THE Physiologist MAGAZINE
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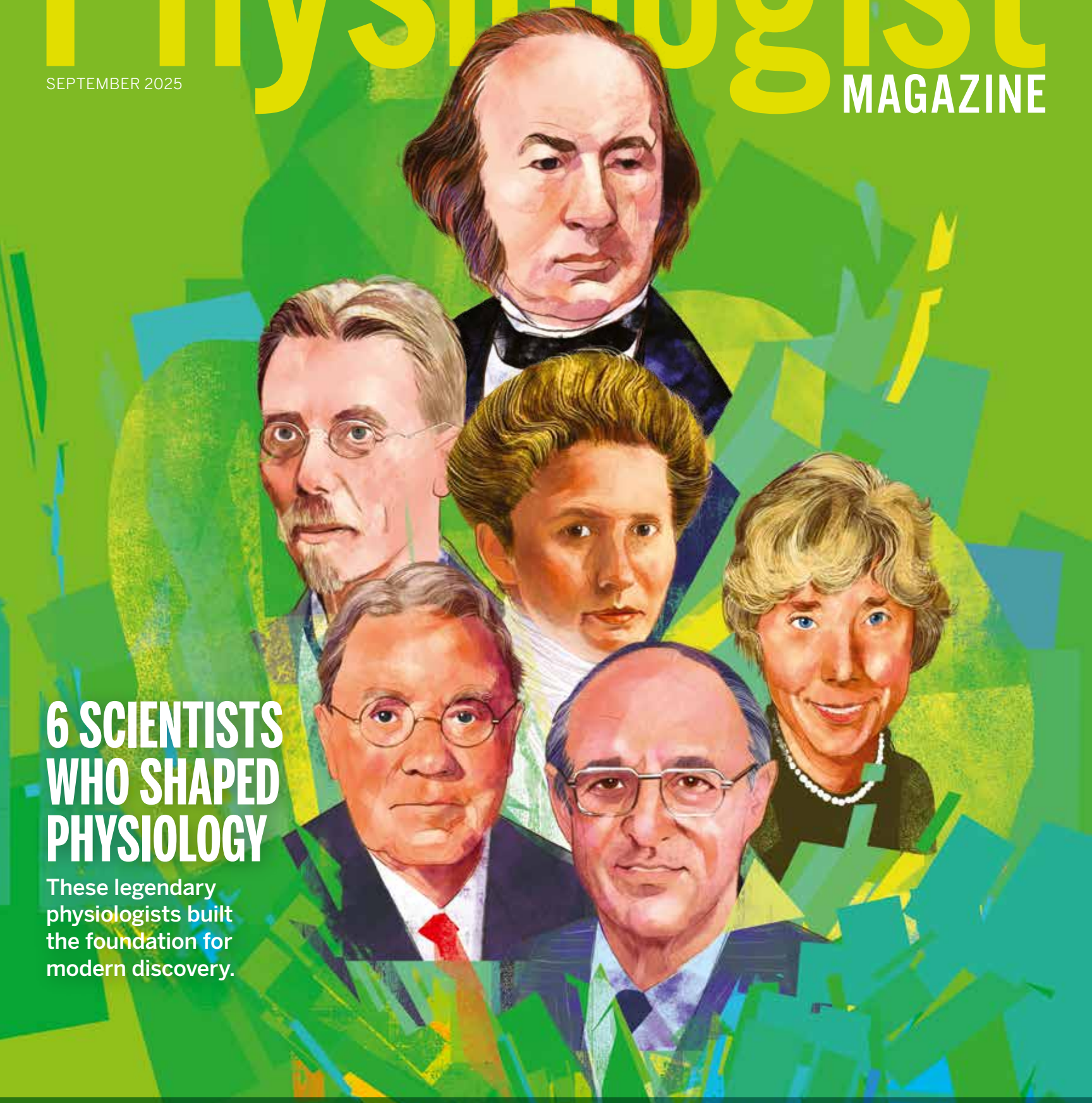

# 6 SCIENTISTS WHO SHAPED PHYSIOLOGY

**These legendary physiologists built the foundation for modern discovery.**

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Cover illustration by John Jay Cabuay

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# New Trends in Sex Differences and Women's Health Research

## October 23–25, 2025

## New Orleans, Louisiana

Join us for this biennial event gathering leading experts in sex differences and women's health. Engage with renowned scientists, expand your network and discover cutting-edge research. Don't miss this chance to be part of groundbreaking discussions shaping the future of sex and gender medicine.

**Learn more at physiology.org/APSSexDiff2025.**

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# Science that Endures

BY AMANDA BERTHOLF, MA

When we set out to choose the legends of physiology featured in this issue, it was no small task. With limited pages and word counts, there are too many worthy candidates to choose from. Narrowing it down proved tough. But we knew what we were looking for: scientists whose work was foundational to the discipline of physiology, whose influence still echoes in today's research and whose stories continue to inspire. We looked for historical figures—who were maybe even considered rebels of their time—who made diverse, meaningful contributions to physiology. And where possible, we highlighted those with ties to APS.

The discoveries by the legends we highlight in this issue surround you in everything you do in physiology. They are so much a part of what the discipline is today that their work is embedded in your day-to-day research.

These aren't just stories from the past, they're also reminders of what's possible. The challenges these scientists faced weren't so different from the ones you see today: limited resources, systemic hurdles, skepticism of science. And yet, they persisted. And in doing so, they helped shape the scientific world as we know it today. That's not just history. That's a road map you can continue to follow. As you face new challenges, you can carry their persistence forward—stay curious, creative and unwilling to give up on what matters.

**"These physiology legends helped shape the scientific world as we know it today. That's not just history. That's a road map you can continue to follow."**

You can read more about the giants of physiology, their work, and why it matters today on page 16.

In the vein of curiosity, we invite you to enjoy our profile of Dane Crossley, PhD, on page 28. This comparative physiologist has long been interested in alligators, snakes, turtles and other reptiles. He studies them not only for sheer fascination but also to learn more about their adaptations and how that might translate to a better understanding of human health.

On page 24, we examine sex-based physiological differences when it comes to addiction. Take alcohol, for example. We've long known that women can feel the effects of alcohol more quickly than men, but chalking that up solely to body size is too simplistic. Physiologists today are researching areas such as hormones and brain function to discover how addiction affects women differently.

Plus, don't miss our conversation with APS CEO Scott Steen, who will retire from his role at the beginning of 2026. During his time at APS, he led a period of change and growth, modernizing the Society and expanding its scientific reach. Read more about his story on page 32.

**Amanda Bertholf, MA, is APS director of communications and the editor-in-chief of *The Physiologist Magazine*. Send questions or comments to the editor at tphysmag@physiology.org.**

Tell us: Who is your physiology legend? We'd love to hear whose story has inspired your work. Send us a note at **tphysmag@physiology.org**.

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APSselect

# Unlocking Anatomy: Learning Through Escape Rooms

Virtual escape rooms—a popular form of gamified learning—that focus on anatomy education concepts can provide medical students with a fun, creative and challenging way to engage with classroom material, improve their critical thinking and identify gaps in knowledge. The case study compares two escape rooms at different institutions. Both used the same platform (Google Workspace), some of the same software (3D virtual images created in-house or viewed on Virtual Human Dissector, ChatGPT) and feedback surveys, but they also diverged in some ways. Abdominal anatomy medical students and staff at Queens University Belfast in Northen Ireland worked through a linear set of questions, puzzles and riddles in small groups, physically together in a lab. Medical students at Edward Via College of Osteopathic Medicine in Virginia progressed individually through a nonlinear, remote escape room.

All participants enjoyed the creative nature of the game, although those who worked on the remote escape room would have preferred an in-person experience. Creating an escape room can be an efficient, fun and effective way to help students understand how relevant concepts are linked together and for physiology educators to identify learning gaps.

Source: doi.org/10.1152/advan.00248.2024

All images: istock

IN BRIEF

## The Latest Research from APS Journals

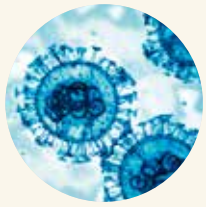
Explore new peer-reviewed findings published across the Society's journals.

**Proteomics and transcriptomics analysis helps researchers learn more about heart function in menopause compared with pre- and perimenopause.**

doi.org/10.1152/physiolgenomics.00133.2024

**A high-fat diet impairs cognitive function in male rats, which is associated with increased stiffness in the parenchymal arterioles, while females retain cognition.**

doi.org/10.1152/ajpheart.00295.2024



**Overexpression of the water channel aquaporin 3 disrupts water handling during severe illness, giving researchers new insights into the role of water balance in COVID-19.**

doi.org/10.1152/physiolgenomics.00174.2024

LUNG PHYSIOLOGY

# Diabetes in Pregnancy Could Lead to COPD in Offspring

Although smoking is the primary cause of chronic obstructive pulmonary disease (COPD), recent studies have revealed that early-life exposures, such as parental smoking during pregnancy, play a critical role in lung development and influence COPD risk later in life. This emerging research underscores the importance of understanding how stressors during pregnancy and early childhood shape offspring's risk factors for chronic diseases later in life. In a new mini review, researchers found that when a parent has diabetes during pregnancy, their children are more likely to be born before 37 weeks—also a risk factor for COPD—and have impaired lung development.

Source: doi.org/10.1152/ajplung.00046.2025

APS*select*

# Sleep May Offset Heart Risks Tied to Anxiety

Getting the same amount of sleep each night may help people with anxiety reduce their risk of heart disease later in their lives. About 20% of adults living in the U.S. have anxiety, and many of them have trouble sleeping. Previous research shows that people who don't sleep well have a higher risk of heart problems. A new study explored the association between poor sleep patterns and cardiovascular health in people diagnosed with chronic anxiety. Volunteers kept a weeklong sleep diary that tracked when they were sleeping, awake and physically active. At the end of the week, the researchers measured several markers of heart health, including blood pressure and blood vessel function. The people who had irregular sleep routines were more likely to have poorer blood pressure control and vessel function.

