In March 2022, the Antarctic reached 40°C above its normal temperature range between –10°C and –60°C and climbed to 47°C higher a day later, while at the same time the Arctic hit 30°C degrees above normal (around 10°C to -30°C). Temperatures in the Arctic breached +32°C in July. The ice shelf on the west of Greenland alone is producing 1.1 million metric tonnes of melt water a minute (Tedesco and Fettweis, 2019). Overall, sea levels are now rising by a centimetre every two years (IPCC, 2013).

Heating causes more evaporation and warm air can hold more water. On cooling, that water is released as dense rainfall, with the latent heat of evaporation driving ever more powerful storms. The frequency and intensity of tropical cyclones (hurricanes, and typhoons), floods, and unusually heavy rainfall events are rising and will continue to do so (IPCC 2021; U.S. Global Change Research Program 2018). Last summer saw floods across Europe, including Belgium, Germany and the UK and at the end of August, with tens of thousands similarly affected in China. This year saw record rainfall and floods worldwide, from Valencia (Spain) to Kwazulu Natal (South Africa). Habitats, infrastructure and crops are impacted ever more severely. Floods can flush vast amounts of fertiliser, sewerage, and manure into waterways, causing disease and poisonous algal blooms (cyanobacteria) to occur (Anderson *et al.*, 2002).

Not only do we need to urgently lower emissions, but we also need to figure out how we cope with the wicked, complex change in the physiological environment in which we all will be living. Each and every one of us must act now to reduce emissions. If we fail to do so, to quote the IPCC, we miss a rapidly closing window 'to secure a liveable future'

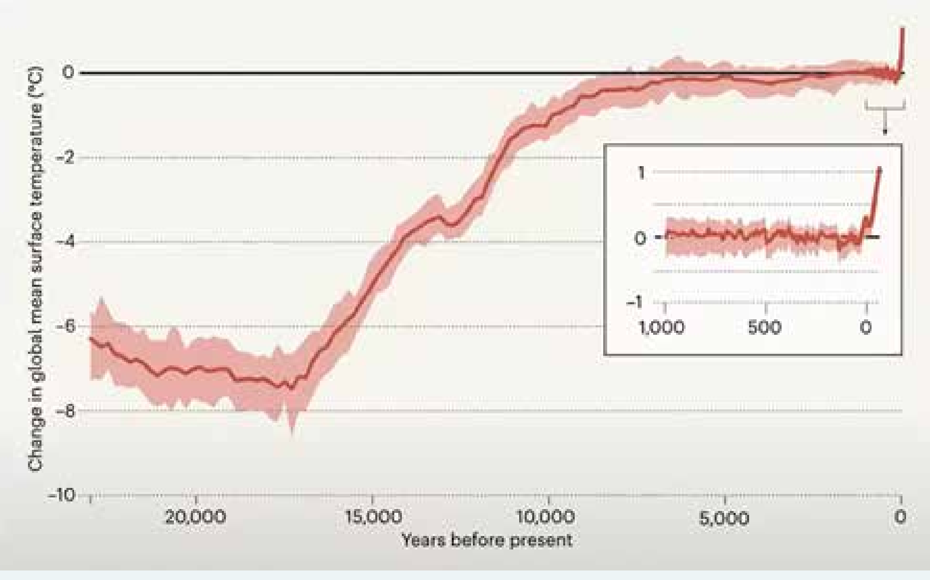


*Figure 2.* **Graph showing dramatic temperature rises, unprecedented in our geological history.** Osman *et al.* (2021)

## The double punch

The combination of drought and fire, then floods have been named the double punch, the consequences of which are far reaching; fires destroy the roots of crops and vegetation and then the lack of structure and soil anchorage means that floods can cause landslides with devastating loss of land and life. The harsh reality of this was seen in British Columbia before Christmas last year, where 18,000 people were displaced.

## Critical condition – are we nearing a point of collapse?

We are currently seeing the harmful effects of a 1.1°C increase in temperature since 1880 (Schwalm *et al.*, 2020). The Met Office has warned that there is a 50% chance of us punching through the 1.5°C mark in the next three to four years. 1.5°C is catastrophically dangerous. Even if we do lower carbon emissions, the IPCC Working Group have explained that we are locked into progressive climate change, the effects ongoing for the next thousands of years.

But it is worse than this. We have triggered, or soon may trigger, a raft of positive feedback loops. In 2019, the fires in Australia contributed 2.5% of global $CO_2$ emissions (Byrne *et al.*, 2021) trapping yet more heat to cause yet more fires. Loss of the reflective surface of snow and ice as it melts, with exposure of darker soil and water beneath, has doubled the rate of earth's energy gain in only the last 14 years. Warming causes methane to be released from stores in frozen tundra and from carbonate rocks, as well as from warming wetlands. Fires release carbon monoxide, destroying atmospheric hydroxyl radicals, which would normally mop up methane thus extending its atmospheric half-life. Further, weather systems can change from one binary state to another. Thus, the water-transporting jet stream will likely stabilise in a northerly position within decades, rendering the whole Iberian Peninsula devoid of significant rainfall, and depositing that water in Northern Europe (Cresswell-Clay *et al.*, 2022; Gallego *et al.*, 2011). The split in the jetstream, which caused Northern Europe's heatwaves of 2022, may become more permanent. The Atlantic Meridional Overturning Circulation, which brings warm water from the Pacific past UK shores as the Gulf stream, may have largely faltered within decades.

Catastrophe is nigh, but there is time to mitigate this if we act fast and hard and that includes physiologists, whether through their personal, political or professional lives. To limit global temperature rise to (a still catastrophic) 1.5°C requires that we all reduce our emissions by 50% by 2030. The Physiological Society has some suggestions on what you can do (The Society, 2022). We cannot rely on politicians to deliver. 26 COP negotiations have not resulted in any reduction in emissions at all. Not only do we need to urgently lower emissions, but we also need to figure out how we cope with the wicked, complex change in the physiological environment in which we all will be living. We must all act now to secure a liveable future. If we fail to act now, to quote the IPCC, we miss a rapidly closing window to secure a liveable future.

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# Heat stress and its severity during pregnancy

## The worsening realities of heat stress for pregnant women in West Africa

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We all know that the climate is warming, and that this is changing our weather and increasing the frequency of heat waves, hurricanes, flooding, and drought. Two additional risk factors to the health effects of extreme heat are pregnancy and working outdoors – something millions of women across the tropics, who perform formal and informal labour, experience. Understanding how heat is impacting these women, who live in the most vulnerable and affected areas, is important in order to place their experiences at the centre of our understanding and to build the relationships that allow co-production of adaptation policies. In this article we focus on pregnant or recently pregnant subsistence farmers in The Gambia, West Africa to explore their experience of working in the heat whilst pregnant (Spencer *et al.*, 2022).

### Impacts of climate change in West Africa

In the Sahel region of West Africa 50%-100% of the population will be at risk from extreme heat by 2100 under current emission scenarios, with current levels around 20%. Extreme heat definitions depend upon geographical region, as humans acclimatise to the region they live in. Heat stress indexes, such as the Wet-Bulb Globe Temperature (WBGT) or apparent temperature allow temperature and humidity to be combined into a metric that takes into account the impact of humidity on heat loss, as it is harder to lose heat as humidity rises. Dangerous levels of heat stress occur at WBGT above 31°C. Additionally, reduction in crop production and yields (due to soil degradation and changing rainfall patterns) will plunge a similar number into food insecurity – resulting in the reduction in quantity or quality of food, increased experience of hunger and malnutrition and the resulting impacts on health and wellbeing.

### Subsistence farmers

In The Gambia, more than 60% of the population work in agriculture. The Gambia is similar to much of the world, where most farms (84% globally) are small-hold farms, they produce up to 1/3 of the world's food but usually are entirely dependent on manual labour, with very little mechanisation. These farmers are usually amongst the world's poorest, they often experience food insecurity and are considered particularly vulnerable to the impacts of climate change.

### Why focus on women?

Women make up 50% of the small-hold agricultural workforce and in many places, including The Gambia, the work is gendered. Women work in the horticultural gardens and rain-fed rice fields, whilst men grow cash crops or are responsible for animal husbandry. Due to the gendered nature of the


*Figure 1.* **Photo from the field study exploring heat in pregnant farmers in The Gambia, West Africa.** Photo taken by Louise Leeson (London School of Hygiene & Tropical Medicine, UK)

Credit: Louise Leeson/LSHTM

All the women in this study experienced symptoms of heat illness and struggled with working in the heat when pregnant

work, women can work outdoors throughout the year, even during periods of high heat stress. Additionally, women and girls remain responsible for much of the domestic work, including chopping and collecting firewood, collecting water and cooking and therefore have limited ability to shift work patterns to reduce heat exposure to cooler times of the day.

Globally, women and girls are found to be at increased risk of the impacts of climate change (United Nations). This is due to embedded inequalities and societal and cultural factors. An example of this is seen in published research, where few studies focus on women farmers despite their often vital role in providing food for the family. Women's voices are also often missing from policy and decision-making, reducing their ability to provide valuable insights into solutions from their perspective.

## Added risk in pregnancy

Pregnancy is a vulnerable time in a woman's life. Mothers exposed to high temperatures suffer with increased rates of miscarriage, congenital abnormalities, preterm birth, stillbirth and low birth weight babies (Chersich *et al.*, 2020). For example, women exposed to heatwaves are 16% more likely to have a preterm birth than those not exposed. Much of the knowledge of this risk comes from temperate climates where women are not exposed to high levels of heat throughout their pregnancy and predominantly do not perform manual labour throughout pregnancy. A recent study of heat in pregnancy in lower-income countries found a similar effect – heat increased the risk of stillbirth and preterm birth (of particular concern in settings with limited healthcare resources) (McElroy *et al.*, 2022). It is likely that women working in the heat are at even more risk than an average population risk, due to exposure during the hottest part of the day.

## Experience of working in the heat when pregnant

All twelve of the women we interviewed recognised that they were being exposed to high levels of heat stress and that this had worsened in the recent years. Almost all of them found working in the heat harder when pregnant compared to non-pregnant. They also experienced that their bodies felt the heat more acutely and that it seemed more difficult to cool down or stay cool when pregnant: *"I feel like my body is burning"*. The most common symptoms they experienced were headaches, dizziness, tiredness, nausea and chills.


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*Figure 2.* **Pregnancy is a vulnerable time in a woman's life.** Mothers exposed to high temperatures suffer with increased rates of miscarriage, congenital abnormalities, preterm birth, stillbirth and low birth weight babies.

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## Ways to cope or reduce heat exposure

Community support from nearby family was often instrumental in reducing heat exposure, where physical work, domestic chores and childcare duties were shared. However, in most instances this remained highly gendered with sisters, female relatives or co-wives providing the support. Working as a group had some benefits – in that others would help to water their plot on days they were not feeling well, but could also cause problems with social pressure to work the land coming from other members in the group, even when feeling unwell.

Socioeconomic factors were also important, with several women describing that spousal support allowing them to reduce the amount they needed to work in the fields; however, this was not possible for most of them.

Finally, the women used several personal cooling strategies: self-pacing, frequent breaks, cooling with water on their heads or showers, freely drinking cold or iced water, reduction in land cultivated and altered work schedule to reduce exposure.

## Difficulties in reducing heat exposure

However, many women (33%) stated that they would have liked cold/iced water but did not have access to this due to lack of electricity and/or money. There were also difficulties in wearing cooler clothing whilst working in the field with cultural concerns preventing them from wearing clothes that they would then wear around the home. Some of the women (17%) also acknowledged that they would prefer not to work in the fields and so protect themselves, but without start-up capital for alternative business ventures, this was impossible.

## Most pressing concerns about climate change

All the women farmers shared that they have seen a significant change in the weather in the last 5-10 years with an increase in heat and intensity of the sun and a reduction and shortening of the rains. This has already reduced the amount of crops they are able to produce, especially the rice yields. Where this previously would have provided enough food for the family for the following 6-8 months, it now will only last 3-4 months. They also described the intense heat burning plants and the difficulties in accessing water during the dry season. The women almost all expressed great concern regarding their ability to produce food and income, and hence, the ability to provide for their family needs going forward.

