Western Science

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EPISODE TITLE

Can Metals Help Heal the World?

PODCAST SUMMARY

Precious metals don't just exist in Lord of the Rings. Western University researcher Martin J. Stillman joins the show to detail how antibiotics are able to morph themselves into the perfect puzzle piece in someone's body, the chemical bonds required for photographs, and the issues surrounding mass solar cell implementation in neighborhoods just like yours.

INTERVIEW

Henry Standage 0:29
Hey, welcome to the Western science speaks podcast. Today, we're lucky enough to be joined by Western chemistry professor Martin Stillman. Martin has been at the forefront of innovation concerning metals within chemistry for the best part of 50 years. His work is capable of looking inward, such as looking at the effects of metal delivery can play with them biology, as well as outward - he's long been at the forefront of solar technology, innovation and implementation, he was gracious enough to come on the show to discuss the forward thinking nature of his research, and what he thinks the future holds for humans biological relationship with metals. Later on, we talked about the likelihood of universal prominence of solar cell technology in neighborhoods just like yours and mine. Here we go.

You describe your research area as being bioinorganic chemistry. So why don't you tell us the distinction between that and bioorganic chemistry and everything that encompasses.

Martin Stillman 1:37
Yeah bioinorganic chemistry is a sub discipline of inorganic chemistry, which therefore, makes it quite different than the subdiscipline of organic chemistry. In bioinorganic chemistry, the interest is in metelines and their interaction with biological molecules, that is, interaction with physiological chemistry. Those molecules of course, could be considered to be bio-organic chemistry, but it is the metal-ion interaction that's important. And it is said, because this is something you can't count as easily, that over 30% of all enzymes involve metals. In other words, the metals carry out a critical role in physiological chemistry that makes it very much an inorganic chemistry of the biosphere. That's the difference between bioinorganic chemistry therefore, and bioorganic chemistry.

Henry Standage 2:26
Yeah, you say that your research concerns metal ions in the body, does that include only essential metals?

Martin Stillman 2:33
Now that it's a very good point. Well, I said that about 30% of all enzymes involve a metal and then there are many other metals that carry out functions such as nerve impulse, muscle activation, and so on. These are the essential metals, the ones that we tend to call the minerals, but the body is also impacted by toxic metals and bioinorganic chemistry plays a very important role in understanding how those toxic metals interact with the same proteins that the essential metals do. Toxic metals, of course, are in everything we eat, and we are dynamic organic entities, so that everything in our body is turning over all the time. So therefore, the toxic metals quite often are flushed out to get there at very low levels. So, if you eat some cabbage grown in, well, at the moment, leafy green vegetables grown in Holland Marsh, because it's near an industrial site and near heavy duty urbanization, there will be lead and cadmium in those leafy green vegetables. That's because it gets washed out of the air or it gets incorporated

from the soils, but their such low levels that we can cope with them. The problem and a major part of bioinorganic chemistry concerns what happens with much more toxic metals or metals that are toxic in much greater concentrations. There are numerous outbreaks of heavy toxicity, meaning toxicity that kills a fraction of the population or mains them. And at the moment, for example, in Northern Ontario, by Dryden, we have a lot of mercury that was spilled during the pulp and paper industries 50 years ago, that now is polluting the waters and is absorbed by fish and the fish are eaten by population. That side of bio inorganic chemistry is critical to understanding how these toxic metals impact human health.

Henry Standage 6:17
How dangerous is it for a healthy cell to receive that?

Martin Stillman 6:22
Almost all these metallo drugs are very toxic. And, I think this is quite general from many of the anti cancer chemotherapy agents, that is, drugs you take, and radiation, you wouldn't want to have either exposure to those drugs or exposure to the radiation if you're healthy, because in both cases, there is damage, but it's no payoff in the risk and the benefit, the benefit is if you can kill the cancer cell, then the rest of the physiological chemistry can recover. So particularly chemotherapy is pretty tough. The biggest, the most well known of the metallo drugs used in chemotherapy is called cisplatin. It's a platinum-based molecule. And exposure to that is deadly for the kidneys. In other words, when it is released, when it's put in the body and it flushes out through the kidneys, it typically causes immense damage to the kidneys. But there is a way around it. And what one does is one co-administers bismuth salts back to bismuth. And that enhances the production of protein I talked about before in the kidney, and therefore, as the platinum comes through the metallo binds the platinum drug, and then it excretes in much more safely and preserves the kidney function. So, you get around the problem, but you wouldn't want to do any of this, if you're healthy.

Henry Standage 7:59
Now I'd like to transition and talk about some of your research regarding solar technology, I think a lot of our listeners would be surprised to know that this technology has existed as far back as 1839. Why is it that only more recently we've seen it arise as a modern mainstream alternative technology?

