**Takeaway Science**
*Research Stories*

**Mike Bullivant**
Welcome to takeaway science – another in the series of short podcasts produced by BLAST! at the Open University. Later on Patricia Ragazone, who did her PhD with the OU, finds out all about nanotubes from researchers at the University of Nottingham. And BLAST!'s David Smith meets David Gambling, an associate lecturer with the Open University, to discover what life is like as an OU tutor. But first David – Smith that is – catches up with two researchers from the University of York, who are actually growing a cure for malaria. The interview starts with one of them, Professor Dianna Bowles, explaining what their research is about.

**Professor Dianna Bowles**
What we are working on is trying to increase the level of artemisinin in the plant Artemisia annua. Artemisinin is a key chemical, which is part of a treatment for malaria, and this treatment is recognised by the WHO to be the most effective treatment for malaria that exists. The problem is that the plants that produce artemisinin currently produce the chemical at quite low levels and so what we are doing is working to try and increase the levels of artemisinin in those plants so that the plants have increased yields of this important chemical. And that will stabilise the supply chain and enable much greater production of these important anti-malarials.

**David Smith**
So are you using genetics to increase the yield?

**Professor Dianna Bowles**
No we are not using genetic modification. We are – this is non-GM. What we are doing is exploring the natural variation that exists in this almost wild species and finding out how the plant makes artemisinin and then using that information screening for individuals that have high levels of this chemical and then putting them into a traditional reading programme.

**David Smith**
Why are you looking at the plants to produce this? Can it be made synthetically in the lab?

**Professor Dianna Bowles**
Well no it can't be made synthetically in the lab but interestingly one of our partners, globally, what they are doing is they have taken the genes from the plant and they have put some of those genes, the ones that they could find, into a bacterium and then cultured that bacterium in fermentors and they can get quite a long way down the pathway of making artemisinin. They can't quite get there but they can get quite a long way down the path. So this is another route to making artemisinin which is currently being optimised as well. But all of the economics of understanding the treatments and the forecast need for how much, how many treatments will be needed in the world, suggests that in a few years time we are looking for five hundred million treatments of artemisinin combination therapies, every year, which is like everybody in the population of Europe having to have this treatment every year. And it seems that from these economics that plants will continually have to provide the bulk of the artemisinin for these therapies, but the synthetic in the bacterial fermentation route may provide about ten to twenty per cent of what's needed globally.

**David Smith**
Are there any other uses for this compound?

**Doctor Elspeth Bartlett**
There is some work to develop artemisinin for other medical uses such as cancer, but they are still in a development stage, yes.

**David Smith**
But could you apply this research you are doing to other plants and other drugs?

**Professor Dianna Bowles**
Yes. Oh yes. And I mean you can apply it to whatever plant. And it's particularly true when you have plants that for example are almost wild species. I mean wheat plants or many of the food crops have been very, very highly developed over many, many years such as maize or wheat. And so in a way they are already quite well developed for traits such as yield. But when you are looking at a plant like Artemisia which is near wild, then there is a lot of scope for improvement.

**Mike Bullivant**
David Smith talking there to Professor Dianna Bowles and Doctor Elspeth Bartlett from the University of York's Centre for Novel Agricultural Products.

**Mike Bullivant**
Now, if you found that interesting, you might want to check out an OU course called "Biology, Uniformity and Diversity". It's a Level Two course that provides a broad foundation in biology at the levels of molecules, the cell and the whole organism. It also looks at the interactions of organisms with the wider environment. The approach taken by "Biology, Uniformity and Diversity" reflects modern biology, emphasising areas where research is developing rapidly and demonstrating the exciting and dynamic flavour of biology today. It takes as it's main theme the astonishing diversity of forms that develop from just a few basic life processes. The first half of the course deals mainly with these processes and how diversity arises from them while the second half examines examples from the kingdoms of microbes, plants and animals. You can check out the course by logging on to ww3, that's the numeral three, ww3.open.ac.uk/study. Click on the link to "Science" on the right hand side of the page and follow the link to biology courses. Well, earlier this year, Patricia Ragazone, who studied for her Chemistry PhD with the Open University, popped along to the Royal Society's Summer Exhibition where against a noisy background she got to talk to two academics from the University of Nottingham about the cutting edge research they are doing into building nanotubes from carbon atoms.

**University of Nottingham**
…. using carbon to hold single atom so this has been unthinkable before so we can do thermophysics effectively in the beaker. So we can study the property of the atom. And carbon nanotubes that can hold molecules that we can actually do chemical reactions inside carbon nanotubes so we can use it as a very small test tube and in fact we have the Guinness Book of Records for the smallest test tube in the world – yes. I think this is just a new way of doing chemistry and physics really so and unfortunately we don't have small fingers to handle molecules so we have a very clever and utilise properties of carbon structures to hold the molecules in position in the way we like.

