**Krill Oil:**

**A Special Interview with Nils Hoem, Ph.D.**

By Dr. Joseph Mercola

**JM:** Dr. Joseph Mercola

**NH:** Nils Hoem, Ph.D.

**JM:** Omega-3s, we all know that we need them, but what's the right type? Plant-based or animal-based? Hi, this is Dr. Mercola, helping you take control of your health. Today we are privileged to be joined by Dr. Nils Hoem, who is coming to us from Norway. He is one of the leading scientists in omega-3 phospholipids. He's going to help us answer that question and a whole variety of other interesting topics. Welcome and thank you for traveling all the way from Norway to visit with us.

**NH:** Thank you very much.

**JM:** I appreciate having you. Most people watching this video will not know who you are. Maybe you can give us a little history, because it's really fascinating. I believe earlier, you were sharing you really wanted to be a fisherman. Your whole family is from this fishing background. But you got sea sick, so you went to science instead.

**NH:** I had to go to science instead. After having tried my fortune on the high seas for a little while, I realized that this is nothing for me. Science was a better choice.

**JM:** It's a big occupation in Norway, right? A large percentage of the population is employed in fishing.

**NH:** It used to be.

**JM:** Not anymore?

**NH:** But it's still a very important part of our economy and everything that has to do with what we call the “blue economy.”

**JM:** Blue for the water?

**NH:** Yes. Meaning, looking at the ocean as a source of materials and food. Not just traditional fisheries, but also such things as harvesting algae and harvesting everything that is in the seas in a responsible way. Regulating the fisheries has been a tremendous success actually. Today, for example, the herring fisheries that was almost dying out when I was a kid (and I still remember it) is back at capacities that we haven't seen since World War II.

**JM:** That's exciting news.

**NH:** Yes it is.

**JM:** To see that this can be turned around. It's excellent. Why don't we address the basic question I opened up with? Because I think there's a lot of confusion on this issue, and there's good reason to be.
Because if you just look at it simplistically, it would seem the closer you get to the foundational sources of nutrition, the better it's going to be.

But there's this problem with this. Because most plant-based omega-3s are completely different from animal-based. That would be that they have this fatty acid called ALA or alpha-linoleic acid. It's 18 carbons. That doesn't work. Our body really needs the 20 and the 22 carbons like the EPA and the DHA. There's a little enzyme that converts it and does it. It doesn't work well in most people.

**NH:** No. It's really a very interesting question. How did human and actually most mammals get dependent on a type of fatty acid or a type of fat that you only find in the oceans?

**JM:** Great question.

**NH:** That's a really interesting question. Without getting too far into that one, we have to realize that when we start to look into how lipid affects our health.

The earlier work, for example by Jorn Dyerberg and his associate, H.O. Bang, in Greenland. They found these very interesting long-chained fatty acids, polyunsaturated fatty acids, and they realized that the two of them, EPA and DHA, had their first double-bond in the third position. Then they named them omega-3 fatty acids, which chemically and technically is correct.

The research that has come since then has focused on these two fatty acids. We've slowly learned about the biological effects of those fatty acids and how they're important for our health. Of course, then we realized that there's a similar type of fatty acid called omega-6 fatty acids. Usually, they're a little shorter and they seem to have some opposite effects. They're also essential for life but for different degree.

Then of course, chemically you could name any fatty acid that has its first level bond in the third position or omega-3 fatty acid. Increasingly we see that different players are trying to use the label “omega-3” as a general label for healthy or a general label for having biological effects in line with EPA and DHA. That's simply not the case. It's kind of a mislabeling.

**JM:** We see this a lot in omega-3 eggs in the grocery store at least in the United States.

**NH:** We see the same in Norway.

**JM:** That's not the same omega-3 that you find in fish at all. They just feed them -- you should...

**NH:** You could actually say -- we should be distinct in saying marine omega-3s, or we should say long-chain omega-3s, that's correct. But the 18-carbon-chain omega-3s, they do not have documentation about biological effects. In fact, extensive studies, meta-studies, pretty much come out with them neither being bad nor good. We can a very small amount of them into long-chain omega-3 fatty acids, but it really doesn't help as much.

There may be genetic differences as told by a professor from Japan. Certain people in Mongolia seems to be better to do that elongation and saturation. But all in all, you cannot label the same type of biological and health effects on the shorter-chain omega-3s as you can do with EPA and DHA.

In Norway, for example, just ahead of Christmas, we had a big headline in our main newspaper telling us that reindeer meat contains as much omega-3s as cod, which is, of course, right.

**JM:** Technically correct.

**NH:** Technically correct. But it really confuses people. I think that's confusing.
**JM:** Let's provide a bit more foundation as to – are there any other reasons other than the limited conversion of the short-chain fats into the long-chains that a lot of people have and the lack of documented benefits. In other words, the short-chain or plant-based (ALAs) doesn't provide the same benefit. There's no really research to do that. There's no research that shows it's going to convert to the longer-chain animal fats.

**NH:** That's correct. Also if you simplify this, when you look at the uptake and distribution of EPA and DHA (and that's something that myself and scientists at Aker Biomarine have been doing), you see something very strange. I could hardly believe it the first time I saw it. After a meal of salmon or after you take in krill oil or fish oil, you actually see a fatty acid in plasma or blood for more than three days after. You have a meal and your body works on its distribution and redistribution and re-redistribution for three days. That's hardly consistent with being food.

When you look at the short-chain omega-3 fatty acids or any other short fatty acid, you see them being rapidly absorbed. They peak at a couple of hours and then they're gone in 10 hours. Our bodies are clearly handling them very differently. That shouldn't really surprise us because the short-chain fatty acid is simply food. They're sources of energy. The really long-chain and those that are more than 20, especially the EPA and DHA, are structural elements. They're not mainly foods, but they are elements that actually make up our cells. That's two completely different functions our body.

**JM:** I'm a little bit confused as to why they'd be around for 72 hours after eating them. Is there another, other than a structural component, hormonal signaling aspect to that?

**NH:** Yes. We also know that there are social aspects. They are really interesting ones. And many, many biological effects. I think the common denominator for the biological effect is inches around effects on inflammation, and also around what I would call short distance or short-term communication either within the cell or between cells.

But still, what I just see is very extensive distribution. It takes time to deliver this to the right tissues. It has to get into the heart. It has to get into the brain. We know by now since two years, with the work of David Silver and his associates at the National University of Singapore, that there is a specific transporter in the blood-brain barrier even in the placenta and probably also in the liver that transports these molecules directly.

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It's not a straightforward mass distribution; it is a very concerted process of sending these very important constituents of cell membranes where they belong. That is not in the adipocyte or being directly broken down.

**JM:** There are some scientists who speculate that the human proximity to the sea, which you alluded to earlier, and access to these fats, these long-chain fats, is really what catalyzed the development of our cortex, our higher thinking capacities. I'm wondering if you could expand on that or have any other insights.

**NH:** These are interesting ideas. First of all, we have to realize that what is now landlocked areas like the inner part of Africa wasn't previously. If we go many hundred years back in time, humans probably did emerge along the coast.

