



A 'crater carpet' lines the floor of a lounge at Arizona State University, where engineers, biologists and Earth and space scientists all mingle.

THE RESEARCH RETHINK

Arizona State University is trying to reinvent academia by tearing down walls between disciplines.

BY JOSH FISCHMAN

Worlds both familiar and strange come together inside a large glass-walled room at Arizona State University in Tempe. Images of the Moon's surface fill giant screens as planetary geologist Jim Bell shows off panoramas from one of the university's cameras, which is currently flying on a lunar orbiter. Bell, tall and enthusiastic, gets even more animated when he talks about plans to visit an odder place: an asteroid named Psyche made almost entirely of iron. Researchers are keen to explore it because it is essentially a naked version of Earth's metallic core, something that scientists have never seen.

Designing a mission to study a rapidly spinning hunk of iron more than 255 million kilometres from Earth calls for close collaboration between scientists and engineers. Bell finds that kind of coordination

easier at Arizona State University (ASU) than when he worked at Cornell University in Ithaca, New York, on the Mars rovers.

At Cornell, "the engineers were somewhere else on campus", he says. "So you'd come up with an idea for an instrument, kind of toss it over the wall, and then a year later they'd toss a design back to you that may or may not work, scientifically." But at ASU, Bell works at the School of Earth and Space Exploration (SESE), which includes engineers and computer scientists. "They are people who are interested in the same science I'm interested in, and we get things done faster and, I think, better."

The exploration school, formed in 2006 from the former departments of astronomy and geology, is the most striking embodiment of the ambitious vision of Michael Crow, who took over as president of ASU in 2002 with the goal of turning a public university with a middling reputation into something much greater. ASU was not known for exceptional scientific research, and attracted students mainly from within the state.

Crow has sought to transform ASU's research and education by tearing down walls between traditional academic departments and bringing together disparate disciplines to tackle large issues such as exploring the Solar System, finding alternative ways to attack cancer and solving problems that matter to Arizona as well as the rest of the world, such as severe water shortages. Crow has travelled extensively, talking up what he calls the "New American University" that is taking root in the desert.

ANDY DELISLE/ASU

"We're going to best serve our students, and the world, by preparing them to tackle the big problems of the modern age," he says.

More than a decade into his tenure, the results are mixed. On the positive side, ASU has more than doubled the amount of federal money it attracts for research. And the culture at the university has shifted to make research and education more interdisciplinary. "I think some of the things Arizona is doing could have a real impact," says Daniel Fisher, a physicist at Bio X, a multidisciplinary institute at Stanford University in California.

But seen from another perspective, the changes at Arizona are modest shifts — layering new institutes on top of traditional departments, for example. And the reinvention effort may not have substantially improved the quality of ASU's research. An analysis of scholarly output conducted by *Nature* shows that ASU's record has improved by some measures, such as the number of papers published, but the university has gained little ground compared with similar institutions.

The results underscore how hard it is for large universities, which employ thousands of researchers, to alter their fundamental character by uprooting entrenched academic disciplines. Even Crow says that "the biggest challenge that we've had has been the strength of 'the invisible' colleges — the fact that people show more allegiance to their disciplines and the structure of those disciplines than to the institution they are a part of".

CHANGE AGENT

Still, the signs of change are all over the university — literally. Big placards in hallways announce "A New American University" with eight ambitious calls to action. "Fuse Intellectual Disciplines" is one, along with "Transform Society", "Value Entrepreneurship", "Enable Student Success", and "Conduct Use-Inspired Research". The campus itself has a modern, utilitarian look: large buildings with clean lines, many topped with solar panels. Construction cranes poke into the sky as they continue a building boom that has been under way ever since Crow arrived. Throngs of students thread their way around them — ASU has the largest undergraduate and graduate enrolment of any public university in the country, at about 76,000.

There are a lot of new faculty faces as well. Nearly 500 of ASU's 1,700 or so tenure-track faculty have been hired in the past ten years — the turnover has largely resulted from normal retirements — and the university has deliberately sought people who work well with others and look beyond disciplinary walls.

"I've worked at places where we'd have pitched battles over lab space if room opened up," says Cheryl Nickerson, a microbiologist at ASU's Biodesign Institute, a cross-disciplinary centre dedicated to understanding how organisms are built down to the molecular level, and how that differs between health and disease. Nickerson, who sends bacteria on NASA missions and works with many physicists and engineers, says, "Here, I'm not saying we're perfect, but several times I've seen people give up space to accommodate a colleague with an expanding project."

All these changes are part of Crow's grand vision for reinventing the university, and his tireless promotion of that vision has brought him to prominence in the world of higher education. He chairs or participates in several national committees, including an advisory council on innovation and entrepreneurship for the US Department of Commerce. And he travels the world to lecture at World Bank meetings and other international gatherings. Much of what Crow talks about is how ASU has focused on replacing narrow academic divisions with big, bold structures. "Other leaders espouse this principle of interdisciplinarity, but Crow has gone the furthest in embracing it, and is the loudest voice," says Jerry Jacobs, a sociologist at

the University of Pennsylvania in Philadelphia and author of the book *In Defense of Disciplines* (University of Chicago Press, 2013).

