DM: Dr. Joseph Mercola

SS: Dr. Stephanie Seneff

DM: We all know that sunshine is healthy for you. But why is it so healthy? Hi, I’m Dr. Mercola helping you take control of your health. Today we are joined by Dr. Stephanie Seneff, who is a senior research scientist at the Massachusetts Institute of Technology (MIT), and she’s going to help us answer that question. Welcome and thank you for joining us today, Dr. Seneff.

SS: Thank you for having me. It’s my pleasure.

DM: We’ve interviewed you previously, and one of your somewhat controversial comments, positions, or theories (I guess would be the best and most accurate definition of it) is that one of the ways that sunlight works is that it shines on your skin and forms something called cholesterol sulfate.

SS: Wow. Yes. Well, I have a lot to say about cholesterol sulfate. I identified it as an important molecule many years ago. Ever since then I’ve really been combing the literature to learn everything I can about cholesterol sulfate. There’s very little literature on it. Most people are just not paying attention to this molecule. Mostly what you’ll see is, “Oh, yeah, there’s always cholesterol sulfate in the blood, and we don’t know what it’s for.”

We do know that the red blood cells produce cholesterol sulfate and that it protects them from falling apart. If the red blood cell can’t produce enough cholesterol sulfate (they call it hemolysis), it will just spill its contents out into the blood. Now, you’ve got to have all these cells scrambling to clean up the mess that’s left behind. That’s not a good thing. The red blood cells need the cholesterol sulfate to stay healthy. It’s very elegant, I think, concept that they need the sunlight to make the sulfate.

This is something that… I sort of came upon this as an idea just thinking about the skin. The skin makes a huge amount of cholesterol sulfate. It’s the main producer, the cells in the skin. Of course, the skin is exposed to sunlight and it also produces vitamin D sulfate at the same time. The vitamin D that’s produced in the skin is transported in the sulfated form. I started to think in terms of transporting sulfate as I saw that these molecules we’re being sulfated.

The neat thing is when you sulfate the cholesterol, you turn it into a water-soluble and a fat-soluble molecule. It can get just about anywhere on its own. It doesn’t have to be packaged up inside, for example, in the low-density lipoprotein (LDL) particle. The LDL particles are the things that are high in
association with heart disease, and they’re giving everybody a statin drug to try to knock it down, which is a very bad idea.

The cholesterol sulfate serves the really important goal of distributing both cholesterol and sulfate to all tissues. I think that’s what it does, one of the really important things that it does. It’s incredibly important because the cholesterol and the sulfate are absolutely essential to the well-being of all the cells.

DM: Would it be your understanding or position that exposure to sunlight is going to be less beneficial if you don’t have enough sulfur?

SS: Yes, definitely. You need the sulfur in order for it to work at all, right? You also need the molecule that makes it. This is where it’s very interesting. I was looking to try to figure out which molecule might it be in the red blood cells making the sulfate. It became very clear to me that it must be this molecule called endothelial nitric oxide synthase (eNOS). This is the molecule that has been extremely well studied. There are thousands of papers probably on it.

They understand that it makes nitric oxide as you might imagine because that’s its name – endothelial nitric oxide synthase. It makes nitric oxide. It also makes superoxide. They’re well aware of that. They consider that to be a pathology. They think when it’s making superoxide, it’s doing something wrong. But the fact is a superoxide is needed to oxidize the sulfur to make the sulfate. The sulfate is SO4(2-). It has four oxygens and one sulfur. Nitrate – it’s nitrogen plus three oxygens.

DM: Is the sulfate the biological active form of how it’s used in our tissues?

SS: It’s one of the very, very important ones. All of the cells are surrounded by an extracellular matrix, where they have these sugar molecules with the nitrogen attached to them that also have sulfates attached in random places. It’s very fascinating. These are really complicated molecules, and we don’t understand them very well but they have really, really important role in the blood. For example, in the endothelial wall lining the blood vessels, these sugar molecules, sulfated sugar molecules, control what gets in and what doesn’t.

