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Episode 29: Engineering Ice Cream

Engineering Ice Cream

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

ERIC VAN BEMMEL
Hello, Eric van Bemmel here from the Up Close podcast production team. As we enter the summer holidays here in the southern hemisphere, Melbourne University Up Close presents a special summer season of science. A mini-season of three specially produced fortnightly episodes, each featuring a young scientist in brief conversation on their specialised area of research. In this episode, the first of our summer season, we join Up Close science host, Dr Shane Huntington as he speaks with chemical engineer, Dr Ray Dagastine of the Department of Chemical and Bio-molecular Engineering, here at the University of Melbourne, Australia. Dr Dagastine looks at emulsions and the role they play in our everyday lives.

SHANE HUNTINGTON
Welcome, Ray.

RAY DAGSTINE
Hello, thank you for having me.

SHANE HUNTINGTON
Now, you work on emulsions, so, give us the low-down, what are emulsions?

RAY DAGSTINE
So, emulsions isn!|t a terribly exciting title. Emulsions, technically, are just mixtures of oil and water, where the two liquids are miscible but one is broken up into tiny droplets. Best example you can think of, an oil vinaigrette salad dressing. When you shake it up, you!|ve got a bunch of oil droplets moving around in the water. And so, that wouldn!|t be an emulsion !V if you just have the oil on top, it would just be oil and water. But when you actually shake it up and it is a mixture of oil droplets and water,

or water droplets and oil, that is when you have an emulsion.

SHANE HUNTINGTON
But, it doesn!|t stay that way, does it?

RAY DAGSTINE
Well, that!|s the problem about emulsions. With salad dressing, we know, if we set it on the counter, and let it sit there over time, it will separate out !V the oil goes to the top. Now, that process is fine in salad dressing. We just shake it up again. But a lot of products we use in our everyday lives are made up of emulsions. Shampoo, for example. And if our shampoo separated when we went to use it, instead of getting shampoo we!|d get this oily mess in our hands. We wouldn!|t want to put that in our hair at all. So, dairy milk, ice cream, they are great emulsions. Ice cream is rather popular summer time emulsion. Also, drug delivery systems such as pharmaceuticals can also be emulsions. So, they are in our everyday lives in a lot of ways, but we don!|t generally see them or think of them that way.

SHANE HUNTINGTON
Now, obviously there is a lot more work that goes into something like ice cream or shampoo compared to salad dressing which is just me mixing the two together at home, what kind of work does go into making something like ice cream, not separate?

RAY DAGSTINE
So, what goes into making the ice cream not separate? I just want to steal the salad dressing example for one more second. In this salad dressing, we!|ve got all these tiny little droplets, moving around, colliding with each other. And you could think of it as two large beach balls; when they collide with each other, they can bounce off. They deform a little. That is because they are oil drops and they are soft. But, sometimes they bounce together and they stick. Imagine the beach balls had velcro on them. And what makes them stick or hold together or bounce off are actually the surfactants. Or, the molecules are effectively the velcro, they are making the velcro really smooth. And so, the molecules which are really surfactants stick to the outside of these oil drops are the things we add in. Now, salad dressing doesn!|t really have surfactants. But shampoo and ice cream, those are all surfactant systems. So there is molecules at that interface and they really control or affect how those collisions happen.

SHANE HUNTINGTON
Surfactants are soaps, is that right?

RAY DAGSTINE
Surfactants are soaps; technically, surfactants are called !¢Dsurface active molecules!|. Which just means they like to be at interfaces. So, there is an interface between where the oil meets the water. And, chemically, surfactants love to hang out there, as opposed to just in the water or just in the oil. They!|re very social molecules. They like to be at the edges. And so, surfactant soaps are just the most

common form. But a lot of different things other than soap work as surfactants. In fact, a lot of their proteins, in milk, like you!|ve heard term !¢Dcurds and whey!|, well, sometimes whey proteins can be used as surfactants as well. So, there is a whole range of molecules that are surfactants. Soap is just one class.

SHANE HUNTINGTON
Now, you mentioned before that you work on a very small scale as a chemical engineer, what exactly do you do? I mean you don!|t have ice cream and salad dressing, I assume, in your lab, but you are mimicking these conditions, somehow. How does that work?

RAY DAGSTINE
Well, yes, that is a good point. Actually, working on ice cream would be kind of cruel because we!|d have to put everything in a freezer, put on parkers, and it would like an experiment, although working with ice cream has, of course attractive plans for dessert at lunch. So, what we do is use a collection of nano-technology tools to actually look at the collisions of oil droplets on the nano scale. But, back to that beach ball example where you collide two beach balls together, we would do this under water, but we actually scale the whole thing down. So, the size between the beach balls get to be about 100 nano meters apart. Maybe 50 microns wide. So, maybe the size of the thickness of your hair. And we do this in a very controlled environment. So, it is a rather fundamental measurement. By doing this fundamental measurement in a controlled environment, where we can drive these two drops together, put in different surfactants, different molecules to coat those oil drops, we can get behind the fundamental physics that helps us make a better shampoo or understand the problems in ice cream when it separates. Because a lot of the physics behind that doesn!|t always have to always reside in the application. We can use it to understand the application.

SHANE HUNTINGTON
When you scale these things down in this sense, obviously the forces of interaction are not like what you get between two beach balls, they are significantly smaller, how do you go about actually measuring, I guess and characterising these forces?

