Nancy: It's September 1962, and all across the western world, the Cold War is in full swing. Since the end of the Second World War Americans and Russians have been testing atomic bombs, demonstrating their ever more powerful ability to destroy each other.

At the same time, the chemical industry has been hard at work, creating a mind-boggling number of substances intended to make our lives better — from plastics to pesticides. Pesticides, especially one called DDT, were seen as miracle chemicals. They could kill mosquitoes and quell malaria outbreaks, rid soldiers of lice, and attack insect invaders like the ravenous gypsy moth, which defoliated huge swaths of forests in the Eastern US.

It was a time when humankind was learning how we could manipulate the forces of nature — but not always for the better.

Enter a quiet, unassuming American marine biologist by the name of Rachel Carson. Her work with the US Fish and Wildlife Service, writing popular science articles about the agency's research, increasingly made her aware of just how damaging these new "miracle chemicals" —pesticides — could be.

And she knew how to describe the natural world in a compelling way. Her first book, "The Sea Around US" was on the NYTimes best-seller list for 86 weeks.

In September, 1962, Carson published her third book — this time documenting just how damaging pesticides were to the environment. She privately called it "the Poison Book." This work would help spawn the environmental movement across the Western world. It was called Silent Spring.

Carson argued that by using pesticides indiscriminately, we risked unintended consequences up and down the food chain — up to and including causing cancer in us humans. Without realizing it, Carson herself would foreshadow her own fate. She died from breast cancer just after the book was released, at age 56.

Nearly 60 years later, DDT has largely been banned, and modern society has realized that we can't just blindly use chemicals willy nilly. But the battle is still ongoing, far from industrialized areas, in the Arctic, where the chemical legacy remains, affecting everything from polar bears to native populations.

Nancy: I'm Nancy Bazilchuk, and you're listening to 63 Degrees North, an original podcast from the Norwegian University of Science and Technology.

Today I'm going to tell you about what researchers have learned about the fate of chemicals in the Arctic, and how what they're learning is changing international law and providing life-saving advice. It's a whodunit with characters like former Soviet

prime minister Mikhail Gorbachev, cute baby seals and charismatic polar bears. And there's the scientists, technological detectives, searching for the fingerprints of these complex chemicals in everything from polar bear breast milk to the bodies and brains of native children living in Russia's far north.

But it's not all gloom and doom.

Like… Just how do you capture a 200 kilo hooded seal so you can take blood and blubber samples?

Bjørn FW: (29:09).... They are extremely difficult to catch — they try to to get them to go into the nets, and then you just have to throw yourself over them, two persons trying to keep it down. Sometimes you have to drag them by their flippers.

Nancy That's Bjørn Munro Jenssen

Bjørn: (0:37) I'm a professor in ecotoxicology or environmental pollution at the Norwegian University of Science and Technology.

Nancy: Although he probably hasn't thought about it this way, Bjørn's career illustrates how our understanding of chemical pollutants has evolved since the publication of Silent Spring.

In the early 1980s, when Bjørn started his scientific career, one of the big worries when it came to pollutants was oil. It was the go-go 1980s, and black gold — oil — was being shipped all over the globe. The demand for oil was so strong that the largest supertanker ever built was launched in 1979.

Although the big catastrophic spills like from the Exxon Valdez and the Deepwater Horizon hadn't happened yet, you didn't have to be a prophet to see the odds of an accident were pretty good. So the oil companies decided to fund some studies of what would happen to wildlife in the event of a spill.

Bjørn (1:11) on_BMJ1: It was 1981, 1982, a project on effects of oil pollution on birds came up. We decided to go with that, because that was one of the major pollution issues in the late in the 70s and early 80s. So we wanted to study how oil pollution affected the plumage of birds, and then we started off exposing eider ducks to oil pollution. And of course, we found you didn't need a lot of oil on the feathers in order to destroy the insulation properties. So that was my start into effects of pollutants on birds, wildlife, and animals.

Nancy: One thing led to another and then….

Bjørn (4:05) Conoco Phillips, they wanted to see if the oil pollution had any effects on seals, because they were starting with exploration out at Halten Banken.

