

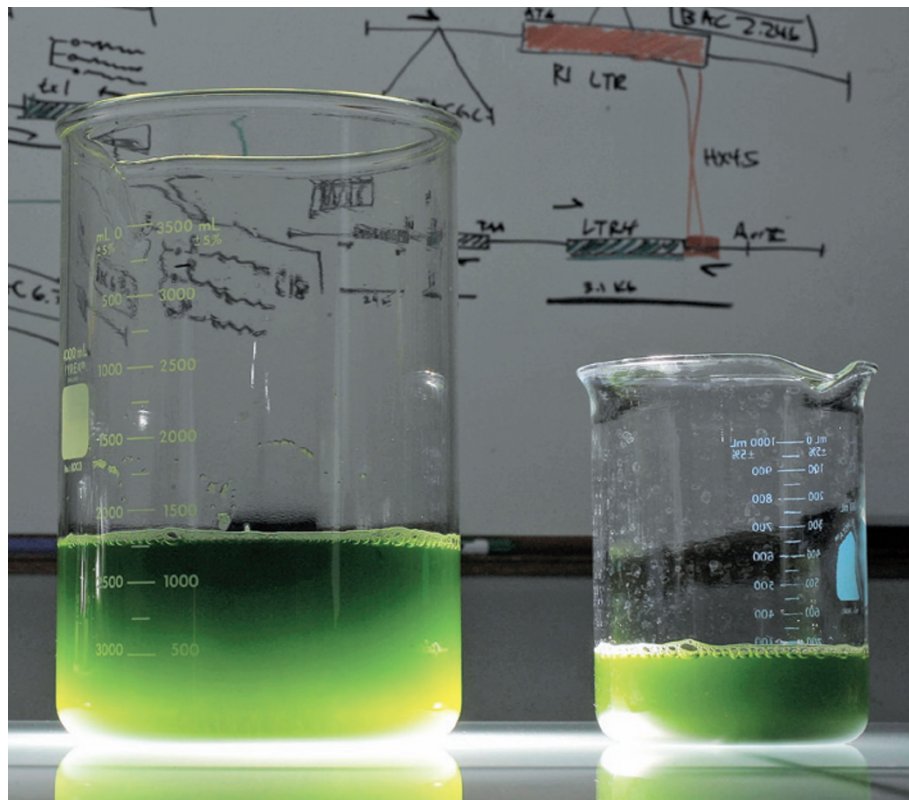
# CAREERS

**CANADA** Postdoctoral researchers endure a heavy tax burden **p.533**

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Early attempts to make algae-based biofuels are creating research opportunities.

## RENEWABLE ENERGY

# Making fuels for the future

*The field of biofuels has suffered from cycles of interest and neglect. Still, enterprising researchers have myriad options.*

BY CHARLOTTE SCHUBERT

**H**aiyu Ren completed her PhD in agricultural and biological engineering in 2006, just as biofuels research was heating up. Oil prices were spiking, and governments and investors worldwide were beginning to look at biofuel options beyond soya biodiesel and ethanol made from maize (corn). Money began to flow to research into fuels made from woodchips, algae and wheat straw.

Ren got only one job interview — with Novozymes, an enzymes company based in Bagsvaerd, Denmark. She was part of a surge of researchers newly enthusiastic about alternatives to petroleum, all competing for the job — but she got it.

Three years later, Ren was working in Beijing, leading a lab of 16 scientists — biochemists, molecular biologists and chemical engineers — collaborating with several Chinese companies on two pilot-scale facilities

that used Novozymes enzymes to help process corn stalks. One facility turned the stalks into ethanol, and another turned them into ethylene glycol, a building block of plastic.

But last year, her career took a turn. Ren left research and development to try her hand at the business side of the industry, with the aim of working on international partnerships. She is now based in the Novozymes business-development office in Bagsvaerd, and later this year will begin earning a master's degree in business administration, courtesy of the company.

