Published on *Up Close* (http://www.upclose.unimelb.edu.au)

Episode 11: Precision Drug Delivery with Nanotechnology

Precision Drug Delivery with Nanotechnology

VOICEOVER
Welcome to Melbourne University Up Close, a fortnightly podcast of research, personalities, and cultural offerings of the University of Melbourne, Australia. Up Close is available on the web at upclose.unimelb.edu.au That!|s upclose.u-n-i-m-e-l-b.edu.au.

SHANE HUNTINGTON
Hello and welcome to Up Close, coming to you from the University of Melbourne, Australia. I!|m Dr Shane Huntington and today!|s topic is Nanotechnology. The field of Nanotechnology promises many new innovations in many different areas. By working on the nanoscale, new materials with extraordinary physical properties have been developed. Our understanding of the interplay between the biological and the mechanical is enabling scientists and engineers to develop new solutions to many existing problems that we have in society.

A leading scientist in this exciting field is Professor Frank Caruso, a Professor at the University of Melbourne and an Australian Research Council Federation Fellow, from the Department of Chemical and Biomolecular Engineering. Welcome to Up Close, Frank.

FRANK CARUSO
Thank you, Shane.

SHANE HUNTINGTON
Now, first of all, let!|s get a feeling of what you think of as nanotechnology because this is a term that we hear a lot of the time. Can you give us a definition that you feel comfortable with.

FRANK CARUSO
In terms of nanotechnology, I see that as the application of nano science, and if we delve into several meanings of that, one common meaning is the !V the ability for materials to exhibit new and exciting properties, for example optical properties or

magnetic properties, primarily based on scaling down their size. As a result of those new material properties, one then is able to take these !V these materials and assemble those into different structures or exploit them as they currently are to design new devices with new functions.

SHANE HUNTINGTON
What sort of big questions or big issues are being investigated in the sort of nanotechnology space world wide?

FRANK CARUSO
So, water, energy, health tend to be three of the !V the main areas and our particular interest is in the !V the !V the biomedical arena.

SHANE HUNTINGTON
I guess just for our Up Close listeners, are there any products at the moment that they would find on the shelf that have, actually, you know come from nanotechnology science research?

FRANK CARUSO
Yeah, again, if we focus into my particular area, in terms of drug delivery type systems, there!|s a couple of companies that have already products on the market in relation to those.

SHANE HUNTINGTON
Frank, your particular area, I guess, is !V or the area you !V you focus on the most is polymers. Let!|s just take a step back and talk about what polymers are and where we see them in the world.

FRANK CARUSO
Yeah, polymers have been used extensively for many decades in our every day lives from polymers used in automotive vehicles, polymers used, for example, even in the chairs that we !V that we sit on and also high performance polymers used in aircraft for example, and paints and coatings in addition to that. So, polymers are !V are used widely. The type of polymers that we!|re interested in are polymers that are largely compatible with the human body and those polymers may be for example, also biodegradable. So they would degrade in the human body.

SHANE HUNTINGTON
Just before we get to your work, are polymers environmentally friendly? Do we have problems with polymers, what are the effects of using them?

FRANK CARUSO
There are polymers, obviously, that are !V are not biodegradable. And those particular polymers if, for example, they get out into the environment and plastic bags are a classic example, they can have serious environmental effects. So there is a need, of course, to have a look at where polymers are being used and what the particular applications are, and to !V and to manage any risks associated with the environment in use of those materials, just like in any new technology, including

nanotechnology,

SHANE HUNTINGTON
Now your particular polymer of, I guess, choice is one that I guess most people wouldn!|t consider a polymer. Tell us a bit about that and !V and, I guess, some of the advantages of looking into it.

FRANK CARUSO
For quite some years we have been working with a whole range of different polymers and many of those would be commercially available and used widely in various applications. About four, five years ago we became interested in DNA, and many of us would be familiar with DNA and the double helix structure that it adopts in nature. Our interest in DNA stems from a number of factors, one of those is because DNA actually is a polymer that we can exploit its programmable nature to assemble new materials from and !V

SHANE HUNTINGTON
So !V so when you say that DNA is a polymer !V what does that sort of mean structurally. I mean how does !V how does a polymer differ from for example you know wood or a metal or !V or other materials that we commonly see?

