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JULY 2024

WOMEN AND SCIENCE

The legacies of leading women scientists are putting a spotlight on a critically important area of research.

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Taking Center Stage: Women's Health Research

BY MEEGHAN DE CAGNA, MSC, CAE

Dear reader:

If you were at the 2024 American Physiology Summit, you heard the big announcement. In case you weren't there: APS is proud to announce the launch of a Women's Health Research Initiative (WHRI), which will run through 2025. What started as a side conversation with APS Chief Science Officer Dennis Brown, PhD, FAPS, has now, after multiple brainstorms and conversations, evolved into a full-on Society-wide effort of critical importance. I'm proud to say this next big initiative is a combination of ideas from amazing APS members and colleagues.

> "The WHRI will elevate the status of women's health and the research APS members are conducting to address health and disease in women."

The WHRI will elevate the status of women's health and the research APS members are conducting to address health and disease in women. Through the power of its community, APS will leverage the expertise of biomedical scientists and science policy and advocacy experts to elevate women's physiology research topics. As part of this initiative, we will offer an expansive scientific webinar series, science policy and grassroots advocacy efforts, teaching curriculum through the Center for Physiology Education, and special calls for papers and curated content collections through the APS journals.

Learn more about the WHRI, how it will evolve moving forward, and the legacy of women in science in our feature article on page 18. In the article, we showcase women in physiology, including nine of our former women presidents, and we tell the story of the WHRI through their lens. It was a joy to get together with them at the Summit—the first time a gathering of past women presidents has occurred—where we photographed them for this issue. The article is a great celebration of how far we've come and the exciting new initiatives we're working on!

THE REST OF THE BEST

Our feature article on page 24 showcases entrepreneurs in physiology. You'll learn how these scientists are taking their research from the bench to bedside. We see how their scientific passion and discoveries inspired them to secure patents, launch companies, and seek funding and collaborations.

In celebration of the Summer Olympics in Paris this year, we bring you a feature on page 30 about the science of sport, diving into the field of exercise physiology. You'll read how studying performance in athletes helps us regular folks, too. And be sure to read the sidebar, which describes the important and fascinating work of the Partnership for Clean Competition.

The sports feature syncs nicely with our upcoming conference also: the APS Integrative Physiology of Exercise conference, November 20–22, 2024, at the Noll Laboratory for Human Performance Research at The Pennsylvania State University. We are excited about this event, which will cover topics such as human performance, thermoregulation and aging, resistance and cardiovascular issues. You can learn more at **physiology.org/exercise**.

WHAT DO YOU WANT TO READ ABOUT?

We rely on you, the members of APS, to make *The Physiologist Magazine* happen. Please share any feedback, suggestions or story ideas with us at **tphysmag@physiology.org**. Thank you for sharing your thoughts with us, and we hope you have a wonderful summer.

Meeghan De Cagna, MSc, CAE, is APS chief community and learning officer and associate publisher and editor-in-chief of *The Physiologist Magazine*. You can reach her at mdecagna@physiology.org.

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LUNG PHYSIOLOGY

Kids' Lingering Lung Issues after RSV

Most children contract RSV (respiratory syncytial virus), a lower respiratory tract disease, before age 2. Mild forms of the disease mimic the common cold, with symptoms such as coughing, runny nose, congestion and sneezing. More severe cases of RSV can include wheezing and breathing difficulties. According to researchers, these issues may linger on—in the form of allergies and asthma—well after the infection has resolved.

A recent study in the *American Journal of Physiology-Lung Cellular and Molecular Physiology* showed that infant mice had "significant defects" in the ability of the lungs to stretch and expand during breathing as long as three months after RSV infection. The research team found structural changes to the mice's lungs as well, including an increase in the size of alveoli—the tiny sacs in the lungs responsible for gas exchange—but fewer individual alveoli. "Importantly, the structural defects of the early-life infected mice largely mimic the clinical setting where severe exacerbations are observed in children for several years following a severe early-life respiratory infection, especially RSV," the researchers wrote.

Source: **doi.org/10.1152/ajplung.00300.2023**

HEART AND CIRCULATORY PHYSIOLOGY

Another Reason to Give up Nicotine: Irregular Heartbeat

Smoking is a known risk factor for heart disease, including heart attack. Using nicotine-containing products can also increase the risk of heart failure, arrhythmia and sudden cardiac death. Nicotine affects the autonomic nervous system and the heart's tissues. Autonomic dysregulation could explain the higher risk of irregular heartbeat in people who smoke, but the exact mechanisms are not yet clear.

A study in rabbits exposed to nicotine examined cardiac sympathetic responses, electrophysiological and structural remodeling of the heart and how these factors influence the potential for arrhythmia. The study in *American Journal of Physiology-Heart and Circulatory Physiology* showed that after 28 days of chronic nicotine exposure, the animals' hearts showed reduced sympathetic nervous system responses and changes in the electrical responses that could be considered harmful and may worsen with longer-term exposure to nicotine products.

Source: **doi.org/10.1152/ajpheart.00749.2023**

All photos: iStockphoto

APPLIED PHYSIOLOGY

Cool Outside? Down a Glass of Beetroot Juice

Beets are known for their bright color, earthy flavor—and their ability to lower blood pressure. Rich in nitrate, a compound that helps the blood vessels relax to improve blood flow, beets can help offset blood pressure spikes often seen in people who eat a diet high in salt.

A recent study in the *Journal of Applied Physiology* found that young men who drank beetroot juice in a cool temperature of around 68 degrees F had higher blood nitrite levels than when they drank the juice in a warmer environment (around 83 degrees F). Nitrite converts to nitric oxide, the compound that promotes blood vessel dilation. The researchers hope the findings will minimize "the cardiovascular strain that accompanies acute cool air exposure."

Source: **doi.org/10.1152/japplphysiol.00593.2023**

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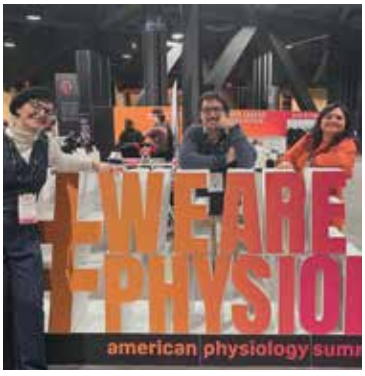
Wayne State University

Stanley Andrisse, PhD
instagram.com/prof_andrisse

Physiology Dept representing at the American Physiological Society #APS2024 Summit #HUYouKnow #blackinphysiology

Vagner Roberto Antunes, PhD
instagram.com/neuralcirculation

Today we finished our attendance at the American Physiology Summit 2024, in Long Beach, California, USA. We presented some work developed at neuralcirculation, had days of much discussion and learning with our peers, promoting the best quality science. Furthermore, we [met] old friends and did networking, so good things are coming! See you next year!



Scott K. Ferguson, PhD
instagram.com/dr.skfergus

My team was a bit bigger this year for the @apsphysiology summit in Long Beach. It was such a treat to share science and [excitement] for physiology with so many great people. I loved getting a chance to make memories with old friends and meet a few new colleagues from across the globe. We were even treated by a lecture from @astro_jessica who closed the meeting after my doctoral mentor, Tim Musch, took the reins of the APS as president. Thanks to all who made time to connect and for my students (past and present) who make all of this work possible! Hope to see everyone next year in Baltimore!

Arohan Subramanya
x.com/arohan_s

Back from #APS2024—was great to see such amazing science & connect w/ friends old & new. And with that, so ends my term as @APSETG Chair. Proud of the lecturers we honored & the trainees we supported. With @goutyprof taking the reins, ETG's future is bright! @pittkidneyctr

Mridula Pachen, PhD
facebook.com/mridulapachen

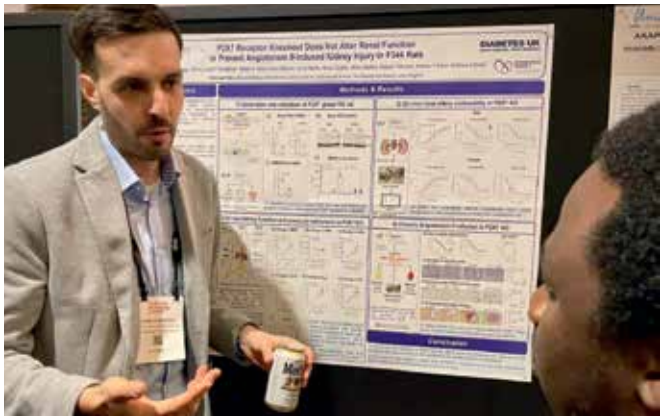
✅ American Physiology Summit, Neural Control and Autonomic Regulation session, Long Beach, California. My talk on my latest research on heart failure, one of the featured presentations in this session. #APS2024 #day2incalifornia #visittoamerica #apsconference

David Pollock
x.com/davidpollock929

Thanks to the Pollockian Clan for a great APS Summit! So glad to see you all!! @APSPhysiology #WeArePhysiology

Josselin Nespoux, PhD
facebook.com/josselin.nespoux

I had a great time at the fantastic #aps2024 summit. My jet-lagged brain still managed to learn so much and I am heading back to Edinburgh with lots of ideas. I am honored to have been shortlisted for the Renal Section Postdoctoral Excellence in Research Award for my work on the P2X7 receptor. It was also great to meet and touch base with many great kidney scientists! Until next time!



Vivian Tran
x.com/vivianvtran

This was my first @APSPhysiology conference and I already can't wait to come back! I've learnt so much in the last couple of days and am excited to take it back home. Thank you to the organisers for an incredible #APS2024!

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LAB NOTES

MENTORING Q&A YOUR QUESTIONS ANSWERED
FROM EXPERIENCE LEADERSHIP AND CAREER TIPS
POLICY IQ PHYSIOLOGY ON THE HILL AND IN THE HALLS
UNDER THE MICROSCOPE OUR MEMBERS, UP CLOSE
PUBLISH WITH POLISH BUILD A BETTER RESEARCH PAPER
IN DEPTH DIVING DEEP INTO SCIENCE
STATS & FACTS PHYSIOLOGY BY THE NUMBERS

MENTORING Q&A | POSTDOC PREPARATION

Landing a Postdoc Spot

How to showcase your skills and experiences to future employers.

Each issue, we ask a student or early-career member to pose their career questions to an established investigator and mentor. Here, Marissa Westenskow, a doctoral candidate at the University of New Mexico Health Sciences Center, asks Antentor O. Hinton Jr., PhD, about how to prepare for and secure a postgraduate position. Hinton is an assistant professor in the Department of Molecular Physiology and Biophysics at Vanderbilt School of Medicine Basic Sciences in Nashville, Tennessee.

