

### Executive Summary

The Board of the General Assembly (BGA) of the International Union of Physiological Sciences (IUPS) commissioned this report to assess the global strength of physiology as a discipline. This exercise serves to shine a light on the similarities and differences within the international community of physiologists, and the realities of their work and lives.

Input was sought from the member organisations of the IUPS to fill in the picture of the field of physiology worldwide. The result is presented here at the General Assembly of the 38<sup>th</sup> IUPS–2017 Congress in Rio de Janeiro, Brazil. A companion piece to this report presents essays including The Progress of Physiological Sciences by the Chair of the BGA, and contributions from the respective Chairs of three Committees (Education, Ethics, and Physiome) and four Commissions (Locomotion, Circulation & Respiration, Secretion & Absorption, and Cellular & Molecular Physiology).

Member organisations gave details on the atmosphere around research, including funding, regulation, public perception, and links with government and industry. Most organisations expressed concern regarding the availability of funding, with financial support from government resources deteriorating in recent years. Several organisations noted that funds are more likely to be disbursed to researchers doing clinical rather than basic research. Most organisations reported technical expertise in physiological sciences, but several remarked on diminishing practical skills for *in vivo* techniques and animal-based experimentation. Several responding organisations noted that animal experimentation is being discouraged.

In all countries, research and training in physiology is conducted under the close surveillance of ethics committees for animal and human research, but in some countries, physiologists are challenged by regulations getting stricter, making both human and animal studies more complicated. The use of *in silico* models is on the rise and has been formalised in some countries via organised groups. The establishment of effective links for collaborative research with other national/international institutions and with industry is strongly encouraged in many regions. The social acceptance of basic research in the physiological sciences is variable across the world, ranging from strong support to the lack of a dialogue causing mutual misunderstanding. Public engagement with science could be improved around the world.

Physiology is taught in specific undergraduate and postgraduate degrees, as well as in medical, veterinary, dental, and nursing courses. Most respondents noted that physiology is taught to students in a broad range of academic programmes, though in some countries physiology as an undergraduate subject does not exist. Several respondents remarked that physiology is not always taught within a

dedicated physiology course, although there is a growing emphasis that physiology is in fact clinically relevant as the foundation of scientific medical practice and has immediate bedside applicability.

Teaching in physiology utilises a mixture of traditional and innovative classroom and remote methods. Recently, there has been increased use of a flipped classroom model in which short video lectures are viewed by students at home before the class session, and in-class time is devoted to exercises, projects, or discussions. Examinations include a variety of question types. Practical teaching is variable around the world, especially as European regulations bar the use of animals in practical exercises. Human volunteers are common in medical educational settings in all countries.

The survey also considered the career prospects of new graduates. Globally, physiologists have good opportunities in academic positions as post-doctoral fellows, research associates in research laboratories, and as faculty members. Other professional opportunities are being sought by new PhDs as the struggle to obtain funding support is very onerous. Career opportunities for physiologists in non-academic institutions appear to be good in several countries. There are options in biopharmaceutical companies, biomedical - equipment related companies, government health programmes and in science journalism.

The achievements in the physiological sciences shared by the respondent societies are very encouraging. The American Physiological Society pointed to a global highlight of physiology in stating that 'Physiology can celebrate the fact that there is a Nobel Prize in Physiology or Medicine.' A common theme of achievements was establishing strong links between physiologists and other scientists in establishing national, international, and industrial collaborations. Many countries take pride in organising national and international meetings and workshops, and in the recognition of their members as recipients of major national and international awards. For example, over 30 members of The Physiological Society (UK) have been awarded a Nobel Prize, the most recent being to John O'Keefe in 2014.

This analysis has led to the development of recommendations to strengthen the global physiological community. With different countries experiencing very different situations, it is not envisaged that these will be universally and identically implemented, but it is hoped that the societies will work with the IUPS and its new Regional Representatives to bring about the recommendations and take physiology to 'Centre Stage'. Progress will be regularly updated to all member organisations, and fully evaluated at the next IUPS Congress in 2021.



## Recommendations

- 1** Societies should advocate for continued funding of basic research and collect evidence to document its state in their country.
- 2** Networks and working groups should be created, domestically and internationally, by IUPS and member societies to facilitate the exchange of knowledge and best practice in teaching and research.
- 3** Societies should continue the efforts of the IUPS Outreach Programme to increase support among physiologists for IUPS initiatives and furthering of the World Health Organization's Health for All agenda.
- 4** Societies should implement outreach activities to raise awareness of and interest in physiology among the public, and encourage the uptake of physiology and related subjects by prospective undergraduate and postgraduate students.
- 5** Societies should develop resources to improve the teaching and learning of physiology, and to ensure graduates have a full appreciation of the complexities at all scales of physiological understanding.
- 6** IUPS must oversee a new Global Mentorship Building Platform to facilitate Mentor/Mentee relationships among physiologists at various career stages, and in academic and clinical settings, to promote dialogue and aid career development.
- 7** Societies should explore new means to leverage funding from government and private sources, to aid the development of new initiatives designed to strengthen the discipline.

## SUMMARY OF COMPANION ESSAYS

Eight essays reflecting the progress, status and challenges in physiological sciences accompany the BGA-IUPS Report. The "Progress of Physiological Sciences by Debabrata Ghosh and Jayasree Sengupta traces how physiology as a science progressed historically to the present state of integrating physiological and allied sciences to realizing the movement from gene-to-tissue-to-organism. Janet Taylor stresses the current challenge of translating the findings of neuronal circuitry for movements to locomotion and grasp to animal models for prevention and amelioration of human disease. The fascinating role of gut microbiome and principles governing secretory and absorptive functions of the gut discussed by Rene Bindel include the need towards their translation in health and disease. A promising approach in this regard is described by Ryuji Inoue wherein 'reverse' or 'synthetic' physiology for 3D-bio printing leads to creation of visceral organ-mimetic of blood vessel, trachea and heart or to heart tissue on chip devices not only for replacement therapy but also to understand the logics and principles governing their functions. Physiologists, notes Jens Rettig require to embrace disciplines of functional genomics, proteomics, epigenetics, bioinformatics to understand the multi-level, multi-scale networking involved in the continuum of health and disease. The IUPS, Andrew McCulloch writes, is at the forefront in this area through collaborative international ventures in multistage computational modelling in systems biology and physiology. As in any other technology-based fields, physiology too has its own share of difficulties that often tend to mar the quality of scientific reporting and erode public confidence in scientific enterprise. How ethical considerations impacts upon physiological sciences is highlighted by Moody Corbett and her colleagues through greater vigilance, development of ethical consciousness in use of experimental animals; authorship issues in collaborative ventures, reproducibility and reliability of reported research studies and the ethical practices in publication of research reports. Eminent physiologist Arthur Vander at a meeting of the American Physiological Society had eloquently stated, "the quality and breadth of our teaching even more than our research, will decide the future of physiology". Robert Carroll has placed an argument of an emergent need to embrace new evolving technologies towards the professionalization of physiology education.