Diving Deep Into the Role of Omega-3s on Cell Membranes A Special Interview With Dr. Nils Hoem

By Dr. Joseph Mercola

Dr. Joseph Mercola:

Welcome, everyone. Dr. Mercola helping you take control of your health. And today we are going to dive deep in a really fascinating area, which is omega-3, which has some controversy about it. But we're going to be discussing it with one of the leading experts in this area who has some conflict of interest because he's a research scientist with the largest company in the world that harvest krill from the ocean, Aker. But he's really, really knowledgeable about this. I'm so looking forward to discussing some of the details of how omega-3 works in mitochondrial metabolism. So, it's going to be fascinating. So welcome – and his name is Dr. Nils Hoem. So, welcome and thank you for joining us today.

Dr. Nils Hoem:

Thank you very much. I certainly look forward to this discussion.

Dr. Joseph Mercola:

Okay, good. Yeah. We had a preliminary call a few weeks ago and it was just fascinating, so we're going to hopefully expand on a lot of topics we dialogued then. So, perhaps you can provide those who aren't aware of you or your work your background so that we can dive into the discussion.

Dr. Nils Hoem:

Yeah. In my academic life, I spent the first almost 20 years as a researcher at the University of Oslo. And so, I got both my master's and my doctorate from the University of Oslo in Pharmacology. And I was an associate professor there until I left for working in early drug development, then more on the commercial side. And I did that until 15 years ago, when I came back to Norway from Germany at that time, and to work for Aker Biomarine. And since then, the last 15 years I've been working within Aker Biomarine. Now, as the chief scientist of the organization. But I'm by heart and mind, really, a pharmacologist.

Dr. Joseph Mercola:

Excellent. So, it gives you an interesting perspective on this. And you've done some deep dives and studied the mitochondria, which is one of my fascinations because from my perspective, it's really one of the primary focuses of optimizing health. Because if you can get your mitochondria working, and working well, and minimize the damage to those organelles and cellular structures, which are responsible, of course, for producing most of our cellular energy, about 90% of it in the form of ATP (adenosine triphosphate), you're going to do pretty well. And it seems to me the crux – I used to think the crux of all disease was insulin resistance, but not really. That's definitely an issue, but foundationally it impacts the ability of the mitochondria to function properly and produce ATP.

Because if you put inside a mitochondrial poison like cyanide, which essentially binds to the complex IV, literally, within a few minutes or maybe seconds, I don't know, you're going to be dead because the mitochondria lose the ability to produce energy and you can't survive without energy. So, I'm not sure what your view of mitochondria is or the importance, but maybe you can share with us and then we can dive deep into some of those components.

Dr. Nils Hoem:

Actually, my way into all of this came through membranes. As from pharmacology, very much of what we deal with, all of it happens in the membrane somewhere. And when you have that perspective on some of the biochemistry, you realize that the membranes are the universal surface onto which, and into, which you assemble the cellular machinery. Very little in the cell just floats around. It's a very complex structure, and membranes are really fascinating that way. And the integrity of membranes is absolutely vital for the function of the cell. And let's not also forget that the membrane hosts, what I call response elements, and there are a number of those, but of course, almost all signaling except for hormones, all short path signaling, much of it starts in the membrane.

Dr. Joseph Mercola:

Yes. And of course, the mitochondria have two membranes, the inner one and the outer.

Dr. Nils Hoem:

Yep.

Dr. Joseph Mercola:

So, they're especially important. So maybe describe your perception of the structure of membranes because there's some controversy on this too. I think Gilbert Lang, I'm not sure if you're familiar with his work, but he has an interesting view on this. And the specific details I'm forgetting now, but I do know that there's some controversy around this topic.

Dr. Nils Hoem:

Now, you know, much of what we know about the membrane is what is called the "mosaic theory," and it's been good for us out of many reasons. But I think it is fair to say, both for the general cell membrane, but also for the internal membranes, that is the Golgi apparatus and the endoplasmic reticulum. And then also of course, the mitochondrial membrane. The complexities of these are relatively large. And to understand exactly how we both build and maintain those membranes, I think there is a lot to learn. We know some of this, but there is a lot that we do not know. Of course, they are lipid structures and that is something that, of course, interests me. And it's lipid structures that are made of phospholipids and a number of other constituents. But the main structure is this bilayer of phospholipids.

And then in membranes, there are two phospholipids that really matter and that is phosphatidylcholine and phosphatidylethanolamine. And both of them are charged – or not charged, but sorry, but they are ampholytic molecules, so they have a polar end and nonpolar end. And they're really interesting molecules because, even from a developmental perspective, because there are the few molecules we know that actually organized themselves into structures

spontaneously. You could take phospholipids and put them into water, and suddenly you have some sort of a sheet or a membrane that forms. So, forming structure rather than chaos is a hallmark of these really interesting molecules.

Dr. Joseph Mercola:

So maybe you can walk us through how these constituents in the membrane get assembled there. We eat our food, so that's the initial raw material substrate that they can be used, but then somehow the lipids or the fats that we consume need to be converted to these phospholipids and assembled in the membrane. Maybe you can help us understand how that works.

Dr. Nils Hoem:

Actually, the biochemical pathway, even to triglycerides – so they're part of this large class of lipids that we call glycerol lipids and the biochemical pathway to triglycerides, even it goes through phospholipids. So that's an interesting one, but of course, some fats we are able to synthesize. Palmitic acid, for example. If you eat sugar and your body fastly will make that sugar into storage in the form of palmitic acid, saturated fat.

Dr. Joseph Mercola:

That's saturated fat, and that's 18-carbon.

Dr. Nils Hoem:

Yes, yes.

Dr. Joseph Mercola:

Is it 18 or 16?

Dr. Nils Hoem:

Sixteen. Palmitic acid would be 18, and then also stearic acid would be 16. [inaudible 00:08:21], the medium-sized. Now, then there are other fats that we are, not to any degree, able to synthesize. So, neither the omega-6, linoleic acid (LA), or alpha-linolenic acid (ALA), which is the omega-3, we can synthesize. And the longer chain omega-3s and omega-6s pretty much – for the omega-3s, the conversion from the shorter chain to the longer chain is really quite lousy. And there is a competition with omega-6s also. And since we decided – I'm not even sure if we decided, but since humans started to consume huge amounts of omega-6 fatty acid, then that is in a very strict competition with the elongation of ALA. And fundamentally, we have to take in the long-chain omega-3 fatty acid that is [crosstalk 00:09:23].

Dr. Joseph Mercola:

Well, let me stop there before I proceed because that's a really important point. And I think it's frequently glossed over, even in healthcare professionals. And so, I just want to restate what you said and emphasize it. And if I'm misinterpreting something then please let me know. But there are two polyunsaturated fats that are considered to be essential in conventional medicine. One of them is the omega-6, linoleic acid, and you said that's an 18-carbon. And the other is the omega-

3, alpha-linolenic acid, and that's also an 18-carbon. But those we can't make and we have to get it from the diet.

Dr. Nils Hoem:

Correct.

Dr. Joseph Mercola:

But the others we can make. The 20 EPA (eicosapentaenoic acid) for omega-3s and 22, which is DHA (docosahexaenoic acid). So they can be elongated, I think by delta-6-desaturase, if I'm not mistaken. And the problem is that there's competitive inhibition for that enzyme, so that omega-3 is literally what most people believe and understand to be the important of essential fats that we need to acquire, especially the longer chains. But when you've got literally 10-fold, that's a thousand percent more omega-6 floating around than supposed to be, than we consumed 150 years ago, then the delta-6-desaturase is going to focus on that. And I think it converts that into arachidonic acid, if I'm not mistaken, instead of converting the alpha-linolenic acid to EPA. So, is that the crux of the problem? Did I summarize it?

Dr. Nils Hoem:

Exactly and it's not just – it's both the elongase as well as there are two different, the delta-5 and delta-6.

Dr. Joseph Mercola:

Okay, okay, so there's two.

Dr. Nils Hoem:

Yeah. But both of these are, basically, when the amount of omega-6s are so high, then they will be busy doing that. There is no reason in this, it's just that the enzymes will take whatever is around. And it's known, for example, that – a Japanese professor showed me data from inner Mongolia where they eat no seafood at all, but they eat a lot of meat from grass fed cattle, but also milk and dairy products where cattle has been only grazing. And then they actually get a lot of ALA and very little omega-6s, and they actually had pretty high levels of EPA and DHA despite not eating any seafood at all. So that tells the story, I think.

Dr. Joseph Mercola:

Yeah, I think that highlights what a really important concept that I wanted to ask you about because one would think, historically, that if you can get your levels down of linoleic acid to 1% to 2% of your total of your body fat, which pretty much everyone had prior to 1870, but now it's up to 25%, 20% to 25%, maybe even higher, folded. So, they've got this store, which ultimately becomes metabolized and used, even if they aren't eating any. But if they get back to historical norms and you have very low levels of linoleic acid, then there's not this competition for delta-6. And if you have a baseline level of ALA, the alpha-linolenic acid, the omega-3, then you can make substantial amounts and have healthy amounts of omega-3 that you need in your body produced from the ALA, that's pretty much available to most foods like linoleic acid and you don't have to rely on taking supplements. Would that be a fair assumption? But this is-

Dr. Nils Hoem:

I think yeah. No, I think that's correct. Yeah, I think, absolutely, that's correct. But of course, with today's food it's highly unrealistic.

Dr. Joseph Mercola:

Yeah, that was the comment I was going to say, almost no one is there. Almost no one is there.

Dr. Nils Hoem:

No. And the only way of doing it today is actually to increase your intake of omega-3s. And that works quite well. It's almost like if you have an aquarium and you want to make that aquarium blue, so you drop a little drop of ink into your aquarium then-

Dr. Joseph Mercola:

Or methylene blue.