Martin Stillman 8:20
The simple answer is that we are looking for green sources, renewable energy sources. And so, we have been coming in this province. We have done this continuously, we call our electricity, hydro, which, of course, it isn't hydro, it's just because hydroelectric power generation dominates Ontario's power production. The issues with the secondary level after that in Ontario, particularly, is that you have to decide how you're going to generate power and we use coal a lot, Canada has a lot of coal in the West. But the coal is dirty. When it burns, it's very polluted, this causes a lot of pollution. And so, in closing down those coal power stations, Ontario is very good. There's still coal generation in Canada, but in Ontario, we've closed down them, including amongst the largest in the world. And you have to replace that generation with something. And that something is complicated. We have nuclear generation, which is clean and neat and tidy. The problem comes in varying ways but to some extent, the Canadian accounting system is fairly clean and the easiest place to leave it is under water. And they're safe reactors, but of course, you know, they're expensive. So, you look around for alternatives and the alternatives amongst others are geothermal. So you dig a big hole and you get energy out of the heat, like out of the ground, there's a interesting thermal system with pipes going out into Lake Ontario in Toronto, same sort of idea, change of temperature, or you use the wind and you have wind turbines. And finally come back to solar. Solar has the advantage of being really portable. You can generate, you can put solar panels on the roof of your house and generate electricity. You don't need a massive mask to put a turbine on, and so on. So, advantage of solar is portability. Now, previously, the solar panels were very expensive, and there were only a few ways of generating enough power. You notice now if you go in the car, driving along an empty country road, you come along, come to a stop sign. You'll see the solar panel above it, that we're just running. This is not connected to the infrastructure, the electrical infrastructure, it's running off the solar panel. So those types of usage have become economical and that is generating the progress because as the panels become cheaper, as the panels generate more electricity per panel, they become more cost effective.

Henry Standage 11:17
Say my local neighborhood decides to exclusively run on solar power, where does your research interests and overall vision within this field come into play?

Martin Stillman 11:28
Our conceptual interest is based on the solar village, the isolated village, so you have an off grid subdivision, so I said a village I should've say subdivision, but villages are already in place. And if you have a concept of saying let's develop a new subdivision, and we're not going to connect it to the grid, so we save a vast amount of money - don't need a big power line coming in. So how are you going to generate enough power? What is your concept of the subdivision? So, let's say you have 100 houses, these hundred houses all connected together today that's easy. And each of those houses go down a big base battery in the basement. Not so easy, but doable. Now you have to say, well, where are you going to put the solar panels, currently you have to use the silicon type panels which are rigid, not flexible, and heavy and expensive. And they're the ones we see everywhere, especially in living in London. If we go outside, we go past farms, we see these great panels, they produce the electricity, but they are expensive. What we think should happen is that the house roofs on all your houses should essentially be the solar panels. And there are two ways of doing this. One way is to put a polymer on top of the roof. So, the roof tiles, not shingles in this case, we would actually have tiles, as in Europe, lots of tiles on the houses. Those tiles would actually solar cells, and you would have a polymer attached to the top because otherwise it wouldn't be strong enough and that polymer has to absorb light. And the question is, what dye do you use, the die has to be robust, tough, and it has to be able to be inserted into a dye and then into a polymer, and then a whole lot connected together. So if you look down on this subdivision, all you will see is particularly green or blue, greenish, bluish tinge of these roof tiles, there would be no obvious solar panels, but in fact, every single roof would be a solar panel. So, our research is aimed at that dye. How can we improve the function and the efficiency of the dye and if we can, can we improve the stability of the dye, because it's got to sit under the sun a long time.

Henry Standage 13:57
So, let's go through that process. What relationship does the dye have to the photons it's absorbing? What is the attraction?

Martin Stillman 14:07
Yeah, that is, is a good question. Just look at any leaf. And there is your dye. And you say, okay, so that's a green leaf. So, it's chlorophyll. So, what's it doing? Well, what the chlorophyll does in the green leaf is absorb photons in the red region. So, 617 nanometers, just on the edge of our visual, visible region that our eyes can detect. So just on the edge on the red, because it absorbs the red it leaves the yellow and blue, and therefore looks green. So, the colour we see is actually white light reflected back to us. So those red photons that are absorbed have a certain energy, something in the order of 1.5 volt a battery, so you get that amount of electron volts out of it. Having absorbed the light, the way it works, is that the Donnie has a vatable electrons, cool guys have Evie. And those electrons are excited into an excited state at a certain energy with quantum mechanics. So, it's a fixed energy that once the electron gets up into the excited state, it now has that amount of potential energy. You could think of it as saying, if you think of a basketball net, if you throw a ball up into the top of the net, when the ball comes down, it has potential energy so it doesn't come down slowly. It's of course attracted by gravity, but it comes down at quite a rate because of the potential energy. If you put that ball in the net onto a turbine like a windmill, no sorry, watermill, then the turbine will go around, you could generate electricity from the ball falling into that water mill. Same thing happens in our electron electrons in the excited state. If you trap it incoming down, it generates electrical energy. And that's how the solar cell works as I will leave worms, the leaf does exactly that it traps the electron in the excited state. And by trafficking it through the membrane, it picks off the electrical energy on its way down. And you can do various chemistry with it in the leaf. The point is to reduce a precursor to the production of sugars. In our case, we don't care where we put the electrons, we just want to store them. So, we do the same thing as the leaf, we trap them. And then we put the electron say into a battery, we do work with it, we could turn them, we know we can do what we like, but we do work where the dye works then is it picks up solar energy which is free. The solar energy is converted into potential energy by exciting the electron into the excited state. And at that point, you do what you can do with it.

