THE Physiologist MAGAZINE

JULY 2022

HOW ANIMALS ARE ADAPTING OR STRUGGLING IN THE MIDST OF CLIMATE CHANGE 24

POLLUTANTS ABOUND. WHAT EFFECT MIGHT THEY HAVE ON US AND OUR PLANET? 30

SOME LIKE IT HOT

Larry Kenney's work sheds light on human limits and how to take the heat.

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BY LAUREN ARCURI

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APS Career Gateway

Succeed at Every Step of Your Physiology Career

Now live! The American Physiological Society (APS) has launched Career Gateway—a new member resource to enhance your professional skill set. Find streamlined access to critical leadership and career advancement content designed to round out your scientific expertise. Resources include tips on:

- leading and managing a team,
- funding and communicating your science,
- intentionally designing your career,
- teaching and mentoring today's students, and
- maintaining scientific integrity.

APS provides professional development for every step of your career journey. Access the Gateway and start moving forward.

Access these critical resources at physiology.org/careergateway.

american physiological society®

How Climate Change Affects All of Us

BY STACY BROOKS

Dear reader:

Finally, it's summer. If you're like me, you're ready to get outside, take some time off and unwind. So, in addition to reading and enjoying this issue, I hope you're finding time for some well-deserved rest and relaxation during these next couple of months.

Here at APS, we've just wrapped up our two June conferences—the Institute on Teaching and Learning and the Control of Renal Function in Health and Disease conference, lovingly called "Kidney Camp," which evokes the spirit of a fun summer meeting with research at the forefront. (Look out for photos from these conferences in the September issue.) Next up is the launch of the Center for Physiology Education and a busy fall full of preparations for next year's inaugural American Physiology Summit in Long Beach, California (April 20–23, 2023).

Warm summer days provide us time to reflect on more than planning for fall activities or the return of students to the classroom. Today, those warm summer days can be downright sweltering—with record-breaking temperatures—stressing people and animals and air conditioners and firefighters on the frontlines of ever-lengthening wildfire seasons. So, in this issue, we take a closer look at our changing environment and what we're learning about how to survive and thrive in these times.

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OUR FEATURES

This month's features spotlight physiologists who are examining how humans and animals adapt (or don't) to the extreme changes our planet is going through. They may not have set out to be climate change researchers—maybe the term "climate change" wasn't even a household phrase when they started their careers—but their work sheds light on this critical issue in the 21st century.

We start with our cover profile of Larry Kenney, PhD, FAPS, a longtime Penn State researcher who looks at how humans respond to high heats. Turn to page 18 to read about his fascinating journey.

On page 24, we turn our attention to animals and how they are adapting or struggling as the environment shifts around them. Physiologists are finding that their hypotheses and methods also have to adjust as the climate becomes more unpredictable. Some researchers are looking to animals for the lessons they can teach us about human adaption and what lies ahead for us all.

Finally, on page 30, we spotlight researchers studying pollutants. It can be scary and overwhelming to realize we are surrounded by toxic materials. Human development has unleashed pollutants in the air and water, in our workplaces and even in our homes. We speak to scientists aiming to discover what small and profound effects this might have on people.

WE WANT TO HEAR FROM YOU

Remember that you, members of the APS community, are the engine that drives *The Physiologist Magazine*. I invite you to email us at **tphysmag@physiology.org** to share your feedback, suggestions and story ideas. I look forward to hearing from you.

Stacy Brooks is the editor-in-chief of *The Physiologist Magazine* and APS director of marketing and communications.

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CALL FOR NOMINATIONS
EDITOR-IN-CHIEF

Journal of Applied Physiology®

Nominations are invited for the position of editor-in-chief of the *Journal of Applied Physiology* (**journals.physiology.org/journal/jappl**) to succeed Sue Bodine, PhD, FAPS, who will complete her term as editor on June 30, 2023. The American Physiological Society (APS) Publications Committee plans to interview candidates in the fall of 2022.

Nominations due: August 1, 2022

Applications due: August 15, 2022

How to Nominate

Nominations, accompanied by a curriculum vitae, should be sent to David Gutterman, MD, FAPS, chair of the APS Publications Committee, via email, care of Charmon Kight (**ckight@physiology.org**) in the APS Publications Department.

Meet the Team

journals.physiology.org/jappl/edboard

Submit Your Best Work

jappl.msubmit.com

THE Physiologist MAGAZINE

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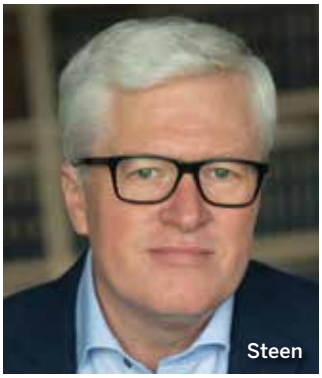
This eighth APS Intersociety Meeting in Comparative Physiology is one of a few international meetings dedicated solely to the dissemination of conceptual and technological advances in comparative and evolutionary physiology.

Join us as we highlight some of the important work being done to understand physiological function in the face of climate change and other anthropogenic factors as well as the emergence of omics approaches in comparative physiology.

All Physiologists Are Translational

APS Executive Director Scott Steen, CAE, FASAE, spoke with Ron Lynch, PhD, FAPS—professor of physiology, director of the Arizona Research Institute for Biomedical Imaging, and associate director for shared resources at the University of Arizona Cancer Center—about the evolution of physiology departments at R1 institutions and the lessons he's learned at Arizona as their undergraduate program has grown from approximately 40 to more than 2,000 students each year.


Steen

Steen: Taking your experience and looking more broadly, how do you think perceptions of physiology have evolved generally within academia, particularly at larger R1 institutions?

Lynch: Very difficult question, Scott. The evolution is that everybody's a physiologist. Not trained as one, but everything has to have a physiological context to it. Translational, right? So, even people who are working at the very basic level have to translate that into a clinical aspect, which in most cases means physiology or pathophysiology.

Now, I think this is where the discipline really plays a role. You can't just think about the human body as a single organ. And many people who consider themselves physiologists are translational people. Really, what they do is they pick an organ and they try to figure out what's going on and how they can make things better, or modulate organ function. But, in the end, I think the immune system—and the interactions of the immune system with other organ systems—shows us dramatically how one needs to think about the body as a single entity, built up of these different organ systems. That's physiology. And I think a lot of medical people who come toward us have a much better appreciation for that.

I think even people like me—I'm an imaging person for the most part—bring a lot to the table when I have these discussions because I am asking questions about holistic types of things, as opposed to really dissecting down to the basic biophysical and molecular kinds of questions, which I've been trained to ask.

Steen: Do you think that understanding of integrative physiology has declined within the discipline? I mean, you look at APS members and many of them see themselves as being specialists, as being cardiovascular researchers and physiologists or renal researchers and physiologists. Has that specialization taken something away from the perception of the discipline?

Lynch: I don't think so. As a matter of fact, I think on the surface what you're really talking about is the *kind* of research. So, when we go to Experimental Biology (EB) or APS meetings, we tend to gravitate to the people who are working in our field, and that's important. But that doesn't mean that we don't go to other sections and see the work of other people. That's the integration I'm talking about.

Naturally, you're going to want to get all the information you can about the area of research you're involved in and meet the people who are important to you to get your grants, to give you feedback on the kind of work you're doing. But in fact, it's the integration between those sections that is really important. And I think we do that all the time. I think that's what those big meetings are best for.

Steen: As we develop our new annual meeting so much of it is about a really renewed focus on that integrative aspect—on big topics that are cross-disciplinary and cross-sectional.

Lynch: I was the APS Joint Program Committee chair for EB for six years. And one of the things that I really pushed for were the interdisciplinary translational kinds of symposia—they were called cross-sectional at the time. Those are some of the best things that we put on, where you had


Ron Lynch, PhD, FAPS

people from multiple sections giving talks on a particular, usually disease-related, problem that brought people across the board into those rooms. Those were exceptional. I thought those were the best things at the meeting.

Steen: What do you see as the current opportunities and threats to the discipline? And maybe to APS as an organization representing the discipline?

Lynch: I think the threats are related to what I would consider the curriculum within the medical college. So now, we're talking at the medical school level, where most colleges have gone to organ system and away from a disciplinary course so that anybody can teach any section of physiology. And sometimes it's not done as well as it should be. I think we lose disciplinary control of the information that's being put out there. I've seen that. I think we're getting a little better at it, but I think that's definitely a threat.

Now, I think there are a lot of opportunities within that. The first one is the undergraduate level, again, because this is being shifted. There's a huge opportunity to get our foot in the door. And often, we're seeing we're a college of medicine undergraduate program; students are really attracted to that, and that's why we have such a large undergraduate program.

I think that would generally be across the board if these things could be offered. But even within the medical school, being a discipline director, being able to really get back into more of an overview of what physiology is and put the discipline in the curriculum in a strong way is important. I've seen our medical school curriculum evolve over time where they understand the need for somebody to oversee physiology and what physiology curriculum's being put into the medical school curriculum, even as it's being limited to a certain extent.

"I think this is where the discipline really plays a role. You can't just think about the human body as a single organ. And many people who consider themselves physiologists are translational people."

—Ron Lynch, PhD, FAPS

Steen: I've heard many members at other institutions refer to Arizona as a model. If there was one thing or a few things that other institutions could learn from Arizona, what would they be?

Lynch: Well, the lessons are being developed. We are learning a lot on the fly. It's very difficult to balance the research mission and a large teaching mission. If there's anything that we can contribute, it's that we are continuing to evolve in that regard. You need to nurture both. And one of the things that drives the undergraduate major is tuition dollars. When you have 2,000 students in your major, there's a lot of resources coming for that. That can skew the perception of the department and also where the resources go when a new person needs to be hired or a new course needs to be opened. Maybe you need to be supporting a junior faculty member as well. Where do those resources go? I think it's really important for the research faculty, the tenure-track faculty, to have a real say in how that research program runs.

View the conversation in full at **www.physiology.org/evolution**.

As the spring semester wrapped up, we found a lot of milestones, appreciations and celebrations on Twitter.

Share your story with us and it may appear in the next issue of *The Physiologist Magazine*. Email your thoughts—and links to your tweets and posts—to tphysmag@physiology.org.

