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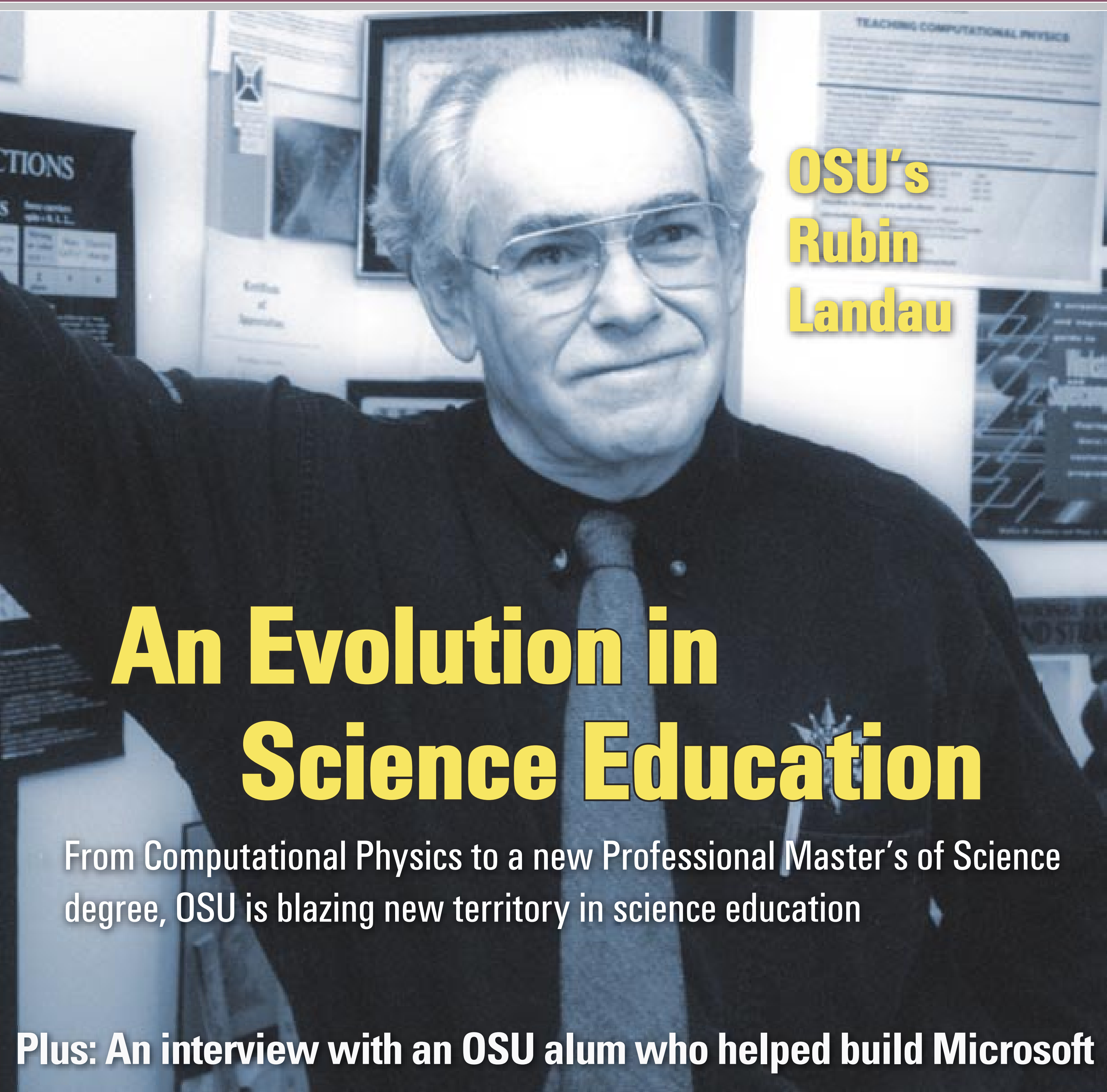

OSU's Rubin Landau

An Evolution in Science Education

From Computational Physics to a new Professional Master's of Science degree, OSU is blazing new territory in science education

Plus: An interview with an OSU alum who helped build Microsoft

A Career path for a New Century

Scientific research and discovery will depend more and more on scientists' ability to exploit the power of the computer. A new program at OSU aims to be the first step in creating those kinds of scientists and its creator hopes it will be the first of many variations on the theme.

by Bob Demyan

Photos by Melinda Luktsch


IBM
HEAVY

Try to imagine any scientist today conducting research without the aid of a computer. Can't be done. Computers have profoundly impacted the way scientists work and have led to advances in understanding in every branch of science.

But how well, really, do most scientists understand the computers so fundamental to their work? How many of them actually have the depth of computational science skills so essential to extracting meaning from data? No one knows for certain, but the answer is probably fewer than you think. The reality is that there's a growing need in science and industry for people who are not only solid scientists but also deeply skilled computational scientists.

At Oregon State University, one man is leading the charge to meet that need. He is Rubin Landau, professor of physics and director of OSU's new Computational Physics program. Landau has been involved with computers his entire professional life and, as a result, saw an opportunity for OSU to take a leadership role in this emerging discipline.

