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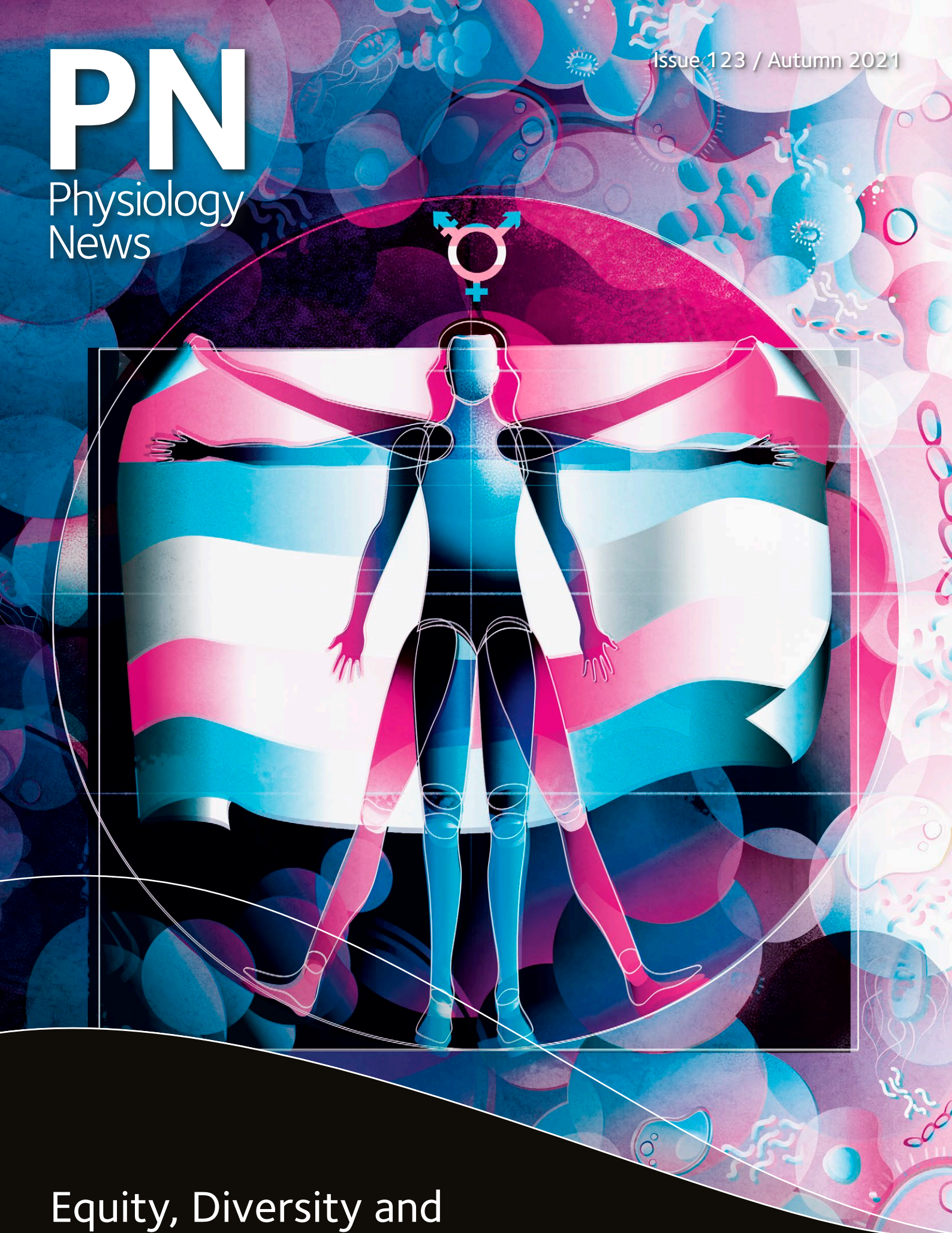
Physiology News
Issue 123 / Autumn 2021



Equity, Diversity and Inclusion Special Issue

The Physiological Society

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Designed and printed in the UK by The Lavenham Press Ltd.

Welcome to the Autumn 2021 edition of *Physiology News*

Introduction

News and Views

Features

Events

Membership

Cover image: Designed by Sophie Minto. To view more of her work, visit **sophieminto.co.uk/.** The image was inspired by the feature article in this issue entitled "Nothing about us, without us: Are we asking the right questions in transgender research?"

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The Physiological Society

Toward a strategy for The Society's Equity, Diversity and Inclusion work

Professor Raheela Khan

University of Nottingham, UK
and Chair of The Society's Diversity and Inclusion Taskforce

My initial curiosity gave way to horror when my son was met by the silence of the hand dryer my (white) husband had just used. It was evident that the dryer, a ubiquitous, inanimate item, would not activate as it was not programmed to 'sense' my son's darker skin tone. A similar problem surfaced early during the pandemic on the poor fitting of face masks for female health professionals working in the NHS. These examples highlight perfectly a widespread lack of biological diversity and inclusivity in product design that standardises for perceived norms of colour (white) and sex (male). In fact, changes in skin tone are one of the current exemplars of understanding the nuances of signs and symptoms in diversifying medical/life sciences education.

In just a few years, equity, diversity and inclusivity have catapulted to the forefront of corporate and institutional change agendas to drive creativity, productivity and improve success measures. In the life sciences including the discipline of physiology, one of the major shifts, identified by initiatives by the Wellcome Trust, has been in recognising the need for an improved, healthier research culture that relies less on metrics, competition and inflexible career pathways and instead promotes a team approach to science, collaboration and a better work-life balance.[1] UKRI also stressed the importance of culture and as I write this the Government launched its R&D People and Culture strategy.[2]

Collectively, these activities and initiatives represent momentous changes to our ways of working. If delivered, this will mean an approach that values and respects individuals and teams, empowering them to flourish while eliminating poor behaviours, bullying and harassment that can undermine professional relationships. The COVID-19 pandemic also raised issues of health inequalities, the disproportionate impact of working from home for female academics and for many of us the direct impact on our students because of the sterile environment of continual, online learning with a loss of real-life lab experience. People-orientated, sustainable cultural change in our organisations is an attainable goal.

Summarising its own commitment to diversity and Inclusion, The Physiological Society, a signatory of the Science Council's declaration on Diversity, Equality and Inclusion, since 2014, established the D&I taskforce in 2020 (more information via Q&As on p. 38) signalling a new direction to embed D&I more directly into its vision. The Society is also a sponsor of the All-Party Parliamentary Group (APPG) and contributed evidence to the recent *Equity in the STEM workforce* recommendations (p. 11). Our Support and Inclusion Fund made over 34 awards in 2020 to help members in difficult circumstances. We have made our content in our publications more accessible (p. 14), and Wiley (the publisher of our journals) has introduced a new author name change policy for reasons of gender identity, religion, and relationships (p. 13). We have also doubled our completion rate for reporting from members on their equality, diversity and inclusion (EDI) characteristics. Some of the important events in 2020 from an EDI perspective included the Conference for Black Physiologists, organised by Black in Physiology, Inc. (p. 36), and our conference for early career physiologists called Future Physiology 2021 (p. 35).

In this dedicated Equity, Diversity, and Inclusion issue of *Physiology News*, we are pleased to include by an article by Javier Bautista in which he describes his journey establishing the LGBTQ+ STEM@UCL network (p. 12). Transgender health is a growing area of medicine but one in which the physiology of transition is scarce. Dr Bastian Greshake Tzovaras, Clara Lehenaff and Dr Mad P Ball provide insight into some of the questions that need addressing especially in relation to the vaginal microbiome (p. 24). The impact of congenital anomalies and sex development are deftly described (Dr Angela Lucas-Herald and Professor Syed Faisal Ahmed). Frailty and ageing (Joseph Taylor, Professor John Gladman, Paul Greenhaff) continue to present physiological challenges illuminated on p. 20. Dr Alastair Noyce and colleagues starkly illustrate the Parkinson's disease research that is needed in underrepresented (non-European groups), to provide new hope and treatments for affected individuals (p. 32). Finally, Dr Katherine MA Rogers and colleagues present examples of incorporating diversity of real-life patients within cases of the taught physiology curriculum (p. 28).

Going forward, The Society is in the process of producing its roadmap on Diversity and Inclusion by Summer 2022. We plan to engage and consult with members to gather feedback that will ensure that we are truly inclusive and diverse with effective and sustainable change driven by our members.

References and Resources

1. Moran H *et al.* (2020). Understanding research culture: What researchers think about the culture they work in. *Wellcome Open Research* **5**, 201.
2. Research and innovation culture. https://www.ukri.org/our-work/supporting-healthy-research-and-innovation-culture/research-and-innovation-culture/

https://doi.org/10.36866/pn.123.5

Professor David Paterson

President, The Physiological Society

In June I was delighted to launch The Physiological Society's new commemorative blue plaque scheme. This initiative honours outstanding physiologists who have contributed to the advancement of physiology through their discoveries, while leaving a legacy beyond their lifetime.

With the blue plaques we aim to increase the prestige associated with the university departments, demonstrating the legacy of physiology academia to potential students as well as raising the visibility of physiology, giving the wider public an insight into the positive role that "the science of life" plays in their everyday lives.

The first plaque was unveiled at the University of Oxford's Department of Physiology, Anatomy & Genetics building, and honours the heritage of pioneering physiologist Sir Charles Sherrington. Sherrington is widely celebrated as the neurophysiologist who shaped our understanding of the central nervous system. He came to the University of Oxford's Laboratory of Physiology as the Waynflete Professor of Physiology in 1913 and received the Nobel Prize in Physiology or Medicine in 1932 with Edgar Adrian for their work on the functions of neurons. Prior to the work of Sherrington and Adrian, it was widely accepted that reflexes occurred as isolated activity within a reflex arc; instead, Sherrington and Adrian showed that reflexes require integrated activation and demonstrated reciprocal innervation of muscles, a principle now known as Sherrington's Law.

Launch of The Society's new blue plaque scheme

Sherrington's blue plaque was unveiled by Professor Sir Colin Blakemore, the first President of The Physiological Society and the longest-serving Waynflete Professor of Physiology at Oxford.

Over the coming months, a series of commemorative blue plaques will be unveiled at academic institutions across the UK and Ireland. I hope they will spark curiosity and help inspire new generations to get involved in the physiological sciences.

More information about the blue plaque and Sherrington, including archive footage, can be found at **physoc.org/about-us/our-blue-plaques/**.

COVID-19 recovery: Visibility, inclusivity and sustainability

Earlier this summer The Society held an event in partnership with the Parliamentary & Scientific Committee to discuss the role of science in the UK's recovery from COVID-19. I was pleased to speak alongside representatives from the Department of Business, Innovation and Skills, AstraZeneca, and the Confederation of British Industry.

I highlighted how I believe the Government should align its recovery to the same core themes as we focus on at The Society: visibility, inclusivity, and sustainability.

Visibility
While COVID-19 is our short-term priority, long-term societal challenges such as our ageing society have not gone away. The demographic challenges facing the UK are stark, with the number of people aged 65 and over set to increase by more than 40% within 20 years.

As we enter the fourth industrial revolution of precision medicine and genomics, the challenge becomes not prolonging lifespan but ensuring our healthcare systems are set up to maximise *health span*.

That means increasing the visibility across government, funders, and public policy of the vital importance of understanding the physiology at play. Within R&D, we need to see more funding directed towards the biological processes of ageing, and within public policy we need greater profile given to physiological age, considering healthy ageing across the whole life course. Greater visibility of physiological mechanisms will improve the quality of public health interventions and medical treatment that can help us live better for longer.

Inclusivity
Our research communities must become more inclusive of a wider range of voices and perspectives. All of us involved in science have a responsibility to redouble efforts to promote diversity – not only gender, but also other protected characteristics.

Sustainability
The UK punches above its weight in R&D, but it is not possible to turn science on and off like a tap. The delivery of COVID-19 vaccines in less than 12 months was made possible by at least a decade of underpinning science and mechanistic understanding. A thriving fundamental research base is essential for a booming life science economy - we cannot afford to let this go.

The Government has "talked the talk" on science with bold commitments to spend £22 billion on R&D by 2025 and increase total R&D spend to 2.4% of GDP by 2027. We now need to see them translate this positive narrative into meaningful actions.

Scientific research operates in a complex ecosystem and the COVID-19 pandemic has exposed stress points, particularly around the quality-related research (QR) funding model for English universities. Medical research charities account for half of publicly funded medical research in the UK but have been forced to cut on average 41% of research spend as philanthropic funding dries up.

COVID-19 has exacted a terrible toll on life and livelihoods. And this will not be the last pandemic. From climate change to our ageing society, the challenges we face in the years ahead are multiple and vast. The vaccination drive has shown what can be achieved when political will aligns with scientific prowess and public determination. By grasping the opportunity to put R&D at the heart of post-COVID-19 recovery, policymakers can unlock the UK's potential. With our sights set on cementing our role as a science superpower, the UK can not only recover, but we can build a stronger economy, safer society, and more optimistic future.

https://doi.org/10.36866/pn.123.6

An exciting start to 2021 for The Society

Dariel Burdass

Chief Executive,
The Physiological Society

Online Member Community now live

Our Member Community zone, an online platform that allows all members to stay connected through forums and personalised content, has now gone live. The good news is that there has been a wave of introductions and based on anecdotal feedback it has been well received by you - our members. It is hoped that this platform will help physiologists to forge connections and build our community of members as more physiologists recognise the value of being part of The Physiological Society.

Also, to celebrate the launch we are hosting a series of "Ask Me Anything's" to allow members to put their questions to key people in The Society. The first two have already taken place as follows.

- Professor Mike Tipton – Editor-in-Chief of *Experimental Physiology* answering questions on the physiological impact of extreme environments and on getting published in *Experimental Physiology*
- Professor Kim Barett – Editor-in-Chief of *The Journal of Physiology* answering questions about publishing in *The Journal of Physiology*

Themes: Find your clan

Our Themes help build communities around specific research interests, which can help shape our future events and activities and bring together researchers from across the full breadth of physiology. The Theme Leads have taken an active role in the Member Community and have begun to engage their Theme members in theme-specific discussions. I encourage all of you to log on and introduce yourself to your fellow Theme members so that you can continue to develop your network of global physiology specialists.

Grants scheme: New and improved

To further tailor member benefits for each career stage and to increase the breadth of our membership, we have launched our new grants programme, for funding opportunities in 2022 and onwards, which is designed to achieve a coherent programme of end-to-end support for our members. The goal of the programme is to both encourage and reward long-term membership with the aim of ensuring professional development, to develop advocates for The Society and to improve member engagement, enabling members to see a clear pathway of membership progression.

For those of you familiar with the existing scheme, you may not notice too many obvious differences. For example, we are still offering funds for attendance at Society and Society-supported events, which are incredibly important and understandably popular, and for institutional engagement schemes such as seminars. However, if you dig deeper into the schemes, you will hopefully be able to see that we offer further funding opportunities for each of you, as you progress through your membership and advance in your physiology career. The four objectives of the new scheme are as follows:

- To target funding at supporting Society and Society-sponsored events;
- To raise awareness and encourage engagement with The Society at an institutional level;
- To generate a Fellowship scheme to recognise and enable excellence in physiology and through this to develop an increasing body of established advocates for the discipline;
- To enable The Society to draw upon the expertise of its Fellow Members to assist in preserving and informing its future.

Alongside our new suite of grants, we are also implementing a range of other activities, to provide both pre-and post-application support. It is our aim to help you succeed. We will be hosting a webinar, giving guidance about how to apply for our grants and in case you miss that, there will be a how-to guide on our website, providing you with valuable tips on how to apply for one of our grants. We also want to hear from you; if you are struggling, or if you have any questions before or during your application, give us a call and someone will be on hand to help. We are also mindful that many of you will be unsuccessful at times, but we do not want you to feel discouraged from applying again. We will be offering feedback to anyone who made it to interview stage and we will also be facilitating and encouraging peer-support groups for those who have had similar experiences so that you can learn and grow collectively from each other.

Your feedback will be very valuable to us and will be at the heart of how the new scheme is evaluated and will assist The Society in making important decisions about how the grants scheme evolves. Please see our Grants - Frequently Asked Questions page on the website for further information **physoc.org/grantsFAQ**.

And the new Trustees are....

I would also like to thank eligible members who voted in the recent elections and to congratulate the new Trustees.

The following three Trustees will take office at the November 2021 Member Forum.

- Research category: Heidi de Wet, University of Oxford, UK
- Clinical category: Mike Tipton, University of Portsmouth, UK
- Republic of Ireland: Áine Kelly, Trinity College Dublin, Ireland

In addition, The Board is pleased to announce the appointment of the next Honorary Treasurer Andrew Parker, University of Oxford, UK and St John's College, Oxford, UK who will take office at the 2022 Member Forum after a year of shadowing the role.

To read a short bio of each incoming Trustee, please see the related news item on our website **physoc.org/trustees2021**.

https://doi.org/10.36866/pn.123.7

Visualising the Novosel Formula: Comments on Dahl and Berg's A formula for the mean electrical axis of the heart

Dr Dragutin Novosel
Matija Alanović
Robert Žunac
Dr Tina Bečić

In a recent publication, Dahl and Berg (2020) discussed teaching the principles of the mean electrical axis of the heart (EA) from standard electrocardiogram (ECG) recordings, its background, its underlining physiological processes and its trigonometry, which were accompanied by an illustrated, typical case. The authors explained the historical background and development of the calculation of the EA, including its clinical applications, graphical representations, and difficulties in its teaching, and they referenced a formula published previously by us (Novosel *et al.*, 1999). Furthermore, Dahl and Berg (2020) discussed future perspectives from an educational-methodological point of view. Their descriptions were clear-cut and instructive. Additionally, they accentuated the differences between the theoretical assumptions of the EA and how it is performed in practice. However, we would like to emphasise three topics: (i) the relationships between the limb leads; (ii) the visualisation of the 'Novosel Formula'; and (iii) the lack of standardisation when calculating the EA.

Relationships between limb leads

The standard (bipolar) ECG limb leads are named as I, II and III. The augmented (unipolar) leads are described as aVR, aVL and aVF. As delineated elsewhere (Novosel *et al.*, 1999, Dahl and Berg, 2020), basically, from any two known leads, any other lead can be calculated: for example, aVR = aVL-1.5*I. The EA can be calculated or graphically estimated from a combination of any two limb leads. Mostly, the EA is calculated or grapically estimated from leads I/II of I/aVF (Dahl and Berg, 2020). However, the EA can be calculated, e.g. from leads III and aVR as EA = ± ArcTan [2 / √3 * (0.75*III-0.5*aVR)/(-0.5*III-aVR)], but the delineation and listings of all formulas are beyond the scope of the current paper. The argument is for at least having access to all mathematical relationships between limb leads and different calculations of the EA results when a manual measurement of the QRS amplitude is needed; therefore, it makes sense to take the two leads with the highest amplitudes to calculate the EA. The error of the manual measurement is relatively lower if the amplitudes are high compared with lower amplitudes. As a consequence, we propose using the leads with the highest amplitudes to estimate the EA.

Visualisation of the Novosel Formula

With the permission of Dahl and Berg, we modified their original figure (Dahl and Berg, 2020) and used their sample of a normal ECG. For the purpose of this publication we are using only the right-down quadrant. They estimated the value of lead I as 0.8 mV and the value of the aVF as 0.8 mV. Correspondingly, the value of the lead II is 1.2 mV. Fig. 1 shows a graphical representation provided by Dahl and Berg of the EA as estimated from a combination of leads I and II. Fig. 2 shows a graphical representation of the EA as estimated from leads I and aVF without correction of the lead aVF. Fig. 3 (the visualisation of the 'Novosel Formula') shows a graphical representation of the EA as estimated from a combination of leads I and II (as shown in Fig. 1) plus a combination of leads I and the recalculated value of aVF (Novosel *et al.*, 1999; the recalculated aVF = 2*aVF/√3).

It is important to note that graphical determination of the EA from leads I/II and leads I/aVF with the correction are identical (also to numerical estimation as described elsewhere, Novosel *et al.*, 1999), whereas the graphical determination of the EA from leads I/aVF without correction (as frequently used in teaching and demonstrations) results in a different (and incorrect) value. The explanation for this error is that the augmentation factor of leads I, II and III (bipolar leads) is different when compared with (unipolar) leads aVR, aVL and aVF (Dahl and Berg, 2020) as recorded and calculated by the ECG device itself due to the mathematical relationships of the leads.

Conclusively, any combination of leads I/II/III or aVR/aVL/aVF separately can be used without any corrections to estimate the EA; however, when a combination of bipolar and unipolar leads is used to calculate the EA, the correction must be made. The differences will seldom reach any clinical significance and are of pure methodological value but may play a significant role in large-scale research and "deep-data" analysis (Wagner *et al.*, 2020).