There’s a lot of signaling that goes on. A lot of important signaling molecules are attached to these sulfated sugar molecules before they go in and then there’s like all this regulation that takes place. When the artery wall is depleted in sulfate, it doesn’t work properly. That’s when you get these cascades and end up producing things like cardiovascular plaque because there’s not enough sulfate in the artery wall. That’s what causes the plaque to build.

DM: Okay. One of the therapeutic recommendations is going to be to increase your sulfate, which would be related to increasing your sulfur. We had discussed in another interview how garlic would really be a good source of food sulfur, perhaps one of the best. But even with that, you’re still going to have problems if you’re eating processed foods because processed foods are loaded with glyphosate.

SS: Yes.

DM: You’ve enlightened us on the fact that glyphosate is just being… Even though wheat’s not GMO, it’s still used massively in GMOs. Anyone who’s eating wheat is getting lots of glyphosate.

SS: Probably.

DM: If you’ve got glyphosate, it is going to interfere with that. Why don’t you review that whole process on how we need to pay attention to those details, otherwise we’re not going to increase the sulfate and not benefit from the sun exposure.
SS: Well, it’s very interesting with glyphosate. Glyphosate disrupts cytochrome p450 enzymes, and I’ve talked about that before. There are lots of them in the liver. One of the things they do there is to activate vitamin D. We have a vitamin D deficiency epidemic right now. I think a lot of it might be due to the fact that it’s not getting activated in the liver because of the disruption of the glyphosate. eNOS, this molecule that I mentioned that gets the…

DM: Liver puts the first hydroxyl molecule on it.

SS: Yeah, right.

DM: When you measure vitamin D, you measure 25-hydroxyvitamin D, which is done in the liver.

SS: That’s right. And you get the 1,25-dihydroxyvitamin D in the kidney, which also depends on the CYP enzyme.

DM: Right.

SS: Both of those activations depend on CYPs I actually think. It’s the double-activated form that’s the active form of vitamin D. Tiny amounts of it can have important signaling reactions.

DM: Really tiny.

SS: I think in a way the vitamin D is actually testing. It’s a mechanism to test. You start out in the skin. Okay, the sunlight is working. It’s making the sulfate. The vitamin D transports the sulfate to the liver. In the liver, it gets oxidized using the CYP enzyme. Okay, good. The CYP enzyme is working in the liver because the vitamin D got activated. Now it goes to the kidney and it gets activated again with another CYP enzyme. Okay, great. The CYPs are working in the kidney. We’re good to go. Now we have this double-activated vitamin D. We can do all these good stuff.

The signal that the vitamin D provides is a message that all those things are working. But if you take huge amounts of vitamin D supplements, you’re fooling the system because you’ve got so much more vitamin D that some of it gets activated. You get a level that appears to be the case that you’ve got healthy CYP enzymes. But you might not because you just put so much vitamin D into the system. You produced enough to fool the body into thinking the CYP enzymes are working properly. That’s why I think, you know. The answer is not to take huge amounts of vitamin D supplement.

DM: That is the best explanation I heard to recommend exposure to sunshine or ultraviolet light to increase your vitamin D rather than taking oral supplements.

SS: Right.

DM: That’s very good.

SS: False message, you know. Anyway, getting back to the CYP enzymes, the eNOS is a CYP enzyme. CYP enzymes are disrupted by glyphosate. People have been successful in poisoning themselves with glyphosate in order to commit suicide. Many people are doing that in India are doing that, for example.

DM: A quarter million have been successful.

SS: Yeah. It’s really scary. But when you take an excess of glyphosate, one of the first things that happen is something called disseminated intravascular coagulation (DIC). What that means is the red blood cells are basically coagulating the blood. They’re falling apart. Because they’re getting this massive exposure to glyphosate, they’re losing their cholesterol sulfate and they’re breaking over. The red blood cells are very sensitive to the glyphosate.
Small amounts don’t cause anything that dramatic, but they interfere with the red blood cells’ ability to supply cholesterol sulfate to the tissues. And the heart. I think heart failure is a direct consequence of insufficient cholesterol and insufficient sulfate delivery to the heart.

