Reinventing tech transfer

US university technology transfer offices are adopting new models in search of increased return on research investment.

by Brady Huggett

Travis Huggett

A change is under way at university tech transfer offices (TTOs) across the United States. Schools are expanding their TTO teams, shifting their business aims and changing their models. The focus is moving to startup companies and proactive outreach to the private sector.

These changes are happening at schools large and small. Some of the earliest initiatives are already bearing fruit: major metrics for gauging tech transfer output—licensing income, licenses and/or options executed, patents and startups formed—have risen over the past ten years, and in particular over the past five (**Fig. 1**). Although this is happening across the board, life sciences is considered a particular driving force (**Fig. 2**).

What are the factors behind these changes, and how are academic institutions attempting to more effectively translate their research? *Nature Biotechnology* took a broad look at this new landscape for life science tech transfer in the United States (**Boxes 1** and **2**, **Tables 1**–**5**).

Disruptive Pennovation

The University of Pennsylvania's main TTO is in a squat, flat structure with a parking garage on top; it looks more like a strip mall than the leaf-covered brick of an Ivy League institution. The building is located a few blocks from the Schuylkill River, and across from the TTO's parking lot, an expanse of infrequently used train trestle sits above a park—rusted steel running toward the horizon in both directions.

The tracks are a throwback to Philly's heavy industry and manufacturing past. But in recent years, the city has begun to look instead to high-tech life sciences, health and education. In 1970, the largest sector of the job market in the city was manufacturing, with nearly 190,000 jobs, according to data from Philadelphia Works. By 2011, manufacturing had fallen to ~45,000 positions, but Philly had established ~184,000 jobs in healthcare, education and social services; currently the three leading job providers in Philadelphia are the Jefferson Health System, the University of Pennsylvania and the University of Pennsylvania Health System, and Temple University.

Yet Philadelphia is hoping Penn can do even more for the city's workforce than it already does. In 2010, Penn bought 23 acres of a former Dupont (Wilmington, DE, USA) industrial park in the South Bank area for $13 million as overflow for the main campus. It is now being transformed into Pennovation Center—a startup incubator and research space—that's tied to a much larger revitalization of Philadelphia itself. Called the Lower Schuylkill Master Plan, the initiative was led by the Philadelphia Industrial Development Corp., the Philadelphia City Planning Commission and the Philadelphia Department of Commerce. When complete, it is expected to cover 3,700 acres (including 46 as green space, with 5 miles of trails), create 5,500–6,500 permanent jobs and have an economic impact of $63 billion on the city.

But the Pennovation Center is but one part of the school's tech transfer overhaul. For more than a year, Penn's TTO has been planning a rebrand from the Center for Technology Transfer to the Penn Center for Innovation (PCI), and in June pushed live a website outlining the new name, new goals and new initiatives, including a more open format that invites relationships with industry.

The quarterback for all this is John Swartley. Hired in 2007, he had venture capital experience at BCM Technologies, and a PhD in microbiology and molecular genetics and an MBA, both degrees from Emory University. He created Penn's UPstart program, which focused on venture creation, and last year the university promoted him

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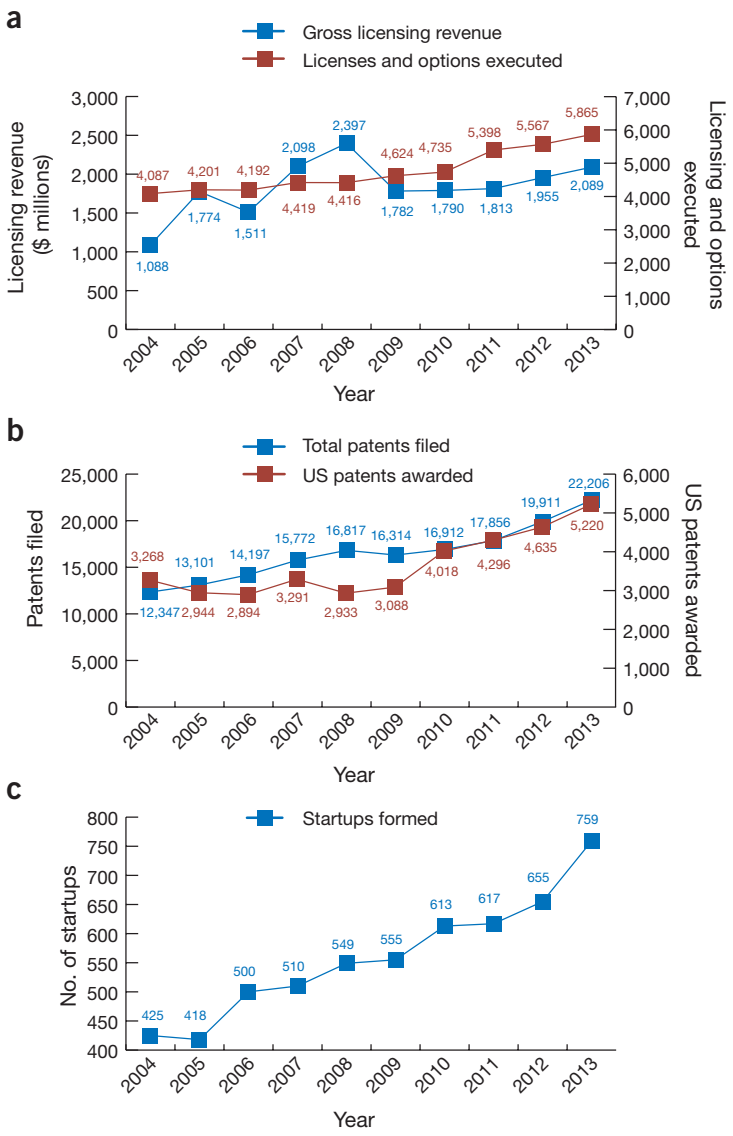

