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00:06 Sarah Crespi: Welcome to the Science Podcast for July 17th, 2020, I'm Sarah Crespi. First up this week, contributing correspondent, Gretchen Vogel, talks about reopening schools during the Coronavirus pandemic. What do we actually know about infections and kids, and how to prevent them in schools? Next, researcher, Kirstie Thompson, talks about changing the process that is typically used to separate crude oil into things like gasoline and plastic precursors. Changing it from an incredibly energy intensive process called distillation to a low heat, low energy approach that uses special kinds of membranes instead.

00:50 SC: Now we have contributing correspondent, Gretchen Vogel. She and two other Science News staff, Jennifer Couzin-Frankel and Meagan Weiland, worked on a comprehensive story on reopening schools during the Coronavirus pandemic. Hi, Gretchen.

01:03 Gretchen Vogel: Hi.

01:04 SC: This is a very complicated story, and to tell to you the truth, I'm a little frustrated 'cause I just want answers, but there are so many unanswered questions out there about Coronavirus in children. So, for example, how likely are kids to get an infection if they're exposed to an infected person? Do we have any numbers on that?

01:25 GV: The story was fascinating but also really frustrating to work on, because we kept saying "Why are these answers so illusive?"

01:31 SC: Right.

01:32 GV: There are no hard and fast answers, but there is accumulating evidence that kids, newborns up to, for our purposes, age 18, are less likely to be infected. It's not clear why that is, but it does seem likely that children are about one half to one third as likely as adults to catch the virus in the first place. That's not 100% clear, but that's consistently showing up in a lot of the data.

02:03 SC: Then once we get past that question of how likely is a kid to get infected, we asked the next question that's still open, which is, if they do get exposed to this infection and they acquire it, do they actually get sick?

02:16 GV: That is also not a number that we know, in part because there's so little testing of people who don't show any symptoms. And to find out if somebody is infected but not showing any symptoms, you have to test a whole lot of people.

02:30 SC: For the trifecta of unknowns, how likely is a kid to transmit this infection? So, there is some evidence out there saying that even if they do get infected, they are somewhat less likely to share it to other people.

02:45 GV: That's correct. There were a couple of intriguing case studies early on. There was a kid in France who was infected. A family friend was in a ski chalet with his family and he caught the virus, he tested positive but didn't yet know that. Between the time he was infected and the time he was tested, he attended ski school and language school and his regular school. Officials tracked down more than 70 of his contacts, and none of them ended up being infected. Even two of his siblings were uninfected. All three siblings shared other viruses; some minor cold viruses they all had, so it wasn't that they hadn't had contact with each other, but the Coronavirus did not pass from this child to anyone else they could find. So that's really intriguing, but it's only one case, right?

03:32 SC: Right.

03:32 GV: So it's hard to extrapolate from that. What our story talks about are some newer data from France that are also intriguing. In a little town north of Paris, there was a pretty large outbreak in a high school, early February. So teachers happened to get infected way before anybody knew that the Coronavirus was circulating in France. And so for two weeks, between the second of February and the 14th of February, when the school went on winter break, the virus had a chance to spread. A few weeks later, when researchers looked at how many people had antibodies to the virus, they found that 38% of pupils, 43% of teachers, and 59% of non-teaching staff had been infected. They also looked, however, at elementary schools in the town. And there they found three kids who, based on when symptoms had started and the fact that they also had antibodies to the Coronavirus, they figured these three kids probably had been infected by their family members and then attended school 'cause they weren't very sick, but they were infected. And they checked with all of their close contacts and it did not look like they had passed it on to anyone.

04:37 SC: So this is getting at the idea that there's a sliding scale, that younger students might be less likely to carry and spread versus older students in the high school years.

