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Geneticist Brittany Barreto (right), chief executive of dating company Pheramor, with her co-founders.

ENTREPRENEURSHIP

Business primer

A beginner's guide to launching a scientific start-up and thriving in business.

BY AMBER DANCE

Materials scientist Sebastian Peter is a dyed-in-the-wool academic with more than 130 papers to his name. A few years ago, Peter, who is at the Jawaharlal Nehru Centre for Advanced Scientific Research in Bengaluru, India, started to wonder about ways to apply his research. In 2016, he heard about the US$20-million XPRIZE. The non-profit organization XPRIZE in Culver City, California, incentivizes innovations that could solve global problems; the competition that Peter heard about was open to teams developing technology to turn carbon dioxide emissions into useful products. Peter co-founded a start-up to compete for the prize.

"It's not in my blood," says Peter, about working in the commercial realm. Nonetheless, he assembled a team and wrote a proposal to use metal-based catalysts to turn carbon dioxide into valuable chemicals such as methanol. It's a process that could make a huge difference to India, which has plenty of coal but imports most of its methanol. The country wants to increase its use of the liquid alcohol for energy, fuel and products such as solvents and antifreeze. "It was the right time and the right problem," says Peter.

The XPRIZE review panel agreed. Peter's company, Breathe, headquartered in Bengaluru, is one of ten teams in the final round of the competition.

Throughout the process, Peter has had to wade into the worlds of business, law and policy. "Every day," he says, "I'm learning."

He's not the only one. Around the world, scientists are learning the lingo (see 'Jargon buster') and discovering what it takes to found start-ups with the support of private investors, as well as universities and governments eager to shepherd scientific research out of the laboratory. It's not as hard as it might seem to start a science business, thanks to incubators and accelerators that provide supportive resources, says Ben Miles, an optical physicist and chief executive of Spin Up Science — a start-up in Bristol, UK, that aims to build a science-innovation network in ▶

the city and, eventually, around the world. Spin Up Science trains and counsels prospective founders and organizes events where they can network and pitch their ideas to investors.

Some researchers, such as Peter, remain firmly in academia, but serve as advisers or board members for commercial spin-offs. Others, often PhD students or postdocs, become full-time entrepreneurs. Scientists who have launched businesses say that it's key to address the right problem, one that people will pay to have solved. Equally important is assembling the right team to bring that solution to market. Moreover, academics should understand that commercial research can be faster-paced and more goal-oriented than the studies they're used to. And success is far from guaranteed; only one-third of US businesses started between 1994 and 2013 survived for a decade or more.

Many researchers turn to the business sector to do some good in the world, with financial gain a secondary or tertiary motive. And start-up founders don't necessarily make a large amount of money. Although they might own most of the company when it launches, over time, the value of founders' shares is often reduced by new investors with deeper pockets. For example, in 2011, biotechnology firm BioVex, a University College London spin-off, was sold to Amgen, a biopharmaceutical firm in Thousand Oaks, California, for up to US$1 billion (an amount that depends on the achievements of the start-up's vaccine technology). Co-founder David Latchman's share of the initial upfront payment of $425 million was just $709: the value of his shares fell during the many rounds of venture-capital funding needed to steer the product through preclinical and clinical trials.

Although there's no way to ensure that any new company will be a blockbuster, business-savvy scientists can maximize their chances of success. Marcos Fava Neves, an expert in business planning at the University of São Paulo in Brazil, has started several companies, including the business-consulting firm Markestrat in São Paulo. The companies that succeed, Fava Neves says, combine the ability to anticipate changes in the marketplace with a passionate and cohesive team and a desirable product. "We have to do what people want, not what we know how to do and think they want," he says.

Learning what the market requires, along with other aspects of entrepreneurship, might not feel as strange as scientists might think. Researchers are well-suited to testing their ideas, points out Brittany Barreto, a geneticist and co-founder and chief executive of Pheramor, a dating company in Houston, Texas. Starting a company, she says, involves running pilot experiments and solving problems — key skills of any PhD.

Pheramor uses sequences of immune-system *HLA* genes and social-media activity for matchmaking. The company says that different *HLA* genes might influence pheromones involved in human attraction. Pheramor has received some criticism over the concept of pheromones in attraction, but Barreto argues that the science of attraction based on *HLA* genes is more sound.