Quite interesting – an interesting aspect of this with regards to raw food, if you eat raw meat or if you eat raw vegetables, you have a hard time surviving. There is one famous experiment where a researcher tried to live like a chimp and spent 18 hours a day gathering food and still couldn't get enough. You simply have to cook the food to get enough calories.
But there is one type of food that you can eat without being cooked and still be able to extract all its nutrition – seafood, in particular shellfish. I was in a vacation in Langkawi in Malaysia and was kayaking. I came around a little island and then suddenly I saw a group of monkeys coming down to the beaches. Guess what they were doing: they were collecting shell. They were eating this as an easily accessible source of food.

Maybe as much as 30 percent of the fatty mass of the prefrontal cortex is DHA. Now, we know also that DHA is also important in the cerebellum. With the work of David Silver, as I mentioned, we also by work in knockout mice, we've seen that the development of a normal brain in a fetus is absolutely dependent on the availability of DHA. I think we will learn a lot in the years to come with regards to how important it is.

**JM:** I think we've established that there's pretty strong support for having a clean source and a healthy source of animal-based omega-3s as you differentiate them from plant-based. Not to make the mistake of confusing those two, because it could have pretty catastrophic health consequences for you.

The next practical question becomes: how do we identify healthy sources? Healthy being not contaminated with toxins, but also structurally intact (it's not going to be distorted in some way), then thirdly and I think importantly, that is absorbed efficiently. Those are three big issues. It's really easy to make a mistake. If you make a mistake in one of them, you're not going to be as successful in integrating these important molecules into your cell membranes.

**NH:** First of all, unfortunately, almost many people would say it's a fact of life that fats are really well absorbed. You eat fat, it's taken on.

**JM:** That's not true.

**NH:** It depends on which fat you're taking. There is one form of the omega-3s that may have an absorption problem, not always. If you have it together with a decent meal, ethyl esters will be taken up. But I myself have seen experiments done where the ethyl esters simply pass through without being absorbed or whatsoever.

**JM:** I'm sorry. What passes through?

**NH:** Ethyl esters.

**JM:** OK.

**NH:** Ethyl esters, just passing through, no absorption or whatsoever. Now if you have it with the right kind of food, you can alleviate that.

**JM:** Where would you find an ethyl ester?

**NH:** That's called the most synthetic form of the marine omega-3 fatty acids, simply a fatty acid that has been sliced off from its triglyceride source usually or from any other source and then it is being ethylated with ethanol. It is a construct –

**JM:** It is typically what they do with fish oil?

**NH:** It is typically what they do in some types of fish oils. For example, in the only – it's not the only anymore – pharmaceutical that contains omega-3 fatty acids made in this way or usually was made this way.

**JM:** What was the rationale in doing it that way?
**NH:** The rationale is to have a safe way of purifying it, because they would have to purify according to pharmaceutical standards, also standardizing it, and the third thing would be to have it concentrated. If you have it concentrated enough, you could gain a very high concentrate of these fatty acids by doing it that way. But you really have to take your fish oil and completely decompose it. Then you would have to chemically react to your fatty acids with ethanol to form ethyl esters.

**JM:** One of the general principles we have is to eat as simple as possible, with the less refinement, the better. This sounds like an awful lot of refinement. There's a lot of room for damaging these very perishable fatty acids, because when there's omega-3, there are double-bonds here. They're unsaturated. They're polyunsaturated actually. Every unsaturated bond is a potential for disaster, for a catastrophe of oxidizing that and causing damage. It becomes not only non-functional but it actually causes complications because it's almost toxic.

**NH:** I would maintain though that the best way of getting your own marine omega-3s would be to eat safe, fresh fish. Whenever I'm asked that question, that is my standard answer.

**JM:** Obviously you have the important omega-3s in there, the animal-based omega-3s, EPA and DHA. But there are also other components in that seafood that probably many of them we don't recognize at this point but work synergistically.

**NH:** Also, I lectured in physiology for almost 20 years. I told my students about how fats are being taken up. They get down into your gut. There are lipases in your gut that will decompose them and they will be re-synthesized in the erythrocyte. They will be taken up and they will be re-synthesized. They will be made into other microns. Small emulsions. Then they will flow through your lymph into the [inaudible ], into your body.

Now, while that is mostly right for the triglycerides, I never even considered what happens with phospholipids. With phospholipids, we've become aware of that it isn't exactly like that. In phospholipids, at least a part of the omega-3s are taken up as lysophosphatidates. They are water-soluble enough to be taken directly up into the blood and then are passed into the liver and are being redistributed before they are sent into the systemic circulation.

That explains part of why it takes so long to redistribute those fatty acids. I think we've been grossly underestimating how complicated this is. We've been underestimating the very fundamental problem our bodies have with regards to the uptake of fat. Fats are not water-soluble. Our bodies have to go through to very radical techniques to emulsify these fats after transporting into different parts of our body.

**JM:** Phospholipid is a technically and scientifically correct term for what we're talking about, but some people may know this is a lecithin.

**NH:** Yes, which is a good one.

**JM:** Maybe you can expand not only on what phospholipids are, what types of ones are available, and their purposes.

**NH:** If we start out very basically, maybe the two largest groups of lipids, of fats are both called glycerol lipids. They're called glycerol lipids simply because the steroid hormone to which you add your fatty acids is glycerol, which is a trivalent alcohol. You could add three fatty acids to this little molecule. If you add three fatty acids onto that molecule, then you get a triglyceride, which you find in oils, fish oil, vegetable oil.

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JM: Which you find in your blood and which is measured as a risk factor for heart disease.

NH: It might be.

JM: If it's fasting.

NH: In nature, this serves as energy, and it's a perfect form of energy because it is dense (it has a high-energy density) and it doesn't find water. Exactly why it's difficult for uptake and distribution. That's exactly why they're so valuable: because they pack these into adipocytes and keep a dense storage of energy for a rainy day.

Then the other molecule, you also start out with glycerol. You add two fatty acids. But then suddenly the third fatty acid, you could add a phosphate and you could add some sort of a head group. In krill oil's situation, it's a choline.

Now, that molecule, at this tiny change, not a tiny change, but this change, renders it into something quite beautiful. If you take this molecule and you take it into water, it actually spontaneously forms membranes or sheets. This molecule really is the molecule that forms the sheets that every cell in our body is made of.

If I were to select a molecule of life, it would not be DNA; it would be phospholipids. Phospholipids make us. It's impossible to think of life without this membrane. These membranes, you can embed different kinds of machinery, anchoring points. Everything that makes up a cell can be made from these membranes.

Here we have two glycerol lipids. One of them is not water-soluble at all. It will not form any sheet because it's completely hydrophobic and is basically used for energy. Then the other type makes us. We're made of it.

JM: What is the difference between phosphatidylcholine in krill and that in soybeans or lecithin or sunflower? Is it primarily the fatty acids that are attached and the length of those fats?

NH: There are two differences. Krill is quite unique with respect to the fact that almost all of its phospholipid is phosphatidylcholine (PC). There is a little bit of phosphatidylethanolamine, but otherwise there are two other types – phosphatidylserine (PS) and phosphatidylinositol (PI) – that you really don't find in krill at all. That's pretty unique. For example, in soybean, lecithins from soybeans, you will find pretty much equal amounts of the four different types.

JM: Interesting.

NH: That's one. The other one –

JM: Distribution.

NH: The fatty acid composition. Krill has very specific fatty acid composition. Almost every PC molecule has one EPA or DHA.

JM: Interesting.

NH: In the other possible position, you will find either oleic acid or palmitic acid. That's pretty much with those four fatty acids. Pretty much describes the phosphatidylcholine you find in krill oil, which is pretty unique.