04:49 GV: Certainly. Babies seem to be least infected and toddlers and then elementary school kids, and then as you get past the age of sort of 10 or 11, the risk of both acquiring and passing on the virus does seem to increase. And high school kids seem to be fairly good at both acquiring and passing on the virus, maybe not quite as good as adults, but there does seem to be an increasing risk of both catching and passing on the virus as you age. But that's great news, right? If that's true, that is really good news for safety of babies, for the safety of preschools, and for the safety of elementary schools.

05:24 SC: We have now our setup. We have the limited knowledge we have about their risks of getting sick or infecting others, and then we are talking about reopening schools as the end of summer approaches. What parents, what administrators, what governments are trying to do is balance the risk to the health of children and staff against the risk of not having their kids in school. What kinds of things do they have take in consideration on that other side of the equation? What are kids missing out on, besides actual learning, if they don't go to school in the fall?

05:57 GV: It's such a balancing act, because schools are really, really important for kids and for society as a whole, right? They go to school for social contacts and for their emotional and social development. And then lots and lots of kids, all around the world, get a fair amount of their food at school, especially the most vulnerable kids, are really dependent on some of the food programs that are at schools. Also, sadly, schools are a place where some of the most vulnerable kids who might be subject to abuse at home, where some of those signs are picked up and where other adults in their lives can raise red flags and say, "Hey, maybe something's not right here." So there have been signs that child abuse cases have also been going up as kids have been staying away from school.

06:42 SC: There's a lot of pressure to reopen schools, but there's not a lot of information about how to do that safely. But as part of your reporting on this, your team did some pretty extensive research into how all these different programs that have reopened have fared. Can you talk a little bit about what you've looked at and what you were looking for?

07:03 GV: We did do a lot of research. We were intrigued because... So I live in Berlin, and Jennifer lives in Philadelphia, and Meagan lives in Washington, DC. Jennifer and I both have elementary and middle school aged kids. Jennifer's were at home, mine started to go back to school with the other kids in Germany at the beginning of May. Now, this is part-time, just a couple of days a week. My fifth grader, for example, went four days the whole week, part-time, and then was two weeks off. And then again, went four days and then was two weeks off. They were trying to keep class sizes super small, so that if somebody did happen to be infected and attend school, they would only infect a portion of their class, not everybody. And they tried to keep desks spaced far apart. So they were trying to keep as few kids in the classroom as possible so that they could keep their distance from each other. That was my experience in Germany. And we wanted to know how other countries had approached the question.

07:56 GV: So we looked at everywhere, from South Africa to Benin, to South Korea and Japan and Taiwan, and lots of countries across Europe, Canada, had opened some schools. Most schools in the US had stayed closed, in part because summer vacation tends to happen a little earlier in the US. So we took a look at what had happened in those countries that had opened up to different degrees. For example, the Netherlands started back with their elementary schools first in small classes and only part-time, but then they gradually, as things went well and they saw very few outbreaks in schools, gradually opened more and more. Then we, at the same time, checked to see if overall rates of infection in the country had changed, and in many places we found they hadn't. There's a big caveat there, though. Most of these countries had fairly low rates at the time that they opened schools and they had the systems in place when an outbreak maybe happened to detect it and to identify contacts and isolate them for the two weeks that you need to isolate people to make sure they're not gonna pass the virus on.

09:03 SC: So what is a common practice when a student tests positive for Coronavirus?

09:08 GV: Some places would close the whole school if one student was infected, other places would only isolate the people who had been in direct contact with the student, so their classmates or the subset of classmates that they had been attending with in their small reduced size classes and then their teacher or any other teachers. We didn't see a big difference in end outcomes between those approaches.

09:30 SC: What did seem to make a big difference when you looked at all these different schools?