Dr. Nils Hoem:

Yeah. So, you want it to be blue and then you put a little drop of ink into your aquarium, then that will make the water blue. Okay, then you decide I want the blueness to be twice as strong. Then you can do two things, you could add one more drop of ink, that's the omega-3s, or you could reduce the amount of water by half. And that's exactly what you're into. The amount of omega-6s are so huge as compared with the omega-3s that the only feasible way of increasing your omega-3s in the membranes is through taking omega-3s. In our research and in many other others' research we've looked at what is the kinetics, how is the dynamics of this. And then there is a 1-to-1 exchange of EPA and DHA for omega-6s in the membrane.

So, the membrane, if you increase one molar amount of EPA and DHA in the membrane, then you kick out exactly the same amount of omega-6s. And it's important to realize this, that the membrane, actually, will be a reflection of your intake of omega-6s versus omega-3s. But you can't really do much with the omega-6s because they're everywhere. You would starve then, but you can fix it by increasing your intake of long-chain omega-3s.

Dr. Joseph Mercola:

I think pragmatically, I think that's correct, but it is possible. And I, myself, have reduced my intake of omega-6 to under 1%. And I've only been doing it for about three or four years. It takes about six or seven to fully get it out of your membranes and your adipose tissue stores, primarily. But I'm curious, and this is what I encourage people, but your explanation really helps solidify this important concept in my mind, which I had recalled some of the specifics, but didn't really consolidate it like I had when I heard you state that. So that's really important, so thank you because I'm passionate about omega-6. I'm actually in the process on the fourth round of a peer review paper for being submitted to Nutrients, which is a pretty high-impact nutritional journal, on a historical perspective of linoleic acid in the context of it.

Big pharma is an issue, but big food is just as bad. In some cases, even worse. So, they've essentially loaded us up with this omega-6 for well over 100 years, coming up on 150. So, it is

really, really, really hard to do, but it is possible. So, the question I had was – I wasn't aware of this, I guess, competitive inhibition, it's a form of that where if you add more omega-3 it kicks the omega-6 out of the membrane. But the omega-3 that we're ingesting is such a small component relative to the omega-6 in most people. So, the question becomes how much would make a difference? And then really the question it catalyzed was what happens to the omega-6 once it's displaced out of the membrane? Is it burned as fuel? Is it put back into the adipose cells? What happens to it?

Dr. Nils Hoem:

I really can't answer that question. I've only seen that on the membrane level, it's kicked out of the membrane. I would guess that it is both being burned as fuel and it will be stored in the adipocytes like other fats. What I can tell you is that we've been studying the kinetics. Remember I'm a pharmacologist, and I'm trained in pharmacokinetics. So, we've been studying the mass transport of EPA and DHA and it's really fascinating. Because you have a meal of salmon today, Dr. Mercola, and [the] EPA and DHA from that meal is going to wash around in your circulation and be exchanged within all different organs in your body for 14 days afterwards.

Dr. Joseph Mercola:

14 days.

Dr. Nils Hoem:

14 days.

Dr. Joseph Mercola:

Why is it? That doesn't make a lot of sense. What allows it to do this?

Dr. Nils Hoem:

Well, we see that it undulates, so it goes in and out of plasma. And plasma is just, how to send it around. So, it goes in and out of, frankly, I don't really know because it's more complex than you usually see with any drug. And you see at least three waves of undulations from when you take it. So, it increases in plasma, then it decreases in plasma, and increases again from six hours, then you have a 24-hour peak, and then you have another one usually, around 30 hours. We don't actually, specifically know, but when I look at how it's being incorporated into different tissues, then that might give you some ideas. You see how, for example, the liver really, really wants EPA and DHA. The brain, we've done experiments with lysophosphatidylcholine (LPC), which is actually the form that is being transported into the brain and into [the] neuronal tissue. And if you inject EPA and DHA LPC, so lysophosphatidylcholine with EPA and DHA on it, it shoots into the brain and it shoots also across the blood-retina barrier.

So, you see some organs that are very keen on grabbing these molecules and it's what we call it [an] infinite sink. So, for example, what goes to the brain seems to stay in the brain until it's broken down. With half-lives that are probably hundreds and hundreds of hours, while in the circulation, the half-life is pretty much like a hundred-ish hours, longer for DHA than for EPA. But what this means is also that when you change your intake, so you change your dose if you supplement, then it takes about 600 hours at least until you are back at steady state. So, you can't

fix anything fast with those fatty acids. You really need to be patient, and the body takes its time until it has settled on a new equilibrium, so to say. But I have never seen any other substance having such a complex distribution and-

Dr. Joseph Mercola:

With the omega-3s in the blood.

Dr. Nils Hoem:

That's the omega-3s. Well, should we be surprised? You find those fatty acids in every single membrane, even in the mitochondrial membrane, every single membrane in our body. And if you ask me, "What's the total size of membranes in us?" I'm in no position to answer that. It's an enormous surface that is made out of a thin, thin, thin layer of lipids where EPA and DHA, and also arachidonic acid, plays a role. But for example, the amount of saturated fat in this membrane seems to be absolutely stable. Nothing happens. So, when you take different fats, then it's mainly omega-6, omega-3 that really changes. Now, there might be other fats also, like uronic acid or some other what I call structural fats that also matter. But so far, our research has been on the omega-6s and the omega-3s. And by the way, I call those fatty acids structural fats because they really do have a structure while the-

Dr. Joseph Mercola:

Saturated fats are structural?

Dr. Nils Hoem:

Structural fats. Yes. Because I think of them like you would do as an architect, they have structures.

Dr. Joseph Mercola:

Mm-hmm. Brick and mortar.

Dr. Nils Hoem:

Yeah. And the other fats, for example, palmitic acid, so the completely saturated fats, they are super flexible and they have far less structure really. It's like a piece of rope really, and really doesn't infer structures in the same way into the membrane.

Dr. Joseph Mercola:

So, what is the structural component of the fat then? I got it confused.

Dr. Nils Hoem:

The circular – it is the double-bonds.

Dr. Joseph Mercola:

Oh really? The polyunsaturated fats.

Dr. Nils Hoem:

Oh yes. It fixes the – because when you have unsaturated fats-

Dr. Joseph Mercola:

I thought it would've been the exact opposite. I thought polyunsaturated fats were fluid and liquid and contributed to-

Dr. Nils Hoem:

Yeah, the polyunsaturated, no, no, no, they make-

Dr. Joseph Mercola:

... the permeability of the membrane.

Dr. Nils Hoem:

They make the membrane probably more fluid because they create space in the membrane. So, they need their own space because they have structures. So, they are in three-dimension.

Dr. Joseph Mercola:

Oh, now I get it. Because they take up room and space because of the double bonds-

Dr. Nils Hoem:

Exactly.

Dr. Joseph Mercola:

... that they're larger molecules. They consume a lot more space. And that makes perfect sense. And the saturated fats are just straight lines.

Dr. Nils Hoem:

Exactly. And then they can coalesce, they can line up side by side.

Dr. Joseph Mercola:

Right.

Dr. Nils Hoem:

And then they actually solidify-

Dr. Joseph Mercola:

Okay, now I got it. Now I got it. Okay. So, you had mentioned earlier, and there's two points I want to follow up on, the lypophosphatidylcholine. Now most of us have heard of phosphatidylcholine, but what is lypophosphatidylcholine?

Dr. Nils Hoem:

Lyso, not lypo.

Dr. Joseph Mercola:

Lyso, I'm sorry.

Dr. Nils Hoem:

Lyso just means that you take out one fatty acid. So [inaudible 00:24:06].

Dr. Joseph Mercola:

Oh, okay.

Dr. Nils Hoem:

And that's a really interesting molecule because it is a form of transporting fatty acids. Now, remember, fatty acids have – the definition of fat is really not very sharp. The definition of fat is largely something that doesn't go into aqua solution, of hydrocarbon that is. So, the hallmark of fats is that they really do not like water. And remember, how do you transport something throughout our body that doesn't go into aqua solution? That's actually a huge problem and that's where the lipoproteins come in and micellar structures. Now-

Dr. Joseph Mercola:

And an example of that would be the lipoproteins for cholesterol, like HDL (high-density lipoprotein) and LDL (low-density lipoprotein).

Dr. Nils Hoem:

Exactly. Yeah, so where cholesterol play-

Dr. Joseph Mercola:

In that case they're transferring to cholesterol as the fat.

Dr. Nils Hoem:

Yeah. And cholesterol plays a very important factor into the structure of any membrane. Without cholesterol we would die, there is no way around that. They're really important molecules. And frankly, I think that we shouldn't go too far into it, but in a way, cholesterol has been demonized. But that's a different story.

Dr. Joseph Mercola:

Yeah, it's a whole different can of worms.

Dr. Nils Hoem:

Yeah. But the thing is that you need a fundamental water solubility for any molecule to move across any membrane. Or to move from one place to another, it must go into solution somehow. Now the maximal solubility of, for example, EPA is 10 to the minus 18th, it's practically completely insoluble. So here comes the problem, how do we then get it into the brain? And nature fixed that. And this is a paper from David Silver and his group in 2014, when that came. They showed that there is a transporter that transports lipids into the brain, but they do not

transport the fatty acid. They transport the fatty acid bound to lysophosphatidylcholine and that molecule is way more water soluble, 10 to the minus 4th actually. And in a way, that's how nature solved that problem. Instead of being on its own, it's like EPA and DHA and a number of other fats actually sit on a ferry boat.

And the ferry boat is lysophosphatidylcholine that transports it into the brain. And then the transporter, MFSD2A it's called, actually brings that molecule, not the fatty acid, but that molecule that brings with it EPA and DHA, and also other fats into the brain.

Dr. Joseph Mercola:

Okay, perfect.