Source: doi.org/10.1152/ajpregu.00271.2024

**People with acute kidney injury may benefit from reduced overexpression of pannexin 1 and less inflammation when channel activity is inhibited.**

doi.org/10.1152/ajprenal.00226.2024

**The study examines the functionality of using tilapia and zebrafish growth hormone transgenic lines for researching growth hormone cell activity in vivo.**

doi.org/10.1152/ajpendo.00471.2024

**Polyamines in mitochondrial metabolism and intestinal epithelial repair after injury is explored.**

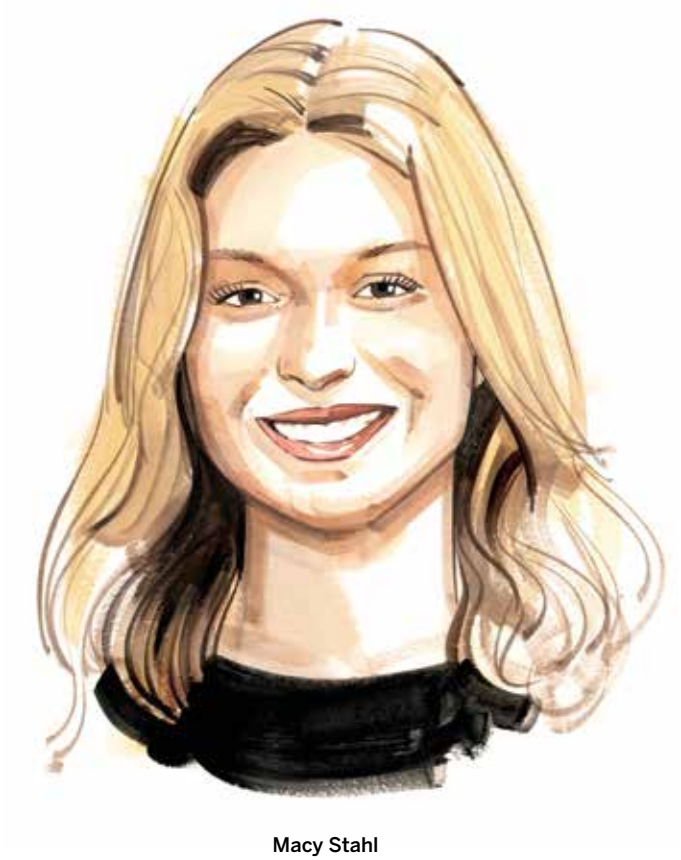
doi.org/10.1152/ajpgi.00023.2025

**Women with heart failure have lower peak exercise oxygen compared with men, underscoring the importance of sex-specific approaches to better treat heart disease challenges.**

doi.org/10.1152/japplphysiol.00153.2025

# LAB NOTES





Macy Stahl

Terrence E. Sweeney, PhD, FAPS

**MENTORING Q&A** | PHD LIFE

# A Balancing Act

## How to handle the demands of graduate school.

Each issue, we ask a student or early-career member to pose their career questions to an established investigator and mentor. Here, **Macy Stahl**, a PhD student in the Department of Kinesiology at the University of Virginia, asks **Terrence E. Sweeney, PhD, FAPS**, professor of biology and physiology program director at the University of Scranton, how to balance work and life, especially during the PhD phase.

Illustrations by Kagan McLeod

**Q: What strategies do you have to maintain work-life balance when your job requires long hours or a high level of responsibility?**
**A:** The strategies changed as my life circumstances changed. When I was a graduate student and living on my own, I needed to answer only to myself, and I managed my stress through regular exercise and social interactions with the other graduate students. I worked long hours as needed, especially in wrapping up my doctoral research and writing.

**Q: How do you juggle the administrative responsibilities that come with academia with the creative demands of grant writing and project implementation?**
**A:** This is part of the same overall balance and follows the same patterns. It's dynamic, the balance changes, and it's never perfect. I've tried to make sure that the administrative work I take on aligns with my goals and priorities, which change. It's critically important to learn how to say no. It took a long time to learn that, but one can only do so much, and learning how to say no is critical to ensuring that your time is dedicated to the work that matters most.

**"Learning how to say no is critical to ensuring that your time is dedicated to the work that matters most."**

Fast-forwarding to the time when I was married, had young children, and was a new tenure-track faculty member, balance took close communication with my wife and family. Balance was a dynamic thing, sometimes leaning toward work, sometimes leaning toward family, as needs dictated. As a senior faculty member, married but with grown, independent children, the balance has changed again and is a somewhat easier task. The balance—and my communication—has never been perfect. Personally, exercise was always an integral part of maintaining balance and sanity. Balance takes being true to your relationships and your personal priorities, which I believe make it different for each individual.

**Q: What relationships did you build in the early phase of your career that have remained pivotal?**
**A:** I'm so indebted to the relationships with my mentors—college, graduate, postdoctoral—and the values they instilled in me. Later, there were my colleagues and collaborators. Being always willing to learn from others is the quickest way to gain peripheral skills and correct missteps. Sometimes the student becomes the teacher; we have much to learn from the people we are seeking to train.

**Q: Is it OK for your research line to change over time?**
**A:** Change is the only constant. My first research projects were in organic synthesis, high-temperature chemical kinetics and cancer research. My most cited paper is on measuring osmolality in biological fluids. Doors open and doors close; personal priorities change. Being open to change is what keeps life fresh and exciting.

**Q: Do you have any advice for students in the dissertation phase of their PhD?**
**A:** Buckle up, but embrace the experience. For me, this was the most concentrated time of learning, exploring, failing and inspiration in my life. To reflect what the experience meant to me, I chose to preface my dissertation with this passage from the song "Close to the Edge" by the band Yes: "Now that it's all over and done, called to the seed, right to the sun. Now that you find, now that you're whole, seasons will pass you by. I get up, I get down."

**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.**

**STATS & FACTS**

## Women are more likely to develop a dependence at lower drinking levels than men.

**Addiction Center**

## 30%

of all cancer deaths are from substance use and addiction.

**American Cancer Society**

## Even though some studies suggest that a glass of wine may lower the risk of heart disease, researchers can't say for sure that a glass of red wine lowers your risk of cancer.

**MD Anderson Lynda Hill Cancer Prevention Center**

## $28 billion

in medical expenses each year in the U.S. is from excessive alcohol use.

**Substance Abuse and Mental Health Services Administration**

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**STREAMING SCIENCE** | SOUNDBITES FROM APS JOURNAL PODCASTS

# Needles and Nerves

Deep dry needling may offer more than pain relief—it could influence spinal reflexes. Physical therapist and researcher Gretchen Sife, PhD, shares how clinical observations led to a study exploring the neurophysiological effects of dry needling on spinal reflexes. In collaboration with neurophysiologist Aiko Thompson, PhD, the team found that dry needling temporarily reduced muscle excitability in targeted areas and enhanced reciprocal inhibition. Improvements in ankle dorsiflexion range of motion were also observed up to 72 hours post-treatment. These findings suggest dry needling produces measurable changes at the spinal level and may inform new approaches to treating spasticity and improving mobility in patients with neuromuscular conditions.

**Catch the full episode of the *Journal of Neurophysiology* podcast and explore the study behind the discussion:**

POLICY IQ | FEDERAL BUDGET

# Advocacy Up Close and Personal

At Capitol Hill Day in April, more than 75 APS members visited their members of Congress to advocate for robust federal investment in research. Two members share their experience.

## The Inaccessible Becomes Accessible

BY VIET DINH

In elementary school, I remember hearing that congressional representatives care about their constituents. We were also told that anyone could become president of the United States, although as we get older, we suspect that isn't the case.

In April, I got to see for myself how Congress works. I had the opportunity to meet with the staff of my representatives—something I never thought I would be able to do. Life had taught me that the inner workings of the government were inherently inaccessible and that only those born into power and privilege could take part in it. But getting to visit Capitol Hill and meet with Rep. Jasmine Crockett's staff and talk about research funding taught me I was wrong. This isn't an exclusive club that we aren't invited to. Despite how unreachable these legislators may feel, it is imperative that we the people voice our concerns if we want real, systemic change to happen.

It was a deeply meaningful learning experience. Just like we scientists need stronger advocacy, it made me consider that maybe we as scientists need to be more welcoming to the non-scientific community.

**Viet Dinh is a PhD candidate in integrative physiology at University of North Texas Health Fort Worth.**

> **"It is imperative that we the people voice our concerns if we want real, systemic change to happen."**
>
> **—Viet Dinh**

## Make Science Policy Personal

BY KARLA HAACK, PHD

I met with staff from both Republican and Democrat offices from my home state. I was nervous but remembered an Audre Lorde quote: "Becoming always vigilant for the smallest opportunity to make a genuine change … is learning to address each other's difference with respect." I was given this opportunity; how was I going to connect despite those differences?

I opened the conversation in my representative's office on shared interests and leveraged that to talk about how science funding does not just impact labs. Their follow-up questions highlighted a clear difference of opinion, so I returned to our shared investment in the problem. My goal was to explain why solutions not typically voted for by my representative were equally effective.

Other representatives' staff were already supportive, but it was still an opportunity to reinforce the importance of science funding. I shared that having worked in both academia and industry has allowed me to see firsthand that funding basic science is a necessary first step to drug discovery and approval. Centering policy discussions on the people affected facilitates more thoughtful engagement across the aisle.

Every scientist has a unique experience to draw from to make a personal connection. Participating in a Hill Day was a fantastic opportunity to do something at a time in which so much feels out of my control. I recommend it for anyone looking to engage.

**Karla Haack, PhD, is a senior medical writer at Merck.**

Courtesy of Sachin Aryal

**UNDER THE MICROSCOPE** | CARDIOVASCULAR RESEARCH

# Love for the Lab

Studying the regulation of blood pressure with colleagues in the lab brings this researcher joy.

Sachin Aryal is a PhD trainee in the lab of Bina Joe, PhD, at the University of Toledo Center for Hypertension and Precision Medicine, Department of Physiology and Pharmacology. His research focuses on investigating the role of gut microbiota, bile acids and epigenetics in the regulation of blood pressure.

**FAMILY LEGACY.** My mom was a nurse by profession. As a kid, I used to visit her at the local health center. I watched her providing medicines to the patients and taking care of them. I remember how my mom described the immense sense of fulfillment she got while helping others. Those early experiences sparked my interest in health and disease. I pursued biology in my high school and undergraduate programs. The more I learned, the more curious I became, so I decided to get my doctoral degree in biomedical science. Through this experience, I aim to contribute to filling the gap in knowledge in the field of biomedicine, especially in cardiovascular research.

**LESSON LEARNED.** Once I was preparing for polymerase chain reaction (PCR). I carefully pipetted all the reaction mix into a plate. When I went to the PCR machine, it did not accept the plate. I tried everything: pushing, tilting and even a gentle tap. I assumed that the machine was broken and almost called the lab manager. But when I looked closely, I realized that I used the wrong PCR plate. I remade the entire reaction mix and used the correct PCR plate this time. I now treat the PCR plate like royalty—one wrong move, and it ghosts your entire experiment.

**"I now treat the PCR plate like royalty—one wrong move, and it ghosts your entire experiment."**

**EPONYM AWE.** If I could meet one scientist, it would be Lewis K. Dahl, MD, founder of salt-sensitive and salt-resistant Dahl rat models. He demonstrated a link that exists between dietary salt intake and genetic predisposition to hypertension. The Dahl rat model is an important and widely used model in hypertension and other cardiovascular, renal and genetic studies. I would ask him how he came up with the idea that salt intake can lead to increased blood pressure and what challenges he faced in demonstrating the concept.

**JOYS OF THE JOB.** I love going to my lab every day, doing experiments and spending time with my colleagues. We celebrate birthdays and share plenty of laughs together, which makes the work environment more enjoyable. One of the highlights of being a researcher is conference attendance. I am always excited to communicate my research work at the conferences and make new friends. It's a great way to know where the field is heading, and it provides ample networking opportunities.

**A MISUNDERSTOOD FIELD.** I think people sometimes assume that physiologists are clinical doctors or that we only study humans. Physiologists may or may not be directly involved with patient care. Most of our research involves a wide range of species, such as zebrafish and rodents, as many physiological processes and genes are conserved across species. It allows us to uncover the mechanisms and lays the groundwork for breakthrough in understanding and exploring how life works and living organisms function.