Nancy: Halten Bank, for the record, is just off the mid-Norwegian coast. And there..

Bjørn: More than 50% of the newborn grey seal pups were polluted by oil in the early 1980s. So we started to look at the frequency of oil polluted grey seal pups.

And actually more than 50% of them were polluted by these small tar balls, when they lie and rest, their fur gets contaminated. But we don't think there are any large effects of that because it's external contamination.

Nancy: But this study led the researchers to discover something more sinister in these little seal pups.

Bjørn: In that connection, also, we started to look for other contaminants like the PCBs, polychlorinated biphenols, and pesticides, like the old DDT, which was used a lot, and they were regulated in Norway at that time, but not globally. And we found actually quite high concentrations of these compounds in the seals…. in their blood or in their blubber we examined. We even found levels in the brains of these small newborn pups.

Nancy: These finds posed a mystery. Where were all these chemicals coming from? They weren't being generated in the Arctic, because there's almost no industrial activity there.

Nancy: It turns out that many of these pollutants can ride the wind or travel in ocean currents. Like PCBs, polychlorinated biphenols, the chemicals that were widely used in electric transformers because they don't burn and are chemically very stable. While they were mostly banned by the late 1970s in much of the world, they're still contained in lots of old transformers.

But if they are spilled or released somehow, some can vaporize and get carried into the atmosphere, where they ride the prevailing winds north. They might condense on their journey, and get deposited on the ground again, only to be vaporized when it's warm enough.

And once they arrive in the Arctic, they tend to stay there, trapped in the snow, or as we now know, contained in the fat or blubber of the animals that live there.
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Bjørn: The Arctic is very important with respect to documenting that pollutants actually are globally transported, they can be transported to the Arctic.

Nancy: But how were those little seal pups getting contaminated?

Bjørn: We saw that the main exposure route was through the mother's milk, because these small pups, they don't eat any other food than mother's milk. So the mother, she transfers her pollutant loads, because these contaminants are lipophilic. They are stored in the fat in the adipose tissue of these seals, and then they are transferred into the blood and then into the milk, and over to the pups, and then they are taken up by the pups. So they were actually relatively highly polluted.

And then we started to look for effects. And we found that there were associations between blood levels of contaminants and levels of thyroid hormones, which are hormones that are very important for growth, for thermal regulation, for producing energy, and so on. So we thought that that might be a very important effect that could affect the survival or the health of the pups.

Nancy: Bjørn and his colleagues weren't the only ones who were worried about finding these noxious substances. One of the key persons to call attention to the problem of pollution in the Arctic was none other than …. Mikhail Gorbachev.

In 1987 Gorbachev gave a landmark speech in Murmansk, where he encouraged the Arctic nations to work together to study the Arctic and protect its environment. https://www.youtube.com/watch?v=jMbS2LEfgY0

Gorbachev: (https://www.barentsinfo.fi/docs/gorbachev_speech.pdf)

Nancy: At the same time as Gorbachev was encouraging the eight Arctic nations to band together … Bjørn would make his first journey to the north.

Bjørn (9:17) The first time I was there, it was in 1987. And then we studied the thermal regulation in Brunnich's guillemot and how they regulate their temperature.

Nancy: Brunnich's guillemots look sort of like a cute Arctic version of penguins, with a white belly and black back. They're about the size of a rugby ball. What's even more fun is how researchers catch them.

Bjørn We catch them with with with like a loop at the end. So we just get this loop over their head, and then we pull it in and catch it without using a reel. …Then we can hold them, we can take blood samples. What we did the first time was that we brought them into the laboratory, and we measured their metabolic rate or the oxygen consumption to estimate how much energy they use.

Nancy: Alas, they don't put little oxygen masks on them.

Nancy: Bjørn continued his work looking at animal physiology — how animals' bodies actually work — but more and more he found that instead of studying basic physiology — like the metabolism of Brunnich's guillemots — his work was shifting to look at how some of the increasing amounts of chemicals in the environment might affect these animals' health.

Bjørn: (14:00) BMJ1: Some of the stuff that we did was to identify contaminants that the chemists didn't think would go to the Arctic because they were so large, their molecular mass or the size was so large that they thought it won't be transported through the atmosphere up to the Arctic, but they were!

