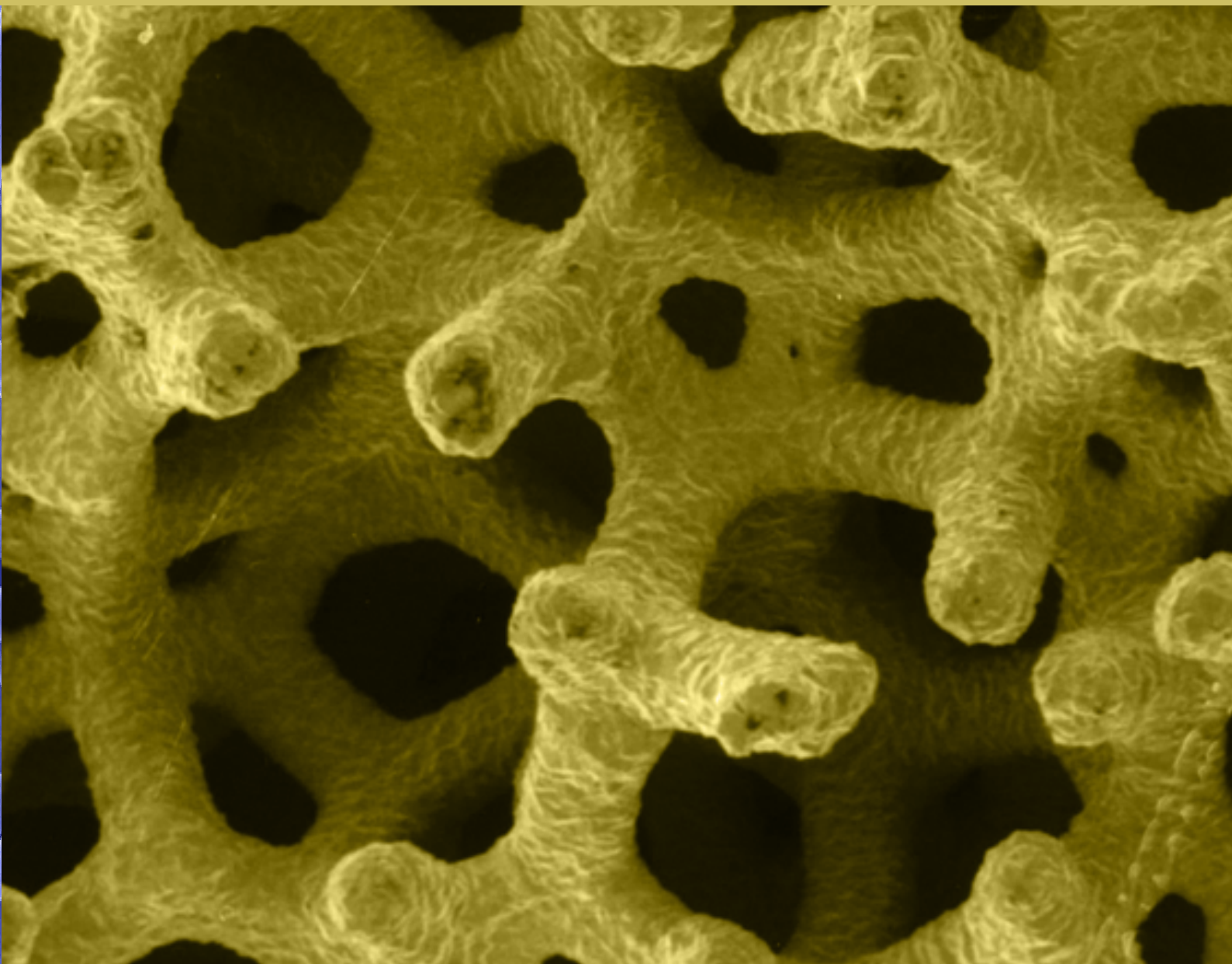


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The health of physiology: a perspective.