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

**PUBLISH WITH POLISH** | CONFLICTS OF INTEREST

# Ensuring Public Trust in Publishing

Publishers, reviewers and authors must commit to identifying and handling conflicts of interest appropriately.

Scientific integrity is central to making sure the public trusts academic publishing. We must ensure that research is objective, the peer review process is fair and unbiased, and that editorial decisions are made without undue influence.

As a society and publisher, it is critical that APS does our due diligence to ensure the integrity of our published content. A conflict of interest (COI), when handled inappropriately, can undermine trust in the peer review process, ultimately diminishing the credibility of published work. This is why the identification and handling of COIs is more than a requirement for APS journals—it is an essential part of what we do and what we continually strive to improve.

A COI is a situation in which an individual's personal or private interests may conceivably interfere with their ability to objectively present, commission, review or publish scientific work. Even the perception of bias can erode confidence in the scientific process. Therefore, transparency is essential. It is important to note that having a COI is not inherently wrong, nor does it automatically disqualify someone from participating in the peer review process. However, a COI must be clearly disclosed so it can be managed in a transparent and appropriate manner by the editorial team.

A COI can take many forms, often arising from relationships or situations that could compromise—or appear to compromise—a person's objectivity. Common examples of COIs include personal or family relationships that might reasonably raise doubts about impartiality, as well as notable personal or professional rivalries, whether publicly known or not.

Lifelong connections, such as those between mentors and mentees, may also present a COI due to their close and enduring nature. Financial considerations are another important factor, including the potential for personal gain or increased recognition for oneself, a close associate or a family member.

Additionally, professional relationships that have existed within the past five years—or are reasonably expected in the near future—may also create COIs. These include working at the same institution, collaborating on research projects, being involved in supervisor-supervisee dynamics, maintaining a funder or program manager/awardee relationship, receiving joint funding, or having recently co-authored a publication.

Flagging COIs rests with everyone involved in the publication process. Reviewers and editors are responsible for identifying and disclosing any potential COIs that could bias their opinion of the manuscript. In these cases, the manuscript can be assigned to different evaluators. In addition, authors are required to disclose any COIs when submitting an article. This includes disclosing any financial interest that could be viewed as having an impact on the submission. We encourage authors to contact the journal's editor-in-chief if they wish to discuss any potential COI before submitting their article.

**Send questions or comments to tphysmag@physiology.org.**

APS Publications is committed to preserving the integrity of peer review and the credibility of our content. We are continually working to improve our processes to ensure that conflicts of interest are managed with care. For questions about conflicts of interest or our practices, email **ethics@physiology.org**.

**STATS & FACTS**

**4+**

alcoholic drinks during one occasion is considered binge-drinking in a female. Heavy drinking is having 8 or more drinks per week.

**Substance Abuse and Mental Health Services Administration (SAMHSA)**

**5+**

alcoholic drinks during one occasion is considered binge-drinking in a male. Heavy drinking is having 15 or more drinks per week.

**SAMHSA**

**"It is what we think we know that keeps us from learning."**

**Claude Bernard**

**"Chance throws peculiar conditions in everyone's way. If we apply intelligence, patience and special vision, we are rewarded with new creative breakthroughs."**

**Walter B. Cannon**

**IN DEPTH** | SLEEP STUDIES

# Dreaming Big

Researchers are looking beyond the brain to untangle how genes and circadian rhythms influence sleep.

Ketema Paul, PhD, holds dual professorships in the Department of Integrative Biology and Physiology and the Department of Psychiatry and Biobehavioral Sciences in the College of Letters and Science at the University of California, Los Angeles (UCLA). As a leading researcher in sleep and circadian rhythms, his work has revealed surprising regulatory mechanisms of sleep found outside the brain. The work could lead to new opportunities to treat sleep disorders and enhance resilience to sleep loss.

**What sparked your interest in sleep and circadian rhythms, and what do you hope to find out?**
My research has always centered on understanding how the circadian clock regulates sleep. From my early work in vision research to studying circadian rhythms and eventually exploring sleep homeostasis—which regulates the ability to recover from sleep loss—I've been driven by the fundamental question of how these systems interact. Using mouse models, my lab investigates the genetic and molecular mechanisms that link circadian regulation to sleep behavior.

One of our main focuses is identifying genes and molecules that contribute to sleep and response to sleep loss. We are also looking at how to manage and recover from sleep loss, as well as why men and women show differences in sleep and responses to sleep loss.

istock

**What insights are changing the game on sleep research?**
Our most important finding so far was that the BMAL1 gene in skeletal muscle helps regulate sleep and the ability to recover from sleep loss. In a 2017 *eLife* paper, we reported that mice lacking BMAL1 in their skeletal muscle showed increased non-rapid eye movement (NREM) sleep and poorer recovery responses following sleep deprivation. However, restoring BMAL1 expression specifically in the skeletal muscle of BMAL1-deficient mice normalized NREM sleep amounts and improved recovery after sleep loss.

Although sleep is regulated by the brain, this work showed that body tissues also play a key role in sleep homeostasis. This mirrors earlier discoveries in circadian rhythms, which were once thought to be strictly neural but were later found to be active in tissues throughout the body. Our research was among the first to show that sleep regulation follows a similar pattern, integrating signals beyond the brain.

This surprising finding is still driving much of the research in my lab. We're working to understand what specific circadian molecules in skeletal muscle are talking to the brain and what signals they use to help regulate sleep.

**Why do you use mouse models?**
Because sleep has been studied in mice for a long time, there is a lot of existing information about how mice sleep and how their sleep is similar and different from human sleep. To understand the genetic regulation of sleep, we use mice with characterized sleep patterns and knock out specific genes to see how these influence sleep.

I'm also working with Christopher Ehlen, PhD, at Morehouse School of Medicine, who is performing optogenetic and chemogenetic activation and silencing of neurons in certain brain areas of mouse models to measure how these regulate sleep. For this work, we conduct basic EEG recordings of sleep and then manipulate specific genes and genetic expression and combine that with sleep disruption and behavioral interventions. This research will help reveal both the neural and molecular mechanisms responsible for sleep homeostasis. We are also studying how those mechanisms interact with stress mechanisms.

**How could your research eventually help people?**
Our research could lead to more effective treatments for sleep disorders like insomnia, perhaps by targeting peripheral tissues such as skeletal muscle. Sleep issues tend to accompany a variety of mental illnesses and somatic body diseases, and we are hoping our research can improve sleep for people with these issues.

Our work could also improve performance, memory and cognitive function for people who aren't able to sleep, such as people serving in the military or first responders working after a natural disaster. We're hoping that by identifying mechanisms responsible for poorer cognitive performance when people don't sleep, we can help people make fewer mistakes and have higher cognitive function when they do experience sleep loss.

> "Sleep issues tend to accompany a variety of mental illnesses and somatic body diseases, and we are hoping our research can improve sleep for people with these issues."

**What do you hope to find out next?**
In addition to studying how BMAL1 in skeletal muscle protects against sleep loss, we are now investigating how sleep loss and recovery influence social behavior and responses to social stress. Additionally, my team is working with colleagues who study neurological and neurodegenerative disorders to understand how neurodegenerative disorders influence sleep. So far, we've studied Huntington's disease and autism spectrum disorders and are currently working on muscular dystrophy.

**How do you think we can continue to strengthen the scientific workforce?**
I received mentorship from many highly esteemed scientists, and I have spent a lot of time paying that forward by making sure that I identify people—specifically people from underrepresented backgrounds like mine—who may not have had much exposure to scientific research during their formative years.

I've dedicated a significant amount of effort to making sure that we are more inclusive in our ability to reach bright people and bring them into our field. For example, I am the director of diversity mentorship programs at the UCLA Brain Research Institute and direct a summer program that's a partnership with historically Black colleges and universities across the nation. I think it's extremely important that we continue to broaden the avenues through which very bright people can come into research enterprises.

**Interview conducted by science writer Nancy D. Lamontagne. Send questions or comments to tphysmag@physiology.org.**

**STATS & FACTS**

# At 3 months

babies usually start to produce and release melatonin. Cortisol development occurs between 2 months and 9 months.

**Cleveland Clinic**

# Up to 40%

of women with lifetime eating disorder behaviors also had substance use disorders.

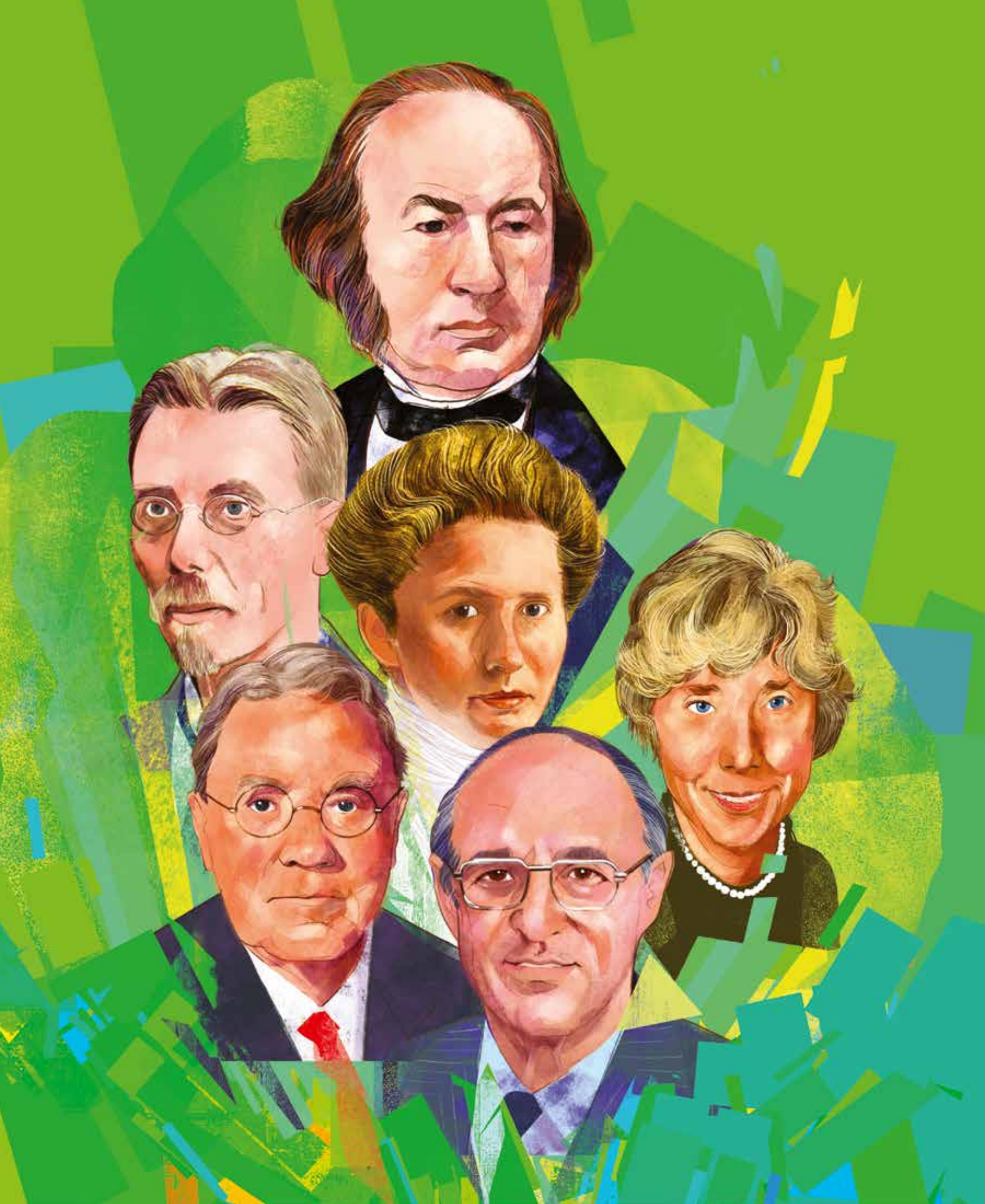
***International Journal of Eating Disorders***

# Marie Krogh was the fourth Danish woman to earn a doctorate in medicine.

# 2:1

is the overall proportion of men to women within the treatment system. This has remained fairly constant, as women are less likely to enter substance use treatment programs.