Figure 1 Growth of TTO output, 2004–2013. (**a**) Gross licensing revenue and licensing and options executed. (**b**) Patents filed and awarded. (**c**) Startups formed. Universities reporting these data ranged from 149 per year to 162 over the time period. Source: AUTM

to associate vice provost for research and executive director at the Center for Technology Transfer, handing him the reins for the PCI transition.

"We've taken a hard look at all of the different types of relationships created between the university, the faculty, the students and the private sector, and those relationships go well beyond what you'd categorize as traditional technology transfer," Swartley says. Traditionally TTOs cover patenting and licensing, he adds, but the school knew it needed to do more than the "blocking and tackling" of tech transfer.

As a recipient of tax dollars, he says, Penn "almost has a moral obligation to find ways to ensure that the intellectual property, the ideas, the concepts and the entrepreneurial energy that is captured here gets bridged and connected to forces outside the university to really make them come to fruition and reality."

This meant an increased focus on sponsored research agreements at PCI, and an outward-looking alliance building group. Penn now will employ individuals with a comprehensive understanding of Penn's arsenal of research programs, key faculty and assets, and task them with liaising with industry, and going out and proactively seeking partners.

One of many

Penn is not alone in revamping its tech transfer. The University of Miami relaunched its TTO two years ago, after realizing "things were not going well," says Norma Kenyon, vice provost for innovation at Miami (**Box 3**).

Several other academic institutions have also been reinventing the ways they engage with industry. In March, Tufts University announced that its Office of Technology Licensing and Industry Collaboration would be reorganized and renamed, and given additional resources to help promote commercialization and to seek strategic industry alliances to support research. In May, New York University (NYU) opened its Office of Therapeutic Alliances, a new "drug discovery accelerator" that works with investigators at NYU's Langone Medical Center to provide outreach to industry, and to financial and nonprofit entities in the hopes of securing partnerships. Running the office is Robert Schneider, hired, in part, for his track record in starting five biopharma companies.

Others are going further. In September, the University of California at Los Angeles (UCLA) announced it had created a not-for-profit company, Westwood Technology Transfer, to focus on "protecting and optimizing" UCLA's discoveries and inventions. The board, which includes the associate general counsel of Abbott Diabetes Care and Michael Cleare (who groomed Swartley at Penn), will guide UCLA's Office of Intellectual Property and Industry Sponsored Research in making investments into its own output. In its press release, the school noted it had developed the plan after consulting with TTOs at the University of Wisconsin, Madison; Stanford University; Columbia University (New York); and the Massachusetts Institute of Technology (MIT) and Harvard University (both, Cambridge, MA, USA). UCLA also noted the launch of a planned $250-million venture fund to invest

Table 1 ***Nature Biotechnology*** **overall ranking of top 15 TTOs output in the life sciences in 2013**

Rank	Academic institution
1	University of California system
2	University of Pennsylvania
3	University of Washington/ Wash. Res. Fdn.
4	University of Utah
5	University of Minnesota
6	Columbia University
7	New York University
8	Northwestern University
9	Duke University
10	University of Massachusetts
11	University of Florida
12	Mount Sinai School of Medicine
13	University of Rochester
14	Wake Forest University
15	Princeton University

Source: *Nature Biotechnology*/AUTM

Box 1 Ranking TTO performance

Success at technology transfer can be measured in various ways. Gross licensing income is one, though that can be perverted by a relic, such as a blockbuster product developed years ago. The number of licenses or options executed per year is another useful metric—this shows how successful a TTO is at finding interested parties for its research. A final measure is to see how many startups have been spun out of the local academic institutions—in theory a way to quantify economic impact on local economies, job growth and the practical uses of research.

Tables 1–**5** show the above metrics (licensing income, the number of licenses and/or options executed and startup activity) together with patents and NIH funding for US academic institutions (for a methodology of the ranking, see **Box 4**).

Our ranking places the University of California system at the top. This is not surprising because of the sheer size of the system—it comprises 14 different entities in our calculations. Although the school is merely average in our list at producing patents in return for NIH funding, the rest of its output places the system clearly in the number one position.