Ren's changing career parallels the evolution of an international field. Growing options stem, in part, from an expansion of research aims: many companies that once focused exclusively on turning biomass into fuel are, like Novozymes, now exploring how to turn plant-derived substances such as starch, sugar or cellulose into higher-value chemicals from which paints, plastics and other industrial products can be made. "The number of jobs has increased significantly since 2006, and there is more variety," says Tom Richard, director of the Penn State Institutes of Energy and the Environment in University Park, Pennsylvania.

Still, the fields of advanced biofuels and biochemicals are young, so uncertainty remains about long-term funding and investment. Hundreds of millions of dollars in government and private financing have been pumped into the industry, but no commercial-scale facility to turn biomass into fuel has yet launched successfully, owing to cooling investor interest, technology lagging behind initial promises, or both. But the field's immaturity also means that there is still a need for highly trained scientists who can make the technology work. For researchers flexible enough to weather uncertainty, biofuels offer an opportunity to help mould an emerging industry.

## BREAKING THROUGH

Research in advanced biofuels focuses on reducing the cost of squeezing fuel out of biomass, aiming to make it competitive with the fluctuating price of oil. To achieve that goal, scientists must find efficient, elegant ways to extract molecules such as glucose — a crucial chemical from which ethanol and other products are made — from lignocellulose, the hard woody part of plants. Companies such as Novozymes use proprietary enzymes to help chew up the lignocellulose after a 'pretreatment' step, which often involves steam or acid. Other firms gasify the lignocellulose to break it apart, or use ►

► engineered, heat-loving bacteria to help with the task. Hundreds of small companies are working on converting all kinds of substances, from municipal waste to algae, into a range of products, including but not limited to ethanol, the industrial chemical polylactic acid, and 'drop-in' fuels such as butanol, that are close substitutes for petroleum, diesel or jet fuel.

After a serious lull during the recession, companies big and small have begun to advertise job openings. They are seeking yeast geneticists, enzyme biochemists, polymer chemists, fermentation scientists, agronomists and chemical engineers, among others. The field's technological challenges have created demand for researchers at all levels — from basic scientists who can engineer microbes and algae to produce fuel to chemical engineers and fermentation experts, whose expertise is needed in scaling up pilot facilities. The near-term demand is highest for researchers in biochemical engineering, biochemistry, microbiology, metabolic engineering and plant biology, says Bruce Dale, a chemical engineer at Michigan State University in East Lansing who has mentored students for more than 30 years.

Employers look for people with broad experience, says Dale, and many of the jobs use interchangeable skills. "This field rewards people who can work collaboratively across disciplines," he says. Dale advises chemical engineers to get training in microbiology or molecular biology, and biochemists to take an engineering class or two. Richard recommends that students undertake coursework in fuel chemistry, combustion science, emissions regulations and analysis of greenhouse-gas emissions. He also advises those interested in advanced biochemicals to take courses in organic chemistry (including green, or environmental, chemistry), materials science and engineering (especially polymer science), and product design.

Ren's education prepared her to work on all aspects of pilot-plant design: optimization of enzyme use, management of waste water and others. Her classes at university ranged from carbohydrate chemistry to one examining the machinery used in crop harvesting, and set her up for work with both biofuels and biochemicals. "I am not an expert in all these areas," she says. "But the education enabled me to apply the right method to solve the challenges step by step, or to find the right person to consult with."



**"We are motivated by this big vision to get renewable energy on board. I dream about my work."**

Haiyu Ren

More jobs are emerging for people with these skill sets, not only in corporate research labs, but also in manufacturing, supply-chain logistics, finance and marketing. "As this industry moves out of the laboratory and into the factories," says Richard, "this diversity and flexibility to absorb allied career tracks can only increase." Recent graduates mentored by Dale and Richard have gone on to work in research positions at DuPont — the chemicals giant based in Wilmington, Delaware — and Novozymes; others are doing postdoctoral work in academic labs, and one became an analyst at the US Energy Information Administration in Washington DC. In the future, opportunities will also emerge for experts in sustainable agriculture and crop-yield optimization, so graduates with degrees in plant physiology, forestry or agricultural engineering will become more sought after, says Dale.