## Improving the working practices for pregnant women

All the women in this study experienced symptoms of heat illness and struggled with working in the heat when pregnant. Despite understanding how to minimise their exposure to heat, this was often not possible. With rising temperatures, alterations in the rainfall and worsening crop yields, this reality is likely to become worse.

This work complements a project exploring the physiological changes in pregnant subsistence farmers exposed to high levels of heat stress (Bonell *et al.*, 2020). By understanding the reality of current heat exposure levels in this region, the resultant physiological changes to both mother and fetus (Bonell A *et al.*, 2021), within the context of women's lived experience, we can attempt to place these women at the heart of any future adaptation strategy.


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# Co-benefits of physical activity

## Assisting cardiometabolic disease prevention and climate change mitigation by active travel to school

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With many children and adolescents at risk of developing cardiometabolic disease (e.g. type 2 diabetes, cardiovascular disease) due to their low physical activity levels (Steene-Johannessen *et al.*, 2020) and global concerns of climate change placing uncertainty on their futures (Gasparri *et al.*, 2022), research on the co-benefits of physical activity for human and planetary health is highly topical and of interest to these young populations.

A recent harmonised analysis (*n*=47,497) reported that around two-thirds of European children and adolescents aged 2–18 years are not sufficiently active, defined as less than an average of 60 min of moderate-to-vigorous physical activity per day (WHO, 2020), when measured objectively, with higher inactivity in girls versus boys and with increasing age (Steene-Johannessen *et al.*, 2020). Targeting young people to aid disease prevention rather than focusing efforts towards treatment in later life may also be of planetary benefit due to reduced greenhouse gas emissions associated with disease either directly via, for example, blood analysis consumables, drug manufacturing and clinical waste disposal associated with diagnosis and treatment, or indirectly via disease effects on lifestyle, among other things (Eckelman *et al.*, 2018).

### A climate change mitigation strategy

Although a universally accepted, detailed definition is lacking (Saunders *et al.*, 2013), "active travel" to school is often assessed according to the number of days walking, cycling or scootering to school across the week and represents a key opportunity for engaging in health-enhancing physical activity among young people. Simultaneously, active travel reduces the reliance of young people on using carbon-consuming transport modalities and, thereby, over time, can help to mitigate the rate and severity of climate change. From a public health perspective, encouraging active travel to school may be a feasible approach to increasing physical activity levels at the population level because, unlike many opportunities for physical activity, transport is typically a necessity of everyday life with almost all young people travelling to school on five days per week across the school year. Further, the transport characteristics (e.g. mode and intensity of the physical activity that constitutes the active travel) and designated route are usually consistent between days, but can be amenable to change to enhance the potential health benefits. Yet, an understanding of the acute and chronic physiological responses to active travel to school is lacking. For example, insight into the intensity of the active travel through heart rate and expired air monitoring would provide a useful quantification of energy expenditure and intensity and examining the cardiometabolic responses, such as glycaemic control and insulin sensitivity, would have implications from a disease prevention perspective.

Active travel reduces the reliance of young people on using carbon-consuming transport modalities and, thereby, over time, can help to mitigate the rate and severity of climate change

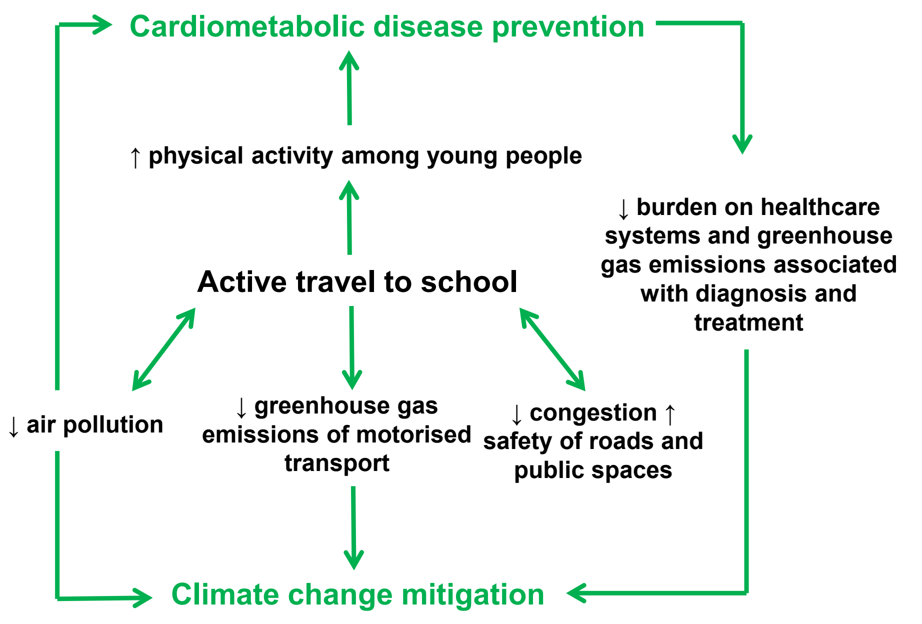


*Figure 1.* Possible pathways linking active travel with cardiometabolic disease prevention and climate change mitigation.

## Healthy and sustainable modes of travel

The weight of the evidence based on intervention and prospective observational studies among children and adults combined supports the positive effects of active travel over longer periods and distances on cardiometabolic health outcomes, particularly for diabetes risk (Saunders *et al.*, 2013) (Fig.1). Although, data in young people specifically were often confined to measures of obesity (Saunders *et al.*, 2013). In a large multinational sample of 6,797 children aged 9–11 years, active travel to school was associated with lower measures of adiposity across 12 countries representing a wide range of sociocultural variability, suggesting that this finding applies on a global scale (Sarmiento *et al.*, 2015). Further, there is some evidence that active travel to school is associated with higher cardiorespiratory fitness among children and adolescents (Lubans *et al.*, 2011). To draw stronger conclusions among children and adolescents specifically, further research utilising study designs from which causality might be inferred, such as randomised controlled trials, crossover trials and interventions, with measures of cardiometabolic disease other than obesity is required (Saunders *et al.*, 2013). Also, current literature has employed varying definitions of active travel, which poses challenges in synthesising the available evidence (Saunders *et al.*, 2013). Indeed, accumulating evidence supports the acute benefits of single bouts of physical activity (often performed in a laboratory environment) on cardiometabolic health markers among children and adolescents, including moderating postprandial concentrations of plasma glucose, insulin and lipids for up to 24 hours (Cockcroft *et al.*, 2015; Thackray *et al.*, 2015). Based on this evidence, which has typically included structured exercise, the likelihood of achieving cardiometabolic health benefits through active travel will depend on the duration, intensity (affected by the nature of the route, inclines and terrain), mode (e.g. walking, cycling, scootering) and frequency of the physical activity that characterises the active travel. Yet, it may not be possible, for example, to achieve moderate or vigorous intensities during a walk to school. As such, determining the health-enhancing physical activity characteristics specifically for feasible active travel modes, intensities and durations that can be implemented in real-life settings would help inform a health-based definition of active travel that could be used in research and practice.

## Real life application of healthy active travel?

When considering application to real life, it may be more feasible for active travel to contribute to light or moderate physical activity, which will inherently reduce sedentary time. Although vigorous physical activity is likely to confer more pronounced benefits to health due to the higher rate of energy expenditure and the heightened demands on the cardiorespiratory system, it may be challenging to achieve such intensities during typical modes of active travel, such as walking to school. In certain instances, it may be possible for active commutes to reach


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vigorous intensities; for example, cycling on hilly routes, but such scenarios may be rare. Further, carbon dioxide production per unit of time increases with physical activity; taking into account physical activity duration and intensity, there may be a specific physical activity intensity that is optimal in terms of the lowest gross carbon dioxide production during the active commute. Such data could help to contribute to efforts to reduce greenhouse gas emissions. Regarding the duration of the commute, five-year-old children who walked to primary school were not more active across the week compared with those who were driven, perhaps because the distance to school at this age may be too short to contribute significantly to daily activity (Metcalf *et al.*, 2004). Hence, the age of the participants may limit the duration of the active commute, which requires consideration for real-life application of possible physiological research showing benefits of longer commutes. For these younger children who require parental assistance on the commute to school, there may be an additional benefit of enhanced physical activity to the parents or caregivers.

## Good for our physical and mental health

Aside from the physical activity characteristics, active travel will increase time spent outside for young people before and after school, which could improve vitamin D status through sunlight exposure, promote social interactions, confidence and self-efficacy, and enhance interactions with nature, as well as having potential knock-on effects for additional physical activity, such as playing at the park during or after the commute. That said, high levels of air pollution on some commutes may negate some of the positive health effects of the physical activity, especially for children who are more susceptible than adults to the adverse health effects of air pollution due to greater physiological sensitivity and higher respiration rates (Al-Kindi *et al.,* 2020). Additionally, active travel may interact with other diet and physical activity-related behaviours throughout the day, such as breakfast consumption, snacking, physical activity at other times in the day, and it is unclear how such potential compensatory responses might either negate or enhance any positive effects of active travel.

## The need to adopt health- and planet-friendly behaviours

Addressing the global burden of preventable cardiometabolic diseases and climate change may require similar, multidisciplinary approaches. Indeed, these two global emergencies share common characteristics, with both escalating in recent decades due to a complex interplay of modern human practices and the consequences often not being tangible or observable until serious adverse outcomes emerge (e.g. blindness with type 2 diabetes, large-scale fires due to rising temperatures). Physiological research can provide an important understanding of the acute and chronic cardiometabolic risk marker responses to active travel across different intensities, modes, durations, and frequencies to inform messages that could help to promote active travel for both health promotion and climate change mitigation (i.e. efforts to reduce or prevent emission of greenhouse gases). Additionally, research focused on adaptation (e.g. minimising the adverse consequences of climate change) will be important to promote active travel in our changing climates, including understanding thermoregulatory responses to help provide an understanding of the possible bi-directional relationship of active travel with climate change in the context of barriers and facilitators to active travel engagement. With this in mind, interdisciplinary efforts across the fields of physiology and behavioural science may be valuable in providing effective messaging based on physiological findings with the hope of increasing engagement in active travel across our communities for human and planetary health benefits. This will aid attempts from public health professionals and researchers to promote various modes of active travel as health- and planet-friendly alternatives to motorised forms of transport.

Addressing the global burden of preventable cardiometabolic diseases and climate change may require similar, multidisciplinary approaches. Indeed, these two global emergencies share common characteristics, with both escalating in recent decades

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# How does air pollution affect our health?

## Exploring the health impacts associated with short- and long-term exposure to air pollutants

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Since The Physiological Society is devoting this themed issue to climate change, one might wonder what air pollution has to do with climate change? Although air pollution comprises a complex mixture of both gases and particles, the primary gaseous air pollutants (e.g. ozone, oxides of nitrogen) are not the same as the primary greenhouse gases (e.g. carbon dioxide, methane) responsible for climate change. However, air pollution is both a *cause* and a *result* of climate change.

More frequent and severe heat events and wildfires directly lead to air pollution in the form of particulates from wildfires and ozone generated during heat events. Furthermore, black carbon generated from industry, internal combustion and fires contributes directly to climate change through absorption of heat by black carbon particles in the atmosphere, and by reduced light reflectance of ice and snow by this black carbon, further aggravating temperature increases. As such, we can expect a worsening of air pollution because of climate change, and an acceleration of climate change because of air pollution.

Air pollution has a significant negative effect on our health. It is the leading environmental cause of mortality, and contributes to cardiovascular disease, respiratory disease, diabetes, stroke, and dementia. Children exposed to higher levels of ozone are more likely to develop asthma later in life. With 99% of the world's population living in areas that exceed World Health Organization-recommended safe levels of air pollution, we can expect an increasing health toll in terms of the negative effects of air pollution.

