PODCAST #2 TRANSCRIPT: “Tribology in Biology” with Alison Dunn, PhD student, University of Florida

KARA: Hello, I’m Kara Lemar. Welcome to the STLE Compass, brought to you by the Society of Tribologists and Lubrication Engineers. The STLE Compass is your convenient and reliable resource for the latest industry developments.

This is Episode Two of The STLE Compass and today’s topic is biotribology. Tribology is concerned with the study of friction, lubrication and wear and biotribology simply applies this study to the human body and biological systems. Biotribology is one research area that welcomes interdisciplinary research and welcomes a diversity of disciplines getting involved with this research.

According to the article “Biotribology: The Tribology of Living Tissues” in STLE’s Tribology and Lubrication Technology magazine, just like man-made machines, excessive wear and tear of moving parts can cause grave breakdowns in the human body. Those in the field try to address this wear and tear and attempt to provide solutions.

There are many bodily systems that fall under this tribological scope including the hips and knees, but also any moving parts such as bone and muscle, the heart, the jaw and teeth, the lungs, and the eyes and this is the topic that we will be talking about today, or ocular tribology.

Our guest today is among those biotribologists attempting to solve the issues of wear as they apply to the human body. Alison Dunn is a PhD student at the University of Florida studying Mechanical Engineering. Alison received her Bachelors and Masters degrees in Mechanical Engineering there as well. She has worked as a research assistant in the University of Florida’s Tribology Laboratory for five years. Alison has published a number of articles on the subject in Tribology Letters, Biotechnology Letters, Wear, and The Journal of Biomechanical Engineering. Alison has also presented at the STLE Annual Meetings from 2005 to 2007 and in 2009. She has also published and done studies with Dr. Greg Sawyer, who heads the University of Florida program and is the keynote speaker at this year’s International Joint Tribology Conference.

KARA: So Alison, welcome to the STLE Compass.

ALISON: Oh, thanks for having me.

KARA: Yeah, we’re really excited to have you. How are you doing today?

ALISON: Oh I’m doing great.

KARA: Good. So I talked a little bit about this in the introduction but can you explain to us exactly what the field of biotribology is? Can you kind of explain what biotribologists study and give us some background on the field?

ALISON: Oh, sure, absolutely. Biotribology is a field that basically combines biology or natural phenomena to tribological systems or with tribological systems, which presents unique challenges and unknowns because nature does not move in a straight line most of the time or a known motion path and also the lubricants that you find in nature are highly complex with lots of different kinds of proteins and chemical reactions, very much different from a synthetic lubricant. A good example is just the tribology of joints – knees and hips. So in your ball and socket joint of your hip, you have conformal surfaces in constant motion against each other whether a person is jumping, running, squatting or just sleeping, those things are always in contact and so they, they have to have a really high performing and good lubricant to keep doing that. Especially when people get a hip replacement, that tribology needs to be really well understood so that those hip replacements can be designed to last a long time, to not wear away and to also be biocompatible, to match with the body’s PH, to match what the body requires of that hip joint.

KARA: Okay. I have heard a lot about hip transplants and things like that. What exactly distinguishes biotribology from other fields like biomedical engineering or biomaterials science?

ALISON: Well, I would say biotribology focuses on the mechanical performance and the lubrication aspect of biomedical devices and biomaterials because tribology is so traditionally about those things like mechanics and lubricants and such. We use those strengths and bring them to biomedical applications, just for example, the eye. The eye, we all know is an organ in the body so a doctor would view it as that. They would view the anatomy, the reactions, the stimuli, things like that whereas biomedical engineers might view it as a tear film or a series of chemical reactions maintaining homeostasis and we view it as a tribological system where there are complex motions of not only blinking, your eyelid coming up and down, but also your eye itself moving around, it’s actuated by the muscles and then we also view the lubricants as a functional lubricant that helps to keep everything moving, protects the eye, and so we have to work within that framework.

KARA: Okay. I know that I mentioned this before, but the eye is more of your specific research interest. Can you give us a little bit more about what you’re currently researching?