**SAMHSA; *Drug and Alcohol Dependence***



# 6 SCIENTISTS WHO SHAPED PHYSIOLOGY

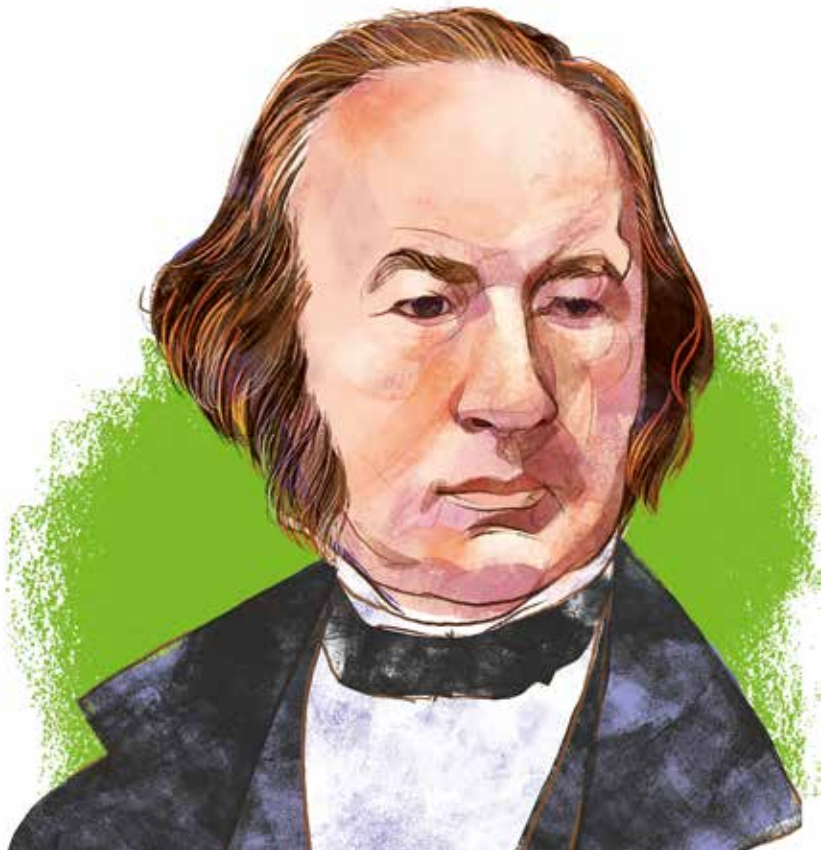
These legendary physiologists built the foundation for modern discovery. Their stories are scientific history—and make the future possible.

**BY KAVIN SENAPATHY**

Physiology dates back to ancient scientists around the world, many of whose findings have been lost to history. Until the 19th century, humans had only an observational capacity to learn about the workings of living things. Then, a perfect storm of elements—like advancements in microscopy and chemical analysis methods and the proliferation of research laboratories—spurred a series of giant leaps for humankind. A group of legends harnessed that perfect storm, laying the foundation for modern physiology and for the physiology greats of the 21st century and beyond.

From discovering the concept of homeostasis to the complexity of cardiovascular dynamics, here are six pioneers who revolutionized the field of physiology.

Illustrations by John Jay Cabuay



THE FOUNDING FATHER

# Claude Bernard

(1813–1878)

While Claude Bernard may not be a household name like Charles Darwin or Louis Pasteur, he is to modern physiology and medicine what they are to evolutionary biology and microbiology. His findings, from how the nervous system regulates circulation to the fact that organs produce and secrete substances into the bloodstream, were as wide-ranging as they were foundational.

**THE BREAKTHROUGH**

Bernard is best known for the concept of "le milieu intérieur," which roughly translates into the internal environment of the body. The idea is that living things maintain a consistent inner state of equilibrium despite a dynamic external environment. That the organism has its own stable, regulated internal space separate from its surroundings seems obvious in modern times. It is, however, Bernard's experiments that underlie the concept. Though he couldn't have imagined its immense complexity, he understood that, in this internal scene, the cells and body systems somehow work interactively to maintain balance.

**WHY THE SCIENCE STILL MATTERS**

The idea was the direct predecessor of homeostasis, a unifying physiological concept, and has "influenced everybody," says APS Chief Science Advisor Dennis Brown, PhD, FAPS, a professor of medicine at Harvard Medical School and the 90th APS president. The question of how cells and organs maintain the body's internal environment, and what goes wrong in disease, remains a vital driver of the field. Also remarkable was Bernard's insistence on—and advocacy of—experimentation with controlled variables rather than observational studies alone. Without causal mechanisms, one cannot effectively treat disease, he posited in his seminal 1865 book, "An Introduction to the Study of Experimental Medicine."

**THE MODERN CONNECTION**

The standards he promoted— clear hypotheses, experimental controls and reproducibility protocols—seem basic to the modern scientist, but they weren't always taken for granted. They are a central precursor to present-day grant review and methodology criteria. Modern systems biology, endocrinology, pharmacology and other subfields can trace their roots back to Bernard's experiments.

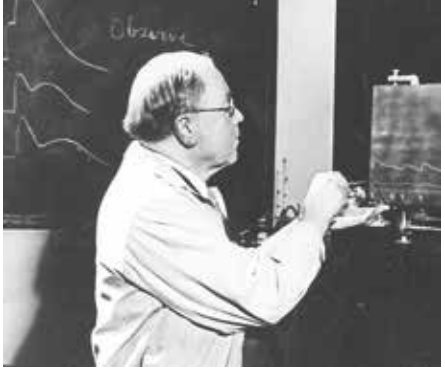
**The standards Bernard promoted—clear hypotheses, experimental controls and reproducibility protocols—seem basic to the modern scientist, but they weren't always taken for granted. They are a central precursor to present-day grant review and methodology criteria.**

THE WORDSMITH

# Walter B. Cannon

(1871–1945)

Building on Bernard's milieu intérieur concept in 1926, Walter B. Cannon coined the term "homeostasis" to denote the constancy of the organism's internal environment despite its often-hazardous surroundings. The word is a combination of the Greek "hómoios," meaning "similar," and "stásis," meaning "standing still."



## THE BREAKTHROUGH

Cannon, who served as the sixth president of APS, carefully selected the Greek term for "similar," rather than the term for same, "homo." This was to convey a subtle but key distinction: Homeostasis is not an unchanging or stagnant state; it's a dynamic one. When an organism is doing well, its blood pressure, pH, body temperature and myriad other internal elements oscillate within a constant healthy range. One or more of the pieces of the unfathomably complex machine that maintains this equilibrium is thrown off in virtually any disease state.

## WHY THE SCIENCE STILL MATTERS

Homeostasis is considered a central unifying concept of physiology. Today, with technology that enables increasingly granular studies, down to the single gene and molecular level, it is largely beneficial to study the organism's constituent parts—but it's also important not to lose sight of the forest for the trees. In this sense, Cannon's holistic view of homeostasis continues to influence physiologists to not only hone in on the tiniest puzzle pieces, but also to zoom out to the whole organism's unified internal harmony.

At its essence, the concept is the basis for the "mindset of trying to understand how the body systems work together," says John Hall, PhD, Arthur C. Guyton Professor and Chair at the University of Mississippi Medical Center and the 74th APS president. Current research questions about how the body maintains health boil down to homeostasis and the ways an organism can struggle to sustain it.

Cannon also coined the term "fight-or-flight" to denote the physiological responses he observed in animals when they experienced fear or other emotional disturbance. The concept remains part of the 21st-century zeitgeist, largely due to its sheer catchiness. Fight-or-flight is not exactly a technical term, explains Brown, but it has a "nice kind of alliteration" that continues to stick with laypeople.

## THE MODERN CONNECTION

Cannon learned at a very early stage that "the use of buzzwords is important," Brown says. The concept highlights the perpetual importance of knowing "how to speak to your grandma" about science. Ultimately, Cannon's popularization of physiology helped set the bar for the Society's emphasis on science communication and outreach.

THE POWER COUPLE

# August and Marie Krogh

(1874–1949; 1874–1943)

Marie Krogh first met her husband, August, in 1904 while she was in medical school. This Danish couple couldn't have known the extent to which they would eventually change the world.

### THE BREAKTHROUGH

August Krogh's most famous work involves capillary blood flow. Before his time, physiologists assumed that capillaries were passive blood vessels that remained open, enabling a steady flow of blood. He upended that static view, showing that capillaries actively engage in dynamic blood flow regulation depending on the needs of tissues and organs. He was awarded the Nobel Prize in Physiology or Medicine in 1920 for this paradigm shift, which has since inspired generations of researchers and underpinned modern studies of microcirculation, exercise physiology, cardiovascular medicine and more.

Marie Krogh is probably best known for her instrumental role in promoting insulin as a therapy for diabetes, Brown says. As someone with diabetes, she epitomized the patient-researcher perspective. By the time she was diagnosed with the condition in 1921, she was already an accomplished researcher who collaborated with her husband on research into the mechanisms of gas exchange in the lungs. She was also a practicing physician.

**The Kroghs founded Nordisk Insulin Laboratorium (leading to today's Novo Nordisk pharmaceutical company) and soon developed methods to scale up insulin production and distribution throughout Europe.**

### WHY THE SCIENCE STILL MATTERS

Marie Krogh's 1921 diagnosis prompted the couple's interest in insulin, which was first isolated from the pancreas of dogs that same year in Toronto, Canada. Shortly thereafter, Marie became one of the first diabetes patients to receive insulin. The Kroghs founded Nordisk Insulin Laboratorium (leading to today's Novo Nordisk pharmaceutical company) and soon developed methods to scale up insulin production and distribution throughout Europe.

### THE MODERN CONNECTION

August and Marie Krogh's legacy is largely a joint one. "She probably never rose to the scientific heights that he did" because of the sidelining of women in science at the time, Brown says. Still, he imagines Marie was "the power behind the throne." Together, the couple "made a huge contribution to academic science, basic science, but also to clinical science as well, and to diabetes in particular," Brown says.