The University of Pennsylvania is second. It scored particularly high in licenses and options executed, startups (no. 2), patenting and NIH funding awarded. It also did well on cost of NIH funding per patent, placing fourth, well above the California system.

The University of Utah landed in the third spot, tied with the University of Washington, mainly on the strength of Utah's startups (third position) and number of life science patents produced versus NIH funding (second highest). The school averages more than 20 startups a year, of all kinds. It features the Lassonde Entrepreneur Institute, a dedicated center for student entrepreneurship and innovation; its first programs were established in 2001. There are plans to open Lassonde Studios in 2016, a physical home (the space will include 400 beds) that includes a 20,000 square foot 'garage' where students work.

The University of Minnesota had slightly above average results for this group in licenses/options in 2013; it also placed in the top five for number of life science patents per NIH funding awarded. To help foster startups, the school launched its Entrepreneurial Leave Program in 2013, which allows faculty to depart school and pursue "entrepreneurial endeavors" outside the university for up to one year. It also has its Minnesota Innovation Partnerships (MN-IP) platform, meant to simplify the process of partnering with industry. MN-IP encompasses two programs: 'Try & Buy', which supplies a low-cost, low-risk way for partners to gauge commercial potential of university technologies; and 'Create', in which industry sponsors university research, getting in return exclusive rights to the intellectual property generated.

The University of Massachusetts, notably, made the most effective use of NIH funding, having the lowest amount of NIH dollars per life science patent. The school pulled in ~$159 million in NIH awards in FY 2013, through 392 awards, including those to the University of Massachusetts Medical School. Matched against its 38 life science patents awarded in 2013, the school is producing a patent for every $4.2 million dollars of NIH grant money spent.

At the bottom of our ranking sits Princeton—an Ivy League stalwart and a sizable earner of licensing revenue. But it executed just four licenses or options in the life sciences in 2013, launched one life science startup and recorded one life science patent in 2013. So although it was not among the largest recipients of NIH funding (~$40 million last year), the patent production means Princeton placed last in our ranking of NIH dollars per life science patent.

in opportunities across the entire University of California system.

Over the past year, more and more examples of these programs are popping up, and it can seem as if they are simply following each other. But Penn is perhaps unique in that the impetus for change came from a moment in its own history. In the summer of 2012, the university announced a bumper deal with Novartis (Basel) on the use of chimeric antigen receptor T-cell technology in cancer. The deal included establishing the Center for Advanced Cellular Therapies (CACT) on Penn's campus and gave Novartis rights to CART-19, a cell therapy in a pilot study at the time. Penn got an undisclosed upfront payment, research funding, $20 million for the establishment of the CACT building and potential milestone and royalty payments.

This was the singular moment that opened Penn's eyes to what the future of tech transfer could be. "It was a monstrous deal," says Swartley, and the school set off in hot pursuit of others.

The research park of tomorrow

Better outreach and a greater emphasis on forging alliances with industry is just half the equation. A wave of schools are conceiving and constructing 'innovation districts' in coordination with local governments, similar to Penn's Pennovation project. The initiatives come in various sizes but almost all blend the

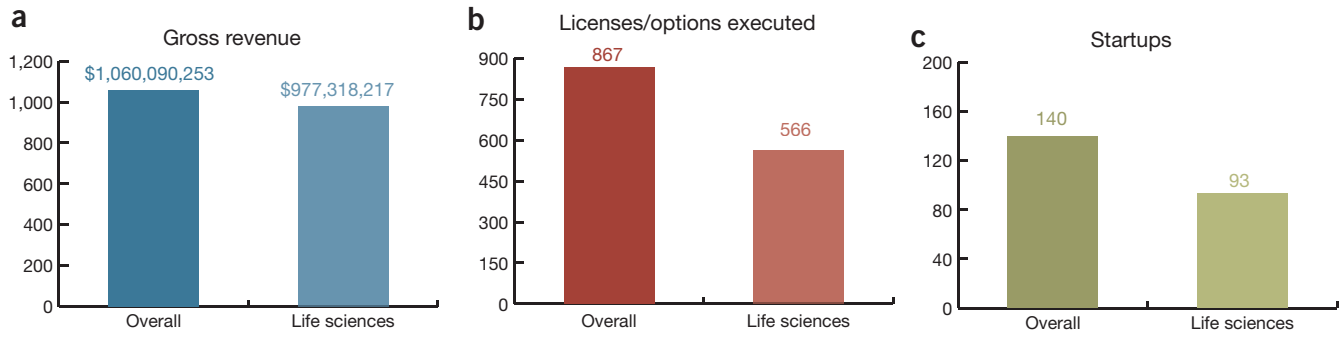

Figure 2 Life science portion of overall TTO output for top ten US universities selected by *Nature Biotechnology*, 2013. (**a**) Gross licensing revenue. (**b**) Licenses and options executed. (**c**) Startups. Source: AUTM and university TTOs.

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Inside the future Pennovation Center.

desires of university TTOs with local, state and even federal government's wishes for job growth. Sometimes an established private industry completes the triangle.