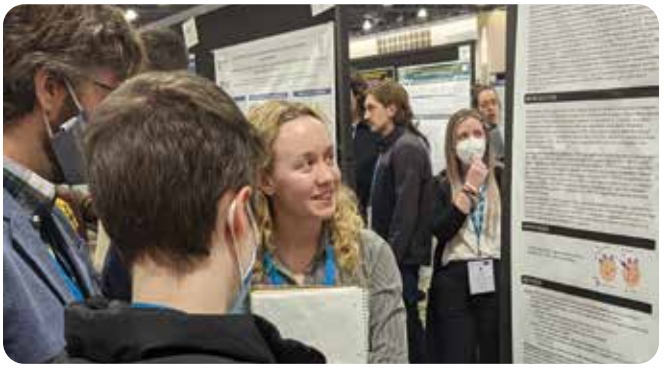
Bianca N Quade
@BiancaQuade

Successful defense = Dr. Quade! 😎

12:32 PM · May 11, 2022

David D. Kline, Ph.D.
@kline_lab

So happy for Katie Langen, an undergraduate in the lab, who graduated from @mubiology with honors this past weekend. Here she is presenting at EB2022. Good things are coming from her!



12:42 PM · May 16, 2022

Dr. Jesse Moreira
@JDM_Physiology

It's been a whole year since I've become a doctor and I never got to wear this fancy ~EXPENSIVE~ robe to a ceremony so you are all receiving these photos again.

1:19 PM · May 10, 2022

Lauren Biwer, PhD
@drlaurenbiwer

Boston rooftop is always a good time when it's >50F and you're surrounded by the best coworkers @TuftsMCResearch ☺️ @IrisJaffeLab @Jai_Ibarrola @rahul_8485 @mgood695 @jenn_vorn @gordonshuggins @DrCamarda @RachelXiang4 @Evon_YH_Wang @KayEverettMDPhD @BhaveShreyas @lizabiotech

9:44 PM · May 12, 2022

Greg Crowther
@TQTHQ

My youngest did a nice bit of skeleton art in pre-school this week. He was mystified, though, when I asked him, "What are the functional implications of having only 1 phalangeal bone for each finger?"

9:59 AM · May 12, 2022

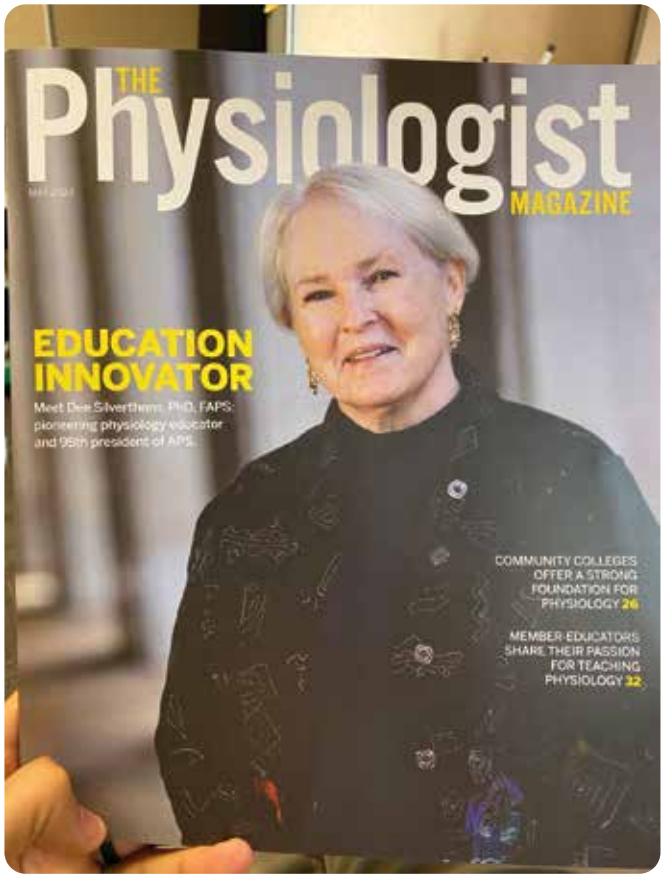
Joe Santin
@santin_joe

Had the privilege of serving as a faculty mentor to a high school student's senior project on sex differences in biomedical research. She crushed her presentation. The future is bright!

11:12 AM · May 16, 2022

Arik Davidyan Ph.D.
@TheMuscleTussle

Great to see @APSPhysiology dedicating a large portion of the latest The Physiologist Magazine to physiology education and educators.



9:46 AM · May 12, 2022

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LAB NOTES

MENTORING Q&A YOUR QUESTIONS ANSWERED
POLICY IQ PHYSIOLOGY ON THE HILL AND IN THE HALLS
RESEARCH FIZZ 2022'S TOP DOWNLOADED ARTICLES
STATS & FACTS PHYSIOLOGY BY THE NUMBERS
UNDER THE MICROSCOPE OUR MEMBERS, UP CLOSE
PUBLISH WITH POLISH BUILD A BETTER RESEARCH PAPER

STATS & FACTS

9.43%

The portion of annual global deaths attributable to extreme temperatures over the past 20 years.

The Lancet Planetary Health

RESEARCH FIZZ

Long-term complications of COVID-19

12,667 Downloads

This review organizes an overview, by organ system, of the epidemiology, pathophysiology and management of long COVID symptoms.

***American Journal of Physiology-Cell Physiology*, January 2022**

https://doi.org/10.1152/ajpcell.00375.2021

STATS & FACTS

19

The additional number of days pollen season is expected to last due to climate change.

National Science Foundation

MENTORING Q&A | WISE WORDS

Focus on Teaching

How to develop your own teaching philosophy.

Each issue, we ask a trainee member to pose their career questions to an established investigator and mentor. Here, Victoria Wolf, PhD, visiting assistant professor at Gettysburg College in Pennsylvania, asks Scott K. Powers, EdD, PhD, FAPS, distinguished scholar of health sciences at Stetson University in Florida, for advice on becoming a great physiology teacher.

Q: Do you have any tips for trainees who are trying to develop their own philosophy of teaching?
A: Many useful teaching resources are available from APS, such as articles in *Advances in Physiology Education*,

Illustrations by Kagan McLeod

and I encourage trainees to read and digest the viewpoints conveyed in these writings. Many of the published articles are written by master teachers and contain the pedagogical wisdom earned through many years of teaching experience. I also encourage beginning teachers to reflect on their own educational experiences and to incorporate those teaching techniques that were most beneficial during their training.

"I also encourage beginning teachers to reflect on their own educational experiences and to incorporate those teaching techniques that were most beneficial during their training."

Q: Should trainees have a teaching mentor separate from their primary research mentor?
A: The answer to this question depends upon whether the research mentor is a highly effective teacher, that is a master teacher. If yes, I do not believe that a second mentor is required. In contrast, if your research mentor is not engaged in teaching, then working with a master teacher mentor will be highly beneficial.

Q: When beginning to search for teaching positions how do you decide what type of institution would be the best fit?
A: Choosing your first academic position following your graduate and postdoctoral training is an important and challenging decision. There are many factors that go into this decision, but deciding whether your primary career goal involves research or teaching is key to making a good decision. Obviously, academic positions at R1 universities require excellence in research and often limited teaching is required. In contrast, many private liberal arts colleges and small state universities expect faculty to engage in research, but the primary job description is a focus on excellent teaching. The question now becomes which of these positions is the best fit for your career goals?

Q: What do you think is the biggest challenge new physiology educators will face?
A: This is a great question, and I predict that the answer provided will often differ between experienced teachers of physiology. However, in my view, one of the greatest challenges is how does the physiology teacher remain current in multiple areas of physiology? Obviously, a teacher/researcher is well-versed in topics related to their research, but remaining current in areas of physiology outside their sphere of investigation is often challenging. However, the growing numbers of published reviews and the "refresher courses" published in *Advances in Physiology Education* are excellent ways to remain in touch with numerous areas of physiology outside your research focus.

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.

istockphoto.com

RESEARCH FIZZ

Is 'not different' enough to conclude similar cardiovascular responses across sexes?

9,541 Downloads

This perspective piece discusses how to integrate equivalence testing across multiple types of study designs when conducting sex comparisons in cardiovascular research.

***American Journal of Physiology-Heart and Circulatory Physiology*, March 2022**

https://doi.org/10.1152/ajpheart.00687.2021

STATS & FACTS

50–78%

The increased cooling costs faced by desert birds due to climate change.

Proceedings of the National Academy of Sciences

RESEARCH FIZZ

Diabetic ketoacidosis and COVID-19: What have we learned so far?

5,497 Downloads

This review explores the management of acidosis in people with and without diabetes, while minimizing complications from COVID-19.

American Journal of Physiology-Endocrinology and Metabolism, January 2022

https://doi.org/10.1152/ajpendo.00244.2021

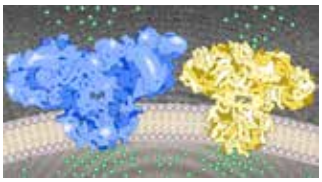
STATS & FACTS

15K

The estimated number of climate change-driven cases of mammals transmitting viruses to other mammals over the next 50 years.

Nature

RESEARCH FIZZ



Calcium-release channels: structure and function of IP3 receptors and ryanodine receptors

3,100 Downloads

This review summarizes current knowledge of calcium release channel structure and function.

Woll and Van Petegem

https://doi.org/10.1152/physrev.00033.2020

POLICY IQ | NIH FUNDING RULE

New NIH Data Management Requirement Begins in 2023

As of January 25, 2023, the National Institutes of Health (NIH) will require all applicants to include a Data Management and Sharing Plan when submitting applications for competing grants, contract proposals or other funding agreements. Implementation was delayed following issuance of the final policy in 2020 to allow time for grantees to become familiar with the requirements and identify appropriate repositories for their data.

Key provisions of the policy include:

- Data management plans must be included at the time applications are submitted.
- Plans are assessed by program staff at the funding institute or center but are not scored. Researchers may update plans throughout the award period with approval of program staff.
- Researchers are encouraged to make use of established repositories for data management and sharing. NIH provides a list of desirable characteristics for repositories, including the use of unique persistent identifiers, long-term sustainability, and free and easy access, among others.
- Fees for personnel costs associated with data management and sharing are allowable, as are fees for long-term data preservation. However, funds for these activities must be spent during the award period.
- The policy does not apply to grants that do not generate data, including for training, infrastructure development and other non-research activities.