JM: EPA or DHA.
NH: EPA or DHA in the middle position.

JM: In the middle position. Then you've got the oleic or palmitic. It's saturated and monounsaturated and polyunsaturated. You've got all three.

NH: You've got all three. First of all, oleic acid, you usually find a lot of it, for example, in olive oil.

JM: In macadamia nuts, too.

NH: Yes. It's interesting. Why is it like this? Probably because krill needs it like this. It lives in the coldest waters on the planet. I've studied phospholipids from krill for many, many years. Consistent analyses show a very high degree of concentration of the structure of the phospholipids that are exactly the same year in, year out. I see almost no variability at all probably because otherwise they would freeze solid. It keeps them fluid.

JM: Getting back to the original question which was to seek to identify these ideal sources of fatty acids that we need. Then you're bringing up the point that it's not just the fatty acids, it's the phospholipids, because independent of the fatty acids that are attached in there, there are other valuable contributions that they make.

I think the simpler principle that we're referring to also is to eat low down on the food chain. Because the lower you go, the less likely the animal has or the creature has accumulated these toxins that are pervasive in the environment, largely as a result of industrialization of the planet, which has occurred in the last century or so. There are a lot of benefits but there are some downsides too to the health.

NH: Of course, that fact also being low in the food chain (that accumulation of toxins, that'd be natural toxins or man-made toxins; there are natural toxins too) makes that less probable. It's also, of course, still – and I would say thank, God – the Antarctic Ocean is still quite clean, because most –

JM: That's where most of the krill is harvested.

NH: All the krill is harvested.

JM: There's not some pirates that are harvesting them.

NH: There are altogether mainly three different kinds of krill. You can find them in all oceans. If you go to Thailand, they will serve you a little omelette in the morning on the beaches. That is actually krill that they harvested just outside on that beach. It looks like tiny little shrimps. You can get it in the fish market in Tokyo. But they will not contain those lipids.

Because Antarctic really is very special. Imagine our planet. There is a band that we call the Antarctic Circumpolar Current or circumglobal current at about 60 degrees south. Below that, in only a few kilometer, the water gets to 2 to 4 centigrade colder. Essentially it's like a curtain. The only lifeforms that really cross this current is whales and birds. Anything living south of it is really confined to that area because they're adapted to the cold waters.

Antarctic krill is one of those. The name is Euphausia superba. Superba is simply Latin for the biggest. The Antarctic krill is the biggest of krill, which is typical for cold-water life in Antarctica. The other thing is that it is large enough to be caught. If it is much smaller than that, you would have to drag your net through the water with such resistance that you would have to spend all your capital for buying oil. Simply, superba is large enough to be caught.
It has a social behavior. They're really fascinating, interesting creatures. It has a social behavior that makes them live in these huge, humungous schools of millions and millions of tons, which also makes it possible to harvest them. They are special creatures with special features.

**JM:** Now, there are many people who are concerned I believe rightly so from some media sources that alarmed individuals that krill are important sources of food for the whales, and that harvesting krill could damage them in some way. I'm wondering if you can comment on that.

**NH:** Absolutely. There is no doubt that that is a valid concern. I would like to go back to the month, January 1958, when I was born. At that date or in that month, *Scientific America* published an article that, for the first time, mentioned harvesting of krill. In this paper, the author says, “Man should stop whaling and should rather harvest krill,” which would be a much better way of dealing with this. There would be enough food both for the whales and for us.

If you calculate at the back of an envelope with the population of fin whales that we see today – by the way, we have two ships then. We actually see those creatures all the time. The number of fin whales has increased.

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**JM:** When you say “we”, are you referring to the company you work for, which is Aker Biomarine?

**NH:** Aker Biomarine, yes. The fin whales are definitely back. They have a fairly short generation time, so they are able to come back. Then we see a lot of orcas. We see humpbacks, seals. They would consume with the numbers we know, and we know pretty much exactly how much they eat. The predators of krill in Antarctica would eat give or take 150 million tons a year. The harvest last year was 210,000 to 230,000 tons, which is a very small fraction.

**JM:** The complete total harvest of krill for commercial purposes, either humans or animals.

**NH:** Yes. 210,000 tons.

**JM:** Versus 150 million tons being consumed by the predators down there.

**NH:** Yes. You have to put this in perspective. Of course, that being said, you would have to do it in a way that is still acceptable.

**JM:** Responsible.

**NH:** Yeah. For example, you can't catch too much in one region. You can't just empty one region, because that might harm the local life. There are regulations that simply give us a quota in a certain geographical space. As we are talking, we have to leave one of these spaces because we reached the quota. All the quotas are set very conservatively.

**JM:** Who sets these quotas?

**NH:** These quotas are set by something called the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), which is an international collaboration between I think 29 or 30-ish different countries. It regulates all harvesting or all activity towards marine life in Antarctica. I think it is a very good example of a good international collaboration, because it has really secured preservation of these areas. All regulations has to be reached by a consensus. There are very strict ramifications for how this works.
Then of course, outside of that, there are independent organizations that also certify or not certify. Actually this is in Antarctica. We have teamed up with the Marine Stewardship Council (MSC) to have our activities in Antarctica. MSC certified. We were the first to get such a certification. I think even when we were certified, the assessment of our activities came out with the best grades ever given by the MSC.

Now, MSC is not set in stone. It is something that has to be repeated. They will follow our activities. They will also follow if there is any change in the climate or in the biology in the area, then the conditions with our certification might change. So far, we've been re-certified. Last year, we had an assessment if they were able to find any inference of our activity in the region where we harvest for fish, and they came up with no. They couldn't even detect any such effects.

That being said, I think questions about responsible harvesting in Antarctica is still very important. You need to do more research. You need to invest in that kind of research in that area to assess, for example, such simple things as total population of krill. It is set with wide safety margins.

Aker Biomarine has invested together with the government organizations, for example, the University of Tasmania in Australia into larger, long-term research projects trying to find out much more about how krill live and what kind of factors will influence, for example, the size of its population.

**JM:** I think it's important to review the enforcement of these standards and policies, because what good is a certification or the recommendation if it's not enforced? What's to prevent a rogue nation from going out and violating these? How are they caught? Maybe you can go into the regulation and enforcement of these standards.

**NH:** Under CCAMLR, any nation that is not a member of CCAMLR would not be allowed to operate in those waters. You always have the [inaudible] or illegal activities.

Now, in terms of Antarctica, fortunately, it's not the easiest region to operate. You're very visible in that area. You would need to transport all your materials down there. The weather condition is pretty harsh. It takes a fairly large operation to go down there. In our case and as part of our MSC certification, we have an independent inspector on board. I think I would require any sensible certification to require an independent inspector.

**JM:** What if one of these rogue nations went in there, very obvious in plain [sight] trekking down to the Antarctica to harvest, how would they be stopped?

**NH:** They will not be able to trade.

**JM:** They could harvest it, but they wouldn't be able to trade it?

**NH:** I guess. It's hard to see how you can stop them from harvesting.

**JM:** That's what I'm saying.

**NH:** You'll send marine ships in there.

**JM:** You can have militaries.

**NH:** You could. If that became necessary, maybe we might consider that. But so far, that hasn't been necessary. It's been too complicated to harvest krill simply. It isn't like any other fishery. It's actually a very sophisticated type of fishery.