THE TRAILBLAZER

# Bodil Schmidt-Nielsen

(1918–2015)

Perhaps best known as August and Marie Krogh's daughter and as APS' first woman president, Bodil Schmidt-Nielsen's legacy extends well beyond her parentage and gender. She helped lay the foundations for comparative physiology, which explores how body systems across species are suited to their unique and often extreme habitats.

## THE BREAKTHROUGH

Schmidt-Nielsen's most significant work was her illumination of how the kidney processes and eliminates urea. She and her husband, Knut, also a physiologist, collaborated to study an extensive range of animals. They unearthed how different species manage homeostatic salt and water levels. Many eminent physiologists, including Schmidt-Nielsen, went to Mount Desert Island off the coast of Maine because it enabled localized access to a variety of animals spanning the terrestrial, the aquatic and everything in between. She was a staunch adherent to her father's "Krogh principle," which posits that for every physiological process of interest, "somewhere out there in the wild is a creature that really does it well and that you can learn from," Brown explains.

## WHY THE SCIENCE STILL MATTERS

Schmidt-Nielsen and her team were known to set out in search of frogs, seals, birds, insects and fish. Brown helps with a course on renal physiology at her former lab, now called MDI Labs, where he sets the scene for students of the famous experiments she carried out there. Ultimately, the creatures she studied across practically every genus—from frogs to insects to camels—expanded physiology beyond humans and lab rodents into an integrated approach involving whole ecosystems.

## THE MODERN CONNECTION

In addition to her groundbreaking research, Schmidt-Nielsen is celebrated for her mentorship. Though Hall didn't know her well, in their interactions, he found her to be warm and kind, while also drawing the respect of her peers not only for her scientific contributions but her aptitude for leadership. The APS Bodil M. Schmidt-Nielsen Distinguished Mentor and Scientist Award continues to honor her legacy today by acknowledging a member of the Society who has made outstanding contributions to physiological research and demonstrated dedication and commitment to excellence in training the next generation of physiologists.

THE SCIENTIFIC GIANT

# Arthur C. Guyton

(1919–2003)

Known for his analytical mind, Arthur C. Guyton was a pioneer in applying large-scale systems analysis to create a mathematical model of the entire cardiovascular system.

### THE BREAKTHROUGH

Guyton amassed data on blood flow and pressure, eventually using analog computers to create an elaborate diagram of the web of factors that govern blood circulation. As his body of work grew, he shifted multiple paradigms. Before Guyton's modeling, it was practically "dogma" that the physical ability of the heart to contract governs blood circulation, says Hall, who worked closely with Guyton for over 20 years. By contrast, Guyton's work showed that the needs of the tissues determine how much blood the heart sends based on how much deoxygenated blood returns to the heart in a given situation. For instance, the bicep of a gym-goer doing a curl will start using more oxygen. This results in increased blood flow to the muscle, which returns a higher volume to the heart, prompting it to continue increased supply to the bicep.

### WHY THE SCIENCE STILL MATTERS

Involving kidney dynamics, the endocrine system, nervous system control mechanisms, blood viscosity and a slew of other elements, the model has grown more detailed over time. But it's not without its limitations, say some scholars, including that the heart may play more of an active, albeit limited, role. Nevertheless, recent studies in living patients have provided validation for his model, which is seen as the foundation for today's understanding of cardiovascular physiology.

Also remarkable is the shift he spurred in the understanding of the dynamics of interstitial fluids. Before Guyton, researchers thought that tissues were passive in the distribution of the fluid system that permeates the body. Instead, he found that tissues are active—fluid pressure in some tissues, such as the skin and lungs, is negative and fluctuates to create varying suction that prevents swelling.

Guyton's research also revealed the kidney's central role in blood pressure regulation and illuminated the mechanisms behind it. This has made a lasting mark, informing treatments for many chronic and acute conditions.

### THE MODERN CONNECTION

Guyton's legacy goes beyond his scientific accomplishments. He contracted polio as a surgical resident, causing extensive paralysis. The virus dashed his ambitions of being a heart surgeon—his family was full of lofty medical ambitions, as evidenced by his 10 children, all of whom became doctors. His disability prompted a change in his scientific trajectory but didn't dampen his tenacity.

He was a teacher with a warm demeanor who trained around 150 physiologists. Guyton advocated for making information accessible and understandable, writing the seminal "Textbook of Medical Physiology" in 1956. He wrote the first eight editions solo, resulting in a cohesive, comprehensive tome that has likely influenced more medical students than any other physiology textbook.

In the years leading up to Guyton and his wife's deaths in 2003 from a car accident, Hall partnered with Guyton to release editions nine and 10 of the book. Since then, Hall has assumed the mantle, releasing additional editions of the indispensable "Guyton and Hall" textbook.

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# Overlooked and At Risk

Female physiology acts differently when it comes to addiction, putting women at peril.

BY JULIAN NOWOGRODZKI

Rates of substance use disorders among women are rising worldwide. Yet, much of what we know about addiction—its prevention, treatment and underlying physiology—is based on research conducted primarily in men and male animals.

In 1990, men were about five times more likely than women to have an alcohol use disorder. Today, that gap has narrowed significantly: Men are now only twice as likely. The COVID-19 pandemic accelerated this shift, driving notable changes in women's drinking behaviors. In the early months of the pandemic, women reported increased binge drinking and drinking earlier in the day. This pattern of increased binge drinking among women has persisted, according to a 2025 study in *JAMA*. Women's drinking habits have not returned to pre-pandemic levels.

However, the research landscape is beginning to shift. In 2014, the National Institutes of Health (NIH) began requiring researchers to include both sexes in NIH-funded animal studies. Since then, new findings have started to uncover differences in sex-based physiological responses to substance use, which could lead to more effective treatment and prevention strategies. This is crucial because female hormones and differences in their metabolism and body size affect how substances are absorbed, processed and affect key organ systems.

This research is essential to raising awareness that women are at risk of both addiction and physiological damage at lower levels than men, says Patricia Molina, MD, PhD, FAPS, head of the Department of Physiology, senior associate dean for research, co-director of the Alcohol and Drug Abuse Center of Excellence at Louisiana State University Health Sciences Center and 88th president of APS.

## BASIC DIFFERENCES

Understanding physiological differences between men and women is important because women experience bodily harm at lower doses of alcohol than men do. Sex-based differences in metabolism, body composition, size and hormone levels all influence how substances affect the body. For example, women's body size is on average smaller than men's, and a certain amount of alcohol will raise blood alcohol to a higher—and therefore more toxic—level in a smaller body than a larger body.

Even given the same body size, women and men metabolize alcohol differently. Women have lower levels of the enzyme alcohol dehydrogenase in their digestive systems, meaning that they cannot process alcohol as quickly as men.

"If I have a drink and a man my same size has a drink, by the time our blood alcohol levels are measured, his levels will be lower than mine because I am not able to process as much alcohol," Molina says. "For women, the negative health consequences—for example fatty liver disease—occur at much lower levels of alcohol consumption."

On the other hand, women metabolize nicotine faster than men. Men seem to be more sensitive to the effects of nicotine that make it addictive. Women struggle more to quit smoking, and nicotine patches and gum do not work as well in women, perhaps in part because of these physiological differences.

In many substance use disorders, women progress to addiction or negative health consequences (for example, liver disease) faster than men do. This "telescoping effect" holds true even in non-substance-based addictions such as gambling, says Wendy Lynch, PhD, a professor of psychiatry and neurobehavioral sciences at the University of Virginia.

## HORMONES

In addition to these basic physiological factors, hormonal differences play a role in how women react to substance use and experience cravings. Estradiol—the primary type of estrogen during the reproductive years—and progesterone both affect addiction.

Estradiol is a huge driver of sex differences around addiction, Lynch says. In rats, estradiol increases vulnerability to addiction and adverse health effects. When researchers block or remove estradiol in rats, they are less likely to become addicted to substances, including fentanyl. When they replace estradiol in these rats, they replace the vulnerability to addiction, Lynch says.

Estradiol seems to act similarly in humans to increase motivation for drug use. In the human menstrual cycle, estradiol is highest during the follicular phase (between the first day of menses and ovulation), while progesterone is highest during the luteal phase (between ovulation and the next menses). Women report liking drugs such as amphetamines more during the phase of their menstrual cycle when estradiol is high, says Jill Becker, PhD, a professor of psychology at the University of Michigan and the Michigan Neuroscience Institute. Women who use cocaine have reported that they felt more "high" during the phase when estradiol is

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INSIDE STORY

# Sex Differences

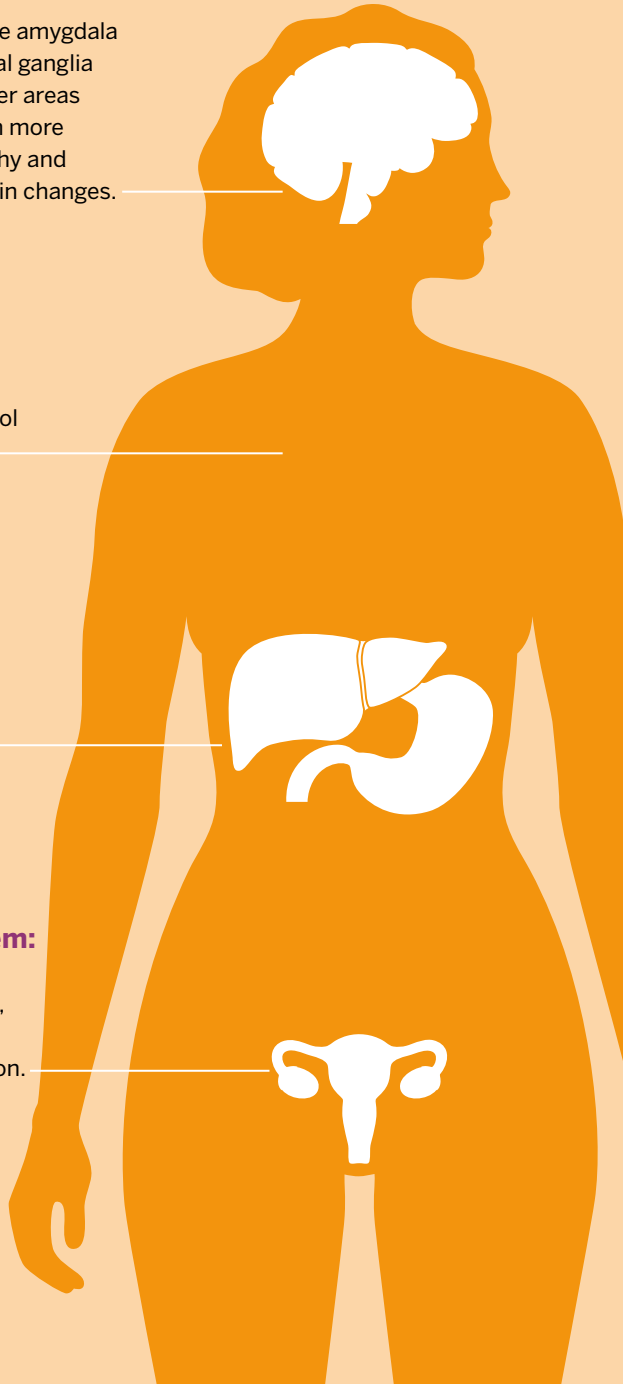
**A woman's body reacts differently to alcohol and other addictive substances.**

**Brain:** Differences in the amygdala (behavioral control), basal ganglia (reward system) and other areas of the brain make women more vulnerable to brain atrophy and other alcohol-related brain changes.