Wake Forest University (Winston-Salem, NC, USA) is a prime example. The workforce of Winston-Salem was long employed by local textile and furniture industries, and at the corporate headquarters of big entities, such as Hanes and Wachovia Bank (now owned by Wells Fargo). But the city's two defining presences arguably have been the tobacco giant R.J. Reynolds, which had headquarters downtown, and the university, which lies a few miles north of downtown, and is somewhat landlocked.

Looking to expand, in 1994 Wake Forest set up the School of Medicine's Department of Physiology and Pharmacology (along with eight researchers from Winston-Salem State University) in a downtown warehouse donated by R.J. Reynolds. The repurposed building was called the Piedmont Triad Community Research Center, and also came to house Wake's Institute for Regenerative Medicine. Around 2005, the Reynolds Corporation gave a swath of land to Wake, plus its old power plant and more tobacco buildings. Benefiting from tax credits for the historic stature of the buildings, the Piedmont Triad Community Research Center grew into the Innovation Quarter and incorporated the warehouse structures.

In 2012, the $100 million Wake Forest Biotech Place opened in the quarter, housing startups and parts of the school of medicine, plus departments of biochemistry, biomedical engineering, microbiology and immunology, among others. IT company Inmar, an operator of intelligent commerce networks, moved 900 employees into offices in the Innovation Quarter, adding an industry anchor. By the end of this year, the Innovation Quarter should encompass 145 developable acres and have more than 50 technology companies and 26 academic units inside it, with 3,100 people working there and about 1,000 in the residential spaces. All this has literally changed

Box 2 Interfacing with investors

For startups to be sustained beyond seed funding, TTOs must engage with risk-capital providers with deep pockets and industry experience. To gauge how the investment community views different TTOs, we surveyed a dozen investment firms (traditional venture capitalists (VCs), corporate VCs, angel groups and fund managers). Full questions and results can be found here (https://www.surveymonkey.com/results/SM-SWQMYX5L/). Feedback suggests investors are aware of the more proactive stance of TTOs in recent years.

Although a couple of respondents indicated they prefer to work with "major" universities, more than half said the size of a university does not matter (though in a follow-up question, half of the respondents answered they prefer to work with universities "considered in the upper echelon"). The survey did reveal a possible downside to dealing with large, active schools: one participant commented that top-tier universities are often busy and perhaps overworked, which can slow down the process of spinning out a university asset and liaising with investors.

The majority of those surveyed responded that any changes in quantity and quality of current university startups is too varied to judge, and most indicated they expected their interactions to either stay the same or increase over the coming five years.

The most important characteristics of TTOs, according to *Nature Biotechnology*'s survey, are schools appropriately valuing their assets, being willing to negotiate and having experience with the startup and VC environment. Half the respondents also felt that "quick response time" was an important characteristic. Perhaps not surprisingly, given that the respondents were investors, the majority (nine respondents) did not find it important for a university to have a gap fund of its own.

The survey unveiled one major (not unsurprising) complaint from investors about TTOs: they overvalue their intellectual property. This can be attributed to the nature of doing business—buyers often tell sellers their asking price is too much, and sellers tell buyers they are undervaluing their goods. Given the shrinking number of investors out there for early-stage life science assets, though, TTOs might take note: keep your expectations in line and be a willing negotiator. More to the point, wily tech transfer officers find a balance between upfront cash payments for licenses and downstream royalties and milestones.

The survey also asked respondents for their current working relationships with the top universities listed in **Table 1**. Given that we sampled investors from across the country and the top 20 includes schools from all areas of the US, the results were also all over the place—there are examples of schools receiving "great working relationship" votes and also "terrible" votes. The dominant response, however, was "no experience with this school."

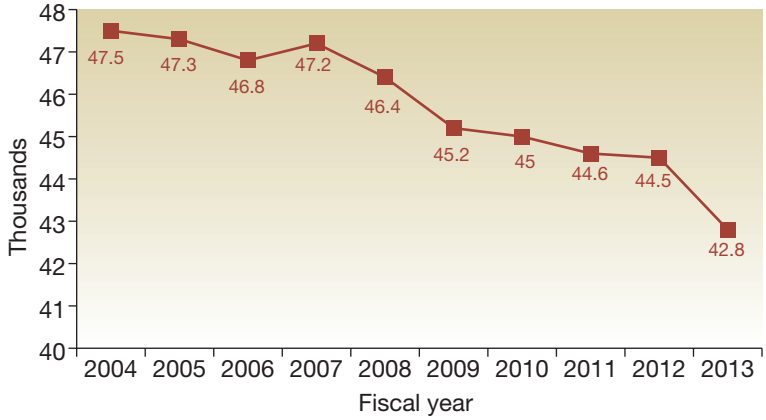

Figure 3 All NIH research grants awarded, 2004-2013. Source: NIH

Winston-Salem's downtown—once a quiet, dark grid of streets after working hours, it now has blocks bustling with pedestrian traffic well after sundown.

