EB 2014 | Data Diuresis

Water and electrolyte homeostasis brings balance to physiology

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1Cardio-Renal Physiology and Medicine, Division of Nephrology, University of Alabama at Birmingham, Birmingham, Alabama; 2Department of Physiology and Biophysics, University of Mississippi Medical Center, Jackson, Mississippi; 3Department of Pharmacology and Physiology, St. Louis University, St. Louis, Missouri; and 4Business Development and Licensing, Janssen Pharmaceutical Companies of Johnson & Johnson, Spring House, Pennsylvania

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Pollock JS, Ryan MJ, Samson WK, Brooks DP. Water and electrolyte homeostasis brings balance to physiology. Am J Physiol Regul Integr Comp Physiol 307: R481–R483, 2014. First published July 16, 2014; doi:10.1152/ajpregu.00246.2014.—The American Physiological Society officially recognized the area of research in Water and Electrolyte Homeostasis (WEH) over 30 years ago when the Section of WEH was established. This minireview illuminates the importance of WEH research to the physiology community. By the narrowest definition, WEH research studies the regulation of body fluids; however, this research area is much broader and more relevant today than when this subdiscipline was first recognized because of the translational and systemic “point of view” of WEH research. This minireview highlights how WEH research serves as a balanced force between the full range of other more traditional organ-based physiological and pathophysiological concepts. The breadth of research in which WEH investigators engage is on full display with the publication of minireviews from the annual Data Diuresis session at Experimental Biology.

The AMERICAN PHYSIOLOGICAL SOCIETY (APS) officially recognized the focused area of research in Water and Electrolyte Homeostasis (WEH) over 30 years ago when the Section of WEH was established. This research area has undergone a transformation from one of a “fine-tuned” research scope to a more broad-based and encompassing research area where investigators still today share a common interest in integrated systems physiology. This minireview illuminates three main concepts related to the field of study in WEH: 1) defining what this area of research means today, 2) providing relevance for the study of WEH more so now than when it was recognized many years ago, and 3) highlighting how this area of research compliments and brings balance to physiological and pathophysiological concepts. The WEH Section of APS showcases WEH research annually at the Experimental Biology meetings in the format of the annual Data Diuresis Session as well as Featured Topic Sessions, Symposium, Starling Distinguished Lecture, New Investigator Lecture, and several poster sessions. The Starling Awardee and the New Investigator Awardee with their lecture titles are found in Tables 1 and 2, respectively, showing the breadth of research that is recognized. In 2001, the American Journal of Physiology (AJP)-Regulatory, Integrative, and Comparative organized for the WEH New Investigator Awardee to submit a review article on their presentation and this tradition continues today. In 2012, the journal extended invitations to the Data Diuresis Session presenters to submit a minireview of their presentations as a novel mechanism to spotlight WEH research.

What is the Study of Water and Electrolyte Homeostasis?

Most scientists would agree that physiology is the study of function in living organisms and is the science of medicine. Today physiology encompasses the fields of biochemistry, pharmacology, genomics, and most any other areas of investigation that enhance our understanding of living organisms. Within the field of physiology, the APS recognizes areas of research that are organized into subdisciplines or sections such as cardiovascular; cell and molecular; central nervous system; comparative and evolutionary; endocrinology and metabolism; environmental and exercise; gastrointestinal and liver; neural control of autonomic regulation; renal; respiration; and teaching; and WEH. In addition, the APS recognizes subsets of sections and cross-disciplines that are organized into interest groups such as epithelial transport, history of physiology, hypoxia, muscle biology, physiological genomics, physiologists in industry, and translational physiology. While it is intuitive to understand the areas of research in most of these sections and interest groups, WEH is not as easily defined and thus deserves some clarification.

Within the context of physiology, as the fundamental basic science, WEH research is defined as the regulation of body fluids. The study of water and electrolyte homeostasis includes concepts such as a cell regulating the secretion or absorption of K+ or Na+, or tissues and organs regulating water absorption and elimination, or signals from one part of the body regulating a separate part of the body to maintain strict K+ homeostasis, or many other regulatory schemes not described or yet to be discovered. As examples of WEH research, recent reports from several laboratories have revealed novel mechanisms for how the immune system regulates Na+ homeostasis in the skin (3, 8), placental ischemia mediates hypertension via activation of auto-antibodies (6), hypertension in systemic lupus erythematosus is dependent on renal inflammation (5), or how neurohumoral mechanisms regulate responses to osmolality (1), preautonomic neurons and neurosecretory neurons maintain water balance (7), and how vasopressin mediates hypertension in mice with activation of the brain renin-angiotensin system (2). Thus WEH research is not restricted to one system or organ, one set of hormones, or a particular set of mechanisms that were known when the section was established. Homeosta-
Table 1. Starling Distinguished Lecture Awards from 1994 to 2014