To assist investigators in preparing their grant applications, the NIH Office of Science Policy has developed a website featuring information on data-sharing policies. The site includes resources for writing a data management and sharing plan, budgeting for allowable costs associated with data management and sharing, and selecting a repository. Visit **https://sharing.nih.gov**.

Looking for Support? Check Out FASEB DataWorks!

As a member of the Federation of American Societies for Experimental Biology (FASEB), APS is pleased to share information about DataWorks!, an initiative designed to bring the biological and biomedical research communities together to advance human health through data sharing and reuse. Check out the DataWorks! website at **https://bit.ly/FASEBDataWorks** to learn more about how to:

- Participate in monthly Salon conversations to exchange ideas and design effective practices for data sharing and reuse.
- Join the DataWorks! Community to hone skills and mentor peers in data management and sharing.
- Take advantage of the DataWorks! Help Desk (launching in 2022–2023) to provide guidance for the research community to navigate and adopt data sharing and reuse policies and practices.

Left: Woll and Van Petegem; Top: istockphoto.com

POLICY IQ | FEDERAL AGENCIES

New Programs Promise Research Innovation

With an eye toward future scientific advances, Congress has established new programs at both the National Institutes of Health (NIH) and the National Science Foundation (NSF) to foster transformational research.

The Advanced Research Projects Agency for Health (ARPA-H) was proposed in 2021 by the Biden administration to bridge the gaps between basic research and development of new breakthroughs. Modeled after the Defense Advanced Research Projects Agency (DARPA), the goal is to develop an institutional culture at ARPA-H that is distinct from NIH, focusing on use-driven ideas to speed health breakthroughs.

Will these new programs grow out of proportion to existing research activities and divert budgetary resources within the agencies?

Despite controversy over whether ARPA-H should be created as part of NIH or as a separate agency, Secretary of Health and Human Services Xavier Becerra, JD, made the decision to place ARPA-H within NIH. However, ARPA-H is not subject to current NIH policies, and the ARPA-H director will report directly to Becerra. Program managers will develop and coordinate research programs, and both the ARPA-H director and program managers will be subject to time-limited appointments to encourage a constant influx of new ideas. Congress provided $1 billion in dedicated funding for ARPA-H in fiscal year (FY) 2022, far short of the Biden administration's $6.5 billion request.

At NSF, the new directorate for technology, innovation and partnerships (TIP) is charged with creating breakthrough technologies to meet societal and economic needs, create well-paying jobs and empower Americans to participate in the research enterprise. While Congress did not provide dedicated funds for TIP in FY 2022, existing programs that fit within the mission of TIP have been brought into the new directorate, including the Innovation Corps, America's Seed Fund (NSF's SBIR/STTR programs) and the NSF Convergence Accelerator.

Looking ahead to funding for these programs in FY 2023, President Biden has requested $5 billion for ARPA-H within the NIH budget and $880 million for TIP at NSF. Of concern to the scientific community is whether these new programs will grow out of proportion to existing research activities and divert budgetary resources within the agencies. This already seems to be the case with the president's FY 2023 budget request. When the Biden administration released budget recommendations in March, the requested funding level for NIH ($50.5 billion) would appear to represent a significant 9.3% increase over the FY 2022 funding level. However, with $5 billion slated to be invested in ARPA-H, some institutes and centers would see their funding cut under the president's plan.

The president's FY 2023 budget request for NSF would provide the agency with an overall increase of $1.7 billion (18.7% over FY 2022), but the effect of funding for TIP is less clear, as existing programs have been moved over to be part of the new directorate.

Advocacy messages, including those from APS, focus on the importance of increasing the base budgets for NIH and NSF research, while providing additional new funding for programs at ARPA-H and TIP.

STATS & FACTS

20

The average number of miles northward 140 marine species have moved from 1982 to 2018.

U.S. Environmental Protection Agency

RESEARCH FIZZ

Recent COVID-19 vaccination has minimal effects on the physiological responses to graded exercise in physically active healthy people

3,428 Downloads

This study found the COVID-19 vaccine did not impair the body's physiological response to recreational exercise.

Journal of Applied Physiology, February 2022

https://doi.org/10.1152/japplphysiol.00629.2021

RESEARCH FIZZ

From heart to muscle: pathophysiological mechanisms underlying long-term physical sequelae from SARS-CoV-2 infection

Downloads: 2,568

This review highlights current knowledge of the mechanisms behind long COVID symptoms, identifies gaps in relevant literature and emphasizes the need for rehabilitation guidelines.

***Journal of Applied Physiology*, March 2022**

https://doi.org/10.1152/japplphysiol.00734.2021

STATS & FACTS

143 million

The estimated number of people in Sub-Saharan Africa, South Asia and Latin America who will be internally displaced by climate change by 2050.

World Bank Group

RESEARCH FIZZ

Altitude physiology then (1921) and now (2021): Meat on the bones

Downloads: 2,252

This editorial looks at how the study of altitude physiology has changed and evolved in the past century.

***Physiological Reviews*, January 2022**

https://doi.org/10.1152/physrev.00033.2021

UNDER THE MICROSCOPE

Rapid Fire Q&A

Analia Loria, PhD, shares what she would look for in a sabbatical, her favorite book about science and what she loves to watch on TV.

Q: What inspired you to become a scientist?
A: Joining a productive research lab as an undergrad.

Q: "Old school" technique you're most proud of mastering?
A: Spectrophotometry—I love it in all versions!

Q: Most challenging laboratory technique you've learned to use?
A: Adrenergic receptor bindings, using a harvester that looks like a crazy scientist gadget.

Q: Items on your lab bench that you are most possessive of?
A: Sarstedt black marker. Don't touch mine.

Q: A lab mishap story that you can share without incriminating the innocent?
A: Sometimes we like to talk slang in Spanish with other lab members, thinking nobody understands—until we realized one new student was laughing hard about a bad joke.

Q: Best "MacGyver" moment in the lab?
A: When I can make the tube label printer work.

Q: If you could meet any scientist (living or dead) who would it be and why?
A: Cesar Milstein, FRS, an Argentine Nobel Prize winner, who said, "Science will only fulfill its promises when the benefits are equally shared by the really poor of the world."

Q: If you could do a sabbatical with any scientist (living or dead) who would it be and why?
A: I will just look for one working in a paradisaic island.

Q: If you were a model organism, which model organism would you be?
A: A mouse, especially when I cannot sleep at night.

Q: Favorite book about science (fiction or non-fiction)?

Photos courtesy of Analia Loria, PhD

Loria with two of her PhD students.

Q: What do you wish the general public understood about science or research?
A: That preventive medicine can be as important as researching drug discovery targets for personalized medicine.

Loria co-organized the eighth annual Healthy Hearts for Women event at the University of Kentucky.

A: "The Thermodynamics of Pizza: Essays on Science and Everyday Life" by Harold Morowitz.

Q: No. 1 guilty pleasure?
A: Setting up the "out of the office" email.

Loria cheers for University of Kentucky Wildcats with daughter Jazmine, age 2.

Q: The scientific discovery or invention (made by someone else) that you wish you had made?
A: DNA, but with the added recognition that Rosalind Franklin should have had.

Q: Most valuable quality in a colleague?
A: Timely responses.

Q: Tell us a surprising fact about you.
A: I like to design and make clothes and accessories.

Q: Favorite part of your job?
A: When data make sense.

Q: Least favorite part of your job?
A: Two incoming emails requesting something new when I believed I was closer to catching up!

Q: Favorite musician/musical artist/band?
A: I am passionate about tango music: Piazzolla, Mores, D'Arienzo ...

Q: Favorite TV show, movie series or podcast to binge-watch/listen?
A: I watch a lot of South American and European soccer leagues and most of the international tournaments. Of course, I'm counting days down until the World Cup.

Q: Go-to snacks to get you through long days working from home?
A: I drink mate, a typical Argentine infusion (made from yerba mate leaves and full of caffeine), the whole day long.

Analia Loria, PhD, is an associate professor in the Department of Pharmacology and Nutritional Science at the University of Kentucky, where she also serves as a diversity ambassador. She has been an APS member since 2005.

PUBLISH WITH POLISH | DEI IN PUBLISHING

APS Publications Department Forms DEI Advisory Board

In 2021, the APS Publications Department began building a Diversity, Equity and Inclusion (DEI) Advisory Board to ensure that DEI is considered in all aspects of our journals. The board, chaired by *American Journal of Physiology-Lung* Editor-in-Chief Rory Morty, PhD, includes diverse representation from APS staff and volunteer leadership. The board meets monthly throughout the year to exchange ideas and make recommendations on ways to deliver inclusive excellence in our publishing program.

A major goal is to increase diverse representation of authors, reviewers and editors. Such an effort requires APS to have demographic information to measure diversity. All data will be protected and reported in aggregate form to guide the expansion of the journals' stakeholder community. Be on the lookout for updates as this project rolls out.

The APS Publications Department has also adopted an Author Name Change Policy and introduced gender-neutral salutations to the peer review system. Authors may change their name for a variety of reasons, such as marriage, divorce, gender transition or religious practice. For more information visit **https://bit.ly/APSAuthorNameChange**. We also added the gender-neutral salutation "Mx" (for Mixter) as an option in all our submission sites. This enables individuals to indicate that a person identifies as nonbinary.

APS Publications staff will continue to strive for diversity, equity and inclusion in all of our activities. There is much to be done, but we will achieve improvements with the guidance of the DEI Advisory Board, authors, reviewers, editors and staff.

APS' experienced publishing staff share their tips and know-how to help you improve the polish of your scientific manuscripts. Got a scientific publishing or style question that you want us to weigh in on? Email it to tphysmag@physiology.org.

SOME LIKE IT HOT

From nuclear power plants to football fields to the changing planet, Larry Kenney's work on thermoregulation sheds light on human limits and how to take the heat.

BY MEREDITH SELL

When Larry Kenney, PhD, FAPS, arrived at Penn State in 1980, he didn't know what his career would be. A PhD student in physiology, he thought maybe someday he'd teach at the college level and coach. Sports and the human body—those were his interests as a first-generation college graduate coming from the tiny coal mining town of Brenizer, Pennsylvania. But an event from a year earlier about 100 miles southeast of Penn State completely changed his career trajectory.