So far the development has been valued at $600 million, but only a "small amount" came from Wake Forest, says Eric Tomlinson, president of Wake Forest Innovation Quarter and chief innovation officer at Wake Forest Baptist Medical Center. Instead, much came in the form of tax breaks from all levels of government, especially for those historic R.J. Reynolds warehouses and smokestacks. There is another $700 million expected soon, and the investment could grow to surpass $2 billion. This has been possible because the school understood that industry, rather than being a negative, is a good partner for research. The school's TTO now has a "broad program that is industry focused" Tomlinson says. "The old tech transfer model we've blown up completely."

These types of developments are collated by a blog (http://innovationdistricts.blogspot.com/) that defines an innovation district as a "collaboration between a city-college-corporation." It reports >80 innovation districts that are at least in the consideration stage. Many of these are former research parks rebranding themselves, but university TTOs are playing a growing part, and, similar to the development at Wake Forest, the life sciences are doing heavy lifting.

The drivers of change

The moves by Penn, Wake Forest and other university TTOs around the United States have been precipitated by major changes in the research funding and commercialization environment in recent years. Over the past decade, the number of US National Institutes of Health (NIH) research grants awarded per year has consistently fallen: from 47,464 in 2004 to 42,839 in 2013 (a dip of nearly 10%; **Fig. 3**). Throw in the recession in 2008 and the resulting financial crisis, which wiped tens of millions from university endowments, and US academic institutions have had to seriously reevaluate strategies for refilling research accounts.

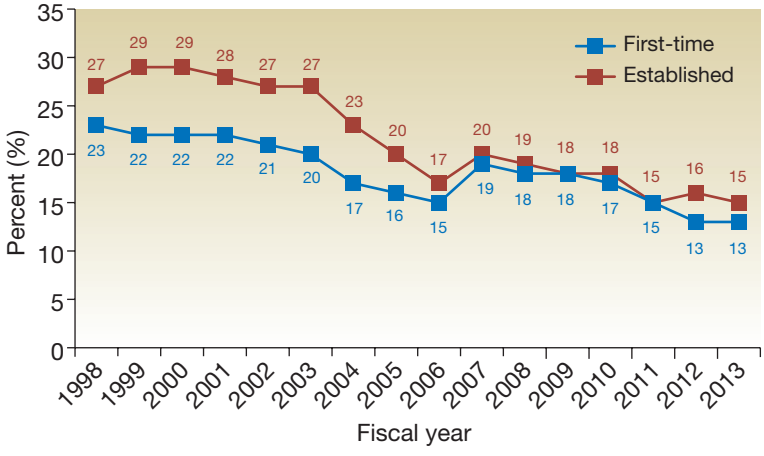

Figure 4 Rate of success for NIH RO1-equivalent award seekers for first-time and established researchers, FY1998–2013. Source: NIH

"When you look at what has happened to budgets after that, with sequestering and cutbacks, it's been pretty clear that relying solely on federal research funding—especially if you're a big player—is dangerous," says Penn's Swartley. "Because there is no obvious path toward big increases in those budgets any time soon."

At the bench, the reduction in federal funding means that faculty spend more time applying for grants, with less success in securing them—a process of diminishing returns. Junior researchers are affected most, but the fact is the funding drought is touching all (**Fig. 4**). In 2000, 29% of established researchers successfully found grants; 22% of first-time applicants did. A persistent decline since then has resulted in a near convergence last year: just 15% of established researchers (who had previously received NIH funding) and 13% of first-time grant applicants won awards.

The drying-up of federal funding is making industry-sponsored research feel like a necessity. These alliances are also huge boons to university bottom lines. Consider the pact between GlaxoSmithKline (London) and the Harvard Stem Cell Institute, signed in 2008 and worth $25 million over 5 years. Three years later, Yale signed a deal with Gilead Sciences to collaborate on cancer research. That agreement is worth $40 million to Yale over the first four years, and potentially $100 million if the option on another 10 years is picked up. Then there is the deal between the University of California at San Francisco and New York–based Pfizer, signed in 2010. This is expected to bring $85 million to the school over 5 years. The two partners also formed a Center for Therapeutic Innovation under which to collaborate, one of several Pfizer established across the United States (*Nat. Biotechnol.* **29**, 3–4, 2011). Agreements such as these show there is a new understanding: industry wants access to early-stage research; academia needs money to pay for it.

The decrease in grants is being compounded by a job crunch. A rising number of life science postdocs (**Fig. 5**) are facing a shortfall in the number of academic positions (**Fig. 6**). The outlook for tenured positions is particularly grim. This means that academia no longer holds the appeal it once had to younger researchers, and with multinational pharmaceutical firms drastically cutting ranks, the result has been a spike in startup interest from both faculty and new PhDs. Some of this can be attributed to a general buzz around entrepreneurism in the United States, but it's also being fostered by faculty and students being exposed to private enterprise to an extent they never were previously. Sadhana Chitale, director of life sciences and technology transfer at NYU, says she had "no contact with industry"

Box 3 Miami on a mission

It "was time to hit the reset button," says Norma Kenyon. Up until the relaunch in 2012, the school's TTO was focused on "just patenting—it was a support mechanism for faculty. [The school] was spending money to patent, but not following them up."