THE INSPIRATION

Any company starts with an idea. "Find a problem and solve it," advises Cather Simpson, a specialist in lasers and spectroscopy at the University of Auckland in New Zealand. She says that's better than brainstorming ways to sell one's research. She started one company because a dairy-industry investor came to her in 2011 with a list of problems in the sector. The one she thought she could tackle was sorting cattle sperm so that farmers could control whether calves were male or female. The resulting company, Engender Technologies in Auckland, uses fluorescent labelling and lasers to separate X- and Y-chromosome sperm.

But it's a long road from idea to product. For academic researchers, the first stop is usually their university's technology-transfer or entrepreneurship office. "It's our job to help the academics see some commercial outcome for their work," says Anne Dobrée, head of seed funds at Cambridge Enterprise, a subsidiary of the University of Cambridge, UK.

Market research should also be an early step, and it involves a scientific approach: generate a hypothesis about who might want the product, then check to see whether they really do. Barreto originally thought university students would be a key market for Pheramor. But a survey revealed that those who wanted such a service, and were willing to pay for it, were 28- to 38-year-old professionals.

Patent protection is also key — even for those who want to share their research widely, says Miles. "If you don't patent things," he explains, "very few people will help you stump up the cash to get it to market."

Scientists who are at this stage might want to hold off publishing or speaking about their work until they have applied for a patent (technology-transfer offices can help researchers do this), but they don't need to wait for it to be fully approved before making the research public. Bin Liu, head of the department of chemical and biomolecular engineering at the National University of Singapore, says that's no great hardship. Once she has results that might lead to commercial products, she files a provisional patent. In Singapore, it takes only a couple of months to receive preliminary approval. Then she'll publish her work.

Similarly, Miles says, in the United Kingdom, inventors need only to file a patent application, not to receive one, before publishing. In the United States, once researchers file for a patent and the patent office publishes the application, the invention is considered 'patent pending' and is protected.

THE PEOPLE

Getting into business should be a team effort. "For academics starting a company, the crucial thing is to not try to do it all yourself," says Dobrée. Her office connects academics with potential co-founders who have business skills. Scientists might prefer to take the role of chief scientific officer or chief technical officer, and to let a chief executive deal with raising money.

But they don't have to stay in those roles. Biotechnologist Shalen Kumar started out as chief technical officer of AuramerBio in Wellington, New Zealand. He co-founded the start-up to make aptamers, antibody-like molecules made from nucleic acids, and chemical tests based on those aptamers. Kumar felt he was valued only for his scientific contributions, but says he is a natural businessperson. "I would buy and sell things all the time," he says. "I used to buy cars, do them up, tidy them up and sell them." Kumar used YouTube tutorials to get up to speed in the business world. He took over as chief executive in May last year.

It's not just the chief executive who matters, however. Start-ups survive or fail on the basis of their team. In fact, 65% of start-up failures

JARGON BUSTER

Need-to-know terms

Start-up: A small company in its first few years of business that aims to solve a problem for customers with its products or services.

Spin-off: A start-up created from another organization, such as a university or research institute.

Intellectual property (IP): Inventions born of creativity, including technology, written works and art.

Patent: Rights granted by a government to a creator of IP, allowing that creator to exclude others from using the material for a set time period.

IP licence: Agreement by which an IP creator allows a licensee to use that IP in return for payment.

Incubators and accelerators: Organizations that help innovators to expand their start-ups using resources such as space, training and seed funding. Although there's no clear-cut distinction, incubators tend to be smaller than accelerators, and less intensive.

Angel investor: Individual who invests their own money in early-stage companies.

Venture capitalist: Person who invests funds on behalf of a large investor pool.

HKSTP

Shalen Kumar started as chief technical officer at biotechnology company AuramerBio.

are attributed to interpersonal conflict.

Investors know this, says Simpson. "They will invest in a 'B' idea in an 'A' team before they'll do it the other way around," she says. She looks to recruit team players who are eager to solve technical challenges, and happy to recognize others' expertise.

MILESTONES AND SETBACKS

The team gets the company up and running. Companies then enter a cycle of hitting goals, seeking more funding and going for the next milestone. For example, Breathe's first milestone was to convert 1 kilogram of carbon dioxide to methanol in a day — then 5 kg, then 400 kg. By the end of the XPRIZE competition, the company hopes to be converting 2 tonnes per day.

