Perspectives of physiology as a discipline from senior-level millennial-generation students

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Submitted 28 July 2014; accepted in final form 20 April 2015

IN THE LAST SEVERAL DECADES, there has been a shift in the mindset of research structure from classical “systems or integrative biology” to more molecular focused “-omics” study. Systems biology is characterized as an approach to cells, tissues, or organs that “put the pieces together” and examines the effects as opposed to taking them apart and examining the individual components (11). Omics, on the other hand, refer to fields of studies that end in the suffix “-omic,” such as proteomics or genomics, and focus on data representing a set of some kind, whether that be molecules, proteins, lipids, etc. These -omic studies operate on the understanding that if we are to advance the field of medicine to the point of personalized and individual healthcare, we must have a better understanding of what makes an individual unique at the molecular level (8). Whereas the counterpoint emphasizes that, despite great advances in our understanding of genomics and proteomics, the immense complexity of diseases and redundancies in human physiological function are inhibiting our ability to apply this knowledge directly into viable treatment options for today’s problems (6, 10).

A recent topic of debate in physiological societies has been whether or not the -omic revolution has delivered in its promises in both clinical medicine and advancing the field of physiology. More importantly, the question arises as to whether a return to “systems biology” and/or “integrative biology” is necessary to form translational connections between laboratories and clinics and be able to use the new information to directly impact healthcare. (5, 6). In addition, physiology is defined as “the study of living organisms and their parts,” and this definition intimately links physiology to an integrative framework much like systems biology. Whether this integration between the two research areas forms connections between laboratories and clinics occurs or not, this returns the discipline to its original definition.

Numerous established scientists have authored editorials on these ideas and stressed the importance of integrative physiology in both scientific practices and educational systems. They acknowledge that there are current limitations to the application of the discoveries but believe that with the development of new technologies we will be able to integrate these new data to elucidate the complex interactions of biological systems (1–5, 9, 10).

The purpose of the present study was to assess the perspectives on the discipline of physiology from undergraduate physiology majors by determining their preference for areas of study between -omic-type lessons and systems-based course work. Seventy-nine millennial undergraduate students (45 male students and 34 female students) were asked to provide a free response answer on where their interests specifically lie along the continuum of molecular to integrative. Millennials, also known as the millennial generation and generation Y, are a generational cohort born between 1981 and 2000 that currently comprises the majority of undergraduate populations in universities (7). This set of students is representative of a varied curriculum taking classes that stress -omic-type education (cellular/molecular biology) as well as integrative systems biology. The class in which this survey was administered is titled “Capstone Laboratory in Physiology” and is a senior-level course often taken by students in their last semester of undergraduate studies. Approximately 80% of these students state a career plan in healthcare with the majority being premedicine. The free response asked students to respond to the following prompt:

Physiology ranges from molecules to [humans]. That is to say we can think of Physiology ranging from understanding molecules/cells all the way up to whole body/integrative function. Many people have a preference along that continuum (i.e., some like receptor phosphorylation cascades while others like how the body functions at altitude) and/or have favorite molecular/system/integrative function. Where are your interests along that continuum and what molecule/system/integrative function do you enjoy studying?

Student responses were initially broken down into the following three categories: preference for integrative or systems physiology, molecular or -omics physiology, or indifferent between the two/enjoy both equally. Not all responses stated

<table>
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<th>Table 1. Student responses</th>
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<tr>
<td>Cellular/molecular response</td>
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<td>Mixed interest response</td>
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those interested in a preprofessional health track.

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millennial undergraduate students is firmly rooted in systems

pathophysiology.

mental physiology as a topic of interest, and 10.3% indicated

students (19.2%) who specifically mentioned exercise or environ-

and ophthalmology (1.1%; Fig. 2). In addition, there were several

(n6.7%), blood/stem cells/immune system (4.5%), endocrinology

system was the most popular answer (28.1%) followed by the

more than one preferred system of study. The cardiovascular

question, we received 89 responses, as some students provided

students outlined one or more preferred organ systems to study

in their response, yielding an unequal number of responses and

students in the survey results. Of the 79 students asked this

specifically in the precise language as above, and so all re-

ponses were sorted by a single investigator into the most

appropriate category. An example response for each category

is provided (Table 1) as well as student indications of their

preferred areas of interest for study. The vast majority of the

student responses indicated that their interests majorly lay

along systems/integrative physiology (67.1%) and that they

would prefer to study this form of biology rather than indepth

cellular and molecular physiology (22.4%), with 10.5% of

students preferring to study both equally (Fig. 1). Second, the

prompt broke down student responses into various organ sys-

tems and were binned based on functional similarity by the

authors to establish key areas of interest. In some situations,

students outlined one or more preferred organ systems to study

in their response, yielding an unequal number of responses and

students in the survey results. Of the 79 students asked this

question, we received 89 responses, as some students provided

more than one preferred system of study. The cardiovascular

system was the most popular answer (28.1%) followed by the

nervous system/brain (20.2%), musculoskeletal system (14.6%),

respiratory system (7.9%), renal system (6.7%), digestive system

(6.7%), blood/stem cells/immune system (4.5%), endocrinology

(4.5%), reproductive system (3.4%), metabolism/nutrition (2.2%),

and ophthalmology (1.1%; Fig. 2). In addition, there were several

students (19.2%) who specifically mentioned exercise or environ-

mental physiology as a topic of interest, and 10.3% indicated

pathophysiology.

This survey clearly shows that the current perspective of

millennial undergraduate students is firmly rooted in systems

and integrative physiology. Perhaps a shift away from curricula

focused on teaching -omic physiology and a return to and

heaver focus on systems and integrative physiology would be

most appropriate and rewarding for physiology students of the

millennial generation. In addition, with the growth of physiolo-

gy as a stand-alone undergraduate major, this shift in teaching

focus could increase enrollment in such programs, especially

those interested in a preprofessional health track.

Fig. 1. Free response survey results asking millennial undergraduate students

their preferred “type” of physiology to study. n = 78.

Fig. 2. Free response survey results asking millennial undergraduate students

specific areas of interest to study. n = 82.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

Author contributions: M.D.S., J.M.P., and E.A.W. conception and design of

research; M.D.S., J.M.P., and E.A.W. performed experiments; M.D.S., J.M.P.,

and E.A.W. analyzed data; M.D.S., J.M.P., K.L.K., and E.A.W. interpreted

results of experiments; M.D.S. and J.M.P. prepared figures; M.D.S. drafted

manuscript; M.D.S., J.M.P., K.L.K., and E.A.W. edited and revised manu-

script; M.D.S., J.M.P., K.L.K., and E.A.W. approved final version of manu-

script.

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