

Changing with the Tides

by Christopher C. Chabot, Professor of Biology

I have been teaching at Plymouth State for 15 years, and during this time, not only has the University changed, my teaching strategies also have changed. I have evolved from science teacher to teaching scientist, partly because of the realization that students learn science best by doing research and conducting experiments, and partly because of the increased opportunities for me to pursue research while teaching here.

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Learning through Research
Why should those of us in the sciences expend the time and energy to conduct research at what traditionally has been a teaching university? First, to best learn science, students need to do science, not just observe it or read about it. Second, part of PSU’s role as a regional comprehensive university is to address and work to answer scientific questions of regional interest through research. And, finally, the experience of engaging in research and conducting experiments can prove invaluable to students who

apply to graduate school or seek employment.

This is why I incorporate research directly into my courses. In my upper-level courses, my initial goal is to capture my students’ interest and enthusiasm by conducting experiments that illustrate fundamental principles of biology and are likely to generate new findings. After analyzing our findings, the students then take the lead on deciding upon appropriate follow-up experiments, with the ultimate goal of presenting our findings at a scientific conference.

Over the past several years, we have been able to achieve that goal. In the spring, I took my students to the 65th annual Eastern New England Biological Conference at Suffolk University in Boston to present the results of their research. This summer, several students were coauthors on presentations at an international conference on horseshoe crabs. While creating these presentations requires all of us to put in extra time, including nights and weekends, I believe the effort is worthwhile in terms of stimulating the students’ interest in biology and teaching them valuable skills, such as writing and critical thinking.

It takes more than time to conduct research, it also takes funding. One of the requirements of being a teaching scientist is



Chabot and his students gather horseshoe crabs for research on the shores of Great Bay Estuary at Adams Point, Durham, NH. Jon Gilbert Fox photos.

applying for grants to help underwrite student research assistantships and purchase equipment. Research equipment for science, and particularly for my primary subject, physiology, can be very expensive. When I first arrived at PSU, we had very little in the way of physiological equipment. Over the past 15 years, I have written many successful grants to accumulate the necessary equipment, including computers, data-analysis software, and sonar trackers, as well as to fund student assistant salaries.

A Journey of Discovery

In addition to infusing research into my teaching, I am also fortunate to be able to pursue my own research interests. This isn’t easy; like nearly all faculty at PSU, I generally have a full

teaching schedule. With a lot of extra time spent over Winterim and summers, and fruitful collaborations with my friend and UNH colleague Professor Winsor Watson, I have been able to develop a research program that has attracted interest from PSU students and granting agencies; we focus on the physiological control of circadian rhythms—commonly referred to as “biological clocks”—in animals, in particular the *Limulus polyphemus*, the American horseshoe crab. Understanding this issue just may help us to better understand and treat such human health issues as seasonal depression and jet lag. (For more information on this research project, visit <http://oz.plymouth.edu/~chris/>. I will continue to update the site as we learn more.)



The American horseshoe crab is a living fossil whose body plan has been virtually unchanged for over 400 million years. Its blood provides a chemical that is used to ensure purity in pharmaceuticals and surgical implants. In addition, horseshoe crabs are considered crucial to the health of coastal ecosystems, and several species of endangered birds depend on their eggs. Furthermore, horseshoe crabs have been used extensively as a model for laboratory investigations of immune-system function, visual physiology, and biological clocks. However, this species is perhaps best known to most people for its mating behavior during the spring and summer months along the Atlantic seaboard from Maine to Florida. During this time, males and

females approach beaches around high tides to mate, and because they can be so easily observed at this time, much is known about their breeding behavior.

Learning more about the physiological control of behavior of the horseshoe crab during the breeding season, and especially during the rest of the year, is the overall goal of my research program. Some of my students and I conduct both laboratory and field studies of horseshoe crab behavior so we can better understand this animal's overall behavioral patterns and how its internal clocks affect its behavior. These clocks have been found in virtually all organisms, including humans, and are believed to be of fundamental importance. One of our early findings contradicted many published papers and books: we discovered horseshoe crabs are not solely nocturnal, and many of them actually prefer to be active during the day.

In Great Bay and Little Bay, New Hampshire, Win Watson and I, along with our students, use sophisticated ultrasonic telemetry systems to continuously monitor horseshoe crab activity in the vicinity of mating beaches. We were delighted to find that, contrary to popular belief, most horseshoe crabs do not leave the estuary during the winter months. We also found that this species continues to be active after the breeding season.

In the lab, we have recently shown that horseshoe crabs have at least two internal clocks: one that tracks time of day and the other that tracks tides. We believe these clocks help this species to

optimally time their behaviors to coincide with the tides. We are collaborating with undergraduate and graduate students to write up our findings for publication with the hope they will help the scientific community better understand how multiple clocks interact in animals in general.

Over the next few years, we will be addressing many more outstanding questions. While it

may not always be easy to balance research endeavors with teaching, it certainly is rewarding to both my students and me. Research not only enhances my students' ability to learn and enjoy science, it keeps me engaged and interested in my work as a teacher and as a scientist. It's a journey of discovery we navigate together.