Absence of standardisation

There are clear and precise recommendations for standardising and interpreting an ECG, including estimating of the normal EA and its deviations (Kligfield *et al.*, 2007; Mason *et al.*, 2007). Even this comprehensive publication neglected to standardise how the EA should be calculated. However, to the best of our knowledge, ECG devices available on the market calculate the EA using different rules. Some ECG devices use the value of a single QRS complex, and some calculate the mean of several QRS complexes and use these mean values to calculate the EA. These EA values could be named as "mean of the mean of the EA". Some devices use leads I and II, whereas others use leads I and aVF (with or without correction). Despite minimal significance in a single case, the results are not amenable to large-scale research as the assessments/calculations do vary. Therefore, we propose the development of a standard for calculating the mean EA.

Conclusion

As recently discussed by Dahl and Berg, there are different factors that should be considered regarding the issue of calculating the EA: theoretical aspects, teaching, rapid measurements in a clinical setting, electrocardiographic device-driven estimation and, as added by use, the standardisation. Certainly, these issues do overlap. Although the standardisation of the calculation of the mean electrical axis may not play any role in basic education and in a clinical, single-case setting, there is a need to standardise the calculation for electrocardiographic devices. Standardisation of the algorithms in electrocardiographic devices gains importance not only in large-scale, multi-centric studies, which inevitably include different devices, but also because of the "big-data" approach now being increasingly used. Standardisation would enable more precise analyses, comparisons, reproducibility and reductions in unnecessary variability caused by the use of different formulas.

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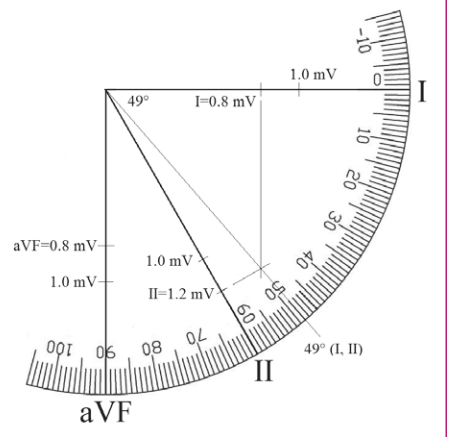

Figure 1. The graphical method used to estimate the mean EA from leads I and II.

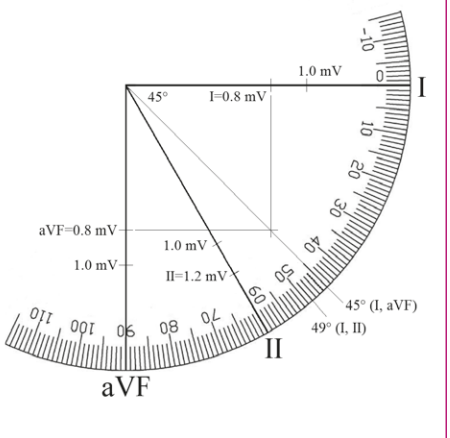

Figure 2. The graphical method used to estimate the mean EA from leads I and aVF.

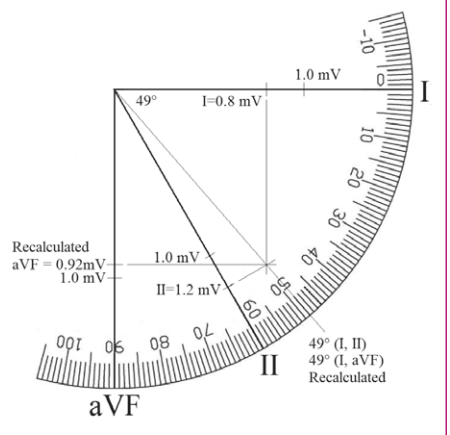

Figure 3. The graphical method used to estimate the mean EA from leads I and II and lead I with the recalculated value of the aVF (the visualisation of the "Novosel Formula").

The story of when kidneys fail and the contribution of Air Vice-Marshal Sir Ralph Jackson

Dr Andrew Davenport
University College London Department of Renal Medicine and Royal Free Hospital, London, UK

Professor Michael K Almond
Anglia Ruskin University, Chelmsford, UK

Following the recent publication in your *Physiology News* magazine of an article by one of us (Davenport, 2021) it has been brought to our attention by a reader that the contribution of Air Vice-Marshal Sir Ralph Jackson and the work of the Royal Air Force at the Princess Mary's RAF Hospital, Halton was omitted. We would like to address that omission here.

The first recorded clinical haemodialysis in the UK was at the Hammersmith Hospital by Bywaters and Joekes in 1946 (Bywaters *et al.*, 1948). Early results were not rewarding, and the method was abandoned for almost a decade.

Dialysis is next described in the UK as performed at Leeds General Infirmary by Frank Parsons and his team in September 1956 (Turney *et al.*, 2011) and the third unit to provide dialysis was the Princess Mary's RAF Hospital, Halton led by the then Group Captain Jackson working with Joekes (who had moved from the Hammersmith) in June 1957 using the new Kolff Twin Coil Artificial Kidney (Royal College of Physicians London, n.d.).

Jackson described his experiences in dialysing his first 20 patients at Halton in 1958 (Jackson, 1958). From the outset Jackson was insistent that the equipment used by the RAF should be unique in it being portable (able to be transported by air) and with the design of the initial machine being improved upon by an RAF technical unit, better electronic monitoring and more efficient blood pumping was achieved (Posselt *et al.*, 2018).

One "mission", where the equipment was delivered to the patient, including a photograph of the machine ready for transport and the weight involved, is described by Honey (Honey *et al.*, 1959). We are fortunate that in 1958 the Royal Infirmary of Edinburgh conducted visits to the three units carrying out dialysis at the time – Hammersmith, Leeds and Halton – to help decide which system in use would be the one Edinburgh would adopt (Robson *et al.*, 1958).

In doing so they demonstrated in their report that Jackson and his team were not only being the first to use the novel twin coil dialyser, but that Halton was using the added refinements of ultra-filtration and veno-venous dialysis, having benefited from the blood pumps developed on site. Following the pioneering work at Halton, the Kolff twin coil dialyser became the standard for the new dialysis units being established in Dublin, Belfast, Edinburgh, Glasgow, the Royal London and Royal Free Hospitals.

We hope this goes someway to fill in any gaps as to the contribution Sir Ralph Jackson and the RAF Medical Services made to the evolution of haemodialysis technology in the UK.

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We welcome your comments sparked by our articles. Please visit **physoc.org/magazine** for more information on guidelines for letters to the editor.

https://doi.org/10.36866/pn.123.9

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.

Education, Public Engagement and Policy Committee

April 2021
The Education, Public Engagement and Policy Committee (EPEP) met online on Thursday 22 April chaired by Dr Lucy Green, University of Southampton.

The Committee received an update on the professional development activities that ran in early 2021, including the outcomes of a focused webinar series for undergraduates, and plans to deliver a series to support members in translating knowledge and research into impact. Upcoming activity relating to the Education and Teaching theme was discussed, noting the value of an upcoming online training programme on advancing careers in higher education through the teaching and learning route, and a symposium on *Conceptual Learning in Physiology* at Physiology 2021.

The Committee was updated on key policy projects, including the recommendations from the recent Knowledge Exchange project. The recommendation to develop a Society Knowledge Exchange Champions network was of particular interest, with the idea of having a champion within an institution as the "go to" person for advice and support. Following the publication of *A National COVID-19 Resilience Programme* report in November 2020, The Society had organised a joint letter co-signed by 75 organisations to the Prime Minister calling for a focus on older people's physical activity levels during the most recent lockdown in England.

The Committee received a report from the Scientific Editor and the Managing Editor of *Physiology News* to update on recent activity and plans for an upcoming Diversity Special Issue. The last Special Issue on this topic was in 2019 and the proposed issue would address areas that were not covered in the previous issue. This idea was supported by the Committee, and it was noted that The Society was currently working on a strategy for D&I that is hoped to be published in spring 2022.

The meeting was also an opportunity to discuss the role of the Committee in supporting the alignment of activities across the Society, to help galvanise momentum towards events.

Publications Committee

May 2021
The Publications Committee met in May 2021, chaired by Debbie Baines. The Editorial Reports for *The Journal of Physiology*, *Experimental Physiology* and *Physiological Reports* were presented. Despite the pandemic, submissions and acceptances to these three journals remain satisfactory. *Experimental Physiology* and *Physiological Reports* have shown particular growth, with the latter's fuelled by an impressive increase in direct submissions. The online usage and social media followings of all three Society journals have grown tremendously in the past 12 months. Jackie Jones, Wiley's publishing representative, explained that the introduction of HTML proofing has helped to significantly reduce time to publication in the journals, a metric highly valued by authors.

The various branches of the Open Science movement were widely discussed at the meeting. Although there are no immediate plans to "flip" *Experimental Physiology* or *The Journal of Physiology* to Open Access, it is clear the publishing landscape is changing rapidly, and further decisions on the publishing models these journals employ must be made in the near future.

Both journals have adopted numerous practices relating to other Open Science initiatives. The introduction of Open Science Badges for data sharing and pre-registration incentivises researchers to maximise the transparency and accessibility of their published research, either through the sharing of datasets or pre-registration of study protocols.

Indeed, *Experimental Physiology* has become one of the first journals in its discipline to offer authors the option to publish Registered Reports, a form of empirical article in which the methods and proposed analyses are pre-registered and reviewed prior to research being conducted.

The Journal of Physiology has taken a great step towards improving the transparency of its peer-review process. Going forwards, the peer-review history of all accepted articles will be published, and appear online including Editors' comments, referee reports (signed or anonymous) and author responses.

Professor Kim Barrett's term as Editor-in-Chief of *The Journal of Physiology* will end in March 2022. The Committee was informed that a recruitment panel has been assembled to oversee the appointment process of her successor and ensure a smooth handover of the role.

How can we make the STEM workforce more equitable? A new report suggests next steps

Abigail Hilditch

Policy and Partnerships Manager, British Science Association

In July 2021, the All-Party Parliamentary Group (APPG) on Diversity and Inclusion in STEM published the results of their inquiry into equity in the STEM workforce. The inquiry launched in November 2020 with the ambition to detail the experiences of minoritised STEM workers and shine a light on positive sector-led initiatives and practices. With the resultant report, the APPG has sought to create the opportunity to work with Government, parliamentarians, sector leaders and community stakeholders to recognise the findings and address the historic and systemic disadvantages faced by minoritised groups in this sector.

This report is based on written evidence from over 85 organisations and individuals, four evidence roundtables with over 40 attendees and additional desk research comprising over 150 relevant sources.

The inquiry found inequity in the STEM workforce is widespread for those from minoritised groups and this inequity intersects across ethnicity, gender, disability, sexual identity, where you live and socio-economic status. This inequity has been worsened by the COVID-19 pandemic.

The report highlights the following key findings:

1. The STEM workforce is less diverse than the wider workforce but consistent data collection and sharing is lacking.
2. There is a need for the Government to take a multi-pronged approach to drive equity in the STEM workforce.
3. Intersectional barriers continue from STEM education into the workforce.
4. There is awareness of structural inequity in some large STEM organisations, but no consensus on solution.
5. There is already considerable inequity in STEM but COVID-19 is making it worse.

The evidence received shows how barriers appear for every minoritised group along the career pathway – from issues in recruitment and retention, to access to mentors, professional development and leadership roles.

The result is an overall lack of representation in the STEM sector of minoritised groups such as Black people, women, disabled people and those from the LGBTQ+ community. Worryingly, evidence has shown that the STEM sector is losing valuable skills, experiences and perspectives, and cannot reach its full potential without greater equity in the workplace.

As a vital economic sector accounting for 18% of the UK's total workforce, the STEM sector is critical to the UK's economic recovery from the pandemic. Evidence detailed in this report shows how diversity and inclusion can improve growth, creating sustainable economic prosperity and opportunities for future generations.

However, the importance of diversity and inclusion in the STEM sector extends beyond the economic imperative, to the intrinsic benefits of equity for societal fairness and success. Addressing the structural issues of inequity inherent in the STEM workforce will not only combat skills gaps but create a stronger, more innovative and trusted sector.

This report makes three recommendations. In some aspects, it requires a cross-Government approach that is fully engaged with the STEM sector. In other aspects, it requires different portfolio holders to lead on specific policy workstreams. Above all, it asks that all STEM stakeholders use the opportunity of the COVID-19 recovery to lead a "STEM Diversity Decade of Action" to tackle the systemic under-representation of minoritised groups at all levels in the sector.

The report can be accessed online at **www.britishscienceassociation.org/appg**. For further information, contact the APPG on Diversity and Inclusion in STEM Secretariat at appg@britishscienceassociation.org.

https://doi.org/10.36866/pn.123.11

LGBTQ+ STEM @UCL Network: Fostering an inclusive and visible community

Javier Bautista

Chair and Co-Founder, LGBTQ+ STEM @UCL Network, University College London, UK

During my undergraduate studies at University College London (UCL), I did not know a single LGBTQ+ staff member working in STEM (Science, Technology, Engineering, and Mathematics). Because of this, I always felt that I had to hide my queerness in order to pursue an academic career. However, once I became a PhD student, I started to explore the wonderful queer STEM community, and decided that I wanted to make a difference at UCL by creating a network for LGBTQ+ scientists.

My interest to get involved with the community was sparked back in 2020 when I attended the LGBTQ+ STEMinar, a great conference showcasing the work of queer scientists across the UK. After this event, I reached out to Dr Scott Orr, Dr Luciano Rila and Sarah Beale with the idea of creating a platform at UCL that celebrates diversity and excellence at all career stages. Together, we founded the LGBTQ+ STEM @UCL Network, a student-staff partnership that aspires to promote the disruptive thinking of UCL staff and students who identify as LGBTQ+ working in STEM fields.

It is not surprising that according to UCL's 2017 Staff Survey, over 40% of UCL LGBTQ+ staff respondents reported that they did not discuss their personal lives openly at work or were not out in the workplace.[1] In addition, an American study surveying LGBTQ+ STEM professionals showed queer scientists were more likely to experience career limitations and harassment, and to consider leaving a STEM career.[2] The culture of STEM disciplines has long been considered to lean away from the overlap between personal and professional lives. The international nature of science has also caused particular concerns for members of the scientific LGBTQ+ community as it increases the likelihood of interacting with cultures that were not yet inclusive of queerness (i.e. attending conferences or doing fieldwork in countries where LGBTQ+ people are criminalised).

Since the launch of our Network in September 2020, we have grown to a community of more than 200 members. We have organised several events highlighting topics relevant to LGBTQ+ scientists, and hosted social events, talks by invited guests and workshops. For example, one of our talks was about the GaySoc at UCL, which is believed to be the first queer society affiliated to the Students' Union founded in a UK university. We also collaborated in organising UCL's LGBTQ+ STEM Festival 2021, a series of free online events connecting and celebrating diversity in STEM, as well as running workshops and panels with queer STEM initiatives, such as EDIS[3], ALBA[4] and PRIDE in STEM[5], and social gatherings.

In the future, we will start hosting in-person social events and hope to closely collaborate with other LGBTQ+ and EDI initiatives raising awareness of the challenges faced by marginalised identities. In addition, there have been discussions about creating a conference highlighting the research carried out by queer scientists, as well as organising an event combining drag, cabaret and science.

A visible LGBTQ+ presence in STEM disciplines is imperative to foster a supportive and productive environment for members of our community. These are the reasons why we want to broaden wider perceptions of LGBTQ+ identities in STEM disciplines, providing a safe space for meaningful connections where queer students and staff can discuss important issues. However, these changes cannot be carried out by the LGBTQ+ community alone. We also need support through allyship, changes in institution policies and wider support for initiatives that make the workplace more welcoming for students and staff, combined with efforts towards gender, race and disability equity.

If you would like to reach out to us, collaborate or get involved, email lgbtq.stem@ucl.ac.uk. You can also follow us on Twitter at @LGBTQSTEMatUCL.

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Wiley's new author name change policy

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Journal Publishing Assistant, Wiley

We at Wiley are proud to be leading the way in trans-inclusive scholarly publishing with our Author Name Change Policy that prioritises the choice of anonymity. The new policy, implemented in December 2020, allows authors to change their names in previously published works without notifying co-authors or the publication of a correction statement.[1] Thanks to the Author Name Change Policy, we are now republishing articles and redelivering updated metadata to indexing services without burdening authors with the responsibility of providing documentation of their name change.

For the transgender community, as well as for authors changing religions or marital status for example, this simplified process is a much-needed improvement over the antiquated practice of publishing a correction notice with each name change. Name changes are never easy, but always important. According to the National Center for Transgender Equality, "gender incongruent identification exposes people to a range of negative outcomes".[2] This exposure comes up often enough in daily life, and publication records make name changes all the more visible for trans authors.

Requiring a trans person to be outed by including works published under their deadname on a job application or faculty webpage can have serious implications for their career and even their safety at work. According to Stonewall's 2018 *LGBT in Britain – Work Report*, "One in eight trans people (12%) have been physically attacked by customers or colleagues in the last year because of being trans."[3] Unsurprisingly, the same report notes that "One in four trans people (26%) aren't open with anyone at work about being trans. This number increases to almost two in five non-binary people (37%) who aren't out at work." Protecting the privacy of authors undergoing name changes allows them to reclaim their publication history without fear of repercussions. Name change policies make sure that an author can maintain a seamless bibliography under the name that affirms their identity.

Wiley's previous policy, which was standard in scholarly publishing, was designed to focus on the integrity of the historic record. As we began considering a policy more sensitive to author needs, we made sure we involved trans researchers at every step of the process to ensure our new policy would work for them.

Along with trans employees at Wiley, one group of trans researchers that united around the issue of name change policies last summer was essential in informing the development of our new policy.

> "For the transgender community, as well as for authors changing religions or marital status for example, this simplified process is a much-needed improvement over the antiquated practice of publishing a correction notice with each name change."

One member of that group is Irving Rettig, a chemistry PhD. candidate at Portland State University. "I'm so pleased with the work Wiley has done to ensure that trans authors were involved at every stage during their policy reconstruction", says Rettig. "Growing support from large publishers like Wiley really helps us apply pressure to publishers who have been reluctant to engage in these discussions. Right now, the publishing landscape is changing in a profound way; before, cisnormative biases informed academic publishing practices and created barriers for trans authors. Now, they are working alongside us to support and uplift our academic excellence in the way that we have always deserved."

Much has changed since we introduced our updated name change policy last December. The Committee on Publication Ethics released updated guidance for author name changes in January, and other publishers have been slowly rolling out their own policies in the months since. In the meantime, Wiley has processed name changes for over 60 authors in the 6 months since implementing our new policy compared with just two name changes in the entire previous year.[4] The numbers speak for themselves—trans researchers waited long enough for these overdue policy changes.

Looking ahead, we know there is more to be done to make scholarly publishing more inclusive of trans community members. One of Wiley's next steps to better serve trans authors is to offer the option to include personal pronouns in author bylines. In the meantime, some authors are taking the initiative to include their personal pronouns in the acknowledgements in their work. Kai J. Huang, an undergraduate researcher at UCLA, took to Twitter to announce "My FIRST journal publication ever includes me as a co-author AND is the first time I've seen an author who uses neopronouns have them included in a publication, especially in STEM!"[5] Kai's excitement speaks to how important accurate self-identification is for trans authors. We are committed to ensuring that trans authors feel respected throughout the publication process.

The scholarly publishing community has come a long way in creating a supportive, inclusive research environment. We are pleased to see that our fellow publishers and the industry as a whole are changing along with us, and we look forward to continuing to drive meaningful and long-lasting change together.

References and Resources

1. https://www.wiley.com/network/the-wiley-network/new-author-name-change-policy-supports-a-more-inclusive-publishing-environment
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3. https://www.stonewall.org.uk/system/files/lgbt_in_britain_work_report.pdf
4. https://publicationethics.org/news/vision-more-trans-inclusive-publishing-world
5. https://twitter.com/kaijhuang/status/1388948631231733760

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Image credit: Wellcome Images

New colour accessibility policy for The Society's journals

Alex Stewart

Deputy Managing Editor,
The Physiological Society

The Journal of Physiology and *Experimental Physiology* recently adopted a new policy relating to the colour accessibility of our published content. Colour vision deficiency (colloquially known as "colour blindness") is the inability for individuals to distinguish between certain shades of colour. Red-green colour blindness is the most common form of colour vision deficiency, though other forms exist. Although this condition is far more common in male than female individuals, its overall prevalence is relatively high (around 5% of the global population). Papers using figures or schematics that present information solely through the use of colour therefore risk excluding individuals with this condition.

How might colour inaccessibility look?