ALISON: Sure. Well right now I’m really interested in the kinetics of friction and other mechanical responses in soft tissues or biological materials, and an example would be, like in the eye. So a lot of people these days wear contact lens and there are many different types of contact lenses and solutions that they can choose from, from what I’ve heard. I don’t actually wear contact lenses. Most people go in, and they try a few to find one that fits them well and then they can buy whatever solution they want. So my interest is finding out how those contact lenses function in the eye mechanically and what their friction response is when they slide against something and how that relates to say, irritation in the eye. And also, I’m working with a series of solutions that have different lubricious materials in them, proteins, and I’m interested in how long it takes those solutions to permeate the contact lens, to diffuse into the eye and then does that change the friction properties of how the contact lens is in the eye and then the time frame over which they dissipate out of the eye because the eye is constantly washing itself with new tear fluid. So, if we can measure friction on like a micro-level, applying the pressures, like on the order of single kilopascals that you would actually see in the eye and then sensing those very, very light loads as a shear response, I think that we could say something about how these lubricants work in the eye and how quickly they both diffuse into the eye and then leave the eye.

KARA: Okay. You talked a little bit about this…you said you didn’t wear contacts.

ALISON: Right.

KARA: So what got you interested in studying the eye specifically, and contacts and the wear patterns within the eye?

ALISON: Well as an undergraduate here at the University, I interviewed with Dr. Sawyer for a research position in his lab after just taking his Fluids class and he had just proposed to begin work on a project measuring the friction on contact lenses and it was simply just a proof of concept project, can we measure the friction on a contact lens and then what can that tell us about the whole system? So I was the student that he chose to put on that project and then that really opened the door to me, where I could pursue more complex issues like really studying those soft biomechanics, using those really light pressures that you find in the eye coupled with very high blinking speeds and the kinetics of the friction change due to solution. Then that has even led on to measuring friction and the shear response of a confluent layer of cultured cells that have come, you know corneal cells from the eye, and then what their response is while those cells are still alive, I mean do they stiffen up, do they try to respond in some way, do they just die? So that initial project just with the contact lenses has opened up a wider field that I really enjoy because it has a lot of the solid math and spatial work of mechanics which you can then apply to this complex problem.

KARA: Yes, definitely a complex problem because the eye is a very complicated organ. So how would this relate to listeners? How would they view your research?

ALISON: Well I think that the listeners will all probably use some sort of biomedical implant device at some point in their lives because all people age and get older, but we don’t want that to happen. We want to use our bodies the same way we did when we were young. So that could be a contact lens, that could be a heart valve or a stint, that could be a partial or a whole joint replacement, that could be dental fixtures, anything that goes into the body in a place where it’s going to have something rubbing against it or sliding against it. Some of those devices are more optional, they make us comfortable and happy but other devices like the heart valve and things like that are critical to keeping people alive. So understanding the mechanics and what happens when those materials function or wear away or cause some sort of inflammatory response in the body is very, very important and critical to keeping these devices working. And in that same vein, there’s a trend right now, or at least excitement, moving towards personalized medicine, which is you know, looking at a person’s particular medical needs and then designing a device that would meet that person’s medical needs rather than choosing from a line of products or somehow tailoring a device to go to that person’s specific needs. So I could envision a time when an ophthalmologist or a doctor could input parameters that somebody would need to heal their eye, like the patient’s particular eye condition, what is the pH of their tear film, how quickly does the tear film break up, what is the shape of their eye and then prescribe a set of contact lenses and a solution which would not only correct the vision but also heal the eye in the other ways that that particular person needs. So I could see it relating to listeners maybe the future.

KARA: Oh, definitely. So considering all those things that would relate to the listeners, what specifically would you consider to be the most important issues in the biotribology field today? What needs to be solved?

ALISON: I would say the most important issue is finding out what’s really happening. And I think a lot of people do that in their field, they really want to understand what’s happening. But in tribology, we study a lot of phenomena by taking a measurement before and then we run a friction test and then take a measurement of some kind afterward and we see the change, like did the chemistry of the problem change, did the geometry change, did the materials change, was there wear debris, and what’s the friction coefficient? But we don’t really have a lot of techniques yet that probe the material responses while the friction tests or wear tests are running. So I would say the most important thing that needs to be solved and that is starting to be solved is this in-situ, multi-approach method for solving contact and friction problems like this. So it’s really just jumping up a level of sophistication. For example, when I apply shear stresses to a layer of confluent cells, I take a microscope image of the cells before, and then I apply a treatment, run the friction test and then take another image afterward but that doesn’t necessarily tell me what the cell response was during the friction test and if I miss that response when I stop the test and then took a microscope image afterward. So one of the things I’m working on now is doing those friction tests inside of a microscope to see exactly what’s happening while I apply the shear stresses, how the cells are moving in relation to each other, if they’re expressing any certain proteins or anything like that, or if they’re stiffening up and to see that response while it’s going on. And then be able to show, this is what’s happening and this is the mechanical response that we see based on that. So it’s a little less guesswork. That, I think, is really where the field is going.

