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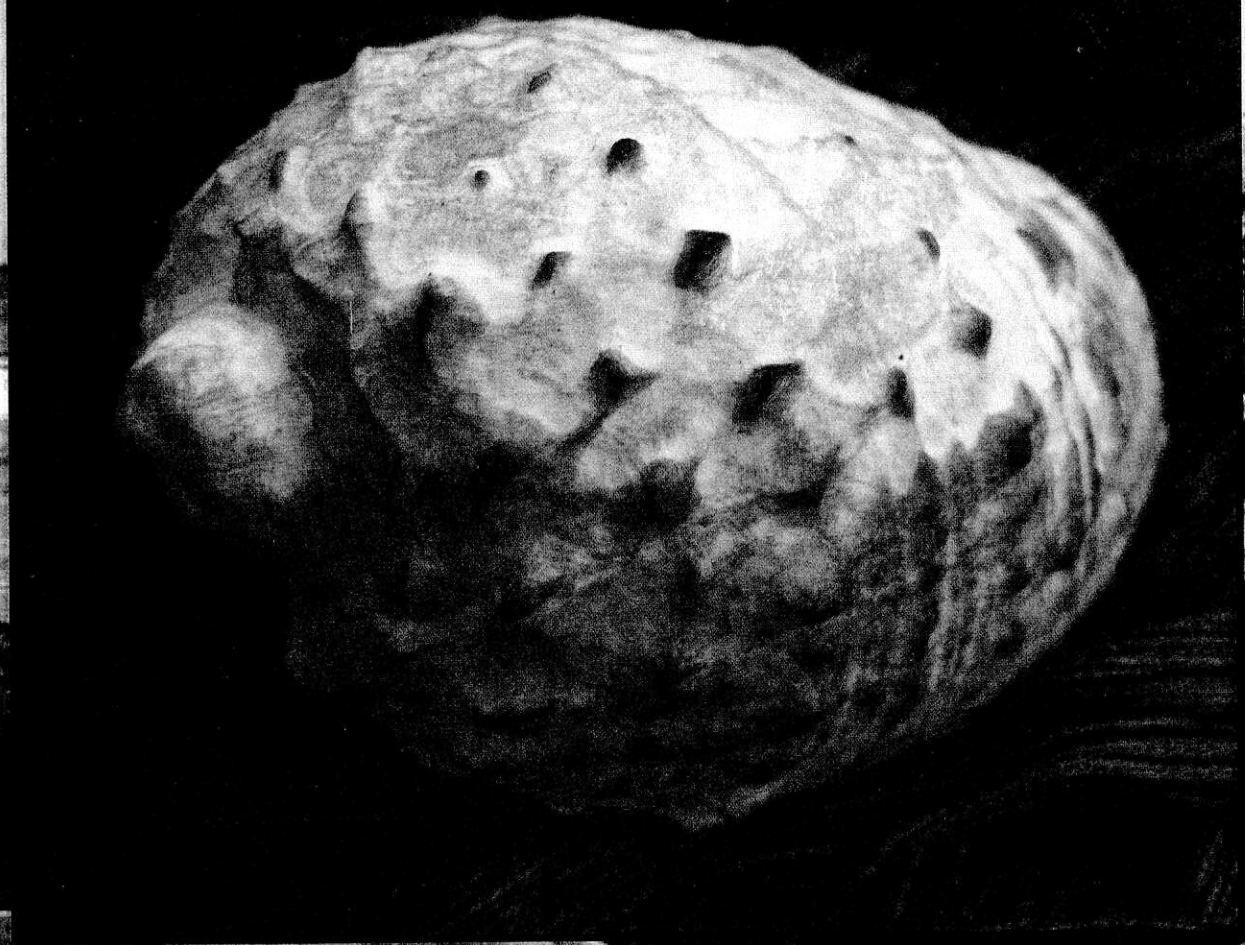

New technologies for bird migration research

Climate change and the prairie–forest border

Observational approaches in ecology

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Bridging the divide between virtual and real nature

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Improving environmental literacy is vital in the 21st century. As global environmental challenges of unprecedented magnitude loom, damages to Earth's living systems are fast approaching irreversible "tipping points" (NSF 2009). Yet, never before have humans had such a wealth of technological tools at their disposal, to help them achieve solutions. These advancements will facilitate collaborations worldwide, allowing us to draw ideas from multiple disciplines, to process and analyze countless data points, and to teach the next generation to view the world in exciting, novel ways that will inspire environmental stewardship.

As environmental educators, we must seek to balance cellular and organismal biology, virtual models and real-time data, science and policy. To confront the ecological and societal challenges we face, future environmental scientists will require skills in assessment, prediction, management, and communication (www.visionandchange.org). However, a major stumbling block in training the next generation of environmental practitioners is the difficulty of effectively integrating technology with in situ fieldwork. Indeed, students born after 1980 typically spend more time indoors with electronic devices than outdoors experiencing nature firsthand (Louv 2005). Although most senior ecologists were inspired by their training in the field, younger scientists may be more familiar with virtual worlds, from computer modeling to gaming and social networking, all of which can lead to so-called "nature-deficit disorder". How can environmental practitioners blend hands-on fieldwork with cutting-edge technology? This conundrum is the subject of ongoing debate.

On a more positive note, new programs are emerging that successfully integrate virtual and real environments. The forthcoming National Ecological Observatory Network will conduct continental-scale environmental monitoring, and their large databases will be accessible to students, citizen scientists, and policy makers (www.neoninc.org). Furthermore, at the North Carolina Museum of Natural Sciences, the new Nature Research Center – with its mission to "engage the public in understanding the scientific research that affects their daily lives" – will house publicly available state-of-the-art research laboratories, a three-story-tall Daily Planet "immersion" theater that will broadcast field science from remote sites via video-streaming, and dedicated virtual and real meet-the-scientist activities (www.naturesearch.org). These examples illustrate the changing landscape for ecology education, and how technology can advance environmental literacy.

What does this mean for a 21st-century classroom? Today, we have the digital resources for an education process unbounded by walls, where large volumes of web-based information are readily available at our fingertips. Hand-held technologies such as smartphones and their associated "apps" are increasingly available as tools to help promote educational activities.

The big challenge for ecology education is not a lack of information, but rather the need to provide the relevant context (NRC 2000) that will motivate the next generation of scientists to collect, access, and interpret relevant information for ecological stewardship. A conceptual understanding of "healthy" ecosystems and related ecosystem services, ranging from food and energy to clean air and water, will be required – not only to serve as the foundation for sound economies, but also to sustain and enhance human well-being (MA 2005). Nature shapes, and is shaped by, communities where people reside, and increasing public awareness of sustainability is best achieved by a blend of hands-on and virtual science education experiences.

Assignments and projects that encourage students to develop curiosity, to get outside, and to test hypotheses are an essential part of scientific learning. When students actively bond with their natural surroundings, investigate environmental issues that affect their daily lives, and then use virtual simulations to understand large-scale ecological processes and drivers, "STEM" (Science, Technology, Engineering, and Mathematics) education becomes more relevant.

Bridging the divide – between the virtual and real environments, scientists and citizens, and ecology and economics – is one of the central issues in the upcoming Ecology and Education Summit entitled "Environmental Literacy for a Sustainable World" (www.esa.org/eesummit). More than 20 national organizations have come together to organize the meeting. Please join in our collective efforts to create and implement an action plan to raise ecological literacy throughout our communities.

References cited in text are available online, in WebPanel 1.