Prior to the introduction of this new policy, these readers will have been at risk of being excluded from fully accessing information included in published papers.

What is the impact of colour inaccessibility?

Given The Society's journals amass upwards of 6 million downloads per year, is it clear a vast number the journals' readership will have some form of colour vision deficiency. However, it is not just readers who might be affected by colour inaccessibility.

Referees and editors with the condition will have more difficulty assessing research paper quality during the review process. Ultimately, authors who do not consider the usage of colour within their manuscript may not only risk rejection based on misinterpretation during review, but also see their work's reach and impact reduced upon publication.

The policy

The Society journals' new accessibility policy ensures that no information is conveyed by colour only. Where this is not possible (e.g. gene expression heat maps), opacity and contrast should be carefully considered. We strongly recommend that authors re-colour figures using accessible colour combinations such as green and magenta or yellow and blue. For micrographs with three or more channels, authors are requested to provide either a greyscale picture of each channel, or a combination of the two most important channels in magenta and green.

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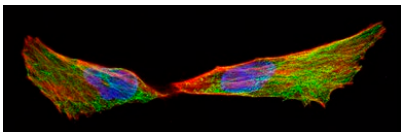

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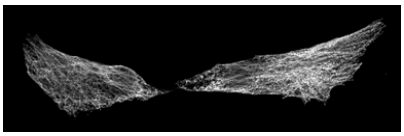
Show greyscale images of each channel



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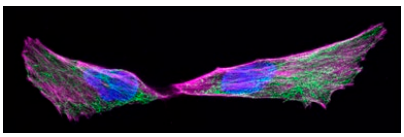
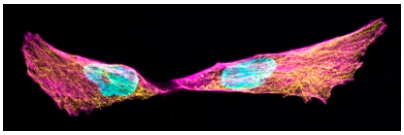


Magenta – Green – Blue



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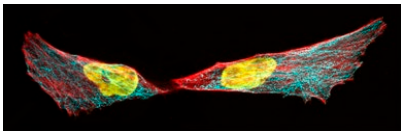

Red – Cyan – Yellow

Credit: Emily Summerbell https://www.ascb.org/science-news/how-to-make-scientific-figures-accessible-to-readers-with-color-blindness/

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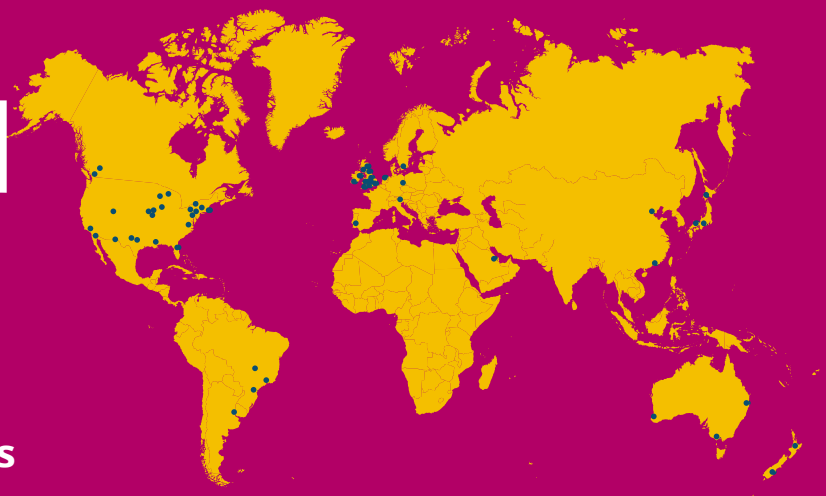
Reasons to submit to

Experimental Physiology



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https://doi.org/10.36866/pn.123.16

The diversity of sex development

What do conditions affecting sex development teach us about sexual diversity?

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Approximately 1 in 50 newborns will be born with a structural or functional change in their body, often referred to as a congenital anomaly. Congenital anomalies, also known as birth defects, may actually be even more common than this, with some not presenting until a later stage in life. These conditions can have a variable effect on the newborn's health. In Europe, in approximately 1 in 1,000 cases, the infant may not survive the first year of life (Boyle *et al.*, 2018). However, in many cases, the congenital anomaly may not have a major direct impact on the child's health but could simply be a signal for a wider group of conditions that may have long-term effects. Lastly, there may also be other relatively minor isolated congenital anomalies that do not have any impact on the child's health. A clear knowledge of the cause of the congenital anomaly as well as information on condition-specific long-term outcome allows a carer to reach a plan that is personalised for the needs of a specific infant.

Atypical genitalia are a relatively common form of congenital anomaly and may affect approximately 21 in 10,000 cases worldwide (Yu *et al.*, 2019). In around three-quarters of these cases, the affected child is a boy (Ahmed *et al.*, 1999, Ahmed *et al.*, 2004). Although this presentation is rarely linked to life-threatening conditions in the newborn, parents and healthcare staff find the birth of the infant with atypical genitalia challenging especially when the genitalia are so atypical that the sex cannot be assigned immediately. Although these situations are, strictly speaking, not medical emergencies, the premium that society places on issues related to sex development and sex assignment, means that an immediate response is required even if it is aimed at reassurance and explanation by an expert.

Recent data from Scotland show that delayed sex assignment because of a concern related to external genitalia occurs in less than 1 in 10,000 infants (Rodie *et al.*, 2019) and with this level of rarity, it is no wonder that the public as well as healthcare staff find these situations so challenging. In some societies, delayed sex assignment at an older age in childhood or the option to not assign sex are accepted alternatives but it remains unclear as to whether these alternatives lead to lower levels of physical or psychosocial morbidity.

Normal and atypical sex development

Over the last few decades, a greater understanding of the developmental biology of the sex organs has allowed a deeper insight into the conditions that may affect

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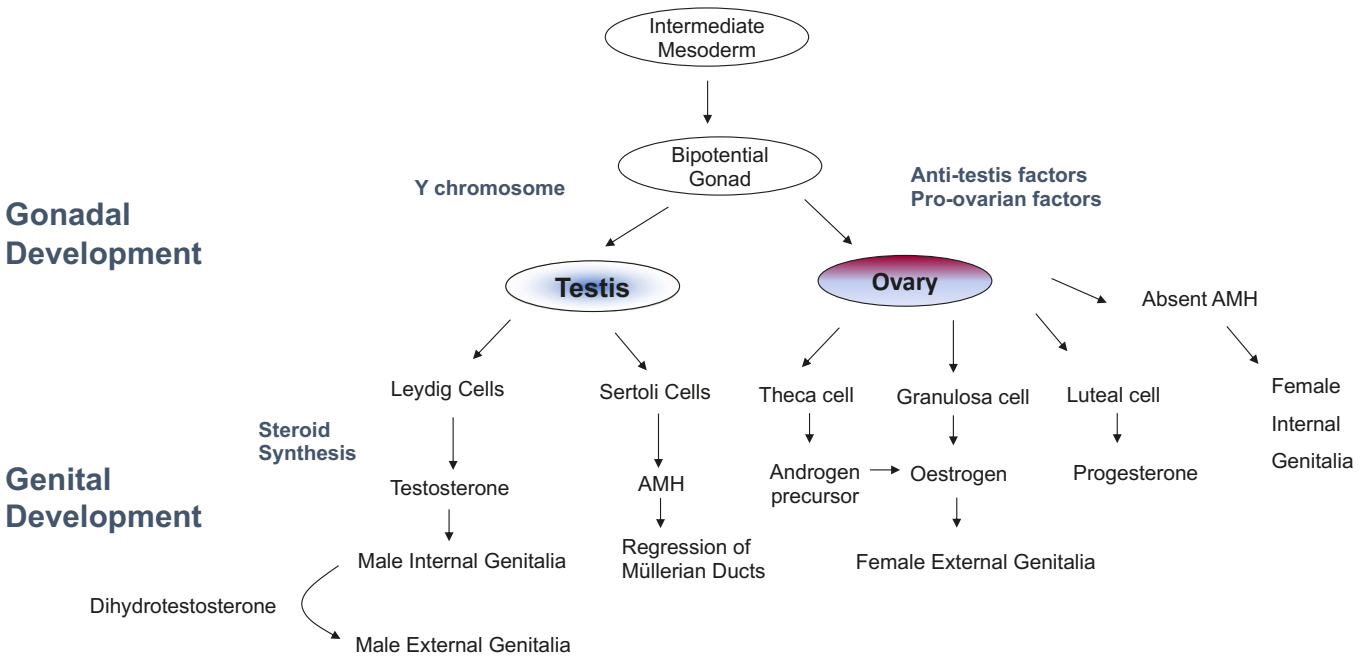

Figure 1. Normal pathways of sex development.

sex development. In mammals (as shown in Fig. 1) sex development occurs in two distinct and sequential stages. The first stage relates to the development of the gonads and the second stage relates to the development of the genitalia, both internal and external. Gonadal development is determined by the complement of sex chromosomes and leads to the specific development of either a male or female gonad from a single undifferentiated bipotential gonad.

The presence of a Y chromosome drives the bipotential gonad toward testis-specific differentiation, whereas its absence results in development of an ovary (Lucas-Herald and Bashamboo, 2014). Increasingly it is clear that there are other factors that can act as anti-testis factors and can push the pathway in the developing testis towards an ovary. There are also pro-ovarian factors, deficiency of which can reduce the potential for ovarian development. A reverse in gonadal development to what might be expected is rarely so complete that a male-specific gonad is replaced by a perfectly functioning female-specific gonad or vice versa. In most cases, gonadal development is disrupted to such an extent that the gonad degenerates at some stage in life, its ability to produce sex hormones or eggs is limited or it may pose a tumorigenic risk (Andrade *et al.*, 2019). Very rarely, in possibly less than 1 in 100,000 births, an infant may possess normally functioning testis and ovarian tissue within a single gonad (Caputo *et al.*, 2019).

The production of androgens such as testosterone and dihydrotestosterone and other hormones such as anti-Müllerian hormone (AMH) by the testis results in the development of the male-typical internal and external genitalia (prostate, vas deferens, penis and scrotum) with a reciprocal regression of the Müllerian ducts, which are the precursors of the female-typical internal genital structures (Fallopian tubes, uterus and upper vagina) (Rey and Grinspon, 2011). However, a deficiency in the production or action of androgens in an XY infant can lead to a reduction in the androgenisation of the male genitalia whilst an excess in an XX infant can lead to androgenisation of the female genitalia. Similarly, a deficiency in the production or action of AMH in an XY infant can lead to the presence of a uterus in a boy with almost male-typical external genitalia (Picard *et al.*, 2017).

In boys, atypical genitalia commonly present as undescended testes, hypospadias, small phallus or a combination of these. A quarter of children with these conditions have an additional congenital anomaly in another organ system and around a third may have an endocrine or genetic condition that affects their gonadal function (Cox *et al.*, 2014). Furthermore, many of these boys may also have adverse long-term health outcomes and the likelihood of these may depend on the underlying endocrine or genetic diagnosis. So, whilst in the past, it was often thought that reconstruction of the genitalia would lead to a resolution of the condition, it is becoming increasingly clear that in some cases, these conditions may have a greater significance, which will only become clearer with detailed longitudinal follow up of physical and mental health outcomes.

Genetics versus hormones

Differences between boys and girls, men and women are not just manifested by differences in physical characteristics but also in the sexually dimorphic nature of several behavioural traits as well as predisposition to illnesses. It is possible that some of these are conditioned by sociocultural factors. However, male humans are more likely to develop bacterial infections and women are more likely to develop autoimmunity. Furthermore, many forms of neurological and neurocognitive conditions including Alzheimer's disease, Parkinson's disease, autism, addiction, depression, anxiety disorders and schizophrenia show a clear sex difference and there is good evidence to support that both genetics and the gonadal hormonal milieu may both have independent effects in modulating this sexual specificity (Dunn *et al.*, 2011).

The idea that there is more to sex differences than hormones was first described in the studies performed on the zebra finch almost 30 years ago when hormonal manipulation in the male or female bird did not alter the genetic male's ability to sing his distinct courtship song (Arnold, 1997). It is also possible that some genes that play a critical role in gonadal development and, thus, sex hormone synthesis play a direct role through hormone-independent pathways. For instance, SRY, the gene on the Y chromosome that directs the bipotential mammalian gonad to develop as testes is also expressed in the human foetal adrenal, brain, heart and pancreas as well as the heart, kidney and liver in the adult.

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"The idea that there is more to sex differences than hormones was first described in the studies performed on the zebra finch almost 30 years ago."

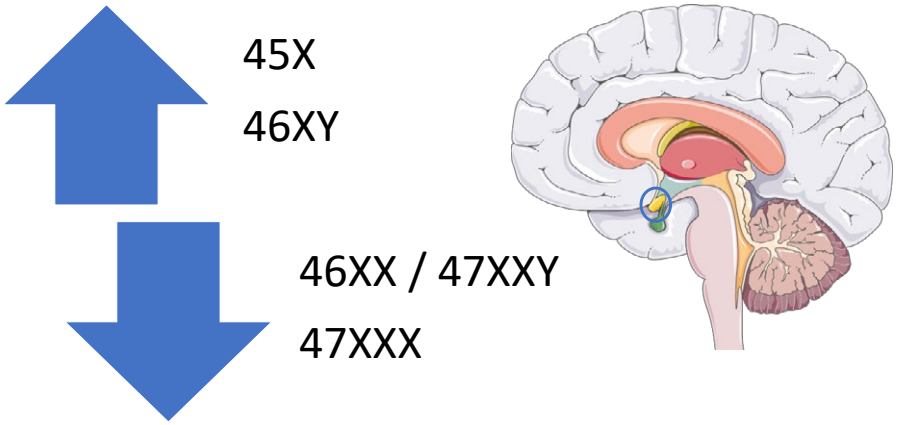

Figure 2. Size of the amygdala of the brain (circled) is inversely proportional to the number of X chromosomes. Women with a 47, XXX karyotype have the smallest size of amygdala whereas women with a 45, X karyotype have the largest.

Lastly, there is also good evidence that there are some sex chromosome-linked genes that may also contribute to the sexual dimorphism. For instance, on the X chromosome, there are genes, such as monoamine oxidase A & B, that are reported to play a dosage-sensitive role in modulating the serotonergic pathway and the development of the amygdala, a part of the brain's limbic system critical for the expression of conditioned fear (Reardon, 2016). In humans, the size of the amygdala is reported to be inversely related to the number of X chromosomes (Fig. 2), such that women with Turner syndrome who have a 45X karyotype have a larger amygdala than 46XX women, and men with Klinefelter syndrome, who have a 47XXY karyotype, have an amygdala that is smaller than 46XY men and similar to 46XX women. In accordance with this, women who are 47XXX have a smaller amygdala than 46XX women (Reardon *et al.*, 2016). However, the size of the amygdala and its activity may also be modulated by sex hormones as evident from functional imaging studies across the menstrual cycle as well as in pathological conditions associated with excess androgen exposure.

Disorder of sex development

The phrase disorder of sex development (DSD) was coined in 2005 to move away from terms such as intersex, which may have different meanings to different people, or pseudohermaphroditism (which is a nightmare to type or pronounce!). Some feel that the term "disorder" in DSD is too pathologising and reinforces the need for correction and would prefer the word "difference". One could relate this paradigm to statural height, which is normally distributed. However, the further away somebody is from the mean, their height becomes abnormal and when they are a few standard deviations away from the mean, then their abnormal height may also be associated with a functional disability. In addition, in some people abnormal height may, itself, not be disabling but may act as a sign of other pathology. Congenital heart anomalies are usually described as congenital heart disease (CHD); one would think that the word "disease" may have an even stronger connotation of morbidity than a disorder, but it is well accepted in that field that some heart conditions that are included within the category of CHD do not need any intervention. Thus, the stance to take could be that atypical genitalia confirm that sex development has progressed in a different way to usual and that there is a need for further investigation to exclude an underlying disorder that may or may not require therapy.

Conditions that are associated with a DSD also cast a spotlight on society's views on the anatomical features that a body should possess for being male or female. XY boys who have AMH deficiency (persistent Müllerian duct syndrome) will have a uterus (Picard et al., 2017). And then there are girls and women with a condition called androgen insensitivity syndrome who have an XY karyotype and testes but no uterus. There are also conditions, such as 5 alpha-reductase deficiency, where the young XY child has female typical external genitalia until the age of puberty after which the external genitalia become more male typical.

Lastly, DSDs also teach us important lessons on differences between the development of gender identity and sex development. Gender identity is the individual's perception of one's characteristics and how they may socially conform to the norms, behaviours and roles that may be typically associated

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with being a boy, girl, man or a woman. Clearly, a newborn child, irrespective of whether they have a DSD or not can be assigned a sex at birth but there is an assumption that the child's gender development will be in accordance with the assigned sex. Whilst there is a possibility that the child may identify with another gender at a later age, studies suggest that the likelihood of this is very low. Recent studies suggest that, overall, dissatisfaction with one's own gender in people with a past history of DSD is similar to the background population (Kreukels *et al.*, 2018). However, there are some specific conditions where gender dysphoria may be more common, and usually in these conditions, prenatal exposure to androgens may be a contributory factor (Hines *et al.*, 2015).

Conclusion

So, whilst the books tell us that biological development into male and female individuals usually follows typical pathways, there are several examples from nature that illustrate the point that, in reality, there is a lot more to sexual diversity.

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https://doi.org/10.36866/pn.123.20

Regard the end

Harnessing physiology to provide better understanding of the mechanisms underpinning frailty

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Frailty is an increasingly used age-related concept, and we aim to highlight here why physiological research, particularly at a system level, can help address the global challenge posed by frailty. Life expectancy has been increasing at approximately 2 years per decade for the last 150 years, with those aged 65 years and over set to represent 1 in 4 of the UK population by 2039 (House of Lords report, 2013). Evidence from the UK Office for National Statistics (Office for National Statistics Statistical Bulletin, 2017) demonstrate that much of this increase in life expectancy since the second half of the 20th century has been due to increased survival of middle-aged people into old age.

For example, in 1950 a 65-year-old woman could expect another 15 years of life (for men this was 12 years); now she can expect another 28 years (for men it has risen to 24 years). Sadly, not all of this life extension is spent in good health. The average UK woman with a life expectancy of around 82 years can expect to live 19 of those years in poor health: men with a life expectancy of 79 years can expect to live 16 of those in poor health. What is needed is an increase in the "healthspan" rather than solely the lifespan.

"Frailty" is a term used in the scientific literature to refer to a state characterised by enhanced vulnerability to, and impaired recovery from, stressor events, when compared with a robust state. Examples of the consequences of the frailty state are the "geriatric conditions" of falls, confusion, incontinence, and immobility, which are common but not unique to frailty. These are the kinds of problems that do not kill older people but impair their quality of life. This makes frailty a potentially valuable target in attempts to improve the healthspan.

Frailty, as we use the term here, is understood to indicate a state of loss of homeostatic reserve, due to the cumulative and interacting effects of impairments in organ structure and function primarily consequent to ageing processes. Although these same ageing processes can lead to states that are diagnosed as clinical conditions (e.g. arthritis, hypertension, kidney disease), frailty and multimorbidity are not synonyms. Similarly, although the ageing processes that lead to the loss of homeostatic reserve in frailty can eventually lead to reduced performance and hence the ability to perform everyday tasks, frailty and disability are also not synonyms, and it is possible to have lost reserves without reaching the point of producing disability.

Moreover, not all old people are frail (the reported prevalence rises from 15% in 65 year olds to over 40% in 80 year olds (O'Caoimh *et al.*, 2018, Song, Mitnitski and Rockwood, 2010)). Whilst we use the term to refer to an intrinsic biological state, we are aware that the word can be used in its lay sense, where it is often understood to have pejorative implications, such as pitiable or

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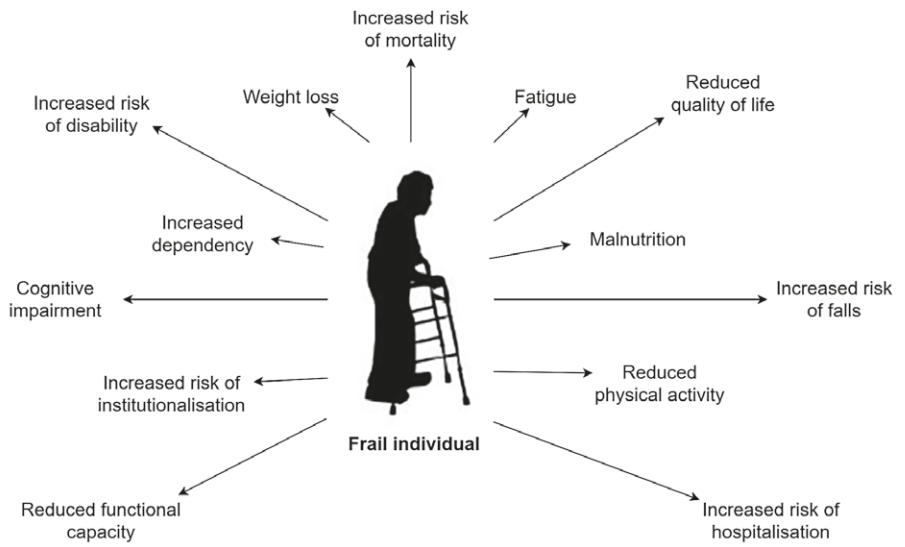

Figure 1. Traits associated with frailty, when compared with a non-frail older person.