KARA: Given that approach and the direction you see things going, where do you think biotribologists should focus their energy?

ALISON: Well I think that they should focus their energy on, like I said becoming more sophisticated with ways to look at what they’re doing in-situ, which may not always be possible because these problems are very complex but I would say that in order to do that, we really have to be creative. I think that science is such an exciting field because it gives people the idea to, specifically in biosciences, look at nature and then really be inspired by that and use your creativity to bring those concepts into the lab. I think that this intersection that makes up biotribology, of traditional tribology, materials science, biological sciences, that is such an opportunity to be creative. One example of that is just thinking about the concept of adhesion which has a lot of importance with all kinds of lubricants and how they interact with the surface of a material, how well they adhere and then how well materials adhere to each other without the presence of lubrication or even a solid lubricant. You can think about the extremes of adhesion. One of the most extreme examples of adhesion is if you think of a gecko, like a lizard that’s clinging to a piece of glass. That thing can climb right up a piece of glass and its feet are perfectly adhered to the glass for its body weight and for what it wants to do. So you can think about that all the way up to hydrodynamic lubrication with proteins and sophisticated lubricants that allow joints to slide as quickly as possible and bear loads at the same time. So if you think of the spectrum of high adhesion all the way up to no adhesion at all, no detectable adhesion, there are a lot of different creative ways to look at nature and then bring that back into the laboratory and apply it to problems.

KARA: It sounds like it. I never thought about a gecko. You mentioned being creative – have there been any major breakthroughs where biotribologists have been creative, they’ve come up with some kind of new approach or anything like that recently? I know you mentioned personalized medicine, but anything beyond that that you’ve heard of or you’ve seen?

ALISON: I guess there’s something that could be sort of related to personalized medicine and that is not just looking at natural lubricants like hyaluronic acid or the gums from different types of beans, or things like that and then trying to mimic those in lubricants, but rather just using those lubricants, trying to extract them somehow from nature and then using them. So it’s not only mimicking natural lubricants, but using those elements, taking the protein or trying to synthesize them and then using them in real devices. That relates to personalized medicine in that maybe the best lubricant to use in someone’s eye to treat dry eye disease was another polymer that was even extracted from that same person’s body. So, I would say the field is moving toward using natural lubricants and then applying them even to synthetic systems and you can see that in the contact lens solution industry. I believe that Bausch and Lomb just came out with a product called BioTrue that has some amount of hyaluronic acid in it, which is the main protein (it’s present all over the body in small amounts, trace amounts) but it’s the main protein that is found in load-bearing joints, like the synovial fluid of the knee joint. So that’s really interesting that you can look to nature and not try to mimic all the properties, but actually use those same lubricants for other applications.

KARA: That is really interesting. So, given all this information, what would you say are the conclusions or concepts that listeners should take away from today’s discussion?

ALISON: I would say that the conclusion is just that nature is really fascinating. And I think that there is a lot of promise for using nature and studying nature to understand tribological phenomena, especially that we find in the human body, that we’re highly interested in. And also to use to solve other complex problems in tribology.

KARA: Great.

ALISON: That’s why I’m interested and that’s why I come to work every day.

KARA: I don’t think anyone would disagree with you in saying that nature is definitely fascinating and there are a lot of things to learn there still. Thank you very much. We do appreciate you and thank you for joining us today and for your insight. I’m Kara Lemar. For more news and information on biotribology, you can visit our website at [www.stle.org](http://www.stle.org). Alison’s and Greg Sawyer’s articles can be found on the STLE website or on the University of Florida’s Mechanical Engineering website. Thank you for joining us today. This has been another episode of The STLE Compass, pointing you in the right direction.