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ABSTRACT

What does a health check for Physiology in the 21st century reveal? Has it run its course as a research discipline? Will it soon be confined to the lecture halls and libraries of contemporary institutions? Or on the contrary, does it have a bright future, a central role to play in the pursuit of fundamental knowledge for the benefit of human health? Physiology's current predicament is a paradox of sorts: increasingly invisible, and to some in rapid irreversible decline, yet it appears never as popular in terms of Society membership, and global celebrations of the discipline, which demonstrably go from strength to strength. As with any conundrum, there are elegant solutions, and a growing interest within the community to seek them out. Against the backdrop of significant failings of the modern reductionist approach, Physiology, with its holistic approach to integrative function of complex organisms, has never seemed so relevant and important. Yet there are worrying signs. Morale in many camps is low. Brand Physiology appears in poor shape to those pulling the purse strings; past its heyday, dated, maybe even dead! Many others at the centre and fringes of the discipline are optimistic for Physiology's future, but it is increasingly clear that physiologists must take action, not so as to merely protect Physiology per se, but critically, so as to ensure it is enabled to contribute to the delivery of ambitious expectations set by the wider community, notably funders spending public monies. Physiology is essential to the realisation of plans for better health outcomes. It is pivotal to progress, once one accepts that progress is a slow incremental affair. It is timely that many conversations have commenced with a view to charting a course for Physiology through troubled waters. I hope to add constructively to the debate with observations and discussion serving to nudge Physiology ever closer to centre stage, where she belongs, in the theatre of the life sciences.

Physiology: a puzzling paradox

What should we think of physiology's current predicament, a puzzling paradox of sorts? To many observers things appear quite rosy, the discipline in fine fettle. Membership of learned societies is on the rise, with a steady influx year-on-year of early career trainees, such that now more than ever, there is a greater number of physiologists on the books. A recent analysis by The Physiological Society revealed that the number of graduates and post-graduates in the UK and Ireland with physiology as a main or major component of their degree is increasing over the last decade, significantly at postgraduate level [1]. Attendance at international conferences is increasing too, a useful measure of the health of a discipline in the competitive research arena, with greater focus on collaborative ventures between societies, and on inter-disciplinary meetings between cognate disciplines, highlighting the continued relevance of physiology to the contemporary multi-disciplinary approach to biomedical science. This is notable in an era where there is an embarrassment of riches in terms of choice, ranging from specialized focused meetings to large-scale congresses in an era of unprecedented travel, knowing no bounds. Publications in physiology are also on the rise, an index of research-related activity, whilst society journals demonstrably go from strength to strength [1].

Optimism is somewhat tempered however, when one considers that there has been considerable progress in these metrics too over this period for many established cognate disciplines and indeed neo-disciplines, such as systems biology. Therefore, the extent to which physiology is keeping pace in this new dynamic landscape is perhaps a better reflection of the strength of the discipline in the 21st century. Whatever the answer to that comparison, it is at least clear that physiology is not in recession; nor is it, as some commentators would have us believe, a discipline that is past its sell by date. Realists might point to the obvious decline in visibility for the discipline in recent years, an identity obscured by the successes (and notorious failures) of the 'molecular' brand of science that has dominated. Morale in many camps is low, leading to pessimism about the future of physiology. On the face of it, funding for physiology is in decline [1], though this proves to be a difficult measure to accurately ascertain due to multi-disciplinary awards, itself revealing a new challenge for the discipline—brand identity.

Welcome to the Department of Convenient Amalgamation

There is clearly a brand issue for physiology in the modern era. The Physiological Society's health of physiology report [1] revealed a significant decline in recent years in the UK, in the number of physiology departments or academic units with physiology appearing in the title. Institutional restructuring and rebranding at the tail of the 20th century, as science itself underwent more than cosmetic change, gave rise to amalgamations with often neutral interdisciplinary labels, such as biomedical sciences or life sciences, most often underpinned by strong disciplines, but disciplines that had to concede a crucial element of their identity.

