THE UNIVERSITY OF RHODE ISLAND

DIVISION OF RESEARCH AND ECONOMIC DEVELOPMENT

THINK BIG WE DO℠

Momentum:

Research & Innovation

Cover Story

THE SCIENCE OF DETECTING SOLUTIONS PAGE 4

Featured Inside

WRITING A NEW CULTURE ON CAMPUS PAGE 16

CURRENTS OF THE WORLD PAGE 44

Spring 2017

Momentum:

Research & Innovation

Welcome to the latest issue of *Momentum: Research and Innovation*, the research and scholarly activity magazine of the University of Rhode Island. We are proud to share with you the unique accomplishments of the faculty, students and staff in developing scholarship that will help to change the world. The responsibilities of a research university such as the University of Rhode Island include teaching and the discovery of new information. Sharing that new information with others allows it to be applied, leading to improvement in our daily lives. *Momentum: Research and Innovation* is one of the ways we can share our new information and new scholarly activities with the world. We hope you will enjoy the adventures.

Sincerely,

Gerald Sonnenfeld, Ph.D.
Vice President for Research
and Economic Development

What's inside

spring 2017

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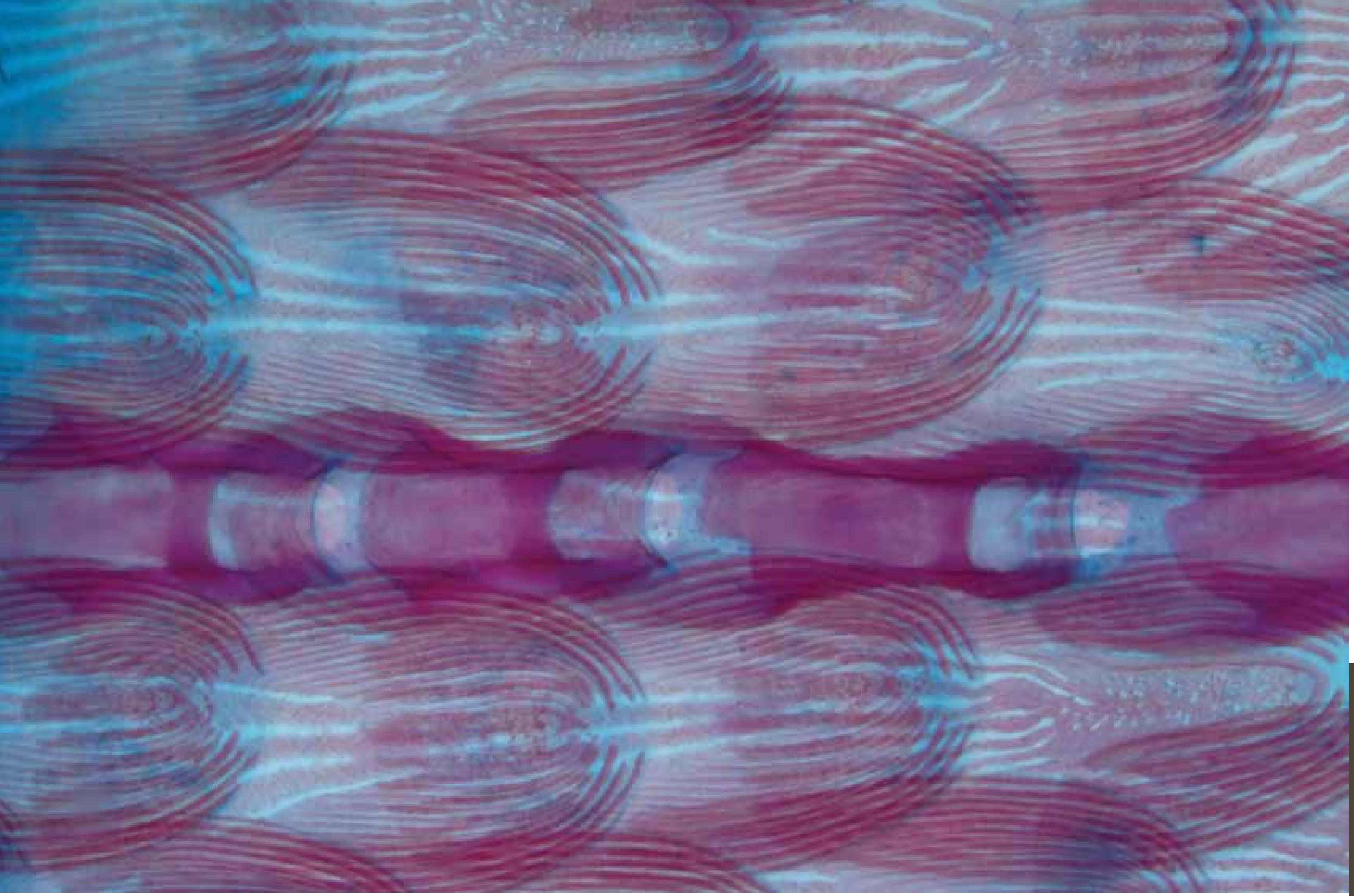
Investigating
The Sensory World of Fishes

written by **ALLISON FARRELLY '16**

"We need to know how fishes navigate their world to understand the ecological roles that they play."