**Patricia Ragazone**
How we're working the cellular membrane is for example making like a hole and changing the flux of potassium or sodium. Do you think that those cages in the future could be –

**University of Nottingham**
Indeed. You've got a very good question I think because there is already a group in the US who are actually working on trying to use the buckyball as drug release agents. So for example you can try and put your drug - substance inside the buckyball and then of course the buckyball is quite small. It can go into the, you know, the blood vessels and go into the human system and then you can target the release of the drug specifically at a tumour for example or something like that. But this is still at the early stage, mainly because we don't know much about the toxicity of this carbon structure as we said already and also we don't

know how effective this whole process is.  But I know that there is active research going on specifically in exactly the area you've just mentioned now.

**Patricia Ragazone**
Once it is in a certain environment, at a certain pH temperature ionic concentration, for how long it keeps that shape or it …

**University of Nottingham**
Buckyball is very stable. It keeps its shape up to about eight hundred Celsius.
It will decompose at some point but it's very, very stable. It's an incredibly stable structure. It's not very stable in very basic pH so if you have sodium hydroxide so it will attack it but under kind of physiological pH's, under normal temperatures, it's stable indefinitely. It oxidises over time so it's actually it's not an inert molecule.

**Patricia Ragazone**
Okay.

**University of Nottingham**
So the chemical properties of buckyball they are quite a different from chemical properties of aromatic compounds such as benzene because it's got this curvature effect on it so it reacts more like a double carbon. Like a carbon-carbon double bond. But it will react with oxygen over time and I'm sure some enzymes in the human body can metabolise it into something and eventually we will probably crack the cage.

**Patricia Ragazone**
Also you get for example like electricity or passage of electrons. I went once to a conference where there was a group in Japan that they were trying to, fibres of DNA - quadruplex DNA. They said that it could conduct electricity. It was a bit strange to imagine that – through the socket DNA – you would think it's going to blow up!

**University of Nottingham**
It's very controversial – conductance DNA – is very hot potato – I don't understand it.

**Patricia Ragazone**
And nanotubes?

**University of Nottingham**
Nanotube conductance is absolutely brilliant. In fact I can demonstrate.
Nanotubes can be both conducting or can be semi-conducting or they can be insulating as well. They have different types of – depending on the structure on how the graphite layer arranges itself in the forming of the tube they can have different electronic properties so Andre now will show you an example. You can do it yourself. Would you like to do it yourself?

**Patricia Ragazone**
Yes

**University of Nottingham**
Okay. So this is a two way process. You can see the device is working as it flashes when I attach them. Now we start with a diamond so we can test diamonds. So you put your cross on the diamond you see there is no carbon so clearly there is no free electrons in the diamond though …. in the spaces between the arc … binding there. Now graphite – let's test graphite. You can see that there is some conductance. It's not great but there is some. And now let's go to nanotubes straight away. That's a nanotube sample - see what happens. It's an excellent conductor. So it actually conducts like a metal and yet it's made of carbon. That's the amazing thing about carbon nanotubes. So to answer your question -  nanotubes are superior conductors. They are much better conductors than many metals around us. And that's why many people get excited about them because of their conducting properties.

**Patricia Ragazone**
How expensive are they?

**University of Nottingham**
It depends on the type of nanotubes. They come normally in two varieties. You can have multiwall carbon nanotubes which are quite cheap nowadays. You can probably buy a gram for ten dollars, five US dollars if they are made in China. And they're pretty good. Single wall carbon nanotubes where you have just a single sheet of graphite wrapped and are still quite difficult to prepare and they are quite impure and that is why I actually I am quite sceptical about biological tests with nanotubes because you don't know what you're testing there. So these tubes it depends on their purity. If you are talking about ninety nine per cent pure tubes they are quite expensive. You are talking about perhaps five hundred US dollars per gram. So it's more expensive than gold. But of course if you make a miniature device out of them you only need a few. So in a gram we have plenty to work with. So and of course you know technology for making nanotubes is improving every year so it becomes simpler and more scalable. And you know eventually, eventually I am sure we will see nanotubes produced by big industrial companies and of course the price will come down even further.

**Mike Bullivant**
Fascinating. Well if you think you're up to building a few carbon based molecules of your own then you might want to register for the OU's Level Three Practical Chemistry Course called "Organic Synthesis, Strategy and Techniques". Designed for experienced chemists the core of the course is a one week residential school, much of which is devoted to a laboratory based project aimed at planning and carrying out the synthesis of an insect pheromone. In the first part of the week you work as part of a team, exploring the chemo selectivity and stereo selectivity of carbon-carbon double bond formation, using the Wittig-Horner -Wadsworth-Emmons Reactions. Obviously not for the faint hearted this one. Later in the week you will carry out the synthesis of one of a group of pheromones, all of which contain at least one carbon-carbon double bond. Don't worry. You will be supplied with the detailed experimental procedures to be followed for most of the synthetic route but you'll need to use the information obtained from the group investigation earlier in the week for the synthetic step that involves formation of the double bond. Throughout the course you will, to varying degrees, gain experience of handling air and water sensitive chemicals. You'll use flash chromatography to purify reaction mixtures and gas chromatography to analyse your reaction products. You'll also record and interpret infrared and NMR spectra. To find out more about this hands on, largely residential, chemistry course, log on to ww3.open.ac.uk/study. Click on the link to "Science" on the right hand side of the page and then the link to "Chemistry".
And so to the final sequence in this take-away science podcast and it's linked very much to the sequence we've just heard. All Open University science courses rely very heavily on the university's associate lecturers, to guide students through the course materials and offer support when it's needed. Often academics from other institutions, the OU's associate lecturers, are the bedrock on which Open University science courses are based and BLAST!'s David Smith caught up with one of them – David Gambling – to find out what it's like teaching for the Open University. And he started by asking him what made him join the OU as an AL?