Kenyon moved to the TTO around 2011 and began collecting data from other schools that were becoming proactive in their partnering efforts. She brought aboard in 2013 the current director of the TTO at the University of Miami, Jim O'Connell, who previously had been director of the Venture Center in the TTO at the University of Michigan. His initial look inside Miami had him likening it to "this ivory tower," with the inside walls covered with patents that "never got outside the tower."

"Now there is better outreach," he says. "We're asking the outside world to sponsor our researchers and our basic science. This also helps make the faculty industry-savvy, and it in turn helps produce better technologies."

Miami faced another problem. Heat Biologics, a public company focused on immunotherapies for cancer, came out of Miami University's 'U Innovation', its dedicated center for technology advancement, in 2008. However, by the time it went public in the summer of 2013 (grossing $27 million), it had relocated to Chapel Hill, North Carolina, to be part of the biotech cluster around Research Triangle Park.

"It wasn't a lack of money, or ideas, but the personal support and the services you need [to grow a biotech] weren't here," says Jim O'Connell. "We need that nucleus of three to five biotech companies to bring people down here to Miami" and keep them there, he says. The school's U Innovation is a step toward rectifying that.

when she was a postdoc, but "today these students have frequent interactions with industry folks."

The increased exposure to life beyond the ivory tower means researchers are more open to considering starting a company of their own than before. This gives TTOs yet another reason to help the process along: to keep talented, entrepreneurial researchers from going elsewhere.

New players try their hand

The University of South Dakota (USD), located in Vermillion, is the life force of the town. It would be difficult, however, to characterize it as a tech transfer powerhouse. If stacked up against an East Coast TTO like Penn (**Supplementary Data**), its output does not compare. In 2013, Penn had a total research expenditure of more than $900 million, executed 130 licenses and options, brought in $86.6 million in gross licensing revenue and formed 26 startups; in contrast, USD reported $18.1 million in research expenditure, one license executed, $9,615 in gross licensing income and one startup formed.

And yet, the funding drought has affected small and large alike (USD's expenditures from grants and contracts fell nearly 7% in 2009) and as a result it, too, is changing the way it does business.

The school's entire TTO is DeVee Dykstra, who took the job in 2011, after USD suffered a rash of turnovers at the position. She has a law degree and is a professor in the school of business, and her husband owns a local business, so the school felt comfortable investing time and effort to bring her up to speed.

Dykstra knew nothing about tech transfer culture but, being a lawyer, could handle the paperwork around disclosures and material transfer agreements. Her initial TTO duties required just 20% of her time. As early as 2002, the school had begun to push for researchers to "get it out there," she says, which meant not just seeking publication, but presenting and considering how technologies might move to market. It hired an economic development liaison around the same time Dykstra took her position, responsible for outreach and handling requests from companies wishing to see USD's facilities and research. The new directives have permeated the school, and now "the culture is starting to change," Dykstra says. The percentage of time she spends handling TTO duties has steadily increased. She used to do 2 or 3 invention disclosures a year, but did 13 in 2013.

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The Lower Schuylkill Master Plan is hoping to provide an economic boost to areas bordering Penn's South Bank Campus.

Table 2 Top 15 TTOs in terms of life science licenses/option executed in 2013

Institute	Number of licenses/ options
University of California system	236
University of Washington/ Wash. Res. Fdn.	134
University of Pennsylvania	112
Duke University	111
University of Utah	58
Columbia University	55
University of Minnesota	48
Mount Sinai School of Medicine	45
University of Florida	31
New York University	29
Wake Forest University	23
Northwestern University	22
University of Rochester	8
University of Massachusetts	7
Princeton University	4

Source: *Nature Biotechnology*/AUTM

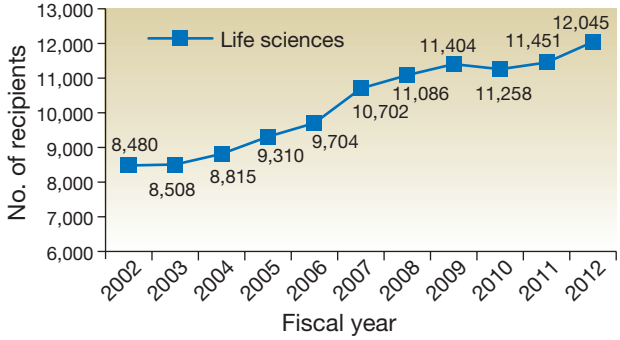

Figure 5 Number of life science doctoral recipients, 2002–2012. Source: National Science Foundation, NIH, US Department of Education, US Department of Agriculture, National Endowment for the Humanities, National Aeronautics and Space Administration, Survey of Earned Doctorates.