- Jacqueline Webb



Pacific Northwest greenling

The course of Jacqueline Webb's career studying the sensory biology of fishes was set by a challenge presented by her Ph.D. advisor — to produce a book chapter on the diversity and evolution of an intriguing sensory system found in all fishes, the mechanoscensory lateral line system. Webb rose to the challenge, and the results of that work have been providing research questions for her research lab to this day.

"There are over 30,000 species of fishes in the world's lakes, rivers and streams and at all depths of the world's oceans, and we still have a lot to learn about these fascinating organisms."

- Jacqueline Webb

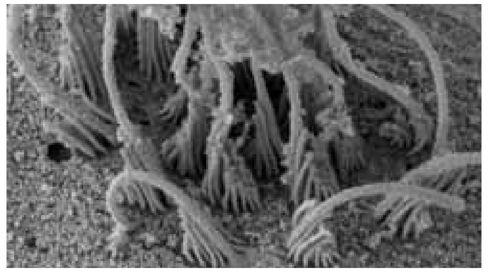
As a post-doctoral fellow, Webb's studies focused on coral reef fishes, the result of what she calls "a great example of serendipity in science."

"What's this?" a colleague asked her when she was a researcher at Cornell University, pointing to a small hole in the skull of a coral reef butterflyfish. The simple question prompted an investigation that would span the next decade.

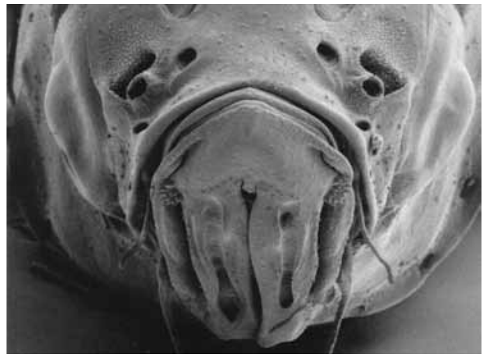
Webb, a University of Rhode Island (URI) professor of biological sciences and the George and Barbara Young Chair in Biology, has studied the structural diversity, function, and development of the lateral line system in a wide range of species, from butterflyfishes and gobies on coral reefs to dragonfishes in the deep-sea.

Neon Gobies

Neuromast receptor organ



Bundles of cilia of a neuromast receptor organ.



Zebrafish

"The ability of fishes to detect prey using senses other than vision is so important, especially given the effects of human activities and global environmental change. With increased nutrient enrichment in aquatic habitats, as the direct or indirect result of human activities, water clarity can decrease significantly. This could give non-visual fishes, those that can detect prey using the lateral line system, for instance, a distinct ecological advantage, which can ultimately alter the composition of fish communities."

- Jacqueline Webb

As the first vertebrates, fishes evolved the sensory organs that humans have: eyes, nose, ears and taste buds. However, fishes also evolved two sensory systems that allow them to exploit the physical properties of water, the electrosensory system and the more ubiquitous lateral line system.

The lateral line system comprises a string of sensory organs found on the head body and tail. Called neuromasts, they detect the slightest water flows in the fish's vicinity - when small hair-like cilia on the surface of the organ's cells are bent even less than a micron, that information is sent to the fish's brain. The neuromasts are found on the skin, but also in canals in the skull bones, and in the scales on the body.

"A fish is really a swimming sensory array," Webb says.

Fish use the nervous impulses from their lateral line system to generate behaviors critical for detection of prey, avoidance of predators, and to communicate with potential mates.

To answer that question posed by her colleague at Cornell in 1989, Webb began to study butterflyfishes. Due to the natural noisiness of the coral reefs where they live — breaking waves, parrotfish chomping on coral, snapping shrimp, dolphins' chirping — scientists had not thought that butterflyfishes would communicate acoustically.

However, when Webb and her students investigated that esoteric hole in the skull, she found that the fish's gas bladder, which is known to regulate buoyancy and amplify sounds, had air-filled tubular extensions in the head that pressed directly against the mysterious hole in the bone, an opening into a canal of the lateral line system. Webb's research suggested that this anatomical specialization was an indication that butterflyfish might convert sounds amplified by the swim bladder into vibrations that are detected by the lateral line system in addition to the ears. This suggested that these fishes might indeed communicate by producing sounds and that they use both their ears and lateral line system to

Jacqueline Webb
professor, biological sciences
George and Barbara Young Chair in Biology

receive and interpret those sounds.

“Connections between the swim bladder and the ear are well-known adaptations for enhancing hearing, but, this was the first instance of a swim bladder-lateral line connection,” says Webb.