Computers have been the engine of scientific discovery in the last half of the 20th century, says Landau, enabling scientists to push ever deeper into the frontiers of scientific understanding. Computers have facilitated quantum leaps in our understanding of nature and the universe and have given scientists increasingly powerful tools with which to conduct their research. Still, many scientists have had to turn to those with greater computational skills to harness the immense power of computers. That's why scientists like Landau believe the future belongs to those trained in the computational sciences. And the new Computational Physics program at OSU positions the university to be a leader in this area.

So what is computational physics exactly? Computational science? Aren't there computer programmers out there who already do this sort of thing? The answer, as Landau unequivocally puts it, is no. While programmers are highly skilled in a particular language, they don't typically have the depth of science and math that can be brought to bear on actual computational problems. As Landau makes very clear, computational science students have a grounding first and foremost in science and math. "The problem you had was computer science students being hired to do scientific work when they were weak in math and science," said Landau.

Landau noted the flip side of the equation as well. "You also had physicists getting hired and going into computing areas where they didn't know computing well enough, or the appropriate math," he said. "So this degree in a sense is aimed at that marketplace—places where you do computing but you apply the science."

As Landau describes it, the new computational physics program is a synthesis of physics, math and computers. "The tools are multidisciplinary," said Landau. Students in the program, he says, essentially become well versed in three disciplines: physics, math and computer science. They won't necessarily have the depth of knowledge that a pure physics or math major might have, but they will be able to do what the physics or math major can't—they will be able to apply computational skills to problem solving in each of these areas. "It's a modern discipline," said Landau. "Industry needs it. Academia needs it."

At its very essence, computational physics is about problem solving. As Landau's website for the program explains, computational physics combines physics, computer science and applied mathematics to solve complex and realistic scientific problems. A computational physicist understands not only the workings of computers and the relevant science and mathematics, but also how computer algorithms and simulations connect the two. For example, if you were looking to model climate change in a given region you would need to understand the physics of climate, have the mathematical skills to describe the complex interactions involved, and be able to create algorithms to process these interactions in a language the computer could understand. In short, you'd need to be a computational scientist.

A real life example of the power of computational physics in another discipline happened recently when an OSU graduate student in botany enlisted one of Landau's students for help in identifying the function of a particular gene in tomatoes. A computer program was developed that compared the tomato DNA to genomes of other plant species. The program discovered that the tomato

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–Chris Sullivan

gene in question helped influence the function of growth hormones in the plant. This discovery, it turns out, may hold the key to developing higher yield tomatoes.

Landau believes that the ability of the computational sciences to solve such complex and computationally dense problems will be the backbone of science in the 21st Century. In that spirit, Landau sees the program evolving at OSU to be the first of many such computational degrees. "I think we should have computational mathematics, computational biology, computational chemistry, etc. and the first couple of years should be the same for all of them," he said. For instance, as molecular biologists and geneticists slice ever deeper into the fundamental building blocks of life, there will be greater need for those scientists to have computational skills.

Chris Sullivan, one of the program's first graduates, now works for the College of Science and is using his computational skills to aid faculty research. He sees a very practical advantage that computational sciences bring to research—enormous savings in time and money. By running computer simulations with research wherever possible, scientists can eliminate or reduce time spent on costly "wet lab" phases of research. For example, he cites how physicists could run an experiment where neutrons are fired through extremely cold mediums and the interactions are captured by thin film reflectometry. The experiment is repeated again and again at different temperatures and the results recorded and compared. This all takes a great deal of time and is quite expensive. Instead, Sullivan says, a computational scientist like himself could set the whole thing up as a computer simulation. "We basically can do this on a computer for a fraction of the cost," said Sullivan. Algorithms can be created which factor in the neutrons' known properties, along with variations in temperature and interactions as well as any other parameters of the experiment. The computer then does the grunt work of performing the millions and millions of calculations necessary to obtain results.

Sullivan says people with this combination of scientific and computational skills are in great demand. "As soon as you pick up the computer skills to solve a scientific problem you're going to have everybody banging on your door," said Sullivan. Like Landau, he is convinced that the real value of this program is its synthesis of physics, math and computing. To have the scientific principles and mathematical skills as the foundation for computing, that is what makes the program unique. "You have to be able to do the science first and the computer second," said Sullivan.

Current students in the program echo that idea. Caleb Joiner, a freshman physics student, found that computational physics had given him a foot up in his other classes. "When I was taking my physics class we came up against a concept and the professor said, 'This can be difficult to get…' but we'd already seen this in our scientific computing class," said Joiner.

Another student, Jennifer Williams, has career aspirations that computational physics fit nicely into. "My ultimate goal is to become an astronaut," she said. Williams believes that people trained in computational physics will be the kind of broad-thinking, problem-solving scientists NASA will need for future missions into space. For her, the program holds out the promise of that future and she is now considering majoring in it. "I'm only a freshman who's taken one course, but I'm really excited to see what's around the corner," said Williams.

OSU is uniquely positioned to become a leader in the area of computational physics. The program is one of only three in the entire nation and has been written about in a variety of publications. This bodes well for the College of Science and OSU. Landau hopes the university can capture this opportunity for leadership and become a real force in the discipline. "This is the program I wished I could have taken when I was an undergraduate because I've had to learn all these things on my own," said Landau.

To learn more about the new Computational Physics program visit:

www.physics.orst.edu/%7Erubin/CPwelcome