**David Gambling**
I joined – this was my first year so I did the residential school last year and very much enjoyed the interaction with adults, more from the fact that the age range is quite exciting to watch, people of all different abilities, all different backgrounds. And that's quite - quite refreshing. But it was more from the fact that I came in for an odd reason - through a change of career. So prior to the OU I held an academic position in Oxford and I spent a long time teaching organic chemistry there and spent a lot of my free time sort of in the books. I've now currently moved to take up a school teaching position in London. And I wanted to keep my Degree Chemistry open so with the OU it gave me the flexibility to just kind of work at home but still kind of having that refreshment of doing some slightly more demanding work than what I am currently doing at school. So it's kind of keeping my fundamental love open and give me a chance to sort of keep exploring different ideas with people that find the subject quite tough.

**David Smith**
If somebody out there is thinking of joining as an associate lecturer what would you say to them?

**David Gambling**
Do it! It's good fun and it – I mean it depends on the different level and what you're going in to. It's quite a lot of work. I mean you have to want to. I would say the Level Three that the students are pretty much geared to working independently so there's not a huge amount of contact at the Level Three which I think as you go lower down to Level One I think the students need much more hands on and sort of ideas of how they should be working and sort of putting together their own study programmes etc. But by the time they've worked through their degree the Level Three demands a much more independent approach and they've pretty much got that in place. So I would say it's … you don't necessarily have as much contact with students but then obviously the work is a lot more work to be looking at. And then obviously where you get a lot more time commitment is actually making sure that you've read their script properly, put appropriate comments back and try to make sure that you nip little problems in the bud earlier. So sort of pre-emptive marking as such. Yeah it's tough. You need some kind of flexibility and you need to be fairly organised in a sense. All the work does just suddenly appear so it's kind of you're not doing anything. That's great. I've got some money this month. Not going to do very much. And then all of a sudden you kind of get two-month's worth of work over a weekend. So you have to be quite sort of regimented and sort of plan your time around it. The tutorials are very good fun. You end up sort of maybe doing something around with the course I'm on about seven hours of tutorials, around that sort of number. And that's quite nice. You go to see your tutor group and they kind of give you their problems before hand and it's nice to see how they develop over time and you sort of do get quite a good relationship with your students. So it's again it's given you sort of it's not like a holiday but you can kind of – because obviously you're working - but it kind of is like a mini holiday to go and do something which you enjoy. And it's slightly different in one sense compared to the teaching I've done before. Because the students don't get much contact time with their tutor they really are very appreciative of any time or any energy you can put in and they're very grateful for it. And that's quite you get a much more sense of they want to be there, they want to listen to what you're saying than perhaps you would in other teaching scenarios.

**Mike Bullivant**
Two David's there – Smith and Gambling – shedding a little light on what it's like to tutor for the Open University as an associate lecturer. Now – are you interested in studying science but afraid that you missed out on science at school? Are you worried that your maths might let you down? Do you wonder whether distance learning is right for you? Well if the answer to any of these questions is "yes" – then you could do worse than register for the Open University's short course called "Science Starts Here". It's an introductory Level One course designed specifically for those students who've done little or no science in the past and whose maths is rusty or even non-existent. Taking the course will give you an ideal chance to find out whether further OU study suits you because it's a course that runs over a fixed ten-week period so you can put your toe in the bath water without committing yourself too much. As a narrative "Science Starts Here" explores the role that water plays in sustaining life from the journey of a glass of water through the human body to the effects of pollution. And in the process you'll learn about atoms, molecules and ions and how to read and interpret information communicated in tables, graphs and chemical equations. But don't be put off. This is very much an introductory course that will provide you with a gentle introduction to the basic writing skills, maths and scientific vocabulary needed for S104 – the Open University's sixty point interdisciplinary science course at Level One. But if you want to find out more about this or any other introductory OU science course, log on to ww3.open.ac.uk/study, click on the link to "Science" on the right hand side of the page, and follow the appropriate link under "Where to start in science". Well, that's the end of another take-away science podcast, brought to you by BLAST! at the Open University. For other podcasts in this series re-visit the Open University Science Faculty web site at open.ac.uk/science and if you want to find out more about some of the science outreach work carried out by the OU then visit the BLAST! web pages at blast.open.ac.uk. But that's all for now so from me, Mike Bullivant, adios amigos.