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The Virginia
NEWS LETTER

Science and Technology, and Our Commonwealth

By Anita K. Jones

Who was Time magazine's Person of the Century? It was Albert Einstein. Not Ernest Hemingway, or Georgia O'Keefe, Jack Welsh or Peter Drucker, though their accomplishments are great.

The 20th Century saw unprecedented advances in science and engineering. Some of those advances were the work of a few geniuses such as Einstein. Many are the work of myriad engineers and scientists, working together and alone. Our new century promises much more, through the multidisciplinary work of teams of scientists and engineers. Today, technology—which is the product of scientific knowledge and engineering—is enabling, even driving, change in the very character of our society and culture. Technology has enabled a revolution in business processes, and it has extended our lives. It both degrades and safeguards our natural environment and it enables economic growth. The impact of this growth touches all institutions: The University of Virginia experienced a 44 percent increase in its endowment last year, to some extent because of growth in the economy that derives from the application of new technology.

Research in science and engineering gave rise to the new technologies which are changing our world. Research is primarily performed in our universities and government laboratories, not in industry. New cadres of professionals are educated in our universities for both the research enterprise and for industry.

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For this reason, it is both urgent and crucial for the Commonwealth of Virginia to vigorously seek the ways and means of strengthening science and engineering in its public universities.

The Virginia General Assembly recently demonstrated new support for research at its public universities when it approved creation of the Commonwealth Technology Research Fund—a $13 million fund for projects where a stronger research enterprise in the universities of the Commonwealth should lead to enhanced economic development. This is an important, precedent-setting decision by the legislature to directly support research at our public universities.

No doubt that the University of Virginia's founder, Thomas Jefferson, a great thinker and innovator, would embrace the technology we enjoy today, and would recognize how this technology advances economies and democracy worldwide. Three of the original eight professors at the University taught in areas of science and engineering.

However, at the University of Virginia, we are most noted for our humanities programs, our professional schools, and most of all for

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our undergraduate education program. In those areas, we are the university that Jefferson envisioned. But we are less well known for our programs in science and engineering. We have great strengths in these areas, but there is room for improvement.

U.Va. President John T. Casteen III recognized the need to advance our science and engineering programs into the new century. He created the Virginia 2020 Science and Technology Planning Commission, which I have had the honor to chair. Our commission is composed of leading faculty, students and administrators predominantly from our science and engineering departments, but also including other constituencies.

After almost two years of work, this commission very recently produced a report outlining ways to capitalize on our strengths, and to improve science and engineering across the board. We concluded that it is critical to the University's future that its science and engineering programs be raised to be on par with its excellent humanities programs and professional schools.

In fact, the human studies and technology now walk hand-in-hand. We must endeavor to train and support a scientifically and technologically literate society. The under-investment of science and engineering of the past must be reversed. If not, the University of Virginia is in danger of becoming an antiquated institution, as more technologically based universities soar.

Three schools are the mainstay of U.Va.'s science and engineering enterprise: the basic sciences in the College of Arts and Sciences, the School of Medicine, and the School of Engineering. The commission developed two sets of recommendations that together constitute a sound strategy for moving our science and engineering enterprise to be first rank.

One set recommends that science and engineering be strategically, but broadly, strengthened. To do this we must make strategic new faculty appointments. For this, we need stable, long-lived resources to fund the start-up costs of equipping and renovating associated laboratories. To complement this, we need to improve the quality of graduate education and attract the nation's very best graduate students. The criticality of having excellent graduate students is not typically well understood. They carry out key elements of faculty research, and their ability strongly influences the quality of research results. In addition, graduate students assist in laboratories for the undergraduates. Their insight, ability and motivation strongly influences the experience of the undergraduates in a "hands on" laboratory environment.

We also recommended the establishment of a long-lived Fund for Excellence in Science and Technology with a merit-based selection process to stimulate innovative research in science and engineering. Finally, we recommended strengthening central leadership for our research enterprise. The Provost, the top academic official at the University, should be charged with formulating and communicating a broadly based strategy for science and engineering, and should be empowered with additional resources to implement strategically important programs.

The commission's second set of recommendations revolves around setting clear priorities. The earlier recommendations that I have already sketched provide a context. They state that the quality of the entire enterprise needs to be raised. But, it is unaffordable and unwise to try to advance in a major way on all fronts simultaneously.

The commission, therefore, recommends immediate investment in three priority focus areas. These focus areas are points of emerging strength at the University, and they reflect the future of science and engineering research.

They are:

1: Create a University-wide Information Initiative with the goals to:

- build international leadership in computer and information science and engineering;
- create multidisciplinary bridge programs in which scholars in computer and information science and engineering work with scholars in other disciples to advance both disciplines;
- develop related world-class education programs. We want to assure that by 2003 all students are literate in information technology.

2: Create an initiative in quantum and nanoscale science and engineering. The mission is to investigate the behavior of materials, biosystems, and devices; develop tools and methods to control these structures; and to apply this new knowledge.

3: Create an initiative in biodifferentiation in the life sciences. The mission is to determine how cells and organisms acquire and maintain their characteristic form and function and to apply acquired knowledge to preserving human health

These focus areas are not new disciplines. These are some of the areas where our classical disciplines (e.g. chemistry, physiology, and electrical engineering) are set to explode in terms of research advancement. Presently, there are at least 30 faculty members in each area whose work is directly related to the area. With this critical mass, we are "poised to pounce" and to substantially advance knowledge in these areas as well as to educate our students right at the edge of the state of knowledge in these areas. Because the three focus areas span many department disciplines and all three schools, we strongly recommend that Institutes be founded to catalyze each focus area initiative.