Dr. Nils Hoem:

And the same goes for the eye, but also such places as the liver. The liver has lots of this transport molecule, even maybe the brush border in the gut. Now, it also sits in the placenta. So, the same transporter transports DHA from the mother to the fetus and a number of fats actually. So, it makes a lot of sense for our body to keep itself with a small, but important amount of lysophosphatidylcholine in the circulation.

Dr. Joseph Mercola:

Okay. So this is a key point. This is one I want you to expand on this because I wasn't aware of lysophosphatidylcholine and I suspect many people aren't. But in your definition, it's simply phosphatidylcholine that has a fatty acid. So which-

Dr. Nils Hoem:

Just one fatty acid.

Dr. Joseph Mercola:

Just one fatty acid, and it plays this pivotal role in your body that is foundational and really crucial to optimizing your health. So, it would seem that it's equally crucial to make sure you have a regular supply of phosphatidylcholine in your gut.

Dr. Nils Hoem:

Exactly. Yeah, of course [crosstalk 00:28:22]-

Dr. Joseph Mercola:

Most people don't. This is a common nutritional deficiency.

Dr. Nils Hoem:

No, but when you eat phosphatidylcholine – We had a little bet going on between me and one of my colleagues. We were saying that if you take krill oil, then of course you supply phosphatidylcholine, and then through digestion you would get rid of one of the fatty acids. Then you would see an uptake of lysophosphatidylcholine. To a certain extent, yes, you do that, but then we synthesized lysophosphatidylcholine. We both injected it, and we gave it PO. And big surprise because you definitely see more of an absorption of lysophosphatidylcholine into certain

tissues when you take it alone, and also, there is always a bit of a loss of fats. So, when you eat both triglycerides and phospholipids, you see a loss between 15% and 5%, kind of a block loss in your gut, probably because the digestion is too slow. But we were really surprised to learn that when taking lysophosphatidylcholine as it is, then you actually saw a different pattern of uptake in distribution than you do when you take PC or phosphatidylcholine.

So, we were just wrong. And if you ask me, "Do I understand why?" Not really. There are two ways – or the standard description of fat absorption, Dr. Mercola, is that it's broken down first into its fatty acid, then taken up into the enterocyte. Then it is resynthesized into a triglyceride. Then it is put into what is called a chylomicron, which is kind of a little fat bubble, and then that one is transported into our body through lymph. So it goes from lymph, and then it is transported into vena cava. Then it meets the whole body, but most substances that we take up from our gut actually have another route. The lymph route is very unusual. The main root is through the hepatic circulation, what is called the portal circulation, from the gut, then directed to the liver, and then from the liver to the rest of the body.

For certain types of – for example, lysophosphatidylcholine, there are quite a few indicators that point to that they may be taken up through that route, so then they hit the liver, which probably explains why you find MFSD2A is transported there. You have these two routes of how lipids enter our body, one through lymph, another through the hepatic circulation. Triglycerides are almost exclusively taken up through the lymph, while with phospholipids and especially lysophosphatidylcholine, then they seem to go both ways. That might be of significance because the processing of these lipids is different. Then as you know, the liver, it has a key role in making the lipoproteins and lipoprotein particles. That is how we actually deal with fats.

Dr. Joseph Mercola:

Yeah. I'm still a bit confused, and hopefully you can clear it up. Lysophosphatidylcholine is crucial to transporting these single fatty acids. There's two ways that we can get it. One is we can get it by consuming phosphatidylcholine and then making it. The other is to actually consume it already preformed in foods like krill. Can you explain if the-

Dr. Nils Hoem:

No, it's a little bit more complex.

Dr. Joseph Mercola:

Of course, of course.

Dr. Nils Hoem:

Even if you eat only triglycerides, you will make lysophosphatidylcholine. We have a capacity.

Dr. Joseph Mercola:

Oh, so it's endogenously produced, the capacity to make that.

Dr. Nils Hoem:

Yes. Yes, it is. But you need choline.

Dr. Joseph Mercola:

Okay, choline.

Dr. Nils Hoem:

And you need the raw materials to make it, and of course, if you are going to make a lysophosphatidylcholine with EPA and DHA, you definitely need those fatty acids.

Dr. Joseph Mercola:

You can't ditch it. So, would you say choline is the rate limiting nutrient to create lysophosphatidyl-

Dr. Nils Hoem:

Yes. Definitely, it is, and choline is super interesting these days. Norway, or the Nordic countries, now will have a nutrient recommendation for choline. It's being proposed these days because it turns out, and you have to excuse me really – it's almost hard to believe that something as central to our metabolism as choline, most surveys suggest, both in the U.S. and in Europe, suggest that the population in general do not get more than 80% to 85% of what we need.

Dr. Joseph Mercola:

Yeah. What's the percentage requirements? 400 or 500 milligrams (mg) a day?

Dr. Nils Hoem:

Yeah, it's in that neighborhood. There is a difference in the U.S. In the U.S., you make a distinction between women and men because we have different requirements. While in Europe, there is only one number, which is 550 [mg], if I'm not wrong. But it's hard to believe that our food isn't rich enough in something as essential as choline. Now, of course, choline is also super important for liver health because it is one of the factors that decides if the liver will accumulate too much triglycerides, and as you know, Dr. Mercola, there is something peculiar about the liver because the liver cells store fat in regular liver cells. That doesn't happen elsewhere in the body. Fats are stored in specialized adipocytes. Liver cells are the only cells that can get fatty, really, and you have non-alcoholic fatty liver disease (NAFLD), which probably is way too more widespread than people are aware of because [crosstalk 00:35:06]-

Dr. Joseph Mercola:

Thanks to linoleic acid.

Dr. Nils Hoem:

Yeah, and it's very hard to diagnose. Basically, you need a biopsy. Now, there are new methods coming around, compound methods to diagnose non-alcoholic fatty liver, and I think we will soon find ourselves in a situation where 30%, 40%, 50% of the population actually has this pre-disease condition that is called-

Dr. Joseph Mercola:

I think we're there now.

Dr. Nils Hoem:

Yeah, I think you're right.

Dr. Joseph Mercola:

Yeah, I think we're there now.

Dr. Nils Hoem:

I think we really need to put more focus onto that because it's the first step on metabolic syndrome. It's the sliding towards steatosis and the [inaudible 00:35:44]-

Dr. Joseph Mercola:

Well, I mean, the liver's so essential or critical, and especially to this part of the discussion, because they're making the lipoproteins. If you have a 40% to 50% impairment in your ability to do that, you can put the raw materials in, but it's going to seriously impair you. So, it's a big issue. It, in my mind, all boils back to linoleic acid. You've got to get it low, low, low, and it's almost a cure for NAFLD. Once you get it low enough, it'll reverse. Thankfully, the liver is probably the single most regenerative tissue in your entire body. I think you can cut out 75% or 80% of it, and it will reproduce itself, if I'm not mistaken.

Dr. Nils Hoem:

Correct. But when you get down to steatosis, as long as there is no structure damage-

Dr. Joseph Mercola:

Oh, the long-term damage.

Dr. Nils Hoem:

Yes. Then you have a structural damage, and then really, its fabulous ability-

Dr. Joseph Mercola:

Too late.

Dr. Nils Hoem:

It's too late. There are several strings of research that shows that – increase your intake of choline, increase your intake of omega-3s, or basically increase your intake of phosphatidylcholine, you could actually reverse from non-alcoholic fatty liver back to a more normal liver, instead of sliding further down into steatosis and metabolic syndrome.

Dr. Joseph Mercola:

Can you review with us the best sources of phosphatidylcholine, which I think would be soy and probably some seafoods, or choline?

Dr. Nils Hoem:

Seafood, definitely, and of course, soy is. But soy phospholipids are different. First of all, you have more of the different classes, so it's not a pure phosphatidylcholine, but also ethanolamine and PI (phosphatidylinositol), so inositol and then serine forms of those glycerophospholipids. The marine forms are usually more pure phosphatidylcholine sources, and then they also usually come with EPA and DHA, the marine long-chain fats.

Dr. Joseph Mercola:

The fatty acids.

Dr. Nils Hoem:

So in a way, marine phospholipid is, in this respect, some sort of a Swiss knife. They have it all, and then of course that's one of the reasons why I'm so interested in krill oil because it's so rich in exactly these marine phospholipids that contain EPA and DHA.

Dr. Joseph Mercola:

For the choline, would it primarily be eggs, is the primary source of choline?

Dr. Nils Hoem:

Yeah, that's one. But frankly, anytime you eat a cell, you will get it. It's just that the amounts are so small. So anything, but the amounts are very small. But of course, if you eat seafood, then you would get some of it, or actually, quite a lot. The one thing that I would point out though, is that choline supplements are almost exclusively salts of choline and mostly the bitartrate, regarded [as] the best one. There is also choline chloride, but that's not so common. Now, there are certain questions about the benefit of that because when you take a choline salt, then bacteria in your gut, and it depends on exactly what kind of biome you have, so what kind of bacteria you have, but they will actually metabolize the choline. So, it will be reduced, and it will be made into trimethylamine. That will diffuse across your body, and your body will then oxidize it, your trimethylamine oxide, and then excrete it again.

But that sequence has been questioned with regards to cardiovascular health, and it's been pointed that carnitine is part of this sequence also. So, it may explain why you do indeed see higher levels or you see increased levels of cardiovascular disease when you have a high intake of red meat, but there are still parts of that puzzle that we do not understand. But we've done research where we looked at if you take phosphatidylcholine, will that be metabolized by bacteria? And the answer is, so far as we have looked at it, no. When you compare it directly with the bitartrate, then we see an increase in the plasma levels of the oxides or trimethylamine oxide when you take it as a bitartrate, but you do not see that increase when you take phosphatidylcholine.

Dr. Joseph Mercola:

Interesting. So that's a side effect of taking supplemental choline.

Dr. Nils Hoem:

Yeah.

Dr. Joseph Mercola:

That's interesting. Another powerful support for eating whole foods. It's really hard to go wrong when eating-

Dr. Nils Hoem:

I totally agree.