**JM:** Actually I went to Norway in 2009, which was seven years ago now and visited your main offices in Aker Biomarine, and was very impressed. To think at that time, the ships were relatively new. You made
heavy capital investment in creating these ships, which literally put it at the forefront of this type of harvesting. Maybe you can discuss some of the technology that's involved to do this, because it's really quite elaborate.

**NH:** I think if we knew what we were doing at the time we were doing it, we would probably not do it. It turned out to be a very difficult investment. We had to simply had to learn how to do it.

**JM:** Right. There was none. You pioneered this type of harvesting.

**NH:** The Russians have been doing it in the '80s by conventional trawling.

**JM:** You know what that is, but many people don't. Could you –?

**NH:** I will explain that. Conventional trawling is simply you drag a net behind your boat. Then when the net is full, you hive it. You drag it on board the boat and you [inaudible]. That is not very efficient and then there are dangers. Whenever you take it out of the water, you risk catching something that you don't want to catch. The last thing you want to do when you catch krill is to catch anything else. Not just to be kind, but it will ruin your product.

We have technologies where we keep the trawls submerged. The net is submerged for weeks at a time. Then instead of hiving the trawl and getting it on board, there is actually a large hose, an 11-inch hose, through which we levitate the krill live on board. It actually flows through this hose and then get on board. This means that we can go on –

**JM:** As fresh as you can get.

**NH:** As fresh as you can get. And you could keep your machinery going for 24 hours a day. Also when doing research, this is a treasure trove because you could actually sample the krill from different depths live. This is what we utilize with this project with the University of Tasmania, because we have 10 months worth of sampling every day or many times a day. This technology – we call it eco-harvesting – made it possible for us to do it this way. Also there are provisions to keep any other animal from entering the trawl.

**JM:** You're not harming other wildlife, which is common in almost all other sources or strategies for harvesting krill, whether they're killing penguins and sea lions.

**NH:** Bycatch is now completely eliminated. I think last year the total amount of bycatch we got –

**JM:** Bycatch is excess in a harvest.

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**NH:** Yes. What you do not want. That amount, you could fit it in a regular freezer or less. It's really nothing.

**JM:** On the ships that you've produced and refined this technique with.

**NH:** Yes. Remember, we have the inspectors on board. I don't think you should never trust anyone, but independent inspectors for these things. Of course, again, it is definitely in our interest to avoid bycatch, because it will ruin our product. Then I have to say, I know the crew. We've had the same crew for years and years now.

**JM:** How big is the crew?
NH: It is about 80 people. At the time, we exchange crews. We have two boats. Now, the crew, they are hooked on Antarctica. They send us pictures. They send us descriptions of the wildlife.

JM: Is your crew from Norway or South America?

NH: Some of the crew is from Norway and some of the crew are Russians. Russians are probably the best crew you could get.

JM: Really? Why is that?

NH: Because they know ice. They know how to handle ships under very difficult ice conditions. You really see that they get fond of the area. I think the last thing they would like to do is to ruin the area. They grow a personal interest. Not that that really matters, but at least it helps.

JM: So you're responsively harvesting this with minimal impact on the existing wildlife, but then, the other component of this once you've captured the krill in a live state is that you have to process them in some way that's not going to damage those very perishable fatty acids. Maybe you can describe that because that's another big and really important part of the equation.

NH: Krill is interesting that way. Remember it has to live from whatever it can find in Antarctica. It's cold. It's actually very cold. The minimum temperature would be below the freezing point.

JM: They can do that because of the salt in the water.

NH: Yes. But also, they have to digest food at that temperature.

JM: What is their food? Is it plankton?

NH: It is plankton. They are actually a plankton.

JM: They are plankton.

NH: They're not really. They're swimming. They're really quite interesting creatures. In Tasmania, they have an aquarium with live krill in it. They're really active. But they feed from blooming algae mainly and they feed from microalgae. You will find it all times in the region. They have to digest this at below the freezing point.

Now, in your stomach, it's 37 degrees celsius. Your lipases are really active at that temperature. If you had dropped the temperature down to freezing temperature, your lipases wouldn't do a thing. But krill lipases do that, so they're able to digest at really low temperatures, which means that if you leave a bucket of krill in a frozen state, it will still decompose. You really have to inactivate the enzymes. The standard way of doing that is to heat it.

The first thing you do, you would heat the fresh krill for a very short period of time, like a few minutes, 90 seconds or whatever to inactivate the enzymes and also to kill off bacteria. There are bacteria in the water. Then after you would remove water. You don't want to transport water from the South Pole or the Antarctica all the way through around the globe. You take out the water.

Basically what's going on on board the boat is we make a dried krill. Shortly heat-treated and then dried. That's the product that we bring onshore and from which we extract lipids. We learned how to do that in a very gentle way. You keep a blanket of water vapor on top to displace air as we go. We do it that way.

JM: How is it further extracted once you've collected them, denatured the proteins and the lipases so that they don't degrade prematurely?
**NH:** When I entered Aker Biomarine, I thought, being we have a vast fish oil industry in Norway, that we could do it the same way as we do with fish oils. No way. You can't do it the same way as you do it with fish oils. Fish oil, you could use quite harsh extraction techniques. You also have to completely clean it up. You decompose it. You use a lot of heat for distillation and the similar. None of that can be done with krill oil. You would completely ruin your phospholipids.

We're using only ethanol and water. That's the magic medium by which you could extract both triglycerides and phospholipids. We manage to take out quantitatively the lipids out of the krill meat. Of course, when that has been done, you have to remove some of what you do not want. Again, you can't just decompose the lipids and rebuild them like you do with fish oils. You have to be gentle.

We have a separation technique, again, only using water and ethanol, taking out all polar constituents like salts, trimethylamine oxide, and so forth. Removing that and you're left with a lipid that is clean, but in many respects extracted almost like virgin olive oil. It's very gentle.

**JM:** This is close to the ideal way to do it, but not all companies do this. I can recall a number of companies that would use more dangerous solvents like hexane. Ethanol is pretty simple. I believe it's a two-carbon alcohol. It's what gets people drunk. It's toxic in high amounts, but in small amounts it's certainly not dangerous. In fact people pay regularly to consume them in small amounts.

**NH:** I would maintain that ethanol in small amounts –

**JM:** Is beneficial.

**NH:** Is a nutrient. You can find it in all sorts of fruits, and in concentrations below one percent, it has no toxic effect or whatsoever.

**JM:** Methanol is quite the opposite. It's a one-carbon alcohol and quite toxic. We've interviewed Dr. Woody Monte who believe strongly that all concentrations of ethanol helps, at least in humans, detoxify the methanol and get it out of your body safely.

**NH:** It is actually the standard treatment for methanol –

**JM:** Methanol overdose.

**NH:** Intoxication is actually treat via the ethanol. You just have to keep the ethanol running until they've flushed out the methanol.

**JM:** The point here is that ethanol and water is the only thing used in this strategy. There are no toxic solvents that are involved. That's a really important consideration, if you're going to choose krill oil as a source of omega-3, that you really need to confirm if that's being done.

**NH:** I think that's pretty unique because this way of making the oil, no water marine oil I know of is made this way.

**JM:** Almost all the other ones or all the other ones are using toxic solvents?

**NH:** Not necessarily toxic solvents, but they are using much harsher techniques with regards to the clean up of the oil. Fish oils are traded as a commodity. It sits in big tanks in Amsterdam.