RAY DAGSTINE
We use a very tiny force measurement tool. It is actually called an atomic force microscope. It!|s just a very sensitive spring. But the spring is, again, 2[00]-300 microns long, so, you can still see them by eye if you have reading glasses on, or if you really stare, but it is a very, very sensitive spring. So, we attach an oil drop to that spring then we actually attach an oil drop to a surface and we can drive them together with something that is in very controlled fashion. We use something that is called a Piezo tube. And basically, it is a distance actuator but it is on a small scale. And the remarkable thing about small-scale distance actuators is you think, well an actuator is just a motor. It can make anything move. Like a car, or even, a garage door opener. But when we try to do that on a small scale we have problems, because gears cause friction and kind of kick back. So, what we have is a special ceramic that actually works on an electric current and we are able to give smooth

motion when we do this on a very small scale. So, that is how the instrumentation gets very complicated. Just because we want to be able to manipulate things in a very controlled, smooth, clean motion as we simulate our collision and drive two droplets together.

SHANE HUNTINGTON
These forces are so small, this small spring must be incredibly sensitive to actually determining what those interactional forces are and I guess, you talked about deformation, are you able to talk about the deformation with this instrument?

RAY DAGSTINE
The forces are actually so small that if the room temperature were to heat up by two degrees, we would see this little spring bend. It is that sensitive. But to actually understand how much we are deforming the drops we work with the mathematicians to actually help model our experiment, so, we are able to analyse from a very fundamental standpoint the data and the measurement we are doing and the model lets us understand beyond the physics or beyond what we even can measure. And so we can go from just doing the measurement to understanding it and possibly being able to be predictive. And so if we understand what is going on, we could change the molecule and possibly predict what would happen without having to do so many experiments.

SHANE HUNTINGTON
Where does this work that you are doing, in particular, lead to?

RAY DAGSTINE
So in all of the cases, for a shampoo or an ice cream, we actually, typically want stronger expectations out of most of personal products in our everyday lives. So how do you improve that? Well, shampoo works. Soap has worked for a long time. We!|ve had soap around for quite a while. And as it turns out, it is not that hard even to clean hair with soap. But to actually get the conditioners to work is a bit trickier. So, a lot of it is improving these products, making them better. But to give you an example of why that can have impact, well, if you have a shampoo that works better than maybe you need less of it. Well, that would use less water, possibly, certainly less soap, we!|d have less soap running down the drain. The idea of controlling emulsions with surfactants has implications in industries like mineral processing. And they actually, in some of their processing, use emulsions. And if they could understand those better they might make a small improvement. But in the minerals industry, a very tiny improvement because of the scale can be millions of dollars. So, we have the potential to really impact a whole range of fields in making things better. If I can go on, to that end, we are actually, working with a personal care products company. So, we have gone from doing our fundamental measurement to actually working with a company to help develop their next generation of technology that they!|re going to put in their products. In the dairy industry, if we can actually find where surfactants can work better in emulsions we can actually help Australia develop new products for new export markets. And since in Australia specifically, the dairy industry has a very large export market that has the potential to translate into

some real payback to Australia as well.

SHANE HUNTINGTON
Now Ray, one last question though I need to ask you is, I can!|t imagine when you were in high school, you looked ahead and said, !¢DI want to be studying two very small, one tenth the size of my hair, bubbles of oil interacting with one another in the near future!| - I mean, what got you into this particular field? It is quite an unusual field, but quite an important one at the same time.

RAY DAGSTINE
I have to admit that I didn!|t even know about the field of emulsions and there is a larger field called colloids, which is basically, emulsions or particles in emulsions !V what really got me into that, I had a pretty strong interest in chemistry and math in high school. And so, I followed that into chemical engineering, which actually was this huge area I didn!|t realise !V most people don!|t have a feel for what chemical engineers do. Chemical engineers basically bring physics, chemistry and math together to do things on a large scale. Now, when we do that on a large scale, there is a lot of different times in chemical processing where you worry about emulsions or mixtures of particles in water, and so chemical engineering a lot of times is distillation in very large-scale chemical processes. But in all of those you have these interfaces with molecules and surfactants so I got interested in it from more of a processing point and then said, !¢Dyou know there!|s a lot of really interesting chemistry and physics behind this and I!|m just fascinated by the fact that these things which act over such small scales, 100 nano meters or less, can have such a large impact on whether or not it separates, whether or not it flows and they can really impact our everyday life, even though they!|re so tiny.!|

ERIC VAN BEMMEL
That was Up Close science host, Dr Shane Huntington talking with chemical engineer, Dr Ray Dagastine. Melbourne University Up Close is brought to you by the Marketing and Communications Division in association with Asia Institute of the University of Melbourne, Australia. Relevant links, a full transcript, and more information on this episode can be found on our website at upclose.unimelb.edu.au. We also invite you to leave your comments or feedback on this or any episode of Up Close. Simply click on the !¢Dadd new comment!| link at the bottom of the episode page. This program was produced by Kelvin Param and myself, Eric van Bemmel, audio recording is by Craig McArthur and the theme music is performed by Sergio Ercole. Melbourne University Up Close is created by Eric van Bemmel and Kelvin Param. Until next time, thanks for joining us. Goodbye.

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