As physiologists, what can we do to mitigate these negative health effects? A few things.

### Is it safe to exercise in poor air quality?

The pathophysiology of air pollution is still poorly understood. Air pollution is a complex recipe of gases and particles that varies by location, season, weather, and time of day. These varying recipes can have different physiological and pathophysiological consequences. Exposure studies in a variety of conditions with healthy and clinical populations are an important means to investigate these interactions. Furthermore, many air pollution countermeasures have been proposed, such as mask wearing, nutritional interventions, and even medications. These require further evaluation to assess their efficacy and tolerability.

One focus of our laboratory is the interaction between exercise and air pollution (Fig.1). Exercise is a proven tool to prevent and treat many conditions (including the cardiovascular disease, respiratory disease, diabetes, stroke, and dementia mentioned earlier). However, there has always been the concern that exercise may worsen the effects of air pollution. This concern comes from the fact that, by definition, exercise leads to an increase in metabolic rate, and therefore lung ventilation, which can increase the inhaled dose of air pollutants. Furthermore,



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as exercise gets more intense, we tend to breathe more through our mouths and less through our noses. Since the nasal passages act as natural filtration systems, more intense exercise can theoretically lead to an even higher inhaled dose of air pollution (Giles and Koehle, 2014). These potential concerns have led to very mixed messaging for active individuals, uncertain as to whether they should exercise when air quality is poor.

## Why it is important to keep active?

When messaging to the public is conflicting, often it means that good-quality research is lacking. Therefore, for the past 10 years, we have been studying the interaction between air pollution and exercise using both laboratory-controlled air pollution exposures and field studies in ambient, polluted air.

We have explored the fundamental question of "Does exercising in air pollution exacerbate the negative effects of air pollution?", and have also explored other questions such as: "Do medications exacerbate or help symptoms when exercising in air pollution? Can we adapt to air pollution? What are the effects of pollution exposure before exercise? How does exercise intensity influence the effects of air pollution on the body?" (Figs. 2 & 3).

What we are learning is that although air pollution can lead to the many diseases mentioned above, doing exercise does not make these effects worse (Giles and Koehle, 2014; Sun *et al.*, 2019; Andersen *et al.*, 2015). At most, for certain conditions (e.g. dementia), it appears that air pollution might diminish or obscure the beneficial effects of exercise (Raichlen *et al.*, 2022). On the whole, it seems clear that although air pollution has many negative effects, we do not need to avoid exercise during prolonged periods of poor air quality. In fact, decreasing physical activity in response to poor air quality can lead to a synergistic epidemic (termed "syndemic") combining the negative effects of sedentary behaviour with the consequences of air pollution (Ding and Elbarbary, 2021).

## When and what type of exercise to undertake in poor air quality?

We therefore advise individuals that air pollution is bad for our health 24 hours per day. We should do everything we can to reduce our personal exposure to air pollution as much as possible. Everything except stopping exercising. For example, choosing to exercise in the early mornings, when both ground-level ozone and particulate matter levels are often at their lowest, can minimise the pollution dose. Furthermore, distancing the location of exercise away from pollution sources (such as busy roads) dramatically

*Figure 1.* **Ozone chamber for exposure studies.** With the addition of ozone generators and pollutant sensors, we have modified our altitude chamber to be able to deliver precise amounts of ozone during rest and exercise. Photo credit: Bennett Stothers

*Figure 2.* **A participant exercises while breathing ozone.** Photo credit: Bennett Stothers

*Figure 3.* For diesel exhaust exposures, we collaborate with colleagues in the UBC Air Pollution Exposure Laboratory pictured here. Photo credit: Dr. Luisa Giles

reduces the impact of pollution. A nice rule of thumb is that 400 metres from a source, pollution levels decrease to the background levels for the area. For individuals, this might mean exercising closer to the centre of a park, and not right next to a roadway.

Are there forms of exercise that are better to undertake in poor quality air? Probably. Very prolonged exercise (>90 minutes) has not been adequately studied but could lead to a very high dose of inhaled pollutants, thus having the potential for greater effects. Conversely, from acute exposure studies, we have learned that shorter, higher-intensity exercise seems to be well-tolerated (Giles *et al.,* 2014). We have also learned that medications (e.g. asthma medications) that open up the airway (and theoretically increase the dose of pollution) do not make symptoms worse in humans (Koch *et al.,* 2021; Stothers *et al.,* 2022). Therefore, individuals with asthma or exercise-induced bronchoconstriction are advised to continue taking their medications as prescribed by their physicians.

## Can we adapt to air pollution?

What areas need more research? Masks, nutritional supplements and adaptation to name a few. We know that high-quality masks can reduce the intake of certain pollutants (especially particulate matter), but research is lacking around their utility and efficacy during exercise and in high pollution. There is evidence that some supplements (e.g. vitamins C and E) may be efficacious against certain pollutants (e.g. ozone), but more work needs to be done to optimise dosage and preparations.

Adaptation is a key strategy for humankind with the climate emergency. Interestingly, there is even evidence that we may be able to adapt to certain pollutants, especially ground-level ozone (Sandford *et al.,* 2021; Foxcroft and Adams, 1986). We need to understand how effective this potential adaptation may be, and under what circumstances, and in what populations.

One area where physiologists are increasingly playing an important role is in sport. Ever more frequently, I see high-performance teams considering air pollution exposure as a health and performance factor in the lead-up to important events. For example, in Canada's recent successful campaign to qualify for the 2022 football World Cup Finals, they engaged physiologists to advise on air pollution mitigation during important matches held under polluted conditions. Likewise, in the preparation for the Tokyo Olympics, not only were the high ozone levels a consideration for teams and athletes (especially in the distance events), athletes adjusted their pre-competition training times and locations to minimise pollution exposure during training camps. With upcoming Summer Olympic Games in Paris and Los Angeles, we can expect that not only heat, but polluted air will be a factor for the athletes to contend with.

In summary, air pollution is becoming an increasingly important issue in conjunction with climate change. Developing strategies to mitigate the adverse effects of air pollution while promoting healthy physical activity is crucial for preventing a syndemic of air pollution and inactivity.

> It seems clear that although air pollution has many negative effects, we do not need to avoid exercise during prolonged periods of poor air quality. In fact, decreasing physical activity in response to poor air quality can lead to a synergistic epidemic (termed "syndemic") combining the negative effects of sedentary behaviour with the consequences of air pollution

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# Helping the most vulnerable survive heatwaves today and in the future

## Using physiology to identify cooling interventions that work

*Professor Ollie Jay*

Heat and Health Research Incubator, University of Sydney, Australia

For several days in July 2022, people across the United Kingdom and the rest of Europe tasted a sample of the future effects of climate change. Peak temperatures (measured in the shade) exceeded 40˚C in the UK for the first time in recorded history, while the mercury soared beyond 45˚C in some parts of mainland Europe. This weather follows a string of record-breaking heatwaves in South Asia from March to May where in highly populated cities such as New Delhi, residents suffered through 5 heatwaves in 8 weeks, the fiercest of which peaked at 49.2˚C.

The devastating effects of extreme heat on human health are clear. Heatwaves are already responsible for more deaths than all other natural disasters (Gasparrini *et al.*, 2015). The legacy of human activity over the past century means more intense and frequent heatwaves are all but assured for at least the remainder of this century. While epidemiologists have provided important information on the subgroups of society that are most at risk of the negative health effects of extreme heat, physiologists can provide essential insight into a) why some people are more intolerant than others to extreme heat exposure, and b) the types of interventions that can be used to increase extreme heat resilience of the most vulnerable.

### Adaptative capacity is key to coping with heatwaves

The ability to safely endure a heatwave is dependent on the combined physiological and behavioural capacity to adapt to extremely hot environments (Fig.1). From a physiological perspective, age-related decrements in both sudomotor function (i.e. autonomic nervous system control of sweat gland activity) and levels of cutaneous vasodilation compromise the ability to regulate body temperature in the heat (Kenney and Munce, 2003), and thus elevate heatstroke risk. Emerging evidence indicates that these thermoregulatory ageing effects may be further compounded by the presence of chronic diseases such as diabetes (Kenny *et al.*, 2016). People with pre-existing heart conditions are at a heightened risk of heat-related morbidity and mortality, but not necessarily due to critically high body temperatures. The most likely mechanistic pathway is a compromised capacity to tolerate the elevated cardiovascular strain that evolves with the greater cardiac output required to maintain blood pressure upon the large reductions in total peripheral resistance caused by heat-induced cutaneous vasodilation (Ebi *et al.*, 2021). Heat stress risk is also exacerbated in people who are excessively exposed to extreme heat because of a low behavioural adaptive capacity. Air-conditioning (AC) use offers exceptional protection against heat-related illnesses in a heatwave (Bouchama *et al.*, 2007), and it is now the leading heat coping strategy globally. Yet, because of high capital and operational costs, AC is often inaccessible to people living with poverty who subsequently rank highest

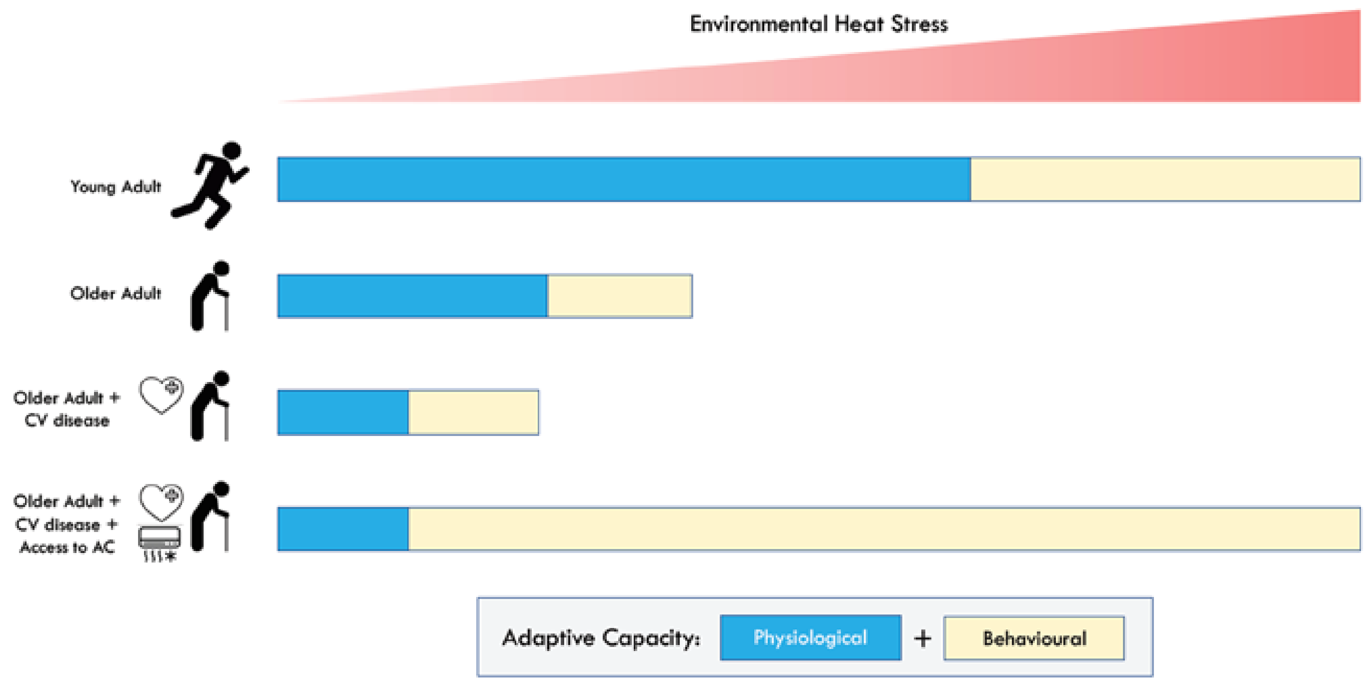


*Figure 1.* A conceptual illustration of differences in physiological and behavioural adaptative capacity to environmental heat stress with ageing, chronic disease and access to mechanical cooling.