**JM:** Actually that's a good tangent. Because fish oils are traditional omega-3 animal-based source of fats. But what is the volume of fish oils relative to krill oil?

**NH:** I can't –
JM: At least commercially or roughly.

NH: At least 100 to one. At least. There are really large amounts.

JM: Maybe we can go back to sustainability, kind of reinforce that. That's pretty clear from the information you provided that krill is harvested sustainably. It's almost impractical if not almost mechanically impossible to do it otherwise, because of the regulations and everything.

NH: It's hard.

JM: But how does that – nothing like that is occurring for the fish industry. They're decimating food supply by creating fish oil a hundred times the source of krill oil.

NH: First of all, if you could source fish oil responsibly, then really I have no objections to that at all. It is what it is. I never see krill oil in a direct competition with fish oil.

[----- 50:00 -----]

JM: Why is that?

NH: First of all, krill oil is a mixture of phospholipids and triglycerides. Actually fish oil is almost a constituent of krill oil. Krill oil is like a box in a box. Krill oil is everything that fish oil is.

JM: And more.

NH: And more. It's like with Annie Get Your Gun, “Everything you can do, I can do better.” Fish oil has its place, but krill oil is a much more complete lipid package. It's a more complete nutrient.

JM: It also has this important antioxidant astaxanthin that is not present in fish oil and that helps protect these highly perishable and oxidizable fatty acids.

NH: Interestingly, when you eat salmon, it is present in salmon. That's again a point where krill oil is (maybe not correct but a tempting way to phrase it) is more efficient than fish oil. Krill oil contains more of the complete lipid package that you would get when you eat fish. Our gut is made for digesting and absorbing food.

Now, the question about sustainability, there are a couple of fisheries that are MSC certified that also provide fish oils. There is one: Alaskan pollock. As far as I know, the cod liver oils that are not from Norway is also certified. Those are the two I know of.

I know that the fish oil industry these days pay a lot more attention to these things. But while it has been fairly easy to do this with krill because of the deep size of the population in krill, which is in the hundreds and millions of tons, and in the area where we catch krill it's at least 60 million tons, it's much harder to do so in a fishery that take out about 20 percent of the population. There are basic metrics that make it easier to do this with krill.

Then of course, since we are a new fishery, we're challenged. This was going on in Antarctica. We were challenged to do it right, because people wouldn't allow us to go there if we don't do it.

JM: Maybe you can compare quantities of krill that one would need to supply the omega-3s as opposed to that with fish oil. Because of the phospholipids, the krill are more efficiently absorbed, so you would need less. Maybe you can give us an idea what the range is.
NH: It's a little bit of how you define the word “absorption” here, because the direct uptake from the gut into our bodies is usually very good. I like to use the word coined by Andrew Sinclair in Australia. They talk about digestibility. Fats are in general very digestible.

Now, what really is interesting and weaves back a lot of our research is what happens after it has passed the gut barrier. When it gets into your bloodstream or when it gets into your body, what happens then? The issue is the tissue. For the omega-3 fatty acids really form most of its effects, it really needs to get into the membranes. If it stays in the adipocyte, nothing much happens.

JM: Or in the blood.

NH: Or in the blood. Where krill really shines is in the way it delivers to the tissues. In general, you would see give or take about twice as being delivered into the erythrocyte or the red blood cell milligram by milligram when you take it as a phospholipid as compared with –

JM: Which is where you want it. The primary reason why you're consuming these fats is so they are deposited in your cell membranes.

NH: Exactly.

JM: That's where they do their thing and really facilitate the other health benefits. If they're not there, they're not working.

NH: At least for the majority of their effects, yes. Also remember that both European authorities as well as the American authorities has had a fairly large assessments going on with regards to the intake of choline.

JM: Which is the phospholipid that's primary in krill.

NH: Yes, phosphatidylcholine.

JM: 85 to 90 percent.

NH: I would say 90 percent. It's really a good source of phosphatidylcholine. The intake of choline both in the United States and in Europe is about 80 percent regard as what we need. Remember, now we're talking about a basic building block.

JM: What do we need choline for as a building block?

NH: You need it for your membranes. You need it as a methyl donor in a number of fundamental and biochemical transformations. It's simply almost like a basic building block for our bodies. You also need it for phosphatidylcholine, a neurotransmitter. You need it to maintain normal liver health. Just to mention a few.

While choline salt, if you take choline chloride, for example, most of that is not taken up at all. It actually ends up as food for bacteria, which makes it into trimethylamine, it is taken up, and then excreted as trimethylamine oxide. The phosphatidylcholine form really is taken up, because it's not being broken down. We know now that a substantial part of it is taken up directly and delivered to the liver.

JM: I think this is not new information. This has been known for a long time. This is one of the reasons why decades ago many health food enthusiasts were recommending lecithin as a source of phosphatidylcholine.
Again, the primary difference between soybean lecithin or sunflower lecithin and the phosphatidylcholine you get from krill is the fatty acids. Rather than getting an omega-6 based fatty acid, which we have too much of, you're getting an omega-3, not just any omega-3 but a high order, long-chain fatty acid, EPA or DHA omega-3s. Would that be –

**NH:** Exactly. That's the main difference. The main difference is the different classes, but also the fatty acids that sit on krill oil, almost every molecule, 95 percent of them are either EPA or DHA. It is an omega-3 phospholipid. It is not just a phospholipid.

**JM:** Which is an omega-6.

**NH:** There might be more to that than we think. Then also, quite interestingly, if you look at the omega-3 index, which is one way of measuring your status of omega-3s. How much omega-3s do you have in your body? One way of looking that out is to simply look at how much do you have in your erythrocyte or in your red blood cell?

**JM:** Omega-3 to -6 index?

**NH:** No. Omega-3 index. You do that. We've done research on that and we followed it in a situation where we could look inside exactly what happens over time. The erythrocyte changes only in two ways. You could see that the amount when you supplement with omega-3s. You could see that EPA and DHA increases in the red blood cell, but then it's a zero sum. Something has to go out.

The question is what goes out. The answer is really – it should be quite obvious – but nothing changes to the saturated fatty acids. They are exactly the same because they are also necessary for the structural integrity of the membrane. What is being exchanged is almost one by one omega-6 by omega-3. You increase your amount of omega-3 and omega-6 goes out.

There you're back to what happened after World War II when in the Western diet we have frenzied on omega-6s. In themselves there is nothing wrong about them, but we are taking such humungous amounts of it that we're getting an imbalance of omega-6 versus omega-3.

**JM:** I read this paper just recently that discuss this issue. It looked at the amount of soybean oil consumption in 1900 and compared to the soybean consumption in 2000, and it was a thousand-fold increase. Not 10, not 100, 1000 times. Soybean is almost exclusively omega-6.

[----- 1:00:00 -----]

**NH:** Yes it is.

**JM:** Not only just omega-6. If it was healthy, organic, and not damaged. But almost all of it was heavily refined, processed with toxic solvents, and grown, at least recently, with genetically modified herbicides like Roundup. It's contaminated. You've got almost everything going wrong with that. It's a thousand-fold increase. How could it not be reasonable to assume that that would have some serious, potentially catastrophic consequences on the health of the population consuming that?

I think that's one of the reasons that we have these health epidemics – diabetes, heart disease, cancer, neurodegenerative diseases.