**DM:** How does the eNOS enzyme impact that? Can you review that again?

**SS:** How does it do what?

**DM:** The eNOS, how does that enter into the equation? The eNOS enzyme.

**SS:** Well, hugely, because it makes the sulfate. We wrote a paper – and I would recommend if someone wants to learn more to read this paper. It’s open access. You can get it on the Web. If you type “Seneff Moonlighting,” you’ll probably find it. It’s called “Is Endothelial Nitric Oxide Synthase a Moonlighting Protein Whose Day Job is Cholesterol Sulfate Synthesis? Implications for Cholesterol Transport, Diabetes and Cardiovascular Disease.”

eNOS is a dual-purpose enzyme. When it’s attached to the membrane, it makes sulfate. When it’s detached from the membrane and the cytoplasm, it makes nitric oxide, which eventually becomes nitrate. It’s basically like, “Do I oxidize sulfur or do I oxidize nitrogen?” That’s the choice. It’s a very intricate control mechanism that allows every single eNOS molecule to switch back and forth between those two decisions.

It’s important that it’s one molecule controlling both the sulfate and the nitrate because these two molecules have very opposite effects on the blood. Sulfate gels the blood and nitrate turns it into water. It’s called kosmotropes and chaotropes in chemical terms. They have opposite effects. And the body is always negotiating, “Which way? Do I need to be here? Maybe the blood’s too thick, [there’s] too much viscosity, let’s put out some nitric oxide in. Or maybe it’s too thin, let’s put some sulfate in.” It’s able to titrate between the two very nicely with that one molecule.

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The eNOS in the red blood cell always hangs around the membranes. They don’t understand why it’s there. Articles are written where they’re puzzling over why is it that red blood cells have eNOS, because there’s no reason they would want to make nitric oxide. It’s like carbon monoxide. It would poison the hemoglobin. They think, “Oh, well, maybe it’s vestigial.” It’s just crazy.

**DM:** They’re totally discounting the cholesterol sulfate component.

**SS:** Exactly. They know the red blood cells make cholesterol sulfate. They know it’s essential to keep them from falling apart. But it never occurs to them that eNOS might be the molecule that’s playing that role to make the sulfated using the superoxide, which it produces when it’s on the membrane. It totally makes sense.

**DM:** Could you elaborate a bit more on how the eNOS does that to produce the cholesterol sulfate with the superoxide?

**SS:** Yeah. Well, superoxide is O2-. It’s an oxygen with a negative charge. You need to have electron mobility to make it. You have to fire an electron at the oxygen molecule. You’re getting the oxygen from the blood, right, because you’ve got that. You’re breathing, and the oxygen’s going into the blood, O2. The electron comes from the sulfated glycosaminoglycans. It’s really interesting. Now, on the case of the red blood cells, they have the cholesterol sulfate that makes the gelled water around the cell…
DM: This is really interesting because in the past, I’ve interviewed Dr. Gerald Pollack at the University of Washington. He’s a biophysicist out there. His whole approach is on water and this gelling of the water. He calls it EZ water or…

SS: Exclusion zone.

DM: Exclusion-zone water or basically structured water. He’s calling it H₂O₃, which provides this thing. Maybe you can comment on that and your take on it.

SS: Yes. It’s really fascinating because it builds these hexagons. Two O₃ makes O₆. It builds a hexagon of water, which is similar to the hexagons in these molecules that transport sulfate. I think it’s connected, these rings. The rings are really interesting because they allow electrons to go around the ring.

The water that Gerald talks about is negatively charged. It chases away protons. They end up sticking along the edge. You have this picture like a bowl of Jell-O with water on top of it. Between the water and the Jell-O, there are these protons that are being pushed out of the Jell-O. They end up kind of gathering along that boundary between the water and the Jell-O. Those protons end up with mobility. They can move.