Also, like Penn, USD is tying in with government and local business development leaders on a research park—in this case, 80 acres of mostly alfalfa farmland scheduled for development over the next 20 years, located just outside Sioux Falls. That's about 50 miles from USD's campus, but adjacent to the already present University Center, which offers programs from six South Dakota universities, and next to the USD Graduate Education and Applied Research (GEAR) Center, the home to the school's biomedical engineering program. The land was, in essence, donated: the South Dakota Board of Regents is leasing the land for $1 annually for 99 years, and the state of South Dakota has approved $500,000 to help fund the first phase of development. The end result—the University of South Dakota Research Park—is intended to be a techy mix of South Dakota academic research, private industry, residential space and pedestrian and bike greenways. There's also meant to be an incubation program for startup companies.

Dykstra's TTO workload now commands 50% of her time. And she still estimates that the TTO is "going to grow, and quite a bit more. We need more outreach to industry [in life sciences], but I see growth coming down the pike." This might mean she soon faces the decision of choosing between her teaching career—where she's won a handful of USD teaching awards—and tech transfer.

"Pretty soon I'll need to make some personal decisions," she says.

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DeVee Dykstra, University of South Dakota's technology transfer officer.

Table 3 Top 15 TTOs in terms of life science licensing income in 2013

Institute	Licensing income ($)
University of California system	972,218,208
Northwestern University	256,163,456
New York University	213,137,273
Columbia University	137,000,000
Princeton University	130,000,000
University of Pennsylvania	86,100,000
University of Washington/ Wash. Res. Fdn.	47,428,701
Mount Sinai School of Medicine	41,038,042
University of Utah	37,079,781
University of Minnesota	34,400,000
University of Massachusetts	32,624,826
Duke University	28,724,925
University of Rochester	27,139,128
Wake Forest University	2,206,625
University of Florida	1,484,399

Source: *Nature Biotechnology*/AUTM

The meaning of innovation

The very definition of the word innovation speaks to unpredictability. Yet, there are 80-plus innovation districts across the US all betting on the same outcome: research breakthroughs, startups and job growth. It will be an interesting experiment, testing whether fresh, collaborative thinking can be forced, and whether a model everyone else is using can still be called innovative.

The life sciences field is perhaps the most difficult from which to translate discoveries into products; its startup drug companies face horrific attrition rates for their compounds and massive financial requirements. Yet local, state and federal politicians are continuing to look at the life sciences for solutions to the world's health, food and environmental issues, and to serve as a new economic driver. These leaders see the Bay Area of San Francisco thrive with tech and biotech innovation, and note how Boston tapped Harvard and Tufts and MIT and Massachusetts General Hospital to create a world-leading center of biotech innovation, and they yearn to imitate. And yet questions have been raised as to whether innovative, rather than service companies, can really drive such job growth in the 21st century (*Nat. Biotechnol.* **32**, 597, 2014).

Time will tell. For now, the move of TTOs from a patent "dog and pony show," as Miami's Norma Kenyon puts it, to actively seeking the

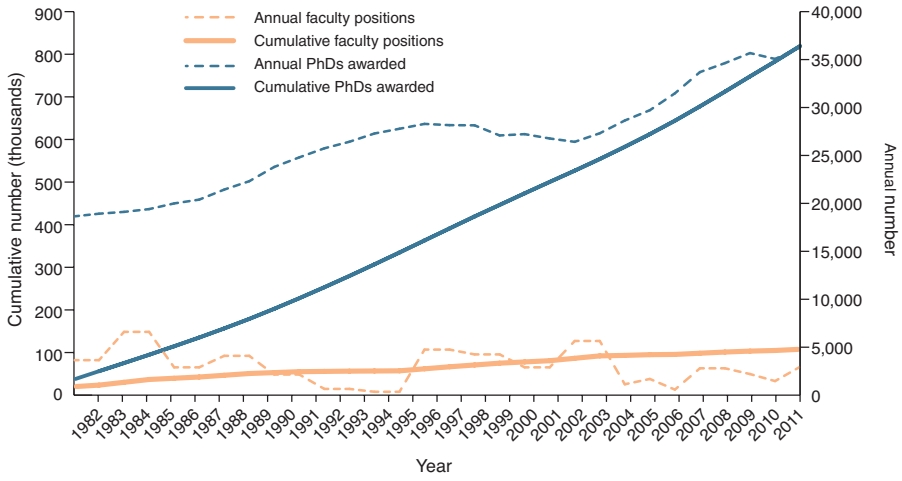


Figure 6 New faculty positions versus new PhDs. Since 1982, almost 800,000 PhDs were awarded in science and engineering (S&E) fields, whereas only about 100,000 academic faculty positions were created in those fields within the same time frame. The number of S&E PhDs awarded annually has also increased over this time frame, from ~19,000 in 1982 to ~36,000 in 2011. The number of faculty positions created each year, however, has not changed, with roughly 3,000 new positions created annually. Source: National Science Foundation

Table 4 Top 15 TTOs in terms of life science startup activity in 2013

Institute	Startups
University of California System	55
University of Pennsylvania	22
University of Utah	15
University of Washington/Wash. Res. Fdn.	9
University of Minnesota	9
University of Florida	7
Columbia University	6
Duke University	6
New York University	5
Wake Forest University	4
Northwestern University	3
Mount Sinai School of Medicine	2
Princeton University	1
University of Massachusetts	1
University of Rochester	0