The devastating effects of extreme heat on human health are clear. Heatwaves are already responsible for more deaths than all other natural disasters

among the most vulnerable. People with disabilities, especially those living in isolation, may lack mobility and be unable to engage fully in heat-avoidance behaviour. The heat-health effects of these factors are further aggravated by residing in housing constructed of low-cost materials with poor thermal performance, especially if situated in densely built urban settings, where heat exposure is further amplified by the urban heat island effect.

## The search for cooling alternatives to AC in heatwaves

Identifying simple and accessible cooling strategies that can be adopted by those with both a low physiological and behavioural capacity to adapt to extreme heat is a high priority for optimising public health preparedness in advance of an impending heatwave disaster. Electric fan use has been widely considered as an attractive option. They are cheap to purchase, consume less than one-twentieth of the electricity required to operate AC, are simple to use, and widely available. The effectiveness of electric fans for cooling in heatwave conditions though has been contentious for decades. In the 1990s, fan distribution programmes targeted the most vulnerable in cities such as New York and Chicago as part of their heatwave management strategy. But these programmes were discontinued due to concerns that fans paradoxically increase the risk of heat-related illnesses. In fact, most major public health agencies (e.g. WHO, CDC) now insist that fans should not be used during heatwaves because they can supposedly "speed the onset" of heat exhaustion when used above 35˚C. Similarly, in their most recently issued heatwave guidance, the National Health Service in the UK (National Health Service, 2022) state that fan use above 35°C "may not prevent heat related illness", "can cause excess dehydration", and they should be placed "a certain distance from people, not aiming it directly on the body and to have regular drinks". This is apparently "especially important in the case of sick people confined to bed".

The notion that fan use may be detrimental in heatwave conditions most likely arises from the understanding that as air temperature exceeds skin temperature, which reaches ~35°C when fully vasodilated, more sensible heat will flow into the body with additional air movement. After all, this is the basis upon which fan-assisted ovens accelerate cooking. However, unlike a lump of meat in an oven, humans secrete sweat on to the skin surface when heated and the subsequent evaporative heat loss serves to greatly cool the body. Moreover, this evaporation can be massively enhanced with greater air velocities, leading to the evaporation of sweat that would otherwise either sit on the skin, or drip off the body altogether and provide no latent cooling. It is therefore clear that only when the additional sensible heat gain cannot be counterbalanced by greater evaporative heat loss will fans accelerate body heating. However, there are physiological limitations to sweating that will impact the efficacy of fan use (Jay *et al.*, 2015). Age-related


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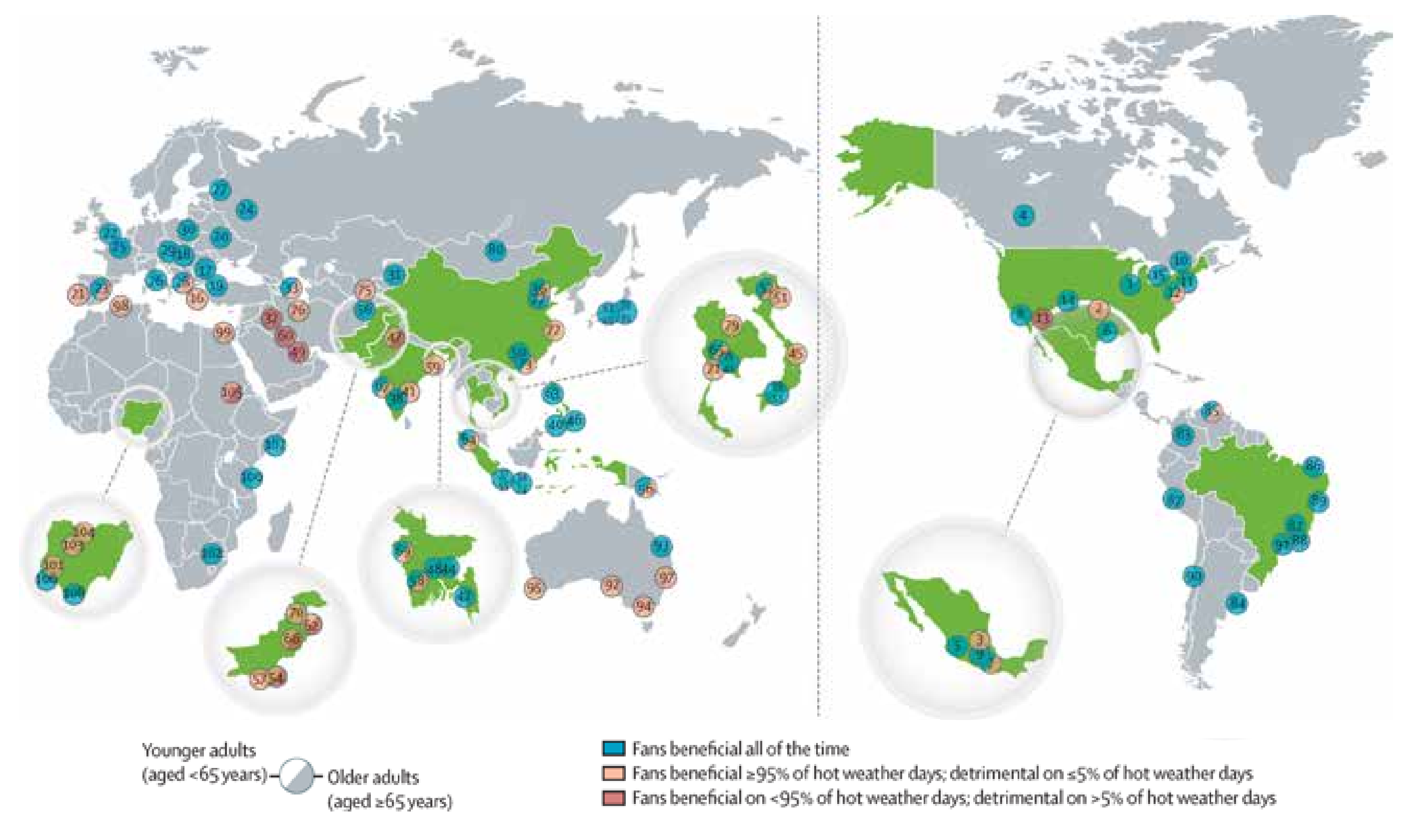


*Figure 2.* Fan use recommendations from Morris *et al.* (2021) for healthy younger and healthy older adults based on the peak and 95th percentile environmental conditions recorded between Jan 1, 2007, and Dec 31, 2019. Countries highlighted in green represent those identified as the 12 countries with the greatest potential for growth in air conditioning use by the end of the 21st century. A list of cities corresponding to the numbers is given in the appendix. of the article by Morris *et al.* (2021)

decrements in sweat output for example are progressively observed above the age of 60 years (Kenney and Munce, 2003), most notably on the forehead, face, and arms (Inoue *et al.*, 1991). Furthermore, in arid conditions most sweat will freely evaporate even in relatively still air owing to the higher water vapour pressure gradient between the skin and environment, meaning that during very hot and dry heatwaves fan use may only generate minimal evaporative benefits while forcing additional heat into the body via convection. Notwithstanding the rationale described above, no empirical evidence seems to yet be available supporting 35˚C as a critical threshold beyond which fans do not help alleviate heat stress, or even worse, aggravate it. Indeed, a 2012 Cochrane review, which is often cited as supporting evidence for existing public health guidance on fan use, concluded "no evidence at all exists supporting or refuting the use of electric fans during heatwaves" (Gupta *et al.*, 2012). It is also unclear what other personal-level cooling strategies can be used as alternatives. Actively wetting the skin with water should boost evaporative potential, while immersing limbs, which are highly vascularised and have a high surface area-to-volume ratio, in cold water could augment conductive heat transfer away from the body.

## Using physiology to identify cooling interventions that work

Changes in the risk of heat-related illnesses can be inferred from the measurement of a triad of biomarkers of physiological heat strain. Rises in core temperature indicate the risk of hyperthermia, while measures of rate-pressure product (i.e. systolic blood pressure × heart rate) serve as an indicator of myocardial oxygen consumption and therefore cardiovascular strain, and rates of whole-body sweat losses determine dehydration risk. Under simulated heatwave conditions in climate chambers, physiologists can measure these variables in a variety of participants with different clinical profiles to systematically assess the potential cooling efficacy of personal-level interventions.

Using a humidity-ramp protocol, pioneered by the Noll Research Laboratory at Penn State University (Kenney and Zeman, 2002), to identify the critical environmental condition under which the physiological compensation of cardiovascular strain and thermal strain is no longer possible, we observed a protective effect of electric fan use at both 36˚C and 42˚C in young healthy adults – some 1˚C and 7˚C above the current NHS fan use threshold, respectively (Ravanelli *et al.*, 2015). Specifically, elevations in cardiovascular and thermal strain occurred at a higher humidity at each temperature with fan use. When comparing absolute humidity thresholds, our young healthy participants experienced less physiological heat strain with a fan at 42˚C than they did without a fan at 36˚C.

We further assessed whether an expression of ambient conditions that combines the effects of temperature and humidity (i.e. heat index (HI) – which adjusts temperature to the value that would elicit the same thermal sensation as the prevailing conditions if absolute humidity was fixed at 1.6 kPa) should be used to recommend fan use in heatwaves (Morris *et al.*, 2019a), as per the US Protection Agency who instruct people to turn off fans at an HI of 37˚C. During an acute exposure to hot/humid (40˚C, 50% RH) conditions with a high HI – representative of common heatwaves in temperate climates, e.g. Western Europe, North America (except Southwest), Eastern China, fan use reduced cardiovascular and thermal strain. Yet, in very hot/dry conditions with a lower HI – representative of heatwaves in arid climates, e.g. Middle East, South Asia, Australia, fans worsened physiological heat strain. The use of HI as a means of determining whether fans should be used or not is therefore not recommended.

Importantly, these studies assessed the physiological responses of young healthy participants free from thermoregulatory impairments. Subsequent studies assessing fan use in older adults (>60 years) have


*Figure 3.* An infographic from Jay *et al.* (2021) summarising sustainable and accessible cooling strategies supported by physiological studies. Source: https://www.thelancet.com/infographics-do/cooling-strategies.

shown that the beneficial effect of fan use is eliminated, and potentially reversed, at 42–43°C (Gagnon *et al.*, 2016; Cramer *et al.*, 2020). Using biophysical modelling informed by these and other physiological data, we have subsequently proposed humidity-dependent air temperature thresholds at which fans should not be used for healthy young adults, healthy older adults, and older adults taking prescription medications that interfere with sweating (Morris *et al.*, 2021). While recognising that indoor temperature and humidity for a given set of outdoor conditions in a heatwave can vary, and be strongly affected by housing typology, providing historical heatwave conditions for context, we found that fan use should be almost universally recommended as an alternative cooling strategy in the UK, most of the rest of Europe, large swathes of Asia, North America, and South America (Fig.2). On the other hand, fans should be routinely discouraged in the Middle East due to high temperatures coupled with low humidity. Using these historical conditions, we also generated simplified fan-use temperature thresholds for public health messaging at which fan use would not be detrimental irrespective of humidity: 39°C (young adults), 38°C (healthy older adults), and 37°C (older adults taking anticholinergic medication) (Jay *et al.*, 2021).

The one concern by public health authorities about fan use in heatwaves that has been supported by physiological studies is accelerated dehydration. Despite smaller rises in core temperature, sweat rates are higher with fan use, most likely due to a higher skin temperature modifying the onset threshold and thermosensitivity of the sudomotor response (Ravanelli *et al.*, 2020). However, practically this greater risk of dehydration can be offset with the ingestion of extra ~100–150 ml of water every hour.