**NH:** When I was a student, it was still not clear exactly how does non-steroidal anti-inflammatory drugs (NSAIDs) work, how does aspartame work. The mechanism of action wasn't known.

**JM:** When I went to medical school, it wasn't known. It was unknown.
NH: In 1972, the prostaglandins were discovered. Then we came to understand how fats or lipids are not just stuffing. It's not just energy. They're really important molecules for signaling. Of course, arachidonic acid (AA) is the prime substrate for cyclooxygenase (COX). Only when we started to look at the omega-3s or the long-chain omega-3s did we realize that it isn't only arachidonic acid; it's also EPA and DHA.

I think only recently have we started to realize that we need a balance between these two. Of course, you need inflammation, but when inflammation overshoots or it become to keen, then it may do more harm than good, or at least it may do harm and good at the same time. You need your omega-3s in the right proportion to modify or modulate inflammatory response.

By now we also know that the omega-3s have important actions downstream. You have the inflammation started, for example, by arachidonic acid. To start it all, what our bodies need to do at the same time is to start the stopping of the inflammation. As a downstream of EPA is being made by the prostaglandin, you will have something called resolvins or maresins, which actually serve to stop the inflammation at the right time. It's an on mechanism and then after a while you have to switch it off.

JM: Where are these resolvins? Are they in whole foods like fish?

NH: No. You will only find them as secondary products to prostaglandins. Prostanoids or eicosanoids made from EPA and DHA. If you don't have enough EPA and DHA: one, your primary inflammatory response might be too vigorous and secondary, one of the importantly regulating downstreams stop mechanisms do not occur. This is something that has become quite clear. Then there other aspects of this complicated lipid signal molecules that in the years to come will be clarified. But lipids are not as straightforward.

JM: No. Now, I appreciate your point about balance. That is really key. There are some non-proponents of omega-3 supplementation that criticize heavy doses of omega-3 supplements. I believe that there may be some validity to that criticism when they're focusing on high dose, highly processed fish oils as sources of omega-3s relative to obtaining omega-3 from the sources that we really recommend: clean fish, usually lower-order fish.

By clean, I mean non-toxic. Things like anchovies, sardines, wild-caught Alaskan salmon. Those types of foods, which provide these healthy sources of EPA and DHA but also these phospholipids. Taking that and then also eliminating the highly toxic omega-6s – not eliminating all omega-6s but having healthy sources of omega-6 from seeds primarily. Seeds and nuts. Would you comment on that? Is there a concern of overdosing on omega-3s from sources like fish oil in your experience?

NH: I haven't seen it. For example, one of the things that is quite often pointed to with regards to omega-3s is that they might cause bleeding. Now, I still haven't seen it. Of all the years that we've looked into this, when we measured both platelet aggregation as well as coagulation, I have not seen any substantial influence on that all.

JM: There's a standard pre-surgical warning to stop fish oil.

NH: It is. It is actually quite interesting because I know a little bit about the kinetics of these. For example, to reach a steady state taking DHA, let's say you eat salmon, you would have to eat salmon for more than half a year until you reach your steady state. It's a very slow molecule. It's also quite interesting because to me it looks like our bodies really do not want to give it away. If it grabs it, it stays.

JM: Does it recycle it at all? Like when the cell membrane – is it regenerated or recycled if a cell's damaged?
NH: That's really hard to say. I wouldn't think so. I would think it goes to the membrane where it needs to be and then it's being consumed.

JM: So it's consumed. It's digested. It's not recycled.

NH: In the end, it will be oxidized. In the end, it will go. No molecule lasts forever. This is a long-lived molecule for a molecule to live for months and months in our body.

JM: It's unusual.

NH: It's pretty well done. The half life would be give or take 60 days or so with DHA. EPA, on the other hand, is much faster.

JM: It's smaller, but two carbons.

NH: It's smaller and it behaves differently. Among other things, we think it is fair to say that EPA is the mother of DPA, which is the third member of the family and which has gained a lot of interest lately.

JM: Is that 22 also?

NH: Yes, 22:5.

JM: It's not omega-3; it's omega-5.

NH: No. It's a 22:3 but it has 5 double-bonds. It's a 6. It's the sibling of DHA.

JM: In the trio – EPA, DHA, and EPA – what is the percentage? Because there are still other fatty acids that are even longer chains, beyond 22. What is the percentage of those fatty acids? Is it 80 percent? 90 percent?

NH: You don't find much DPA in regular seafood, neither do you find it to any extent in krill. The only seafood I really know where you can find it is whale.

JM: We don't want to eat whale.

NH: Whale blubber and you find it in seals. But our bodies make it. You eat EPA, and a proportion of your EPA becomes DPA. EPA in a way is a programmedDPA. It's actually I think a really interesting story. I think we'll learn a lot about this in the years to come.

But EPA is fast, a much faster molecule. It has a half life of over, in my hands, about 80 hours. You would reach steady state in 15 to 20 days, which is important when you do research on this. Because if you study long-chain omega-3 effects for three weeks, what you will see is the effect of EPA. To see the long-term effects of DHA, you would have to keep going for months and months and maybe years, especially for the central nervous system. Long-term studies are necessary.

JM: Krill is about 50 percent DHA and EPA.

NH: No. You find this in seafood. Typically about twice as much EPA as DHA. Even when you take in less DHA than EPA, because EPA goes faster, you typically see that the plasma levels of DHA is twice or three times as high as the EPA.

JM: Interesting. Even though it's half the concentration.

NH: Because it accumulates. Our bodies really do not want to give away any DHA. The same with EPA.
JM: There are companies that extract DHA from marine sources. It's a chemical process, and it really is in my view a form of processed foods. You're just getting the isolated DHA typically extracted from algae.

[----- 1:10:00 ----- ]

NH: Typically extracted from algae.

JM: Which is where the krill are eating from. But it really isn't a whole food. What is your take on any potential concerns or toxicities? Because I believe infant formula is supplemented with DHA from these algae sources.

NH: There's a reason for that. In infant formula, you're really quite concerned about allergens. With fish and with shellfish, there is no way you could chemically define the product as completely free of allergens. I have never seen a shellfish allergy elicited by krill oil nor have I heard about it.

JM: But it's commonly recommend: if you have a shellfish allergy, you probably should avoid krill.

NH: Definitely. That's a standard medical advice. There is no way you could avoid that. The main reason for the algae form is that you can't provide a form of DHA in baby formula where you can guarantee...

JM: Do you have any concerns of potential complications of taking the isolate as opposed to having the fatty acids in a balanced format that you would with a wholefood like krill or fish?

NH: How do I say this? Either fish or krill with regards to the allergens, you're left with that source.

JM: I know. But assuming that's not the issue. Some people, maybe a vegetarian or a vegan, maybe not a vegan but certainly a vegetarian would say, “It's OK to get DHA extracted from algae if I'm not going to get it from the omega-3s, plant-based omega-3s.”

NH: You will get it in its native fatty acid or triglyceride from algae. It will not come in the phospholipid form.

JM: It's more like fish.

NH: Yeah. You're right, krill extracts its EPA and DHA from the algae. It's the algae that are –

JM: The sources, they're the ultimate sources.

NH: Exactly.

JM: But it's the other fatty acids. The whole thing I want to get back to is this mixture. It's like you're taking vitamin C, ascorbic acid. It's different from getting it from acerola or Barbados cherries. Because with all these associate micronutrients and the balance of those nutrients is actually what provides the benefit. The isolates seem to not work as well.