Biofuels companies will take on researchers with basic experience in microbiology or yeast genetics, but it helps if applicants are educated at an institution with a reputation for putting a large number of scientists into the field. In Europe, that means programmes such as that at BE-Basic, a consortium of universities, research institutions and industry based at Delft University of Technology in the Netherlands. Brazil is a leading global manufacturer of sugar-cane ethanol, and trains experts at the Brazilian Bioethanol Science and Technology Laboratory in Campinas, among other institutions. In the United States, graduates with prospects are emerging from the Energy Biosciences Research Institute (EBI) at the University of California, Berkeley, which was launched with a \$500-million ten-year grant from the oil giant BP in 2007. Other up-and-coming institutions include the Great Lakes Bioenergy Research Center, a joint venture between Michigan State University, the University of Wisconsin–Madison and others. The centre is one of three established by the US Department of Energy in 2007.

The key to navigating the field, says Ren, is to shift goals to fit new opportunities that might come up — such as her move into business development.

#### PLANNING FOR THE FUTURE

The future of the biofuels job market will depend on oil prices and how government policies evolve. "There is a lot of market uncertainty," says James McMillan, a biochemical engineer at the National Renewable Energy Laboratory (NREL) in Golden, Colorado.

Some government initiatives are sending positive signals. In January, for instance, the US Department of Agriculture announced new loan guarantees for commercial-scale plants — dependent on the recipients meeting pre-specified targets. Beneficiaries included Coskata, a start-up based in Warrenville, Illinois, which received \$250 million to build a refinery that will make 200 million litres of

ethanol a year out of wood chips; and Enerkem of Montreal, Canada, which got \$80 million for a plant to make 38 million litres of ethanol a year out of municipal solid waste. The US military has ambitious targets for how much alternative fuel it will use in the future, and is a driving force behind research into algae-derived biofuels — an endeavour that has spawned dozens of companies. And in March, the Brazilian government announced US\$600 million in loan guarantees and other funding for developers of biofuel technologies.

All this government support is creating new jobs. For example, Enerkem is currently hiring mechanical, environmental and electrical engineers, analytical chemists and a business-development director.

But government backing is not assured for the future. McMillan says that researchers at NREL wonder whether the US Congress will cut programme budgets in the next few years. And policies do not ensure a stable market price for the fuel that will emerge from the nascent industrial-scale facilities, says Jeff Passmore, a consultant and past chair of the Canadian Renewable Fuels Association in Ottawa.

Still, investors have been steadily financing smaller-scale efforts, creating jobs in research and development. Venture capital and private equity investment in advanced biofuels worldwide hit \$525 million in 2010, according to

K. STEPNITZ/MSU COMMUNICATIONS



**Bruce Dale advises biofuels hopefuls to get interdisciplinary experience.**



Caroline Taylor, a bioenergy analyst at the EBI. That is up from \$410 million during the recession in 2009. (Total investment spiked at \$900 million in 2008, up from \$300 million in 2007.) These numbers do not include the hundreds of millions of dollars spent each year by large companies such as DuPont, ExxonMobil and the Brazilian energy giant Petrobras.

#### NEW DIRECTIONS

Emerging business models could buffer biofuels companies financially, helping to lure investors and foster job opportunities. Last December, the trade journal *Biofuels Digest* ranked the leading bioenergy companies for 2010–11, and reported that 11 of the top 25 also had plans in place to produce high-value industrial chemicals. At the top of the list was Amyris of Emeryville, California, which opened its first industrial-scale facility in April, in Piracicaba, Brazil. The plant will turn sugar-cane syrup into farnesene, an industrial chemical that can be used to make cosmetics, perfumes and industrial lubricants. Farnesene is currently derived mainly from petroleum, and sells for around \$265 per litre, according to a spokeswoman from Amyris, or seven times that for small quantities. The company is now hiring dozens of people, from computational scientists to fermentation specialists.

The ultimate vision for some of these companies is to build a 'biorefinery' to produce a range of products, from fuel to high-value, small-volume chemicals. Even if the technology does mature to the point at which such facilities can be built routinely, opportunities for scientists will continue to emerge, assuming that companies in the area maintain research and development units in the same way that the petroleum industry continues to innovate today, says McMillan.