Dr. Joseph Mercola:

Food is your primary source of these. Because you have this intellectual perception of a biological need, and you know, for whatever reason, you're unable to meet that for your dietary choices. So you choose to supplement, and there's consequences for that. I mean, that's why the general philosophical decision or strategy is to, literally every single time, acquire it from a whole food source. Can't go wrong.

Dr. Nils Hoem:

Yeah. An interesting kind of factoid there is that if you eat salmon, then you will get your EPA and DHA from two different sources. You would get it from the triglycerides in the salmon, but you will also equally get it from the phospholipids that you find in the tissues of the salmon. Actually, you get about 50/50. You eat salmon, you get 50% phospholipids and 50% triglycerides as carrying EPA and DHA. Fish oils are pure triglycerides. There is nothing wrong with that, but you do not get the phospholipids. You get both with salmon, and in a stupid way of looking at krill oil then is that krill oil, in a way, is more fish than fish oil because it provides both, which is kind of strange.

Dr. Joseph Mercola:

Yeah, yeah. I definitely want to go there, but before I get there, I just want to make a point on the salmon you mentioned because it's really good food. But we're presupposing that this is an ideally raised and caught salmon, which is absolutely not the norm. That is actually the exception. Most salmon now are farm-raised. They're fed primarily linoleic acid. They are not fed algae and DHA and EPA at all. Maybe they're given astaxanthin to color them up, and they're full of all their toxins, especially if they're given soy and corn. They probably have glyphosate in there and just not a good food. I mean, it is possible to find wild-raised Pacific salmon, typically never Atlantic, that's not farm-raised. Devil's in the details because if you're going to have seafood, you've got to be really careful of the source.

Dr. Nils Hoem:

But there is nothing in itself that makes farmed salmon bad. You can farm salmon without antibiotics at all with the right kind of feed or the right mix of feed, and there are a few.

Dr. Joseph Mercola:

Right, but that's not done.

Dr. Nils Hoem:

No, that's correct. There are brands that do it right. There are farms, definitely, and increasingly so also, because in a way, nature teaches us to do the right thing because if you feed salmon the wrong kind of food, the salmon gets sick. You see pericarditis in salmon.

Dr. Joseph Mercola:

Yeah, [inaudible 00:43:55].

Dr. Nils Hoem:

You see inflammatory disease. It's in the salmon farmer's own interest to feed it the right kind of food or feed because it keeps the salmon healthy, and of course, profits depend on that. But there's no doubt that the amount of EPA and DHA in salmon today and from salmon, even the best qualities, are maybe down at a half of what it is in wild salmon. But toxin-wise, unfortunately, and it's kind of sad to say this, but because we have polluted the oceans, PCBs (polychlorinated biphenyls), for example, tend to be higher in wild salmon than in farmed salmon, which it's a crazy notion. Nothing is straightforward in this world, so in a way, the basic idea of aquaculture, to my mind, is correct because it can feed larger populations with seafood. It's just that it needs to be done right. That's the crux.

Dr. Joseph Mercola:

Interesting. I wasn't aware of the differences in toxins for farmed salmon versus wild salmon, but it makes sense. It's probably because of the amplification in the food system with toxins, and you're giving them pretty clean feed in the farm version, hopefully an ideal scenario and not one that's bioaccumulated up the food chain.

Dr. Nils Hoem:

Exactly.

Dr. Joseph Mercola:

Thank you for allowing, I think, a really important diversion, tangent, but I want to get back to the other thing you mentioned. You reminded me, and I'd really like you to expand on this because there's a lot of confusion. We've published articles on this before. People understand, realize and believe they need to supplement with omega-3. Even now, we're going to go into more, but you provided loads of justifications to augment your normal omega-3 because almost everyone watching us – I would say it's 1 person in 1,000 watching this that has a healthy level of linoleic acid. Almost everyone is elevated, so as a result of that, your need for omega-3 is increased because you're just simply unable to make it no matter how much ALA you're making because of this inhibition of the delta-6-desaturates and elongases.

We recognize that there's a large number of people who understand the importance of supplementing with omega-3, so they choose fish oil supplements, which is the most common form of omega-3 supplements out there. It's my impression that the vast majority of them should be avoided, and they may be worse than not taking it at all. I definitely want you to comment on this, and this is because most of them are synthetic. They are not the triglyceride form that you

mentioned earlier. They are an ethyl ester, which is an artifact of the, as I understand, distillation process, and I'm sure you understand this at a much deeper level. I'd like you to walk us through the differences between the synthetic version of fish oil and the one that you find in real seafood, the triglyceride form.

Dr. Nils Hoem:

First of all, I do think that since we really need the omega-3s, then almost any type you take is good for you, but I think that's at the basal level. There are two natural forms of taking EPA and DHA. It's the triglyceride form, and it is the phospholipid form. That's how nature provides them. And then of course, the free fatty acid. Let's not forget about that. But there is a pharmaceutical form, and I still think that has its utility as a pharmaceutical. Pharmaceutical use of these is actually to reduce really high levels of triglycerides. So triglyceride will be above 500, there are clear indications for that. But to be able to make that into a pharmaceutical, you need it in a very clean form, that is, from a clean means, the same always.

Then you make a synthetic form, so you esterify it, not onto a glycerol molecule, that's how we make triglycerides or phospholipids, but you actually esterify it to ethanol, which is also an alcohol. Glycerol is a trivalent alcohol. But then you get something called ethyl esters, so then you have the fatty acid with sort of an ethanol molecule added onto the acid function. That's why we call it a fatty acid. They do not exist in nature, and a main problem of them is that they are harder to digest. You must take it with a lipid-rich meal. So you actually need to synchronize it with the intake of a meal that contains enough lipids to kick off the digestion of it.

Now, when it's taken up, of course, then I don't think it makes much of a difference because then the fatty acid will be absorbed as is, and the ethanol will be left behind in the gut. Nature made EPA and DHA in the three forms that I mentioned: phospholipids, triglycerides, and free fatty acids. And then we invented the ethyl esters. As I said, they definitely have an absorption problem, so on average you will not be able-

Dr. Joseph Mercola:

That causes the fish belching or burping that people-

Dr. Nils Hoem:

Yeah. Well, your body doesn't recognize it as fat, so if you take pure ethyl esters all on its own, it will just slide through your body. It actually ends up in your stool. But if you take it with a fatty meal, then of course, your body recognizes fat and starts the digestion process, but I've seen ethyl esters glide through the gut almost unabsorbed.

Dr. Joseph Mercola:

Wow. What if you took it with a lipase enzyme?

Dr. Nils Hoem:

Yes, you could, but you'd only need to take it with some food that tells your body that here comes fat.

Dr. Joseph Mercola:

To make lipase, yeah. Okay.

Dr. Nils Hoem:

In my world, it has its utility, but I do prefer the natural forms. I do prefer the TG (triglycerides), and I do prefer the phospholipid forms, then also as free fatty acids. That's how nature does it.

Dr. Joseph Mercola:

Why don't you break down the three natural forms and tell us the primary sources of these? Does most all seafood have all three forms or some forms? Are they higher in certain types of-

Dr. Nils Hoem:

Most seafoods would have, depending a little bit on – But they would typically have both triglyceride, phospholipids, and of course, the interchange form is the free fatty acids. Free fatty acid is really minor. You won't find much of free fatty acid. You find some, but it's really the two major classes of glycerolipids: triglycerides and phospholipids. That's nature's way of doing it, so whenever you eat whole foods, that's what you get. Even though I work with phospholipids and krill oil, I won't talk down fish oils because that's how most people get their EPA and DHA, and it is way better than not getting it. I don't want the best to be the enemy of the good, so to say.

Dr. Joseph Mercola:

Sure. So, you're not opposed to ethyl esters in fish oil supplements, assuming they're high-quality and they're consumed with a meal?

Dr. Nils Hoem:

Correct. But there is one thing that I really do not appreciate, and this is a particular for the United States. You're allowed to call ethyl esters fish oils, and frankly, I don't like that at all. It needs to be clearly labeled what you buy, so there is something that needs to be done.

Dr. Joseph Mercola:

It's really a type of fraud.

Dr. Nils Hoem:

Of course, there might even be mixtures of the different kinds that might be beneficial, and of course, one advantage of the ethyl esters is that you could really clean them out. You could really clean up and take out environmental toxins. Now, the price you pay for that is, as you pointed, there is a high thermic load on the molecules. You know the history of partially hydrogenated fats and trans fats, and we've had our bad experiences with having imposed changes in fatty acid or in molecules that we didn't even know about. Then 50 years down the road, we found that it had killed a million Americans, really, with the partially hydrogenated fats, and now, they're banned both in the U.S. and in Europe.

Dr. Joseph Mercola:

It took a long time too.

Dr. Nils Hoem:

It did.

Dr. Joseph Mercola:

It was actually a letter catalyzed by Fred Kummerow, who died at over 100 years old. He was a research scientist at the University of Illinois, who really pioneered the investigation of trans fats. In the early 2000s, the FDA finally banned them, and they're still in foods. They give you a limit. I forget what it is.

Dr. Nils Hoem:

At about 1%.

Dr. Joseph Mercola:

Yeah, it's under 1% per serving. But they can make the serving ridiculously small, and they could radically increase it, which is typically done.

Dr. Nils Hoem:

No, and it's interesting, Dr. Mercola, because why are they dangerous? Well, they're dangerous because they have the wrong geometry. They have the wrong structure. Exactly they bend in the wrong direction, and enzymes with certain response elements that read fat, so to say, read them wrong. The way they are inserted into membranes, for example, is not normal. So, you get a bent fat. There are a couple of natural trans fats, vaccenic acid that you find in dairy products. We [crosstalk 00:55:04]-

Dr. Joseph Mercola:

From omega-3s, right. Yeah, they're actually probably biologically beneficial. Is CLA trans? I think it might be. Conjugated linoleic acid.