When heatwave conditions exceed the thresholds for safe fan use, applying water to the skin using a spray bottle or sponge reduces heat-induced cardiovascular strain, improves thermal comfort, and slows the development of dehydration in heatwave conditions up to 47°C (Morris *et al.*, 2019b). Under the same conditions, the immersion of both feet in a bucket of cold tap water for 10 minutes every 20 minutes improves thermal comfort and reduces dehydration risk. Such interventions may potentially be useful for people living in very low-resource environments without access to any electricity. They also provide an option as an emergency intervention for people during power outages, which have occurred with increasing regularity during heatwaves in recent years as more people turn to air conditioning and frail energy infrastructure has been unable to meet electricity demands with sufficient supply. The sustainable and accessible cooling strategies supported by the latest physiological evidence have been reported in our recent collaborative Lancet Series on Heat and Health (Jay *et al.*, 2021) and are summarised in an infographic that is currently available in English (Fig.3), Spanish and Hindi.

## The next steps

While these initial physiological studies provide a strong indication of sustainable and accessible cooling strategies that can be used to help the most vulnerable navigate safely through heatwaves, confirmation of their cooling efficacy in larger-scale studies is essential. This is particularly relevant for people with chronic diseases, such as cardiovascular disease, and over multi-day exposures in real-world heatwaves.

Any additional or multiplicative benefit from combining interventions, as well as interactions with chronic dehydration and different prescription medications also needs to be urgently assessed.

> Identifying simple and accessible cooling strategies that can be adopted by those with both a low physiological and behavioural capacity to adapt to extreme heat is a high priority for optimising public health preparedness in advance of an impending heatwave disaster.

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# Looking forward to our 2023 conferences

## Sharing science, connecting communities, and furthering physiology

We look forward to welcoming you to the historic spa town of Harrogate for our Annual Conference, Physiology 2023

*Sarah Bundock*

*Head of Events and Marketing, The Physiological Society*

After two years of solely online conferences and meetings, we are excited for 2023's conferences portfolio, which will support The Society's new strategy.

## Annual Conference

We are very much looking forward to being in Harrogate from 10 to 12 July 2023 for The Society's Annual Conference, Physiology 2023.

It will be the first time since 2019 that we will be able to meet face to face at The Society's flagship event. It's an opportunity to hear the latest in physiology while catching up with friends and colleagues from around the world.

You will enjoy a warm welcome, with first-class science, unmissable networking opportunities and seven exciting Prize Lectures, all in the historic Victorian spa town of Harrogate.

Harrogate Convention Centre is in the heart of Harrogate and close to many bars, restaurants and hotels, with excellent transport links. We are working closely with the team at the venue and also Visit Harrogate on those finishing touches that really help members make the most of their time at the conference, for example, early morning park runs, civic receptions and much more.

We know that networking is one of the most important aspects of our conferences. Physiology 2023 will bring together physiologists from across the globe. World experts, educators, and researchers at all career stages will come together to discuss their work and make new connections.

There will be many opportunities to present posters and oral communications, as well as participate in small-group discussions. Physiology 2023 will provide a wealth of fantastic opportunities to receive real-time feedback on your research from peers and colleagues on your research.

Across the three-day scientific programme, you will hear from world-leading physiologists who will be discussing their latest research. With our inspirational Prize Lectures, symposia and workshops, our conference will feature physiology from across our Scientific Themes. With opportunities to interact and ask questions, this is a great way to advance your knowledge.

### Conference prize lecturers

- **Annual Review Prize Lecture**
  Professor Anant Parekh, National Institute of Environmental Health Sciences, National Institutes of Health, US
- **Annual Public Lecture**
  Professor Andrew Murray, University of Cambridge, UK
- **Bayliss-Starling Prize Lecture**
  Professor Neil Herring, University of Oxford, UK
- **Hodgkin-Huxley-Katz Prize Lecture**
  Professor Indira Raman, Northwestern University, US
- **Joan Mott Prize Lecture**
  Professor Janna Morrison, University of South Australia, Australia
- **Otto Hutter Teaching Prize**
  Dr David Greensmith, University of Salford, UK
- **Paton Prize Lecture**
  Professor Richard Morris, University of Edinburgh, UK


https://doi.org/10.36866/pn.127.34

Professor Julia Choate giving her Prize Lecture in 2019

Professor Kevin Fong giving his Prize Lecture in 2019

Our professional development programme at Physiology 2023 will also focus on the core areas members have told us they value. These will be tailored to support you in advancing to the next stage in your career.

**physoc.org/events/physiology-2023**

## Two-Day Scientific Meetings

From 2023, The Society is offering members the opportunity to organise a two-day focused research meeting to bring your community together. You can invite high-profile speakers to present their latest research in your field, schedule time for oral communications and poster sessions, and network with both early career and established researchers and forge new collaborations.

These will be held at universities, offering you the chance to showcase your institution and your research to invited speakers and attendees.

There are two deadlines per year, March and September. All applications will then be reviewed by The Society's Conferences Committee. There will be up to four of these meetings in 2023.


Our 2023 conferences will have plenty of opportunity to share your research

As Scientific Programme Organisers you are responsible for the scientific content of the meeting and The Society Events Team is responsible for the logistics, operations and budget. Scientific Programme Organisers are expected to liaise very closely with the Events Team to ensure the success of the event. The Physiological Society will set a fixed budget for the event, taking into account anticipated attendance and sponsorship.

These meetings will be vital to support The Society's ambitious strategic goals in having a larger, more engaged and more diverse community of members and also be essential and influential for establishing their career.

**physoc.org/our-events/meeting-workshop-support/two-day-scientific-meetings**

## Online symposia

Online conferences have been fantastic in enabling presentations and the sharing of research and data, and The Society is pleased that we were able to quickly adapt in 2020 to offer online conferences, webinars and symposia.

We are evaluating what role online conferences and symposia will play in The Society's conference portfolio going forward, which we know brings global and diverse communities together.

*We look forward to meeting you at an upcoming conference or meeting later this year or in 2023. See our full events listing at* **physoc.org/events***. As always, if you have any comments, queries or suggestions, please do get in touch with us by emailing* **events@physoc.org**

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Meeting Report

# Processing and Modulation of Sensory Signals: From the Periphery to the Cortex

*Caitlin Oates*

*Events and Marketing Manager, The Physiological Society*

"Processing and Modulation of Sensory Signals: From the Periphery to the Cortex" was designed to help foster new connections and cross-pollinate ideas between researchers studying sensory systems in different modalities and at different levels.

Originally due to take place back in June 2020, the COVID-19 pandemic forced a postponement to March 2021. Fast forward to early 2021 and the first Omicron wave, March 2021 became June 2022.

As we approached June 2022, things were on track and we were excited about providing sensory signals researchers the opportunity to reconnect face to face again. However, strike action on the rail network and tube lines was announced and the meeting was affected for a third time.

After much discussion, the difficult decision was made to move the conference online and the conference finally took place on 20 – 21 June 2022.

Whilst it was disappointing not to meet in person, the conference provided attendees with an excellent line up of speakers, covering various sensory systems in sessions that included peripheral and brainstem processing, thalamic and cortical processing, sensation, location and action and modulation of the senses. The keynote lecture was delivered by Dr Kathleen Cullen, Professor of biomedical engineering at the Johns Hopkins University School of Medicine, US exploring vestibular processing during natural self-motion, and researchers from various institutions were able to showcase their research in our two flash talk sessions.

We would like to offer our thanks to the scientific organisers (Dr Jamie Johnston, Professor Jennifer Linden and Professor Susan Deuchars) for their efforts, determination and persistence to ensure this conference came to fruition and the invited speakers and attendees for their understanding and continued enthusiasm to participate.

Dr Maarten Frans Zwart, an invited speaker, and Hodan Ibrahim, a flash talk presenter, share their thoughts.

**Dr Maarten Frans Zwart**
**University of St Andrews, UK**

"The Processing and Modulation of Sensory Signals conference was a very enjoyable two days of talks covering a wide range of topics. While the emphasis was on experimental work in rodents, there were plenty of excursions into other model systems and theoretical approaches. Especially welcome to me was the combination of regular talks and shorter "Flash Talks", which meant researchers at all career stages had the opportunity to present their work. While the online format meant there were no social events, the lively discussions following talks went some way to compensating for this. The savings in carbon emissions also helped me to appreciate the online format even more! I was grateful for the opportunity to present our work to such a distinguished audience, and I thank The Physiological Society for supporting this excellent, well-run conference."

**Hodan Ibrahim**
**University of Central Lancashire, UK**

"Attending the virtual Processing and Modulation of Sensory Signals: From the Periphery to the Cortex meeting was a great opportunity to listen to and interact with researchers from across the world. I think the organisers did a great job of adapting the conference to an online meeting at such short notice".

Especially welcome to me was the combination of regular talks and shorter 'Flash Talks', which meant researchers at all career stages had the opportunity to present their work


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Meeting Report

# Climate Change: Research Gaps and Policy Priorities

*Online webinar held on 15 June 2022*

*Shania Pande*

Policy Officer *The Physiological Society*

*"Climate change is the single greatest threat to a sustainable future but, at the same time, addressing the climate challenge presents a golden opportunity to promote prosperity, security and a brighter future for all."* – Ban Ki-Moon, Former Secretary-General of UN.

Physiology is an essential part of the scientific response to mitigating as well as adapting to climate change. Held on 15 June 2022, the webinar, chaired by Professor Mike Tipton from the University of Portsmouth, UK brought together over 100 physiologists from across the world, along with speeches from organisations such as the Intergovernmental Panel on Climate Change (IPCC), Wellcome, and Lancet Countdown on Health and Climate Change. The key aims of this meeting were to understand the major physiological research gaps and set priorities for public policy. The webinar can be found here: physoc.org/climatechange

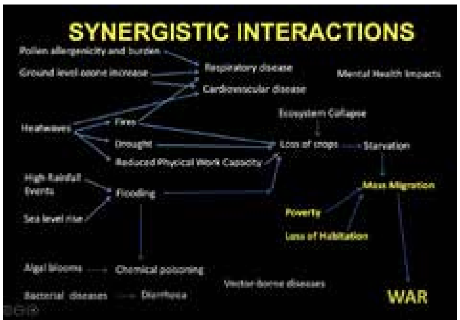
The webinar comprised three sessions followed by panel discussions after each session. The speakers highlighted the breadth of ways in which physiology can contribute to mitigating climate change such as altering people's behaviour so that they are able to adapt to extreme heat environments without relying on air conditioning or by developing sustainable diets that meet the required nutritional standards. Physiology also plays a vital role in adapting to climate change through the development of countermeasures such as masks and PPE kits and safe working practice guidelines for workers in extreme environments.

The webinar highlighted the need for interdisciplinary collaboration between physiology and other sciences to ensure that the strategies developed are implemented on the ground and help protect the most vulnerable from the devastating impact of climate change. It is also vital we consider the health of our planet as a whole and not just human health. This can be done by research into the workings of different physiological systems in plants and animals in response to changes in temperature, air pollution, and other weather events.

This meeting report captures some of the key calls to action from two of the meeting's keynote speakers: Professor Hugh Montgomery from University College London and Lancet Countdown on Health and Climate Change, and Dr Hans-Otto Pörtner from the Intergovernmental Panel on Climate Change of the United Nations.

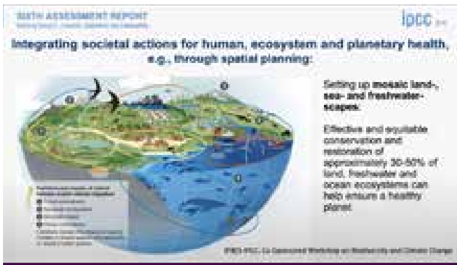
**Professor Hugh Montgomery**
**Professor of Intensive Care Medicine, University College London and Lancet Countdown on Health and Climate Change**

The direct health impacts of climate change pose an existential threat to humanity. Progressive heatwaves produce fires and dust, increasing ground-level ozone, which worsens respiratory and also cardiovascular health. Heatwaves themselves cause drought and reduce physical work capacity. Conversely, high rainfall events and rise in sea levels causes flooding. These adverse events lead to the collapse of ecosystems, which ultimately reduces crop production resulting in mass starvation. Algal blooms and flooding cause chemical poisoning and increase bacterial diseases. Further, changes in the territory and breeding pattern due to climate change affect vector-borne disease patterns. Physiology not only has a role in the mitigation of climate change from reducing greenhouse gases to changing diets to reduce methane emissions, but also in understanding how we cope with the complex changes in our physiological environment.