**Pain perception:** Women experience more physical pain when alcohol is taken away.

**Liver and stomach:** Women have lower levels of the enzyme alcohol dehydrogenase, which metabolizes alcohol.

**Reproductive system:** Estradiol increases vulnerability to addiction, while progesterone decreases risk of addiction.



high than during the phase when progesterone is high.

In both animals and humans, progesterone decreases risk of addiction. "If you give a person—male or female—progesterone, you can reduce positive reinforcing effects and craving," Lynch says. Pregnancy is also a period of especially high progesterone, and lab animals show reduced cravings for drugs during pregnancy or pseudopregnancy.

Rats don't have a menstrual cycle similar to humans, but rhesus monkeys do, and their menstrual cycle influences their consumption of alcohol. Kathleen Grant, PhD, chief and professor of neuroscience at the Oregon National Primate Research Center at Oregon Health & Science University, has worked for decades with rhesus monkeys using an alcohol self-administration protocol. The monkeys in these experiments can self-administer alcohol or water several times throughout the day and night by interacting with a panel. This allows Grant's team to study monkeys that choose to drink heavily, moderately or hardly at all, to glean what factors predict who is at risk for heavy drinking.

Female rhesus monkeys chose to drink more during the luteal phase and the most in the late luteal phase, when progesterone declines rapidly. Progesterone derivatives called neurosteroids are active at GABA receptors, which are an inhibitory force in the brain. During the luteal phase, progesterone rises gradually over seven to 10 days, and neurons probably adapt to this increasing inhibition, Grant says, similar to the way your eyes adjust when the lights gradually dim.

When progesterone plummets just before menses, the neurons may become over-reactive, the way that your eyes would be hyper-reactive if you were in a dim room and someone suddenly turned on the lights fully.

**In many substance use disorders, women progress to addiction or negative health consequences faster than men do. This "telescoping effect" holds true even in non-substance-based addictions such as gambling.**

One theory is that this shock could nudge people—and monkeys—toward drugs to cope.

Some populations of women take supplemental estradiol, which would seem to offer valuable natural experiments that could further elucidate the role of estradiol in addiction. But published data on these populations are either nonexistent or in early days. For example, Lynch's team is beginning a study of women who have had their ovaries surgically removed, which is a component of some hysterectomies and can also be done independently. After the estradiol-producing ovaries have been removed, some women choose to receive estradiol treatment and others do not. Lynch plans to compare these two groups.

Some transgender women also take estradiol as hormone replacement therapy, as do some perimenopausal and menopausal women. Lynch has not been able to get proposals funded to study menopausal women, she says, though this population is becoming more important to study.

"Usually drug use is much more prevalent in adolescent and young adult populations, but that's not what we're seeing now. There's a lot of drug use going on in baby boomers," Lynch says. "It's definitely something that we need to look at."

## BRAIN FUNCTION

Sex-based differences in brain function also affect addiction. Researchers have observed subtle differences in how women's and men's brains—and the brains of female and male lab animals, including rats and rhesus monkeys—react to addictive substances such as alcohol, tobacco, cocaine, opioids and methamphetamine.

"If we want to come up with treatments for addiction," Becker says, "the neural circuitry is the key to develop the next generation of drugs." She believes that understanding sex differences will allow more effective and precise treatments. "What we currently have are sledgehammers."

Different substances of abuse each act on a different part of the brain initially, says Scott Edwards, PhD, an associate professor of physiology and neuroscience at Louisiana State University Health Sciences Center. They bind to different receptors and have different targets. "But there's this common ability to increase dopamine neurotransmission," he says. "Because the brain is connected, they do have this final common result."

In both rats and rhesus monkeys, females and males have differences in the bed nucleus of the stria terminalis (BNST), a part of the amygdala involved in behavioral control. In rhesus monkeys, Grant's team found that females' BNST neurons are more excitable at baseline—without alcohol—than those of males. In addition, alcohol increased excitation in both sexes—but, in males only, alcohol also had a counterbalancing inhibitory effect. Females did not experience this inhibition, only the excitation, which might make them more vulnerable to alcohol-related brain changes.

Becker and others have also observed sex differences in the rat striatum, a part of the basal ganglia that is part of the brain's reward system. One estradiol receptor in the brain is called GPER1. When Becker activates or blocks this estradiol receptor locally in the dorsal striatum of males, she sees an effect. By contrast, in female rats, activating the GPER1 receptor locally has no effect—it only has an effect if activated in the whole brain.

Becker's working hypothesis is that estradiol needs to be active at GPER1 in more brain regions in females than in males. In an additional wrinkle, activating the estradiol receptor decreases how much males like cocaine, but it increases motivation for cocaine in females, Becker says. It's not clear why estradiol has these opposite effects in males and females.

Perception of pain is another area of sex differences. Female rats addicted to alcohol have a lot more pain when the alcohol is taken away than males do, Edwards says, "and that matches what we see in humans."

Becker is hopeful that research in rodents might encourage people to do research in humans. "People say it's so expensive, but it is expensive to have people who are addicted and out on the street and can't support themselves. For me, this is a no-lose situation."

# Beneath the SCALES

Dane Crossley, PhD, studies the early development of alligators and other non-traditional models in his comparative physiology lab.

**BY SARAH BAY**

Alligator wrestling is pretty far down the list of job responsibilities for a professor of physiology—well behind teaching, mentoring and research duties—but it still makes the list for Dane Crossley, PhD. When you're gathering data on alligator exercise performance, you have to be ready for escape attempts, and you have to keep your cool to get the gator back into the pool. Luckily, for anyone interested in reptile cardiovascular function, Crossley is up to the task to make sure the data are collected.

As a kid growing up in the Pacific Northwest, Crossley spent most of his time outdoors. "I was always interested in animals: collecting them, looking at them. Snakes and tadpoles, frogs and salamanders. It's always been there, as long as I can remember."

Facing page: photo by Justin Clemons

Clockwise from top, Crossley holds an olive ridley sea turtle and an American saltwater crocodile during a trip to Mexico; caimans photographed during a project in Brazil.

It isn't hard to connect the boy exploring the creeks of Oregon and chasing down scaly friends to Crossley today, studying developing turtles and alligators. A professor at the University of North Texas (UNT) and chair of the APS Comparative & Evolutionary Physiology Section, Crossley has traveled the world for his research. He studied in Denmark and Sweden and taught in Mexico and Brazil. He conducted field work in Puerto Rico, where he collected frog eggs to better understand heart rate variation between clutches.

Crossley loved biology in high school and went on to double-major in biology and zoology at Oregon State. By the time he graduated college, he knew he was interested in research and physiology. Out of the countless potential branches of biology, why physiology? "I love puzzles," he says.

He followed those interests to a master's degree, working on the regulation of blood pressure in cane toads at Portland State, then headed to UNT for his doctoral research. That's where his interest in developmental physiology grew. He worked with Warren W. Burggren, PhD, FAPS, diving deep into the development of cardiovascular regulation in the chicken embryo, looking for differences between ex utero development in the egg compared with the better-studied mammalian fetal lamb system. Crossley also studied the same processes in desert tortoise embryos, moving beyond previous descriptive morphological studies and beginning to quantify the physiological mechanisms at play.

As he progressed from graduate student to postdoc, the developmental stage of his research subjects grew alongside him. "I began to understand the embryos, so I wanted to extend that into the juvenile," he says. At the University of California, Irvine, he assessed physiological differences between clutches of juvenile alligators. Next up, he studied embryonic chicken physiology, first as a postdoc at Oregon Health & Science University and then as a research fellow at Linköping University in Sweden.

Crossley's wide-ranging curiosity about the "puzzle of organismic function" continued to drive him as he began his independent research career at the University of North Dakota (UND). He continued to work with a breadth of nontraditional models, including avians, reptiles and amphibians.

"By looking at multiple species, you can look at commonalities that are shared, at the common solutions to problems. Then you find, of course, there are also unique features: You have an organism that has a unique way of handling some process, and you can investigate how they deal with that challenge," he says. "It gives you the capacity to find out which animals are unique in the way they respond to a given scenario and then to dive deeper into how they do that and whether it is an advantage for them."

## DEVELOPING HIS LAB

Establishing a research lab is no small feat, but for Crossley it was simply the next obvious step in his ongoing journey to try to tease apart the question that, at that point, had fascinated him for more than a decade.

"I was studying developmental programming in bird embryos again, looking at chickens and different species of ducks, and then snapping turtles—all looking at developmental physiology and how the developmental environment influences that developmental physiology. I just kept going, and it's all evolved from there."

Crossley was recruited to UNT in 2010, where he remains. Today, his work is a combination of teaching courses, mentoring students and working in his lab—still driven by his fascination with how the environmental circumstances of an animal's embryonic life can predispose it for different physiologies and alter its physiology as a juvenile and adult.

Photos, this page, courtesy of Dane Crossley, PhD

"I'm really amazed by how an event early in development can have long-term repercussions."

It's that fascination that led to Crossley working closely with alligators, setting him up for the occasional bout of alligator wresting. Exercising animals raised under different oxygen conditions and comparing blood flows in major arteries has expanded the understanding of those long-term effects. By examining how the creatures of our world function and their adaptations to the challenges imposed by their environment, Crossley, and other comparative physiologists, help us better understand diseases in humans and animals.

## NURTURING FUTURE SCIENTISTS

Crossley, who has been teaching since his master's program, thrives on it. At UND, students recognized him as a "faculty star" for undergraduate teaching.

His teaching activities have taken him far and wide, from a course on ecophysiology in aquatic vertebrates in Mexico to courses on cardiovascular and cardiopulmonary physiology in Brazil. At UND, he was a faculty mentor for National Science Foundation-funded summer Research Experiences for Undergraduates. The program was designed to provide hands-on research experience in neuroscience for students from Tribal and rural colleges in the area. He mentored a student completing an honors thesis at UNT, and his current courses there include comparative physiology and an introductory biology course, which he particularly enjoys because of the excitement students show as they're exposed to physiology—many for the first time.

When it comes to lab mentorship, Crossley's approach is tailored to the "developmental stage" of his students—who range from high schoolers to master's students up through postdocs.

"With the postdocs, I tell them, 'Here's the question,' and give them pretty much free rein—within reason—to do what they think we should do. PhD students are trying to develop their own ideas, and I'm pretty hands-on for the first couple of years for any students who are early on in their degrees, and then later on, I take a step back and let them go."

Crossley's science is necessarily collaborative. "I do a lot of surgical interventions and a lot of looking at pharmacological manipulations—low levels of oxygen, high levels of CO2, blood gasses, those kinds of things—but I'm not the expert in, say, transcriptomics. So, I go out and find someone to help with that. I have someone else that helps me with histology and so on."

This approach underscores Crossley's desire to understand the full picture, from the smallest pieces of the molecular puzzle to adult physiology.