Illustration by Sean Mcabe

Kenney at the 2022 Penn State graduation with graduate students and colleagues.

On March 28, 1979, in the early hours of the morning, a pressure valve in a nuclear reactor at Three Mile Island failed to close. Over the next 16 hours, the plant on a sandbar in the Susquehanna River came within an hour of total meltdown. The worst nuclear energy disaster in U.S. history led to the shutdown of the plant and kicked off a 12-year process of cleanup. That's where Penn State researchers, including Kenney—who's now a professor of physiology and kinesiology at the university—came in.

"When I got to Penn State, my adviser, Eliezer Kamon, had a contract to look at heat-stress issues related to workers who were going in and cleaning up the damaged reactor building," Kenney says. "These guys were putting on three sets of plastic clothing, two or three pairs of gloves, respirators, masks, taping everything shut and then going into areas that were up to 165 degrees Fahrenheit. It took them a couple hours to get dressed, and they could only work in there for 20 minutes or so because they couldn't evaporate any sweat."

Kenney jumped into the research right away, collecting data from Three Mile Island as well as other nuclear power plants across the country. He also participated in lab-based projects at Penn State's Noll Laboratory, the first freestanding building in the country dedicated to studying exercise and environmental physiology. Those projects included examining the different physiological responses of men and women to heat stress and the effects of different types of clothing on people working in the heat.

Kenney was hooked. Not only did human thermoregulation offer countless angles to explore, but the research findings were directly applicable to people's lives. Things like hypertension, cardiovascular fitness, obesity and age all came into play.

As Kenney neared the end of his PhD program in 1982, Kamon had a medical emergency that prevented his return to the lab. Elsworth Buskirk, PhD, the founding director of the Noll Lab, asked Kenney to stick around as a postdoc and manage Kamon's grants and research projects. Kenney agreed and soon found himself leading a research team of graduate students several years older than he was. "I was just one of the team," he says. "I just happened to be the one who had to write grants and reports, be in charge of projects and do teaching on the side."

Along the way, he started writing his own grant proposals, honing in on questions regarding the ability of older adults to tolerate high heat and humidity. He noted that when heat waves struck around the world, the vast majority of people who died or

At the turn of the 21st century, heatstroke was known, but it wasn't well understood and addressed in arenas such as pro sports. In 2001, the death of NFL lineman Korey Stringer began to change that.

ended up in emergency rooms with heat-related illness were over the age of 65. He began wondering: "What physiologically changes with aging that causes us to be less heat-tolerant, and what can we do to improve those responses?"

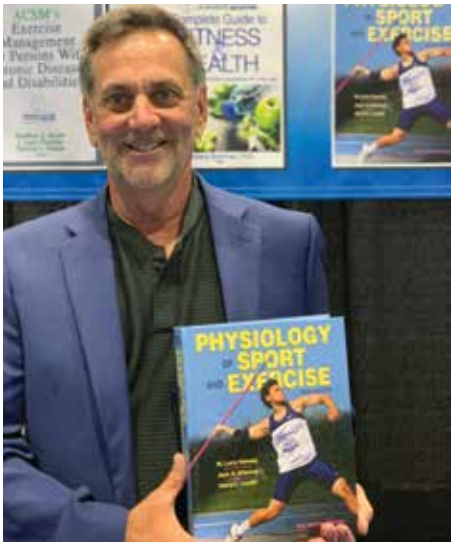
Starting in 1986, his work on heat stress and the elderly was funded by the National Institutes of Health (NIH) for 29 years straight. With the help of graduate students and post-doctoral fellows, Kenney conducted dozens of cross-sectional studies, comparing college-age students to older adults. He looked at sweating rates, how many sweat glands in the skin individuals activated, how the cardiovascular system responded and how much blood the heart pumped to the skin in certain conditions. The insights gained were helpful—and not just for the elderly.

OVERHEATED FOCUS

At the turn of the 21st century, heatstroke was known, but it wasn't well understood and addressed in arenas such as pro sports. In 2001, the death of Korey Stringer began to change that. A 27-year-old offensive lineman for the Minnesota Vikings, Stringer died August 1 that year after the second day of summer training. The cause: multiple organ failure due to exertional heatstroke.

At the time, NFL teams started summer training wearing full gear, all the pads and layers you'd see at the Super Bowl. Stringer, who was known to be a "prolific sweater," according to ESPN, vomited three times on the unusually hot first day of training and left early on a cart to cool down. The second day, July 31, was even hotter, nearly 90 degrees. Stringer threw up once but otherwise pushed through practice until he fell over during a block bag drill and was again transported to air conditioning. When he was finally brought to the hospital after becoming unresponsive, his internal core temperature was 108.8 degrees.

Attorneys representing Stringer's widow and young son enlisted Kenney to create an expert report on how much heat the athlete gained



Kenney with the eighth edition of his bestselling textbook on exercise physiology.

Kenney presenting at a conference in Spain on heat stress and hydration.

"The Three Mile Island situation ... was an immediate impending disaster. Global warming and climate change is a more slowly developing, but equally impending, disaster unless we do something about it."

and why the treatment he received was suboptimal. Boxes of paper reports, autopsies and interviews arrived at Kenney's office. The more he read, the more tragic the whole incident became.

"When there's a sudden heat challenge, like the first day of football camp … the body hasn't geared up yet to respond to the heat stress," Kenney says. "It takes usually between nine and 14 days to fully acclimate to exercise in a hot environment."

Stringer's life could have been saved by timely and appropriate heatstroke treatments. His death led to seismic change in the NFL. For Kenney, it further confirmed the value of understanding heat stress.

HEAT WAVES BECOME NORMAL

What was a disproportionately hot summer day in 2001 may now be normal. Thanks to the advancement of global climate change, extreme heat events are becoming more frequent and severe—and an aging baby boomer population means the number of at-risk elderly is growing as well. What environments are too hot (and humid) for humans to handle? That's the question Kenney's current NIH-funded research aims to answer, with a particular focus on the upper limits of body temperature regulation for the elderly.

In March 2020, as COVID-19 swept the globe, the new project kicked off. In the first two years, due to pandemic limitations, data collection focused on younger subjects. Now, Kenney's team is recruiting subjects ages 65 to 85 so they can compare heat tolerances to the younger subjects. Collaborators at Vrije Universiteit Amsterdam in the Netherlands and University of Sydney in Australia are collecting the same data to see if the findings ring true in different climates.

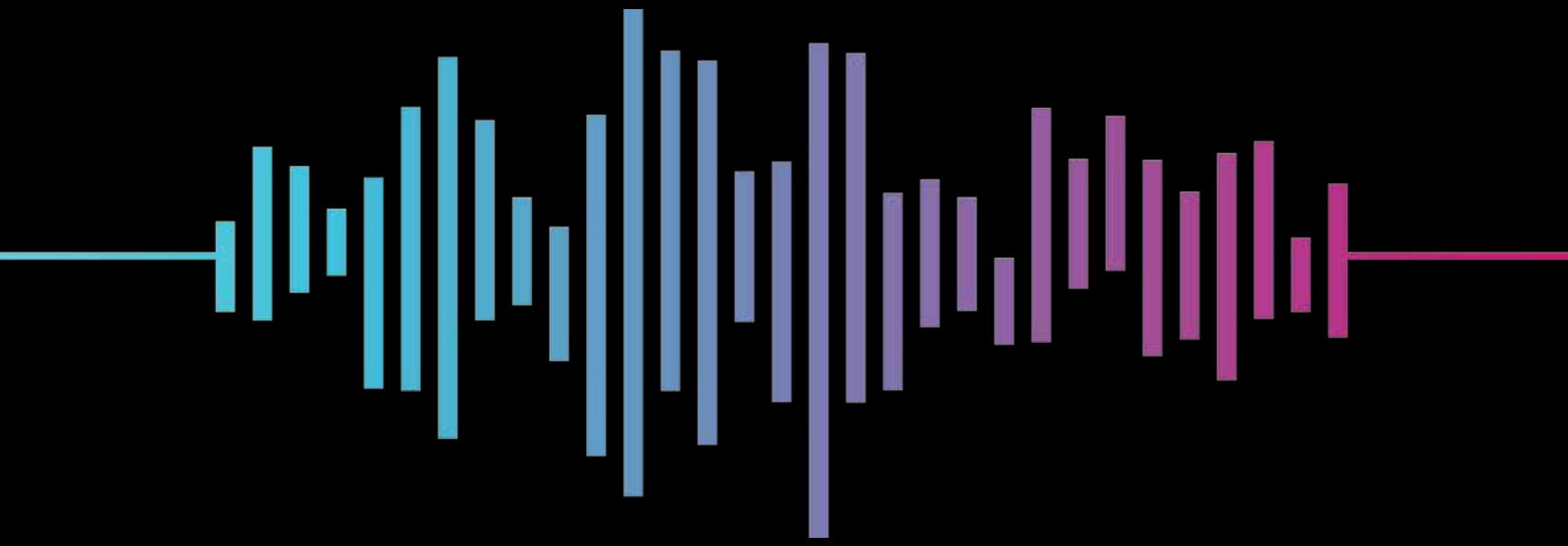
"The Three Mile Island situation … was an immediate impending disaster," Kenney says. "Global warming and climate change is a more slowly developing, but equally impending, disaster unless we do something about it."

In determining upper limits of temperature regulation for elderly versus young adults, Kenney's current research aims to provide practical information that can be used to support human health and safety when extreme heat events happen. That could look like community alerts and warning systems, as well as guidance for emergency rooms and retirement homes to triage the most vulnerable elderly before, and when, heat hits.

Kenney with his wife, Patti. The couple has three adult children who work in artificial intelligence, higher education and orthopedic surgery.

Really, that's been Kenney's research goal all along: to make discoveries that can ultimately help people.

"While our lab sometimes focuses on cellular and molecular mechanisms, we never lose sight of the big picture: how we can impact community health, athlete and worker safety, and public policy by knowing more about the physiology and biophysics of human temperature regulation."