Synergistic interactions. Part of Professor Hugh Montgomery's presentation covered the health impacts and knock-on effects of climate change.

**Dr Hans-Otto Pörtner**
**Co-Chair, Working Group II, Intergovernmental Panel on Climate Change, United Nations**




How to ensure a healthy planet? Dr Hans-Otto Pörtner discussing policy and public changes to sustain life on Earth.

*The recent IPCC Working Group II report on Impacts, Adaptation and Vulnerability.* Physiological knowledge has shown that taking urgent climate action needs to be a priority. Climate-resilient development has human health and wellbeing at its core, but also considers the importance of equity and justice. It also draws on ecosystem and planetary health, highlighting the need to take a whole-systems approach to climate change.

We need to develop an improved and quantified understanding of how the system as well as its components work and we are just one of those components. We do not know enough about mechanisms, cause and effect, warming and limits concerning the vulnerability of species, biodiversity, humans, and understanding the when and why of biological and societal tipping points in response to ecosystem degradation. There is also a need to consider the scope for and limits to adaptation. On the species side it is evolutionary adaptation that involves the modulation of physiological mechanisms.

*Following the webinar, The Physiological Society has committed to work with other climate-focused organisations to push national governments to prioritise human health as part of the COP27 agreements, which will be published following the meeting of world leaders in November 2022. You can read our latest report: The Climate Emergency: Research Gaps and Policy Priorities here: physoc.org/climatechange*

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Meeting Preview

# Environmental Impacts on Pregnancy and Offspring Outcomes: Lessons Learned and Avenues for Intervention

*Thursday 29 September 2022, London, UK*

*Professor Peter Nathanielsz*

University of Wyoming, US

This one-day Physiological Society meeting organised by Dr Amanda Sferruzzi-Perri and Dr Emilio Herrera is extremely timely. The concept of the fetal origins of adult disease emerged in the last decade of the last century. Its central tenet is that challenges to the fetus such as undernutrition and overnutrition at plastic periods of fetal development result in changes in the organism's developmental trajectory.

The outcomes of these challenges change the organism's phenotype, altering its predisposition to chronic conditions such as diabetes, cardiovascular disease, endocrine and neurological function, and other physiological systems that impair life-course health. The scope of this concept, sometimes called developmental programming, or the Barker hypothesis after David Barker who led the charge against the conventional wisdom at that time, and still present in some areas of biomedical research. Is the sole importance of our genetic endowment at fertilisation on life-course function.

This field of research has now grown to encompass the plastic periods of neonatal, in addition to fetal, life and is now referred to as the developmental origin of health and disease. To show the widespread acceptance of these concepts, there is now an International Society for the Developmental Origins of Health and Disease that will meet in August in Vancouver. Several of the invited speakers at The Physiological Society meeting are also speaking in Vancouver so The Society's September meeting will be completely up to date.

Research over the last 10 years has shown that development of each unique physiological phenotype depends as much on epigenetic as genetic mechanisms. The eight invited speakers have contributed substantially to knowledge of both mechanisms and outcomes of programming. The London meeting will be an opportunity to review the most recent advances.

Physiological science has been a leader in building firm, evidence-based knowledge in this area. The titles of the meeting's talks cross many boundaries: neuro-cardiovascular, metabolism, inflammation, diet and obesity and oxidative function.

This is an exciting area for those interested in careers in physiology. Knowing all the speakers as I do, this is a glorious opportunity to listen to thought-provoking new ideas from world leaders, getting help with presenting your own ideas and who knows, perhaps an opportunity to find a mentor of a laboratory where you could join in this fascinating research in the next phase of your career. Registration is open until 15 September, please visit: physoc.org/pregnancyoutcomes Don't miss this meeting.

This is a glorious opportunity to listen to thought-provoking new ideas from world leaders, getting help with presenting your own ideas and who knows, perhaps an opportunity to find a mentor of a laboratory where you could join in this fascinating research in the next phase of you career.



https://doi.org/10.36866/pn.127.38

# Mentoring in the Society

*Eleanor Newton*

Professional Development, Grants and Engagement Manager

The Society gives you access to a network of physiologists, and the new mentor directory  can help you to identify a mentor to support your career growth. Mentoring can be a great sounding board for addressing challenges and opportunities in your professional life, such as testing out new ideas or strategies, career planning, developing motivation and self-confidence, and developing knowledge of the wider discipline and sector.

The Society particularly promotes a developmental style of mentoring and encourages members to initiate a discussion with a mentor who is outside of their immediate professional environment.

Gaining clarity over why you think you need a mentor is important to help navigate those initial conversations and to set goals. Initiating and maintaining a good mentoring relationship can be daunting at first but is a great opportunity to potentially gain a mentor for life.

Dr Miriam Hurley, Postdoctoral Researcher at The University of Leeds, UK, has previously been mentored by a Society member and gives advice for making a success of this unique relationship.

*"Having a mentor is invaluable, whatever stage you are at within your career. I gained a mentor through The Society during my PhD and still know that I can reach out and contact my mentor now, even years later within my postdoc career.*

*First, be open. You have an opportunity to speak to someone within your field, who is further on in their career and has a wealth of expertise, so don't hold back.*

*Be flexible. As you navigate this stage in your career, things will change around you. So, be flexible as to the topics you discuss and the opportunities that may arise. The mentor/ mentee relationship is designed to evolve over time as you progress.*

*Take initiative as this mentoring is designed to challenge and be of benefit to you and your career. Ultimately you get out what you put in."*

Professor James Clark, Professor of Cardiovascular & Physiology Education at King's College London, UK, has benefited as both mentor and mentee throughout his career and is now a mentor for The Society.

*"I have been in the fortunate position to have worked with some inspirational people with whom I have been able to formally discuss my career plans as well as looking deeply into some important strategic choices.*

*I would advise mentees to choose their mentor carefully and bear in mind that it is quite likely that your first mentor will not be a match made in heaven. There are many different career paths, especially through the academic track, and it is important that your mentor really "gets" your approach to your work rather than simply being there to try and impose their view of the world. My first mentor was not working for me at all. They were full of great career advice and was a good listener but their idea of what makes a successful career did not align to mine.*

*Be honest with your mentor. To get the best out of mentorship you need to put all your cards on the table, not just those you would be prepared to share with senior management. These conversations are essential to be able to reflect on how things are going.*

*And finally, be prepared to think differently. It's good to have a plan; however, it's very important that you are flexible and take on board discussions you have with your mentor. I have had many 'have you tried…' conversations, some of which have led me nowhere, but others have made a big difference. Looking back, if I had 'stuck to my guns' on many aspects of my career I would be in a very different place right now!"*

As a member, you can log in to the Member Directory and search through the list of mentors who are open to be contacted. For more information on how to find a mentor, or how to sign up to be a mentor, please visit our website page **https://www.physoc.org/professional-development/mentoring/**

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# Physiology to the rescue

*Professor Mike Tipton & Dr Gemma Milligan*

Extreme Environments Laboratory, School of Sport, Health and Exercise Science, University of Portsmouth, Portsmouth, UK

The amount of energy in Earth's atmosphere is increasing at an alarming rate (1.6 W $m^{-2}$), and that rate has doubled in the last 14 years (Loeb *et al.,* 2021). This energy is reflected in both an increase in average global temperatures, and more widely varying and severe weather patterns. Physiologists are working hard in many areas associated with the mitigation of, and adaption to, climate change.

One area that is sometimes overlooked is "occupational physiology": this includes investigations of the impact of increased workplace heat stress on the risk to health and productivity of workers (Heat Shield, 2016). It also includes the response to the increasing number of extreme weather events. These include: hurricanes, wildfires, heat waves, cold snaps, drought and flooding. In these areas, the work undertaken by physiologists ranges from assessments of the habitability of bushfire shelters (Taylor and Haberley, 2015) to thermal monitoring and cooling strategies for firefighters (Notley *et al.,* 2018; Fullag ar *et al.,* 2021).

## Flood risk

It is sometimes forgotten that extreme weather events not only put members of the general public at risk, they also place very significant demands on the emergency services. Flooding is a good example; floods are increasing in terms of frequency and intensity around the globe; they are likely to get worse with climate change (increased rainfall, river flows and higher coastal storm surges). Internationally, the percentage of the global population at risk from flooding has risen by almost a quarter since the year 2000. In England, in 2008, it was estimated that around 5.2 million properties (one in six) were at risk of flooding. More than 5 million people lived and worked in 2.4 million properties that were at risk of flooding from rivers or the sea, one million of which were also at risk of surface water flooding. A further 2.8 million properties were susceptible to surface water flooding alone (Ellis *et al.,* 2021). Looking forward, flooding has been predicted to increase by an average of 15%-35% in the UK by 2080 (Environment Agency, 2009).

## The health and safety of rescuers

These increases are putting ever greater demands on those responsible for flood rescue, and it is physiologists who are establishing the associated risks and recommending interventions. Until recently, little was known about the physiological demand placed on flood rescuers. To rectify this, we undertook a study (Tipton *et al.,* 2019) that replicated a typical UK post-flood rescue scenario in representative "warm" and "cold" conditions. Flood rescue technicians undertook two conditions dressed in their normal protective PPE:

- "Cold": standing for 60 mins in knee-height moving water (4.8 km $h^{-1}$) at 7.7°C, with simulated rain, air temperature and wind speed of 4°C and 16 km $h^{-1}$ respectively).
- "Warm": six bouts of walking (2.16 km $h^{-1}$ for 7 min) in knee-height moving water (3.2 km $h^{-1}$) at 15.6 °C pulling and controlling the release of 10 kg (simulating rescue boat hauling), with 3 mins rest separating bouts of activity. Air temperature, wind speed and radiant heat load were 20°C, 0 km $h^{-1}$ and 500 W $m^{-2}$ respectively. A range of measures examined the metabolic, thermal and performance responses of technicians.

The results were illuminating. In the warm condition, following what was regarded at the time as acceptable working procedures, the first technician became exhausted in 10 mins and had an uncontrolled increase in deep body temperature, set to reach 40°C in 43 mins. Even when work demands were reduced to "minimum" levels, deep body temperature increased uncontrollably in half the technicians, average heart rates at the end of the simulated rescues were 87% of predicted maximum, oxygen consumption averaged 30 mL $kg^{-1}$. $min^{-1}$ and sweat losses were over 1 L $h^{-1}$. These values are too high to be sustainable without mitigation. In the cold condition, foot temperatures cooled to levels where non-freezing cold injury, a potentially life-changing condition (Golden *et al.,* 2013), became a risk.

Surf Life Saving GB flood rescue volunteers

## Improving work practices

This applied physiological study had widespread consequences in terms of: equipment design (PPE, wearable monitoring technology); working practices (technician numbers, shift allocations, work: rest schedules, hydration strategies, fitness standards, expectations). Such interventions should not only help flood rescue technicians fulfil their role effectively, they should also help the technicians avoid heat- and cold-related health problems.

This is just one example of the importance of physiology research and its application for the health and safety of rescuers and the communities they serve.

Physiology to the rescue!