Illustrations by Kagan McLeod

Q: How can I market my graduate school skills and experiences to future employers?
A: One of the most important skills from graduate school is being a self-advocate. Focus on the research projects undertaken during graduate school, emphasizing not only the technical skills but also project management, problem-solving and collaboration abilities.

Promoting skills learned should not be exclusive to laboratory skills, but rather the complete suite of advantages you can offer and the perspective that you bring as a result of your cumulative life experience. This includes showcasing any publications, presentations or grants and highlighting any teaching, mentoring or leadership roles that indicate an ability to communicate complex concepts effectively and lead teams.

Q: What does a reasonable timeline for obtaining post-graduation employment look like?
A: The timeline will vary, and it is important to have a diverse mentoring network to offer advice on fellowships. Generally, one should start searching for postdoctoral fellowships or other jobs at least six to 12 months before graduating. This allows sufficient time for networking, researching potential positions and preparing application materials. Being open and honest about your timeline is important, as unexpected delays may come up.

Q: What are some things to consider regarding peer mentoring and preparing less-experienced trainees to take on more senior roles in the lab?
A: Mentoring is the lifeblood and fuel of scientific innovation. However, critically, there is no one-size-fits-all approach to mentoring. Rather, intentional and individualized mentoring is necessary. Generally, I've found a structured mentoring program with multiple mentors is helpful to prepare less-experienced trainees. I pair junior trainees with more experienced researchers for guidance and support, as well as pair mentor groups and mentoring triads with postdoctoral fellows and myself, the principal investigator (PI). This provides multiple sources of encouragement and advice.

As a PI, I encourage open communication and provide opportunities for skill development through workshops, seminars and hands-on training. These mentoring networks also foster a collaborative and inclusive lab culture where everyone feels valued and supported in their professional growth.

Q: How should an early-career researcher navigate a transition into a new field of physiology after graduate school?
A: This requires careful planning and adaptability—again, mentors will be a critical resource in such a change. Drawing on existing networks, you should seek to see if you have someone in the field you wish to transition into. If you do not already know somebody, do not be afraid to reach out to your mentors or colleagues to let them know about your transition and ask if they can connect you to relevant researchers in the new field.

While a new field can be intimidating, remember that you will have many transferable skills and experiences from graduate school that are relevant to the new field. Highlight those in applications. While the transition can be daunting, embrace the learning curve and be open to new challenges that can lead to opportunities for growth.

Got a career question you'd like to submit? Email it to tphysmag@physiology.org. We may use it in an upcoming Mentoring Q&A.

"Mentoring is the lifeblood and fuel of scientific innovation."

STATS & FACTS

1977

The year the U.S. Food and Drug Administration (FDA) issued guidelines recommending "women of childbearing potential" be excluded from early clinical trials. The definition specifically included women using contraception and those "whose husbands had been vasectomized."

U.S. Food and Drug Administration

8 out of 10

The number of drugs withdrawn from the market by the FDA between January 1997 and December 2000 that had greater adverse effects on women than on men. For four of these, the disparity could be because they were disproportionately prescribed to women.

U.S. Government Accountability Office

"Our data suggest that many of the cultural themes that contributed to the underrepresentation of women across clinical trials prior to the 1990s still shape sex-based research exclusions."

Margaret Waltz, Anne Drapkin Lyerly and Jill A. Fisher in the 2023 article "Exclusion of Women from Phase I Trials: Perspectives from Investigators and Research Oversight Officials"

Ethics & Human Research

FROM EXPERIENCE | INNOVATION

Embrace What's New

Be open, stay open.

For long-term career success and fulfillment, stay wide open to new ideas, to new colleagues and to collaborating with different people. When Laurent Messonnier, PhD, professor at Université Savoie Mont Blanc in France, was an assistant professor, he had the opportunity to work in the laboratory of Professor George A. Brooks at Berkeley—a formative experience for him. "I grew a lot through his mentorship and met so many new colleagues and friends," he says. "It was our discussions and our sharing of ideas that greatly improved my general scientific level." Being open to these experiences fosters innovation and may even lead to your next breakthrough.

Share your best advice, leadership tip or productivity hack with us at tphysmag@pshyiology.org.

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POLICY IQ | ADVOCACY SKILLS

The Path to Science Advocacy

Summit speakers share how to get more involved in public policy.

Anyone with a research background can start making a difference in public policy. Panelists at the 2024 American Physiology Summit's science policy symposium explored ways to make that happen. Speakers Emily Berry, PhD, and Debra Cooper, PhD, discussed their paths from the bench into careers in policy and the lessons they learned along the way. They highlighted critical skills necessary to be an effective advocate for science, such as collaboration and teamwork, and outlined the ways a researcher can start to make that career transition.

However, you don't have to leave your scientific career to be an effective advocate. APS member Jazmine I. Benjamin, PhD, joined Berry and Cooper to represent that perspective. Benjamin, a medical science liaison at Syneos Health in support of Ipsen Pharmaceuticals, has met with congressional offices to advocate for stronger science funding through her participation in the APS Early-career Advocacy Fellowship and as a Howard Garrison Fellow with the Federation of American Societies for Experimental Biology (FASEB).

For researchers looking to make a career transition, a career in science policy can take many forms. Berry works in the California State Assembly as a legislative director. Working in a state or national legislature means a fast-paced environment that demands adaptability and quick thinking. Just like experiments in the lab, not every legislative effort is successful. But there is always something new to work on.

Cooper brought a different perspective from her work as assistant secretary with the California Health and Human Services Agency. She faces many different policy issues in her role and emphasized the importance of communication and collaboration.

There are many ways to take the first step into science advocacy, from reaching out to your state representative or senator to participating in an organized Capitol Hill Day event. U.S. residents can contact their members of Congress at any time to promote funding of scientific agencies or to discuss specific policies. Advocating for science doesn't have to be a huge time commitment—it can be as simple as making a phone call or writing a letter.

Stay updated on policy efforts and sign up for APS Action Alerts at physiology.org/advocacy.

GET MORE INVOLVED

New APS Advocacy Course

APS is now offering a course on science advocacy, in which you can learn how to tell Congress about the importance of supporting research. Learn more at **physiology.org/advocacycourse**.

Science Policy Fellowship

If you are interested in a science policy career, consider applying for a fellowship. Several state-level fellowships are available, including the California Council on Science & Technology Policy Fellowship. National fellowships include the AAAS Science & Technology Policy Fellowship and the Christine Mirzayan Fellowship program with the National Academies. Some FASEB societies offer fellowship opportunities as well. Learn more at **faseb.org/awards/member-society-fellowships**.

UNDER THE MICROSCOPE | EDUCATION INSPIRATION

The Power of Teaching

Finding inspiration from students and helping them find their path.

Erica A. Wehrwein, PhD, FAPS, is an associate professor of physiology at Michigan State University (MSU). She is passionate about teaching, service and mentoring with students at the K–12, undergraduate and graduate/professional levels.

ROLE MODELS. My two main role models on my path to being a scientist are my mom and my award-winning high school biology and chemistry teacher, Mr. Ellis. My mother intentionally fostered my curiosity and gave me every opportunity to thrive. She was trained as an elementary school teacher and used those skills to teach me as a child. We went to museums, played learning games and explored. Mr. Ellis mentored me in an independent research course, where I learned experimental design, data collection and statistics. It was from Mr. Ellis that I first learned about graduate school.

MINDSET SHIFT. I try to see misfortune or mishaps as opportunities. I developed a severe allergy to the lab animals during my PhD such that I had to wear a full canister filtration mask (affectionately known as the Darth Vader mask) to finish my dissertation work in rats. This was a turning point that allowed me to explore human research and teaching. It led me to choose a postdoctoral fellowship at Mayo Clinic in integrative human physiology. I am thankful for that fork in the road that took me to a very rewarding career focused on teaching a human physiology capstone laboratory course to pre-health students and medical school physiology, both of which draw heavily on my Mayo Clinic training.

A BRIGHT FUTURE. I am one of the rare people who feels that my work is truly aligned with my core values and purpose. It is an honor to be in this role. My favorite part of my job is to be inspired by new students every semester. I see students daily who aim to live a life of purpose and contribute to the world in positive ways. Through my lens, we have a lot to be hopeful for in the future because of them.

LIFE MEETINGS. I find deep purpose in the mentoring aspects of my job as I coach students on their career path and professional skills. I have "life meetings" to help my students find their next steps. I work with seniors and want to be present at this critical time as they step into their life beyond college and really find out who they are. My least favorite part of my job is dealing with the glacial pace of academia. I like to innovate, make positive changes, fix problems and have impact. It can be frustrating when things are stymied by unnecessary process and naysayers.

> **"My favorite part of my job is to be inspired by new students every semester."**

PHYSIOLOGY IS THE KEY. The biggest misconception about physiology is that it is an irrelevant discipline. Physiologists are the key to ensuring understanding of whole-body function, organ system interactions and feedback loops. While there are insights to be gained through advanced genetic and molecular techniques, we need scientists who can put the pieces together and study the impact at the level of the whole body. Now is the most crucial time to reinvigorate and restore the role of physiology in science and education.

Do you know someone we should meet? Email us at tphysmag@physiology.org and tell us more.

PUBLISH WITH POLISH | WOMEN'S HEALTH

Women's Health Research Collections

Society journals will spotlight critical research in a variety of ways.

iStockphoto

In March 2024, President Biden signed an executive order to launch the White House Initiative on Women's Health Research. This far-reaching program demonstrates a renewed high-level interest in women's health throughout the lifetime. APS is on board, organizing its own Women's Health Research Initiative (read more about the launch of the initiative on page 18).

This effort will involve several areas of the Society, including the Publications Division. As part of the initiative, APS Publications will leverage current and future content to spotlight women's health research in its journals. An online collection of journal articles will be sourced from the APS portfolio to represent diverse scientific perspectives on women's health research. The collection will also be promoted in conjunction with a translational research webinar series the Society is organizing, broadening the reach of both efforts.

New Calls for Papers

To highlight specific areas of interest, the journals will introduce new calls for papers centered on women's health. Each journal-specific call for papers will also be featured in the cross-journal collection. In line with the above initiatives, the *American Journal of Physiology-Heart and Circulatory Physiology* paved the way for expanding physiological reporting to include female/women subjects in research articles. In 2023, the journal began requiring authors to consider sex as a biological variable in cardiovascular research (or provide strong scientific justification otherwise). This policy aligns with the National Institutes of Health's (NIH) expectation that "sex as a biological variable will be factored into research designs, analyses and reporting in vertebrate animal and human studies."

The *AJP-Heart* policy on Sex and Gender in Study Design was met with great success, with only 2% of manuscript submissions declined in its first few months due to a lack of sex/gender balance. The pilot was so well-received that other APS journals are developing their own plans to roll out similar requirements. Additional resources for authors and editors include the Sex and Gender Equity in Research guidelines and the NIH Office of Research on Women's Health website.