Dr. Nils Hoem:

They are conjugated linolenic acids. No, I don't think so. But they're special, and you also find them in dairy products.

Dr. Joseph Mercola:

They're typically considered beneficial. One of the other downsides of omega-3 fats is that they are highly unstable. They're even more unstable than omega-6 fats, which means they're perishable, and they're highly susceptible to oxidative stressors. That leaves them predisposed to oxidation, which can spin off these advanced lipoxidation end products, like 4-hydroxynonenal, which is the omega-6 version. I think that's 4-HNE, and I think it's 4-HNN for omega-3s.

Dr. Nils Hoem:

Yeah.

Dr. Joseph Mercola:

Then malondialdehyde, glyoxal, methylglyoxal. There's a lot them. There are hundreds of them.

Dr. Nils Hoem:

Yeah.

Dr. Joseph Mercola:

So, the key point here is that it's predisposed to doing this spontaneously. It's even more susceptible than omega-6. So, when you have a whole food version, you typically don't get this because there's intrinsic antioxidants. In krill, it's astaxanthin. In other vehicles vitamin E can actually stop this peroxidation. So, I'd like you to discuss this because this is a really big issue because a lot of fish oil supplements, they just don't smell good. And that's a clue that there's some oxidation. It's rancid.

It's gone bad and it's only the pure omega-3 that's going to be beneficial, I think. Maybe I'm confused. So, interestingly, in a tangent, we've just started carrying a cod liver oil product that is just the most amazing supplement I've ever tried because there is absolutely no odor, no taste. It has a taste of lemon, but you would never know it's even fish oil. It is just shocking how well-preserved it is. And I don't know why that is because of – but it's the way it's processed or it maintains its structure without being oxidized. It's just fascinating. So, can you walk us through the oxidative risk and what can be done to minimize that?

Dr. Nils Hoem:

I think I know that cod liver product you're referring to and you're absolutely right. It is amazingly free of peroxides. And remember our noses have, we've developed an extremely sensitive sense of smell for peroxidized fats. So that's interesting in itself. It is really.

Dr. Joseph Mercola:

Yeah. Rejection.

Dr. Nils Hoem:

We don't like – and we could smell it at levels that are even difficult to analyze by the most sensitive analytical machinery.

Dr. Joseph Mercola:

Wow. I didn't know that.

Dr. Nils Hoem:

Yeah. No. It's, we-

Dr. Joseph Mercola:

We're almost at dog level.

Dr. Nils Hoem:

Yeah. For peroxides, we are almost like dogs. But how does nature preserve? So you mentioned vitamin E, about your tocopherols, and then you mentioned astaxanthin. And astaxanthin is, if you look into the kingdom of crustaceans, then astaxanthin is really the molecule nature provides and it is a fantastic antioxidant in the lipid phase. Antioxidants, most of them are water soluble and the scales for how efficient they are actually defined in the aqueous phase and not in the lipid phase.

But astaxanthin, it's just amazing. When you have astaxanthin together with your unsaturated fats, then the astaxanthin is being sacrificed and down into very small levels. Phospholipids are interesting in another aspect because of the phosphate group and what is called the head group, which in phosphatidylcholine's case is the choline group. There is a drag on what we call the pi electrons, but they do not oxidize as easily as the free fatty acid or as the triglycerides. The most oxidizable will be the free fatty acid. And then the next one would be probably the ethyl esters and then triglycerides. And then phospholipids seem to be the most resistant.

Dr. Joseph Mercola:

Wow. So phospholipids are the most protected. Can you walk us through why it's the most protected again? Because that was-

Dr. Nils Hoem:

Yeah. If you look in nature, you find the EPA and DHA, or actually all of the polyunsaturated fatty acids, you will basically find them in what is called the middle position. In triglycerides you have three positions.

Dr. Joseph Mercola:

Okay.

Dr. Nils Hoem:

But in the middle position they are the closest to the highly charged phosphate group and it holds onto its electrons in the double bond. So, the peroxide cannot come in and kick out electrons. It's kind of "I want my electrons for myself," and of course then they're more resistant to be oxidized, but of course in any such fat, you need a good antioxidant. And astaxanthin is definitely very, very good. And that's exactly why nature makes it that way. There are some other retinoids, some other similar structures that will do the trick. And typically, I don't know if you know, but it's not the fish that makes EPA and DHA, it's the algae.

Dr. Joseph Mercola:

It's the algae. Right.

Dr. Nils Hoem:

That makes it, so fish actually just transport it to us. And the same with krill. Krill doesn't make EPA and DHA. It eats that from the basic algae source, and algae produce these antioxidants also – maybe krill is able to produce astaxanthin, there are some papers that suggest that. But algae

produce a number of such pigments, and we quite often call them photosynthetic pigments, but they are also functioning as antioxidants. Zeaxanthin, for example, is one of those. But there are a number of these molecules and astaxanthin happens to be the one that we recognize because of its very red color, but there are more.

Dr. Joseph Mercola:

It's a carotenoid, as is the zeaxanthin as is lutein.

Dr. Nils Hoem:

Yes.

Dr. Joseph Mercola:

Which are also in eggs, zeaxanthin and lutein.

Dr. Nils Hoem:

Yep.

Dr. Joseph Mercola:

Really powerful and well-known and documented for eye protection and improvement in vision. So, I just want to get back to the cod liver oil because I'm just personally curious, shocked would probably be even more accurate that it is so free of peroxides. I mean, it just is so pleasant to consume. Is it possible because there's a lot of these, the omega-3s are bound up as a phospholipid and they're sort of protected [crosstalk 01:02:35]?

Dr. Nils Hoem:

Cod liver oil is a pure triglyceride, but it simply has to do with the fact that it is produced from absolutely fresh cod liver, which is unusual. And then it is really, really cleaned up. It's an extensive cleanup process. So first of all, as I said, you start out with something that is pristine and absolutely fresh. It's not stored in huge tanks and it's not sitting around in [inaudible 01:03:03]-

Dr. Joseph Mercola:

For weeks or months.

Dr. Nils Hoem:

-for two years before it's being processed. So, it's being early on processed. And then of course many peroxides are volatile substances and that's exactly why you distill them. But you can make very clean such oils. But of course, Dr. Mercola, the best way of all of this would be to eat your fish or to eat your crustaceans because there they are preserved and it's the freshest you could get. So, it is possible to make supplements and among them krill oil to higher degree, to a high standard. And then the fortunate thing about krill oil is that it really doesn't oxidize that much because of the astaxanthin, because of the structures.

But you need then very high standards [of] production. And then you need, to be able to do that, you need monographs that require that. And unfortunately, that is not always the case. With krill oil we have something called IKOS (International Krill Oil Standards), which is a third-party certification by Nutrasource that actually, in a way, don't take our word for it, take the third-party's word for it. And then for all of these product categories, Dr. Mercola, I think one should have independent third-party quality certification schemes.

Dr. Joseph Mercola:

So, as I mentioned earlier, you worked for Aker, which is the world's largest harvester of krill from mostly I believe the Antarctic where you spend a lot of time. You were just down there this year and been there regularly doing your research. So, can you walk us through the process of how the krill is harvested, how it's certified by the Marine Stewardship Council to be sustainable and not threaten any whales from extinction, and also the processing and how the special types of expensive ships that have been developed to optimize this and minimize any oxidative damage due to a delay in processing?

Dr. Nils Hoem:

Yeah. Of course, I've been there [for] quite a few years now and I have to admit, Dr. Mercola, that I have fallen in love with Antarctica. It makes a very lasting impression when you get down there because it's the really the last part of this globe that is relatively unspoiled by man. And so, you see nature as it used to be. Krill is probably the largest single species marine biomass.

Dr. Joseph Mercola:

On the planet?

Dr. Nils Hoem:

It's probably, around the Antarctic region you find more than 500 million tons. In the region where we harvest it, that is in West Antarctica, the estimated biomass is 60 million tons. And I've been on surveys to find out how much there is, and at least for now the amount has not gone down. So, for the last at least decade or even more, the amount seems to be stable around 60 million tons. The last large-scale server was in 2019 and I was actually following that one. And at the same time, Dr. Mercola, the whales are back. I have actually seen it with my own eyes that [the] number of whales over the years I've been there has increased. And now occasionally you see thousands of whales. So, the whale population is back at where it was pretty much pre-whaling, which it's good to see.

And the catch we're allowed, there is an international body called CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) that actually regulates all the fisheries in the Antarctic region. And then the krill, you find types of krill all over the globe, but the Antarctic krill is very particular. It is larger than other krill. And krill oil by definition only comes from Antarctic krill because in other parts of the world then the lipid structure will be different. But we are allowed to catch less than 1% or 1% of the total biomass, so 620,000 tons. And we've been around half a percent up until now. That's extremely conservative quotas. And there isn't anything to suggest that what we do will harm the population. Also, the way we harvest this, you have to be able to harvest-

Dr. Joseph Mercola:

Before-

Dr. Nils Hoem:

Go ahead.

Dr. Joseph Mercola:

Before we go into the details of the way, I just wanted to note that some people are concerned that the harvesting of krill is going to impact the whale population, which is why I wanted to emphasize the point that you mentioned that, in fact, the whale population has increased to pre-whaling levels from your discernment.

Dr. Nils Hoem:

Yes.

Dr. Joseph Mercola:

So that's a good thing. The krill harvesting is not impacting whale populations, and it's certified by [the] Marine Stewardship Council, which is a third-party independent, not-paid-off front group to establish that it is being done properly.