She says her discovery of this unusual, and seemingly minor piece of anatomy prompted a series of investigations of butterflyfish behavior on coral reefs and the impact of sound on their social behavior by colleagues in Hawaii.

“It goes to show you that anatomy needs to be studied, because you never know what you will learn or where it will take you,” Webb says.

When Webb arrived at URI in 2006, she looked for a pair of fishes that have distinctly different lateral line systems to study the role that the lateral line plays in prey detection. She turned to the cichlids, the largest family of freshwater fishes, which includes a few thousand different species found primarily in the Great Rift Lakes in Africa. Webb says this is a commonly studied family of fishes, especially with reference to feeding, because of the rapid evolution of their teeth and jaws. Their visual system had been studied intensively, but their ability to find prey using their other senses, including their lateral line system, was unknown.

She chose to compare two cichlids from Lake Malawi in Africa, a species with widened lateral line canals in the skull (a peacock cichlid, in the genus *Aulonocara*) and a narrow canal species in the genus *Tramichomis*. Both fish eat invertebrates that live in the sandy bottom of the lake, but were known to have different strategies for catching prey.

By studying their feeding behavior in the lab, Webb and Margot Schwalbe, her Ph.D. student at the time, determined experimentally that the narrow canal species depend on vision for the detection of live prey. The widened canal fish, however, used their lateral line system to detect prey, and were able to detect live prey in the dark — a behavior of cichlids previously unknown to scientists.

“This was a really big discovery,” says Webb, noting that the behavior of cichlid fishes during the day has been well studied, but little is known about the behavior of the cichlid fishes in Lake Malawi, or of most fishes for that matter, at night.

“The ability of fishes to detect prey using senses other than vision is so important, especially given the effects of human activities and global environmental change,” says Webb. “With increased nutrient enrichment in aquatic habitats, as the direct or indirect result of human activities, water clarity can decrease significantly. This could give non-visual fishes, those that can detect prey using the lateral line system, for instance, a distinct ecological advantage, which can ultimately alter the composition of fish communities.”

The lateral line system has been known as a sensory system of fishes since the 19th century. However, while writing a comprehensive review chapter for a book on the lateral line system a few years ago, Webb noticed significant gaps - the lateral line system of some prominent groups of fishes had never been studied.

“No one knew that much about the sensory biology of deep-sea fishes,” she explains.

That is when Ashley Marranzino, a master”s student and National Science Foundation graduate research fellow in the Webb lab started studying deep-sea hatchetfishes and their relatives.

“These are wonderfully bizarre fishes that live in all of the world’s oceans,” Webb says. Through intense study of preserved specimens collected on cruises and borrowed from museum collections, Ashley found that the prehistoric-looking fish’s body is covered in hundreds of small neuromast organs that appeared as white dots, and she found the same thing in more than two dozen closely related deep-sea fishes.

“This is the first time anyone has done a detailed study of the lateral line system in these fascinating deep-sea fishes,” Webb says. “Ashley’s discovery has opened up a whole new world of possibilities for understanding the sensory biology of fishes in the deep ocean.”

Webb trained at Cornell University and Boston University, and did post-doctoral fellowships at the Scripps Institution of Oceanography, CA, and the Friday Harbor Laboratories at the University of Washington. She has published more than 40 works on the lateral line system over the past 30 years. Her research has been supported by National Institutes of Health Fellowships, a Grass Foundation Fellowship, a Summer Research Fellowship at the Marine Biological Laboratory in Woods Hole, MA, and several major National Science Foundation research grants. She is also a research

Butterflyfishes

associate in Ichthyology at the Museum of Comparative Zoology at Harvard, and a Guest Investigator at the Woods Hole Oceanographic Institution.

In July 2016, Webb was named the first George and Barbara G. Young Chair in Biology, which also is the first-ever endowed chair in the URI College of the Environment and Life Sciences. The honor is reserved for individuals with an exceptional teaching and research record, and is one of the highest honors bestowed on a professor at the University. As a woman in a field that was predominantly male when she entered it, and still is, this honor carries special meaning for Webb.

“Any recognition of a woman at this level is very important, especially in the eyes of students and younger colleagues,” says Webb.

Today, two out of three students in the thriving URI Marine Biology Program, which she directs, are women. In contrast, she remembers when there were just one or two women in the biology department when she was a student.

“Now there is now a growing ‘old girls’ network in addition to the ‘old boys’ network,” she adds.

With respect to her work, Webb says, “We need to know how fishes navigate their world to understand the ecological roles that they play, how to exploit them sustainably, and how to conserve fish biodiversity. There are over 30,000 species of fishes in the world’s lakes, rivers and streams and at all depths of the world’s oceans, and we still have a lot to learn about these fascinating organisms.”

As she tells the students in her courses on marine biology and evolution and diversity of fishes, if nothing else, one of the most important reasons for studying fish is simply that, “fish are cool.”

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