I believe they actually go into the cytoskeleton and charge up the acidic zone like the lysosomes and the mitochondrial intermembrane space. Those places need to be very, very acidic with lots of protons. I think there’s a whole mechanism to the cytoskeleton. We’re studying this to try to see if we can get enough evidence to piece it together.

DM: Who’s we? Dr. Samsel, too?

SS: Yes, Samsel as well. And also I have some other people who I’m working with particularly Robert Davidson, who is really, really interested in this area. He’s very smart. He’s got an MD, PhD.

DM: You’ll have to definitely keep us posted on that because it’s fascinating work.

SS: Yeah. I’m thinking that protons go in through the cytoskeleton to make the very acidic environments that you need in some compartments in the cell. Meanwhile the electrons…You’re doing a separation between protons and electrons. That’s how you do work. That’s basically like electricity.

DM: It is electricity.

SS: Electrons end up inside the structured water. They also become mobile. You have these mobilized electrons. If you’ve got an oxygen gas molecule coming in, it’s going to get hit by one of those electrons. It’s going to make O₂-. O₂-, you need two of those to make O₄ (2-), right? O₂- O₂- = O₄ (2-).

DM: Right.

SS: You stick that on to a sulfur, and you’ve got sulfate. Simply speaking, that’s what eNOS is doing. eNOS actually has a zinc atom inside the cavity between the monomers and the dimer structure of the eNOS. That zinc atom has a positive charge. It draws that O₂- and then it’s got these sulfurs from the cysteine sitting all around it. It’s like a perfect environment to grab one of these sulfurs and turn it into sulfate from those O₂- that are coming in.

DM: Zinc’s an important catalyst for the process. If you’re zinc-deficient, it doesn’t work.

SS: Yeah. Zinc deficiency is another issue with glyphosate.

DM: Interesting. Glyphosate causes zinc deficiency, doesn’t it? It precipitates it out.
SS: It does. It chelates the zinc. It’s just like all these other things. You end up with zinc deficiency plus the glyphosate reaction with eNOS’ active side that messes it up. Plus the glyphosate brings in the aluminum, which also knocks the iron out of the heme unit of eNOS. eNOS is being attacked in many different ways by the glyphosate and the aluminum. It can’t do its job. You can’t make the sulfate, and you get this system-wide sulfate deficiency. That chases to all the diseases.

DM: Yeah. It’s pervasive. Let’s get back to the sunlight a bit. One of the dangers, and as I’ve mentioned in the introduction that dermatologists don’t like the sun, because they think it causes…

SS: I know.

DM: They’re convinced it’s wholly responsible to the increase of skin cancers. But let’s go into skin cancers because I think it relates to this eNOS mechanism you’re discussing with the nitric oxide.

SS: It totally does.

DM: I’m wondering if you can expand on that and how glyphosate might even be related to the increase in skin cancer.

SS: I totally think it is.

DM: Let’s get your take on that.

SS: I think it makes a lot of sense. Because if the eNOS is derailed, it can’t do this. Part of what the sulfate synthesis is doing is protecting you from sunlight because you’re using that UV light to catalyze the whole thing. But you’re also safely absorbing it and keeping it from causing disruptive damage elsewhere. This mechanism of making sulfate, one of the really important things it does is protect you from sunlight. It also captures energy in the sunlight in making that sulfate anion. This is a way of basically using a solar energy, right, in your body. It makes sense that all living species that have access to sunlight are going to find a way to use it, because sunlight is a free source of energy.

DM: It’s a free energy, yeah.

SS: You’d be foolish not to use it. But unfortunately, the way we use it has an incredible vulnerability to the aluminum and to the glyphosate. The aluminum is actually in sunscreen. Many of the high-end sunscreens have aluminum nanoparticles – zinc oxide and titanium dioxide. The aluminum is added to make it emulsified, so it’s not like this white paste. It makes it easier to spray it on.