Source: *Nature Biotechnology*/AUTM

Box 4 Our ranking

Using data from >150 US universities in AUTM's STATT database (which is not broken down into sectors, such as life sciences, IT and energy), *Nature Biotechnology* selected the top 20 gross licensing revenue earners over the 2009–2013 period. We then contacted each school and asked for data points related to just the life sciences for 2013; boutique patent firm IP Checkups provided us with biotech patents awarded to these universities when listed as first assignee. We also pulled NIH funding information. This information can be found in **Tables 1–5**. Schools are ranked against each other according to their total life science TTO performance, in which each metric category (e.g., license income, licenses/options executed and patents awarded) was assigned an average value, and the schools ranked above or below it. Adding those scores provided the final ranking.

All schools represented are performing tech transfer at a high level—these rankings merely rank the schools against each other for life science tech transfer production, not against the broader world of US universities. Readers should note that MIT, Stanford, the University of Texas system, California Institute of Technology and the University of Wisconsin at Madison are in our original top 20, but because they could not break out information attributed to life sciences, they are not shown in **Tables 1–5**. Individual TTO performance across research disciplines for these 20 schools and a few notables, including USD, can be found in **Supplementary Data**.

Table 5 Top 15 TTOs in terms of NIH funding/no. of awards in 2013

Institute	NIH funding ($)	No. of awards
University of California System	1,741,730,393	4,239
University of Washington/Wash. Res. Fdn.	454,274,167	932
University of Pennsylvania	451,194,908	1,081
Duke University	350,249,092	753
Columbia University	348,146,222	860
University of Minnesota	264,302,067	608
Northwestern University	233,095,315	593
New York University	220,178,414	612
Mount Sinai School of Medicine	208,435,128	458
University of Massachusetts	158,659,306	392
University of Rochester	146,849,347	382
University of Utah	140,494,332	381
University of Florida	127,141,750	326
Wake Forest University	101,760,292	242
Princeton University	39,609,228	117

Source: *Nature Biotechnology*/AUTM

best partners for a university's research assets, is smart business. Greasing the path for faculty disclosures and toward commercialization is a win-win. The efforts already in place, plus the growing interest of academia in entrepreneurism across the United States, seems certain to spur continued licensing, startup and patenting activity. Historically lesser-known schools, such as USD, will see the quickest rate of growth, as it is harder to move the needle at established, successful schools such as Penn.

Though it will not be for lack of trying. On a cloudy Halloween afternoon, the university held a "Celebrating Innovation at Penn" day on the grounds of the Pennovation Center, as part of a ceremonial groundbreaking. Buses carried students and faculty over the Schuylkill River and through the security gate to the South Bank campus. Under canopies, Penn faculty and researchers gave mini-presentations on their work, followed by a forum discussion titled "From Idea to Innovation: The Impactful University." The talk was a one-on-one chat between Penn president Amy Gutmann and the writer Walter Isaacson, who has written biographies on innovative thinkers Benjamin Franklin and Steve Jobs, among others.

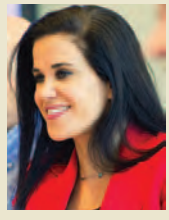
The one-on-one lasted an hour. When it ended, Penn's chairman joined Gutmann on stage, and workers scrambled to open flaps at the back of the tent. A founder of Penn startup KMel Robotics joined the group and dispensed controllers, and for a handful of seconds, four small drones hovered in the air at the front of the room. The crowd was encouraged to stand, and Penn's school anthem came over the speakers. Beyond the tent, sunlight suddenly broke through the clouds, shot down and then disappeared, as if on a timer. Two of the drones veered away, zipped out the tent opening and headed toward the top of the adjacent building. Firework fountains blazed to life on the lawn, and when the drones reached their destination, they triggered the release of a huge banner—Pennovation Center Coming in 2016—which dropped down and flopped against the brick.

Confetti cannons fired.

Everyone clapped.

Note: Any Supplementary Information and Source Data files are available in the online version of the paper (doi:10.1038/nbt.3085).

First Rounders Podcast:
Daphne Zohar



Daphne Zohar is the founder, CEO and managing partner at PureTech, a venture creation company with a new approach to building biotechs, and she sits on the board of several life science firms. Her podcast conversation with *Nature Biotechnology* covers starting her first company (in high school), the usefulness of Bioentrepreneur courses, and women in venture capital. (http://www.nature.com/nbt/podcast/index.html)

Corrected after print 9 December 2014.

Erratum: Reinventing tech transfer

Brady Huggett

Nat. Biotechnol. **32, 1184–1191 (2014) published online 5 December 2014; corrected after print 9 December 2014**

In the version of this article initially published online, the name of the University of Pennsylvania president Amy Gutmann was misspelled. The error has been corrected in the HTML and PDF versions of the article.