Crow's manner can be blunt and aggressive, says Joshua LaBaer, who left his position as head of Harvard University's Institute of Proteomics in 2009 to work at the Biodesign Institute. But LaBaer says that the decisions by Crow and his team have generally been sound. "I don't see the faculty rankling under a loss of power," he says. "The goals here are good ones, and you can take advantage of new opportunities." And of resources, too: in 2013, the US National Institutes of Health (NIH) gave ASU researchers some US\$48 million, about \$22 million of which went to the Biodesign Institute. By comparison, the university pulled in just under \$20 million from the NIH in 2003.

A substantial share of those resources have helped to build LaBaer's unique facility for producing and analysing thousands of proteins, as part of efforts to understand their function and role in disease. In secure rooms full of automated machines, human cell cultures churn out full-length proteins in vials, then robotic arms whisk the molecules to machines that determine their sequence and structure. What sets LaBaer's operation apart is the ability to manufacture and probe thousands of proteins before they lose their natural folding patterns and function. The scientists then compare the proteins to see which shapes and folds are linked to particular diseases.

One priority for the university has been to boost biomedical research of this type — a tall order for an institution without a medical school. It has done so in part by forging close ties with the nearby Mayo Clinic in Scottsdale. That relationship helped ASU to attract LaBaer from Harvard.

There were a lot of worries when Crow and his administrators first started to reshape the university. In 2005, for example, the anthropology department was incorporated into a new School of Human Evolution and Social Change, and anthropologists fretted that their discipline was going to be diluted into non-existence. But by 2011, according to

anthropologist Alexandra Brewis, the number of faculty members in the school had risen by 40%, and three-quarters of them were anthropologists. The other research slots were occupied by applied mathematicians, epidemiologists, political scientists and human geographers.

In 2010, Brewis and some colleagues surveyed all 54 tenured faculty in the school to find out who they collaborated with. The strongest partnerships, they learned, were still between traditional sub-disciplines such as archaeology and physical anthropology. Many

non-anthropologists in the school often had stronger ties to anthropology than they did to one another. So diversity within the school had not led to fragmentation, the researchers concluded, and all the disciplines were contributing to anthropological research. For example, a team of researchers is studying the western Mediterranean, an area that has supported dense populations as well as productive agriculture for thousands of years. The team is developing computer models that show how population size, economic behaviour and vegetation change in the region have affected the sustainability of natural resources, and how those resources are likely to fare in the future.

ASU's funding numbers show that grant-givers find the cross-disciplinary approach attractive. From 2003 to 2012, the university's federally financed research portfolio grew by 162%, vastly outpacing the average increase seen at 15 similar public institutions, which were picked for comparison purposes by ASU's governing board. And the money that ASU gets is supporting more interdisciplinary work than ever before.

The number of funded projects with principal investigators in two or more departments rose by 75% between 2003 and 2014, whereas projects led by one department climbed by just 8%.

A similar trend has occurred at Michigan ►

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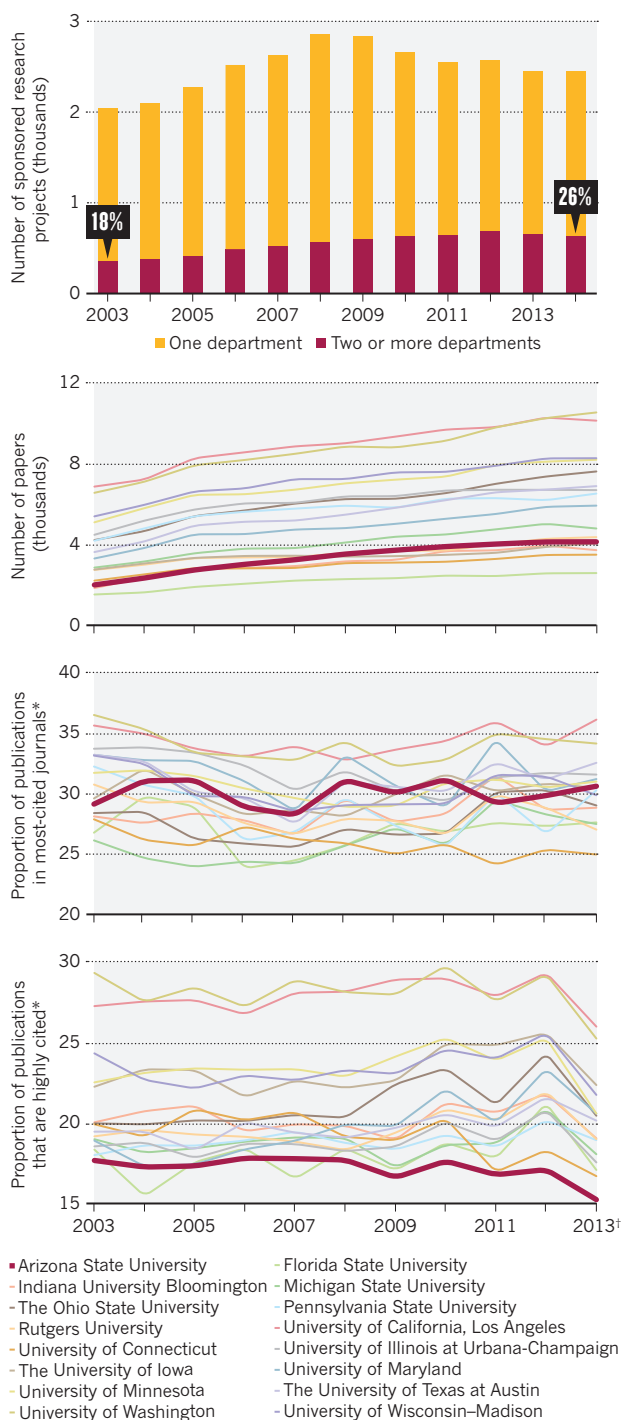
► State University in East Lansing, another institution that has pushed for greater collaboration between disciplines. Stephen Hsu, the university's vice-president for research and graduate studies, says that, like ASU, Michigan State has seen the value of shared projects. "Due to increased specialization, you have experts in specific techniques or types of analysis scattered among different departments," he says. "To address many