Henry Standage 16:52
It's imitating some of the natural processes that occur in leaves, right, which is which is really cool. But are there any other examples Have this in your work where you have to design the technology, obviously, but the inspiration is actually all around you.

Martin Stillman 17:09
The factory is not very efficient, not only doesn't leave not really absorb as many doesn't absorb photons at the rate it should do. It also is so energetically dangerous for the leaf that about every 20 minutes, everything is remade. So, this is continuously remaking the system. Now, we can't do that. So, our designs are based on molecules that look like chlorophyll. But they're designed to be tougher than chlorophyll because we can't we make, we don't have a mechanism in our polymers to remake them, we have to make a molecule that can last five or 10 years without getting bleached.

Henry Standage 17:47
I'm going to put you on the spot a little bit here. So, you look at two different types of chemistry one inside the body and one in nature. Which one do you think is developing at a faster rate? Which one do you think we're at a better spot in, in 2020?

Martin Stillman 18:05
Yeah, well, you know, like you asked a musician. Which piece do they really like? What's their favorite music? The musician will say, well, the piece I'm playing now, in other words, and then if they play a different piece. So, I've been doing this job for a long time. I actually enjoy the challenges of each project. You can't really place them on a trend line. We're not engineering because tomorrow can be a hold up, that would stop us for six months. And this is one of the problems that you can be paused - you think you're going fast and then something can slow you down. So, I think all of it, in my bioinorganic group, and we call ourselves a the Stillman bioinorganic group, all of us. The very many students who've come through, researchers who worked with us, each of their projects changed our understanding of the world either from a technological point of view, or from a physiological point of view, and each contributed to knowledge. And that knowledge in time permeates. So, I noticed some papers of ours, people now pick up and say, they're 10 years old, and they say, now knowing this, well, you know, we knew 10 years ago. It's only become appropriate today. So, you can't predict the future. I'm reminded of the Nobel Prize that was just was recently awarded to physics and it was awarded for the development of compressing a laser into very sharp fine packets which allowed certain types of optical work to be done, but that work was done 20 years ago, but only recently was it recognized as being so unique and so fundamental to the optical community and to technology, that she received the Nobel Prize. We don't know what your work is doing, really until 5 years, 10 years, 15 years later, you look back to say, well, what changed the world?

Henry Standage 20:17
Speaking of things that change the world, what's next in solar cell implementation?

Martin Stillman 20:23
I think getting the dye polymer mix right. So that we get stability, because when I said that we absorb photons, so we designed dyes that absorb more photons in a better wavelength range than the leaf and, therefore very good contenders to act as absorbers of light, especially low levels of light. And of course, in the Northern Hemisphere, it was on a day like today, if we're very bright. We need to absorb light as wide a range as we can, even into the dusk, because that's the issue with solar cell, of course, is that when the sun goes down, we don't have any solar photons. But there are photons. They're just very weak photons at that point.

Henry Standage 21:12
So, we'll end here as somebody with an extensive knowledge of the relationship certain metals can have with the cells in my body. What would you recommend I stay away from digesting?

Martin Stillman 21:26

Well, I think you're okay. I think, old tuna, certainly, mostly in Florida, but you can't go to Florida or anywhere at the moment, but most fish in the Gulf of Mexico, warm water, fish. Big, large warm water, fish, shark and so on. They are loaded with mercury. And so there was a very good survey, a good study issued by the National Research Council of Canada in the 1970s, a long time ago and these researchers in northern Quebec, north of the St. Lawrence measured the madhumita Mercury, the very dangerous neurological poison of mercury. They measure that in the blood within one hour and two hours after eating fish that was just taken from the St. Lawrence. So this is their normal life. The fish were their typical source of protein. And the scary part was that the blood level of mercury shot up. They then compared the blood level of mercury with neurological issues reported by the community. And it wasn't one to one because it was very close, though, to a linear trend. So the more fish you had, the greater the chance was that you would have neurological issues and this went all the way from not sleeping all the way to dementia so unfortunately in Canada, because we are surrounded by waters full of fish, unfortunately in many cases those fish are not safe. Now, does that mean you should stop eating tuna or stop eating shark? No, you just don't eat them every day or every, you know, more than once a week. And you just have to check where they come from.

Henry Standage 23:24
So, we'll wrap up there. But thanks so much for coming on.

Martin Stillman 23:28
Thank you for inviting me. And it's interesting to do this and I think it's very important, actually.

Henry Standage 23:34
Well, you did a great job. So, thank you.

That concludes another episode of Western Science Speaks. If you enjoyed the show, subscribe to us on Apple, Spotify and PodBean by searching westernuscience. You can find previous episodes of the show at uwo.ca/sci/podcast. For now, I'm Henry Standage, signing out. Thanks for listening.