Chemistry Nobel Laureate Professor M. Stanley Whittingham

Thomas Player (Keble 2013), DPhil student in the Hore group, interviews 2019 Nobel Laureate Professor M. Stanley Whittingham

Has Stanley Whittingham had enough of being congratulated for his Nobel Prize in Chemistry, awarded last December? His simple reply: it comes and goes.

Whittingham shares the prize with John Goodenough and Akira Yoshino for research that began in the late 1960s and led to the development of lithium-ion batteries. Commonly used for portable electronics, as well as electric vehicles and other applications, they are a type of high energy-density rechargeable battery that relies on lithium ions moving between the electrodes. It is perhaps surprising that such a ubiquitous invention – you likely have one in your pocket – had until now remained unacknowledged by the Nobel committee.

Whittingham's early work at US energy company Exxon in the 1970s, developing intercalated materials where molecules or ions are incorporated into a layered solid, preceded that of both of his Nobel co-recipients. Goodenough was at Oxford in the late 1970s and early 1980s when he expanded on Whittingham's work, using lithium cobalt oxide as a material for battery cathodes, and this was later developed and commercialised at Sony by Yoshino. Nowadays lithium batteries are vital in a multitude of settings, from smartphones and laptops to electric cars and national grids. "It's very gratifying. I think everybody in the field is happy because it [lithium battery technology] is being used."

In the early days investigating the fundamental properties of lithium electrode materials, did Whittingham have an inkling of how widespread this technology would become? "We were working on all kinds of energy problems at Exxon, and I think they recognised that oil was going to run out." This led to lots of work on batteries, with Whittingham pitching his lithium project to the board of directors in "what they call an elevator speech these days".

Professor M. Stanley Whittingham.

Even at that time, the development and manufacturing teams at Exxon had goals that remain familiar today. Developing electric vehicles, still a major concern for the automotive industry, was one. "Back at some of the old talks I gave we even talked about smoothing the [national] grid using large batteries – I think people were thinking along the same lines [as we do today]".

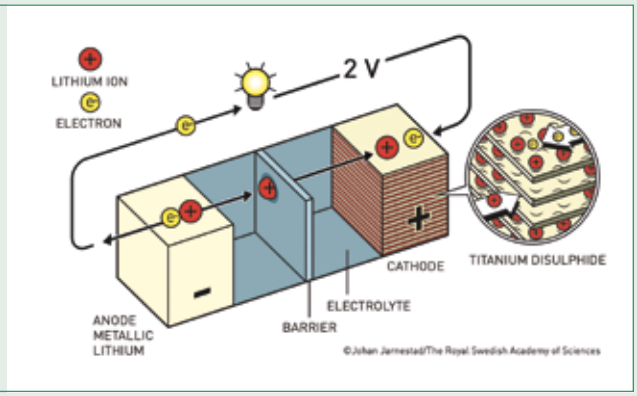
"There's a huge push here, particularly in New York State and California ... to install solar and wind power and combine them with batteries". One advantage of this is that you can quickly turn the batteries on to meet peaks in electricity demand – faster than pumped hydro-electric generators, and greener than fossil fuel stations. "It's very clear now: I don't think anyone's going to build new coal power plants, they're just too expensive compared with wind and solar. [Renewables] may be a bit more expensive in the beginning, but the fuel is free and it needs almost zero maintenance." Battery technology is similarly low-maintenance – Whittingham cites a battery facility that he visited where they proudly informed him that their biggest maintenance task is mowing the grass.

Whittingham is unsure that receiving the award has had a large impact on his research, although the associated publicity has certainly raised the profile of lithium-ion batteries and their importance. But if the Nobel Prize has not had much impact on his work over the last few months, something that certainly has is the COVID-19 pandemic.

"Obviously we've stopped all experimental research

for several months. It's kept me basically at home, and I would have been on the road 60–70% of my time during March to June." He is curious whether Oxford will be opening up to students in October, and it seems the academic struggles related to the virus are similarly felt all over the world. Whittingham states the problem simply: "chemistry has to have labs".

Whittingham has been based at Binghampton University in New York state for the last 31 years. Before emigrating to the US he studied for both his BA (1964) and DPhil (1968) in the Chemistry department at Oxford. He remembers that tutorials with Peter Dickens took place in his house on Sunday mornings, complete with tea and biscuits. Dickens – New College tutor in Chemistry at the time, and later Whittingham's Part II and DPhil supervisor – died in October 2019, just two weeks before it was announced that his former student had been awarded the Nobel prize.



The Whittingham Battery. © Johan Jarnestad/The Royal Swedish Academy of Sciences.

During his Part II year, Whittingham's research was funded by the office of the US Air Force in London. It was the peak of the space race and they were particularly interested in topics such as the reactions of oxygen atoms with rocket nose cones, leading to Whittingham's early work on tungsten bronzes. His DPhil, funded by the British Gas Council, was supposed to focus on catalysts for converting coal gas into natural gas. "They gave me the fellowship, and then I think it was early August when they struck natural gas in the North Sea and said 'we're not interested in that anymore – you can do whatever you like, send us a report at the end, and don't bother us with anything in the interim'." They honoured the funding, and this gave Whittingham the freedom to follow his interests during his doctoral studies.