"Frailty, as we use the term here, is understood to indicate a state of loss of homeostatic reserve, due to the cumulative and interacting effects of impairments in organ structure and function primarily consequent to ageing processes."

implying moral deficiency. With these caveats, Fig. 1 illustrates the traits associated with frailty.

As we have defined it, the conditions contributing to frailty are those identified as contributing to physiological decline during ageing, such as sarcopenia, inflammation, dementia, loss of appetite, etc. It is as yet unclear why these ageing processes develop at different rates in different people, or what comprises the cellular and molecular mechanisms directing the trajectory of age-related decline. Hence, why the frailty state is reached at an earlier stage in some people and delayed in others is unknown. In this article we posit that frailty (the reduction of which is the overall target of ageing research) is a multi-system concept, and therefore an integrative systems physiology perspective is likely to be the most illuminating and productive approach. The breadth of physiological systems affected by the ageing processes, and crucially how they interconnect to lead to dysfunction that manifests at the whole-body level is currently unknown.

There is limited but growing evidence that both ageing and the frailty state are not inevitable and unalterable processes, but are amenable to intervention. It seems likely that the differences in healthspan seen in different geographical populations and in the same populations over time are due to environmental and lifestyle factors. Apart from existing health hazards such as obesity, smoking and excessive alcohol consumption, the other obvious and known candidates associated with both increased longevity and greater healthspan are habitual physical activity levels, exercise and diet (energy content and composition). The mechanisms by which factors affect the underlying ageing processes in people are not yet known. Similarly, it is not yet known if the impacts of negative environmental and lifestyle factors on longevity and healthspan can be reversed, or whether greatest attention should be given to targeting interventions in pre-frail people (people who present with frailty traits, but less than frail individuals) to slow the decline into frailty.

These unknowns will be best addressed by longitudinal interventional study designs in which temporal change is quantified at multiple levels (molecular, cellular, tissue) in multiple physiological systems concurrently. Given physiology aims to understand the mechanisms of living, from the molecular basis of cell function to the integrated behaviour of the whole body, these unknowns represent a real opportunity for physiologists to positively impact on research and public health outcomes. In keeping with this, in 2019 The Physiological Society published the *Growing Older, Better* report, which highlighted the role of physiology in achieving this mission. More recently, the House of Lords Science and Technology Committee published its report *Ageing: Science, Technology and Healthy Living*, which focused on how approaches from science and technology could be used to increase health span, to mitigate some of the negative effects of ageing, and to support older people living in poor health (House of Lords Science and Technology Committee., 2021).

How is a frail person identified?

Assessing whether a person is frail remains a challenge. There are two main approaches at present. One approach is to classify people as robust, pre-frail or frail on the basis of five traits, which are assessed by simple functional tests such as handgrip strength and walking speed, and questionnaires concerning perceived unintentional weight loss, physical activity levels, and exhaustion in everyday life (Fried *et al.*, 2001). This approach views frailty as a physiological syndrome. The other approach to identification of frailty views frailty as the cumulative effect of multiple deficits upon systems, and in this approach a "frailty index", based on the proportion of possible deficits an individual has, is used to classify their frailty status (Mitnitski *et al.*, 2001). Both approaches predict future clinical outcomes in populations. But neither approach is yet sophisticated enough to provide an assessment of the degree to which an individual is vulnerable and in what way. As yet, it is not possible to identify frailty on the basis of the consequences of multiple deficits due to ageing processes: a mechanistic understanding of underlying pathophysiological events is lacking, and frailty is clearly entirely operationally defined.

Why should a physiologist be interested in frailty?

One of the limitations of ageing research to date has been attributable to experimental approaches focusing on individual physiological systems – approaches that have served us well when dealing with single diseases and in the basic understanding of single organs. With respect to ageing, separate studies have highlighted dysregulation in brain (reduced brain volume, increased lesion volume, microstructural integrity deterioration; Tian *et al.*, 2020), skeletal muscle (reduced muscle cross-sectional area, increased muscle fat fraction; Cesari *et al.*, 2006; Lewsey *et al.*, 2020), and cardiovascular (increased left ventricular mass, ejection fraction, arterial stiffness (Nadruz Jr *et al.*, 2016) systems in the decline to frailty. However, longstanding evidence demonstrates the physiological phenotype of frailty encompasses simultaneous dysregulation in multiple systems.

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"Longstanding evidence demonstrates the physiological phenotype of frailty encompasses simultaneous dysregulation in multiple systems."

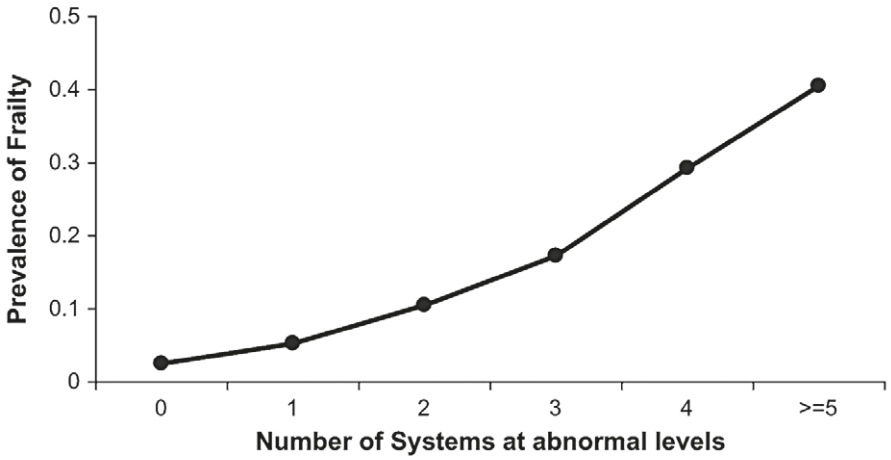

Figure 2. Prevalence of frailty in the study population in relation to the number of dysregulated physiological systems (*Fried et al.*, 2009).

For example, Fried *et al.* (2009) demonstrated that the prevelance of frailty increased, from 2%-3% in people with no abnormal body systems to over 40% in those with five or more abnormal systems (Fig. 2), suggesting studies assessing individual physiological systems are providing limited insight into frailty. Promisingly, the multi-system dysregulation framework is now receiving more attention in the context of frailty (Ghachem *et al.*, 2020; Li *et al.*, 2015), and is bringing greater physiological perspective to the condition. For example, analysis of purported biomarkers (anaemia, inflammation, IGF-1, dehydroepiandrosterone-sulphate, haemoglobin A1c, micronutrient status, adiposity and fine motor speed) of eight different physiological systems was performed in frail and non-frail elderly women. It was concluded that increased prevalence of abnormal biomarker status was related to the increased likelihood of frailty, such that abnormality in three or more biomarkers was deemed a significant predictor of frailty (Fig. 2).

Whilst effective in illustrating dysregulation in several suggested biomarkers during frailty, evidence from an amalgam of more robust physiological end-point measurements is still missing, particularly dynamic measurements of physiological function such as muscle protein synthesis, cardiac function, and cerebrovascular function. Accordingly, it will be important to build on these findings with more comprehensive structural and functional assessments of physiological function, in an integrated way, to uncover the main pathophysiological traits and mechanisms of frailty. Such an approach will inform the development of interventions to blunt or reverse the syndrome, which is likely to more efficacious than studying physiological systems in isolation.

How can collaboration help?

We assume that there are reversible mechanisms which could be enhanced or amplified to ultimately make a significant impact upon frailty and hence well-being in older age. These could be put in practice through novel drugs and custom-designed foods, and through individual changes to lifestyle and behaviours, and enhanced through economic and political processes. Key to making an impact on frailty is a requirement to harness research and technology that allows us to understand the mechanisms underpinning it and its progression. Collaboration between geriatricians and physiologists seems an obvious positive way forward, but also building collaboration between researchers in different physiological disciplines is a necessity, considering the multi-system nature of frailty described earlier.

Evidence from single-system studies suggests the amalgamation of brain, skeletal muscle, and cardiovascular research would be a productive starting point. Insight will be best served by dovetailing multi-modal approaches that allow complex physiological processes to be studied with granularity and relatively non-invasively *in vivo* in people, such as neuromuscular and motor function, anatomical and dynamic MRI, and stable isotope tracer measurements of metabolic turnover. This approach also lends itself well to the investigation of volunteers at multiple time-points in longitudinal study designs bringing detailed temporal insight of the trajectory of frailty and effectiveness of interventions to offset decline. Fortunately, we live in an age in which such technology platforms have been established, allowing investigation of multiple physiological systems to be undertaken concurrently in human volunteers, so we do not need to rely upon animal models of dubious validity.

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Can physiology help to develop treatments for frailty?

Ultimately, research into degenerative syndromes should strive to aid in developing patient treatment options. In this regard, physiology will be fundamental in providing the foundations for frailty treatment, through identifying the syndrome's pathophysiological characteristics, which can then be considered as targets for intervention. For example, it is widely accepted that frailty is concomitant with deterioration in skeletal muscle mass and metabolic resilience, but there is a scarcity of studies that have determined muscle mass and metabolism using gold standard approaches, such as MRI and stable isotope flux measurements. Further, studies have often been flawed by shortcomings in study design (e.g. an absence of gender stratification prior to analyses and/or the allocation of pre-frail and frail individuals into a single study group for analysis), reinforcing the need for clarification through physiological research. By effectively determining the relationships between frailty and skeletal muscle pathophysiology, interventions such as increased physical activity and/or resistance exercise could be further developed to help combat physiological dysregulation underpinning frailty. This of course begs the question of when is it best to intervene? Exercise intervention may not be at all feasible in the hyper-frail, but interventions that promote the mechanisms that are stimulated by exercise could be applied. An alternative would be to target the pre-frail using long-term and lifestyle interventions.

Where do we go from here?

Considerable research effort is required before the distinct pathophysiological processes and mechanisms of frailty development are comprehensively established. At present there is a lack of well-designed longitudinal studies investigating temporal relationships between frailty progression and wide-ranging and robust physiological end-points. Without longitudinal and multivalent data, it will be difficult to delineate mechanisms driving physiological decline into frailty. Furthermore, to date frailty research has primarily focussed on resting state measurements, which may not accurately reflect the dysregulation of dynamic homeostasis that some believe underpins frailty (Varadhan *et al.*, 2008). In short, in the absence of acute infection, illness and injury, without the presence of external stressors such as feeding or physical activity, the dysregulation of physiological homeostasis in frailty may be subtle and undetectable. Accordingly, investigating frailty under conditions of controlled physiological stress was identified as a significant knowledge gap some time ago (Fried *et al.*, 2005), and remains relatively unaddressed. This represents a real research and public health opportunity for physiologists.

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https://doi.org/10.36866/pn.123.24

Nothing about us, without us

Are we asking the right questions in transgender research?

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The absence of research in transgender health has real consequences – consequences that some of us have experienced firsthand. One of us (Clara), a trans woman, recently had to deal with vaginal flora dysbiosis; a condition in which the homeostasis of the microbial flora is disrupted. She observed distinct changes in odour and discharge, which seemed to fall within discrete types and could change dramatically over a period of weeks. This observation sparked her curiosity. But when she started to explore the scientific literature, no knowledge seemed to exist on the topic. To address the dysbiosis, she obtained probiotics at the local pharmacy, not knowing whether those would actually work for her own physiology. While these often did seem to help, there was a fundamental lack of information – no one seemed to know what the trans woman's vaginal flora consists of.

Understanding the (neo)vaginal microbiome

The vaginal microbiome of cis women has been extensively characterised thanks to metagenomic sequencing. This technology allows the identification of individual bacterial species based on conserved 16S ribosomal RNA genes and thus enables the mapping of bacterial communities. Based on this, we know that cis women's vaginal microbiome mainly falls within five distinct community state types that are characterised by dominant bacterial taxa (Ravel *et al.*, 2011). Furthermore, it is now clear that the vaginal microbiome is linked to a variety of health issues and diseases, that not only include dysbiosis but also gynaecological cancers (Champer *et al.*, 2018) and neoplasia (Mitra *et al.*, 2015).

This is in stark contrast to the scientific knowledge on the neovaginal microbiome. Many trans women undergo vaginoplasty surgery; the resulting organ – often called a neovagina – becomes populated with a microbial community. So far, how the neovaginal microbiome is implicated in health conditions is not only unknown, but even its basic composition is largely unclear, with only three studies having tried to address the question of how diverse the neovaginal microbiome is (Weyers *et al.*, 2009; Rizzo *et al.*, 2018; Birse *et al.*, 2020). While each study represents an important effort, all studies to date have significant limitations, in particular with respect to the variety of surgical techniques used to create a neovagina – e.g. using penile, scrotal, and/or intestinal tissues – with most studies only investigating a single surgery type. Furthermore, small sample sizes, a lack of time between surgery and microbiome sample collection and a focus on culturable bacteria make it unlikely that the true diversity of the neovaginal microbiome has been accurately captured.

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An example of the outreach materials used for the Transbiome crowdfunding campaign, which exceeded its target to study the neovaginal microbiome.

The Transbiome project

To address this knowledge gap, we decided to launch Transbiome (www.transbiome.org) – our own metagenomic exploratory research project. We wanted to start answering the question: what does the vaginal flora of trans women look like? And is there a correlation between the microbiome and factors such as surgery technique and postoperative care? In addition, based on the research on cis women's vaginal microbiome we suspect that self-care and other factors may influence the microbiota, including: douching, infections, medication and probiotics, and sexual behaviour. In the midst of all these potential influences, very little is known – even about whether any "typical" microbial state exists! Transbiome aims to improve this situation by profiling the bacterial and fungal species of up to 50 samples contributed by trans women. Beyond increasing the sample size by a factor of 5-10x compared with other recent metagenomic/metaproteomic studies, we additionally expect a larger diversity in our cohort of surgery types, and sample collection time post-surgery among other factors.

From the start, we envisioned Transbiome to be done by the community, for the community – allowing trans women to help and contribute to building the science. After initial discussions on the protocol design, we shared the effort on social media and launched a successful crowdfunding campaign; thanks to over 200 contributors, we have funding to cover sample collection and analysis costs. With support of communities in France, Germany, and Spain, our outreach also helped reach trans women across Europe that volunteered to contribute samples. Study participants were sent a kit by mail, asked to sample their own flora themselves, send back the samples, and complete an online questionnaire. The analysis of the first 35 samples is currently underway, and we are exploring potential future studies, e.g. studying longitudinal changes and stability of the microbiome over time.

Gaps in trans research

Transbiome seeks to understand the neovaginal microbiome, but there are other trans-related topics that may be underexplored (Ortiz-Martínez and Ríos-González 2017). Another firsthand experience we can share relates to transgender hormone therapy, a routine aspect of medical transition. Another author (Mad), after beginning testosterone therapy, was surprised by a physiological change not addressed by their informed consent process: an effect on crying. Testosterone therapy resulted in an immediate and dramatic reduction in their capacity to cry. Belatedly they discovered it was a common experience reported by others in online forums, and the effect seems to have attenuated over time. While an impact on lacrimal function from increased testosterone (or indirect effects on prolactin) may be consistent with existing literature (Mathers *et al.*, 1998), it was seemingly absent in transgender research and clinical information.

Transgender communities raise a variety of questions the authors are familiar with, for example: Do trans women have a hormonal cycle? Or could cycling the treatment be a good idea? What are the symptoms associated with vaginal and uterine atrophy in transgender men, and how can they be managed? How are trans womens' penises and testicles affected by oestrogen and testosterone blockers? And what about other organs? How does hormone therapy affect future fertility? Should lactation be induced in the trans parent when a child is born? And there are many more. How well does the current state of research cover these?

Historically, funding has been scarce for LGBT research (Coulter *et al.*, 2014), and transgender issues remain a subset within these. Furthermore, an "LGBT" grouping may be problematic, as it combines transgender communities with sexual orientation minorities. Research related to sexual orientation understandably focuses on fields influenced by sexual and social behaviour. However, unlike sexual orientation, the concerns of many transgender individuals relate to physiological topics involved in gender-affirming medical transition (see Table 1).

This bias likely affects the focus of research, potentially reducing focus on physiological questions relevant to the transgender community. When we examined a random

https://doi.org/10.36866/pn.123.24

Hormones and other medications		
Feminising	Oestrogen and progestogen therapy: • Estradiol • Progesterone	Therapy typically aims to achieve cis-female testosterone and estradiol levels.
	Antiandrogen therapy: • Cyproterone acetate (Europe) • Spironolactone (US & Canada)	Oestrogen therapies are often combined with antiandrogens for more effective suppression of testosterone and its effects.
Masculinising	Androgen therapy: • Testosterone	Therapy typically aims to achieve cis-male testosterone levels.
Other	Androgenic alopecia treatments: • Minoxidil • Finasteride	May be used in both feminising and masculinising contexts, to rescue miniaturised follicles to restore hair growth and prevent further hair loss.
	Gonadotropin-releasing hormone analogue agonists: • Leuprolide • Nafareline • Goserelin	Used to suppress effects of sex hormones, including delaying puberty in transgender youth.
Surgery and other procedures		
Feminising	Gonadectomy: • Orchiectomy (testes) Feminising genitoplasty: • Clitoroplasty, labiaplasty, vaginoplasty Non-genital surgeries and procedures: • Breast augmentation surgery • Facial feminisation surgery • Permanent body/facial hair removal	Surgical interventions are generally less frequent relative to hormonal therapy, and often have higher barriers or requirements (e.g. history of hormone therapy, psychiatric diagnoses).
Masculinising	Gonadectomy: • Hysterectomy (uterus), oophorectomy (ovaries) Masculinising genitoplasty: • Metoidioplasty (clitoral release), phalloplasty, scrotoplasty, urethroplasty Non-genital surgeries and procedures: • Mastectomy, reduction mammaplasty	In many cases individuals never pursue surgical interventions (e.g. genitoplasties), as the outcomes may not be considered necessary or adequate to outweigh costs and risks.

Table 1. **Gender-affirming physiological interventions used by transgender individuals.**
This list is not comprehensive: availability of treatments and standards of care vary, and additional or other approaches may be used to achieve efficacy depending on physiological response and goals.

"So far, how the neovaginal microbiome is implicated in health conditions is not only unknown, but even its basic composition is largely unclear."

sample of 280 trans-related publications, the majority of these were about medical policies, sociology and society, sexually transmitted diseases, and mental health. This is a stark contrast to physiology-related interests we've seen in transgender communities: When we asked the question of which research would be useful to trans individuals in a Facebook group on trans issues, the answers were mostly related to transgender hormone therapy. In our sample, only roughly 5% of literature seemed related to hormone therapy.

Mapping the state of trans research

A comprehensive understanding requires better knowledge of the current state of transgender research - and we're interested in seeing this improve. While a number of systematic reviews on trans topics exist, they exhibit the same skew in topics as individual research with most of them addressing medical policies, mental health and sexually transmitted infections.

A potential topic for our future work might be a project that better addresses this. We envision a participatory project, inviting contributions from trans individuals and allies, which could be used to better map the state of trans research. For example, a web-based tool could automatically track all trans-related publications, invite contributors to classify and tag these, and enable users to explore trans-related literature according to topic. Given the low number of publications, we could have a first mapping completed in less than a year.