Dr. Nils Hoem:

It's been certified and it's supported by the research that is being done in the area, so in all sectors of the Antarctic, the whale population has increased. There is one sector in the Pacific region that lags a little bit behind, but it's also the species of whales. It's also humpback whales. It's fin whales. It is orcas. Blue whales are a little slower. They have a longer generation time. So they will probably keep increasing for the next maybe decade or the next decades, maybe even in [a] centennial. But yes, we are back and then we are back at the time when we also harvest krill. But the whales will eat way more krill than we harvest. I've seen a calculation that suggests that whales at a full population will take out something in the neighborhood of up to 200 million tons a year.

Dr. Joseph Mercola:

Wow.

Dr. Nils Hoem:

Krill lives for about six years and seems to have a tremendous ability, given enough algae to increase its biomass. It increases its biomass up until levels regulated by other factors really. So, it's really the algae bloom in Antarctica that governs the amount of krill really.

Dr. Joseph Mercola:

You would think that the variables that contribute to algae bloom would actually be improving, which is not necessarily good from an environmental perspective because typically it's phosphate pollution that causes the algae to grow. Now I don't know if that pollution reaches the Antarctic, but if it did, that would certainly speak well for the algae. Right?

Dr. Nils Hoem:

No. In Antarctica, no. Antarctica is very special. It's an ecosystem almost completely isolated from other ecosystems because of the circumpolar current. There is a drop in temperature along that current that is only a few kilometers wide or only a few miles wide, but there is a drop of 3 or 4 degrees Celsius, a sudden drop in the Southern Ocean when you pass through that one. So, for example, krill will die. If you put krill in water at about 2 degrees Celsius, they start to die. They must be in that cold water. And that's typical for all life there.

Dr. Joseph Mercola:

What's the temperature of the Antarctica where they are? Is it zero?

Dr. Nils Hoem:

Yeah. It's from zero and down to – the minimum amount I would say on the average is probably -0.5 [degrees] Celsius, so that's 36 [degrees] Fahrenheit or 35 [degrees] Fahrenheit.

Dr. Joseph Mercola:

I thought it'd be below 32. Wouldn't it? Is zero [crosstalk 01:12:02]-

Dr. Nils Hoem:

Yeah. No. Sorry. My calculation error. So yes, it's down at 32, 30 [degrees Fahrenheit] in the freezing range. It all goes down to -1.3, -1.4 [degrees] Celsius. So freezing conditions, really. And it's really a very special situation. There is little iron in Antarctica. So you see, for example, krill doesn't have iron as its oxygen carrying prosthetic group. It actually relies on hemolymph, which has copper as its [inaudible 01:12:44]

Dr. Joseph Mercola:

Interesting.

Dr. Nils Hoem:

Yeah.

Dr. Joseph Mercola:

Who would've known?

Dr. Nils Hoem:

So that's why krill actually contains a fair amount of copper. And the phosphates, there is no phosphate pollution in Antarctica. You do see some PCBs, very, very small amounts. But you see very special patterns of PCBs in Antarctica and you see some other pollutions that will be transported by air, and then condensate in the cold climate.

Dr. Joseph Mercola:

What about heavy metals like mercury?

Dr. Nils Hoem:

Very little. Heavy metals, we've analyzed for it and others have analyzed for it. And you find very low amounts of, for example, mercury, lead. Yeah, they're not there. There are volcanoes in the area. For example, in what is called Deception Island, which actually is an active volcano. And there you can find it, but it's not spread around.

Dr. Joseph Mercola:

Okay. Interesting. It's fascinating. So, an argument that many people have about consuming krill is that as a food, is that it's not a food source for humans, that ancestral humans didn't consume krill. So how would you respond to that?

Dr. Nils Hoem:

Well then, the same goes for any crustacean. Krill is a crustacean as good as any other crustacean. And certainly, humans have been eating crustaceans. We haven't harvested Antarctic krill because it's where it is, but we certainly eat other types of krill. You know, you could walk along the beaches in Thailand, for example. And people have a little net that they drag into the water and then what comes up, it's called shrimp, but it's actually krill, but that's different [inaudible 01:14:51].

Dr. Joseph Mercola:

Really?

Dr. Nils Hoem:

Yeah. Of course.

Dr. Joseph Mercola:

Oh. Okay.

Dr. Nils Hoem:

So, I was tempted to say that 9 out of 10 whales eat krill, why shouldn't we do it? The first paper on the suggestion on eating krill, Dr. Mercola, was published in 1958, actually the month I was born, and a guy called Peloquin suggested in Scientific American that we should stop whaling and rather fish krill, so.

Dr. Joseph Mercola:

Eat higher up the food chain for sure.

Dr. Nils Hoem:

Yes. Of course, we should harvest as far down in the food chain as we could. Now, ideally, we should have harvested algae, but don't ask me to harvest the microalgae that is five micrometers across. You won't be able to do that. And to me krill is just the sweet spot of it. Krill does the algae harvesting for us, and then we harvest krill instead. And that's energy efficient and, yeah, it's just the sweet spot.

Dr. Joseph Mercola:

Alright. So, it seems the best retort to that concern [that] humans historically haven't eaten krill is that's not necessarily true. They've eaten krill probably in some Asian countries, but just misidentified as shrimp. So, in many ways, it's just a different version of shrimp. So, if you've eaten shrimp, you're pretty much eaten krill, which also has the other concern and is a legitimate one. Absolutely. That if you have a shrimp allergy, then you really should avoid krill because you're most likely to be allergic to krill too.

Dr. Nils Hoem:

Absolutely. Yeah. You know, the primary allergen in crustaceans is tropomyosin. And if you take tropomyosin from crab or from shrimp and you cross-react it with krill, then you definitely see a cross-reaction. So, again, krill is a crustacean and it has the same type of molecule. And if you're allergic to crustaceans, then you should stay away from krill, no doubt. Yeah. The Japanese also actually have eaten krill, what is called Pacific krill. If you go to Japan, in every bar, they will serve you dried Pacific krill as a snack.

Dr. Joseph Mercola:

Oh. Okay. Good. Alright. Well, that's good to know. So you also mentioned that krill has some copper in it. And I've also been fascinated with copper since encountering Morley Robbins. And, you know, many people seem to be deficient in copper. And iron deficiency anemia actually is frequently confused with a copper insufficiency or actually the lack of optimally integrated copper into your metabolism in specifically ceruloplasmin. So, what type of dosages are you seeing in micrograms of copper?

Dr. Nils Hoem:

Oh. This is really from the top of my head.

Dr. Joseph Mercola:

Okay.

Dr. Nils Hoem:

But it's a significant amount. Let's put it this way, it's enough for – if I leave krill to oxidize, I actually see the typical blue-green color in some extracts of copper substances. If I'm not wrong, if I say something like 5 micrograms per gram, then I think I'm not too far.

Dr. Joseph Mercola:

Wow. That's significant.

Dr. Nils Hoem:

It is. It is definitely significant. The hemolymph, so the blood of krill, hemolymph is the oxygen binding molecule in krill blood. That has copper as its prosthetic group. It's copper that is the center, that is coordinating the oxygen binding. You also find a little bit of zinc. You find some iron. Now, the Southern Ocean is iron-poor, but you find, yeah – zinc is also one of those that you find a little bit of in krill.

Dr. Joseph Mercola:

So you make a pretty strong argument for considering krill as a source of omega-3 and another valuable nutrient like copper.

Dr. Nils Hoem:

Yeah.

Dr. Joseph Mercola:

And lysophosphatidylcholine. And the phospholipids and the triglyceride lipids. I meant lipids, I mean EPA and DHA.

Dr. Nils Hoem:

Yeah.

Dr. Joseph Mercola:

So, it's a good source. Now interestingly, those lipids are relatively small when you compare it to a typical fish oil supplement. You know, in my memory, I don't know [the] specifics, but you would know, but I think it's like 90% less. Now to compensate for that is the radically improved absorption of the phospholipid form as opposed to the ethyl ester or even the triglyceride form.

Dr. Nils Hoem:

I would say more on the distribution part of it. So, it doesn't really help you that much if your EPA and DHA resides in your white fat or if it resides-

Dr. Joseph Mercola:

Oh. That's interesting.

Dr. Nils Hoem:

So, it's really on the utility of it. Ethyl esters are special. They do have an absorption problem. I would say neither phospholipids nor triglycerides really has an absorption problem. They're fairly well digested. Where you see the differences between them is in how they're distributed. And that's exactly why I think you need both.

Dr. Joseph Mercola:

Wow.

Dr. Nils Hoem:

So, I would never talk down fish oils. Now krill oil is more similar to what was called 18/12 oils, so in fish-

Dr. Joseph Mercola:

You said 18/12?

Dr. Nils Hoem:

Yeah. Krill is typically 8% to 9% DHA and 12 to 15% EPA.

Dr. Joseph Mercola:

Okay.

Dr. Nils Hoem:

So, it's not that different from what you find in natural sources.

Dr. Joseph Mercola:

Okay.

Dr. Nils Hoem:

You do not find any natural source with super high concentrations of EPA and DHA. Then it is a concentrate of some kind. In nature usually do not go outside of 18/12.

Dr. Joseph Mercola:

Okay.

Dr. Nils Hoem:

So that's just the way nature packages it.

Dr. Joseph Mercola:

Okay. All right. But the distribution, so can you just talk more about the distribution because the light bulb went off when you said that. Because I never really appreciated that until you said it. I'm assuming it's winding up in the tissues that you really need it, like your brain, your retina, your mitochondria.

Dr. Nils Hoem:

Yeah. I'm actually, as we speak, writing up a paper on some of this because what we've done is that to be able to analyze this, you actually have to use radiolabel substances. So, we've made them synthetic and then we've put in a radioligand. So, C14, a better emitter in the carboxylic acid group. Because otherwise your experiment is going to be way too diluted. And by doing this, in animals, you could actually see exactly where the different labeled fatty acids go. And what I can tell you is that there is a clear difference between the different forms.