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APS ACTION ALERTS

Survival *of the* Fittest

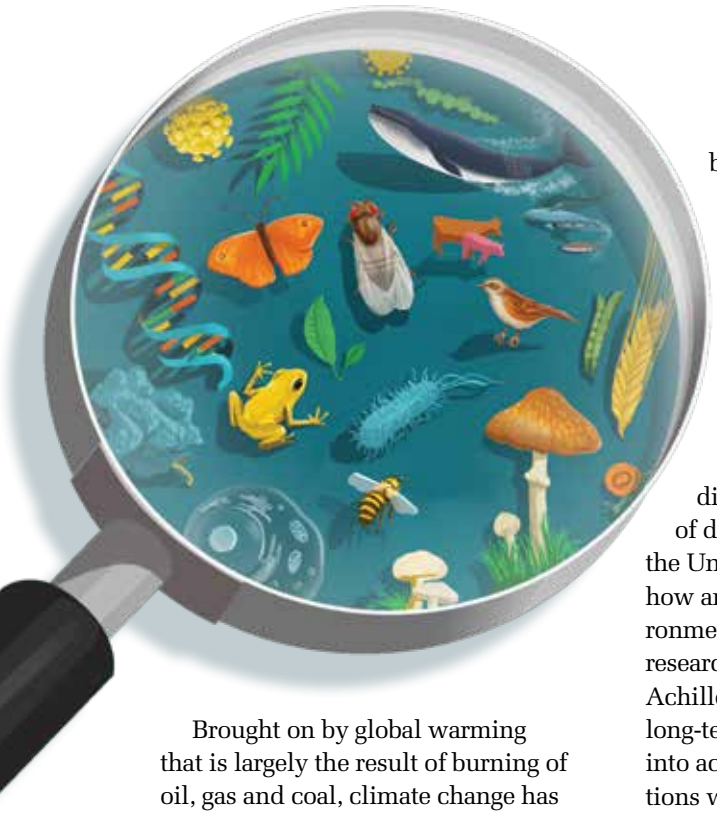
Researchers study how animals are adapting or struggling in the midst of climate change.

BY GLENN COOK

John Wingfield, PhD, has spent several decades examining how animals cope with the changing environment. Like most physiologists, his job has become increasingly complex as the world struggles to deal with global warming and climate change.

"That used to be just seasonality. Now it includes climate change resulting in changing seasonality as well as unpredictable extreme weather events. We now have to look at our research in different ways," says Wingfield, distinguished professor emeritus at the University of California at Davis.

Illustration by Michael Glenwood Gibbs



Brought on by global warming that is largely the result of burning of oil, gas and coal, climate change has resulted in increased heat, drought, wildfires, floods and insect outbreaks around the world. Since the Industrial Age, the Earth has warmed an average of 1.9 degrees Fahrenheit; once this number reaches 2.7 degrees Fahrenheit, scientists say the planet will tip into an "irreversible future" that also includes food scarcity and mass migration.

As scientists warn of these devastating effects, physiologists are studying how organisms are responding to change and how that will impact human and animal populations. In the process, they are moving away from tried-and-true research models on environmental changes.

Hollie Putnam, PhD, associate professor at the University of Rhode Island who studies the ecophysiology of marine invertebrates, says coral reef ecosystems are at high risk due to climate change. The reefs have an annual value "on the order of hundreds of billions of dollars" because of their impact on coastal protection, fisheries, tourism and the production of pharmaceuticals, she says.

"Currently, the rate of environmental change is pushing corals to the brink of collapse, which threatens food security, the coastal habitat and cultural connections," Putnam says. "Passing a tipping point can represent catastrophic consequences for the system, as well as the humans that depend on them."

Warren Burggren, PhD, FAPS, distinguished research professor of developmental physiology at the University of North Texas, studies how animals adapt to different environments. He says past and current research on climate change has "an Achilles heel" because it focuses on long-term projections and doesn't take into account "the huge weather variations we're seeing."

"A lot of the predictions on climate's effects on speciation, population dynamics and the survival of populations are based on what is projected to happen to temperature over 100 years or 500 years," Burggren says. "I love the quote by Mark Twain: 'Climate is what we expect. Weather is what we get.' And the weather is affecting animal populations in dramatic ways."

CHALLENGES FOR ANIMALS

Researchers are witnessing a race to see whether animal populations "can, through natural selection, modify at a rate quickly enough to catch up or to maintain their survival in changing environments," Burggren says. Most can't, but some "very rapid rates of evolution" will allow others to survive.

"The problem is that when you look at things like temperature or water availability, you're looking at not just coloration or a little change in body size, but some pretty fundamental physiological changes that are induced by either water availability or temperature. That fundamental physiological retooling is not really able to occur at the rate that many environments are changing," Burggren says.

Wingfield, who combines field studies with laboratory experiments to see how birds and other animals respond to changes in their physical and social environments, says researchers are "not always clear" in distinguishing between the predictable environmental changes over the seasons they have traditionally studied and the effects of climate change. The unpredictable nature of the latter, he says, has resulted in "acute and sometimes chronic stress," leaving some populations as "refugees from their normal habitat."

"How an animal responds to something it can predict, such as seasons, is very different from actually responding facultatively to what's going on in the immediate present," Wingfield says. "The unpredictable component is a real problem."

Jonathon Stillman, PhD, professor of biology at San Francisco State University and the University of California at Berkeley, has focused his research on how climate change and human activities affect marine and aquatic organisms. His lab has studied these problems in an array of organisms, including crabs, sea hares, coccolithophores, clams, freshwater crustaceans and insects.

In the laboratory's study of intertidal zone porcelain crabs, Stillman has seen how populations move away from long-term habitats as they are affected by warmer average temperatures and more frequent and severe heat waves in the winter and summer. This affects both the population density as well as "inter-individual interactions," which can lead to greater aggression, fighting, injury and ultimately decreased fitness.

"Stressed humans are in a different physiological state than relaxed humans, and the same is true for animals," Stillman says. "If climate change causes species distributions to shift, that can change the way that

Illustration by Sam Falconer

Since the Industrial Age, the Earth has warmed an average of 1.9 degrees Fahrenheit; once this number reaches 2.7 degrees Fahrenheit, scientists say the planet will tip into an "irreversible future" that also includes food scarcity and mass migration.

organisms interact with others from the same or from different species."

THE CHANGES WE SEE

Wingfield's research, which involves the study of birds for more than three decades in Arctic Alaska, shows that climate change is affecting migration and breeding.

"Some species are moving further north, and growth of shrubs and small trees like willows are increasing on the tundra," Wingfield says. "Before they were only 10, 15, maybe 20 centimeters tall; now some are two meters plus. As a result, these birds are retreating further north where tundra is still mostly short. Other species from the south are moving onto areas with expanded growth of shrubs where the higher arctic birds used to be."

What was once a four-week Arctic summer has become eight weeks in just the past two decades. "Some birds had just four weeks or so in which to raise young, so that would limit them to one brood. If they lost a brood early enough to a predator, maybe they could renest, but mostly it's just one brood," he says. "Now we're seeing evidence that these birds are raising two. That's quite a change for the Arctic. It is phenomenal."

Wingfield says physiologists are "really just beginning to understand" how major storms, which are coming with greater intensity, duration and frequency, affect animals and humans. He says the most important data involve integration of field work and in-lab research.

"The rate at which we're accumulating data is not as rapid as we would like," Wingfield says. "Because lab work does not always apply to what is happening in the field, we stay out there during storms and actually follow what the animals are doing, but not everybody likes to do that. We take those novel field observations into the lab and do controlled experiments that allow us to get at some of the mechanisms."

HOW ANIMALS AND ORGANISMS ADAPT

Stillman says some organisms affected by climate change have been shown to adjust their physiology and behavior better than others. His research has shown that organisms with the greatest tolerance to high temperatures have a "zero thermal safety margin," meaning they can't adapt to environmental changes or differences. In that instance, he says, the increased intensity of heat waves "is likely to cause a reduction in population size," while others can survive the climate shifts.

"For terrestrial animals, another major environmental driver is availability of water to prevent dehydration and for evaporative cooling," Stillman says. "As climate warms and droughts intensify, many organisms may not overheat, but rather dehydrate, as has been evidenced in mass mortality of birds and mammals in Australia."

Rising temperatures and the increasing intensity and frequency of marine heat waves have a negative effect on corals, Putnam says. This increase in temperature results in coral bleaching, a breakdown of the interaction between the coral and their symbiotic algae. Bleaching can result in coral starvation and mass mortality.

An adult coral can be 10 to hundreds of years old, she says, and once it settles on the ocean floor it is "in that position for life." Because of climate change, Putnam says much of her research is focused on "the legacy of the environment throughout connected life stages."

"Given this fairly long generation time, the changes that are now taking place in the environment are happening very rapidly," she says. "It is critical not only to examine any single life stage, but how conditions such as marine heat waves impact all the life stages and may generate carryover effects or environmental legacies that may benefit the coral through thermal priming, or negatively impact them through compounded or accumulating stress."

Corals typically follow one of two reproductive modes, Putnam says. In the first, corals send their gametes into the ocean in a synchronized manner on a lunar schedule, with

"Rather than ask, 'What happens if we take a freshwater fish from 20 degrees to 25 degrees over a number of years?' how about, 'What happens if we take it from 20 degrees to an average of 25 degrees, but fluctuating on a daily basis?' I think in the long run that information will be much more revealing."

—Warren Burggren, PhD, FAPS

larval development taking place while exposed to the ocean conditions. In the second, they fertilize and brood larvae internally for a period of one to several months, after which the larvae are released to settle and attach quickly to the ocean floor.

"It is essential to study a variety of aspects of coral reproduction each year to generate data that can be used to understand when and how climate change is impacting the various life stages," Putnam says. "Even more important, it is essential mechanistically to understand life-stage specific sensitivities or carryover of the stress response from one stage to another."

Wingfield points to instances in recent decades in which birds arrived in Europe ready to breed but found their food supply had already peaked. The "mismatch" means these birds missed their best opportunity to raise their young. Nonetheless, there are signs that some have been "more flexible and are able to adjust and arrive earlier to initiate breeding at the right time," he says.

"When you look at animal populations and plants, there's no clear trend for a slow change or a dramatic one or a rapid one. There're always some species that are much more adaptable and flexible and respond with greater rapidity than other species," Wingfield says. The next question is "why are some populations and individuals more flexible than others?"

Even though Putnam is worried about the long-term effects of climate change, she notes many corals have proven they can acclimate. "What doesn't kill corals can make them stronger, even across a generation," she says.