Our sense is that research into the physiological aspects of transition is scarce. Mapping current research would give a better insight into

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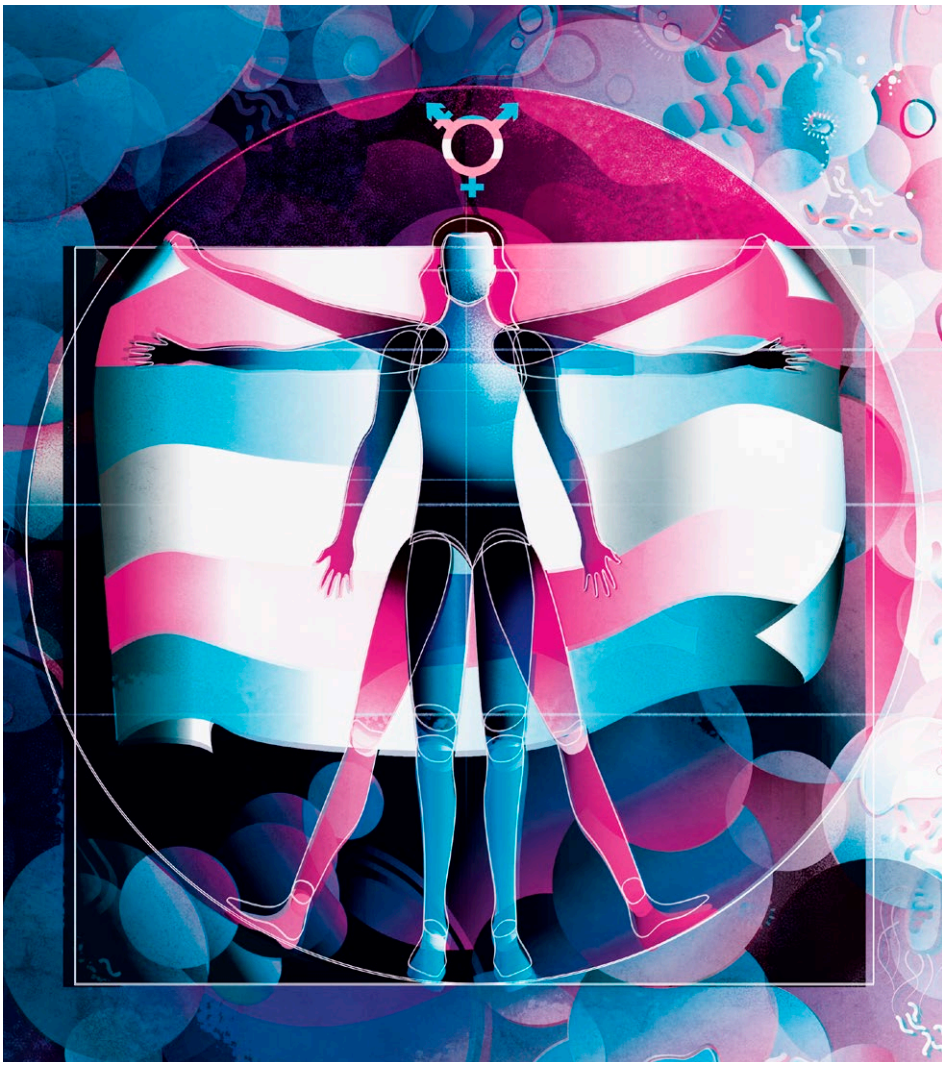

this. It would also provide both transgender individuals and clinical practitioners with a better way to navigate what *is* "known".

Closing the gaps – with the community

Topics of research are influenced by the perspectives and interests of funders and researchers. When these entities are overwhelmingly cis-gendered, what they see as relevant, interesting, and important may unintentionally stray far from the interests and needs of the transgender community (Galupo, 2017). In that sense, transgender research reproduces the biases we see in media and art fields, where trans people are often written, drawn, and portrayed by cis writers, painters, and actors. These can lead to a representation that is unrelatable, unrecognisable, and even insulting to the trans community.

How can we close this gap? There are a number of approaches that can help improve the situation. First, research needs a better overview of the concerns and needs of the trans community. For example, one could survey the trans population to identify which research questions they view as priorities. A similar approach has been taken in the past by a UK charity, Autistica, to generate a list of research priorities voiced by autistic people ("Your Questions: Shaping Future Autism Research" 2016). Furthermore, as the time and resources of individuals are often limited, inviting trans associations to be involved and influence research agendas could be greatly beneficial as it is their goal to represent and support transgender communities.

Second, beyond the research agenda setting we think it would be highly beneficial to make deliberate efforts to also include the community in later stages of research – e.g. in the design and testing of research protocols. Trans people have unique experiences that mean they can bring insights, viewpoints, and ideas that cis people are unlikely to have (Katz-Wise *et al*,. 2019). As a result, their inclusion could greatly improve the quality of research.

This is not to say, however, that only trans individuals can research trans individuals. We should, on the contrary, put more effort into researching trans issues in the wider scientific and medical community. But it seems that, in general, forgetting to include the minority that is researched in the process of researching greatly impairs the scope and impact of the research.

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https://doi.org/10.36866/pn.123.28

Diversifying the case study

How far has physiology education come in integrating equality, diversity and inclusion into the curricula?

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Physiology can be quite a numerical subject. We think of rates (heart, respiratory, filtration), volumes (stroke volume, tidal volume, body fluid volume) and concentrations (plasma hormones, intra vs. extracellular Na+ and K+) as we describe the homeostatic mechanisms that control and maintain these values. They provide a framework through which we can talk about hyperkalaemia, hypovolaemia, or tachypnoea; but they also provide a means to look at variation and think about what is "normal".

Physiology teaching using the "textbook person"

One of the common ideas in physiology is that of the "textbook person", the archetypal character that exists in textbooks as a paradigm of normality. On first encounter, this sounds a bit like the average person (*l'homme moyen*) put forward to some controversy by Aldophe Quetelet (1842), but it is not really. Instead, the textbook person is drawn from a much smaller sample size, with very specific criteria – he is male, aged 21-25 and weighs 70 kg and from the repeated observations of one of the authors, he occurs at a rate of ~0.5% in a typical, undergraduate medical cohort. On one hand, the scarcity of such an individual is a positive, allowing for the selection of a single individual from a cohort to embody cardiac output or a similar variable. On the other, it wholly excludes 99.5% of that population so in those terms what does a statement such as "cardiac output is approximately 5 L/min" actually mean?

For a number of parameters like plasma electrolytes, or glucose and vitamin D, most "normal" values are given as a range. In most cases these are calculated from the mean of a representative sample and the range calculated as plus and minus 1.96 standard deviations from the mean (to include 95% of the population). Since, by definition, 5% of normal values will lie outside the range, these now tend to be referred to as reference ranges rather than normal ranges. This too goes back to Quetelet who showed that many human traits were normally distributed around the mean. Quetelet was an interesting character, not only as a pioneer of statistics but he also developed the idea for body mass index (Eknoyan, 2008).

In a previous edition of *Physiology News*, Ord (2019) highlighted the differences in cardiovascular variables across childhood, while Strait and Lakatta (2012) have elsewhere highlighted the changes in structure and function that occur in the ageing population. In a population of over 2000 Chinese individuals, Cattermole *et al.* (2017) highlighted the change in a number of cardiovascular variables including cardiac output across the life course (data shown in Table 1).

Despite this large variation, the idea of a "normal" value can be useful. If we think of our "textbook" cardiac output, we can think of the situations that may alter this and the homeostatic controls that bring it back to normal. Indeed, we often think about cardiac

https://doi.org/10.36866/pn.123.28

Age (years)	0 – 2.9 (*n* = 65)	3–5.9 (*n* = 353)	6–11.9 (*n* = 773)	12–17.9 (*n* = 460)	18–29.9 (*n* = 276)	30–59.9 (*n* = 223)	60+ (*n* = 77)
CO (L/min)	2.6 (1.6–3.9)	3.7 (2.5–5.3)	4.8 (3.1–7.8)	6.2 (3.6–9.7)	5.4 (3.1–9.0)	4.9 (2.5–7.8)	5.2 (3.0–7.5)

Table 1. **Table showing changes in cardiac output (CO) (L/min) across age ranges.**
Data shown are median (2.5%–97.5% range). Data taken from Cattermole *et al.* (2017).

Weight (kg)	<10 (*n* = 18)	10–14.9 (*n* = 96)	15–19.9 (*n* = 299)	20–29.9 (*n* = 451)	30–49.9 (*n* = 577)	50–74.9 (*n* = 686)	75+ (*n* = 91)
CO (L/min)	2.0 (na)	3.0 (2.2–4.9)	3.6 (2.6–5.2)	4.4 (3.0–6.7)	5.6 (3.3–8.4)	5.5 (3.0–9.45)	5.7 (2.7–9.8)

Table 2. **Table showing changes in cardiac output (L/min) across weight ranges.**
Data shown are median (2.5%–97.5% range). Data taken from Cattermole *et al.* (2017).

output in terms of changes in exercise and/or heart failure. However, while physiology is crucial for maintaining our own "normal" values it is also crucial in setting them in the first place, as many variables are dependent on physiology. As depicted in Table 1, age has a significant impact on cardiac output, but, along with other factors, it is also affected by sex, genetics, environment and diet.

Cattermole *et al.* (2017) showed an apparent sex difference in cardiac output, with male individuals having larger outputs than female individuals. However, this disappeared when corrected for weight; instead, rather than a sex difference, cardiac output increases as weight increases. The data from weight ranges are also shown (Table 2). Similarly, a supposed sex difference in exercise limitation has been shown to disappear when lung size is taken into account (Boseman *et al.*, 2017). These data show that a person's height, weight as well as environment can also impact on other physiological variables. For example, when considering haemoglobin concentration, altitude is an important consideration. Similarly, the latitude of your population is likely to impact on the "normal" vitamin D levels.

Another example that has raised a lot of media attention recently is that of serum creatinine, used to calculate the estimated glomerular filtration rate (eGFR). Creatinine is a breakdown product of creatine phosphate in muscle. It is released by muscles and filtered and excreted by the kidneys. The serum creatinine measured is therefore a function of how much is produced (the muscle mass) and how much is cleared (renal filtration), so if it is to tell you anything about glomerular filtration rate (GFR) then it needs to take muscle mass into account. There are a number of algorithms that estimate GFR from serum creatinine but mass (and certainly muscle mass) is rarely available so proxies are employed. Age, sex, and weight can make these estimates more accurate but the inclusion of race in these has recently caused some concern, not least in how a social construct like race impacts on a biological process (Vyas *et al.*, 2020). The inclusion of the race factor leads to a significant increase in the estimated kidney function possibly missing some reduced function, while exclusion of the correction factor may underestimate renal function (Levey *et al.*, 2020).

Crucial here is the lack of a genetic race difference (Birney *et al.*, 2021), highlighted poignantly with the case of the Biggs twins (Edwards, 2018). Any arbitrary creation of groups will lead to perceived differences, but these could easily just be artefacts or the result of confounding biological or sociodemographic factors, just as supposed sex differences discussed above were really an issue of weight or lung size.

If the idea of the textbook person has value as a reference point to help teach physiology, then perhaps it should cease to be the definite article and become a textbook person instead. Whether it persists with the 22-year-old, 70 kg male or we choose instead a 56-year-old, 80 kg female, it does not really matter so long as we keep in mind that it is just one version of normal from a myriad of others on offer.

Integrating equality, diversity and inclusion to the physiology curricula

Educators on healthcare courses need to provide an educational experience that equips students with the knowledge and expertise to (verbally and non-verbally) interact with and care for patients while being mindful and respectful of inclusion, diversity and equality issues. Lots of studies discuss the integration of cultural awareness in nursing and medical education, and such advances in these programmes are widely recognised (Leung *et al.*, 2020), yet most studies focus on the sociology themes of equality, diversity and inclusion (EDI) awareness for healthcare practice.

"The textbook person is drawn from a much smaller sample size, with very specific criteria – he is male, aged 21-25 and weighs 70 kg and from the repeated observations of one of the authors, he occurs at a rate of ~0.5% in a typical, undergraduate medical cohort."

https://doi.org/10.36866/pn.123.28

	Traditional physiological parameters	EDI considerations/alternatives
Clinical observations		
Diagnosing cyanosis	Blue-purple colour observed in the nail beds	Colour may be more easily observed in mucous membranes (gums, lips, around the eyes)
Risk factors		
Type 2 diabetes	Recommended waist circumference varies with gender and ethnicity	Deposition of adipose tissue in the abdominal region differs with gender and ethnicity leading to different circumference measurements considered "safe": 80 cm (31.5 in) for all women 94 cm (37 in) for most men 90 cm (35 in) for South Asian men
Gender differences		
Signs and symptoms of myocardial infarction (MI)	Traditional symptoms and diagnostics are based around the male patient	In women the clinical manifestations of MI are often different, e.g. the pattern of referred pain may differ or be absent entirely; this lack of awareness negatively impacts on diagnosis and standards of care received by women leading to significant numbers of avoidable deaths from cardiovascular disease

Table 3. Case study considerations to encourage greater inclusivity in physiology education.

"Co-developed real-patient cases, informed by research, should be included to embed EDI in our curricula."

Perhaps these sociology themes that underpin a significant portion of pre-registration nursing and medical training are not adequate to equip students with the awareness of EDI issues in the clinical setting. Should responsibility also lie within life science components of the curriculum to encourage students to consider the links between cultural EDI issues and a patient's physiological differences? This is not a new hypothesis – it was cited by Beagan (2003) – but does the fact that we are still discussing it suggest that little progress has been made in the intervening years?

Case-based scenarios are a tried and trusted way to teach students physiology. However, we ought to recognise that the educational scenarios we provide may not represent the diversity of patients our students are likely to care for. In teaching physiology, we need to be reflective and aware of the bias in our stereotyping of patients (Bleakley and Bligh, 2008) and proactively champion EDI. Co-developed real-patient cases, informed by research, should be included to embed EDI in our curricula. Table 3 illustrates how we can tweak aspects of the case study to be more inclusive.

In our physiology teaching we highlight examples of diversity within risk factors during lectures and use them as prompts for more detailed discussions that integrate EDI consideration in tutorials. We also included these differences in risk factors to some of our assessment questions.

We probed the issue of EDI in physiology teaching among nursing and medical students using the following questions (distributed by email). Despite being students on different courses (who have never met) it was interesting to note the similarities in their answers.

Student perspectives

The interviewees are Deirdre Boyle, a final-year nursing student, and Kate Bennett, a year 2 medical student.

Do you think your physiology education has adequately equipped you to deal with issues of EDI in the clinical setting?

Deirdre Boyle (DB): Our life sciences education has given us a good foundation into the awareness of how certain conditions can be more prevalent in various ethnic groups. Distinguishing between genetic input and other determinants of health can then direct how we help to educate and empower our patients, so that better outcomes are achieved.

Kate Bennett (KB): Case-based learning is a new form of teaching and learning introduced by the School of Medicine in September 2020. The cases challenged us as a team to work through clinical scenarios, consider communication with patients and colleagues, and appreciate the individual expectations and lifestyles of each patient. The cases were written to represent the demographic of Northern Ireland (NI). For example, one case focused on phenylketonuria (a particularly prevalent genetic disorder in NI), patients working in agriculture and the implications they face with illness, and the cultural diversity within local communities. The cases

https://doi.org/10.36866/pn.123.28

brought prescribing guidelines to life for African/Caribbean patients with hypertension, the consideration of sickle cell anaemia amongst Black, Asian, and minority ethnic (BAME) patients, and the burden of care that multigenerational families bring to patients.

What can we do differently in physiology teaching that might better equip students for clinical practice today and in the future?

KB: It would be beneficial to develop a greater appreciation for the language barrier often experienced in clinical practice and how this impacts the treatment provided. I would like to learn how clinicians overcome communication difficulties and hear the patients' perspective in these situations. Furthermore, I would be curious to understand more about the increased impact certain illnesses (such as COVID-19) have on BAME patients.

DB: While genetics may only be one factor in why BAME groups have poorer health outcomes, perhaps delving deeper into the role genetics plays could enhance understanding. Allowing for more discussion of these topics during tutorials would be helpful because these discussions give the vital opportunity to ask questions and independently research evidence-based literature. It would also be useful if lecturers included more recommended reading on the topic. From my experience on clinical placements, the big challenge is language barriers and accessing translation services to assist with the nurse/patient relationship. In clinical practice, I think it will entail things like observing how the multi-disciplinary (MD) teams advise various communities and the resources available.

Are there any aspects or examples of physiology teaching that are notable to you as being useful or highlighted EDI issues?

DB: Our life sciences tutorials provided the opportunity to acknowledge that certain conditions were more (or less) prevalent amongst BAME populations. However, perhaps case studies that facilitated more in-depth discussion would be useful. Due to the nature of my placements thus far I have not encountered much cultural diversity among the patient population. However, previous work experience in a maternity and general hospital in India highlighted the worrying trends of increasing numbers of patients with Type 2 diabetes and its resulting effects if poorly controlled. The rising number of pregnant women presenting with gestational diabetes, and its implication for increased instrumental deliveries and Caesarean sections, along with an increased likelihood of developing Type 2 in the future. Overall, maternal death and infant mortality were at a higher rate than the UK; however, the mortality rate among BAME mothers in the UK is greater than among mothers of non-BAME origin. Topics such as these would be interesting to consider further in our physiology education.

KB: The family attachment scheme (during which we are assigned a family to work alongside for a year) provided us with the invaluable opportunity to gain perspective on living with chronic illness and what it is like to be a patient in the health service. The scheme allowed us to listen to patients whose experiences were impacted by their community, occupation, education, and family. The scheme was like working through a real-life case study in real time and helped us to apply many aspects of what we learned, but also increased our awareness of the impact of EDI issues as they arise in clinical practice.

Conclusion

The student experience of diversity and inclusion issues in the clinical practice setting is variable. So perhaps, when developing new case studies for teaching bioscience subjects to students on health professions courses, we should garner some co-production elements and include student experiences in our teaching. Using more representative case studies in teaching physiology that illustrate the impact of not only age and sex, but also race and socioeconomic class can help students understand unequal health outcomes. Moving beyond single factors to an intersectional approach highlights important differences between groups that are frequently presented as homogeneous – such as men, women, migrants, and minorities (Kapilashrami and Hankivsky, 2018).

As physiology educators we could be clearer about modifiable and non-modifiable factors that contribute to health and disease. Human physiology is predominantly non-modifiable but is significantly influenced by modifiable factors. We need to help students be more aware of these differences in their clinical practice; making our case studies more diverse is a good place to start.

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https://doi.org/10.36866/pn.123.32

Tackling underrepresentation to aid understanding of Parkinson's disease

Progress and further opportunities

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Neurodegenerative diseases, such as Parkinson's disease (PD) and Alzheimer's disease, increasingly rival infection, cancer and cardiovascular disease as leading global causes of death and disability (GBD 2016 Parkinson's Disease Collaborators, 2018). Large increases in the burden of neurodegenerative diseases have been observed over the last two decades, with some of the greatest increases observed in low and low-middle income countries.

The pathological hallmarks of PD include severe and progressive depletion of dopaminergic neurones concentrated in the substantia nigra and widespread neuronal loss in other brain regions. In surviving neurones, there exist aggregations of abnormally folded proteins, with alpha-synuclein as the predominant constituent.

Once believed to be predominantly a motor disorder characterised by slowness, stiffness and tremor, PD is now recognised as a highly heterogeneous progressive disease, that manifests in the central, autonomic and peripheral nervous systems. Non-motor manifestations of PD include changes in mood, autonomic function (constipation, erectile dysfunction, hypotension, bladder complaints), sleep disorders and loss of smell. There is no cure, despite effective symptomatic treatment for motor symptoms having been available for around 60 years.

Fundamental to the search for better treatment and cures is understanding the underlying pathophysiology of disease. As for other complex diseases, most investigation has been undertaken in persons of mainly European ancestry, residing in high-income countries, who are affluent and well educated. As such, our understanding of the genetic basis, environmental risk factors, clinical manifestations and response to treatment is heavily biased (Ben-Joseph *et al.*, 2020). However, there is growing momentum to tackle the biases that foster and perpetuate inequality. In this article we will outline some of the work that has been done, the initiatives that are underway or beginning, and commitments that must be made to further erode inequality in our understanding of PD.

Research efforts thus far

To date there are limited examples of minoritised ethnic groups being included effectively into research programmes seeking to understand the basis of PD. Non-European cases of PD (both familial and sporadic) were instrumental in our early understanding of important genes and pathways that are affected (Kitada *et al.*,1998; Hulihan *et al.*, 2008). Yet nowadays, understanding of common genetic variation that underpins sporadic PD has largely been shaped by the inclusion of participants of white, European ancestry into genetic studies (Nalls *et al.*, 2019). This is changing, as outlined below.

Studies exploring environmental risk factors for PD have also systematically failed to recruit persons of colour adequately, and so

https://doi.org/10.36866/pn.123.32

"As for other complex diseases, most investigation has been undertaken in persons of mainly European ancestry, residing in high-income countries, who are affluent and well educated."

our understanding of the epidemiology of PD is also heavily skewed by this bias. Whilst studies describing clinical aspects of PD have been undertaken outside of Europe and North America, there exist few examples of clinical studies of PD undertaken in diverse populations in high-income countries. Of note, it is not just participant recruitment that has the potential for serious bias; standard assessments used within clinical studies are not well validated for use in minoritised groups and may lack "cultural fairness" (i.e. they may perform differently in different groups, again leading to bias).