There are many fine examples of sensible and strategically sound new constructs in various institutions globally that led to strengthening of individual disciplines, whilst providing a multi-disciplinary platform essential for large-scale success. There are plenty of examples too, where physiology has integrated seamlessly into modest or massive mergers, pivotal to success but at a price—physiology, in all but name. Such examples prove both encouraging and worrying. Physiology is clearly thriving in these models, which might go some way to explaining the apparent recent growth of the discipline, but its identity requires an institutional memory that can fade, or indeed a history that can be remembered differently. Physiology may not smell as sweet next summer. Moreover, there is considerable potential for a distinct loss of identity at the

interface of the university and the community, which erroneously can suggest that the discipline has withered and been replaced. Worse than that, in some quarters, physiology has been allowed to atrophy, replaced wholeheartedly by ‘nouveau science’. This is particularly problematic when one considers a new generation of trainee biomedical scientists who may not have *real* exposure to the fundamentals of physiology, despite the apparent necessity of such training if the lofty ideals of the institute and its respective funder are to be met, for example in the context of translational medicine.

Whilst the tongue-in-cheek title of this section is admittedly unfair on visionary university administrators (and academics) who presumably are seeking to keep pace with a rapidly evolving state of play, it nevertheless serves as a sad reminder of depressing accounts from colleagues from around the world for whom institutional upheaval and ill-conceived mergers have led to a steady erosion of brand physiology, a discipline that demonstrably once held centre court at many of the same institutions only yesteryear. Sadly, for some colleagues, the vista appears truly bleak.

Lasciate ogni speranza voi ch'intrate

—Dante

Blind spots, deaf ears and hard noses

Physiologists in the community are critical of the apparent blind spot that many administrators (and funding agencies) appear to have for physiology and its relevance in the contemporary discussion of applied research for better human health outcomes. Their dismay grows as appeals appear to fall on deaf ears. Moreover, hard-nosed decisions have disadvantaged physiology, disproportionately it seems, even within the sphere of the biomedical sciences. When one adds to this the more than occasional penchant for poor taste and ironic tendency to be out of touch with the contemporary role of traditional disciplines—erroneously viewed as dated and not relevant—the significant deficiencies of the all-too-powerful bureaucrats can give rise to rather senseless decision making. The result is that many physiologists feel as though they are an endangered species in a rapidly shrinking habitat!

What's wrong with the P word?

How have we arrived at this strange juncture? Where and when did things turn sour for physiology, the noble discipline that once held centre stage? In recent times, I have taken to wonder what's wrong with the P word? Unlike her sister disciplines, the mere sounding of physiology it seems can often and quickly polarize a gathering. There are those for whom it speaks of tradition, a rich and proud history, with its central tenet of organismal function and focus on integration at every level in the exploration of the very logic of life. All with a modern twist, as new generation physiology plays its part in ambitious plans to translate fundamental knowledge to better appreciate disease mechanisms and treatments. But for others, against that backdrop, the discipline is viewed as outdated, in decline, dying, even dead!

An issue is the disappearance of physiology from the lexicon. The re-branding of academic units, whether departments or institutes, and university chairs and traditional degree outlets have led to word substitution (approaching deletion), providing us with a modern dialect strategically aligned to the buzz words of those who pull the purse strings. There is confidence that physiology is alive and well, but hidden. There is concern however that physiology is not being nurtured and adequately promoted, and that it will soon be invisible, lost to a new generation of life scientists.

More popular than Podiatry!