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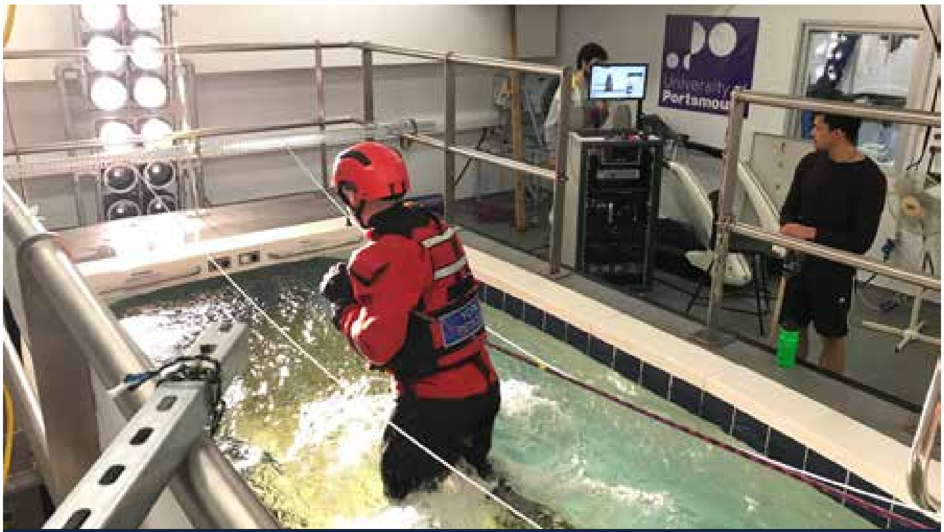

Investigating the thermal demands of flood rescue – Volunteers from the Surf Life Saving GB flood rescue are tested in different conditions.

It is sometimes forgotten that extreme weather events not only put members of the general public at risk, they also place very significant demands on the emergency services.


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# New appointments, awards and honours

The Physiological Society's Board of Trustees is delighted to announce the appointment of six new Honorary Fellows. Honorary Fellowship is the highest honour that The Physiological Society presents to an individual and it recognises persons of distinction in science who have contributed to the advancement of physiology.

- Professor Kim E. Barrett, PhD, University of California, Davis, Davis, California, U.S.
- Professor David Julius, PhD, University of San Francisco, San Fransisco, California, U.S.
- Professor Gary Richard Lewin, PhD, Max-Delbrück Center for Molecular Medicine (MDC), Berlin, Germany
- Professor Diane Lipscombe, PhD, Brown University, Providence, Rhode Island, U.S.
- Professor Ardem Patapoutian, PhD, Scripps Research, La Jolla, California, U.S.
- Professor Irene Tracey, CBE FMedSci, University of Oxford, Oxford, UK

The Society will also be welcoming two new Trustees, who will be joining The Board from the December 2022 Member Forum:

- Dr Nephtali Marina-Gonzalez PhD, who will serve as a General Trustee with an EDI focus (Equity, Diversity, and Inclusion)
- Professor Hugh Montgomery OBE, FMedSci, MBBS, BSc, FRCP, MD, FRSB, FFICM, FRI will serve as an Independent Trustee with a clinical focus

Lastly, The Society is delighted to recognise the experience, commitment and contributions of distinguished members by appointing our 2022 Fellow Members, as well as awarding our Exemplary Service to The Society Award. These accolades will be celebrated at the 2022 Member Forum, held at The Royal Society in London on 2 December 2022.

**Fellow Members:**

- Professor James Duffin, University of Toronto, Toronto, Ontario, Canada
- Professor Ian Forsythe, University of Leicester, Leicester, UK
- Dr Michael Gray, Newcastle University, Newcastle upon Tyne, UK
- Stephen Harridge, King's College London, London, UK
- Professor Philip Jakeman, University of Limerick, Limerick, Ireland
- Professor David Sheppard, University of Bristol, Bristol, UK
- Professor Michael Taggart, Newcastle University, Newcastle upon Tyne, UK

**Exemplary Service to The Society Award**

- Professor Ian Forsythe (University of Leicester, Leicester, UK) for his dedicated service to *The Journal of Physiology* and enthusiastic support of The Society over many years.

# Congratulating our 2022 Honorary Fellows

*The Physiological Society's Board of Trustees is delighted to announce the appointment of six new Honorary Fellows. Their appointment will be celebrated at the 2022 Member Forum, which will be held at The Royal Society on 2 December 2022. Honorary Fellowship is the highest honour that The Physiological Society presents to an individual and it recognises persons of distinction in science who have contributed to the advancement of physiology.*

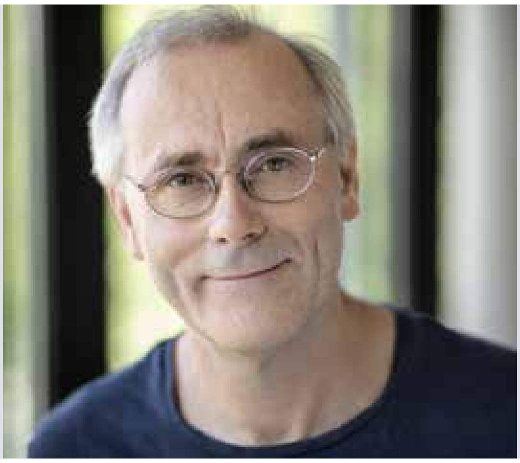
## *Professor Kim E. Barrett, PhD*

Kim Barrett is Distinguished Professor of Physiology and Membrane Biology and Vice Dean for Research in the School of Medicine at UC Davis (USA), where she is leading initiatives to bolster both basic and clinical research activities. She is the recipient of numerous awards and has been highly active in scholarly publishing. Recently she completed a six-year term as Editor-in-Chief for *The Journal of Physiology* in 2022.

## *Professor David Julius, PhD*

David Julius is currently the Morris Herzstein Chair in Molecular Biology and Medicine and Professor and Chair in the Department of Physiology at the University of California, San Francisco, USA. A major focus of David's work is to elucidate molecular mechanisms of somatosensation and pain, and sensory adaptation. Among his many awards is the 2021 Nobel Prize in Physiology or Medicine (shared with Ardem Patapoutian).

## *Professor Gary Richard Lewin, PhD*



Gary Lewin is Professor of Molecular Physiology of Somatic Sensation at the Max-Delbrück Center for Molecular Medicine (Berlin, Germany). His work has led to the development of new therapies to treat sensory disorders. He was an ERC panel member for 10 years, elected member of European Molecular Biology Organization (EMBO) in 2008., and in 2019 was honoured with Ernst Jung Prize for Medicine.

*You can find out more about all our Honorary Fellows at physoc.org/honorary-fellows/*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## *Professor Diane Lipscombe, PhD*

Diane Lipscombe is Reliance Dhirubhai Ambani Director of the Robert J. and Nancy D. Carney Institute for Brain Science and the Thomas J Watson Jr. Professor of Science in the Department of Neuroscience at Brown University (Rhode Island USA). She studies ion channel expression, modulation, and function with interest in the molecular and cellular mechanisms that underlie neurological and psychiatric diseases.

## *Professor Ardem Patapoutian, PhD*

Ardem Patapoutian is the Presidential Endowed Chair in Neurobiology and an Investigator of the Howard Hughes Medical Institute. His laboratory identified the molecules that sense temperature and pressure involved in touch, pain, and regulating blood pressure. He is a co-recipient of the 2020 Kavli Prize in Neuroscience, the 2021 BBVA Foundation Frontiers of Knowledge Award, and the 2021 Nobel Prize in Physiology or Medicine (all shared with David Julius).

## *Professor Irene Tracey, CBE FMedSci*

Irene Tracey is Warden of Merton College, University of Oxford, UK and Professor of Anaesthetic Neuroscience. She will be the next Vice-Chancellor at the University of Oxford, taking office in January 2023. She was a founding member of the world-renowned Oxford Centre for Functional Magnetic Resonance Imaging of the Brain. Her multidisciplinary research team has contributed to the understanding of pain perception and pain relief within the human central nervous system using advanced neuroimaging.



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# Obituary: Professor Colin Blakemore (1944-2022)

Professor Colin Blakemore

It is with great sadness that I report the death of Professor Sir Colin Blakemore FRS, FMedSci, HonFRCP, HonFRSM, HonFRSB, HonFBPhS, MAE, Emeritus Professor of Physiology, University of Oxford, and Emeritus Fellow of Magdalen College, Oxford. Colin passed away peacefully at Sobell House on Monday 27 June surrounded by his daughters.

Colin was a world-renowned neuroscientist and a passionate advocate for physiology who significantly contributed to our understanding of vision, and how the brain develops and adapts. He was influential in establishing the concept of "neural plasticity" — how brain cells reorganise themselves in response to the environment after birth and even in adulthood.

Born in Stratford-upon-Avon in 1944, Colin was educated at Coventry's King Henry VIII School before winning a state scholarship to Corpus Christi College, Cambridge, where he gained a first-class honours degree (1965) and MA (1969) in Medical Sciences. Following a PhD in Physiological Optics at the University of California, Berkeley in 1968, he returned to the University of Cambridge as a Demonstrator, Lecturer in Physiology, Director of Medical Studies (Downing College), and Royal Society Locke Research Fellow until 1979.

Colin became Waynflete Professor of Physiology at the University of Oxford in 1979, the youngest to be appointed to the position at just 35 years old. This was three years after being the youngest person to give the BBC Radio 4 Reith lectures. He was also appointed to a Professorial Fellowship at Magdalen College that same year, holding both positions until 2007. He was the longest serving Waynflete Professor in the history of the department. The university awarded him a DSc higher degree in 1989. From 1990 to 1996, Colin directed the McDonnell-Pew Centre for Cognitive Neuroscience, and from 1996 to 2003 the Oxford Centre for Cognitive Neuroscience. From 2003 to 2007, Colin took Special Leave to serve as Chief Executive of the Medical Research Council. He returned as Professor of Neuroscience and Supernumerary Fellow at Magdalen College until 2012.

In late 2012, Colin was appointed to the newly created Professorship of Neuroscience & Philosophy at the School of Advanced Study, University of London, where he directed the Centre for the Study of the Senses. He remained an Emeritus Professor at the Department of Physiology, Anatomy and Genetics (DPAG) until his death.

Colin was well known for his passionate belief in the importance of public engagement with research. He held several influential positions, including serving as President of the Biosciences Federation (now the Society of Biology), the British Neuroscience Association and The Physiological Society, and as President and Chairman of the British Association for the Advancement of Science (now the British Science Association). He presented and contributed to hundreds of radio and television broadcasts, wrote several popular science books and numerous articles for major British and overseas papers, worked for many medical charities and not-for-profit organisations, and served in advisory roles for several UK government departments, agencies, foundations and government departments overseas. Colin received a knighthood in 2014 for services to scientific research, policy, and outreach.

Colin was profoundly influential in the field of Visual Neuroscience. He was one of the first to demonstrate that the visual cortex undergoes active, adaptive change during very early development, helping the brain to match itself to the sensory environment. He went on to show that such plasticity results from changes in the shape and structure of nerve cells, the distribution of nerve fibres, and the selective death of nerve cells. His proven concept that the mammalian brain is "plastic" is now a dominant theme in neuroscience. The plasticity of connections between nerve cells is thought to underlie many different types of learning and memory, as well as sensory development. He also demonstrated that the visual cortex is "taken over" by the other senses, especially touch, in people who have been blind since infancy. Colin's most recent work identified some of the genes involved in enabling nerve cells to modify their connections in response to the flow of nerve impulses through them.

Colin was also well known in the world of arts and media. He inspired artists Patrick Hughes and David Hockney, who painted Colin. Last year, Patrick created and donated *Popsee* to the Department in honour of Colin, which will become a lasting memorial to him.

Colin was honoured for his scientific achievements by numerous prizes, including but not limited to the Royal Society's Michael Faraday Prize (1989), the Royal Society of Medicine's Ellison-Cliffe Medal (1993), the Alcon Research Institute Award (1996), the British Neuroscience Association Award for Outstanding Contribution to Neuroscience (2001), the Royal Society Ferrier Award and Lecture (2010), 10 Honorary Degrees from British and overseas universities, and the highest award of the Society for Neuroscience – the Ralph W. Gerard Prize (2012).