INSIDE STORY

## Quick Questions

1. **What's your best piece of career advice?**
   Always work hard.
2. **What's your idea of happiness?**
   Being on a lake in Minnesota.
3. **If you could be any animal, what would it be?**
   Wolverine.
4. **What's one of the weirdest animal facts that sticks with you.**
   Some turtles can live without oxygen for months.
5. **What's the best part about teaching?**
   Helping others.

"I take it from the whole-animal level down to the mitochondrial level so that I have the capacity to study everything from the response of the juvenile down to the mitochondrial responses in cardiac tissue, or at the cellular level, looking at cardiomyocytes and how they function—which again, I do with collaborators. I get their help with doing those kinds of studies."

## CONTINUING TO BUILD

What excites Crossley most today? "It's the same thing that excited me when I started: the influence of the developmental environment on the phenotype of the animals. This area of study has been around for a while, but with non-traditional models, we're still scratching the surface as to how the environment influences their embryos and how that affects the juveniles and the adults."

He also acknowledges the translational aspect of his work, acutely aware that his research could help mold treatments for human disease. "By studying these nontraditional models, we find out things we would never find out in some other species. Maybe these models can tolerate environmental factors that mammals or humans couldn't. You delve deeper into the question of 'How do they do it?' There clearly are connections between what we find in these nontraditional models and how that might translate to human health."

Today, when he's not working, Crossley may be spotted on a fishing trip, communing with some of the aquatic vertebrates he doesn't study. And while he focuses on mentoring and teaching undergrads and postdocs, he may also be lamenting about how much writing is involved in being a scientist. But he doesn't mind it too much, just as long as he gets to keep putting the puzzle pieces together.

# *A Tenure of* TRANSFORMATION

## APS CEO Scott Steen reshaped the Society. Now he's retiring to Tuscany.

**BY AMANDA BERTHOLF**

When Scott Steen, CAE, FASAE, walked into his second interview for the CEO role at APS, things didn't go as planned. He stepped to the front of the room to begin his presentation, but when the search consultant clicked the mouse, the screen froze. So, Steen took a seat, turned to the room of APS leaders, and said, "Let's just have a conversation about where we are and what we can do together." The rest of their time was spent talking about APS, its challenges and how the organization could move forward.

That moment was about more than a technology glitch—it was a preview of Steen's leadership style: transparent, collaborative and unafraid of disruption. In less than an hour after leaving the interview, he received a call offering him the job.

Steen had spent the previous eight years as president and CEO of American Forests, a conservation organization with a history dating back to Teddy Roosevelt. But he was ready for a change and had just begun the search for a new role.

Photo by André Chung

**"APS needs to evolve from an organization that was focused on providing member benefits and giving members an opportunity to share their science, to also being a better defender and advocate publicly for physiology."**

"I never intended to take the first offer that came my way," he says. "But the fit felt right. I liked the people around the table. I believed in the mission—and I knew I could help."

Over the next seven years, Steen led APS through a period of change and navigated pressures from outside forces—tackling legacy systems, updating the organization's governance structure, creating a new annual meeting, launching strategic initiatives and reinforcing the Society's role as a champion of physiology. And now, as he heads into retirement in early 2026, he reflects on his time at APS and what the next phase of his life will bring.

## BUILDING A TEAM

Founded in 1887, APS has long had a presence in the scientific community, but aspects of the organization had not evolved as quickly as the landscape around it. It was time for a new phase of modernization to better align with emerging technologies and member expectations. When Steen arrived, he found a society with a proud history, loyal members—and a deeply centralized operational model. Nine departments reported directly to him, and even routine decisions landed on his desk.

His first step was building a senior leadership team. "I hired for ability and emotional intelligence," he says. "And this team works so well because people are strong enough to share their ideas, and they are humble enough to let the best idea win."

He also elevated internal talent, promoting staff into strategic roles. "There was a layer of people just waiting for permission to lead," he says. "We tapped into that."

With leadership in place, APS began evolving quickly, a pace Steen says reflects the quality of the APS Board of Directors. "From the start, they gave me wide latitude to make changes. They knew what they were getting—I was clear in interviews: 'If you want slow, incremental change, I'm not your guy.'"

Old technologies and communications platforms were replaced. The Society's visual brand, identity and website were updated, and *The Physiologist Magazine* was launched to reflect the professionalism of the Society's members and to tell the stories behind the science.

Another notable change included withdrawing from Experimental Biology, the longstanding annual meeting APS had participated in with other societies for years. Steen knew early on he wanted to explore other meeting options. "Good annual meetings do three things: strengthen the discipline's brand, build community and offer a great attendee experience," Steen says. "We knew we could deliver on all of those things more successfully if we went off on our own."

In 2019, the APS Board of Directors unanimously voted to create a standalone annual meeting, the American Physiology Summit. "People would say, 'This is all happening so fast.' And I'd ask, 'Which of these changes would you not have made?' But it wasn't the changes themselves—it was about the concept of change in general that was hard," he says. "But now, many of those same people agree the changes were necessary."

## OUTSIDE CHALLENGES

Steen's tenure also overlapped with major external pressures. The COVID-19 pandemic, the rise of open access publishing, economic fluctuations, political headwinds and growing hostility toward science have all tested the Society's resilience. Despite these pressures, Steen says APS has remained steady with a focused and clear plan.

Even with that clear plan, science is at a precarious moment. But Steen says because physiology is the cornerstone of every discovery about life and human health, it is more essential than it ever has been. And the Society has a role in speaking up for physiology.

"What's changing about the Society's role is we need to evolve from an organization that was focused on providing member benefits and giving members an opportunity to share their science, to also being a better defender and advocate publicly for physiology. We must take our role as an advocate for the discipline far more seriously."

A major part of that effort is a strategic communications campaign APS launched in July. The campaign will elevate awareness of and appreciation for physiology as a foundational discipline in life science and medicine, while advocating for the importance of science funding. The goal of the campaign is to build support for physiology among the public, funding agencies, policymakers and the scientific community.

## FULL SPEED AHEAD

As APS looks ahead, its next leader will need to keep pace with the external landscape as much as the Society's internal needs—and be ready to adapt quickly. Because the pace of change today and the threats to science are unrelenting, Steen says the Society's future leader must have a clear vision but also be open to ideas.

"It's a cliché, but it's true, and it's being driven by external forces beyond our control," Steen says. "Whoever steps into this role must be highly skilled at navigating change and be incredibly agile."

The challenge is that agility doesn't come naturally to membership associations. Boards meet three times a year. The member leaders doing the work have day jobs. These are organizations built for stability, not speed. "APS has moved faster than many, but it's going to have to move even faster in the years ahead," Steen says.

While finding that agility may mean copying from the business playbook, Steen acknowledges that some members are uncomfortable with describing APS as a business. "The truth is, we have to operate like one," he says. "That doesn't mean abandoning our mission. The science is paramount. But it does mean managing smarter, making hard decisions when needed, and staying focused on long-term sustainability."

## READY FOR RETIREMENT?

As he moved through his career, Steen began to recognize a pattern about his personality. The ability to push through uncertainty wasn't just a skill—it was personal. The more challenges he took on, the more he started to understand what motivated him. "I get bored easily. It's in my DNA. If I'm not doing the hard things, if I'm not addressing what really needs to be done, I tend to lose interest and move on. I'm not wired to coast."

Steen wasn't the only one who noticed this pattern. "A colleague once told me, 'You always choose the hardest thing, the hardest way. You always touch the third rail,'" Steen says. "That's probably true. Why do I do that to myself? Why do I tend to tackle a bunch of hard things at once? I think it is because they have to be done and frankly, we now have a team that demands it."

He's quick to clarify that not every leader needs to work that way. Leaders can build stable, successful organizations with small, steady, incremental changes over time. "That approach can be great for a team," he says. "But that's just not how I'm built, and I don't think it fits the times we are in. The world around us is changing incredibly quickly, and we have to keep up."

Steen is retiring at age 61, not because he's finished but because he says APS is ready for what's next and he is ready for his next challenge. "We've hit a natural transition point. There's a strong team in place. The new leader won't have to build a foundation; they can start constructing something new."

Even heading into retirement, a time in life that for most people means moving at a leisurely pace, for Steen the drive to take on something new hasn't faded. As he looks ahead, he knows slowing down won't come naturally. "I've been thinking, what does retirement look like for someone like me?" he says. "I still need something that pushes me."

That's why he and his husband are relocating to Tuscany in Italy. They will immerse themselves in a new language, a new culture and a new bureaucracy. The experience of learning to live in a completely different place is part of his retirement calculus. "I can't imagine doing anything else," he says.

## LEAVING A LEGACY

As Steen reflects on his time at APS, he is proud of the progress the Society has made. "We've come through a whirlwind of several years as a healthy, vibrant organization," he says. "We're more professional, we deliver more for our members, and we're poised to deliver more for the discipline moving forward."

Much of that progress, he says, is because of the people driving it. "We've built a team of people who are fully capable of taking this organization into the future, making it better, and continuing to make it stronger," Steen says.

From Tuscany, Steen's future may be offering him a new set of challenges, but he leaves confident that APS is well-positioned for the road ahead.

CAMPAIGNS

## National Campaign Launches

APS has selected JPA Health to lead a national campaign aimed at elevating awareness and appreciation of physiology as a foundational discipline in life science and medicine, while advocating for the importance of science funding. JPA Health is an award-winning public relations and communications agency specializing in science and public health.

JPA Health was chosen through a competitive process for its innovative approach, bold creative concepts and proven expertise in bioscience advocacy and stakeholder engagement. The agency brings deep expertise in bioscience communication, a proven track record with federal agencies and scientific societies, and an understanding of the policy and funding landscape that shapes biomedical research.

The campaign will support a key objective of the APS Strategic Plan: elevating the visibility and standing of physiology within the broader scientific and biomedical communities. In April 2025, the APS Board of Directors approved funding for this initiative—affirming the Society's commitment to positioning physiology as a central force in advancing health, understanding life and disease, and informing biomedical innovation. APS will work in partnership with JPA Health to build public, policymaker and scientific community support for physiology.

JPA Health will lead campaign development, creative execution, media strategy, digital engagement and public affairs outreach in collaboration with APS. The multichannel effort launched in July, with initial phases focused on message development and stakeholder alignment.

APS COMMUNITY

## APS Announces Efforts to Broaden Engagement

As the political and social landscapes evolve, APS is working to meet the needs of the community and reduce unnecessary risk to members, the discipline and the Society. Here's how APS is evolving efforts to cultivate a welcoming and inclusive scientific community.

**Diversity Statement**

The APS Board of Directors approved an updated diversity statement that reaffirms the Society's commitment to building a welcoming community where all individuals can engage and contribute. The revised statement reads:

"APS believes in the inherent value of all people and their capacity to contribute meaningfully to scientific discourse and achievement. We are committed to fostering an environment where all individuals have the opportunity to contribute to scientific knowledge, serve the community and advance the Society."

**Awards**

In June, the Board, other member leaders and staff engaged in a process to revise some of the Society's award eligibility criteria, and those revisions have been implemented. This effort ensures awards and initiatives will be open to all who share the Society's values, reflect our diverse community and promote excellence in physiology.