Concern about the public appreciation of physiology is not a new phenomenon. Like many others I have witnessed this first hand during informal and always fun-filled discussion with prospective students and their parents at university open days, where enthusiastic (and loud) students meet staff and students of various disciplines, as they carefully consider the university course that they will next likely embark upon. Despite our posters, props, and other useful paraphernalia, proudly celebrating physiology in action, we are more often than not met with puzzled looks: physiology—what's that? I now recognize a hierarchy in the recognition stakes. School-leavers, at least in Ireland but I strongly suspect elsewhere too, recognize pharmacy, physiotherapy, psychology, and at times pharmacology and psychiatry, ahead of physiology. Encouragingly, once a conversation ensues, it becomes quite clear that they have in fact a much better appreciation of physiology than any of the aforementioned disciplines. They enthusiastically engage in discussion across a far-reaching spectrum of applications. So there may well be an issue with the P word amongst the public in need of address, a point worth returning to later. Parenthetically, whatever the woes of physiology in terms of public perception, encouragingly we consistently find by some measure that it is more recognizable to our guests than podiatry, a discipline surely on firm footing!

Comparatively speaking

Of course one should acknowledge that physiologists themselves have been drivers of much change. The shedding of the physiology cloak was commonplace in many fine institutions, by many fine physiologists. Moreover, the collective romance with the wonders of the molecular world meant that physiologists quickly adopted the language of molecular biologists with a fascination for unravelling the 'molecular mechanism' of a physiological process or phenomenon. More common again was to consider any interest in nervous control of a process sufficient grounds to re-brand oneself a neuroscientist, casting off the shackles of traditional physiology. Neuroscience is a brand that works. It taps into public and professional fascination with the brain, the mind, and more. It carved out an impressive niche, and strongly advocated for greater public understanding of the self-proclaimed discipline and in so doing leveraged an impressive amount of funding, which inevitably perpetuated the fashion. Neurophysiologists followed the trend; they had no choice. One can readily build an argument along the same lines in respect of the public's fascination with the genome. Significantly, in the context of traditional brands, nouveau science offered glimpses of the future, not the past, and promised much that would be delivered on foot of heavy investment. Physiology, though ostensibly still evident of course, was forced to follow suit, evolving into something else: the same, but different. In short, physiology had a great product, but alas a weak brand.

Far from passive during intense competition, physiologists ought to recognise too their role in confining specialized areas of the discipline to the shadows. Comparative physiology is perhaps the exemplar, foolishly under-rated and under-funded, and often seen as the poor relation of mainstream physiology. Physiology's own blind spot may be its casual ignorance of the lessons that nature teaches. Physiologists do little service to the brand by way of sweeping (erroneous) criticisms of sub-sectors of the discipline. The strength of the discipline is its diversity, and holistic approach to the study of organismal function. Into the future, the strength of the discipline depends on greater unity within the discipline.

For whom the bell tolls,

It tolls for thee.

—*John Donne*

Many languages—one voice

Strong voices in the community have provided clarion calls signalling a new dawn for physiology [2, 3]. Their theses are motivated by a passion for the discipline, but much more than that—recognition that physiology must and will take centre stage again in the theatre of the life sciences and medicine. Translation of the wealth of information to hand towards better health outcomes for the population requires integration. Physiology is integration. It is a fundamental starting point in the process of understanding the manifestation of disease, and the complex pathophysiological adaptations and maladaptations of disease. Physiology is function. It is time for many voices to echo this sentiment. The community at large can begin this conversation in the corridors of institutions where physiology has fallen silent. Let them learn that physiology is spoken there (Fig. 1); shout it loud. Within learned societies serving to promote physiology, an increased focus on education and outreach, and policy and communication, will provide the international community with a consistent coherent voice that advocates for physiology.

Reach out to outreach

Public understanding of science is a crucial component of the 21st century landscape for all disciplines, including physiology. Whilst there have been considerable gains made in the translation to the general public of the core activities of physiologists in the community, better communication of the essence of the discipline and its experimental approach is required. It is important that major findings are conveyed to wide audiences through the host of social media channels now available to help disseminate the message. But beyond that, leaders in the community are obliged to reach out to the public to facilitate a better understanding of physiology: what it is and why it is important. The very nature of physiology, the music of life, lends itself to extraordinary opportunities for engagement in arenas where, at first, one might not expect to find it, as I found to my pleasure during an international festival of music, art and conversation in my hometown Cork in September 2015 [4]. As with all good conversations, there is much to say and much to listen to.