What's Ahead

"APS Publications is excited to build on APS' reputation as a leader in women's physiological health research," says Colette E. Bean, MA, APS chief publishing officer. "By engaging authors, editors and peer reviewers in publishing women's health research, we hope to leverage the breadth and depth of our publications to elevate existing research in women's health and encourage development of new research studies to improve women's health and well-being."

Learn more about the Women's Health Research Initiative at physiology.org/WHRI.

STATS & FACTS

1993

The year Congress passed the National Institutes of Health (NIH) Revitalization Act of 1993 that mandates that women and minorities be included in NIH-funded clinical research.

NIH Office of Research on Women's Health

22%

The portion of Phase I clinical trial participants who were women, according to a 2018 analysis of FDA registration dossiers.

British Journal of Clinical Pharmacology

"[NIH funding] really brought us to life."

Testimonial from Meng Chen, PhD, co-founder and vice president of Nanova Inc. The biotechnology company used NIH Small Business Innovative Research funding to develop a stent for coronary heart disease that is less likely to cause clotting.

U.S. Small Business Administration

$1.3 billion

The amount set aside from NIH's Research & Development Funding specifically for small business programs.

NIH Small Business Education and Entrepreneurial Development

IN DEPTH | DATA SCIENCE

The Power of Data

Research on how to use data differently could transform health care and address health disparities.

Niranjan Karnik, MD, PhD, is a professor of psychiatry at the University of Illinois at Chicago, where he also serves as director of the Institute for Juvenile Research, co-director of the Institute for Research on Addictions, and interim director of the AI.Health4All Center for Health Equity Using Machine Learning and Artificial Intelligence. Karnik leverages data science, technology and community-based interventions to advance health equity.

How do you describe your area of research, and how did you get interested in it?
I am a child psychiatrist by training, and my PhD is in sociology. My work covers three major domains: clinical trials, working with underserved populations using technology as a bridge, and leveraging artificial intelligence and data science to improve health care for patients. I became interested in this last area when I was a graduate student. My PhD adviser was a sociologist and one of the few women in the field looking at computers, data and information. She showed me how important social elements are in thinking about data and information.

How are you innovating in data science and health care? Why is this important?
We're no longer in a time where you can just have one piece of data or one type of data and be able to use it effectively. For example, new therapeutics for cancer are increasingly using genomic data from the cancers to develop the intervention and to personalize that treatment for the individual and their cancer. This requires a lot of data, but genomic data is just one piece of it. We also need to think about what other elements of data are around that person, especially in terms of social determinants of health. It's great that we can design a cellular intervention to address a certain cancer, but it won't make a difference if the patient can't get to the hospital to receive it.

At the AI.Health4All Center, we are developing an approach to manage and make data accessible for researchers. We are working very hard to pull data from our electronic health records system into an environment that's called a data lake, where it could be accessed by researchers for various types of research. This system will contain structured data such as vital signs or lab data—data that has fields in the electronic health records—as well as narrative and imaging data, which includes information that doesn't fit neatly into a form. We are thinking more broadly about data as we start to have different types of omics data, as well.

Drazen Zigic

What challenges are there in building a system that holds so many types of data?
The challenges are in figuring out how to bring all that data together and how to manage it while also determining how much data is enough and how much is too much. For example, in one of my studies, I gave smartphones to youth experiencing homelessness to see if we could use the devices to engage these young people who had psychiatric and substance use problems but who were not in a place where they were going to come to the clinic. We started looking at geolocation to find out where they were in the city of Chicago. It turns out that an enormous amount of location data is produced by just one device—too much for me to use as a clinician. So, we had to figure out what distances of movement were important. We found out that geolocation tended to correlate with degree of depression and degree of post-traumatic stress disorder in the study participants.

There is a similar challenge when we think about data that comes from people doing more basic science work. Because this data can also be either too fine-grained or not fine-grained enough, we have to figure out the right level of detail for each data type. When you start to combine data to make predictions, it gets even more complicated because this requires figuring out how much to weigh one type of data versus another. For example, how much does someone's genetics predict their cardiovascular disease risk versus their movement and exercise? We understand this at a population level, perhaps, but we don't know this at the individual level.

"We're no longer in a time where you can just have one piece of data or one type of data and be able to use it effectively."
—Niranjan Karnik, MD, PhD

How could this work help improve health care?
My hope is that the system we're developing helps bring us closer to the idea of precision medicine—where we can tailor interventions to the needs of the person in their unique circumstance. For our center and our university, we also hope that data will help us address health equity issues and health disparities.

We want to start to think about to what extent we can combine various measures and electronic tools with the science that is developing. There are algorithms that provide early prediction for sepsis, for example. We want to find out if you can use similar approaches around other issues such as substance use. My team is trying to predict substance use disorders in inpatient environments by using algorithms that scan the electronic health record within the first 24 hours of admissions. This creates a list of patients in the hospital who are at the highest risk of substance abuse. A team then goes and sees these patients in the hospital. We found that 70% of the patients identified had been identified by other systems. However, about 30% of patients were not known. For these patients, the team worked to understand their situations and offered possible changes or interventions for consideration. This model was very successful in one hospital system, and we're looking to replicate it at a few more.

How do you motivate your team to tackle these ambitious projects?
Some of the biggest challenges I've faced in my career have come from people who don't seem to have a larger vision to drive their work and get very bogged down in the details. I try to encourage my mentees and the faculty working with me to think about the larger context. I tell them I don't want to hear about incremental science. I want to hear big ideas. We're not going to advance if we just take little steps.

Interview conducted by science writer Nancy D. Lamontagne.

STATS & FACTS

48%

The portion of drugs for orphan diseases approved by the FDA between 1998 and 2007 developed in a university lab.

Nature Reviews Drug Discovery

1 million+

The number of competition results, over 46 athletics event groups, processed by the international governing body, World Athletics, annually.

World Athletics

38 years

The time between the setting of the previous world record in men's discus throw in 1986 and the new record, set April 14, 2024, by Mykolas Alekna of Lithuania.

Reuters

"Four minutes was the Everest, and somebody said to me recently it's like they've put a chairlift up Everest now."

Track and field coach Peter Thompson tells CNN how running the men's mile in under four minutes has shifted from a historic achievement to a regular occurrence.

CNN Sport

Women *and* Science

The legacies of leading women scientists are putting a spotlight on a critically important area of research.

BY AMANDA BERTHOLF

Photograph by Rainer Hosch

Past APS presidents, from left: Patricia Molina, Kim Barrett, Susan Barman, Dee Silverthorn, Linda Samuelson, Jennifer Pollock and Hannah Carey.

In 1918, Danish physiologist and physician Marie Krogh developed gestational diabetes while pregnant with her youngest child. As a result, she and her husband, Nobel Laureate in Physiology and Medicine August Krogh, became focused on potential treatments for the disease. Shortly after the discovery of insulin in 1922, the Kroghs became instrumental in bringing it to Denmark and spreading its use as a treatment for diabetes throughout Europe. They also founded the Nordisk Insulin-Laboratorium, which today, as Novo Nordisk, is one of the largest pharmaceutical companies in the world.

That baby born in 1918 from a line of brilliant scientists was Bodil Schmidt-Nielsen, who went on to become an eminent physiologist in her own right. During her long career, Schmidt-Nielsen, DDS, DSc, carried out significant studies on fluid and electrolyte balance and nitrogen excretion in mammalian and non-mammalian vertebrates.

In addition to her accomplishments in research, Schmidt-Nielsen was the first woman elected president of APS. This year marks the 50th anniversary of her historic election in 1974. At the time of her election, Schmidt-Nielsen said, "I think the best way I can represent women in physiology is to do my best possible job as president."

The legacy she started of women in APS leadership continues today. Since Schmidt-Nielsen was elected, 10 other women have served as APS president, and the Society has continued to evolve, reflecting a more diverse membership and leadership. "Increasing participation of women in setting priorities for development and growth leads to an organic evolution of initiatives supported by the Society," says Patricia E. Molina, MD, PhD, FAPS, professor and chair of the Department of Physiology at Louisiana State University Health Sciences Center New Orleans. Today, women are thriving in the Society:

- Half of APS section chairs are women.
- Nine editors-in-chief of APS journals are women.
- Nine of the 17 committee chairs are women.
- Eight of the 12 elected members of the APS Council are women.

To continue that legacy of women leading the way in science and to shine a spotlight on a critically important area of research, this year APS has launched the Women's Health Research Initiative (WHRI). At the 2024 American Physiology Summit in Long Beach, California, nine of the past women presidents of APS were on hand to introduce the initiative, including three member advisers who are directing the effort: Janie Reckelhoff, PhD, FAPS; Linda Samuelson, PhD, FAPS; and Kim Barrett, PhD, FAPS.

For the next year and beyond, APS will leverage the expertise of biomedical scientists and science policy and advocacy experts to elevate issues surrounding the state of women's health research and increase the visibility of women's health research specialties and investigators. In partnership with the Society for Women's Health Research and National Institutes of Health (NIH), and in support of the White House Initiative on Women's Health Research, this effort will address topics such as autoimmune diseases, breast cancer, cardiovascular disease in women, migraines, novel perspectives on sex as an investigative variable, menopause, pregnancy and postnatal conditions, and more.

The WHRI presents an opportunity to provide education and awareness of basic and translational research that may improve the understanding and treatment of diseases that affect women exclusively or predominantly, as well as gender disparities in health care. "We have a chance to highlight the importance of considering gender-specific differences in disease presentation, diagnosis, treatment and outcomes and make the world a healthier place," says Susan Barman, PhD, FAPS, professor in the Department of Pharmacology/Toxicology at Michigan State University.

Molina says this work is important because when women spend their lives in poor health or with varying degrees of disability, it affects their ability to fulfill their roles at home, in the workforce and in the community. "They also report adverse, serious and fatal events from approved medicines more frequently than men," she says. "Because women carry most of the burden for child care, focusing on closing the gap in sex and gender health equity will positively affect society and improve future generations' health."

ADDRESSING THE GAPS

Prior to the 1990s, women were rarely included in clinical trials and research studies, despite accounting for nearly half the global population and outnumbering men in the U.S. for decades. Policies aimed

at protecting fetuses and pregnant women, historical prejudice, misconceptions about women's health, and the difficulty in recruiting women for trials and studies have led to them being underrepresented in research. This has created gaps in the scientific understanding of women's health. "By ignoring females in research, we overlooked that the physiology of women is not always the same as that of men and that promoting women's health may require a different approach," says Dee Silverthorn, PhD, FAPS, Distinguished Teaching Professor of Physiology emerita at Dell Medical School at the University of Texas at Austin.