WHAT LIES AHEAD

What are the next steps that physiologists should pursue to get a better handle on how climate change is affecting animals and, ultimately, humans?

Burggren says physiologists should "reconsider our experimental paradigm" by focusing on stochasticity—the random variables that are taking on increased importance in climate change. "There's a whole underlying undercurrent of stochastically driven biology that we haven't really plumbed as physiologists," he says. "Our training is to hold everything constant, except the one variable we're interested in, and then we manipulate that to a new level.

"Rather than ask, 'What happens if we take a freshwater fish from 20 degrees to 25 degrees over a number of years?' how about, 'What happens if we take it from 20 degrees to an average of 25 degrees, but fluctuating on a daily basis?' I think in the long run that information will be much more revealing."

Physiologists who work at the cell and molecular levels will need to collaborate with ecologists, as well as behavioral and evolution biologists, before they can "get some handle of the answers" about the effects of climate change, Wingfield says.

"In the recent past, we've taught our students to be specialists. They tend to focus on very narrow topics out of necessity to apply all the cutting-edge techniques to a very clear, but focused, question," Wingfield says. "Out there in the field we see animals responding to a suite of information. We've got to find some way to integrate field and lab investigations. Understanding the future of environmental change and how plants and humans are responding to climate change requires us to collaborate as each brings expertise needed to address the problems."

Stillman agrees: "Comparative physiology is ever more important as human activities are changing Earth's environment on a global scale," he says. "Most of what we know about physiology comes from a rather small group of organisms. Though all life shares fundamental biochemical and cellular architecture, the great biodiversity of nature is reflected at the physiological level, too."

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AMERICAN Toxic

In the air and water, at work and at home, pollutants abound.

BY LAUREN ARCURI

From the air we breathe to the water we drink, from the food we eat to the places we work, humans and other animals are exposed to a wide variety of environmental pollutants that potentially endanger our health. While some toxic substances—such as arsenic—occur naturally, by and large, it's human activity and technology that expose us to toxic pollutants.

Ambient air pollution is a major risk to human health. According to the World Health Organization, an estimated 6.2 million deaths occur each year worldwide due to air pollution, which we know causes cardiovascular disease and chronic respiratory illness. Air pollution is made up of a "heterogeneous mixture of different-sized particles in the air," explains Loren Wold, PhD, FAPS, associate dean for research operations and compliance and professor of medicine and nursing at The Ohio State University.

Illustration by Mark Hess

As humans have developed agricultural and manufacturing industries, we haven't always understood what pollutants we were creating in the process, nor what effect they might have on us and the rest of the planet.

There are thousands of different chemicals, gases and particulates that are considered "particulate matter." They fall into three main categories by size: ultra-fine, fine and coarse. "Our interest is mainly in the fine particulates because they're known to have the greatest effects on human health, and they're the size predominantly produced by the combustion of fossil fuels," Wold says. This category of particulate matter is 2.5 microns in diameter (PM2.5) and smaller.

Wold's research began in the early 2000s, studying the effect of these small particles on the body in a mouse model. "We knew they affected the lungs, but our interest was: Is there potential for effects on other organ systems?" he says. "Initially, we started looking at the heart, and now we've branched into potential effects on brain health."

Because elderly people are more likely to have heart disease, and make up the main population with Alzheimer's disease, Wold's lab wondered if there was a potential link between the two. Their hunch proved correct: "We've now shown that exposure to concentrated air particulates not only causes heart disease but can also potentiate early-onset neurodegenerative disease," he says.

One of the prevailing theories of Alzheimer's disease is that it is caused by changes in the brain's vascular system. Research has shown that PM2.5 are small enough to pass through the endothelial lining in the lungs and into the bloodstream. Once in circulation, they can have direct effects on any organ system and can pass through the blood-brain barrier and impact the brain through the vascular network.

But Wold's lab is interested in uncovering whether the particles could also be having a direct cardiac effect. "And then, is there a communication network between the heart and brain, what we call the heart-brain axis?" he says. "We don't know what the communication network is yet, but we know there's an inflammatory response with heart disease, and reactive oxygen species are produced. Both could potentially communicate to the brain."

While the mechanisms of communication along the heart-brain axis are still under study, Wold's lab has shown, in the mouse model, that exposure to these particulates leads to both heart disease and greater deposition of β-amyloid plaque in the brain. "What we think it is," Wold says, "is a combination of both inflammation as well as the production of oxidative stress and the promotion of an oxidant environment that can lead to a whole host of diseases."

Wold also studies the effects of burn pit exposure on veterans via a mouse model. The researchers have found effects not only on the exposed mice, but their offspring. "I think this is an area that is under-discussed," he says. "There's a lot of personal choice that we take when exposing ourselves to certain environments that could have dramatic effects on our future children."

John Hollander, PhD, professor and assistant dean for professional programs in the School of Medicine at West Virginia University, also studies the effect of pollutants on offspring. Specifically, his research focuses on nanoparticulates, "anywhere from 1 to 100 nanometers in size," he says. To study them, the lab aerosolizes the nanoparticles and administers them via the lungs.

While there are many nanoparticles out there, Hollander's lab focuses on nanosized titanium dioxide, which has been recognized as a risk by the National Institute for Occupational Safety and Health. Nanosized titanium dioxide is found in many products, from white paint to processed foods such as salami to sunscreen and other cosmetics. "It's virtually everywhere," Hollander says. "Anything that has the ability to repel water, it can be used. And these materials are manufactured in a plant that deals with some kind of nanoparticulate." So, not only are consumers affected, but workers may have particularly high exposure.

His lab found that these exposures affect cardiac function, which seems to be suppressed, affecting the ability of the heart to contract. To under-

stand why the heart isn't working optimally in the face of these exposures, Hollander's team studies the function of the energy powerhouses of the cell, the mitochondria.

"We have found that when you acutely expose these animals, there is a pronounced decrease in mitochondrial function. Sometimes we see effects in certain subtypes of mitochondria; sometimes it affects multiple types and sometimes only one. But the effects are things such as a decrease in respiratory capacity within the mitochondria and enhanced permeability transition of the pore opening," he says. "So, the mitochondria will go through an apoptotic program much more easily." They've also seen changes in electron transport chain complex activity, suggesting that the mitochondrial dysfunction may be a result of that complex being impaired.

Hollander's most recent work is focused on gestational exposure. In his model, the researchers are able to monitor the cardiac function of fetal pups in utero via echocardiography. In both mothers and pups, they see decreases in not only cardiac function, but mitochondrial function and bioenergetics.

"This has been really exciting for us," Hollander says. "Our most recent work has been geared toward a phenomenon termed 'mitochondrial programming.' The hypothesis is that in utero, when the pregnant dam is exposed, it is impacting the mitochondria of the fetal pup such that they're being reprogrammed."

While this can cause damage to the pup in utero, it might not always. Hollander and his colleagues hypothesized that even the healthy-appearing pups might have some undetected damage from their exposure. "When the mouse encounters a secondary insult later in life that challenges the bioenergetics of the heart, we wondered if the mouse might be worse off than a mouse without that fetal exposure," he says.

"Our preliminary data suggest that this is the case. There are epigenetic changes that are occurring in utero. Those genes that are being epigenetically modified are changing such that down the road, the mitochondria have been reprogrammed to not be able to either tolerate or respond as appropriately to the secondary insults," he says. Those secondary insults might be anything from an additional nanoparticle exposure to a known risk factor such as a high-fat diet.

Both Wold and Hollander's research adds data to the hypothesis that pollutant exposure at the fine- and nano-level affects not only the animal directly exposed, but future generations.

While there is no shortage of epidemiological data showing that these environmental pollutants damage human health and cause various diseases, there's a need for more basic research to help us understand more fully how this is happening.

POLLUTANTS IN THE WATER SUPPLY

Environmental pollutants are everywhere, including in our water supplies. And they're not always put there by humans. Arsenic is a good example: While sometimes it's in the soil from farming with pesticides and other human activity, it also simply occurs naturally in the earth's crust, in higher proportion in some geographical areas than others.

If your water supply is municipal, your municipality likely tests for arsenic, making sure it's at a safe level, generally under the Environmental Protection Agency standard of 10 parts per billion (ppb). "But if you look at many parts of the country and the world—people who are on well water in New England, many of the Plains states, and other countries in the world like Chile and Bangladesh—they tend to have levels that might exceed 500 or 1,000 ppb," says Mark Kohr, PhD, associate professor of environmental health and engineering at Johns Hopkins Bloomberg School of Public Health in Maryland.

There is robust epidemiological evidence to suggest that both men and women suffer cardiovascular effects due to arsenic exposure. That said, "Arsenic doesn't just affect the heart or cardiovascular system," Kohr says. "It affects nearly every organ system in the body and has been labeled as a carcinogen."

> **"I think it's critical that as researchers we're thinking about the whole person, the whole body, when we're thinking about exposures."**
>
> **—Tara Nordgren, PhD**

Kohr's lab looks at sex differences in cardiovascular disease, trying to understand the mechanisms that protect the female heart, at least until menopause. "So far," he says, "we see strong sex-dependent effects with arsenic exposure. The adult male hearts are the most affected." The female mice seem to be protected, at least during the short time frames Kohr has studied so far.

The arsenic-exposed male mice develop something called pathological hypertrophy: Their hearts get bigger and stronger, partly in response to an increase in blood pressure. "Although it's initially a compensatory response and beneficial, eventually those mechanisms break down and it could culminate in heart failure." While their studies haven't yet shown heart failure due to their duration, Kohr says the development of this pathologic hypertrophy "is not a good sign for the males."

Kohr's lab is currently looking at gestational exposure to arsenic, trying to quantify its effects on cardiac development. "This project started because there's a fair amount of literature that suggests that pregnant women exposed to arsenic might have a higher risk of having babies born with congenital heart defects," he says.

Like Hollander, Kohr's lab uses echocardiography to study the developing heart, and after the pups are born, they measure the heart's function. So far, they do see some cardiac dimensional changes. There are impacts on the mother's cardiovascular system as well, Kohr says. "There might be effects on maternal health here, too, which is a very understudied area. A lot of studies in both basic science and humans seem to focus on the health of the baby, but not the health of the mom."