And they also thought that these compounds were too large to to get through the membranes in the body so that they wouldn't be taken up from the stomach and the intestines, but we found them in several species in birds and also in polar bears, which contributed to showing that these animals up in the Arctic, they are actually accumulating higher levels of these compounds.

Nancy: The big worry was a group of chemicals called...

Bjørn: (15:11) BMJ1. the polybrominated flame retardants, or the brominated flame retardants, which were used a lot in the 70s, and increased production up to around the year 2000, when we discovered them in the Arctic.

Nancy: This particular find came as a HUGE surprise, because….

Bjørn 16:28 they were discovered to be toxic and harmful in the 1990s, at the end of the 1990s. And polybrominated flame retardants are generally regulated or banned now. You're allowed to use some of them for some particular causes. So we didn't expect to find up them up there. But then we found them in polar bears. And that was a big surprise.

Nancy: The scary thing about these brominated flame retardants is that they had structural, chemical, physical and toxicological similarities to another well known bad guy, PCBs.

PCBs had been around long enough that people knew they could mess with how an animal's body worked. In fact, Bjørn was among the researchers who documented in the early 2000s that PCBs as well as organochlorine pesticides could disrupt the thyroid and sex hormone balance and immune function in polar bears. Not good.[1]

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[1] Sørmo, E.G., Salmer, M.P., Jenssen, B.M., Hop, H., Bæk, K., Kovacs, K.M., Lydersen, C., Falk-Petersen, S., Gabrielsen, G.W., Lie, E. and Skaare, J.U. (2006), Biomagnification of polybrominated diphenyl ether and hexabromocyclododecane flame retardants in the polar bear food chain in Svalbard, Norway. Environmental Toxicology and Chemistry, 25: 2502-2511. https://doi.org/10.1897/05-591R.1

Nancy: What was possibly the most scary thing about all this PCB research is that these chemicals were mostly banned in the 1970s. But they and their breakdown products were still hanging around decades later, and causing harm. And Bjørn's research showed that the flame retardants could work the same way.

Nancy: It's one thing to discover all of this disturbing information. But in this case, that research made a difference. And here's how.

Back in 1995, the United Nations Environment Programme realized that something had to be done about all of these chemicals in the environment, in part because, like PCBs, they were persistent. In fact, they got given a collective name, POPs, or persistent organic pollutants. After lots of discussion and debate, the nations of the world agreed in Stockholm to ban 12 of the worst POPs, including DDT and PCBs.

Since then, 16 more chemicals have been banned, including the worst brominated flame retardants, like hexabromocyclododecane.

And one of the reasons these substances have been banned is because of Bjørn's research.

Bjørn: (17:34) BMJ1 So we contributed among other people, to show that these contaminants actually were present in the Arctic food chain, and that they were persistent and bio magnified in the food chain to reach relatively high concentrations in polar bears.

Nancy: At this point you may be asking yourself, if this is a problem for polar bears, what about people who live in the north?

Jon Øyvind Odland: It's the indigenous people who are the innocent victims of industrial activity in the south.

Nancy: That's Jon Øyvind Odland, a professor of global health at NTNU and a professor of international health at UiT —The Arctic University of Norway. He's also a medical doctor and gynecologist.

Nancy: Like Bjørn, Jon Øyvind has been working on toxicants in the Arctic for decades. He has been especially interested understanding what these chemicals mean for indigenous people whose diet is based on traditional foods that contain high amounts of fats, like whales and seals.

Most recently, he's reported results from a population of native people in Chukotka, an area in easternmost Russia on the Bering Sea.

Just like with polar bears, Jon Øyvind has found that the pollutants are

Jon Øyvind:(24:19) …flying up to the north, going into the diet and we can find it a very high concentration in humans in Chukotka.

Nancy:And they've found some scary stuff.

Jon-Øyvind: We have found associations with high PCB levels in in children and also reducing the effects of vaccines for the traditional child diseases.

Nancy:
Some of this can be countered with good dietary advice, he says, but there can be other complicating factors. You can be careful about avoiding these harmful pollutants in your food, but if you smoke, for example, that is far worse than the pollutants in your food.