One such policy by the U.S. Food and Drug Administration (FDA) was a result of the thalidomide tragedy in Europe in the early 1960s. Although it was not approved by the FDA for use in the U.S. at the time, thalidomide was available over the counter in Europe, where it was marketed as a medication for morning sickness and deemed safe to use during pregnancy. However, it caused severe birth defects in more than 10,000 children across Europe and resulted in thousands of miscarriages. As a result, many governments and medical authorities tightened their pharmaceutical review processes. In 1977, the FDA called for an exclusion of women of reproductive potential from Phase 1 and 2 clinical trials unless they had a life-threatening condition.

Researchers and medical investigators also excluded women from studies due to concerns that their hormonal cycles would interfere with the results and would not provide a stable baseline to measure specific mechanisms against. This led to an emphasis on using male animals for studies, using experimental models or male patients—and male health getting a lot more attention. "Most scientists back in the day were men," says Kim Barrett, PhD, vice dean for research and distinguished professor of physiology and membrane biology at UC Davis School of Medicine. "Most organizations were headed by men. There just was a natural emphasis on men."

Today, female subjects continue to be underrepresented in animal research across disciplines. Some researchers who conduct animal studies avoid using female mice, believing the use of females will hamper research because of the need for increased samples sizes and the increased costs. A 2018 review published in *Current Opinion in Behavioral Sciences* found male bias in studies from eight out of 10 fields: general biology, neuroscience, physiology, pharmacology, endocrinology, behavioral physiology, behavior and zoology—reproduction and immunology were the exceptions.

A Blueprint to Move Women's Health Research Forward

The work and activities of the APS Women's Health Research Initiative (WHRI) fall into four areas and will highlight critically important areas of research that have been under-explored and under-appreciated, says Dennis Brown, PhD, FAPS, chief science officer at APS. "This effort will raise the profile of physiology in the broader scientific and biomedical community," he says. "A detailed exploration into women's health-related issues is an important priority for APS moving forward, and we hope it will stimulate all biomedical scientists to incorporate sex and gender considerations into their research programs." Here are the main components of the initiative:

Virtual and live events

- Translational research webinar series on women's health topics such as breast cancer, migraines and Alzheimer's disease.
- Women's research forum discussions
- Special sessions at the 2025 American Physiology Summit
- Sex and gender specialty conference

Science policy and grassroots advocacy

- Policy statement supporting increased funding for women's health research
- Materials and resources to help scientists advocate to policymakers and the public

Publishing

- Special APS journal article collections
- Calls for papers
- Themed episodes of journal podcasts

Center for Physiology Education

- Resources to incorporate women's health into advanced physiology education curricula

For the latest updates on the APS Women's Health Research Initiative and to learn about how you can get involved, visit **physiology.org/WHRI**.

> **"The more that investigators hear about the fact that there are gender differences, it's going to raise awareness."**
>
> **—Janie Reckelhoff, PhD, FAPS**

Barrett says the lack of female subjects in studies has led to health care disparities. "We have such a wealth of information about physiological mechanisms and pathophysiological mechanisms and disease," she says. "But so much of that information derives either from studies of male animals or studies of male humans."

MAKING CHANGES

When Bernadine Healy, MD, became the head of NIH in 1991, she pushed for researchers to include women and minority groups in all NIH-funded research. But there was a lack of funding and no enforcement mechanisms. Janie Reckelhoff, PhD, FAPS, Billy S. Guyton Professor and Chair of the Department of Cell and Molecular Biology and director of the Women's Health Research Center at the University of Mississippi Medical Center, says this led to more attention on including women in research, but not to the extent needed. "The data were never separated from men and women. They were all combined in one group," Reckelhoff says. "For example, when the notable study came out that said aspirin is supposed to protect you from heart disease, well, that works in men, but it doesn't work that way for women. What works for women is that aspirin prevents strokes. Those are big differences."

Fast forward to 2012 when Janine Clayton, MD, became director of the NIH Office of Research on Women's Health. She's the architect of the NIH policy requiring scientists to consider sex as a biological variable across the research spectrum. The policy received resistance initially. But once the policy began to take effect, researchers were finding differences. "I always tell people to look—look at the animal model and see if the females and males are different, and they always are," Reckelhoff says. "It doesn't matter what it is. It's exciting when you can get people to actually do the experiments."

But there's more work to be done. Despite policy and social changes, women remain underrepresented in research. A study published in *Contemporary Clinical Trials* found from 2016 to 2019, women accounted for just 41% of participants in trials. The underrepresentation is significantly higher for women of color.

"Researchers are 'factoring' for sex, but I have no idea what that means," Reckelhoff says. "They are not actually looking at the men and women separately and then doing an analysis." Reckelhoff cites the SPRINT trial, which set the guidelines for blood pressure control. The studies were conducted with 60% men and 40% women, and because there were so few women in the trial, researchers did not separate the data. The study indicated a blood pressure reading of 120 mm Hg resulted in reduced cardiovascular events. But when a group of women cardiologists analyzed the data, they found that women were not as protected from these events as men at that blood pressure reading.

"We're still fighting this, and so that's why it's important to get the Women's Health Initiative rolling right now," Reckelhoff says. "The more that investigators hear about the fact that there are gender differences, it's going to raise awareness."

THE RIGHT TIME

APS and the physiology research community have been out in front of this issue for decades. "Physiology research has been near and dear to my heart for the vast part of my career and in the training of the next generation of scientists," says Jennifer Pollock, PhD, FAPS, professor in the Department of Medicine, Division of Nephrology, at the University of Alabama at Birmingham. "Physiology is central to the practice of medicine and the creation of therapeutics to treat disease. From my perspective as a scientist, fundamental knowledge is critical to understand women's health across the lifespan. There is not a group of basic scientists better equipped to lead this research than APS members."

APS first sponsored a biennial conference on sex and gender 24 years ago, well before this issue was widely recognized as a gap in the health research landscape. "Physiologists have identified important sex-dependent aspects of physiologic function,"

says Linda Samuelson, PhD, FAPS, John A Williams Collegiate Professor of Gastrointestinal Physiology at University of Michigan. "And now, APS and the physiology community are poised to take advantage of the recent broader recognition of the gap in knowledge to make a difference in women's health going forward."

Meredith Hay, PhD, FAPS, professor in the Department of Physiology at the University of Arizona, says the continued investment by APS in women's health research is a continuation of these efforts. "This will position APS to take the lead in the national response to fulfill the White House's new initiative to advance these areas of research," she says.

That national response includes the White House weighing in on the importance of studying gender differences and disease. In March, President Biden signed an executive order that builds on the White House Initiative on Women's Health Research, which was established last November. The effort is being led by First Lady Jill Biden and the White House Gender Policy Council and directed by Carolyn M. Mazure, PhD, founder and director of Yale School of Medicine's Women's Health Research Center. "The White House initiative elevates the importance of women's health research in the nation, which is really extraordinary," Mazure said in a statement. "We have outstanding opportunities to make the progress that we need."

The executive order outlined actions to:

- Prioritize and increase investments in women's health research and integrate women's health across the federal research portfolio.
- Expand and leverage data collection and analysis and galvanize new research on women's health.
- Strengthen coordination, infrastructure and training to support women's health research and assess unmet needs to support this effort.
- Create dedicated NIH funding opportunities for this work.

BLAZING FORWARD

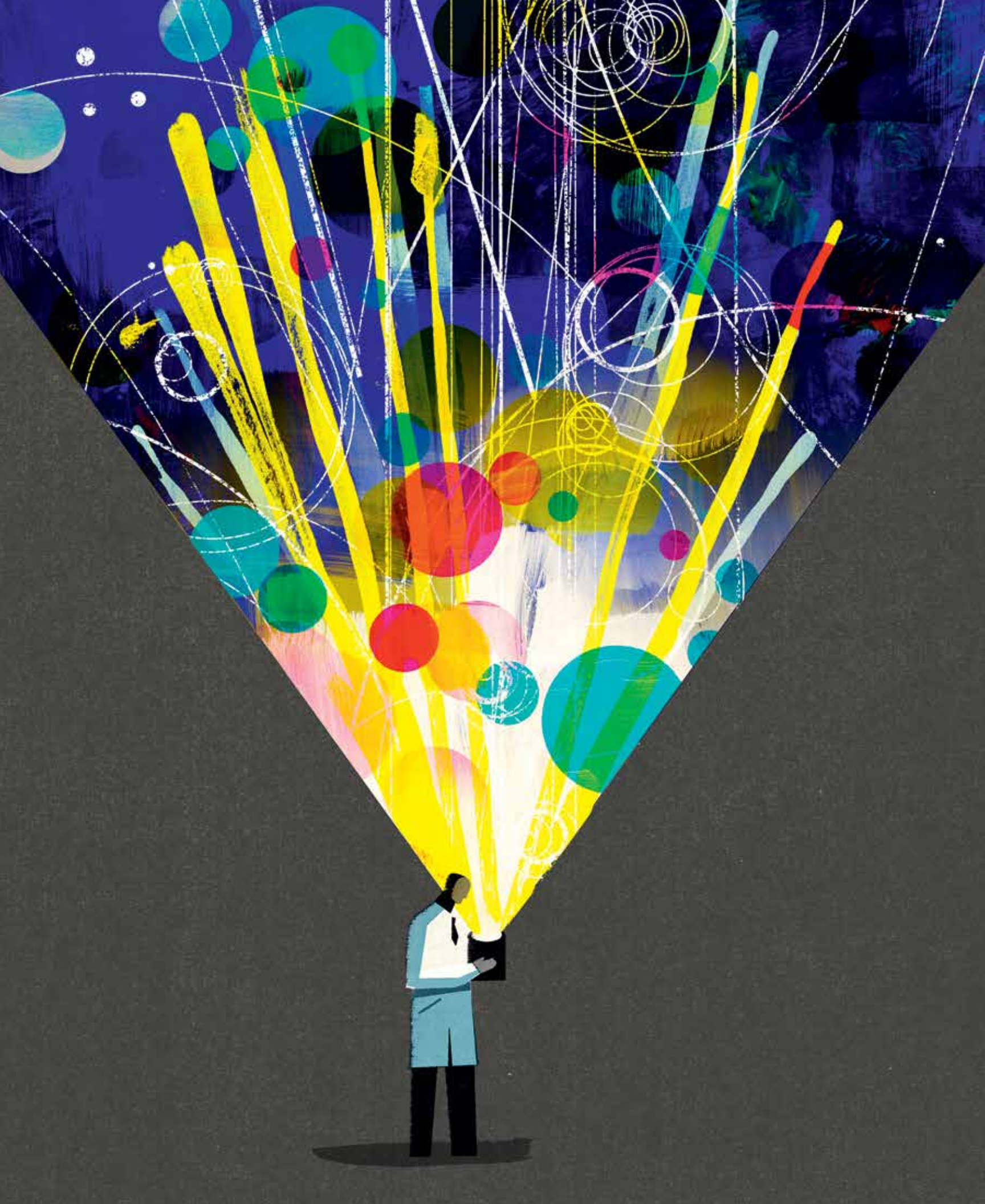
There are bright spots on the horizon—and the future starts with the people conducting the research. More women are choosing career paths in science, and that could lead to more interest in this work. "The opportunities for women in science, including those who have chosen physiology as a focus in their careers, have expanded substantially over the last several decades," says Hannah Carey, PhD, FAPS, professor emeritus in the Department of Comparative Biosciences at the University of Wisconsin-Madison. "From basic to translational research and advancements in the teaching of physiology, women have played key roles in the explosion of physiological knowledge that forms the basis of new developments to improve health. That knowledge also sustains animal health for domestic species and for wildlife, which are key components of the ecosystems in which we all live."