POLLUTANTS IN THE WORKPLACE

For many people, work is a place of potential pollutant exposure. More than 9 billion animals are raised for food each year in the U.S., the vast majority of them on concentrated animal feeding operations (CAFOs), according to the Natural Resources Defense Council. Epidemiological research over the past two decades establishes that CAFO workers, specifically hog farm workers, suffer health effects from dust in the air that contains endotoxins, fungi, microbes, ammonia, hydrogen sulfide and an array of other volatile organic compounds. Research has shown the dust also affects people who live near CAFOs.

An interdisciplinary team published a 2021 review in the *American Journal of Physiology-Gastrointestinal and Liver Physiology* that laid out the evidence for the mechanistic effects of environmental dust pollution on the human gut and how the gut and lungs are interconnected—how exposure via one body system, such as breathing in hog dust, might lead to effects on another system, such as gastrointestinal barrier function. That team is Tara Nordgren, PhD, assistant professor at Colorado State University in Colorado; Declan McCole, PhD, professor of biomedical sciences at the School of Medicine at the University of California, Riverside; and Meli'sa Crawford, PhD, a postdoc in McCole's lab.

One route: When we breathe particles in, our lungs' mucociliary escalator brushes them upward out of our airways and into our throats, then we swallow them into our stomachs and onward through the rest of our gastrointestinal system. But it's possible that exposure to one system could cause effects in another body system in ways such as by promoting systemic inflammation and through other mechanisms yet to be discovered.

Research shows that CAFO farmers and farm workers experience chronic airway inflammation as well as gastrointestinal symptoms such as vomiting and diarrhea. "We wanted to know, how is that happening?" Crawford says. "Is it solely because of changes to the microbiome, or could it be something else?" A more permeable intestinal barrier sets the stage for inflammatory bowel disorders such as Crohn's disease.

To better understand the mechanisms and physiology involved, the team used a prepared formula meant to mimic real-life exposure to the dust, called hog dust extract (HDE), in a mouse model. They exposed the mice intranasally to the HDE for a three-week period and found increases in intestinal barrier permeability and serum endotoxins,

Crawford says. "This is indicative of systemic endotoxemia, so inflammation—and this is only after three weeks. So who knows what prolonged exposure could do."

They also found some inflammatory markers upregulated in the intestine, including TNF-alpha, a cytokine that can signal the upregulation of other pro-inflammatory cytokines and cause leakiness of the gut barrier.

"So now, we're looking at the gut microbiome, because if there's an increase in serum endotoxins and intestinal permeability, that means the gut microbiome is also going to be affected by this," Crawford says. They have already found a decrease in the abundance of one particular beneficial bacterium in the mouse gut microbiome. "Right now, we're trying to figure out how the decreased abundance of this species contributes to the inflammatory effects we're seeing after exposure," Crawford says.

Nordgren's focus is on how HDE affects the lungs. "We see quite dramatic lung inflammation with an acute exposure. And if we expose them over a period of 21 to 24 weeks, we see not only inflammation but fibrosis happening—really dramatic pathological consequences for these exposures in a long-term setting," Nordgren says.

The collaboration between McCole and Crawford, who both work on the gut, and Nordgren, who studies the lungs, has been an especially fruitful one. It's emphasized for them just how interconnected our body systems are, particularly when it comes to exposure to these tiny particles in our environment.

"I think it's critical that as researchers we're thinking about the whole person, the whole body, when we're thinking about exposures," Nordgren says.

As their research continues to unfold, they're hoping to elucidate more connections along the gut-lung axis.

"This is a unique opportunity to really look at how these two organ systems are interacting to impact overall health," Nordgren says.

POLLUTANTS THAT DON'T FADE AWAY

Persistent organic pollutants (POPs) are a varied family of environmental contaminants that are dispersed globally and known to stay in our bodies and the environment for a long time. They are found in our food, our air, and our household and commercial products. There are many POPs, but Jenny Bruin, PhD, associate professor of biology at Carleton University in Ontario, Canada, studies six major classes of them: dioxins, polychorinated biphenyls, organochlorine pesticides, organophosphate pesticides, flame retardants, and per- and polyfuoroalkyl substances.

Bruin studies how POPs affect β-cells, the pancreatic endocrine cells that regulate our glucose homeostasis. Her recently published review shows strong evidence that POPs contribute to β-cell dysfunction, impaired glucose homeostasis, and altered metabolic and oxidative stress pathways in islets. This supports epidemiological studies that establish that exposure to POPs increases diabetes risk. However, there are some significant gaps in the data that Bruin hopes her lab can begin to fill in.

"There's evidence for all six classes that these pollutants have the potential to affect insulin secretion," Bruin says. "We need more studies in different types of models, not just in immortalized β-cell lines, but the existing studies certainly are convincing that POPs have detrimental effects on β-cells."

While the ways POPs affect the β-cell may differ, with some causing constant overstimulation and others impairing insulin release, the overarching theme is that there is consistent evidence that insulin secretion is disrupted.

Like other researchers who study environmental pollutants, Bruin's lab is trying to determine the mechanism. How exactly are these pollutants exerting their effect on the β-cells? One of the pathways they're investigating is the aryl hydrocarbon receptor (AhR) pathway, which is known to mediate most of the effects of the dioxin family of pollutants.

"We've demonstrated very clearly that the AhR pathway is activated in islets by exposure to pollutants," Bruin says. "So we're exploring the role of AhR in β-cells and how downstream molecules that are activated via AhR affect β-cell physiology. More specifically, we're looking at some of the drug metabolism enzymes that are induced by that pathway. And what do those drug metabolism enzymes do in the islet? That's something that hasn't really been explored before."

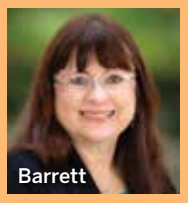
TIME FOR SOLUTIONS

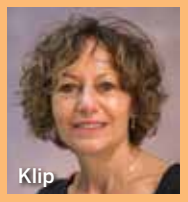
Industrialization brought with it global environmental contamination. As humans have developed agricultural and manufacturing industries, we haven't always understood what pollutants we were creating in the process, nor what effect they might have on us and the rest of the planet.

While there is no shortage of epidemiological data showing that these environmental pollutants damage human health and cause various diseases, there's a need for more basic research to help us understand more fully how this is happening.

"I think if we can better understand the mechanisms, we will better know how to approach potential solutions to mitigating these effects," Kohr says.

APS Members Chosen as IUPS Fellows





The International Union of Physiological Sciences (IUPS) has announced its 2022 class of Honorary Fellows and Fellows of the IUPS Academy of Physiology. Fellow status is awarded to those who have made exceptional contributions to the physiological sciences. The following APS members have been selected for the 2022 class of IUPS Fellows:

- **Kim E. Barrett, PhD, FAPS,** vice dean for research and distinguished professor of physiology and membrane biology, University of California Davis School of Medicine
- **Marcia Hiriart, DSc,** senior researcher, National Autonomous University of Mexico
- **Amira Klip, PhD, FAPS,** senior scientist, The Hospital for Sick Children; professor, University of Toronto, Canada
- **Duncan Mitchell, PhD,** emeritus professor of physiology and honorary professorial research fellow, Brain Function Research Group, University of the Witwatersrand, South Africa; adjunct professor, School of Human Sciences, University of Western Australia
- **Mark T. Nelson, PhD,** university distinguished professor and chair, Department of Pharmacology, University of Vermont
- **Juleen R. Zierath, PhD,** professor and research group leader, Department of Molecular Medicine and Surgery, Karolinska Institutet, Sweden; professor and executive director, Novo Nordisk Center for Basic Metabolic Research, University of Copenhagen, Denmark
- **Irving H. Zucker, PhD, FAPS,** Theodore F. Hubbard Professor of Cardiovascular Research, University of Nebraska Medical Center

Gopalan Receives Fulbright Fellowship

Chaya Gopalan, PhD, FAPS, has been awarded a Fulbright-Nehru Academic and Professional Excellence Fellowship, enabling her to provide professional development workshops and train college educators in India on the use of flipped classroom techniques. Gopalan is a professor in the Department of Applied Health at Southern Illinois University Edwardsville. She has been an APS member since 1999.

Lisberger Elected to National Academy of Sciences

Stephen G. Lisberger, PhD, professor and chair of neurobiology at Duke University School of Medicine in Durham, North Carolina, has been elected to the National Academy of Sciences. This prestigious honor recognizes continuing achievements in original research. Lisberger's research focuses on how the cerebellum learns simple motor skills and how visual inputs guide movement. He has been an APS member since 2002.

Navar Admitted to Research Hall of Fame

L. Gabriel "Gabby" Navar, PhD, FAPS, has been inducted into the Tulane University Research Hall of Fame. This lifetime achievement award honors the stellar careers of Tulane's researchers and scholars. Navar is recognized for his work on regulation of kidney function and the role of angiotensin in hypertension and diabetes. He is a professor and chair of the Department of Physiology at Tulane University in New Orleans and is co-founder of the Hypertension and Renal Center of Excellence. Navar has been an APS member since 1971.

Ranadive Receives Graduate Faculty Mentor Award

Sushant Ranadive, PhD, is the University of Maryland's 2022 Graduate Faculty Mentor of the Year Award recipient. The honor recognizes faculty members who have made exceptional contributions to and have served as outstanding mentors in the graduate student experience. Ranadive is an assistant professor of kinesiology in the University of Maryland's School of Public Health. He has been an APS member since 2010.

Silverthorn Awarded Teaching Prize

APS President Dee Silverthorn, PhD, FAPS, is the 2021 recipient of The Physiological Society's Otto Hutter Physiology Teaching Prize and Lecture. This award recognizes "excellence and originality in physiology teaching at the undergraduate level." The honor includes giving a keynote address at Europhysiology 2022 in Denmark. Silverthorn is a distinguished teaching professor of physiology emerita in the Dell Medical School at the University of Texas at Austin. She has been an APS member since 1977.

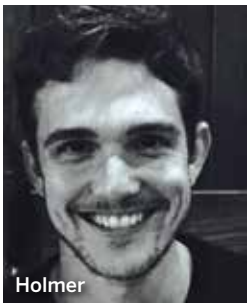
NEW BLOG EDITOR

I Spy Physiology Blog Recognizes Volunteer Editors

The APS Marketing and Communications Office is pleased to welcome Natalya Zinkevich, PhD, as the incoming volunteer blog editor of APS' award-winning I Spy Physiology blog. The I Spy blog is a member-driven vehicle to highlight physiology in everyday life. The volunteer blog editor contributes posts to the blog, assists with outreach to recruit new member-contributors and reviews posts for scientific accuracy.