Jon-Øyvind: the mother smokes 30 cigarettes per day, that is really killing the harmful effects of a PCB molecule.

Nancy: Another complicating factor can be the problems with non-traditional diets, something Jon-Øyvind calls….

Jon-Øyvind: the Arctic dilemma, that's where you see that the traditional diet in the Arctic, that is based on centuries of history, you know, where we eat very much fat rich diet, of course, in the cold. And that means the pollutants follow the food, the best nutrition you can get. So that's the Arctic dilemma.

But in Greenland there this disaster story about when they got high levels of organic pollutants, and they stopped eating traditional food. We call it the chips and Coca Cola generation where they imported food, and people got diabetes and cardiovascular diseases instead.

Nancy: In the end, in some ways, it's easier with people than with polar bears. Because people can get advice, and choose.

Jon Øyvind: 28:40 What we do is we have very good dietary advice now for the younger generation when they have their children. This is very important to give the proper dietary advice to reduce the effects the exposure to the baby. So that's where we can really play a big role.

Nancy: But Jon-Øyvind and Bjørn aren't the only detectives out there. And at least one of them has uncovered something really surprising.

Ida Beathe: I find it very interesting to see how the contaminants end up in the Arctic, since they're not produced there. And I'm driven by the interest of finding new contaminants in the Arctic, actually, and, and see what we can find and what they're potentially doing there, where they come from.

Ida Beathe: My name is Ida Beathe Øverjordet. I'm a research scientist at SINTEF have been for 10 years, actually.

Nancy: Sintef is Scandinavia's largest independent research institute and works closely with NTNU. In fact, Ida Beathe was one of Bjørn's PhD students. That's what started her on her career as a chemical detective.

Ida Beathe: We have some projects going on with pharmaceuticals in the Arctic, which is actually very interesting. And we have found some very surprising results there with the Calanus and different zooplankton, that's also other small crustaceans that we have sampled in Svalbard and analysed for pharmaceuticals. And we found quite high levels actually of painkillers, like ibuprofen and diclofenac. And also antibiotics and antidepressants we found in these tiny creatures living in the Arctic**.**

Nancy: Calanus are these miniscule, rice-grained sized creatures that are kind of like tiny shrimp. They have this little fat sack along the length of their bodies, so they provide a lot of energy to predators compared to their size. That means a lot of creatures eat them, including, as it happens, Ida Beathe.

Nancy: Have you ever eaten one?

Ida Beathe: Yes.

Nancy: You have?

Ida Beathe:Yes. It's not very good.

Nancy: Now, Ida Beathe and her colleagues are trying to figure out just where these pharmaceuticals come from. They know that some can come from the raw sewage that's dumped from cruise ships or from Arctic settlements, like Longyearbyen, the largest town in the Svalbard archipelago, with 2000 inhabitants. But what if these medical pollutants are travelling far, like PCBs?

Ida Beathe: We're now having a project where we want to explore the possibility of long range transport of pharmaceuticals through the ocean currents, all the way from Europe. This is a collaboration with Poland. So we sample from Poland, all the way

along the coast of Norway and up to Svalbard. So that's ongoing now. Very interesting.

Nancy: It’s too early for Ida Beathe to have any results to share, but it’s clear that the message that biologist Rachel Carson wanted to send, 50 years ago now, has had an effect.

And what of Bjørn? After a lifetime of studying pollutants in the arctic, does he still have hope?

Bjørn: I'm both a pessimist and an optimist, if it's possible to be that, because I see that the regulations that we have had on places and organic pollutants, they work, the most harmful ones, they have been removed, although concentrations slowly are declining, they will continue to decline in general. So it's, it shows that it's actually possible to do something. What we as scientists can do is just to give feedback in in to the political world, because they are the ones that really do have the power to do the changes, but it shows that it actually works.

Nancy: I’m Nancy Bazilchuk, and you’ve been listening to 63 Degrees North, an original podcast by the Norwegian University of Science and Technology. For more information and links to academic articles about the research, check out our show notes. Editorial help and sound design by Historiebruket. Thanks for listening.