NH: What I've seen of research on the topic is I've never seen a research that hints to toxicities.

JM: Not really toxicity. I guess maybe not the optimal benefits, because it's not in a balanced form.

NH: That'll depend on how you formulate the rest of your formula. You could add krill oil to your formula.

JM: Sure. But most of the time, it's not. This is simple DHA.
NH: I think the limitation is that it comes as a clean source or whatever you would call it, as a simple source. But again, I still think of krill as almost an ideal way of harvesting algae.

JM: Because most people aren't going to eat algae. The algae is actually an emerging area of providing nutrition and seaweeds. There's more and more interest in this. I think it's a great thing, because we really need to harvest these foods from the sea. There's a lot more sea. You have to be careful with the toxicities, of course. Obviously that could be a concern. If you're not growing these in clean water, it's going to bioaccumulate the toxins.

NH: With microalgae, there are a number of things you have to – in temperate waters, you have peptide toxins that you need to be very aware of. Domoic acid, which is an interesting one. It's not a pollution. It's part of the defense mechanism that you see in these algae. Typically shellfish toxins can accumulate in algae. You have to be very careful about that. Then there are some lower-molecular toxins too that may accumulate in algae. Now, of course if you can take care of that...

JM: No problem. I think the other point to becomes cost-benefit analysis. I think it's well-established we need these omega-3s, animal-based omega-3 fats. How do you get them? You get it from fish, which I think is close to the idea if it's clean fish – sardines, anchovies, sustainable wild Alaskan salmon. But it's a bit costly. It can be.

NH: And there isn't enough of it.

JM: That's a good point. There is not enough. What is a more rational approach? We've got this process called krill. Actually even the few hundred thousand tons that are being harvested, it's my understanding that the majority of that harvest really isn't going for humans; it's going for animal production. Maybe you can comment on that.

NH: It is going to aquaculture. Again, if we are going to feed 10 or 11 billion people fish, to my mind, there is no way I would start aquaculture. If that is going to happen, we have to do a differently from the way we're doing it.

JM: Because there won't be fish to provide that many people.

NH: No.

JM: That's like a generation away. Two generations away.

NH: It's happening quite fast. We're moving aquaculture out into the open seas. We're moving it onshore. We're changing what we feed them. Antibiotics is going away. There are a number of things that can be done. You can do aquaculture absolutely wrongly and really do it badly, or you can do it right. I think one key aspect of modern aquaculture is that if the fish isn't healthy, it isn't healthy for you.

JM: If you don't give them healthy food, how can you have healthy fish?

NH: It's really quite interesting to see, because we've done a lot of research in this area, when you keep fish on a standard diet of soybeans.

JM: Which is common in these fish farms.

NH: They suffer from exactly the same civilization diseases as we do. They die from cardiac arrest, pericardiac inflammation, they have widespread systemic muscle inflammation, and they simply do not thrive. You see on a diet of krill, that their health really, really improve.
Pretty much the same way you'd expect people who take the right amount of omega-3s and of course fish are made to eat this too. It's part of their signaling system. It's part of their biochemistry. Even the endocannabinoids is part of the equation when it comes to fish.

I think you're right. Most of what we're doing, because it's a rich protein source. To be able to provide healthy aquaculture, that is going to be necessary.

**JM**: I'd like to get back on these fatty acids again and the emulsification that we're talking about with the phospholipids. One of my new passions is optimizing mitochondrial dysfunction. As a result of that, the understanding is to shift to a diet that has somewhere between 70 and 80 percent of your calories coming from fat.

If you're going to make that commitment to that massive amount of macronutrient, you've got to pay very special attention to the quality of fat or you will ruin yourself. That's been my focus. I chose to obtain most of my omega-6 from seeds and some nuts, but mostly seeds like black sesame, black cumin. I also use things like flax and some chia for the omega-3.

We're not vilifying omega-3 fats, plant-based. You do need some ALA, alpha-linoleic acid; you just don't need an excess of it. Don't be delusional thinking you can convert that to EPA and AHA, because you just aren't. But that doesn't mean you shouldn't take it. You should. It's a very healthy fat.

I take these seeds. I used to grind them fresh before I consume, but now I soak them overnight, which actually softens them considerably. When you put them in an immersion blender to put a smoothie out of it, it works pretty well.

It recently occurred to me that these are fats. I would absorb them better if I emulsify them. I've been taking some krill phospholipids, which is not a product that's commercially available, but because of our relationship with you, I was able to get a supply. I've been using a few grams a day in these smoothies.

If you take large amounts of these krill phospholipids, there's a significant taste to it, but if it's a small amount – I don't think you need very large amounts. Maybe you can talk about the amounts that you need and some of the benefits of that strategy of emulsifying these fats in a smoothie.

[----- 1:20:00 -----]

**NH**: It's well known that even more important than the fats themselves that there are a lot of micronutrition in your seeds. It's the oldest strategy our bodies have followed: to emulsify them. If something is quite fat-soluble, one way of having a good uptake is to increase its [inaudible ].

**JM**: This emulsification as supplements, we call them liposomes. It's the same process. Liposome is a form of emulsification, which massively increases the ability to absorb it and integrate it into the cell membrane.

**NH**: For substances that are lipid soluble and not very well taken up, it is the strategy: increasing its uptake. You only need a little bit. Having too much might not really help you.

**JM**: There's not a benefit. You only need so much to emulsify something.

**NH**: If we're talking about how much you need omega-3s in general, I think there's been a great lack of reliable ways of measuring them. I only think I can answer that question by measuring.

**JM**: The omega-3 index?
NH: Yes. A paper recently came out on, only a week ago, that looked at the omega-3 intake on a global scale and identified countries with high intake and low intake of omega-3s. I think it was by Ken Stark and Norman Salem who's also involved in this paper. It's a tremendous paper. It really puts a lot of numbers behind things that we really need to know with regards to the global consumption.

They also compared different ways of measuring omega-3s – in your blood, plasma, and erythrocyte. They found consistently that the best way of doing it, the one that correlates best with tissue levels on your whole body level is the omega-3 index.

JM: Which is the red blood cell or erythrocyte.

NH: Yes. It [inaudible] in a specific way and a reproducible way. Doing that, you will know. Your index should be somewhere above six rather eight.

JM: It's close to 10.

NH: There is no danger. In experimental animals, I've seen levels up to 20. I've heard that dolphins have levels way above 20. They're really loaded with omega-3. Their diet will secure that. They're pretty intelligent animals too. Their brains will be well supplied. I think the really way to answer that question is to have people measure their levels. They would have to adjust their dosaging until they reach their levels.

JM: We're in the process of highlighting that test and making it available to people. I think it's an important measurement. Otherwise you're just guessing. You don't know. You could take certain supplements or food sources but you don't know until you measure it. You'll be surprised when you finally do measure it.

NH: I think so. It will depend on your lifestyle. It will depend on your intake of fatty fish. For example, we know for sure that athletes, people who are doing hard sports like Nordic skiing, burn off their omega-3s quite easily.

JM: That long half-life of DHA is actually decreased conservatively because they actually burn it as fuel rather than using it as a structural component of their cell membrane.

NH: Exactly. Because when your body has a priority of structural component, energy comes first.

JM: This is a good question. Because most people who are watching this are not – their metabolism is such that their primary source of fuel is carbohydrates. It's not fat. That's a sad tragedy because I really believe that's a primary reason why so many people are getting sick.