And according to the Association of American Medical Colleges, for the first time, there are more women than men in medical school. "If I had decided to go to medical school when I graduated from college, I would have been one of three women in a class of over 100," Silverthorn says. "Today, we are seeing more women in undergraduate biology classes, and it is spreading into graduate schools. In May 2022, more than half of our APS trainee members under age 40 were female."

But in the end, this isn't just about women. "This benefits men, too, because we're better able to develop specific guidelines for health and more precision medicine that is specific to each of us, which is what we all need," Reckelhoff says. "It improves health care for all." A legacy that Bodil Schmidt-Nielsen would no doubt be proud of.

"This will position APS to take the lead in the national response to fulfill the White House's new initiative to advance these areas of research."

—Meredith Hay, PhD, FAPS



THE ENTREPRENEURIAL PHYSIOLOGIST

The skill sets of researchers can translate to a successful and meaningful business career.

BY BRIAN BUSENBARK

As he was working toward his doctoral degree in biochemistry and molecular biology at the California Institute of Technology, Oliver Losón, PhD, planned to pursue a career in academia, with ambitions of heading a research laboratory focused on studying disease.

"But somewhere along the way during my graduate work, I was bitten by the entrepreneurial bug," says Losón, who ended up working in Caltech's Office of Technology Transfer, where he oversaw intellectual property, licensing and entrepreneurship. Today, Losón is vice president of business operations at Holoclara Inc., a company developing therapeutics to treat allergy and autoimmune diseases. "More than anything, I was excited by the idea of translating the work being done in an academic laboratory or discovery setting to the clinic with real-world applications."

Illustration by Keith Negley

Losón is not alone. A 2021 analysis conducted by the National Center for Science and Engineering Statistics shows the percentage of academic-owned utility patents has steadily increased over the past several years and is nearly double the rate from a decade ago.

Physiologists looking to join those ranks face a variety of challenges, including funding their projects, carving out the time to push their entrepreneurial ventures forward and navigating the maze of legal and logistical hurdles. The good news: Achieving entrepreneurial success is closer than you may realize.

"There's nothing more gratifying than watching something that you discovered or invented go from an academic setting to the bedside."

—Oliver Losón, PhD

PROTECT YOUR INTELLECTUAL PROPERTY

Success in the business world and academia is dictated by many of the same skill sets. "There's a lot of overlap," says Losón, a past APS Porter Fellow. "As scientists, we're trained to be thoughtful, gather the facts, assess what the data is telling us and determine next steps. In many ways, entrepreneurship isn't too different." (See sidebar "5 Essential Traits.")

For those in academia, the resources necessary to get the ball rolling are often not far away. Most major research institutions have technology transfer offices (known as TTOs) or technology licensing offices (called TLOs), which function as liaisons between academic research and industry. Though they can take on a variety of names, the primary purpose of these departments is to help facilitate the commercialization of research that takes place at the institution.

One of a TTO's foremost responsibilities is helping an inventor protect their intellectual property by guiding them through the patent process. In fact, it's the first conversation a scientist should have once they've determined that their invention or idea is novel and has potential commercial usefulness.

"Don't publish papers, don't present it at a meeting, don't do anything that someone could go back and say it's already in the public domain," says Robert Hester, PhD, FAPS, APS president-elect, Billy S. Guyton Distinguished Professor of Physiology at the University of Mississippi Medical Center and founder of HC Simulation LLC, a company that develops physiological simulation models.

From there, a provisional patent is typically filed. This ensures the owner has patentability for a year should there be a public disclosure or subsequent similar invention produced. During this one-year period, the institution will likely conduct a more thorough examination of the invention's commercialization potential. Meanwhile, the inventor should continue to advance the idea or invention to prepare for a non-provisional patent application.

If a U.S. patent is awarded, the holder typically has exclusive rights to the production and sale of an invention for 20 years. The inventor then has the option to license their patent to another individual or company. The process of assessing the market value of a license and

negotiating its sale typically requires further assistance from the inventor's TTO, attorney or other entrepreneurial consultants.

SEEK OUT HELP

Leveraging the connections and relationships already established on—or around—a research institution is critical to advancing an idea or invention toward commercial viability.

The University of California (UC) San Diego's Office of Innovation and Commercialization puts a unique twist on introducing its researchers to industry leaders. "They organize a sort of 'Shark Tank' event, where they bring in patent lawyers, venture capitalists and people from different areas of the biotech and pharma communities for investigators to present their ideas," says Farah Sheikh, PhD, professor in the Department of Medicine, Division of Cardiology, at UC San Diego School of Medicine and founder of ARVC Therapeutics Inc. "You're able to get some positive feedback through this effort and really learn what they want to see to move the technology forward."

Many universities also house entrepreneur-in-residence (EIR) programs to help support research-based entrepreneurship. There, EIR experts provide inventors with industry-informed experience on commercialization strategies and can assist in building business models, fundraising techniques and other common business challenges.

And for scientists like Hester—who didn't have access to these types of programs when he sought to market software he was developing—a nearby business college can be a valuable resource. "There's a small college here, Millsaps College, with a business school, and one of their faculty had done intellectual property work before," Hester says. "He told me all the things I needed to do and is actually still on my board of directors."

DETERMINE THE RIGHT PATH

For Sheikh, the decision to pursue entrepreneurism was personal. She was already researching the genes associated with arrhythmogenic right ventricular cardiomyopathy (ARVC), a rare genetic disorder that can lead to sudden cardiac death in young, otherwise healthy individuals, when someone close to her was diagnosed with the disease. "It was at that moment that I realized I really needed to move this research beyond just understanding the biology and toward a therapeutic," Sheikh says.

She determined that commercializing her work—and forging partnerships with experienced entrepreneurs who could help her navigate that path—was the most efficient route to patient therapy.

5 Essential Traits

Our experts weigh in on the key characteristics of successful entrepreneurial physiologists.

Innovative. In addition to a sound scientific foundation, a patentworthy concept or invention must be novel. Identifying which problem to address in a particular field or market and developing a solution to that problem requires innovative thinking.

Adaptable. Selling businesses and investors on an idea or invention comes with plenty of rejections. "You get that in academia with grant applications, but in an entrepreneurial setting, it's different because it sometimes feels much more personal—a lot of the interactions you have are face to face," Oliver Losón, PhD, says.

Risk tolerant. Even with all the requisite research and due diligence, some concepts won't work. "If you are open to failing, you're probably going to pursue that idea and at least see if it has merit," Farah Sheikh, PhD, says.

Connected. It's hard to travel this path alone; savvy entrepreneurs lean heavily on a robust network of friends, colleagues, past contacts and fellow alumni.

Opportunistic. Eliminate the word "no" from your vocabulary. "Never turn down an opportunity," Robert Hester, PhD, FAPS, says. "It may blow up and not work out, but you never know where it's going to lead you."

She founded a startup company, ARVC Therapeutics Inc., which later emerged as Stelios Therapeutics Inc. and was ultimately acquired by LEXEO Therapeutics, a clinical-stage genetic medicine company.

Leveraging the experience of seasoned entrepreneurs and the resources of larger, established companies has allowed Sheikh's research to rapidly progress toward clinical application. Her ARVC therapy is currently in human Phase 1/2 clinical trials, a milestone achieved much more quickly than if she attempted to go it alone. LEXEO's recent initial public offering ensures that her work will continue to have the necessary funding behind it. "The IPO will help bolster some of the clinical trials that will be important for moving my therapeutic forward," she says.

Importantly for Sheikh, she maintains a close collaboration with LEXEO on the work that remains meaningful to her. But that arrangement may not work for everyone. Fortunately, the various paths to exploring entrepreneurship—or to not go that route at all—give physiologists a wide array of options. Some areas to consider include:

Goals. What do you want to accomplish? How will commercializing your idea or invention help you reach your goals?

Time. Starting and maintaining a business venture requires more time than most people think. Do you have the bandwidth? Determine how involved you want to be, understanding that the business will take you away from other endeavors. "If you're really intellectually curious and you like to be working on lots of different projects, that's harder to do in a startup or company setting, as they require focus to maximize efficiency and capital," Losón says.

Organization. It's important to determine what type of entrepreneurism best suits your personality, involvement level and goals for your work. Assess the strengths and attributes of potential partners, identifying traits that complement yours, and partners who can manage pieces of the business you are not as well-suited for.

Finances. How will the business be funded? Ensure your personal finances can withstand the pressures of starting a new venture. "In a company, be aware that you probably will be the last person to be paid a salary," Hester says.

Logistics. Things like health insurance, facilities and how part-time hours may affect your standing at your institution must all be taken into consideration.

BENEFITS OF BUSINESS RUN DEEP

Donning the entrepreneur hat often requires you to practice different skills and to take time away from your base work. At the same time, it can make you a better scientist overall. Managing a business requires strong time and project management skills. While you are likely accustomed to selling the value of your ideas to obtain grants, securing investors is a different animal—and typically will require results on a much shorter timeline than a grant would.

Of course, the financial benefits of scientific entrepreneurism can be substantial. But what drives many physiologists who take their ideas and inventions to market is unquantifiable.

"There's nothing more gratifying than watching something that you discovered or invented go from an academic setting to the bedside," Losón says. "Seeing something that you've been working on and is helping people with disease or the like—there's nothing like that."

APPLY FOR SOCIETY AWARDS

american physiological society®

The American Physiological Society (APS) offers more than $1.2 million in awards and fellowships each year as part of our mission to encourage excellence in physiological research and education. These awards are a vital investment in our researchers and educators of all career levels.

Learn more about all the available opportunities and apply for the awards highlighted below at **physiology.org/awards**.

July **1**

Ernest H. Starling Distinguished Lecture of the Water & Electrolyte Homeostasis Section

$1,000 honorarium. Recognizes a member for exceptional contributions and lifelong dedication to water and electrolyte homeostasis research.

July **14**

Henry Pickering Bowditch Award Lectureship

$2,500 honorarium. Recognizes an early-career member with original and outstanding accomplishments in the field of physiology.