Experts advise researchers entering the field to do their homework — many companies over-hype their technology or suffer from poor management, warns McMillan. Applicants who can network with established researchers in the field, and understand the scene outside their own immediate areas of training, will be well placed to assess opportunities in a rapidly changing field. "If we are going to build up this industry, we are going to have to move a phenomenal amount of biomass around," says Dale. "In ten years, this field is going to look a lot different."

A desire to make a difference may be the defining feature of biofuels researchers as the field evolves. Many practitioners believe that they can help to wean the world off oil, and aid the environment and society in the process. "We are motivated by this big vision to get renewable energy on board," says Ren. "I dream about my work at night." ■

**Charlotte Schubert** is a freelance journalist based in Seattle, Washington.

## COLUMN

# Oh, Canada ...

A tax-law change has dealt a heavy blow to Canadian postdocs, argues **Lucie Low**.

**A**s a newly appointed postdoc, I was excited, nervous and enthusiastic about moving to Canada last July. I had just completed a PhD, which is no small task in itself. I had applied for, and been awarded, an international scholarship to move from Britain to Canada and work in a world-renowned brain-imaging laboratory. The salary would apparently be tax-free. "Wow," I breathed to myself, "this is actually happening, this really is my dream come true!"

Fast-forward 11 months, and how things have changed. Postdoc salaries are no longer tax-free and I have learnt that the status of postdocs in Canada is generally 'undefined' (see *Nature* doi:10.1038/news.2010.429; 2010). All because last year's budget clarified the rules for tax credits, removing the 'student' loophole that gave some postdocs tax-free salaries.

Cue a hefty pay cut (I suppose I'll pay back my student loan when I win the lottery), mounting frustration over the paucity of resources and respect given to postdocs and a growing disillusionment with the whole situation. Oh, Canada! Country of maple syrup, lumberjacks and mounties! You could have got it so right. But you didn't.

Taxes are fine if they mean you get certain benefits — annual leave, for example. Then there's access to a pension scheme and maternity pay. Unfortunately, Canadian postdocs now find themselves paying full staff taxes, but still ineligible for these benefits. In many Canadian institutions, postdocs are classed as 'trainees', which seems to be a catch-all to describe being neither a student nor a staff member. This means that we are easily ignorable, often dealt with by departments more tailored to graduate-student issues — departments without the time, energy or resources to work out the complexities of postdoctoral status (be it 'student', 'trainee' or 'staff').

In an April 2010 letter to the Canadian Association of Postdoctoral Scholars (CAPS), the Canada Revenue Agency justified the use of 'trainee' as a term by arguing that postdocs are similar to "apprentices, articling students,



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and medical residents". (CAPS had requested clarification on the tax laws.) This would be fine if postdocs were getting the same salaries as, say, articling students (as newly qualified lawyers are called in Canada).

But we're not. And, with the recently added tax burden, some postdocs are finding themselves in the bizarre situation of earning less than the graduate students in their labs. Taking into account that the average age of a postdoc in Canada is 33 (according to a CAPS poll) and that 48% of postdocs have dependents, this pay cut places a heavy burden on those with mortgages, children and other responsibilities. Now there's an incentive to complete your thesis.

I realize that few people become scientists for the money. Those keen on big salaries usually seek to become lawyers or surgeons. I'm also aware that postdocs aren't all equitable elsewhere. But if this inequitable treatment of Canadian postdocs continues, Canada will lose some of its brightest minds. My advice for now? Weigh up the pitfalls and limitations of your situation before considering a Canadian postdoc.

Still, all is not doom and gloom. There are countless opportunities to help improve the situation — by setting up institutional postdoc associations, working with CAPS or liaising with your institution to make it aware of the problems — which is exactly what I'm doing. *Vive la révolution!*

So I do see the benefits of my move, and of living and working in Canada. And for now, I am learning to ice skate and enjoying Canada's maple syrup. I'm also, I'm afraid, educating myself about the nuances of Canadian tax laws. ■

**Lucie Low** is a postdoc in neuroscience at McGill University in Montreal, Quebec.