**Committees**

In July, the Board received and approved recommendations from the Diversity, Equity & Inclusion (DEI) Committee chair, leaders and APS staff for evolving the committee. Moving forward, the DEI Committee is now the Community Engagement Committee, charged with ensuring that all individuals, regardless of background and experience, are supported and encouraged to thrive, contribute and lead within the APS community. Learn more about the committee at **physiology.org/communityengagement**.

EVENTS

## Explore Concepts in Women's Health Research

It's not too late to register for the APS Sex Differences and Women's Health Research conference. The event will feature experts on topics such as sex differences in cardiovascular risk, menopause, exercise and obesity. View the program and learn more about the speakers, who are leaders in their field. For the latest integrative and translational breakthroughs, join us in New Orleans, Oct. 23–25. Learn more at **physiology.org/APSSexDiff2025**.

PUBLICATIONS

## Publish Open Access Without APCs

All articles in the 2025 issues of 10 of the Society's primary research journals will be open access under Creative Commons licenses. These articles will be published with no article processing charges (APCs), which are often required for open access publishing. Most articles will only be charged a flat fee. Learn more about APS Subscribe to Open and what it means for you at **journals.physiology.org/subscribe-to-open**.

## New BioRender Pilot Program Launches

APS launched a pilot program that gives authors access to BioRender's premium image tools at no cost. The Society is offering this service to authors to communicate their science more clearly, especially when visualizing mechanisms, workflows or concepts. Explore a walkthrough and start creating at **journals.physiology.org/biorender.**

**Sachin Aryal**, a PhD candidate in the Department of Physiology and Pharmacology at the University of Toledo, is the 2025 recipient of the university's **Daniella Gamboa Pabon Award for Research Dedication** and **Graduate Student Recognition Award**. Aryal's research focuses on how gut microbiota, bile acids and epigenetics regulate blood pressure.

**John Buckwalter, PhD, FAPS**, has been appointed **provost and executive vice president for academic affairs** at the University of Central Florida. He earned his master's degree and PhD in kinesiology with an emphasis in exercise physiology from the University of Arkansas. Buckwalter previously served as provost of Boise State University.

**Patricia Halpin, PhD, FAPS**, is the 2025 recipient of the **University of New Hampshire College of Professional Studies' Excellence in Teaching Award**. The award recognizes a faculty member who creates a positive learning experience for students and applies innovation and creativity in course design and pedagogy. Halpin's research focuses on engaging undergraduate students in learning physiology and related subjects with songs, skits, case studies and team activities.

**Ishan Manandhar**, a PhD candidate in the Department of Physiology and Pharmacology at the University of Toledo, is the recipient of the university's inaugural **Tower of Excellence Award**. The award "recognizes students who exemplify the University of Toledo's core values through exceptional academic performance, leadership and service to the community." Manandhar's research focuses on novel gut microbiota-mediated mechanisms regulating blood pressure.

**Jennifer Pollock, PhD, FAPS**, professor in the Department of Medicine, Division of Nephrology, at the University of Alabama at Birmingham, is the recipient of the **Association of Chairs of Departments of Physiology's Distinguished Service Award**. The honor recognizes outstanding contributions to physiology, leadership and service. Pollock's research centers on early-life stress-mediated vascular dysfunction and hypertension sensitivity, as well as immune mechanisms of kidney and vascular disease in obesity.

**Vernon A. Ruffin, PhD**, is the 2025 recipient of **Black in Physiology's Positive Execution of Excellence in Physiological Sciences (PEEPs) Award**. The PEEPs award recognizes outstanding contributions and commitment to excellence in the field of physiology. Ruffin is the founder and CEO of Ruffin NeuroLab LLC, a training and research facility dedicated to advancing neuroscience, biology and biomedical innovation.

**Erica Wehrwein, PhD, FAPS**, is the 2025 recipient of **Michigan State University's (MSU) President's Distinguished Teaching Award**. The honor recognizes a faculty member who "develops innovative environments that support student learning and success." Wehrwein was recognized for her commitment to upholding MSU's educational mission and leading curricular reform and for exemplary teaching of undergraduate students in an inclusive environment.

**Natalya Zinkevich, PhD**, is the 2025 awardee of the **University of Illinois Springfield's Pearson Faculty Award for Teaching**. This award recognizes excellence in teaching. Zinkevich was chosen for her expertise in vascular biology and pathophysiology, her dedication to her students and invaluable contributions to the curriculum.

# DATES & DEADLINES

## AWARDS

*Award deadlines vary and may be subject to change. For the latest information, including award descriptions, amounts, eligibility requirements and to apply, visit* ***physiology.org/awards****.*

### SEPT. 16

**APS Fellows (FAPS)**

### OCT. 6

**Henry Pickering Bowditch Award Lectureship**

**Physiology in Perspective: The Walter B. Cannon Award Lecture**

### NOV. 17

**A. Clifford Barger Mentorship Award**

**Bodil M. Schmidt-Nielsen Distinguished Mentor and Scientist Award**

**More details: physiology.org/professional-development/awards**

## CALLS FOR PAPERS

### CROSS-JOURNAL CALL FOR PAPERS

**Opioids and Respiratory Depression** (Dec. 1)

**Cardiorenal Physiology** (ongoing)

**Explore our ongoing cross-journal calls for papers on key women's health research topics:**

- Alzheimer's disease
- Autoimmune diseases
- Breast cancer
- Cardiovascular disease
- Hormone replacement therapy and menopause
- Migraines
- Novel perspectives on sex as an investigative variable
- Pregnancy and postnatal conditions:
  - Endometriosis
  - Gestational diabetes
  - Preeclampsia
  - Polycystic ovary syndrome

Join APS in advancing our mission to improve health care outcomes and promote greater scientific understanding of women's health. Learn more about this special call for papers at **journals.physiology.org/womens-health-research-initiative**.

***American Journal of Physiology-Heart and Circulatory Physiology***

- Stress, Exercise and Cardiovascular Disease (Dec. 1)

***American Journal of Physiology-Regulatory, Integrative and Comparative Physiology***

- Integrative Physiology of Gut-Brain Communication (Sept. 30)
- Physiological Adaptations to Environmental Stressors and Challenging Conditions (Sept. 30)

***American Journal of Physiology-Renal Physiology***

- Epigenetics in Kidney Health and Disease (Oct. 1)
- Cardiorenal Physiology (ongoing)

***Comprehensive Physiology***

- Gut-brain communication in metabolic and cognitive control (Dec. 31)
- Heart-Lung Interactions in Pulmonary Vascular Disease (Dec. 31)

***Function***

- Neuroscience (ongoing)

***Journal of Applied Physiology***

- Context-Dependent Mechanisms of Striated Muscle Dysfunction (Sept. 30)
- Physiological Responses to Psychosocial Stress (Sept. 30)
- Cerebrovascular Control in Health and Disease: From Modeling to Translational Research (ongoing)
- Experiments of Nature (ongoing)

***Journal of Neurophysiology***

- Now and Then (Nov. 30)
- Neuroimaging Meets Neurophysiology (Dec. 31)

***Physiological Genomics***

- Nutrigenomics (Dec. 1)

***Physiological Reports***

- The Physiology of Breathlessness (Sept. 1)
- Tissue Fibrosis Through the Life Course and in Transplanted Organs (Dec. 31)

**More details: physiology.org/calls**

## MEETINGS & EVENTS

### 2025

**New Trends in Sex Differences and Women's Health Research**
Oct. 23–25
Tulane University Medical Campus
New Orleans
**physiology.org/APSSexDiff2025**

### SAVE THE DATE: 2026 CONFERENCES

**American Physiology Summit**
April 23–26, 2026
Minneapolis

**Control of Renal Function in Health and Disease**
June 2026

**Comparative Physiology Conference**
September 2026

**More details: physiology.org/professional-development/meetings-events**


# Share Your Discoveries

Present your work at the 2026 American Physiology Summit (#APS2026) to gain valuable feedback and make vital connections.

Participate in our lively poster receptions, where your peers are sharing discoveries on the cutting edge of bioscience.

We will begin accepting abstracts Oct. 1, 2025. Submit your research and apply for awards at **physiology.org/APS2026.**

**Call for Abstracts**
**Oct. 1–Dec. 3, 2025**

## american physiology summit

**APRIL 23–26, 2026**
**MINNEAPOLIS**

# ‘Urine’ Women’s Research?

BY AMANDA SUDA

On my way to lab in the morning, I walk to a cafe near my home. “I’ll have a coffee,” I tell the barista. I’m there often enough that the people working there know me. Sometimes a person on the other side of the counter will ask, “Is that a kidney?” as they gesture at the purple lapel pin on my backpack strap. It is. A colleague gifted me a kidney pin when I chose a renal cell biology lab for my doctorate.

“Cool!” the barista will say, excited to identify the abstract organ. Sometimes they also ask, “Why?”

How do I address this question? What they’re asking, perhaps unknowingly, is “What do you do for a living?”

My project focuses on the role of microRNAs and sex differences in renal-epithelial cells during ischemic acute kidney injury. Do I focus on the kidney biology side of my project—assuming they would be able to find enthusiasm in the topic, or at least some understanding, since they identified the organ on my pin?

Throughout most of my education, the kidney was underrated. Would they find the kidney boring? Should I approach with the disease portion of my studies instead? Even minor loss of kidney function can result in systemic complications. Surely, they’ll find that compelling, right?

Or do I give a less science related and, to some, a more controversial answer? Do I talk about the female sex?

“I work in a kidney lab,” I begin, gauging their interest. Maybe they expect me to tell them that I am a kidney donor or receiver. One person told me this was the case.

Usually, I tell them I’m working on my doctorate in integrative systems biology, but that’s not descriptive. So I elaborate: “I research sex differences in the kidney—how males and females are different.” This, I have found, is what catches most people’s interest. Honestly, it’s what caught my interest in biomedicine as well: women in science. Not just women in STEM, but women as the scientific focus. Women as a biological variable.

“Well, are they different?” they ask, curious and genuinely uncertain. This is my cue, not only that they’re willing to give me their time but that they’re interested.

“Yes!” I begin. “The woman’s body has this fantastic way of controlling the immune system, at least in the kidney. With the disease I focus on, women can keep themselves from getting injured and repair themselves better than men—kind of like how with COVID, some people suffered from an overactive immune response, causing a dangerous amount of inflammation and damage to the lungs.”

I continue, “With the disease I study, after being exposed to a stress, the kidney can get further damaged by its own efforts to stop and repair the problem. Women do a better job at reining in some of these responses.”

I add this isn’t for all women or all men and that things change after menopause. “I’m interested in bettering women’s health,” I continue. “Women have been underrepresented in research.”

I tell them the female sex has this inherent ability to fine-tune the immune response in certain organs, and it gets even more impressive when we consider the placenta. We could hijack that biology and create better therapeutics, not just for women, but men as well.

We say our goodbyes, mine with a coffee in one hand. These types of interactions propel my pursuit in becoming a scientist in biomedicine. This fills me with optimism, and I drink my coffee and continue on my way.

**Amanda Suda is a 2025 KidneyCure Pre-Doctoral Fellow in the Butterworth Lab and a fifth-year integrative systems biology doctoral candidate at the University of Pittsburgh School of Medicine.**

Illustration by Brett Affrunti

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