"I think my lab was a little bit infamous in the Inorganic Chemistry Laboratory. I still remember dismantling part of a hood in there: to generate the draught under the hood you had to light gas that caused the flow up the exit pipe. So, if we had organics then they burnt up the exit pipe too."

Other students were looking at reactions of chlorine atoms. "There was always a slight sniff of chlorine in the air. In the three years I was there I think no-one caught a cold."

"I was doing microbalance studies on reactions of hydrogen with these tungsten bronzes, so I had to build all the electrical systems to control it. We built an automatic liquid nitrogen refilling system, you learnt how to be an electrician, glassblower – you did everything yourself. The glass blowers … would help train you, but they only did specialised stuff, so you had to become almost a jack of all trades." Data was measured using chart recorders rather than computers, so if an experiment was running for a long time you might be in the lab for 24 hours or longer, dozing off when possible to get a bit of sleep.

Whittingham sees a distinction between the custom setups he used in his doctoral studies, which involved a lot of forethought and design, and current approaches. "You've got the opportunity of thinking now. In those days you couldn't do what most students tend to do now, which is to try everything."

Outside of the lab there was still time for leisure, with fond memories of living in Oxford in the 1960s. "In the summer, if you got bored you'd go and watch the cricket; in those days Oxford played international tourists and most of the county teams. If you were in Chemistry you'd just walk, almost out the back door, and into the field."

"[When I was] an undergraduate it snowed between Christmas and New Year once, and the traffic just packed it down … the snow was still there until the beginning of March. If anybody says climate warming isn't happening then they haven't lived long enough to see it."

For Whittingham, science is certainly an international business. "In solid-state chemistry people move from country to country, with collaborators in all different countries. Some of my colleagues use the light beam just outside Oxford rather than ones in the US."

"I said in the banquet speech for the Nobel prize: John [Goodenough] made his inventions in Oxford and I made mine in the US, so in a sense we switched nationalities to do that."

Following his DPhil, Whittingham moved to Stanford for a postdoctoral position. "I moved in 1968, it was cold and miserable in England. I caught a 707 direct to San Francisco ... 70 degrees, sunshine. And that was one of the reasons I went! I think all DPhils, if they wanted a good academic or industrial job, had to go to the US in those days for a postdoc." Subsequently he took a research position at Exxon's new corporate labs, studying "anything energy related that wasn't petroleum or chemicals". He remembers it as a great time to be in industry, and contrasts it with the situation today. "Exxon, Bell Labs, DuPont, General Electric, IBM: they all had these very fundamental research labs – more basic research than academics could ever do – but they're all gone." In his opinion this has been driven by a focus on short term returns, where inventions may still be made in Britain or the US but then "the engineering is shipped off to Asia. They're willing to invest ten years, or whatever it takes, to turn an idea into a product".

He and Goodenough now form part of the Battery500 Consortium, a collaboration that aims to increase the energy density in lithium battery cells to 500 watt hours per kilogram. "That's about double what it is today." Another of his projects is more fundamental, aiming to "understand all the chemical reactions that can occur in battery electrodes". The area for which he has recently been honoured remains ripe for exploration, almost 50 years after he began working in the field.

So, what would his move be today, if he were a DPhil student just finishing up his studies? "Certainly in Britain it will be very stressed in research with Brexit and things like that. I don't know what the British government is going to do, whether they will invest in research to get out of the doldrums or whether they'll worry more about the virus and stop investing in everything. I'm at the end of my career, it's not going to affect me, but I think it's much more worrisome for new folks getting into the field."

Alongside his scientific projects, Whittingham also sits on a task force for the governor of New York State that aims to elucidate the factors limiting the uptake of electric vehicles. He cites range as one of the major limiting factors, but sees no reason why fleets of delivery vans and buses in large cities could not be totally electric. "Most of us believe that large cities like London, New York, and San Francisco will ban internal combustion engines within the next 10 or 15 years."

John Goodenough – co-recipient of the Nobel Prize alongside Whittingham – and colleagues outside the Inorganic Chemistry Laboratory in 1982. Goodenough is second from the left in the front row.

There are stark differences in attitudes to climate change across the US. In Whittingham's view the Democrat-led states, in particular California, are leading the way in the automotive industry. "You've got these big areas pushing for a greener environment, and car manufacturers won't make two different sets of cars so they have to follow the California standards. That's what Trump is trying to change, but I don't think auto manufacturers will change because they want to make cars they can sell around the world."

He remains optimistic about a global response to climate change, explaining that Nobel laureates as a group are certainly in favour of action. "Even Trump will have to listen when his mansion in Florida gets flooded, it's only about two feet above water level now."

One current debate is whether the impacts of COVID-19 related lockdowns on the way we work – more working from home, less commuting – will have a long-lasting impact on our attitudes to travel and pollution. Possibly in the long-term, says Whittingham, but "in the short term it's going to make things worse. People are going to be loath to carpool, they're not really going to want to go on full buses or full trains, but instead they'll opt to drive themselves". He does concede that in Oxford, perhaps, more people might just ride bikes.

In light of his Nobel Prize, Whittingham was recently made an Honorary Fellow of New College. "What are the perks?" he enquired, on hearing the news. "Well, you can park your car inside the quad" came the reply. Perhaps, if Whittingham's predictions on the future of internal combustion are to be believed, when he next pulls up into the quad his car will need to be powered by one of his own lithium-ion batteries.