FRANK CARUSO
In this case, when we!|re talking about polymers, we!|re talking about organic materials and these are made up of monomers that are linked together. A monomer is a small molecular weight, organic material in this case, that is linked together to form a longer molecule which is known as a polymer.

SHANE HUNTINGTON
So a chain of organic molecules of some type and when you get enough of them you link all these little pieces together just like a chain and you end up with a polymer and !V and these can form I guess structures that are exceptionally strong, as you said in !V in planes and so forth or chairs and that, or quite different structures like DNA and like plastic bags.

FRANK CARUSO
Indeed so. And DNA is also a bio-polymer given its wide presence in nature. Our interest in DNA is that we take an individual polymer molecule and we assemble individual layers onto surfaces. And so essentially if you look at building the well defined layers sequentially, so one after the other on a surface and each layer that is deposited has a specific recognition, for the previously deposited layer.

SHANE HUNTINGTON
Right.

FRANK CARUSO
So hence, comes the !V the term programmability in terms of the polymer that is absorbed for example as a second layer onto the first layer, specifically recognises that first layer.

SHANE HUNTINGTON
So, you can only put them in a certain order?

FRANK CARUSO
Yes. Yes. And that!|s indeed correct and so the advantage now is that we can control the characteristics of the final material, because we!|re using DNA as a building block to assemble more complex materials.

SHANE HUNTINGTON
And with this ability to construct things I guess we should try and !V and give our listeners an idea of the scale we!|re talking about here. So that the human hair is about what, between 50,000 and 80,000 nanometers in diameter. How thick are these we!|re talking?

FRANK CARUSO
So typically in !V in these particular systems we!|re talking about one to two nanometers per layer, which is very thin. We tend to call this ultrathin and we have control over the thickness of those layers as well. We have different techniques that we can use to process these layers, but not only the fitness but also the composition. We can control for example, the composition of each layer in the final material.

SHANE HUNTINGTON
How do you see that the layers are actually there?

FRANK CARUSO
We use advanced spectroscopic techniques and advanced optical techniques to determine that the layers are there, including a highly sensitive gravimetric sensors which are effectively mass sensors. So we can weigh down to a !V a couple of nanograms of material on a surface.

SHANE HUNTINGTON
That is absolutely amazing, so you can actually weigh the layers you!|re putting down. Okay, let!|s move forward then. So you!|re putting these layers down, what!|s their function like, what are they then designed to do?

FRANK CARUSO
For example, if we take one particular example that we!|re interested in and that is creative advanced materials from, for example DNA or other biocompatible and biodegradable polymers, and we!|re specifically interested in using these as a vehicle for delivering, for example, drugs, vaccines or genes. And so, it is important, of course, to understand the properties of your delivery vehicles if you!|re going to use those, ultimately, in a biomedical application.

SHANE HUNTINGTON
So, you would actually in some regard here attach what you wanted to deliver in some way to a DNA strand. Tell us, how does that work? I mean, how does that then get into the body?

FRANK CARUSO
So, for example, the first step in this process is to construct a vessel and in our case it!|s a hollow vessel that we can then specifically and selectively load with certain drugs. And the DNA as we!|ve been discussing forms the !V the vessel. So the vessel is composed entirely and solely of DNA and we use the properties of DNA to actually control how we can put drugs in and how they!|re released as well. So it!|s very important to understand the structural properties and others of the DNA layers because they govern what we can actually put into the vessel and !V and release ultimately.

SHANE HUNTINGTON
And, looking at existing drug techniques, I mean we !V we see a lot of different mechanisms for getting drugs into the body these days. Nicotine patches, for example. There are !V there are spray !V you know nasal or delivery systems, there are you know obviously injections, orally, all sources, suppositories and so forth that we can use. What !V what advantages does this sort of mechanism have over that array of potential delivery systems?