DM: Sure. It’s not cosmetically elegant.

SS: Yeah. The aluminum gets into the skin and totally wrecks the eNOS.

DM: It’s absorbed through the skin.

SS: Yeah. And it gets into the eNOS and ruins it, because the aluminum will displace the iron in the heme group, which will make the eNOS not work.

DM: Does it have the same valence as iron? Is it 2+?

SS: Yeah. Aluminum is +3.

DM: Oh, +3, okay.
SS: It’s at least well-established that aluminum displaces iron in heme. Of course, that’s going to cause trouble in the liver, too, because the heme is part of the cytochrome p450 enzymes, which have this heme group that contains iron inside this porphyrin ring. The aluminum messes that up. And then you’ve got to basically break the whole thing down and build another. You’ve got to start all over again once you’ve got that aluminum in there instead of the iron. The eNOS is not going to work with the aluminum.

DM: So, your position is that exposure to glyphosate, which we’re spraying nearly a billion, one billion pounds of in a year in the environment, is increasing the risk of skin cancer through this mechanism?

SS: I think so. I mean, I think it’s messing up the eNOS. Of course, it’s also caging the aluminum. When it gets near the sulfates, it becomes acidic because you’ve got those protons on the edge. I talked about the protons getting pushed out of the structured water. That’s an acidic environment. That’s where glyphosate will release its aluminum. Both the aluminum and the glyphosate will become toxic at that point. It’s delivering it to the red blood cell and causing destruction of the eNOS, which then prevents it from making the cholesterol sulfate and then you have this incredible cascade of problems following that.

DM: Could you elaborate on how it decreases our ability to shield our cells from the toxic effects of ultraviolet rays? Because ultraviolet rays can be dangerous. There’s no question. No one’s disputing that. But if you’re healthy, you’re wise, and you have safe exposure, it’s not a problem. But it is, if you have exposure to glyphosate. Can you explain how it decreases that shield protective effect?

SS: That’s because the structured water is able to absorb the UV rays and turn them into energy, into useful energy.

DM: Okay. And this is throughout the skin?

SS: Yeah, all over the skin.

DM: The structured water is topical?

SS: Yeah.

DM: Okay.

SS: There’s eNOS in these molecules that make the cholesterol sulfate. They have it, too. They’re able to make the sulfate in the skin. The red blood cells, of course, are traveling through the veins. You have all those veins that are on the surface of the skin. Those are also very busy making cholesterol sulfate when they see the sunlight. But if they can’t do it, those UV rays become toxic to the cells and starts doing things like causing DNA mutations and causing cancer.

DM: Okay.

SS: And of course, the aluminum in the sunscreen is contributing to the disruption of the eNOS molecule. It’s not clear that the sunscreen… I think the sunscreen may be making matters worse.

DM: Oh, sure.

SS: I mean, it’s interesting that skin cancer has been going up by two or three percent every year since the 1970s. Ever since then we’ve been increasing the urgency with which people are using sunscreen. There’s a very strong correlation between sunscreen use and skin cancer, which is really bizarre because…

DM: It’s a positive correlation, not negative.

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SS: A positive correlation, a very strong positive correlation. It looks like the sunscreen’s actually causing the skin cancer. And it could be because the aluminum in the sunscreen is messing up the body’s natural way of detoxing the sun. But then you have the glyphosate as well.

DM: Right. I was going to mention that. Right. Talk about the glyphosate.

SS: I don’t know whether it’s the glyphosate that’s causing the increase. It’s a little hard to tell because they’re both going up. The sunscreen and the glyphosate [use] are simultaneously going up.

DM: And then the glyphosate doesn’t work on eNOS, too. It works in other areas of the body like…

SS: It works in eNOS. It does. It disrupts eNOS in different ways from the way that the aluminum disrupts eNOS.

DM: But it also works on…

SS: And also retinoic acid. I didn’t mention that.

DM: Okay.