<table>
<thead>
<tr>
<th>Starling Distinguished Lecture Awardee</th>
<th>Starling Distinguished Lecture Title</th>
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<tbody>
<tr>
<td>2014 Howard Jacob, PhD</td>
<td>Testing human genes for hypertension and renal disease in experimental models</td>
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<tr>
<td>2013 Donald Kohan, MD, PhD</td>
<td>Collecting duct epithelium: The last word in sodium and water excretion and blood pressure regulation</td>
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<tr>
<td>2012 Kathrym Sandberg, PhD</td>
<td>The female paradox: Resistance and vulnerability in hypertension and renal disease</td>
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<tr>
<td>2011 Curt Sigmund, PhD</td>
<td>Divergent mechanisms regulating fluid intake and metabolism by the brain renin-angiotensin system: A story of drinking and donuts</td>
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<tr>
<td>2010 Kirk Conrad, PhD</td>
<td>Maternal vasodilation in pregnancy: The emerging role of relaxin</td>
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<tr>
<td>2009 Alicia McDonough, PhD</td>
<td>Life in the fast lane: Sodium transporter traffic regulates blood pressure and volume</td>
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<tr>
<td>2008 Joey Granger, PhD, PhD</td>
<td>Hypertension during preeclampsia: A lesson in integrative physiology</td>
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<tr>
<td>2007 Pedro Jose, MD, PhD, MD</td>
<td>Salt-sensitive hypertension: A problem with communication</td>
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<tr>
<td>2006 Tom Coffman, MD, MD, MD</td>
<td>The critical role of the kidney in hypertension: Implications for pathogenesis and therapy</td>
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<tr>
<td>2005 Giuseppe Bianchi, MD</td>
<td>The genetic control of renal Na handling in primary hypertension</td>
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<tr>
<td>2004 Christopher Wilcox, MD, PhD, PhD</td>
<td>Oxidative stress and functional NO deficiency in the kidney: A critical link to hypertension?</td>
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<tr>
<td>2003 Fred Luft, MD, PhD</td>
<td>The role of genetic models in elucidating cardiovascular reflex regulation</td>
</tr>
<tr>
<td>2002 Richard Lifton, MD, PhD, MD, PhD</td>
<td>Genetics, the kidney, and hypertension</td>
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<tr>
<td>2001 Richard Roman, PhD</td>
<td>P450 eicosanoids in the control of renal function, vascular tone and arterial pressure</td>
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<td>2000 Gerald DiBona, MD</td>
<td>The neural control of the kidney in health and disease</td>
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<tr>
<td>1999 Alan Kim Johnson, PhD</td>
<td>Parallel and complementary neural mechanisms in the maintenance of body fluid and cardiovascular homeostasis</td>
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<tr>
<td>1998 John Hall, PhD</td>
<td>Cardiovascular and renal pathophysiology of obesity and insulin resistance</td>
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<tr>
<td>1997 Jurgen Schnermann, PhD, MD</td>
<td>Renal salt excretion and the juxtaglomerular cell complex</td>
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<tr>
<td>1996 Allen Cowley, PhD</td>
<td>Role of renal medullia in volume and arterial pressure regulation</td>
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<tr>
<td>1995 Pierre Corvol, PhD</td>
<td>Gene variants of the renin-angiotensin-aldosterone system: Implications in cardiovascular and renal homeostasis in humans</td>
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<tr>
<td>1994 John Laragh, PhD</td>
<td>The endocrine basis for human hypertension and its cardiovascular sequelae: Containment of the renin system as a strategy for prevention of heart attack and stroke</td>
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Why Recognize the Study of WEH as a Subdiscipline of Physiology?

The concept of recognizing WEH research as a subdiscipline or section within the APS was initiated by Dr. Leonard Share at the University of Tennessee with Dr. David Ramsay at the University of California at San Francisco as well as other colleagues within the APS. Dr. Share’s vision of distinguishing WEH research began with acknowledging that none of the other subdisciplines incorporated viewpoints that included “cross-talk” among organs and systems in the regulation of body fluids. In the early 1970s, research in the mechanisms of how mediators from the brain influenced Na\(^+\) and water homeostasis via Na\(^+\) and water excretion by the kidney was extremely active with recognition by the pharmaceutical industry and the National Institutes of Health (NIH). Yet, very little recognition was given by existing sections within the APS. Thus Dr. Share and Dr. Ramsay initiated the recognition of WEH research by the APS in the form of a subdiscipline or section. The section began in 1982 and has sustained recognition of WEH research throughout its history. At present, WEH research is even more encompassing than when it first began and is vertically and horizontally integrated to include all levels of research from cells to organisms and from one organ to the next.