Switching focus to low and low-middle income countries; more than a quarter of the world's population resides in Africa and Latin America. With sustained economic growth and improved life expectancy, many more people in these regions are surviving to older age and the burden of age-related conditions such as PD is expected to grow. Despite the growing public health threat, scientific progress in these regions is very limited. The reasons are multifactorial; limited numbers of skilled healthcare workers, inadequate infrastructure, misconceptions in communities and social stigma, lack of funding or availability of resources more generally, and government/NGO commitment to other disease areas all play a role. For many African countries, the focus of health research is very much on infectious diseases, women's health and reducing child mortality, rather than neurodegeneration. Even receiving an accurate diagnosis of PD and effective treatment may be improbable in some African countries, and PD research in Africa until recently has involved export of samples and data, rather than local capacity building (Dekker *et al.*, 2020). In Latin America, there may be better general recognition of PD, but research is also limited and data are scarce. One possible exception is Brazil, a country that experienced steady increase in research productivity during the last two decades, attached to its economic growth. However, financial constraints and politics now threaten further progress.

Current initiatives to address knowledge gaps

The Global Parkinson's Genetics Program (GP2), supported by the Aligning Science Across Parkinson's (ASAP) initiative (Riley and Schekman, 2021), is an international, collaborative effort to understand the genetic basis of PD from a truly global perspective (gp2.org). It does this by generating and integrating clinical and genetic data from around the world, and similarly providing data access and training opportunities back to clinicians and researchers, wherever they are (GP2, 2021). One specific example of GP2's commitment to increased representation of communities is the Black and African American Connections to Parkinson's Disease (BLAAC PD) study. BLAAC PD has been set up with the hope that beyond genetics, this study will also serve as a foundational cohort to assess the diverse aspects of PD in this population. GP2 has also already partnered with investigators from Africa, East and South Asia, North, Central and South America, Europe, the Middle East, and Oceania.

The Latin American Research Consortium on the Genetics of PD (LARGE-PD) is a part of GP2, but independent in its own right. It was founded in 2005 with the goal of deciphering the genetic architecture (the sum contribution of genetic variation that underlies a given trait) of PD in the Latino population. LARGE-PD involves centres in 13 Latin America countries (large-pd.org) and, amongst several important projects exploring the genetic basis of PD in the region, it recently generated the first large PD case-control genome-wide association study of Latinos (Sarihan *et al.*, 2021).

As part of the International Parkinson's disease Genomics Consortium (IPDGC), the IPDGC Africa project has been created to improve the scientific understanding of PD and other neurodegenerative conditions in Africa. IPDGC Africa is formed by a collaborative group of scientists and clinicians from academic institutions in 12 African countries (https://www.ipdgc-africa.com/). IPDGC Africa aims to study the clinical and genetic diversity of PD in Africa with the goal of achieving equality and genetic discovery in this population.

These are just some examples of the initiatives that will generate valuable data in the effort to uncover the molecular complexity underlying PD aetiology. Equally important will be the emergence of a new vibrant network of researchers from areas previously underrepresented in science, and generating new research capacity where it is much needed.

https://doi.org/10.36866/pn.123.32

Diversity, equality, and inclusivity in research leadership

Although an important step in the right direction, it is not enough to simply be more inclusive when it comes to recruitment and participation in research. Gender diversity in senior roles and in management is recognised to be associated with greater performance and better decision-making. Few could argue against the benefits of having better representation of women at senior levels, yet unconscious bias and large gaps still exist, and in many cases the COVID-19 pandemic may have widened these. Representation from persons of colour in senior roles across all sectors is lacking and has not yet been tackled with the same energy as gender diversity efforts.

In the UK, evidence from the UK All-Party Parliamentary Group inquiry on equity in the STEM workforce showed that when it comes to ethnicity, at least at a high level, parity exists relative to the rest of the UK workforce. However, these data do not paint a complete picture. For instance, the Higher Education Statistics Agency reported that only 1% of all academic staff were Black, whilst individuals who identify as Black comprise 2.7% of the workforce. Notably none of these are employed at professor level within the areas of physiology and anatomy. This in turn suggests underrepresentation of certain groups in the most senior roles.

Priorities from a funder's perspective

Research funders are increasingly utilising their unique position to advance diversity and inclusion in PD research, recognising that previous efforts do not reflect the real-world diversity of those living with disease. In 2020, The Michael J. Fox Foundation (MJFF), the world's largest non-profit funder of PD research, revised one of its core funding initiatives (the Therapeutic Pipeline Program) to request community partnerships and inclusive recruitment plans (Michael J. Fox Foundation, 2021). Moreover, MJFF offered all applicants invited to the final stage of grant review a free consultation with community engagement experts to support their development of inclusive recruitment strategies. These efforts seek to change the landscape of PD research so that data more accurately represent the whole PD community and improve the generalisability of research findings.

Other examples funded by the MJFF include work to understand the barriers and motivations to research participation for underrepresented groups, through the *Fostering Inclusivity in Research Engagement for Underrepresented Populations in Parkinson's Disease (FIRE-UP PD)* study. Most recently, the MJFF launched a dedicated funding initiative focused on PD research in underrepresented populations. The *Promoting Diversity, Equity and Inclusion in Parkinson's Disease Research* call is aiming to support research on the incidence, aetiology, pathology, clinical presentation, and/or access to care in underrepresented populations. Over 90 research proposals have been received from around the world and funded initiatives will aim to build a more holistic understanding of PD, to the benefit of all.

Similar momentum is beginning in the UK to address ethnic disparities in PD research participation. Parkinson's UK has assembled a steering group of members of the PD community from diverse backgrounds and is partnering with organisations embedded in underrepresented communities to tackle related issues and accelerate progress.

Conclusion

A problem such as PD, which affects the global population, requires global representatives to better understand it and to deliver global solutions. Here the term "global" is used not only to describe a "worldwide" context, but one that is comprehensive, inclusive, and equitable. It should be noted that these issues are not unique to PD and action is required in many disease areas. Momentum may be starting to build, not only in PD, but in other conditions too, such as multiple sclerosis (Wood, 2021). Increasing representation in research is not simply about paying "lip service" to an agenda, it is fundamental to achieving a better understanding of the pathways and mechanisms, and a brighter future with respect to treatment and, one day, cure.

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"Research funders are increasingly utilising their unique position to advance diversity and inclusion in PD research, recognising that previous efforts do not reflect the real-world diversity of those living with disease."

https://doi.org/10.36866/pn.123.32

Meeting notes

Future Physiology 2021

19 – 22 April 2021
Online conference

Reports contributed by The Society's Early Career Theme Leads and an attending Society Member.

Future Physiology 2021 was an exciting time for us as the Early Career Theme Leads, and we were pleased to share this conference with so many researchers from all over the globe. It was clear from the high quality of research presented across all Themes that the future of physiology research is vast.

Hosting an online conference during the midst of the COVID-19 pandemic brought with it the challenge of re-creating the benefits of in-person conference. Our aim was to generate a supportive online environment where early career physiologists could share their research, network with peers, and attend career development workshops.

The online platform enabled attendees to ask questions about each presenter's research, which prompted Q&A sessions after each talk; these Q&A sessions provided an opportunity to provide feedback, expand on points, and congratulate the presenters on their hard work.

ePosters allowed presenters to get creative, incorporating videos and additional information to present their research in a variety of formats in addition to the classic poster.

The poster sessions allowed attendees to circulate between presentations and speak with peers. These facilitated two-way and small-group conversations, and hopefully re-created some of the social elements that an in-person conference provides!

In addition to the quality of research on show, some other highlights for us were the panel sessions at the end of each day. These gave us the chance to hear experts discuss topics such as how the pandemic has affected physiological function and how each respective Theme can move forward in terms of focuses and new techniques. They inspired us, and we hope it gave the attendees something to think about too.

It was great getting to know so many of you during the conference, particularly the networking sessions, and hearing about the variety of physiology research being conducted by early career researchers across the world.

Sana Yaar
University of Manchester, UK

Future Physiology 2021 has provided me with an amazing opportunity not only to present my work to an international audience, but also learn about a diverse range of topics from researchers all over the world.

The Physiological Society team have done an incredible job in organising a conference that catered to the interests and needs of early career researchers. In particular I enjoyed and appreciated the focus on the COVID-19 pandemic; it was encouraging to hear how different researchers have been dealing with some of the same challenges I have faced myself this past year. I really liked how the organisers included a panel to discuss the general impact of COVID-19 and lockdown on our work life, but also the specific panel discussing the science behind how lockdown could be affecting our physiology.

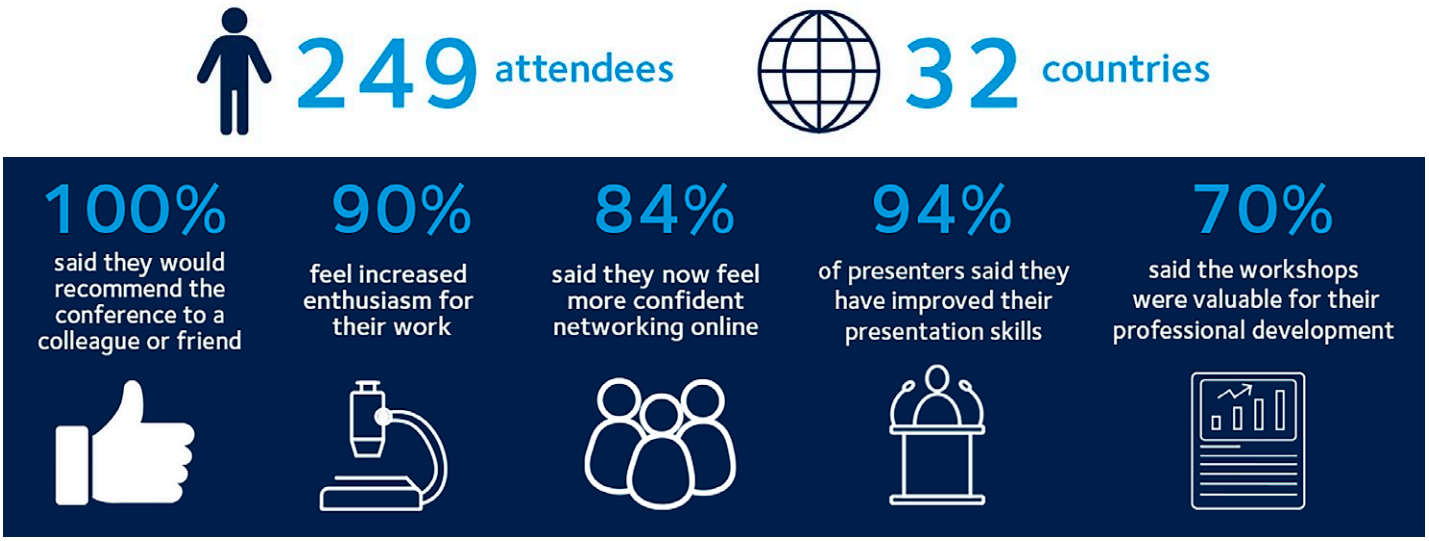
I really enjoyed the wide range of topics covered in both the talks and ePosters; I not only increased my understanding of topics relevant to my PhD but had the rare opportunity to listen in on exciting research completely unrelated to my work. The talk by invited speaker Dr Evelyn Parr on the impact of the pandemic on our eating habits and how this could be realigning our circadian rhythms, was particularly fascinating for me.

The ePoster sessions were also enjoyable to attend; having access to the posters beforehand really allowed me to understand the research presented in a lot more detail, and therefore ask more relevant questions during the live ePoster sessions.

At this year's conference I presented an oral communication during the Cardiac and Vascular Physiology session and was honoured to receive the Michael J Rennie prize for best talk by an early career researcher! Future Physiology 2021 is the first conference where I have presented an oral communication, and to have won this prize, knowing the high quality of talks presented by other researchers, has given me a great boost in confidence.

Following my talk during the Q&A session, where I received some wonderful feedback and tips for my research, I was able to engage in some interesting discussions regarding my work, which have led to new ideas for my PhD. I am incredibly thankful to the early career organising team for giving me this opportunity to present and discuss my work at an international scale.

Overall, I have thoroughly enjoyed both presenting and attending the Future Physiology 2021 conference and I am excited to take part in the conference again next year!



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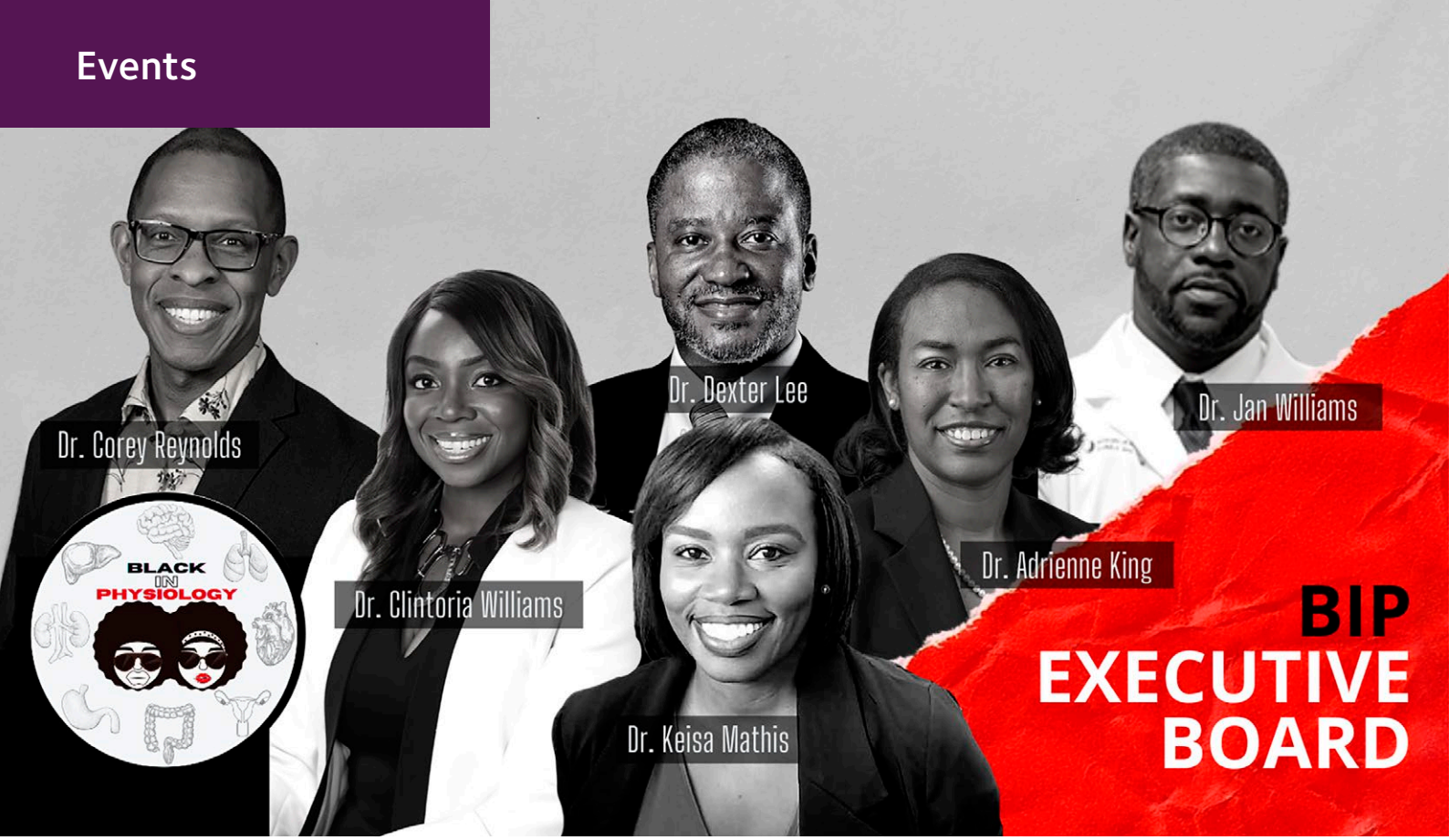

Meeting notes

Conference for Black Physiologists 2021

25 – 27 April 2021
Online conference; organised by Black in Physiology, Inc.

Dr Adrienne King, Dr Clintoria R. Williams, Dr Jan Williams, Dr Dexter Lee, Dr Corey Reynolds & Dr Keisa Mathis, Black in Physiology, Inc., Dover, DE, US

Black in Physiology (BiP) was birthed in the summer of 2020 as the realisation of a double pandemic ensued. Amid multiplying racial injustices and the calamities associated with COVID-19, six Black physiologists joined forces and committed to both nurturing and celebrating Black excellence within the physiology community. Insistent that BiP be the change that is needed to address systemic issues within the physiology community and science as a whole, these pioneers created an organisation with a vision of addressing a void present in the scientific community – the authentic intention to recruit, retain and promote Black physiologists.

The BiP community now serves as an inclusive space not only for those who consider themselves Black and African American scientists in physiology or physiology-related fields but also supporters, allies, and advocates. Together, BiP is dedicated to fortifying a community for Black physiologists by enhancing visibility and ensuring that resources, support and guidance are readily accessible.

Since the inception of BiP, the organisation has been dedicated to utilising the diverse talents of community members to support the professional and scientific development of Black physiologists. Consistent with this goal, the inaugural Conference for Black Physiologists (C4BP) was held 25 – 27 April 2021. Together with the BiP Executive Board, the BiP Programming Committee created a conference filled with professional development nuggets from Black leaders in academia, industry and government; scientific talks from up-and-coming Black stars in physiology; and the all-important social opportunities all meant to help enhance attendees' network and, importantly, their net worth. This well-attended first conference garnered around 150 attendees that drove social engagement to 190.24k on the virtual Socio Event Platform during the 3-day conference.

Day 1 highlights – Personal development

Reminiscent of an in-person poster session, attendees and judges engaged in two days of live poster presentations by junior scientists. On day 1, this showcase of Black excellence was followed by the opening session featuring Stacey Brooks, Director of Communications and Social Media at The American Physiological Society. During her informative talk entitled "Putting Your Best Foot Forward: Tips for Communicating about Your Science and Self", Mrs. Brooks emphasised the importance of developing impactful scientific messages that extend beyond the scientific community.

Drawing from her extensive experience in communications, Brooks outlined six tips to aid scientists in connecting with individuals both inside and outside the scientific community.

Tip #1: Update your lab's website

Tip #2: Use science communication principles in your research articles

Tip #3: Use simpler language to get your scientific messages across

Tip #4: Brush up on your personal branding

Tip #5: Update your social media profiles

Tip #6: Get to know communications staff at your institution and professional societies

This opening session was followed by a Science Communication in 2021 Discussion Panel that was gracefully moderated by Dr Sherry Adesina, Field Medical Director at Akebia Therapeutics. The panel featured Dr Dayne Beccano-Kelly, Career Development Fellow at the UK Dementia Research Institute's Centre at Cardiff University, UK; Dr Myla Patterson, Senior Product Brand Manager at Abbott and Dr Bryan Wilson, Regional Medical Scientific Director at Merck.

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The panelists' discussion centred around the dire need for scientists to intentionally master the art of scientific storytelling to effectively communicate science.

Consistent with the day's overall theme of science communication, the concurrent networking shorts focused on "branding yourself and your science." Some key takeaways from the breakout sessions include:

- Clearly define your networking goals and allow these goals to drive your interactions
- Networking is a critical skill that must be actively developed
- Establish a strong, consistent presence in person and on social media

Day 2 highlights – Science and career

After another exciting day of engaging poster presentations, Dr Vernon Ruffin, Assistant Professor at Virginia Union University skilfully navigated attendees through a day filled with a lively keynote address, dynamic scientific talks and informative professional development opportunities.

The keynote session featured a conversation between Dr Alencia Washington, Assistant Vice President of Research, Wellstar Health Systems, and Dr Robert Carter, Colonel United States Army Futures Command, entitled "Conversations with Leaders in Physiology."

Washington and Carter discussed their respective career paths, strategies used to leverage their network and net worth, and provided inspiration for trainees to navigate their own career paths. During this session, these leaders both emphasised that having a support mechanism that includes senior and peer mentors is essential to navigating any career path. Dr Washington also gave her perspective as a Black woman in science highlighting the point that if society doesn't give a woman a seat at the table, she must be willing to make her own table.

This day also included seven oral presentations from graduate students and postdoctoral fellows. Excitingly, the first ever Future of Black in Physiology Award was presented to Heather Beasley, a PhD candidate at Meharry Medical College. During her featured talk, this up-and-coming Black Star in physiology masterfully communicated her novel research findings on hypercalcaemia and its role in prompting metastatic breast cancer.

Day 3 highlights – Social

The inaugural Conference for Black Physiologists culminated in a business meeting presided over by the new BiP Executive Board. In this meeting, the BiP officers highlighted the many accomplishments achieved in just a short 8-month time span.