Meeting the demands of a growing business can be a challenge, especially for those balancing company and academic workloads. Liu found many differences between her academic and commercial research. Her lab invented a nanoparticle-based tool for fluorescence labelling, then spun off the company LuminiCell in 2014. Partners at Millipore, now part of the pharmaceutical company Merck, wanted the particles to have a shelf life of 12–18 months. "I can never imagine, as a researcher, paying any attention to stability at all," she says. "These parameters took us more than a year."

Liu was careful to draw clear lines between her academic and commercial work. She obtained approval from her university before engaging in commercial work, and kept her institute informed about the start-up and which researchers would be involved.

Although Liu learnt a lot from starting LuminiCell, the workload was stressful, especially during a period between grants when she took on many company tasks. Next time she has an innovation, she says that she might license it to another company. She could earn some money from royalty fees and perhaps help that business as a consultant, but she wouldn't want to feel the same pressure.

Start-up founders must be willing to change gears quickly. "In academia, if something doesn't work out, it's no problem — you just go on to the next project," says Dirk Theis, a mathematician at the University of Tartu in Estonia and co-founder of Ketita Labs, a quantum-computing software company. "In the business world, if something doesn't work out, it immediately puts into question whether your company is going to survive at all." Start-ups must be flexible and ready to try plan B, or even C or D, advises Theis.

And if the start-up runs out of plans, then it might be time to throw in the towel. It's hard to close the door on a company in which one has invested so much time and effort, says Chengeer Lee, co-founder of the now-defunct Labit web platform, which he predicted would be a resource for scientists to create lab web pages and share resources. He shut down Labit at the end of 2017, and is currently working as an English teacher in Gwangju, South Korea, and writing a book about personal development.

"I don't regret it," says Lee. He says he learnt a lot about how not to run a company. For example, his idea wasn't something that lab principal investigators — the people Labit was aimed at — particularly craved. He's not averse to trying another start-up at some point, but next time he won't make the same mistakes.

Breathe co-founder Peter doesn't know yet whether he'll fail or succeed, but he, too, has learnt a lot along the way. "I was a bit scared about the industry, a bit scared about the translation, a bit scared about the corporate world," he says. "Now, I am very confident to say that it can be possible if you come forward and do it." ■

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PUBLICATIONS

One and done

In recent decades, the number of 'short-term scientists' — those who publish at least once but soon stop contributing to the literature — has surged, according to an analysis of astronomy and ecology journals going back to the early 1960s. The study, published in *Proceedings of the National Academy of Sciences*, found that the average 'half-life' of a science career — the time it takes for half the researchers of a given cohort to cease producing papers — has dropped from 35 years in the 1960s to just 5 years in the 2010s (S. Milojević *et al. Proc. Natl Acad. Sci. USA* **115**, 12616–12623; 2018). The study also found a strong decline in the proportion of postdocs, staff scientists and other non-senior researchers who lead publications. In cohorts from the mid-1960s, about 80% of ecology and astronomy researchers had been listed as a lead author on a paper; by the 2010s, that figure had dropped to about 40%. In each field examined, researchers who fail to become lead authors within the first 5 years of their careers are much more likely to leave academia. The study underscores a familiar problem: the number of PhD degrees awarded outpaces the number of available tenure-track or tenured academic positions.

GENDER BALANCE

Quota failure

An effort to bring more women into academia by mandating gender quotas on hiring committees at French universities might have backfired, finds a study of decisions made by 455 hiring committees at 3 institutions (see go.nature.com/2gef3ic). The analysis — posted in November as a SciencesPo working paper from the Paris Institute for Political Studies (LIEPP) — suggests that committees adhering to the quota were much less likely to hire women — perhaps because of retaliation from men miffed by the policy, says study author Pierre Deschamps, an economist at LIEPP. In 2015, France enacted a law that requires all public-university hiring committees to have a gender balance of at least 60%–40%. Deschamps compared committees that had to reconfigure to comply with the law with those already in compliance. He estimated that the quotas reduced the hiring of women by 38% in the affected committees. The effect was most pronounced in some male-dominated fields. Deschamps didn't have access to individual votes, so it's unknown which committee members chose to hire men over women.