And again, phospholipids have certain specifics when it comes to the brain, the eye, the liver. Triglycerides seems to have some specifics when it comes to, for example, in [the] heart muscle. But our heart is able to extract EPA and DHA from the circulation quite well. There is a very high lipase activity there. But what I can say is that it is a really diverse pattern. And what it tells me so far is that we need both forms. And let me also point out that krill oil also does contain EPA and DHA in triglyceride form. Krill oil really isn't an oil, it is a lecithin. It's a mixture of

triglycerides and phospholipids. So nature provides both, and I think we need both.

Dr. Joseph Mercola:

Alright, so let's expand on the benefits of putting EPA and DHA in those tissues. The three that you mentioned were the brain, the heart and the liver. So can you expand on the utility of having higher concentrations of those essential fats?

Dr. Nils Hoem:

Well, it goes into every tissue, Dr. Mercola-

Dr. Joseph Mercola:

But it goes into there better than the others, you said, because that was [inaudible 01:24:34] difference-

Dr. Nils Hoem:

Yes, for [the] brain and for the eye, without a doubt. And also, the transport across the placenta is dependent on the-

Dr. Joseph Mercola:

Ah, a fourth one.

Dr. Nils Hoem:

But remember – how do I say this? EPA and DHA serve as substrates for what I call lipid-derived signaling. And one must not forget that cells need to talk with themselves. They need to talk with their nearest neighbors. That's how everything is kept at bay, how cells self-regulate in a way that is beneficial for us. Now, the substrate for that signaling is usually fats or a fatty acid. And that's not strange at all, because those membranes that we talked about are everywhere in the cell. Everything in the cell is connected to a membrane. So, the main signaling system – and then maybe people have heard about prostaglandins or prostacyclins or thromboxanes, they are being made from fats excised from the membrane. And you could excise either omega-6s or omega-3s from the membranes, and that's dependent on the amount of these in the membrane. And you get two classes of signaling molecules. So when you make the signaling molecules from EPA, for example, you get PGE-3 (prostaglandin E3) and not PGE-2 (prostaglandin E2). And the same goes for a number of these super important signaling molecules.

And then further down the road, there is a type of molecules called resolvins and moracins, which, actually first you have inflammation, but inflammation needs to stop. So, inflammation is there to fix a problem, but then it needs to be stopped, to be resolved. And EPA and DHA and also DPA (docosapentaenoic acid), the forgotten of that triumvirate-

Dr. Joseph Mercola:

That's a 24-carbon one, right?

Dr. Nils Hoem:

No, DPA is 22. Like DHA, but it has only five double bonds.

Dr. Joseph Mercola:

Oh, okay.

Dr. Nils Hoem:

And there is actually one type of DPA that is omega-6 and another one that is omega-3. And I'm talking about the omega-3 DPA.

Dr. Joseph Mercola:

Of course.

Dr. Nils Hoem:

Now, maybe as much as 25% of EPA is made into DPA and ends up in membranes. But we're becoming more and more interested in the DPA. But those resolvins is absolutely necessary to stop inflammation from overdoing its job. First inflammation, then resolvation. And that's the key to healthy inflammation-

Dr. Joseph Mercola:

Now, can I stop you there, and I'm sorry for the interruption, but it was my understanding that the resolvins and the protectants, the moracins you referenced are available in whole food, like krill or cod liver oil, forms of omega-3 supplements. Not in the synthetic chemically derived fish oils.

Dr. Nils Hoem:

No, they're not available in – These SPMs (specialized pro-resolving mediators), as they're called, are very short-lived. They live for microseconds. That's typical for a signaling molecule. So, you can't take them as is. It's been tried in pharma to synthesize stable analogs. It's turned out to be a bad idea, because the whole essence is that it is going to be made in situ, from EPA and DPA mainly, but also some from DHA. Do their job and then be gone. So, you have to do it the nature way here. So, there are no such SPMs in any oils of any appreciable amount. And if it was there, it would die in your stomach or in your absorption anyway. So, to have a good SPM response, you need to load your membranes with EPA and DHA. Most of your brain-

Dr. Joseph Mercola:

The source of the EPA and DHA is not an issue then? I was confused.

Dr. Nils Hoem:

No, the source is not really an issue at all. It is all about-

Dr. Joseph Mercola:

Well, thank you for that clarification. I just thought it was a whole food source, but they're very short-lived molecules and they're actually produced in situ rather than-

Dr. Nils Hoem:

In situ, yeah.

Dr. Joseph Mercola:

Okay. I did not realize.

Dr. Nils Hoem:

Yeah. It's a very common misunderstanding, but it's really all about in situ production. And again, it's part of this fairly complex signaling cascade, really. Our bodies have other such cascades; for example, the coagulation system. When you kick off coagulation, you at the same time, but in a time-fused manner, kick off fibrinolysis also. It's a normal theme in nature.

Dr. Joseph Mercola:

Okay. So, thank you for explaining all this. I'm still a bit confused, though, and I suspect some other people are also, with respect to the relatively low concentration of the EPA and DHA in krill relative to other fish oil, which you said could be super concentrated. So, you're in agreement that they're actually both beneficial. But can you provide the argument why adding krill, if you're taking a non-krill form, such as if you were taking cod liver, that there may be a good cod liver supplement that was processed, ideally, that there probably is some benefit to taking krill as an adjunct? Because both together is probably better than either alone.

Dr. Nils Hoem:

Exactly, because you get choline, and you get choline in its natural form. That is, phosphatidylcholine, which is important. And you get a supply of both the molecule itself, but also the raw material for the molecules that provide your body with lysophosphatidylcholine, which is necessary for the transport into these specific organs that I mentioned.

And then of course, with regard to liver health, then choline and phosphatidylcholine have their own function. And it's been shown that both omega-3s as well as phosphatidylcholine play a role in non-alcoholic fatty liver development. And you actually can reverse by eating marine fats, specifically marine phospholipids and long-chain omega-3s in that condition. But I don't mind at all if people mix and match. For example, people ask me all the time, "What if I can't afford krill oil?" So then I say, "Well, take what you can afford and then add on fish oils." I don't mind that at all.

Dr. Joseph Mercola:

Okay. So that helps. There's benefit to doing both, ideally, and you just have to take more of krill. And you're right, the cost is higher just because of the harvesting. It's a lot more – I actually interrupted you in the harvesting for a tangent, so maybe if you can recall where you were about the harvesting? We were talking about the processing. Because we never finished that thread.

Dr. Nils Hoem:

This is where it's really different, because we harvest krill in a continuous process. Actually, we have a trawl, which is a huge net out there, and then there is a pump at the end. Or not really a pump, there's a suction pump. But it comes live onboard. So, I myself can put my hands into the flow of this and then I'll have live krill in my hands. And we then process it. That really means drying at relatively low temperatures immediately. And then we bring that on land and we extract it, not by heat or by any type of heat treatment, but by ethanol extraction, which is very unusual for marine fats. Usually you need a lot of heat. And this is because it's a phospholipid triglyceride mixture. Triglycerides are really not soluble in ethanol, but phospholipids are, and the phospholipids drag the triglycerides out together with them. So, the whole processing from the very beginning, the way we fish it and all the way through, is different for krill oil than for the other marine fats. Way less use of heat, really.

Dr. Joseph Mercola:

And heat is one of the variables that will increase the peroxidation of those perishable fats?

Dr. Nils Hoem:

If you're not doing it right, absolutely. And this is where you have found a source of good cod liver oil that's obviously is doing it the right way. There are ways you can do it, but-

Dr. Joseph Mercola:

It's all about the processing.

Dr. Nils Hoem:

It's all about the processing. It's all about being fresh. People may not know this, but most of the at least cheaper fish oil products are made from fish oil that is stored in huge tanks for years, really. Of course they try to do it the best way they can, but-

Dr. Joseph Mercola:

Do they at least freeze it?

Dr. Nils Hoem:

Yep. And then you would have to process that raw fish oil into something that has the quality that you want. We don't do it that way. We take care of the raw material from second one, and we don't store it away in large storage tanks and then refine it to the quality we need. We try to take care of the quality from the very beginning to the very end. And by the way, we own the whole value chain.

Dr. Joseph Mercola:

Yeah, and I think you're the largest harvester of krill in the world, right? In a large way. Like the giant. Like almost no company comes-

Dr. Nils Hoem:

Oh no, typically our three boats typically do 60% to 70% of the total catch among 12 boats. So we are by far the largest. And then of course, we have the infrastructure necessary also. But of course, you're absolutely right that quality is something that you get when you put quality into every step in your chain.

Dr. Joseph Mercola:

Well, thank you for helping us understand that. And now I have a curiosity question with respect to one of my passions, which is the mitochondria. And I thought it was a shared passion. But from your knowledge of membrane physiology, is there any specific benefit or function, biologically, of the EPA and DHA in the mitochondrial membrane or certain other molecules like cardiolipin that are so important in the cristae function?

Dr. Nils Hoem:

There is no doubt that EPA and DHA also are incorporated into the inner membranes of the cell. So, they will be a reflection of your total intake, exactly like what we call the outer membrane. Now, if a membrane is inside or outside, that's a different story. It's a very philosophical question, what membranes really look like. It's not like a ball. It's a very convoluted structure. There are some fascinating aspects of that called topology. So, mathematical. But I think the verdict on EPA and DHA in the mitochondrial membrane is still out. And frankly, I asked Dr. William Harris, as per today, if they are the ones who measure EPA and DHA in the erythrocyte membrane, and I asked him, "Have you ever looked into EPA and DHA in mitochondrial membranes?" And he said that they were really interested in doing so, but so far, they haven't really.

Dr. Joseph Mercola:

Well, it's hard. How are they going to do it?

Dr. Nils Hoem:

Well, but it's not at all impossible. For example, you could do it by radio labeling. We could actually get some interesting results on that. It's absolutely doable.

Dr. Joseph Mercola:

How could you target to go to the mitochondria though?