Dare to teach

The research agenda prominent in higher education institutes has sometimes negatively impacted on the perception of teaching amongst research active staff. Assurances of parity of esteem for teaching and research activities in the promotion stakes are often sceptically regarded, despite structures that promote pedagogy and career progression through teaching scholarship. Budget cuts and course re-structuring have squeezed out practical provision in biomedical disciplines from many curricula. If public celebrations of physiology are seen as a gateway to university courses centred on physiology, then active provision of experimental physiology within those courses must surely be a key element in the retention of future researchers. It is worrying to learn of the decline of laboratory-based “hands-on” training for undergraduate students of physiology [1]. It is not uncommon to learn that this can extend to significant deficiencies in the provision of final year research projects that match the quality of experience enjoyed by current staff during their student days. Leaders of the discipline must find a way to stop this rot.

Researchers are born in laboratories, not libraries, as the discipline is revealed through experimental design and execution. Re-populating undergraduate curricula with comprehensive laboratory-based experiences, and protecting those courses that have managed to buck the trend are likely to prove essential investments in the future of physiology.

Building the brand: leaders and loyalty

It seems therefore that the major challenge for physiologists is to build the brand. Leaders in this context span the spectrum from novice to Nobel laureate. There will be many faces to the 21st century brand, as dynamic interactions with multiple stakeholders are established. The fulcrum is loyalty. Loyalty to the P word. Loyalty to general meetings of learned societies. Loyalty to physiology journals. Loyalty to physiologists in niche but important areas of the discipline, and to colleagues in developing nations. The ripple effect of meaningful change built on loyalty to brand physiology can be far-reaching.

The turning tide: let's agree on integration

There are those who proffer the notion that the advent of systems biology signalled in effect the end of physiology as a contemporary relevant discipline. Cynics flippantly (or perhaps just humorously) suggest that the neo-discipline *is* physiology—but with funding! Optimists however rightly focus on the comfortable co-existence of these two disparate approaches to the difficult task of unravelling nature's biological mysteries. Beyond the apparent disciplinary differences, it will likely prove useful into the future to consider their similarity, and the potential offered by a combined multi-disciplinary approach. Systems biology strives to link complex molecular networks on a cellular or sub-cellular scale seeking to construct functional representation—a move away from the progressive reductionist approach of molecular biology. It has clear parallels with physiology's endless quest of scaling toward a holistic macro view of organisation and function. Between the two, integration represents a common central tenet. Both approaches are independently valid, but the two together provide a powerful investigative approach. Greater collaboration should help to foster approaches that serve to bridge the many gaps in our knowledge between molecules, mechanisms and malady. By extension, physiology is an obvious partner in interdisciplinary relationships throughout the sphere of the biomedical sciences and medicine.

There is a perception that physiology has endured stormy seas in-and-around the turn of the 21st century. There is a growing sense now however, that perhaps the tide has turned. Physiology's relationship with sister disciplines in the next few decades ought to dramatically shape the landscape of the biomedical sciences in 21st century.

After Fernel: *Physiologia* for the future

There is no reason to doubt Fernel's assertion, borne out of observation and experience, that physiology is the natural part of medicine [5]. In contemporary terms, one cannot simply make the leap from molecule to malady. An understanding of form and function and the pathophysiological process of disease is fundamental. Physiology, which bridges molecule and man, is fundamental. There appears to be a wider recognition in the biomedical community in recent times of this traditional creed. The next step is to encourage patience. The complexity at play is truly astounding. Unravelling this complexity is a slow, but steady, process. It is not a code that can be easily cracked.

Physiologists will determine the future of physiology. It is in their gift to create the future of the discipline. I suggest active optimism. Summer is coming; Physiology is flourishing; build the brand!

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