July **14**

Physiology In Perspective Walter B. Cannon Award Lecture

$4,000 honorarium. Awarded to an outstanding member in recognition of their original and outstanding accomplishments in the field of physiology.

July **15**

Claude Bernard Distinguished Lectureship of the Teaching of Physiology Section

$1,000 honorarium. Recognizes an established investigator with a history of excellence in education and making outstanding contributions to teaching and learning.

July **31**

Solomon A. Berson Distinguished Lectureship of the Endocrinology & Metabolism Section

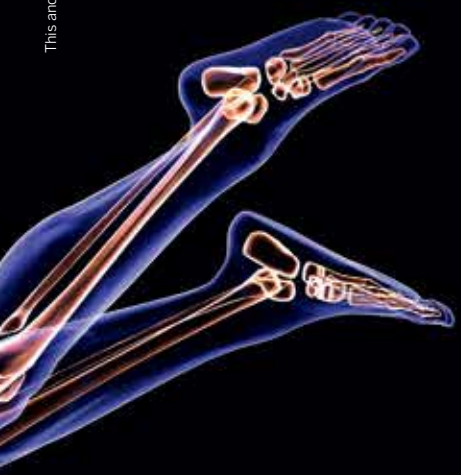
$1,000 honorarium. Presented to a distinguished scientist for their outstanding contributions to the areas of endocrinology and metabolism physiology research.

HOW HUMANS PERFORM

Exercise physiology shows us how people move and adapt, advancing our knowledge of the possibilities and limits of the human body.

BY CHRISTINE YU

This and facing page: iStockphoto



On July 26, 2024, the Games of the XXXIII Olympiad will open in Paris, France. Over 10,000 athletes will gather to compete in 329 events across 32 sports—from gymnastics to weightlifting, from equestrian to surfing—pushing the boundaries of human performance. While world-class athletes are gifted genetically, they don't arrive on the biggest stage in sports by their genes alone. It takes years of dedicated training. And a lot of science.

The field of exercise physiology—and sports science, more broadly—helps researchers understand how bodies adapt to training and move efficiently. It helps people become better athletes, but it also brings us closer to understanding the limits of human performance.

But studying the science of sports doesn't just benefit the most active among us. Ultimately, it helps us all.

> "When you put the stress of exercise on the body, all the systems are going to change—heart rate, ventilation, blood flow, core temperature."
>
> —Kimberly Stein, PhD

WHY WE STUDY EXERCISE

Exercise physiology examines how exercise stress affects the body's physiological systems. "When you put the stress of exercise on the body, all the systems are going to change—heart rate, ventilation, blood flow, core temperature," says Kimberly Stein, PhD, senior principal scientist at Gatorade Sports Science Institute (GSSI). "Exercise physiologists look at those changes and evaluate what's safe and what's not. They also look at adaptations over time, when you train consistently or when you stop exercising."

But the field didn't start with the express purpose of improving athletic performance. For example, when the Harvard Fatigue Laboratory was founded in 1927, its main purpose was to investigate how humans respond to physiological, psychological and sociocultural stress caused by daily activity and industrial work. By understanding what causes the body to tire, researchers could help companies improve worker efficiency. Exercise offered a clear way to study fatigue and "steady state" activity.

During World War II, the U.S. government contracted the Harvard lab to make recommendations for military operations in extreme heat and cold. This directive drove research to understand how to acclimatize to different environments and what that meant in terms of thermoregulation and hydration.

"These principles of acclimatization are all the same. You modify them to specific populations," says Michael Sawka, PhD, adjunct professor of biological sciences at Georgia Institute of Technology. "When athletes got interested in how to acclimatize to the heat, they could take the same basic principles and apply it to sports."

PERFORMANCE FACTORS

Despite playing collegiate basketball and softball, Stein didn't necessarily expect her career to involve so much sweat. At GSSI, she oversees the elite athlete services program, which, most of the time, involves sweat testing.

Regulating body temperature and proper hydration is critical for athletes. "If you don't sweat appropriately or don't replenish the fluid and electrolytes lost, you risk heat illness," Stein says. Dehydration can lead to reduced blood volume, decreased skin blood flow and increased core temperature. It's a particular concern when exercising in hot, humid environments or when athletes use a lot of equipment, such as in football.

Hydration also affects physical and cognitive performance. "An approximate 2% loss in body weight is when you start to see performance detriments," she says.

But there isn't one hydration strategy that works for everyone. "Everyone has a unique sweat profile in terms of how much you sweat and how much sodium you lose," she says. So, Stein's team travels to a team or athlete's location for sweat testing in their specific environment.

They weigh athletes before and after practice and note any body weight changes. "It's old-school, but it's still the best way to know how much fluid is lost during exercise," she says. They measure any fluid that leaves the body as urine, as well as anything the athletes eat or drink during practice. Athletes wear a patch on their forearm, which is analyzed for electrolytes. The team then determines each athlete's individual sweat profile and hydration plan.

Hydration and thermoregulation are just two factors that influence performance. Muscle, genetics, nutrition, biomechanics, psychology and gender differences all play a role. By studying the mechanisms behind these factors, researchers help build the foundation for better training programs, which benefits not only elite athletes but anyone who wants to be physically active.

"The goal is to promote an efficient, safe and evidence-based way of training to maximize progress and minimize potential downfalls," says Christoph Handschin, PhD, professor of pharmacology at the University of Basel in Switzerland.

With the advent of wearable technology, there's a potential goldmine of data from a wide range of people across age, sex, racial and ethnic backgrounds. Not only will these data help researchers understand the spectrum of human health and performance better, they could help make better decisions, too.

For example, Sawka is part of a team that is using wearable data, artificial intelligence and machine learning to predict heat stroke. Where others could predict heat stroke two

Partnership for Clean Competition

Sports are predicated on a simple premise: May the best athlete win. There's an assumption of fair play, but when the stakes are high, athletes sometimes resort to using performance-enhancing substances to gain a competitive advantage.

Some substances, such as anabolic steroids, growth hormone and erythropoietin (EPO), are banned by the World Anti-Doping Agency because they can boost performance. Others, such as diuretics, are prohibited because they can help mask the presence of a banned drug during testing. Athletes also violate doping policy if they manipulate their blood, genes or cells to improve performance.

But athletes must worry about more than just steering clear of banned substances. Sometimes traces of drugs can be found in over-the-counter medication, vitamins and supplements. Athletes with a medical condition who need to take an otherwise banned substance must request a therapeutic use exemption first.

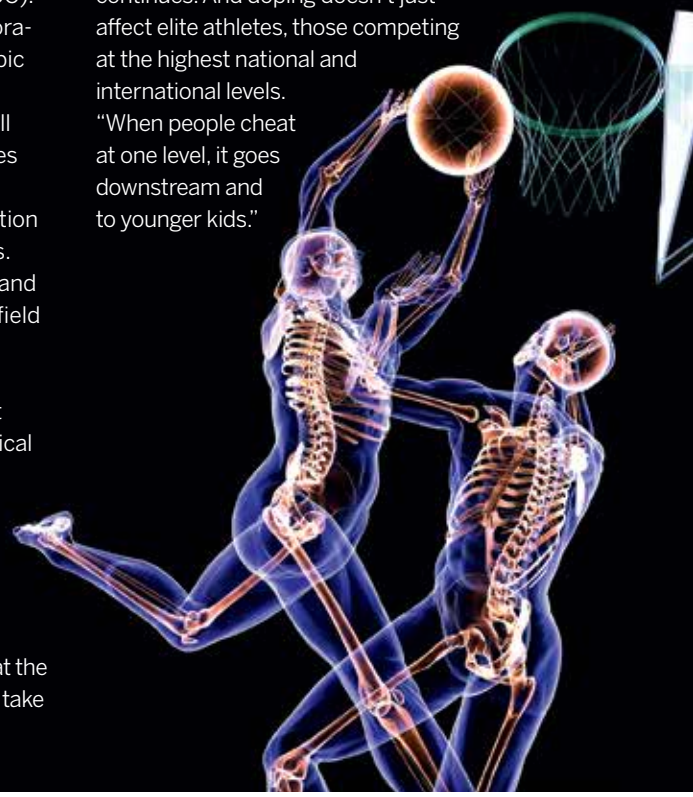
With the rise of designer drugs and more sophisticated doping methods, anti-doping efforts have become paramount for keeping sport clean. "These people that cheat, they follow the literature, too," says Michael Sawka, PhD, adjunct professor of biological sciences at Georgia Institute of Technology. "It's a constant game of cat and mouse. You're not going to catch them all, but if you can catch a certain percentage of those cheating, people are less likely to take the risk."

Sawka, who is an expert in blood volume control and environmental physiology and performance, among other areas, is a scientific advisory board member of the Partnership for Clean Competition (PCC). PCC is an anti-doping research collaborative founded in 2008 by the U.S. Olympic and Paralympic Committee, National Football League, Major League Baseball and U.S. Anti-Doping Agency. It provides grants and supports working groups around the world to improve the detection of performance-enhancing substances. PCC also funds postdoctoral scholars and fellowships to introduce people to the field of anti-doping research.

Sawka is working with others to improve the athlete biological passport (ABP), which tracks an athlete's biological and physiological profile longitudinally. Suspicious fluctuations may suggest doping. For example, Sawka says they're trying to identify biomarkers that are indicative of blood doping that could be added to the ABP.

They're also examining ways to look at the age distribution of red blood cells. "If you take blood out, put blood in or start on erythropoietin, you're going to see a difference in the age distribution of the red blood cells," Sawka says. "The trick is how do you get good markers of age distribution so we can look at how it changes?

"Athletes want fair sport. They don't want to compete against cheaters," he continues. And doping doesn't just affect elite athletes, those competing at the highest national and international levels. "When people cheat at one level, it goes downstream and to younger kids."



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to three minutes ahead of time, Sawka says they're able to predict it 40 to 50 minutes early. "It's a limited number of cases, but it shows the power of this type of approach," he says.

WOMEN IN SPORTS

Historically, women have been underrepresented in sports science research. (See "The Gender Gap," *The Physiologist Magazine*, July 2021.) The lack of scientific evidence, coupled with sociocultural beliefs about women's physical capabilities, has restricted women within the athletic arena. "Our culture limits our physical capacity and keeps us from being our best biological selves," says Sandra Hunter, PhD, professor of exercise science and director of the Athletic and Human Performance Research Center at Marquette University in Milwaukee.

In recent years, understanding gender differences has become a major area of focus as researchers attempt to tease apart female physiology and what that might mean in terms of training guidelines. To reach their athletic potential, should women train differently?