really big problems, for example, climate change, you need teams with multiple skills, and therefore must transcend departmental boundaries."

But for all the changes, ASU has had limited success in raising its scientific profile relative to its peers — a least in terms of its publication record. Using Elsevier's SciVal analysis tools, *Nature* compared the publications of ASU researchers to those at some of the same peer institutions identified by the university's governing board. Over the past decade, ASU has more than doubled the number of articles it produces each year, the biggest percentage rise in its peer group. But because everyone increased their production substantially, and because ASU started near the bottom, the university moved up only slightly within the group. In climbed from fourteenth to twelfth place between 2003 and 2013 (see 'Raising Arizona').

RAISING ARIZONA

Research at Arizona State University has become more interdisciplinary, seen here by the increase in projects involving more than one department. Its scholarly output has risen sharply, but the university has not gained on peers in several other metrics.



MIXED NUMBERS

Other metrics suggest that ASU researchers are having mixed success in generating scholarly impact. The university ranks in the middle of its peer group in getting papers into the most cited scientific journals and broke into the top five for a couple of years during the past decade. Yet it generally comes in last place in producing papers that attract the most citations.

George Raudenbush, ASU's executive director of research analytics, argues that citation data are not the best measure of research quality. And he counters that the relative increase in publications is truly dramatic. It shows that the university has come a long way in a short time, given that it did not emphasize research as much before Crow's arrival, he says.

Beyond metrics, there are also questions about how profound the organizational changes at ASU really are, and whether they represent a major departure in higher education. Few traditional academic departments have been eliminated; the university has simply established most of the new units on top of them. And most of the faculty members in the new schools and groups are actually tenured in traditional departments. (SESE is an exception.)

In fact, some of what ASU has accomplished in terms of promoting interdisciplinary research can be seen at other, more staid institutions. "Traditional universities have research centres, and that's where interdisciplinary ideas get addressed," says Jacobs. When he studied the top 25 research universities in the United States, he found that they have about 100 research centres each, on average.

But ASU's administrators maintain that there is something unique happening there. By emphasizing new schools and institutes, rather than centres within disciplinary departments, the university has built conduits among very different specialities that encourage collaboration, says Crow. And hiring broad-thinking researchers and pairing them with practical technologists — engineers and computer scientists, for example — leads the way to addressing broad issues.

As an example of something the university is doing differently, Crow points to its broad-based approach to cancer research. The university's Center for Convergence of Physical Science and Cancer Biology, financed by the National Cancer Institute, brings astrobiologists and physicists together with oncologists and evolutionary biologists to explore how cancer starts and evolves (see *Nature* 474, 20–22; 2011).

Some of the centre's researchers have developed a theory that as a cancer spreads, it activates a series of ancient genes that were key to the success of the first multicellular organisms (C. Lineweaver, P. C. W. Davies, & M. D. Vincent *et al.* *Bioessays* 36, 827–835; 2014). The deep roots and robust genes might explain why some tumours are so hard to get rid of, the researchers propose. The idea implies that cancer is an organized response, rather than a series of genetic accidents.

That line of enquiry, borne from an unusual marriage of disciplines, is unlikely to come from a typical university, says Crow. "We don't want to ask the same questions as other institutions do." ■

Josh Fischman is a senior editor at Scientific American. (*Nature* and *Scientific American* are published by Nature Publishing Group.)

SOURCE: RESEARCH PROJECT NUMBERS FROM ASU; PUBLICATION DATA FROM ELSEVIER'S SCIVAL