But once someone has shifted to burning fats as their primary fuel and they're really efficient at doing that, do you think that there's any issue with timing that? Would the half-life decrease? Because I suspect the half-life you quoted was from someone who's burning carbs primarily. That's most people. That's the average person you're going to see.

NH: I couldn't possibly answer that.

JM: Speculate.

NH: I could speculate. There is an interesting speculation on this. The kinetics is such that – actually triglycerides and phospholipids are different in that way. When you take your EPA as a phospholipid, you peak at about 12 hours. It's a very slow uptake and then you see the decline after. When you take it as a triglyceride, it actually peaks at about six to seven hours. That's very consistent.
It's actually such that you could see immediately if you've taken a triglyceride or a phospholipid, which in itself is quite interesting because it tells me that the body is handling this quite differently. Now, being “Is it seven hours? Is it 12 hours” is not an important thing; the important thing is that would you like to take your omega-3s at the time when you have a need for energy? Probably not. I would guess taking your omega-3s in the afternoon is a smart move rather than in the morning.

**JM:** Along those lines, I'm thinking would it be wise to take another fat that has shorter carbons like MCT oil or coconut oil, which is a medium-chain triglyceride and burns more quickly. They would sacrifice themselves for fuel rather than burning these higher chain fats, which are more important structurally.

**NH:** That's an interesting speculation. I think you're onto exactly why the uptake of long-chain omega-3s is so slow. I think they're so slow to get below the radar, not to be eaten. They kind of hide themselves. Yes, that might be one strategy. Take them together with other fats. The other strategy is also, as I said, I would probably advise athletes to take their krill oil in the afternoon after they've had their exercise not just to have their exercise, just during the uptake phase.

**JM:** Keep it a few hours away from the exercise.

**NH:** Yes.

**JM:** That would make sense.

**NH:** Of course, only research would be able to close that question, but it's an interesting speculation.

**JM:** The primary viewers of this discussion would be Americans who are notoriously low on omega-3 from a variety of studies. I'm wondering if you can provide your recommendations from your understanding of the literature as to how they would get those back up. Again, the quantities but ideally it would be coming from fish if they can manage to budget that into their food sources. But if not, good sources of krill or even fish oil. But I think krill is better for a variety of reasons. Maybe you can discuss the dosages.

**NH:** With regards to fish, don’t forget fish isn't just fish. If you eat tilapia, it doesn't matter. It will not provide any long-chain omega-3 to speak of.

**JM:** Why is that?

**NH:** It simply doesn't contain that kind of – there is a lot of fish that really do not contain omega-3.

**JM:** Not all fish.

**NH:** No.

**JM:** The fish ideally would need to be harvested from cold water.

**NH:** Yes.

**JM:** That's the trigger for these high fats, because the algae that supply them are planted.

**NH:** There are particular types of fish that are fatty fish and fish that lives in cold waters. You need to simply inform yourself with regards if your particular type of fish contains enough of the long-chain omega-3s or not. But I would guess in a fatty fish, typically I would say two servings, two to three servings a week. Normal servings a week of that fish would be enough. Because of the kinetics, if you take it three times a week, that's OK.
With regards to krill oil, again depending on who you are and what you do, but I certainly would not recommend less than a gram.

**JM:** What might be ideal?

**NH:** Maybe I should answer by myself. I take two grams a day. By that I am well supplemented. I'm between eight and 10.

**JM:** In your omega-3 index.

**NH:** In my omega-3 index.

**JM:** Which is the ultimate test. We can make general recommendations, but ideally you want to test yourself. This is not a hard test to get. It's available. You can do this omega-3 index to confirm it whether this dose is right for you. Because maybe you're taking it right with exercise and you're burning them as fuel rather than integrating them into your cell membranes.

**NH:** Also I would say I wouldn't ever be within the dosage ranges we're looking at. I wouldn't be afraid of taking too much. I hardly think, within the normal ranges we're seeing, that we would be able to do that. I have still not yet seen an overdose of fish.

**JM:** Other than an allergy. Because if you have any food on a regular basis.

**NH:** Allergies absolutely.

**JM:** That could be the healthiest food you can have an allergy to. That's why it's good not to eat the same thing every day and it's good to mix things up a bit.

**NH:** Agree.

**JM:** I think one of the most important items that we discussed, which I opened up the interview with, is this confusion, this massive confusion between plant-based versus animal-based omega-3s. We just really want to set the record straight: you are seriously deceiving yourself if you believe that excluding all animal-based and focusing on taking large amounts of plant-based is going to provide you with the raw materials you need for a healthy body and a healthy brain. It's just not going to work because your body can't convert that much. There's a lot of people who believe that. Even a lot of health professionals who believe that.

**NH:** I think it is pretty clear. All research point in that direction. I would be lucky to elongate and desaturate. The fats is quite limited or not to say very limited. There is no way, within the normal population, outside of having marine long-chain phospholipid.

**JM:** It's not to vilify plant-based omega-3s. We need them. We really need them. If you only had marine based omega-3s, you would not be healthy. You need the balance. You need all of them. You don't want to exclude one or the other. You need them both.

**NH:** I totally agree. It is not a question about this or that. You need both, but you need them in a balanced quantity. You cannot simply avoid marine long-chain omega-3s by taking huge amounts of plant-based.

**JM:** I think we've established it pretty clearly. Maybe you can provide us with some advice for those who are staunchly vegetarian for whatever reason, philosophical or otherwise, and they refuse to eat fish, which is fine or krill even because they view it as a life form. We could take a level below krill which would be the algae.
NH: Algae.

JM: What would your recommendation be for those individuals with respect to algae? Obviously addressing the items of concern and toxicities that we talked about earlier.

NH: I think you're still left with some lipid extract from algae. I do not know much about it. I know that the products used for baby formula is technically speaking very high quality with respect to control of the extraction and, for example, any residual solvents. But you're simply left with that.

I would still maintain that the best way of doing it would be some sort of seafood. I don't know if any larger algae from marine sources would ever be available. As I said, there would always be concerns with algae from marine sources if they may contain natural toxins.

JM: What about sources like chlorella or spirulina? Would they have the EPA and the DHA in the mussel?

NH: No.

JM: They don't. Because they're not grown in water. That's the reason.

NH: Not that I know of. Still, there is a lot we don't know about algae. They're quite interesting sources of nutrition. I think in the years to come we will see a lot more.

JM: Of exciting new research.

NH: Still I maintain that krill is a perfectly good way of collecting.

JM: And cost-effective. As many people are limited on budget for having the right type of fish at a frequency you need to improve your omega-3 index, krill may be a reasonable alternative.

NH: It's also a question about your carbon footprint. Because krill lets us do this in a way that makes sense with regards to the amount of energy that we have to invest in the harvesting. If you are going to harvest something like microalgae, we have to invest enormous amounts of energy. Even growing algae requires a lot of energy.

JM: Sure. If you're going to do it in a way that it's going to be clean from these toxins, it's a very capital and energy resource-intensive initiative or investment.

NH: I still think that the advice that was given in the January 1958 issue of Scientific American that we should stop whaling and rather catch krill is still a very valid point.

JM: Yes. Those words are good to close. I want to thank you for coming all the way to Chicago from Norway and for enlightening us with your wisdom.

NH: Thank you very much.

[END]