These accomplishments included 1) the first Black in Physiology Week, 2) a BiP Professional Development Workshop, 3) two features in recent publications, 4) the inaugural Conference for Black Physiologists, and 5) the incorporation into a non-profit organisation - Black in Physiology, Inc.

BiP aims to be world-renowned in the scientific community as a beacon of leadership. In the short time that Black in Physiology, Inc. has been in existence, the organisation has made a significant impact on the international physiological field.

Understanding that diversity, innovation, and collaboration are critical to the professional and scientific development of Black physiologists, the organisation has and continues to carry out the purpose, mission, vision and values upon which the organisation was founded.

Recordings of the inaugural Conference for Black Physiologists sessions can be viewed on the Black in Physiology YouTube channel. Please join the celebration of Black Excellence during #BlackinPhysiologyWeek 2021, 11-15 October 2021. For more information about Black in Physiology, Inc. visit **www.blackinphysiology.com**.

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Diversity and Inclusion Task Force: Introducing the members leading The Society's EDI work

The Society's drive to support diversity and inclusion extends to all areas of activity. To achieve this we established a network of individuals called the Diversity and Inclusion Task Force, which is made up of a member representative from each of our Advisory Committees.

Our Diversity and Inclusion Task Force is made up of Professor Raheela Khan (Trustee Champion), Dr Sue Deuchars (Trustee Champion), Dr Dayne Beccano-Kelly (representative from Conferences Committee), Dr Keith Siew (representative from Education, Public Engagement, and Policy Committee) and Professor Kim Barrett (representative from Publications Committee).

The Diversity and Inclusion Task Force works to ensure that the principles of diversity and inclusion are embedded across all activities of The Society. To read more about The Society's Diversity and Inclusion work, visit: **physoc.org/diversity**

Images used in this article are taken from our our animation called Being Black in physiology: Diversity for scientific excellence.

Tell us a bit about yourselves, both mentioning your scientific career but also anything you want *PN* readers to know about your personal background.

Professor Raheela Khan (RK): I grew up in a diverse London neighbourhood and was inspired by my father who worked in the medical field in Pakistan and encouraged his six children to aim for a university education. Even though I loved English literature, my curiosity in the natural world drew me to biology (although not creepy crawly insects). Imagine the irony when I ended up doing a PhD on the neuromuscular system, working with cockroaches daily! During this period my fascination with ion channels developed and I was fortunate to land a postdoc position studying potassium channels in the human uterus, and I continue to work in this field today. It was during this initial period that I realised how little was known about the specifics of female reproductive disorders and the relative lack of funding in women's health, especially around pregnancy.

Dr Sue Deuchars (SD): I am proud of the fact that I am a scientist and a mum, choosing to work part-time for 21 years in order to balance my career and children. I obtained my PhD in Cardiovascular Physiology from The Royal Free Hospital and did a postdoctoral position in London before taking my first maternity leave and then moving to Leeds without a job. At that point, I took my decision to apply for funding in my own right as a PI but working 60% and luckily, the British Heart Foundation were very forward thinking and they funded me. I stayed working part-time, first as an independent researcher, then as an RCUK Fellow before moving straight onto Reader in Neuroscience. I still love neurophysiology and I want to inspire others to feel that a career in science or academia is open to everyone, regardless of their circumstances.

Dr Dayne Beccano-Kelly (DBK): I have always been interested in how science can impact real-world health. During my undergraduate degree I went to the Mayo Clinic in Jacksonville Florida to do a year in industry, which showed me how fascinating neurodegeneration is and that this was the area I wished to concentrate on during my career. I went on to do my PhD and postdocs in Alzheimer's Disease and Parkinson's Disease, focusing on electrophysiology.

Dr Keith Siew (KS): Well for those who might not know, I'm a mish-mash of various oddities. I'm a first-generation PhD from a largely working class family background, I'm biracial/biethnic (born to an Irish mother and Chinese-Malaysian father in Dublin, Ireland), I'm a cisgender openly gay man, I'm dyslexic and an atheist (although the latter seems like less of a minority these days).

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I wanted to be a scientist since about the age of 5 (thanks to many hours of David Attenborough) and fast forward almost three decades later, I'm now living the dream as a renal-cardiovascular physiologist with Sir Henry Wellcome Postdoctoral Fellowship at UCL working in a mixed team of clinicians and scientists to investigate the renal control of blood pressure.

Professor Kim Barret (KB): I got my PhD in biological chemistry and did a postdoc in immunology, but eventually I saw the light and moved my research programme into the area of gastrointestinal physiology, where I have been ever since. Most of my time has been spent as a professor in the medical school at the University of California San Diego, but I was also Dean of the Graduate Division for 10 years and am currently working as a rotating Division Director at the National Science Foundation in Washington DC. I grew up in London, and neither of my parents completed high school, but I got interested in science at an early age and knew I wanted to make it my career.

What inspired you to get involved with D&I work?

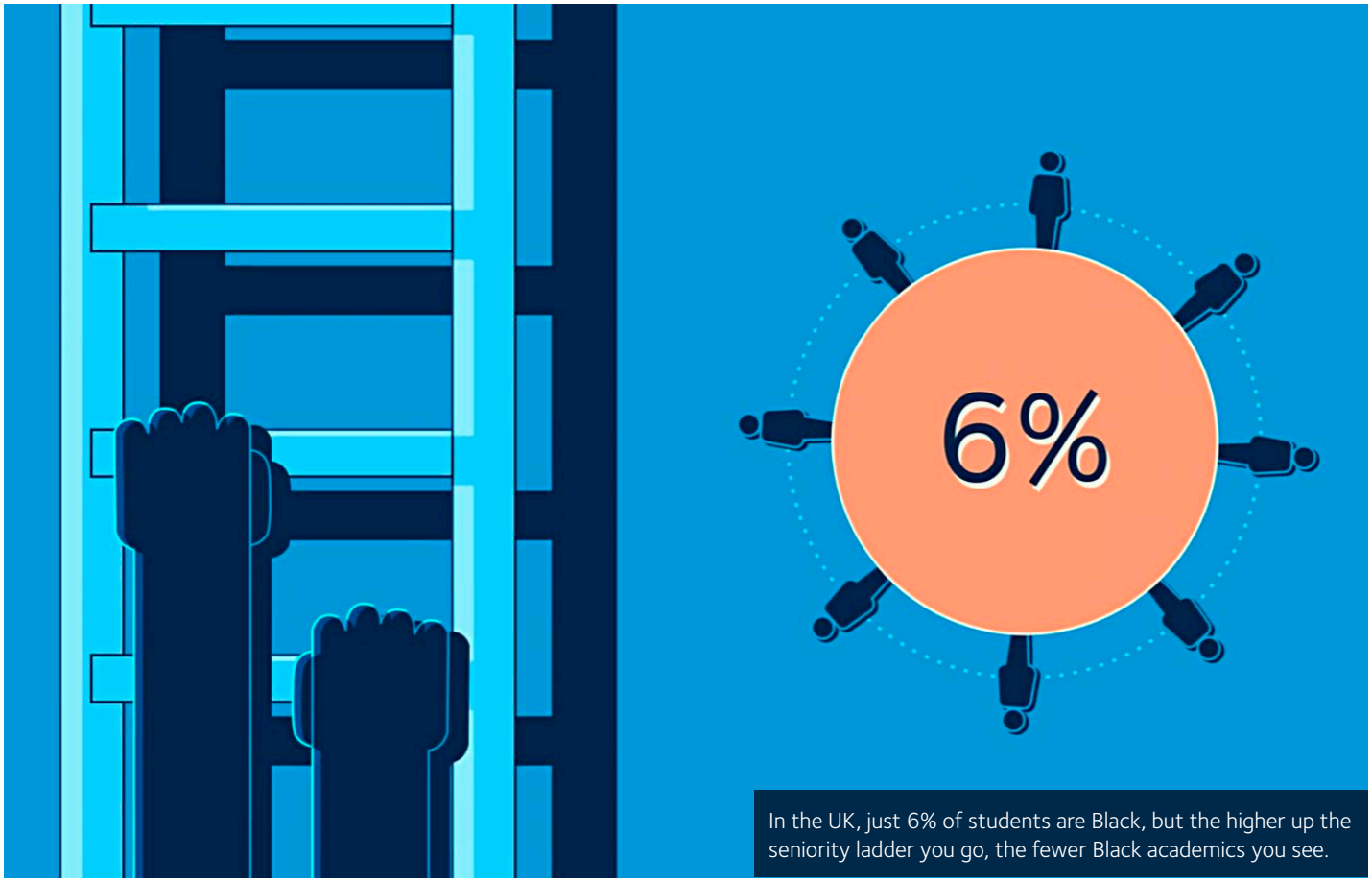
RK: As a young scientist, one often views the world favourably and certainly in my time, I didn't really pay much attention to inequality apart from an ethnicity perspective. I did think it felt unfair when the Wellcome Trust had no policies to support my maternity leave - that surprised me. As an academic, interacting more at the committee/management level, I began noticing certain exclusions on panels such as few women and even fewer people of colour or with a disability, let alone invisible, protected characteristics. Apart from taking part in demonstrations against apartheid, for example, professionally I came to D&I quite late but had my own lived reality of certain forms of prejudice. Until recently, I was lead of the Athena Swan Committee in the School of Medicine in Nottingham. As a parent, another very powerful driver in getting involved in D&I is to combat overt discrimination and implicit biases that can impact on people from a very young age.

SD: When I started out as a neurophysiologist, it was clear that there were very few women in science who had succeeded on a part-time basis or by setting their own agenda. I therefore wanted to motivate people to have conviction to work in science in the way that suits their lifestyle or situation best and not to be afraid to speak up about the obstacles that still exist to prevent this. As I took up different academic roles, it became clear that there was still not enough in place in science to support people with diverse characteristics, from undergraduate level to those in leadership, and I want this to change.

DBK: As a British-born scientist with Caribbean heritage, I have not encountered any Black scientists in positions of academic authority in my area of research to date. This led to feelings of isolation and imposter syndrome, questioning of the viability of my chosen career as a scientist of my colour, as well as a lack of role models to ask for advice. As a result, now that I am a group leader, I want to do my part to help eliminate these hurdles.

KS: During the early part of my studies, I was still struggling with my own identity, and this was not helped by the fact that almost every other LGBTQI+ person I knew in STEM during my BSc and MSc dropped out or transferred to the Arts & Humanities. When I got more involved with The Physiological Society as a PhD student I met a handful of other queer peers, but saw no one like me represented among the more visible members of The Society. In recent years I've decided to be more open about my diversity characteristics and experiences, because I felt that if I wasn't seeing myself being represented, maybe I needed to stick my head above the parapet.

KB: My first-gen status was one of the most important factors, along with starting out as a woman in chemistry, where there were very few female role models at the time – there were no women on the academic staff in the Chemistry Department at UCL during my time as a student there, for example, and many experiences of overt sexism.



In the UK, just 6% of students are Black, but the higher up the seniority ladder you go, the fewer Black academics you see.

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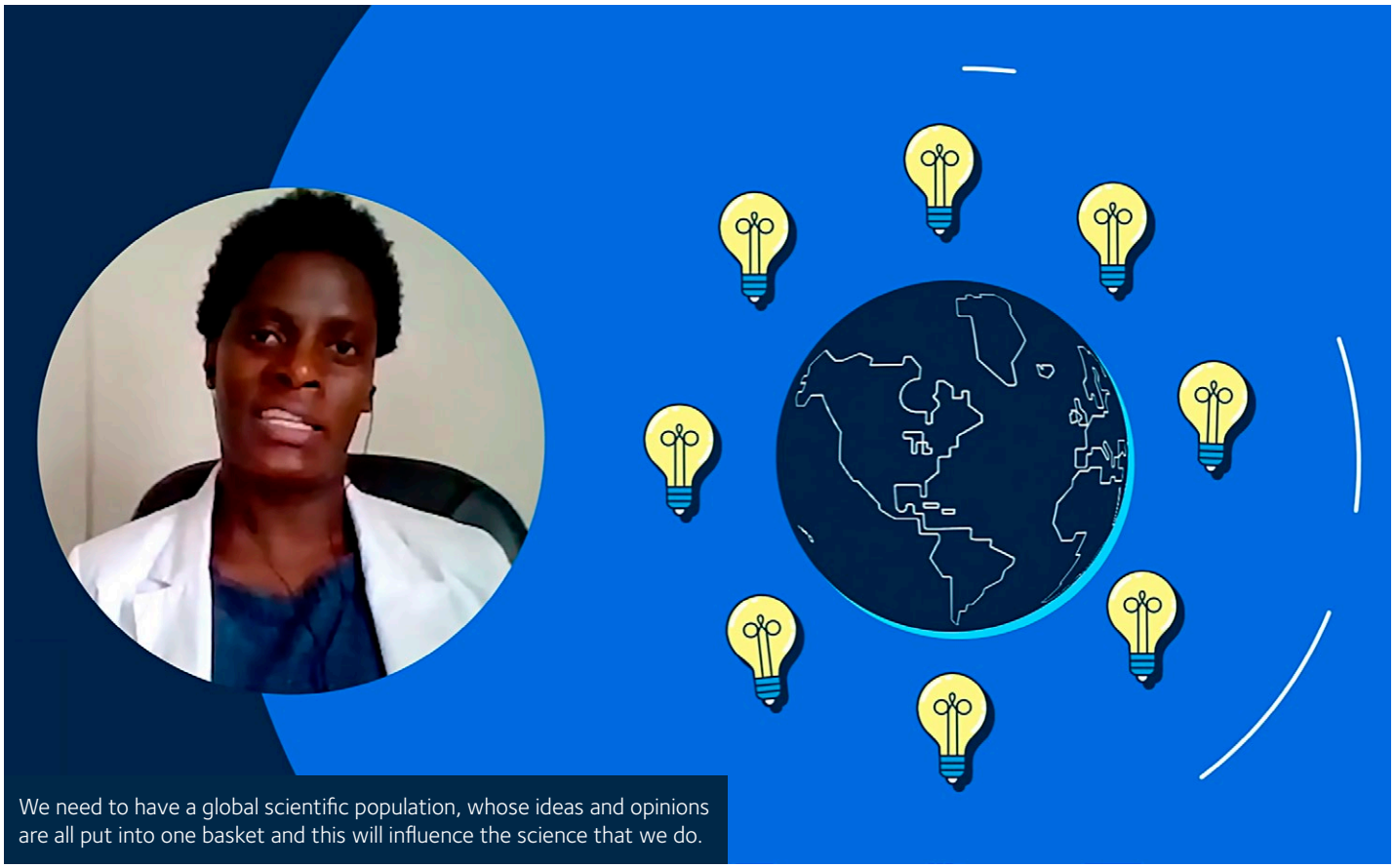

We need to have a global scientific population, whose ideas and opinions are all put into one basket and this will influence the science that we do.

What is the main aspect of positive change in the D&I world that is happening currently?

RK: For me, it's the local and global efforts tackling the root causes of inequality – such as the Black Lives Matter movement, which has made us challenge our own biases but also generated awareness around Black scientists through social media promotion. Not everything about social media is good but used appropriately, it is helpful in wider dissemination and discourse, in forming new ideas and also challenging corporations, organisations and governments to accelerate change in EDI. For scientists, the open discussions around research and workplace culture will hopefully lead to more equitable routes to success through fairer peer-review processes, funding outcomes, diverse boards/panels, and better work-life balances to overcome many of the unhealthy expectations of a career in science.

SD: The fact that society and, more importantly to us, scientific and academic communities are moving from mere acknowledgement of the issues to positive actions to ensure equality and inclusion. Being involved in the Equality, Diversity and Inclusion in Science and Health coalition has really encouraged me to believe that we will be able to make change, rather than just paying lip-service to the issues. This is being supported by strong guidelines from funding bodies such as UKRI, who influence the careers of so many in our community.

DBK: Accountability. Institutions like UK Research and Innovation are publishing statistics on the demographics of their membership and awardees. This provides empirical evidence that is hard to refute, thus shining a spotlight on areas of inequity. Furthermore, the fact that the data are in the public domain means that changes can be monitored over time to track progress.

KS: I think the fact that the necessary conversations are actually being had (although not always comfortable). Old perspectives, laws and cultural norms are being challenged, and largely with a view to change things for the betterment of everyone. I'm most encouraged to see large organisations like funding bodies incorporate policies that will truly motivate change, because money talks!

KB: The biggest change I have seen in my lifetime, which was totally breathtaking to me, was the rapidity with which society at large started to accept the marriage rights of the LGBTQIA+ community. When I look at my nieces and nephews, sexual preferences just don't seem to be an issue for them. That is not to say, however, that we are anywhere near full acceptance of this or other underrepresented communities in STEM fields and in academia, and many people still feel they cannot bring their whole authentic selves to the scientific workplace.

What is a major obstacle that often goes unnoticed, that is keeping us from a diversity-inclusive and equitable scientific community?

RK: Barriers due to age – either being too young and therefore perceived as lacking experience to contribute effectively to decision-making or older scientists in mid-late career who may not be as well supported but still have ambitions to do their best science.

SD: As a female scientist, I have been encouraged by the changes made over my career to promote gender equality in science but we are still not taking into consideration to the same extent other characteristics such as disability, ethnicity, sexual orientation or socio-economic status. Until this changes, we are not supporting our whole community to achieve to the best of their ability.

DBK: Underrepresented demographics (such as those who identify as Black) lacking in positions of authority means that there is less of a driving force for the issues that matter to certain demographics. Whilst people with the power to effect change do understand the importance of improvement in D&I, it does not affect them personally and the issues are not prioritised.

KS: I think what one might call the "invisible" disabilities. There are too many people who quietly suffer from mental health issues such as depression or anxiety that fly under the

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radar. There is both a lack of awareness (I myself didn't know how to recognise I was depressed during my PhD write-up until 2 years or so into it) and also pervasive dismissive attitudes towards mental illness that would never be tolerated if it were physical illness.

KB: I think that those who hold first-gen status in academia, and/or who come to science from disadvantaged backgrounds, are something of an invisible minority. There are so many cultural touchpoints and unwritten rules for us to navigate.

If you could give your younger self one piece of advice, what would it be?

RK: Don't judge a book by its cover – we are all shaped by different, diverse experiences that are not obvious unless you listen and observe.

SD: Have conviction in what you are capable of and how you work – others are not always doing it better!

DBK: Recently I have discovered networks and collectives of Black academics that exist to support some of the issues I identified above. I wish that I had sought these out earlier in my career and would have told my younger self to do so.

KS: Everyone is the protagonist in their own story; you're just another side character. In other words, people aren't thinking about you as much as you think they are, so be less self-conscious, be more yourself and embrace your differences. In the end it'll often be what people value most about you.

KB: Stop listening to the constant voices of doubt, and just do it!

Have you any words of advice for your colleagues on how to be an ally, to any community?

RK: Find out how minorities feel, learn from them and support them by calling out inappropriate actions. I think this is an area that needs more attention to encourage people who don't know what it means to be an ally, but can make a huge difference to individual wellbeing and culture.

SD: Have confidence in your ability to speak out in any situation where you feel that others are not being treated equally or there is unwarranted prejudice. If you chat to others, you will realise that there are many in the same or different situations as you who will also relish having a strong informal network of support. Do not be afraid to be actively involved – if you state your situation explicitly, it will help others to speak out, thus avoiding relying on implicit assumptions.

DBK: The networks I have mentioned do not have to solely be for Black people. I would encourage people to join them, listen to the issues raised, and suggest ways to change things, as opposed to asking how to solve problems and deferring responsibility back to Black scientists.

KS: Don't be afraid to ask questions; most of us don't bite. Be a good listener, and take part in activities where you can grow your social circle to include more diverse communities.

KB: Those of us with privilege definitely need to step up. We can't expect those who have historically been marginalised, or who continue to suffer microaggressions, to carry all the weight of making our discipline more diverse and inclusive. Simply stopping the action, asking questions, and gently calling out what Jana and Baran have labelled "subtle acts of exclusion" can make a huge difference.

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My life journey as a physiologist in a developing country: Q&A with a Fellow Member

Professor Ibiyemi Olatunji-Bello

Lagos State University, Lagos, Nigeria

Professor Ibiyemi Olatunji-Bello was awarded a PhD in Physiology in 1998 at the University of Lagos, Nigeria. She then became First Professor of Physiology at the Lagos State University College of Medicine, Nigeria in 2007, a position she still holds. Since then, she has obtained many academic fellowships and awards. A distinguished scientist, she is known for her brilliant academic work and she has over 56 publications to her credit. Physiology News spoke to Professor Olatunji-Bello to learn more about her life and work.