How the Study of WEH Balances the Study of Physiology

Physiology is the study of function in living organisms. The regulation of water and electrolytes is integral to all functional aspects of body fluids. It is critical in many physiological and pathological states, thus WEH research is not limited to only a few mediators, one organ, or one function. One of the very positive aspects of work within the WEH research area is the continued evolution of ideas and concepts that have no boundaries.

Table 2. Water and Electrolyte Homeostasis New Investigator Awards from 2001 to 2014

<table>
<thead>
<tr>
<th>WEH New Investigator Awardee</th>
<th>WEH New Investigator Lecture Title</th>
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<tbody>
<tr>
<td>2014 Paul O’Connor, PhD</td>
<td>Searching for the link between high salt diet and renal oxidative stress</td>
</tr>
<tr>
<td>2013 Jeffrey Gilbert, PhD</td>
<td>Exercise for treatment of hypertension in pregnancy? Potential mechanisms and mediators</td>
</tr>
<tr>
<td>2012 Jennifer Sasser, PhD</td>
<td>Renal microcirculation: How important those small vessels are for the kidney</td>
</tr>
<tr>
<td>2011 Ahmed Elmarakby, PhD</td>
<td>Genomic strategies for dissecting cardiovascular and renal disease</td>
</tr>
<tr>
<td>2010 Alexander Chade, PhD</td>
<td>Chronic inflammation and the development of hypertension</td>
</tr>
<tr>
<td>2009 Michael Ryan, PhD</td>
<td>Sexual dimorphism in the development of hypertension and renal injury in spontaneously hypertensive rats</td>
</tr>
<tr>
<td>2008 Armin Just, PhD</td>
<td>Dynamics of cardiovascular regulation</td>
</tr>
<tr>
<td>2007 Barbara Alexander, PhD</td>
<td>Low birth weight, the kidney, and hypertension</td>
</tr>
<tr>
<td>2006 Volker Vallon, PhD</td>
<td>The role of sglk1 in Na(^+) and K(^+) homeostasis: Insights from the knockout mouse</td>
</tr>
<tr>
<td>2005 Simon Malpas, PhD</td>
<td>What sets the long-term level of sympathetic activity?</td>
</tr>
<tr>
<td>2004 Robin Davison, PhD</td>
<td>Functional genomic analysis of cardiovascular function in health and disease</td>
</tr>
<tr>
<td>2003 Christine Schnackenberg, PhD</td>
<td>Physiological and pathophysiological roles of oxygen radicals in renal microvasculature</td>
</tr>
</tbody>
</table>

WEH, Water and Electrolyte Homeostasis.
aspects of all living organisms. Many of the investigators that study WEH are committed to understanding how the cardiovascular, renal, and neuroendocrine systems as well as ingestive behaviors integrate and interact with one another to maintain water and electrolyte balance and other homeostatic systems such as blood pressure. An appropriate analogy would be that WEH is the homeostatic balance to the other research areas within physiology and is required for proper regulatory control. Work by WEH investigators serves as a balanced force between the full range of other more traditional organ-based subdisciplines of physiology.

Data Diuresis Mini-Reviews: WEH Research in the Spotlight

 Initiated in 2011, the Data Diuresis Session, sponsored annually at Experimental Biology by WEH, serves as a preview of some of the most exciting WEH research being presented at the meeting. The format is that of a data blitz and typically opens the podium to brief presentations by young investigators chosen based on their submitted abstracts to WEH-sponsored topic categories. In 2012, AJP-Regulatory, Integrative and Comparative initiated a plan to publish brief reviews from selected presentations at the sessions (4). In the current issue of the journal, six of the presenters at Experimental Biology 2014 accepted the opportunity to publish minireviews of their work. These reviews represent the breadth of work that WEH encompasses and highlights the importance of taking an integrative approach to physiology. In summary, the regulation of water and electrolytes is integral to all functional aspects of all living organisms, and WEH research is more relevant today because of the translational and integrative approaches utilized by this research area.

ACKNOWLEDGMENTS

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DISCLOSURES

J. S. Pollock discloses that she is the current chair of the WEH Section in APS. M. J. Ryan discloses that he is the current secretary/treasurer of the WEH Section in APS. W. K. Samson discloses that he is the current Editor-in-Chief of the American Journal of Physiology-Regulatory, Integrative, and Comparative Physiology. D. P. Brooks discloses that he is the former chair of the WEH Section in APS and a former Councillor of APS.

AUTHOR CONTRIBUTIONS


REFERENCES