SS: But the retinoic acid in sunscreen also suppresses cholesterol sulfate synthesis.

DM: But it also affects the pathway, the shika… I have a hard time pronouncing it.

SS: Shikamate.

DM: The shikamate pathway in the gut, which the microbes utilize.

SS: Yes.

DM: Discuss that connection.

SS: Well, actually there is a connection there, too, because cobalamin is produced by the gut bacteria and is produced by the bacteria that is disrupted by glyphosate, so that you have a reduced cobalamin production. Also we discussed celiac disease as poor cobalamin absorption. Cobalt is chelated by glyphosate and cobalt is the key active atom in cobalamin.

In our paper, we showed how we suspect that cobalamin attached to a glutathione molecule is present in the active side of eNOS when it’s making the sulfate. It uses the cobalamin to hold on to the sulfur atom that’s going to turn it into sulfate. We believe cobalamin plays an essential role in making the sulfate in the skin. Cobalamin deficiency is going to contribute to the problem of not being able to make sulfate.

DM: It’s fascinating how glyphosate interacts with the microbial bacteria. Most of the people know that we have about 10 trillion cells, our own cells. There are a hundred trillion bacteria. But evidence shows that for every bacteria, there are 10 bacteriophages or viruses. So, there are one quadrillion phages. I’m wondering if you’ve looked at the influence of glyphosate on these phages or viruses.

SS: I haven’t specifically looked at that connection between the phages and the glyphosate. But I am really, really fascinated by this whole issue of all these viruses being available to deliver genetic material to cells. I think that there’s been a major paradigm shift in the view of how evolution happens.

Some very interesting recent papers have shown, for example, that cancer cells can, first of all, incorporate viruses into our DNA and secondly, they can send out thousands of DNA that can end up showing up in the sperm cells. The cancer cells can deliver DNA to the sperm cells. Viruses can deliver
DNA to cancer cells. You start to see that there’s this massive ability to mutate into various unique forms or to provide whole pieces of genome material from these viruses that may serve a useful purpose in sort of adapting to a nasty environment.

I think there’s been a new view, which is an old view, of Lamarckian evolution actually being important, not just DNA. There was a whole battle between Lamarck and Darwin back in day when they… Darwin won basically and Lamarck argued that you could inherit an acquired trait. As a person is experiencing life, things that he experiences could end up influencing the genome or the phenotype of his offspring. Lamarck lost and Darwin won.

Darwin said there are just totally random mutations, and the ones that survive – because it’s a survival of the fittest kind of thing – get passed on to the gene. But they’re now realizing that there’s a whole mechanism by which viral DNA… I believe that viral DNA can end up in the sperm, which then means that the sperm can send off this message to the next generation to produce something – some protein, some regulatory RNA, or whatever – that’s coming from a virus.

It might be even one of these…I don’t know. It could even be one of these bacteriophages. I mean, there are all these viruses, these reverse RNA viruses, like human papillomavirus (HPV) and human immunodeficiency virus (HIV). Cervical cancer, for example, is caused by the… It’s really, really interesting that these viruses have little snippets of genetic material, which I suspect plays an important role in allowing the species to evolve in order to be able to handle a suddenly toxic environment.

Right now, we’re being exposed to this glyphosate and all these other chemicals as well. We’re desperately trying to find a pathway towards a new solution that can cope with these things without getting into all those troubles that we’re getting into. We end up with monsters sometimes and many times it doesn’t work. But they’re sort of trying out all of these ideas.

And they’re inspired. Ideas are inspired by the experience with the environment. They’re not just random. They’re actually very carefully selected to be things that might be important to solve that problem. To change a particular gene in a particular molecule that’s particularly stressed by this environment and try to find a different solution that might work better. I think it’s really, really fascinating.

DM: Okay. Well, I want to thank you for your insights. I appreciate your time and perspective on this issue because it is an important one. There’s no question. I really appreciate all the work you’re doing.

SS: Thank you.

[END]