Dr. Nils Hoem:

Well, you would just give it to a whole animal and then [crosstalk 01:37:41]-

Dr. Joseph Mercola:

Oh okay, extract the mitochondria and see the percentage.

Dr. Nils Hoem:

Exactly. And by radio labeling, you could really see if it happens. The other thing is the interaction with cardiolipin. That's an interesting one. And as you know, the standard, so to say, ligand for cardiolipin is actually, as far as I know, palmitic acid, isn't it?

Dr. Joseph Mercola:

Mm-hmm.

Dr. Nils Hoem:

So, what will the effects on cardiolipin be if you see an interaction with other fats? And frankly, I don't think we know.

Dr. Joseph Mercola:

Yeah. It seems to me there should be some, really, Goldilocks equilibrium. You certainly don't want to [be] full of it, like it is today in most everyone, because of the massively increased amounts of omega-6 linoleic acid. So, a lot of the cardiolipin is – it has four fatty acids, and in many people, all four of them are linoleic acid. Probably almost none of them should be. But there probably is a small amount, probably on the order of way under 5%, maybe 1% or 2%, that serves some biological valuable function that we just don't know or appreciate. But it's important. And if it's not there, something's going to be working less than optimally, I would think.

Dr. Nils Hoem:

I think you're right. And then also with the mitochondrial membranes, we really need to make a difference between the inner membrane and the outer membrane. And my take on it is that the outer membrane reflects the plasma membrane more than the inner membrane.

Dr. Joseph Mercola:

That makes sense, yeah.

Dr. Nils Hoem:

Yeah. But again, remember that mitochondria need to communicate, and there will also be lipid-derived signals there. But now I'm easily ending into something that scientists shouldn't do; we end up in speculation, rather. But I think we have to realize that these are white spots on the map. We have been viewing lipids as energy for decades, or almost from forever, and not as structure, despite the fact, Dr. Mercola, that we're made of lipids. The phospholipid membrane defines life. It defines the border between me and the environment outside. Without the membrane, no life. So, we are at the very, very core of our own definition.

Dr. Joseph Mercola:

So, could you expand – you touched on it earlier about the structural component, and helped me realize that it was because of the conformational increase in size, because of the shift due to the double bonds, it takes up more space so it can contribute to structure as opposed to these saturated fats where they're just simply straight lines. So, can you just expand how that

contributes to the structure? And then after that, go into the signaling component, which also I didn't appreciate was so important a function and process of these fats.

Dr. Nils Hoem:

The unsaturated fatty acids in general, and in particular EPA and DHA, are bulky fatty acids. And they're bulky simply because they have these double bonds fixed. DHA is more of a linear bulky structure, while EPA is more of a circular bulky structure. And it can't rotate around its carbon, so it's really fixed. And I think of them more as an architect than [as] building blocks. Now-

Dr. Joseph Mercola:

Like a Lego, right?

Dr. Nils Hoem:

Yes. And then you have to start asking yourself, "What's going on in the membrane?" Well, the membrane has response elements in it. So that is [the] transporters, iron channels, the electron transport chain, you name it. All of this is connected to the membrane, and a lot of response elements need to flow transversely in the membrane. So when I say that the fluidity of the membrane, don't necessarily think of it as it's flexible on its outside, but more how response elements can flow transversely in the membrane, how element A can reach to element B. Because quite often, you have two or three such elements that needs to coalesce into one element to be activated.

Now, if we go to signaling substances, the best way to describe this is to be specific. And if we take prostaglandin, which is a universal inflammatory signal, it is being made from, for example, arachidonic acid. So an omega-6. First of all, the enzyme that is doing this sits on the inside of the membrane. So in the cytosolic part of the membrane. And it sits there closely to the membrane because the substrate is a fat, the fat isn't soluble in water. So, phospholipase A-2, for example, is excising out the fatty acid and feeds it directly into what is called the hydrophobic pocket of that molecule. So, it doesn't have to traverse water to get in there. And it's not really one enzyme, it's two enzymes in one. So, it's an epoxidase and an oxidase. And instead of arachidonic acid, it spits out PGE-2. Okay?

Dr. Joseph Mercola:

Mm-hmm.

Dr. Nils Hoem:

And if instead phospholipase A-2 takes out an EPA, it spits out PGE-3. And PGE-3 has been shown to be less inflammatory, usually, than PGE-2. So that's one. So, the omega-3s are not anti-inflammatory. They are modulators of inflammation, and they're part of a measured inflammatory response. And then downstream, PGE-3 is formed into moracins, for example, so the resolvins, and actually actively stops the inflammation and then starts restoration instead. And the omega-6s do not do that to the same extent. So, you need EPA and DHA and DPA to have this resolving function going as it should. And, really, we are only scratching the surface of this-

Dr. Joseph Mercola:

The tip of the iceberg. The [inaudible 01:44:50] iceberg.

Dr. Nils Hoem:

So endocannabinoids for example, is another class of such lipid-derived signaling substances. There is really a whole sociological garden coming around of these signals. So, there's going to be a lot of exciting stuff. And the prostaglandins were discovered at the end of the 1960s and the very beginning of the 1970s. When I was educated as a pharmacologist, I could still read about the action of aspirin in "Goodman and Gilman's Pharmacology." That was completely wrong.

Dr. Joseph Mercola:

Yeah. When I went to med school, we didn't know – in pharmacology class, they didn't tell us how aspirin worked. They didn't know.

Dr. Nils Hoem:

No. They didn't know. Or they came up with very, very inventive ways of describing it that were completely wrong.

Dr. Joseph Mercola:

Yeah, absolutely. So, this has been so delightful. Massive gratitude for helping me more fully appreciate the importance of regular omega-3 supplementation. At least until you're into the sub 1% of the population who has very low linoleic acid and you're eating enough alpha-linolenic, then maybe you can do it yourself. But if you're not part of that, you're going to need to take omega-3 because of all the important functions you mentioned.

Dr. Nils Hoem:

Yes.

Dr. Joseph Mercola:

And probably the simplest and best way, and my final question to you is, from your perspective and your science background, your take on the ideal 6-to-3 ratio in the membrane, in the RBC (red blood cell) membrane, that is inexpensively obtained and without a doctor's order. What should that be? And is it just the ratio that's important, or is there an absolute value or quantitative component that is also important?

Dr. Nils Hoem:

It really doesn't matter, since there is an exchange one by one. So, if you increase your omega-3 index to eight, then there will be a fixed amount of omega-6s left. So, it really doesn't matter. You should get your – measured by omega quants or Dr. Harris' method, you should be at least seven. I keep my level up at 10 or 11. There's probably not much use in getting higher than that. I know that in dolphins, for example, we find levels of 20.

Dr. Joseph Mercola:

Wow.

Dr. Nils Hoem:

And I guess [in] the whales that I see in Antarctica, they will be sky-high. But you should be eight, and the only way to knowing this, Dr. Mercola, is to test yourself. And it's available as a dried blood spot test. And if you know your level, and if you know how much omega-3s you need to take to be at that level, then just stay there. Our metabolism of these fats is quite reliable, so if you know your individual dose necessary to be there, then just be there.

Dr. Joseph Mercola:

Okay.

Dr. Nils Hoem:

Yeah.

Dr. Joseph Mercola:

And because it's a red blood cell test and red blood cells are the substrate for it, they basically live for about three months. So there really is a limited benefit to testing more frequently than every three months. But what do you recommend? Once a year? Once every six months?

Dr. Nils Hoem:

I would think if you do it once a year, then yes. And remember, the kinetics is very slow. So, if you double your dose, it will take the best part of three to six months until you are at a steady state again. And the same goes for if you reduce your dose to half, it also takes three to six months. It's exactly the reverse. This is something that makes this tricky, because you wouldn't recognize from day one to day two your change, but you will recognize it in six months. So, it's long-term. This is not pharmacology, it is nutrition. And it's a question about being prepared when you need your lipid-based systems to function correctly. If you do not take care of your membranes with regards to the right fatty acids, when you need them to respond correctly or in a measured way, it's too late to take them.

Dr. Joseph Mercola:

Yeah, yeah. This is being proactive and really the foundational basics. And it's a simple strategy, and I really appreciate your perspective. You're deep in the science and you have the knowledge base to give us insights that, really, it’s hard to get in many other places. And you're objective about it. You're not really providing us with biased or skewed information that's going to promote the sale of your company's products. It's just the facts are the facts. You're a true scientist. So, I deeply appreciate that.

Dr. Nils Hoem:

Thank you very much. That's the only way you can do science.

Dr. Joseph Mercola:

Well, I would have to strongly disagree with that one. All we have to do is look back to the last two years and see what the heck they did with COVID, and Fauci being science and having to

trust in him. No, it's not the only way. There's another way that is just almost a polar opposite. So, thank you for being a true scientist and really applying it the way it was designed to be.

Dr. Nils Hoem:

Thank you very much. It's been a real pleasure.

Dr. Joseph Mercola:

Yeah, yeah, I was looking forward to this and I certainly wasn't disappointed, so thanks so much. When it changes my health strategy, it's a big win. And if it's a win for me, it's going to be a win for a lot of other people. So thanks, because you clear up a lot of confusion on some really important and foundational topics. And I think there's a lot of confusion on this in the general population, so I think this is going to really help a lot of people.

Dr. Nils Hoem:

Lipids have been the forgotten molecules. I told internally in Aker Biomarine that I would be satisfied with my work in Aker Biomarine when phosphatidylcholine is on the front page of Time Magazine and voted the Molecule of the Year.

Dr. Joseph Mercola:

Maybe someday, but Time is a woke magazine and they probably have some transgender person on there as their spokesperson of the year. So anyway, all right, thanks so much. You keep up the great work and keep educating us.

Dr. Nils Hoem:

Thank you very much.

Dr. Joseph Mercola:

Alright, bye now.

Dr. Nils Hoem:

It's been a pleasure. Thanks.