FRANK CARUSO
Our aim is to !V is to engineer an intelligent drug delivery system whereby within the actual system one would have the drugs that are loaded and then depending on the specific application, those drugs would be specifically targeted to a particular site in the body, through, for example, receptors that we!|ve attached onto these DNA receptors.

SHANE HUNTINGTON
So, these are !V receptors are like I assume little antennas that tell the DNA when certain things are nearby. Is that !V

FRANK CARUSO
Yes, so for example an antigen would be able to specifically seek out an antibody on, for example, a cancerous cell. And so, that!|s one of our aims: to specifically attach these antibodies onto our capsules that, then, can selectively target cells, and that should be able to maximise the therapeutic effect of the drugs in the particular area of the cell. And that!|s !V that!|s in the area of targeted drug delivery. And so, the engineering of the polymer structures is very important of course and they!|re bio-compatible and bio-degradable properties, and also how they eventually allow the drug to be released is important as well.

SHANE HUNTINGTON
And I suppose the biocompatibility part is !V is important from the point of view of how the body reacts to the delivery system itself in addition to the drug, is that !V is that correct?

FRANK CARUSO
Yes, that!|s correct, and that!|s why it!|s important to start out with biocompatible, biodegradable materials.

SHANE HUNTINGTON
You!|re listening to Melbourne University Up Close. I!|m Dr Shane Huntington and we!|re speaking with Professor Frank Caruso about Nanotechnology. Frank how far along are we with this sort of work. Are we, you know, still a decade away from actual use or is it in the clinical trial phase. I mean where !V where are we at there along that pathway?

FRANK CARUSO
In our particular case there is still quite a lot of ground that needs to be covered. The !V the antibodies that we!|ve been working with are actually in clinical trials at present, phase 3 clinical trials. The !V the actual systems and the application thereof of those systems are many years off yet.

SHANE HUNTINGTON
I guess the fact that you are so closely linked with some of the !V the medical research institutes is !V is a good thing too because it allows you to you know even at the early stages of the work, interact on an ethical base that they have firmly placed in their !V their mindsets, and that sort of must flow over a bit.

FRANK CARUSO
Sure and the !V the medical institutes have of course their own risk assessment systems in place, and of course, we adhere to those. And so we!|re privileged to be able to work with world class medical institutes that have that infrastructure and !V and we can work with them in order to work on a project that hopefully will have ultimately an important outcome in the health area.

SHANE HUNTINGTON
And !V and Frank I guess just a sort of final question there if !V if you had a message for the !V for the general public and for the Up Close listeners with regards to what they should expect to see coming out of Nanotech in the next few years, what would that be and !V and how would they get more involved?

FRANK CARUSO
Sure, nanotechnology is underpinning a lot of developments in the diverse range of areas from computing to diagnostics and therapeutics, so, in the health area to advanced materials, lightweight materials for example for aircraft, or even in the automotive industry. So, many breakthroughs in the area of nanotechnology are poised to have significant outcomes on society.

SHANE HUNTINGTON
Professor Frank Caruso, thank you very much for joining us today on Up Close.

FRANK CARUSO
My pleasure, thank you very much.

SHANE HUNTINGTON
The Up Close team would like to invite anyone listening to our broadcast to provide

feedback and comments and views on the topics that we discuss and we are inviting you all to do that and the details are listed at the end of the podcast. You can contact us through our website.

Melbourne University is brought to you by the Marketing and Communications Division in association with Asia Institute of the University of Melbourne, Australia. Our producers for this episode were Kelvin Param and Eric Van Bemmel. Audio recording by Craig MacArthur. Theme music perform by Sergio Ercol. Melbourne University Up Close is created by Eric Van Bemmel and Kelvin Param. I!|m Dr Shane Huntington, and until next time thank you for joining us and goodbye.

VOICEOVER
You!|ve been listening to Melbourne University Up Close, a fortnightly podcast of research, personalities and cultural offerings of the University of Melbourne, Australia. Up Close is available on the web at upclose.unimelb.edu.au, that!|s upclose.u-n-i-m-e-l-b.edu.au. Copyright 2007 University of Melbourne.