Zinkevich

Zinkevich, an assistant professor at the University of Illinois at Springfield, performs research primarily focused on the cardiovascular system and teaches courses related to human anatomy and physiology, comparative vertebrate zoology, and human disease. She began her two-year term in May.


Holmer

We would like to extend our heartfelt thanks and appreciation to outgoing volunteer blog editor Brady Holmer. Holmer, a PhD student in exercise physiology at the University of Florida, stepped into the volunteer editor role in May 2020. He played an instrumental part in referring new contributors to the blog—and contributing multiple posts himself—during the height of the coronavirus pandemic, when most labs were shuttered and research paths were uncertain. An avid science communicator, Holmer also served as an Experimental Biology meeting blogger for I Spy Physiology in 2021.

Enjoy science communication? Email **communications@physiology.org** for more information about becoming an I Spy Physiology blog contributor.

MEET THE EDITOR

Ana Domingos, PhD

American Journal of Physiology-Endocrinology and Metabolism

Ana Domingos, PhD, will begin her term as editor-in-chief of the *American Journal of Physiology-Endocrinology and Metabolism* on July 1, 2022.

"I'm an associate professor of neuroscience in the Department of Physiology, Anatomy and Genetics at the University of Oxford in England. After studying undergraduate mathematics in Lisbon and Paris, I went to The Rockefeller University in New York City for my doctoral neurobiology studies with Leslie Vosshall, PhD, and my postdoc with Jeffrey Friedman, MD, PhD. I started my lab nearly 10 years ago to investigate the crosstalk between immune cells and sympathetic neurons in controlling adiposity.

I couldn't be more enthusiastic about the prospect of contributing to the *American Journal of Physiology-Endocrinology and Metabolism*. Since its inception in 1898, the *American Journal of Physiology* has been a scholarly reference in physiology. The journal has made several significant contributions to physiology for over a century, having featured publications by Nobel laureates such as Hans Krebs and Henry Dale. Moreover, when women were not recognized as scientists, the American Physiological Society elected Mabel FitzGerald as its second female member because she discovered the effects of altitude on hemoglobin levels—a recognition she did not obtain in her homeland of Britain.

My mission as editor-in-chief is to capitalize on the journal's rich past to build a brighter future. Keeping alive the journal's history is just as crucial as modernizing, and this will entail globalizing its authorship base while paying close attention to diversity, gender and geographical representation. I thus extended my team of associate editors to include representation from China and Brazil and diverse focus areas that are gaining momentum in the field of endocrinology and metabolism."

MEET THE CHAIRS

Two New Section Chairs Elected

CELL & MOLECULAR PHYSIOLOGY SECTION CHAIR

Sandrine V. Pierre, PhD

Associate professor of biomedical sciences, Marshall Joan C. Edwards School of Medicine; interim director, Marshall Institute for Interdisciplinary Research

"It is a great honor to serve as chair of the Cell & Molecular Physiology Section. I am humbled and excited to take on this responsibility! I am especially looking forward to working with all stakeholders to enhance the section's impact on the members it seeks to represent and support."

APS would like to thank My Helms, PhD, associate professor in the Department of Internal Medicine at the University of Utah in Salt Lake City, for leading the APS Cell & Molecular Physiology Section from spring 2019 to 2022.

CARDIOVASCULAR SECTION CHAIR

Farah Sheikh, PhD

Professor, Department of Medicine, University of California San Diego

"My goal is to re-envision the Cardiovascular Section mission with American Physiology Summit 2023 in mind, such that it supports and promotes outstanding research in the cardiovascular field through innovative programming. I look forward to engaging with our members and adopting new mentorship programs to expand and diversify our membership."

APS would like to thank Michael Sturek, PhD, professor in the Department of Anatomy, Cell Biology and Physiology at Indiana University in Indianapolis, for his leadership of the Society's Cardiovascular Section from spring 2019 to 2022.

AWARDS

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

Henry Pickering Bowditch Award Lectureship (July 1)

The Physiology in Perspective Walter B. Cannon Award Lectureship (July 1)

A. Clifford Barger Underrepresented Minority Mentorship Award (September 15)

Bodil Schmidt-Nielsen Distinguished Mentor and Scientist Award (September 15)

Hugh Davson Distinguished Lectureship (Apply anytime)

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

More details: www.physiology.org/awards

CALLS FOR PAPERS

American Journal of Physiology-Cell Physiology

- Skin Homeostasis: Peptides, Hormones, Proteases and More (July 1, 2022)
- Tumor Host Interactions in Metastasis (September 1, 2022)
- Epitranscriptomic Regulation of Cell Physiology (September 30, 2022)

American Journal of Physiology-Heart and Circulatory Physiology (August 31, 2022)

- Considering Sex as a Biological Variable in Cardiovascular Research
- Innovation in Improving Rigor and Reproducibility in Cardiovascular Research

American Journal of Physiology-Renal Physiology (July 31, 2022)

- Kidney Disease: Role of Inflammation and Immunity
- Molecular Basis of Kidney Injury and Repair

Journal of Neurophysiology

- Visual, Vestibular and Somatosensory Interactions for Visuomotor Responses: A Tribute to Jerry Simpson (July 29, 2022)
- Artificial Intelligence and Machine Learning in Neuroscience (August 1, 2022)

More details: www.journals.physiology.org/calls

MEETINGS & EVENTS

APS Intersociety Meeting in Comparative Physiology

Conference dates: October 28–31, 2022, San Diego

- Advance registration deadline: September 20, 2022
- Registration deadline: October 14, 2022
- Housing deadline: October 25, 2022

More details: www.physiology.org/Comparative2022

WEBINARS

APS-Alzet Osmotic Pump Webinar
September 13, 2022

APS Respiration Section-Coy Labs Webinar September 21, 2022

APS-Elements SRL Webinar September 29, 2022

APS-FAUNABIO WEBINAR SERIES

Careers Entrepreneurship Roundtable Session 1 September 15, 2022

Careers Entrepreneurship Roundtable Session 2 September 22, 2022

APS CARDIOVASCULAR WEBINAR SERIES

Androgens and Cardiovascular Diseases in Women: From Basic Research to Clinical Practice September 14, 2022

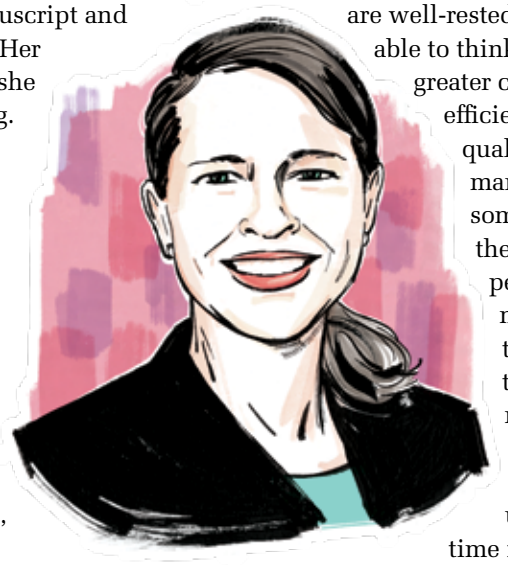
Inflammation and Vascular Damage in Hypertension
September 28, 2022

More details: www.physiology.org/webinars

How Do We Prevent Female Physiologists from Leaving?

BY GINA YOSTEN, PHD

Not long ago, a graduate student from another lab asked to meet with me. She was only halfway through her second year of graduate school but had already produced enough high-quality data to construct her first manuscript and present at a national meeting. Her grades were outstanding, and she was, by all measures, excelling. In spite of these accomplishments, she told me she felt like a failure and that she was thinking of quitting.



Unfortunately, this is not an uncommon story. I have personally encountered many, many female trainees from institutions across the U.S. who have expressed similar feelings, the majority of whom ultimately left academia, and some have exited science entirely. Many hypotheses have been proposed, but the data paint a very clear picture: Although women now comprise the majority of our graduate student body, we are, as a discipline, wholly unprepared to effectively mentor them. Based on my own experiences and those of my female peers, I offer up the following steps that we as a scientific community can take to keep our brightest stars from burning out.

"Although women now comprise the majority of our graduate student body, we are, as a discipline, wholly unprepared to effectively mentor them."

Listen. Many women in science do not feel heard, which leads them to believe that what they say is not important. This in turn contributes to imposter syndrome, which is rampant among trainees, particularly women. Mentors can greatly impact the lives of their trainees by simply, but actively, listening. Close your laptop, silence your phones and look your trainees in the eyes as they speak. In so doing, mentors can send a clear message to trainees that what they say *does* matter and that they can trust us to listen.

Create a supportive lab environment. Foster an internal culture of collaboration where lab members are highly encouraged to help, rather than compete with each other, and one in which each person's success is viewed as the group's success. Remember that each laboratory microenvironment is dictated entirely by the attitudes and opinions of the principal investigator (PI). If the microenvironment is inhospitable to trainees, only the PI is capable of exacting change, and it is their responsibility to do so.

Mitigate unrealistic expectations. People who are well-rested and well-adjusted are able to think more clearly, demonstrate greater concentration, are more efficient and produce higher quality work. Why then do many mentors encourage and sometimes even mandate that their trainees spend 60+ hours per week at the bench? The mentors who have the best track records for effectively training female students recognize the unsustainability and impracticality of this approach, instead urging their trainees to take time for their families, personal affairs and themselves.

Share your own struggles. Many women, particularly those who are mentored by female faculty, see all that their mentors manage and wrongly believe that they will be unable to perform at their mentor's level. This is often because faculty tend to hide the hardships they face, leaving female trainees to believe that they are the only ones who are struggling. Reassuring trainees that their experience is valid, that it feels difficult because it is difficult, and that in spite of those difficulties, they are performing well is an important part of ensuring women build the confidence they need to succeed.

Gina Yosten, PhD, is an associate professor of pharmacology and physiology at the Saint Louis University School of Medicine in Missouri. She is also editor-in-chief of the *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology.*

Illustration by Brett Affrunti

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- Teaching and Learning Integrative Physiology
- Physiology Education Research
- Curriculum Development

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