It is very clear to the commission that the University must define priorities. These are the right areas for today. The University should invest in these areas with funds, faculty lines, and new building space. Eventually the scholarship in these areas will be self-supporting. Periodically in the future, new and quite different strategic selections of areas should be made, and they should be similarly, aggressively advanced.

I want to turn now to a related topic. Yesterday, to be considered educated, one had to be literate in history, literature and art. Today, a person is not educated unless he or she is also literate in science and technology.

Our students become voters, jurors, legislators, legislative staff, business principals, and concerned members of churches and neighborhoods. In all those capacities they are faced with an increasing number of decisions that turn on issues of science or technology.

To illustrate how pervasive technology-based issues are in life, I recently scanned one week of articles in the Charlottesville Daily Progress. Here is a sample of what I found:

- Neighbors of a local landfill need to determine whether their water supply is contaminated, and they also need to determine whether promised action by the landfill will prevent contamination in the future.
- Several articles lead to the question of whether our citizens want traffic surveillance of the public in the form of cameras to catch drivers running red lights, automatically read highway toll tags and embedded transmitters in the navigation systems of cars.
- What is adequate privacy for YOU on the Internet?
- And a Daily Progress editorial told us about manmade weather. Urban heat islands, better know as cities, cause thunderstorms that drop rain hundreds of miles away. Is there some responsibility of one region to another?

There also were Progress articles about the introduction of the abortion pill, and the ethical questions that arose when a couple chose among alternative embryonic cells in order to have a designer kid whose blood could help a sister.

These excerpts, from a one-week sample of news reports, provide ample documentation that the average citizen—and therefore our students—must be able to make reasoned decisions about issues with a substantive technical component.

Thomas Jefferson believed that the best protection of democracy was an educated citizenry. Today, that education—for all—must include technological literacy.

Today, education must include technological literacy.

So what do you teach in a technological literacy course? The first lesson must define the scientific method. How do researchers come to "know" something? The scientific method relies on the notion of a hypothesis that can be precisely stated, and then shown to be either true or false. For example, Pluto has 9 moons—true or false?

But the public becomes impatient when a scientist, with hypothesis in hand, cannot determine its truth or falsehood. The scientist replies, "it depends: experiments under these conditions show this, and under those conditions show that." Our students should understand the scientific method and how to "know." They should be comfortable reasoning under uncertainty in the scientific paradigm. I would note that the scientific method is only one way of "knowing".

Let me return to the subject of multi-disciplinary research and education. The commission recognized that much of the research in science and engineering is now necessarily multidisciplinary. Knowledge in one field builds on new knowledge in another; no one field advances in isolation. This movement toward multi-disciplinary research does not stop with science and engineering. Today a project may require collaboration between chemists, mechanical engineers, biologists, and biomedical engineers. Tomorrow's projects will require close and deep collaboration of humanists and the technical folks.

I assert that such collaboration is more possible today than in the past. The reason is that humanists have now gotten a powerful tool of science—an instrument that helps them with their observations. That instrument is the computer. Any scientist will tell you that science is made possible by its instruments. Now the humanities have a new instrument. Masses of data, that previously was manually unmanageable, can be collected and processed. This is a boon to many humanist fields.

It also means that technical fields can share some research methodology with the humanities. Accessible data makes experiments reproducible. It lets one researcher use the same data to explore a competing hypothesis. My daughter is a histo-

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rian. She tells me that historians always look back in time. Computers may even put the historians in a new business: predicting the future!

If you believe as I do that some of tomorrow's projects will require close and deep collaboration of humanists and technical folks, then the fact that the computer is a powerful tool for the humanists will help cement the relationship. For issues where computers are used, their methods of experimentation and exploration will be common.

Let me give you one big example of a research issue that requires both technical folks and humanists to properly address. Democracy. The U.S. is on its way from being a representative democracy to being a participatory democracy. Technology is the driver. In a representative democracy we elect legislators every 2, 4 or 6 years. Constituents check on their performance once in a while—at least at election time. In a participatory democracy, citizens tell representatives and government employees what to do-perhaps quite frequently—such as daily!

Will we, should we, and in what form might the U.S. evolve to a participatory democracy?

It is a question that at once is political, technical, psychological and cultural. Research—and we should research it—to address this change is already in progress. It ought to involve all relevant disciplines in a deep collaboration.

To conclude, this University is at a cusp in time. The Virginia 2020 strategic planning exercise is most timely. We need to determine where we collectively want to take this University as it enters its third century.

Strengthening science and engineering is both urgent and crucial. This should not be at the expense of other quality endeavors. But if this important portion of the University is not strengthened, I believe that the University will be, and will be perceived to be, inadequate to the task of creating the knowledge that society needs and wants and inadequate to the task of educating citizens who must cope with this increasingly complex and technical world.

One author describes this world as a permanent white water river, in terms of what a person has to steer through in order to succeed professionally and to live life. Technology is the greatest contributor to the roiling of the waters—for good, and for ill. The University can make it more to the good. We can teach future generations to navigate that white water. To do so our students must be able to reason about issues with substantial technical aspects.

This requires strengthening science and engineering—both research and education. •

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