Take hydration. Stein notes that there are physiological changes in the luteal phase of the menstrual cycle that might affect thirst, but when drinking liquid freely, whenever and in whatever volume desired, overall fluid balance and fluid retention don't change. "Most people assume that there are going to be

big sex differences. While, technically, there are some differences, women for the most part have similar physiological responses to dehydration," Stein says. "It doesn't warrant different hydration recommendations."

However, there may be other areas where sex differences do make a meaningful difference and may call for different recommendations. Scientists are beginning to uncover these nuances, but more research is needed. (Read more about women's health research on page 18.)

FROM OLYMPIANS TO AVERAGE PEOPLE

When you consider that sedentary behavior and lack of physical activity increase disease risk and accelerate aging, it makes sense that researchers want to study muscle and understand how and why exercise confers so many health benefits. "In order to understand the bad, you have to understand the good," Handschin says.

Muscle does more than just generate force. "You could argue that it's not just a tissue, that it's an organ," Handschin says. "Repeated bouts of exercise over time leads to remodeling and shifts in cellular aspects like inflammation, metabolism and so forth. We want to understand the molecular mechanisms that control muscle plasticity in health and in disease."

Studying exercise allows researchers to understand the whole spectrum of the human body's physical capacity. Elite athletes represent the upper limits. "We've got to know what the 100% physical capacity is because it gives us a boundary. It lets us put that stake in the sand to say this is what we could be," Hunter says. Researchers can then discover the biological and physiological principles that underpin optimum health and performance, as well as the factors keeping people from being their optimal selves.

For instance, a major focus of Hunter's research is on how and when muscles become fatigued. In the lab, she asks participants to perform an exercise, such as a leg extension, lifting a weight equivalent to roughly 20% of their maximum strength. While it might not sound difficult, participants must perform a leg extension once every three seconds for four minutes. Hunter and her team measure the relative decline in muscle power. And with age, muscles fatigue faster.

When older adults contract their muscles repeatedly, like they might when going up stairs, they tire more quickly. Hunter says it's not just because they are less strong or powerful. "There are other factors contributing to the greater muscle fatigue that occurs with aging. If we understand the mechanisms and causes, then we can treat it. We can address it," she says.

For example, Hunter's group is performing experiments in which older adults strength-train in conjunction with blood-flow restriction. They're finding that after eight weeks of three-times-a-week training with the restriction of blood flow, older adults' muscles don't fatigue as quickly. This is the type of technique being adopted in physical therapy clinics and by athletic trainers for older adults and athletes to enhance training.

LOOKING AHEAD

Despite the rich literature on the science of sports and exercise, researchers are only scratching the surface. "Many of the things that we do to train are not evidence-based. Maybe that's the reason why we jump around from training modality to training modality," Handschin says. "There's still so much to be learned."

And as researchers continue to hone our understanding of the science of sports, we can continue to push the boundaries of human performance.

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APS Members Elected 2023 AAAS Fellows

The following APS members have been named to the Fellows of the American Association for the Advancement of Science (AAAS) Class of 2023. Fellows are elected to this lifetime distinction by their peers serving on the AAAS Council.

Michael Caplan, MD, PhD, FAPS, Long Professor and Chair of Cellular and Molecular Physiology, Yale University Medical School

Kevin P. Campbell, PhD, FAPS, investigator, Howard Hughes Medical Institute; director of Senator Paul D. Wellstone Muscular Dystrophy Specialized Research Center; chair and department executive officer, Department of Molecular Physiology and Biophysics, University of Iowa Carver College of Medicine

Christopher G. Kevil, PhD, vice chancellor for research; dean of the School of Graduate Studies; Malcolm Feist Endowed Chair of Cardiovascular Disease; professor of pathology, molecular & cellular physiology, and cell biology & anatomy, Louisiana State University Health Shreveport

Jeffrey H. Miner, PhD, Eduardo & Judith Slatopolsky Professor of Medicine in Nephrology, Washington University School of Medicine in St. Louis

Luis Fernando Santana, PhD, vice dean for basic sciences; chair of the Department of Physiology and Membrane Biology; interim chair of the Department of Biochemistry and Molecular Medicine at University of California, Davis

Frederick Sigworth, PhD, professor of cellular and molecular physiology, Yale University

Viet Dinh Wins Outstanding Service Award

Viet Dinh, a PhD student in the University of North Texas Health Science Center at Fort Worth (UNTHSC) Department of Physiology and Anatomy, is the 2024 recipient of UNTHSC's School of Biomedical Sciences' (SBS) Student Award for Outstanding Service. Dinh studies physiological responses to blood loss with research focusing on pulsatile perfusion therapy. At UNTHSC, he is vice chair of the SBS Values Committee, organizer for the annual Dr. Martin Farias III Memorial Lectureship, and a founding officer and president of PHANatics, the physiology department's student organization. He has been an APS member since 2022.

Julie Freed Named Mentor of the Year

Julie Freed, MD, PhD, a cardiac anesthesiologist and associate professor at the Medical College of Wisconsin (MCW), is the 2024 recipient of the MCW graduate school's Mentor of the Year award. Her laboratory focuses on understanding human microvascular (dys)function during health and disease. Freed mentors undergraduate, graduate and medical students, as well as postdoctoral fellows and junior faculty. Through MCW's Office of Research, she founded the Clinical Mentoring Board program, called CliMB, to help early-career investigators form effective mentoring teams to guide them toward independent funding. Freed has been an APS member since 2015.

Caroline Rickards Receives Outstanding Faculty Award

Caroline Rickards, PhD, FAPS, associate professor in the University of North Texas Health Science Center at Fort Worth (UNTHSC) Department of Physiology and Anatomy, is the 2024 recipient of UNTHSC's School of Biomedical Sciences' Outstanding Specialized Masters Faculty Member award. Rickards was recognized for her work as director of the Medical Sciences Research Track program, an optional research year for students who have completed year one of the master's of science in medical sciences degree program at UNTHSC. In addition to providing oversight and administration of this program, Rickards also developed and implemented a novel workshop program focused on research fundamentals in recognition of the limited research experience of these students. She has been an APS member since 2006.

Holly Ingraham Receives FASEB Excellence in Science Award

Holly Ingraham, PhD, the Herzstein Endowed Professor in the Department of Molecular and Cellular Physiology at the University of California, San Francisco, is the 2024 recipient of the Federation of American Societies for Experimental Biology's (FASEB) Excellence in Science Lifetime Achievement Award. The honor is "bestowed to women scientists demonstrating not only excellence and innovation in their research fields, but exemplary leadership and mentorship as well." Ingraham was recognized for her work on hormone-responsive nodes in the brain and gut involved in maintaining metabolic, skeletal and cognitive health in women. She has been an APS member since 2023.

David Poole Recognized with Dolph Simons Award

David Poole, PhD, DSc, FAPS, is the 2024 recipient of the Dolph Simons Award in Biomedical Sciences. This honor is part of the Higuchi-KU Endowment Research Achievement Awards and is Kansas' most prestigious recognition for scholarly excellence in higher education. Poole is a university distinguished professor of kinesiology and physiology at Kansas State University (KSU) and holds the Coffman Chair for Distinguished University Teachers and the Elizabeth Chapin Burke Chair for KSU College of Health and Human Sciences. His work focuses on the body's use of oxygen during exercise to resolve the mechanisms of exercise intolerance in health and disease. Poole is past chair of the APS Environmental & Exercise Section and has been an APS member since 1996.

Aylin Rodan Appointed Chief of Nephrology and Hypertension at University of Utah

Aylin Rodan, MD, PhD, associate professor of internal medicine at the University of Utah, has been appointed chief of nephrology and hypertension in the University of Utah Department of Internal Medicine. Rodan's appointment began July 1, 2024. As a nephrologist physician-scientist, her research interests include ion and water homeostasis and ion transport and regulation. Rodan has been an APS member since 2015.

Tijana Simovic Receives VCU Student Award of Excellence in Scholarship

Tijana "Jo" Simovic is a recipient of Virginia Commonwealth University's (VCU) College of Humanities and Science's Student Award for Excellence in Scholarship. Simovic is a PhD candidate in the Vascular and Integrative Physiology Lab at VCU, where her work focuses on investigating the cardiopulmonary effect of regular e-cigarette use in young adults. She has been an APS member since 2022.

Selina Tucker Wins Graduate Student Award for Integrative Physiology

Selina Tucker, a PhD student in the University of North Texas Health Science Center at Fort Worth (UNTHSC) Department of Physiology and Anatomy, is the 2024 recipient of UNTHSC's School of Biomedical Sciences' Graduate Program Award in Integrative Physiology. The award recognizes one graduate student in each of the school's programs. Tucker's research explores changes to the balance between coronary blood flow and myocardial metabolism in pregnancy and the postpartum period. She has been an APS member since 2021.

Yanlin Wang Receives Veterans Affairs Clinician Scientist Award

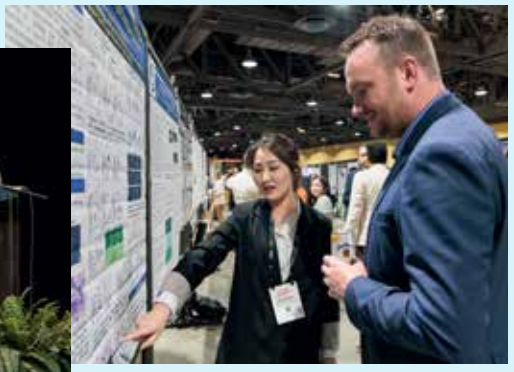
Yanlin Wang, MD, PhD, a professor and chief of nephrology at UConn Health, is a recipient of the Department of Veterans Affairs (VA) Senior Clinician Scientist Investigator Award. This prestigious award recognizes an outstanding clinician scientist engaged in ongoing VA research and providing high-quality care to veterans. Wang's research focuses on novel therapeutic targets for chronic kidney disease. He has been an APS member since 2011.

Jiaojiao Xu Recognized with Paul Erlich Research Award

Jiaojiao Xu, PhD, a research associate at Johns Hopkins University School of Medicine, is a 2024 recipient of the Paul Erlich Research Award. This young investigator award recognizes "contributions to research undertaken during the candidate's studies." Xu's work focuses on different aspects of the gut microbiome and host interaction, including the role of olfactory receptor 558 in blood pressure regulation and the influence of gut microbes on glomerular filtration rate in health and disease. She has been an APS member since 2018.

Relive the Memories

From puppies to posters and everything in between, the photo gallery from the 2024 American Physiology Summit captured it all. Catch up on event highlights and view the photo gallery at **physiology.org/APS2024Gallery**.



APS JOURNALS

Function Editor Named

David M. Pollock, PhD, FAPS, has been named editor-in-chief of the APS journal *Function*. Pollock is the James A. Schafer Professor of Medicine and director of the Cardio-Renal Physiology & Medicine Section at the University of Alabama at Birmingham. He served as the 87th president of APS and has extensive editorial experience, including as previous editor-in-chief of *Comprehensive Physiology*.