What do you value most about being a member of The Society? Which member benefits have you found most useful over the years?

I have been a member since the 1990s and one of the first sets of Fellows. The fact that I am a Fellow Member of The Society gives me more recognition in our Physiological Society of Nigeria, places more responsibilities on me as a role model to many upcoming physiologists and attracts mutual respect from colleagues. The benefits are enormous but the most important to me is the addition of FPhysiol UK to my name.

Other benefits I enjoy from The Physiological Society membership include travel grants, and prizes for outstanding students of physiology. I also have opportunities to present our research for peers to discuss at conferences and seminars. I am especially interested in focused sessions that relate to my areas of research interest, namely medicinal plants, and endocrine and reproductive systems.

Professor Olatunji-Bello presenting a public lecture at the Yaba College of Technology, Lagos, Nigeria.

What have you learned over the course of your work about how to balance productivity and mental health?

Over the years, I have learnt that relationships matter in order to balance productivity and mental health. You must be friendly and get along well with your colleagues, be cheerful and have a good relationship with God. These things keep you going. The realisation that one can do all things through Christ also helps to blot out impossibilities from my mind.

If I try at first and fail, instead of giving up, I will try again and again until I get results. This is my philosophy, and this has helped my mental health. I am also an ordained pastor so alongside my career as a scientist, I counsel young and old on how to stay in good mental health. We are trained on how to make the believer hopeful and never to give up using verses in the scriptures. Memorising these verses helps the believer cope with experiences.

Have you collaborated across different sectors, and if so, what lessons did you learn?

I have indeed collaborated across sectors, mostly with pharmacologists, pathologists and anatomists and occasionally with educators and botanists. These collaborations enable my team to improve teaching methods and help me identify certain medicinal plants, respectively. In research, you are more able to draw more valid conclusions when you collaborate with other departments and the resulting article is richer and more substantive.

What were the most difficult parts of running of your experiments throughout your career?

The unavailability of state-of-the-art equipment is the bane of research in sub-Saharan Africa. In my university, the state government has tried to upgrade equipment, but steady power or constant electricity is not available. Experimental animals are so expensive, not to mention the cost of feeding and keeping them healthy. Human

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subjects need inducements in one form or another before they will take part in studies. This is due to the high index of poverty in our country. Even when these are available, technical expertise might not be available to assist in the research. Needless to say, it is not easy to be a successful scientist in Africa.

What is the physiology community like in Nigeria? What do you think other parts of the world can learn from the way things are done in Nigeria? What are the challenges?

We have a Physiological Society of Nigeria (PSN) where all the graduates and lecturers come together annually to discuss current trends in our field and related ones. We are affiliated to the African Association of Physiological Societies (AAPS) whose current president is my mentor Professor Soga Sofola. He supervised my Masters and PhD. Annually PSN also holds a teaching workshop where we discuss the latest curriculum changes and relevant teaching methods for effective learning.

To flip your question on its head, in Africa, we need to learn from those in developed countries – that is why most of us are members of The Physiological Society. We associate with The Society to improve our lot in the profession. Our challenges are mainly around research funding, and availability of state-of-the-art equipment that makes research more seamless. Training and retraining of members of the recent techniques of research and teaching methods is also a challenge. Finally, digitalisation of the teaching and research processes is still difficult in the remote parts of the country because of lack of good internet facilities.

What do you enjoy about the sector you work in, and what is challenging about it?

I really enjoy teaching. I could stand for hours teaching and you will never see a student asleep or tired. I know I am a very effective and enthusiastic teacher. Feedback from our students also confirms this. One year, I was awarded second place in physiology in my university after my teacher, the late Professor Solomon Ade Adigun.

There was a time when we had many students in medicine, dentistry, pharmacy, physiotherapy, pharmacology and physiology. Teaching was not a problem because we had a big auditorium and there was a projector, but examinations were difficult. I sometimes had to read about 500 scripts of several long essays each, some with indecipherable handwriting. I was devastated. That was the only time I wished I was not a lecturer. Thank God the Nigerian Universities Commission now has a strict accreditation policy that has helped in controlling the number of students in a particular course.

Reporters interviewing Professor Olatunji-Bello after she gave the 40th Inaugural Lecture of Lagos State University, Lagos, Nigeria.

"In Africa, we need to learn from those in developed countries – that is why most of us are members of The Physiological Society."

What are the main challenges you've encountered during your career?

As students, we were discriminated against by the medical community who thought we could amount to nothing good. This affected some of us and as a result, very few of us were determined from the outset to do our PhD and become relevant in the academic community. Now we have the Students' Physiological Association of Nigeria in each university. This has helped to mitigate the discrimination. This body has helped improve the mental state of our students among their medical counterparts.

It was quite difficult for me being female to compete with our male counterparts as a lecturer. As you know, you either publish or perish if you want to advance in academia, and I had extra work I needed to do at home as a mother and wife. The sleepless nights of writing my research articles and the many rejections and revision requests by scientific peer-reviewed journals were difficult moments in my career trajectory. I was encouraged by the acceptances and kept on, sticking to my life philosophy, which is to never give up.

https://doi.org/10.36866/pn.123.42

Thinking a little differently: A member reflects on life as a neurodivergent physiologist

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A controlled mess can be easier to navigate than an orderly filing system.

I believe most neurodiverse people always have some inkling that they are different. It's not until your differences start to inconvenience the outside world that a diagnosis is sought. For many, that means assessment as a child, but for others it can be much later in life. I learned that I was dyslexic when I was 18 after the umpteenth argument with my teachers over my spelling and handwriting. Recently, at the age of 25 I have learnt that I also have ADHD. It turns out PhDs require some amount of executive function, self-motivation, and the ability to sit down and do tedious things for extended periods of time. My self-devised compensations could no longer bridge the gap.

Since I still find it rather difficult to explain neurodiversity, I will use someone else's words. "Neurodiversity is the idea that neurological differences like autism and adhd are the result of normal, natural variation in the human genome. This represents new and fundamentally different way of looking at conditions that were traditionally pathologized" *John Elder Robison*

While not denying the medical significance of disabilities arising from neurodevelopmental conditions, neurodiversity addresses how an individual's sense of self and how they understand the world around them can be different based on their brain. This difference, unlike neurological conditions, is not something that needs to be cured.

For example, there is compelling evidence showing the previous genetic advantage of ADHD to ancient people, and the slow selection against it since the advent of farming (Esteller-Cucala *et al.*, 2020). A 2008 study found that nomadic Kenyan tribesmen bearing dopamine receptor mutations associated with ADHD were better nourished than those without it (Eisenberg *et al.*, 2008). The opposite was true for their settled neighbours. Those with ADHD don't then have an illness, but have traits better suited to hunting and gathering rather than spreadsheet maintenance.

So how has being neurodivergent shaped my experience of research life?

On the plus, when you have an insatiable need to learn and a constant craving for new stimuli, a university is the best place to be. From my home in the physiology department, I have wandered into virology, pharmacology, biochemistry, applied psychology, computer science, ancient Roman history, poetry, languages, illustration, innovation, consultancy, opened a company, closed a company, joined an unnecessary number of university committees and started a rebellious student group or two. My competencies within each of these disciplines is as varied as the disciplines themselves; I wouldn't hire myself as a portrait artist nor to build a website, but I had a great time exploring.

As a scientist, my project proposals, so I have been told, are almost always creative and novel. I have been told I bring a chaotic energy to any project I join that always inspires change. The unfortunate counterpoint to this is that trying to get me to write up that project proposal as a grant application is not going to go well. Sitting down to write a review for several days is my definition of torture. If a task I am asked to do cannot be carried out immediately, I'll likely forget to do it. The day-to-day of research life doesn't suit me, but I am still here, thanks to the kindness and patience of those around me.

"The best advice I can provide for someone trying to understand neurodiverse people is to consider them someone whose native language is different to yours: while we may speak your language very well, odds are that our definition of certain words and turns of phrase are different."

https://doi.org/10.36866/pn.123.44

When I recognised that I was having chronic issues that were resistant to most of my efforts, I asked for help. I talked to my supervisory team, and we restructured how my work was planned, executed and supervised. I will forget to do things or procrastinate if I don't have deadlines, so we started to meet more regularly to keep me accountable. Not knowing the next step in terms of producing a thesis caused me a lot of stress, so we broke down all tasks into smaller chunks. "We will see what happens" is an approach that is only allowed for side projects, not the next main step in my thesis.

My favourite of the accommodations[1] made for me actually happened prior to any diagnosis. As the only person in the lab over the first lockdown, I started to spread my equipment out across the lab. When my lab partner came back and started putting things away, I would forget to do certain tasks and we argued frequently over where things were and where they should be. Our solution was to mark out an area. Anything I am working on needs to stay in that area, and anything anyone else finds where it shouldn't be, it gets put there. The area is a mess, but the disputes have stopped, and I can always see what needs to be done.

We are lucky that we have the space to designate a whole bench top to my mess, but there are many other instances when neurodivergent accommodations are easier to incorporate than this. First and foremost, be a patient communicator. While neurodiversity is varied, difficulty in healthy communication is a frequent problem.

The best advice I can provide for someone trying to understand neurodiverse people is to consider them someone whose native language is different to yours; while we may speak your language very well, odds are that our definition of certain words and turns of phrase are different. Our approach to a problem, task or social interaction might be more influenced by our neurodiversity than what is acceptable in the culture we grew up in. The same way us Irish people have to forgive foreigners for answering the question "How're you getting on?" with any response other than "Grand" or "Tipping away", you may need to forgive your neurodiverse friends for sounding a little too curt.

The way I communicate is often misconstrued as indifference, condescension, or arrogance, when I may just have shortened a long sentence in my head in a way that I assume makes sense to everyone else. While I am responsible for making the extra effort to try not to upset others, the kindest accommodation those close to me provide is asking "What do you mean?". If I say something that may sound problematic, they pause, take a breath, and ask. Most of the time, the comment really didn't mean anything. Occasionally of course, I actually am being rude, and then they can call me on it.

I am hoping anyone that reads this will consider looking into accommodations they can provide within their labs or in other walks of life. It's not only the neurodiverse that benefit from an extra bit of patience, or a bit more tailoring of tasks and workflows. We would all feel better being given the benefit of the doubt. Diversity will keep things interesting, and a bit of kindness keeps things going.

References and Resources

1. Accommodations refer to any change made to make an environment or situation more suitable to a neurodiverse individual. They can be made in workplaces, homes, public spaces and relationships. Accommodations do not remove agency or accountability from the individual, but ensure no unnecessary extra burden is placed upon them.
2. Robison, JE (2013). What Is Neurodiversity? *Psychology Today*. https://www.psychologytoday.com/gb/blog/my-life-aspergers/201310/what-is-neurodiversity

https://doi.org/10.36866/pn.123.44

Obituary: Professor Edward Carmeliet 1930 – 2021

Professor Edward Carmeliet

Professor Edward Carmeliet died on 5 April 2021 at the age of 91, just after retiring from a research career spanning the early 1950s to 2020. He was a pioneer in cardiac electrophysiology and throughout his life pursued deeper understanding of mechanisms underlying the action potential and the implications for arrhythmias, leaving a rich legacy.

His research started in the exciting years of the first recordings of action potentials from the heart. Early during his medical studies in Leuven, his physiology teacher, the late Professor Bouckaert, invited Professor Carmeliet to join the lab as a student-researcher. At that time, neurophysiology and skeletal muscle were the main topics, and Professor Carmeliet started on cardiac muscle, initially using the frog heart and subsequently mammalian Purkinje fibres. In 1952, he published his first paper on the effects of temperature and in 1955 published, as sole author, on a topic that stayed with him for the rest of his career, the modulation of the cardiac action potential by frequency. Indeed, in 2006, he wrote a review that incorporated 50 years of experimental evidence and scientific insight in the complexity of frequency-dependent modulation of the action potential duration by altered channel gating and slow changes in ion composition (Carmeliet, 2006).

With a focus on the regulation of the action potential, he studied many ionic currents and ion transporters, and a first interest was Cl^-. Professor Carmeliet joined the group of Silvio Weidman in Bern, Switzerland, studying Cl^- and K^+ conductances (1958 – 1961). His work on Cl^- was the first ever to show increased contribution of Cl- at depolarised potentials in Purkinje fibres. Back in Leuven, he used radioactive tracers for ion flux measurements with his early collaborators, Fons Verdonck and Suzanne Bosteels.

By the late 1960s, voltage clamp in cardiac multicellular preparations began. With Johan Vereecke, who became his life-long collaborator, he visited Johnson and Lieberman at Duke University (1972). With Gerrit Isenberg, he worked at combining voltage clamp and isotope flux studies in Purkinje fibres. He then moved on to use single cardiac myocytes, first using two microelectrodes, and from the early 1980s, patch clamp methods, complemented with molecular biology studies. Jean Prenen was for many years his trusted technician skilled in cellular electrophysiology, with Luce Heremans providing the "wet-lab" support.

An example of his life-long interest in methodological innovation is his work on the late Na^+ current. Early work using Purkinje fibres (Carmeliet & Saikawa, 1982) eventually led to transgenic mouse studies with his son, Peter Carmeliet, on LQT3 (Nuyens *et al.*, 2001). Interest in Na^+ homeostasis, further explored by Fons Verdonck, and work on ATP-sensitive K^+ channels were linked to a broader interest in ischaemia and cardioprotection. In 1990, an international symposium at the occasion of his 60th birthday addressed the wide involvement of ion channels and transport in ischaemia, including contributions on metabolism, pH regulation, oxidative stress, cell death and Na^+ and Ca^{2+} homeostasis. The work eventually led to his authoritative review published in 1999 (Carmeliet, 1999).

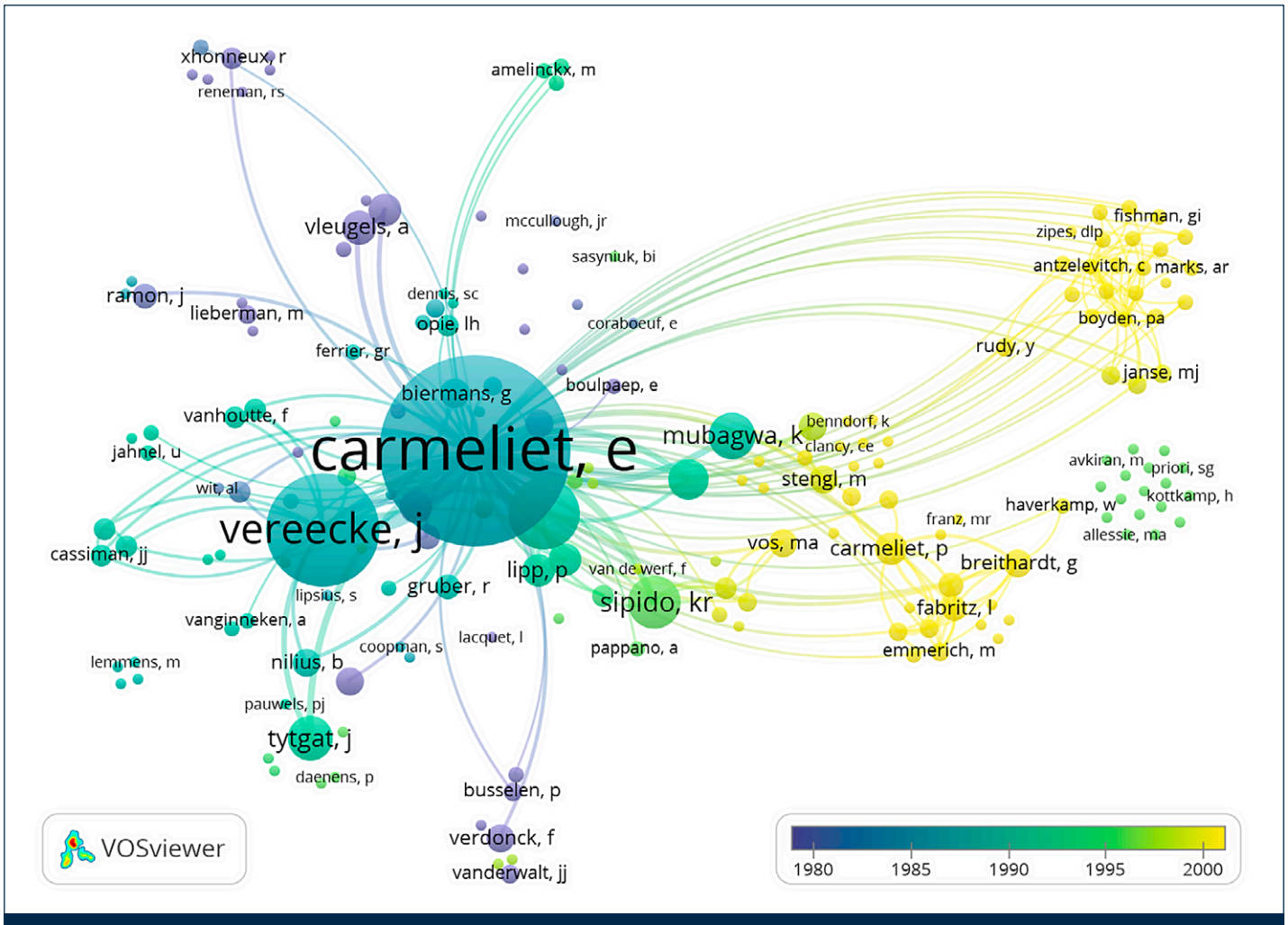
A major topic of study were K^+ currents. The proceedings of a symposium in 1995 on cardiac K^+ channels honour his many contributions to the field, and position his work in the global scientific network. Out of his many papers, we cite the work on blockers of the "delayed rectifier" K^+ current, the properties of the background (IK1) and of the ACh-sensitive K^+ channel, with Kani Mubagwa and Achilles "Oggie" Pappano, as well as the study of the Na-activated K^+ channels. Calcium homeostasis was part of his comprehensive view, converging with his early interests in Cl^- in study of Ca-activated Cl^- currents, with Karin Sipido and Zoltan Papp. His deep knowledge of ion channels and their modulation were at the basis of his membership in the international study group on anti-arrhythmics, the Sicilian Gambit.

Professor Carmeliet was very interested in the elucidation of pacemaker mechanisms. These were first thought to be linked to a waning K^+ conductance, but the work eventually led to the discovery of the funny current, and later expanded into the comprehensive view of a complex clock mechanism, aptly reviewed in 2019 in *Physiological Reports* (Carmeliet, 2019).

Professor Carmeliet served on the board of many distinguished journals. He was an active member of The Physiological Society, attending meetings and introducing his students to The Society. He was a member of the Editorial Board of *The Journal of Physiology* from 1980 to 1987 and remained an active reviewer throughout his life. With Edouard Coraboeuf and Silvio Weidman, he founded, in 1977, the European Working Group on Cardiac Cellular Electrophysiology, a meeting place for discussion of ongoing work, for scientific and social exchange and especially for including young researchers in the scientific network.

"With more than 200 collaborators and former students, the publications of Edward Carmeliet cover the world map and bear testimony to his influence in the field."

https://doi.org/10.36866/pn.123.46



Map of co-publications, based on WoS data and VOSviewer. Each dot represents an individual co-author though in this condensed rendering not all collaborators' names are visible. The top right cloud represents his participation in the Sicilian Gambit study group on antiarrhythmic drug development.

With more than 200 collaborators and former students, the publications of Professor Carmeliet cover the world map and bear testimony to his influence in the field. He reached out to scientists who were working in more difficult conditions, e.g. in the '60s and '70s in Eastern Europe, in China and Taiwan. Collaborations often entailed longer-term visits to the lab in Leuven, to the joy of the local team who could then work with prominent scientists.

Professor Carmeliet was a cautious and rigorous scientist, as critical of his own work as of that of others, but always in a collegial and friendly manner. We, his students, were taught the same. A famous expression was "één is geen", i.e. one observation means nothing. We were encouraged to write that data "suggest" or "indicate" as a definite proof is always difficult to establish. Discussing results and experiments in an open and constructive manner, he shared his enthusiasm and scientific passion with many.

Professor Carmeliet was married to Joanna "Jeanne" Amerijckx from 1955 until her death in 2015. She gave a homely welcome to all visitors and students, and accompanied Edward on many travels. They had four children, Bart, Geert, Peter and Jan. Geert investigates bone metabolism and development, and Peter studies angiogenesis and its role in cancer. Peter gave The Physiological Society's Michael de Burgh Daly Prize Lecture in 2013.

Following the news of Professor Carmeliet's death, numerous messages from colleagues around the world testified how his warm personality and extraordinary scientific spirit left their mark. He is deeply missed.

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The authors thank David Eisner, Manchester University, for his help in preparing the manuscript and Rob Stevens, KU Leuven for providing the photograph.

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