Colin is survived by his three daughters, Sarah-Jayne Blakemore FBA FMedSci (Professor of Psychology and Cognitive Neuroscience at Cambridge and co-director of the Wellcome Trust PhD Programme in Neuroscience at UCL), Jessica Blakemore, and Sophie Blakemore. Colin's wife, Andrée, passed away early this year.

As the last lecturer that Colin appointed during his time as Waynflete Professor and Head of the Department of Physiology, Anatomy & Genetics at the University of Oxford, I will always be grateful to him for his kindness and continued support over the years. The Department of Physiology here at Oxford and British science owe Colin Blakemore (and his family) a great public debt for the bravery showed in defending animal research. I was so pleased we could offer him a Festschrift last August after he was tragically diagnosed with motor neuron disease, and rename the Large Lecture Theatre as the Blakemore Lecture Theatre. Colin was the most eloquent communicator of science, which was beautifully illustrated when I interviewed him for *The Journal of Physiology* in 2012.
Please watch it here: www.youtube.com/watch?v=M9QQ-ihO. From today, the Sherrington Public Understanding of Science Prize Lecture will be known as the Blakemore Public Understanding of Science Prize Lecture in recognition of the love and affection he was held in by his many colleagues and pupils in Oxford and from around the world.

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Written by Professor David Paterson (President of The Physiological Society) and Head of the Department of Physiology, Anatomy & Genetics at the University of Oxford, UK

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# Florence Buchanan: A true pioneer

*Professor Dame Frances Ashcroft*

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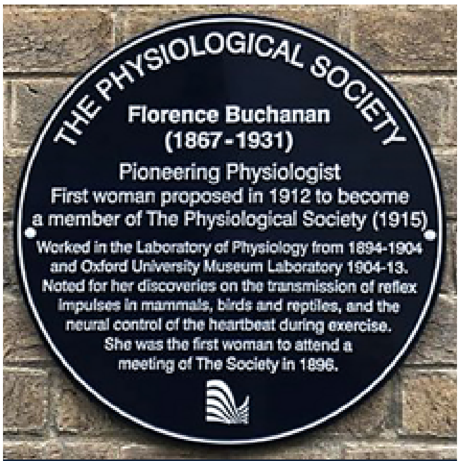


Blue plaque commemorating Florence Buchanan, unveiled on 1 July 2022. Image credit: DPAG.

Florence published several papers on the electrical responses of muscle and in 1896 became the first women to attend a Physiological Society meeting... Florence then moved to the Oxford University Museum of Natural History, where she set up her own lab.

Florence Buchanan is the first woman known to have attended a Physiological Society meeting and the first to be elected to The Physiological Society. Despite this distinction we know very little about her or what she looked like.

She was born in 1867 into a distinguished medical family. Her father, Sir George Buchanan FRS, became the Chief Medical Officer of the UK and is commemorated by a Royal Society medal (the Buchanan medal, which he endowed). She had five siblings, and her younger brother, Sir George Seaton Buchanan, also became a physician (Royal College of Physicians).

Florence read zoology at University College London, graduating in 1890, having published two papers as an undergraduate (something many of our current students would be extremely happy to do). These papers were on the respiratory organs of decapod crustacea and on annelids. She then studied marine polychaete worms with Ray Lankaster, discovering several new species (Buchanan, 1893; 1894).

In 1894 she moved to Oxford to work in the recently established Laboratory of Physiology, as a research assistant with John Burdon Sanderson, the Head of Department. She published several papers on the electrical responses of muscle (Buchanan, 1901), and in 1896 became the first women to attend a Physiological Society meeting. Burdon Sanderson resigned in 1904 when he was 76 – fortunately there was no enforced retirement age at Oxford in those days. Florence then moved to the Oxford University Museum of Natural History, where she set up her own lab. She was given the use of some equipment and she covered her research expenses with grants from the Royal Society.

She was especially interested in the frequency of the heart rate, and how it varied in different species, in hibernating animals and during exercise; for example, she measured the heart rate in awake and hibernating dormice. She also studied the form of the electrocardiogram (ECG), and transmission of reflex impulses in mammals, birds, and reptiles.

In addition to her many independent contributions (Buchanan, 1909; 1912), Florence provided data for August Krogh, who wrote "Miss Buchanan has shown us the very great kindness to take some electrocardiograms on subjects starting work on a stationary tricycle". One of her subjects was the famous Oxford respiratory physiologist CG Douglas, who apparently was "not at all heated" by the exercise. It's interesting that despite providing data for the paper (Krogh and Linhard, 1913), Florence does not appear as an author. Although we might hope this would be less likely to happen now, an article published in *Nature* this year shows that women in research teams are still systematically less likely to be credited with authorship than men – this applies at all career stages and across all research fields (Ross *et al.*, 2022).

It can't have been easy for Florence as not all men were happy with ladies in the lab. The physicist Henry Mosley wrote to his sister in 1909, "I got the Junior Scientific Society to ask Miss Buchanan to read them a paper on heart beats. Apparently Hartley for reasons known only to himself objected and tried to induce Balliol men to stir up dissension. They were to pretend that the presence of a lady in the club was illegal and as she had agreed to read before the fuss began it appeared things would become very awkward" (Helibron, 1974). Happily, the Balliol men didn't oblige and the fuss fizzled out.

Whether Florence was aware of all this is unclear. But she would certainly have been aware of the shenanigans at The Physiological Society. The Physiological Society was founded in 1876 as a dining club "for the mutual benefit and protection of physiologists" in response to a Royal Commission of Enquiry into Vivisection. Meetings consisted of scientific presentations, followed by a dinner, and although women could attend the scientific part of meeting, they were excluded both from the dinner and (although not formally stated) from membership.

In 1912, after she had been going to The Physiological Society meetings for 16 years, Haldane proposed Florence for membership. His proposal in the Candidates Book stated she had a DSc, was engaged in research and had papers on "electrical responses in heart and in muscle". She received 50 signatures of support and they make interesting reading. Haldane proposed her and supporting signatures came from William Osler, considered the father of modern medicine and Regius Professor at Oxford; CG Douglas, one of her subjects; Charles Sherrington, Nobel Prize winner and Waynflete Professor of Physiology; AV Hill; and also August Waller, who recorded the first ECG. The next step was for the names to be approved by


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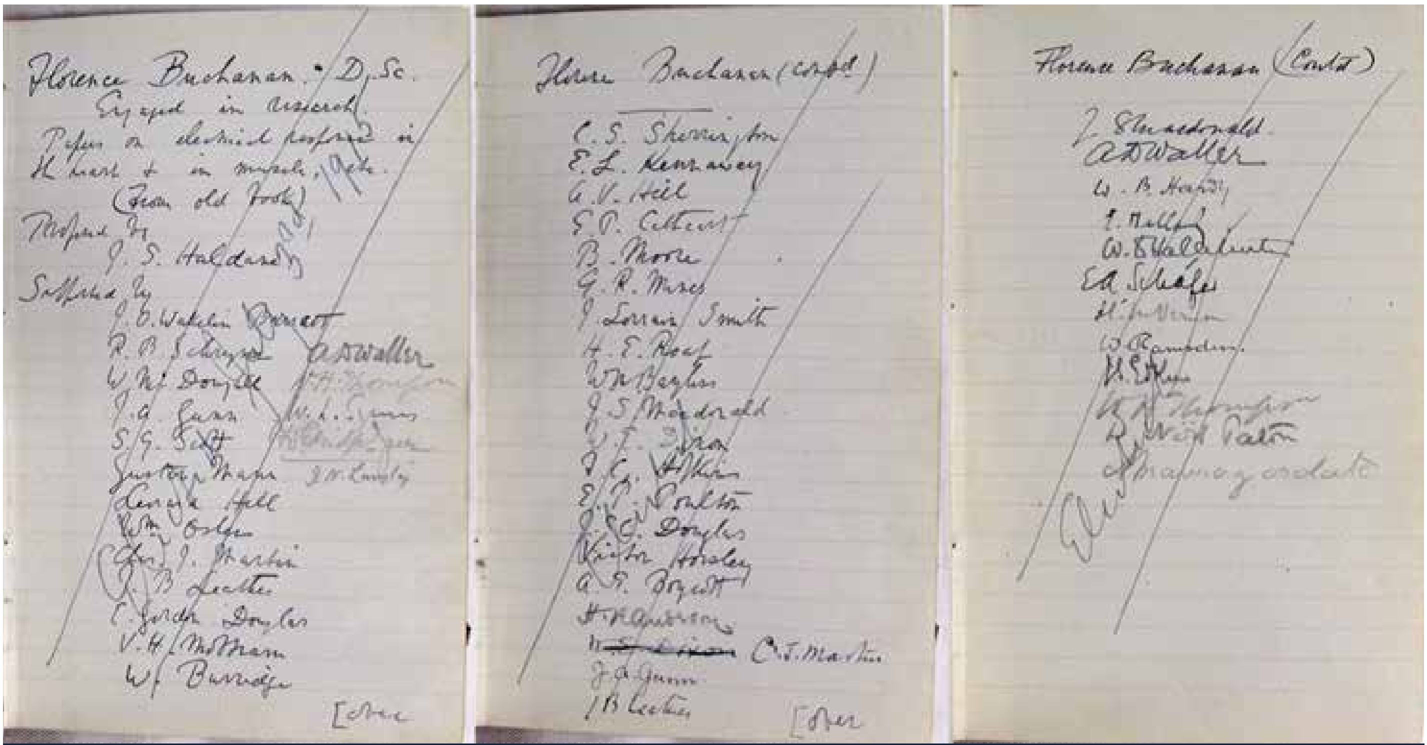
Florence Buchanan, D.Sc.
(From old book)
J. S. Haldane
A. D. Waller
Florence Buchanan (contd)
C. S. Sherrington
E. L. Kennaway
A. V. Hill
B. Moore
H. E. Roaf
W. M. Bayliss
C. J. Martin
Florence Buchanan (Contd)
A. D. Waller
W. B. Hardy
E. A. Schafer

The entry for Florence Buchanan in The Physiological Society Candidates book. It was the first entry in a new book, transferred from the old book where she had first been proposed in 1912. Image credit: The Physiological Society.

a Committee before they were put to a membership ballot. But something clearly went wrong at this stage, because Florence's name does not appear in the list of names put before the membership (Burgess, 2015).

Haldane again took charge and proposed that "it is desirable that women should be regarded as eligible for membership of the society". The motion was passed at the AGM in January 1913. But the idea generated significant opposition, most famously from Ernst Starling, of Starling's law of the heart fame, who argued that it "would be improper to dine with ladies smelling of dog – the men smelling of dog that is" (Evans,1964; Tansey, 1993). Fortunately, however, a membership ballot in June 1914 resulted in overwhelming support for women: 94 members voted to admit women on the same terms as men, 36 to admit them as Associate Members and 31 voted to leave the rules unchanged (Burgess, 2015). And so it was that at a Committee meeting in Oxford on 3 July 1915, with Sherrington in the Chair, the first six women were elected, with Florence heading the list of them.

Florence was probably instrumental in this change as she was not only the first women to be proposed, but she had given at least 10 communications to The Physiological Society, published two papers in *The Journal of Physiology* and three in the quarterly *Journal of Experimental Physiology* (now known as *Experimental Physiology*). Indeed, her paper on the time taken for the transmission of reflex impulses in the spinal cord of the frog was the very first to be published in the quarterly *Journal* (Buchanan, 1908).

The University of Oxford never recognised Florence. Indeed, it did not award women degrees until 1920. However, University College, London was far more enlightened and gave Florence a DSc in 1902 (Tansey, 1993). And in 1910 she was awarded the American Association of Collegiate Alumnae's prize for her research into the transmission of reflex impulses.

She died at the age of 62 in 1931, donating her eyes for research (Burgess, 2015). Her grave is in Wolvercote cemetery, next to that of John Burdon Sanderson.

It is especially appropriate that Florence's contributions have recently been recognised by a Physiological Society blue plaque in her honour, which flanks the entrance to what is now the Department of Physiology, Anatomy and Genetics in Oxford. Better late than never!

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