Pollock's wide range of research interests focuses on high blood pressure and kidney disease. His lab has uncovered how endothelin regulates renal handling of high salt diets, as well as key preclinical evidence for use of endothelin antagonists in the treatment of diabetic and sickle cell nephropathy. Most of his recent work has focused on circadian-related mechanisms contributing to blood pressure control and end-organ damage, as well as the relationship between organ-specific molecular clocks following changes in diet. Learn more about *Function* at **academic.oup.com/function**.

CHAPTER NEWS

APS Chapter Awardees Announced

Launched in 2023, the Chapter Advisory Committee (CAC) established two awards: One recognizes an individual at the local level who goes above and beyond to serve their chapter, and the other honors a chapter that best fulfills the missions of the Society. On behalf of the CAC, APS is pleased to announce the recipients of the 2024 Chapter of the Year and Extra Mile awards. The **Midlands Society of Physiological Sciences** is the recipient of the APS Chapter of the Year award, which honors excellence in promoting physiology research, education and outreach. **Harold D. Schultz, PhD, FAPS**, the APS Chapter Extra Mile awardee, was recognized for his outstanding service going above and beyond for the Midlands Society of Physiological Sciences.


Schultz

APS INTEREST GROUPS

New Chair Elected

Meet a new APS interest group chair:

Epithelial Transport Interest Group (ETG)
Owen M. Woodward, PhD

Associate Professor, Department of Physiology
University of Maryland, Baltimore

APS thanks outgoing ETG Chair Arohan R. Subramanya, MD, for his service to the interest group from 2020 to 2023.

AWARDS

**Award deadlines may be subject to change*

Water & Electrolyte Homeostasis Section Ernest H. Starling Distinguished Lecture (July 1)

Henry Pickering Bowditch Award Lectureship (July 14)

Physiology in Perspective: The Walter B. Cannon Award Lecture (July 14)

Claude Bernard Distinguished Lectureship Award (July 15)

Endocrinology & Metabolism Section Solomon A. Berson Distinguished Lectureship (July 31)

APS Fellows (September 15)

Local Undergraduate Research Awards in Physiology (Applications accepted on an ongoing, year-round basis)

More details: physiology.org/awards

CALLS FOR PAPERS

American Journal of Physiology-Gastrointestinal and Liver Physiology
- Cell and Animal Models of Gastrointestinal Disease (July 1)
- Epithelial Cell Metabolism (July 1)
- The Microbiota-Gut-Brain Axis (July 1)
- Paneth Cells and Mucosal Immunity in Health and Disease (September 30)

American Journal of Physiology-Heart and Circulatory Physiology (August 30)
- Atherosclerosis
- Diabetic Complications in Cardiovascular Health
- Inflammation and Cardiovascular Disease
- RNA Biology in the Cardiovascular System

American Journal of Physiology-Lung Cellular and Molecular Physiology
- Alveolar Biology, Pulmonary Surfactant, and Beyond: A Tribute to Dr. John Allen Clements on His 100th Birthday (July 1)

Journal of Neurophysiology
- Sleep Disorders (July 31)
- Integrative Research on the Functional Logic of Neural Circuits (September 1)

Physiological Genomics
- Integrative Physiology and Translational Omics of Exercise and Physical Activity (September 1)

Advances in Physiology Education
- Teaching in an Era of Generative Artificial Intelligence (July 15)
- Virtual Teaching Technologies (August 31)

Function
- *Function* invites submissions, including original research articles and evidence reviews, in the areas of molecular, cellular and systems neuroscience.

More details: journals.physiology.org/calls

WEBINARS

The 2024 Raj and Prem Goyal Award Lectureship in Pathophysiology of Gastrointestinal and Liver Disease: Mitochondrial Impairment in Intestinal Inflammation
August 1

Insight into Forebrain Control of Breathing
September 4

WOMEN'S HEALTH RESEARCH INITIATIVE

Webinar series begins in September.

APS-PARTNERSHIP FOR CLEAN COMPETITION

Careers in Anti-Doping Research
September 27

More details: physiology.org/webinars

Riding the Winds of Redirection

BY JAZMINE I. BENJAMIN, PHD

As a child, I vividly recall the day I learned to ride a bike. It was a sunny afternoon, and my uncle stood beside me, holding onto the back of the seat. With wobbly legs and a heart full of determination, I pedaled forward, my uncle following close behind. As I careened toward the road, he grabbed my handlebars, redirecting me away from the hazard and helping me continue my journey.

In the scientific process, redirection manifests in various forms. It could be a hypothesis that doesn't yield the expected results, a grant that doesn't get discussed, or a failed exam. Just like my early attempts to ride a bike, each experience provides valuable insight, guiding us toward new avenues of exploration. Consider the story of Alexander Fleming: In 1928, Fleming returned from vacation to find a petri dish contaminated with mold. Rather than dismissing it as a failed experiment, he observed that the mold had killed surrounding bacteria, leading to the development of the first antibiotic and revolutionizing modern medicine.

"The power of redirection lies in its ability to transform setbacks into opportunities."

Redirection also plays a crucial role in interdisciplinary collaboration. By bringing diverse perspectives and expertise together, scientists can tackle complex problems from multiple angles. The Human Genome Project, for instance, involved biologists, chemists, computer scientists and mathematicians working together to map the entire human genome. Through continuous redirection and collaboration, they achieved a monumental scientific feat with far-reaching implications for medicine and beyond.

This motif of redirection has been ever present in my academic life: I applied to college as a psychology major. I switched to biology (then chemistry … then biology again). I had my eyes set on medical school but found that my talents leaned more toward success in biomedical research and scientific communication.

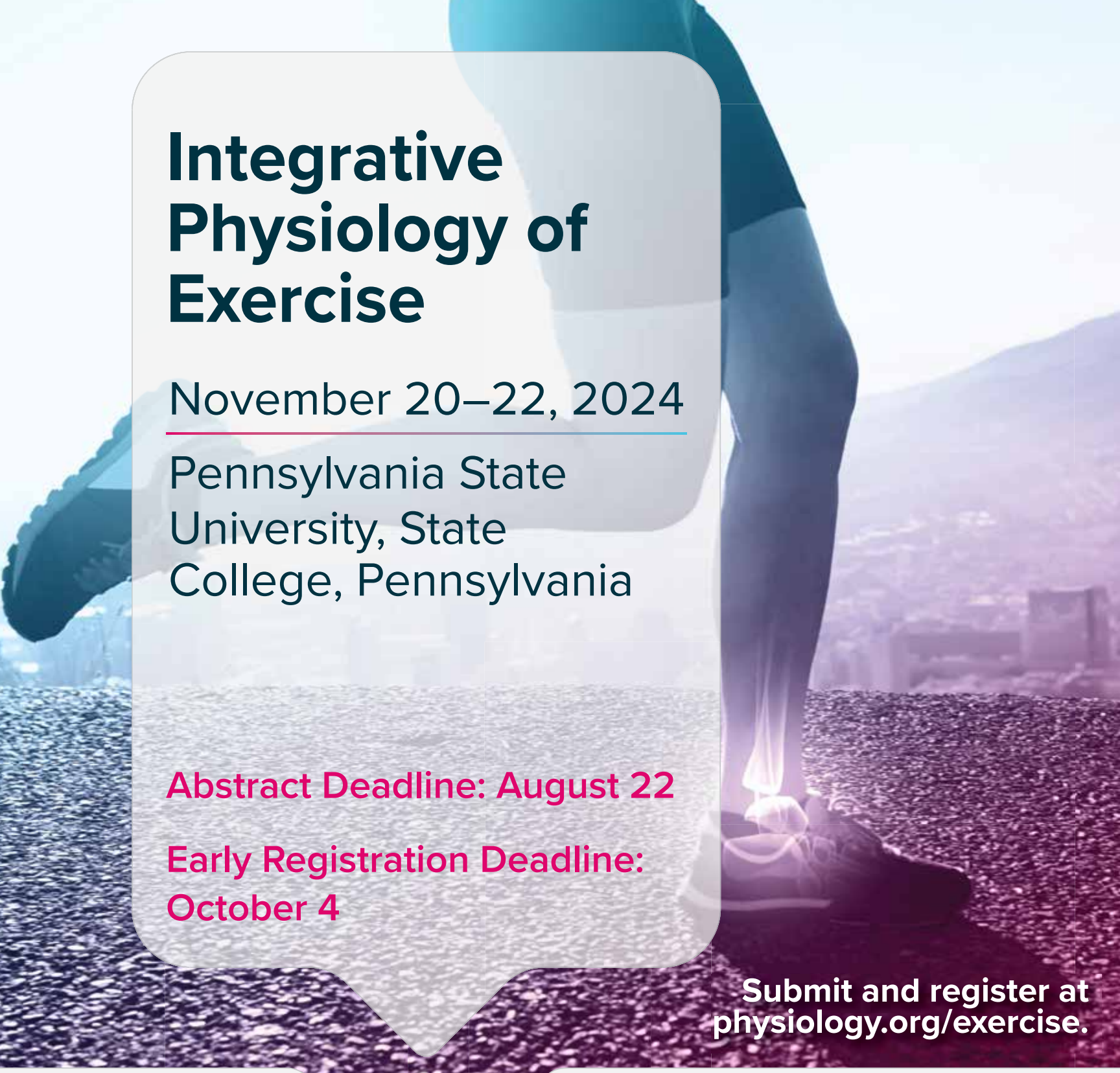
My experience in grad school epitomized redirection: three research labs over six years, each in wildly differing fields—all leading to a short postdoc and finding myself transitioning away from academia to a totally unexpected field. At each junction, when I felt that I was careening toward the proverbial road, a gentle hand guided me in the right direction, keeping my journey going and ultimately pushing me toward my purpose.

In essence, the power of redirection lies in its ability to transform setbacks into opportunities and catalysts for innovation. Like learning to ride a bike, it requires resilience, adaptability and a willingness to trust the process and know that you will end up where you are meant to be.

As we navigate the complexities of science and life alike, let us remember the lessons of redirection embedded in our earlier memories. By embracing curiosity, perseverance and the willingness to change course when necessary, we can unlock new frontiers of knowledge and create a brighter future for future generations.

Jazmine I. Benjamin, PhD, is a medical science liaison at Syneos Health in support of Ipsen Pharmaceuticals. She leverages her experiences in academic research to educate clinicians on specific drugs, resulting in improved patient care. You can find her on LinkedIn at linkedin.com/in/jazmineibenjamin.

Illustration by Brett Affrunti



Integrative Physiology of Exercise

November 20–22, 2024

Pennsylvania State University, State College, Pennsylvania

Abstract Deadline: August 22

Early Registration Deadline: October 4

Submit and register at physiology.org/exercise.

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