09:34 GV: What seemed to make the most difference was keeping classes small so that kids could stay separate, and wearing masks. Now, there were different approaches in different places. For example, most places in Germany made them optional, although in some schools, everybody had masks on, and in others, only when you came in or were in the bathroom or in the hallways did you wear your mask. Israel was one interesting example where they did not try and reduce class sizes. So they went back to their fairly large class sizes of 30 to 40 kids, but they really did mandate masks for everybody, and that seemed to go okay until it got super, super hot. And then, it was just impossible to ask people to wear masks all day. And so the health department and the education department said, "Oh okay, fine. Let's leave the masks away." But then about two weeks later, they had a humongous outbreak in one high school and some other smaller outbreaks in other places as well. So it's suggestive that masks there were making a difference when they couldn't do the distance scene that was happening in other places like Denmark, where they went to great lengths and even held classes in churches or outside or whatever, to keep kids as far apart as possible and with as much fresh air between them as possible.

10:44 SC: I'm in Indiana and I actually have my daughter in a daycare right now, because I'm in a county with extremely low levels. I am very nervous about it and we keep our eye on the numbers, because that's what I see as a really important gauge for whether or not it's safe to have my kid go to a situation with six other kids. Do you feel like that background level, what your community spread is like, is important for what's happening at your school?

11:14 GV: Absolutely. Yes, that is a huge caveat that we cannot emphasize enough, that the background level of community spread needs to be at a low enough place that you can identify outbreaks when they happen and you notice them, and that you can take measures to try and slow them down. I think if that is the situation, then the harm to kids of keeping schools closed vastly outweighs the potential risk of opening schools.

11:42 SC: Right now, schools are closed, colleges are closed. But once the university kids come back and all the schools are open, we might see a very different background that we need to take into consideration, and be flexible if schools do need to close again.

11:58 GV: Absolutely, and universities are such a different situation than high schools or elementary schools. I mean, as we talked about the risk increasing with age, so I think that's gonna be a real issue in the fall as universities try to open back up.

12:13 SC: What do you think are the main takeaways from your review of all these different openings in different countries and in different schools?

12:22 GV: It's still a little unsatisfying...

12:24 SC: Yes, [laughter] sorry Gretchen.

12:25 GV: The data are really, still really sparse, and it's super frustrating because it's such an important question and it feels like we should have better answers, but we simply don't yet. I do think the main takeaway is you have to be flexible. You have to recognize that you can't go back to pretending that the virus isn't there, or if you do, you're gonna end up with big outbreaks and you're gonna have to shut everything down again like happened in Israel.

12:51 GV: One other interesting takeaway that I found was that when we looked at the outbreaks that had been identified, it was frequently teachers who were more affected than kids. Often, it was hard to tell because there were very, very few cases where people had really carefully done the tracing that they did in that town in France, but it looked at first glance as though maybe the teachers were spreading it to each other more than to and from the kids.

13:15 GV: I think that's something that's important to keep in mind as we move toward reopening, because teachers are better able, I think, than kids to do the physical distancing. I think it's helpful to realize that maybe adults are the bigger risk factor than the kids. I know a lot of teachers are super worried about going back, for good reason. We know as parents and teachers that kids are generally really good at spreading germs, right?

13:42 SC: I was gonna say. It's their specialty.

13:43 GV: Oh, it happens every single winter. Exactly. And so in the middle of a pandemic, where people are dying, and then somebody says, "Well, you have to go back and stand in a classroom with even a half of the normal kids, but be in contact with these lovely little people who you really enjoy being with but who you also see as germ accelerators all day long," is definitely giving a lot of teachers pause for good reason. But I think one of the things that we did see emerging as a pattern was that teachers maybe should be wary of each other more than they need to be wary of their students.

14:18 GV: I do think also that reducing class sizes and finding some sort of creative hybrid solution where kids are in school part of the time, but then doing the distance learning also part of the time, I think that's gonna have to be, unfortunately, the way forward for now, until we get things a little bit more under control.

14:38 SC: We've talked mostly about anecdotal findings so far. Are there studies in schools that are taking a look at this and gonna give us some good answers?

14:48 GV: That's another thing that the story mentions. There are a couple of real studies that are starting. In the UK, there are researchers who have started the projects at several schools where anybody who wants can be tested, both for antibodies and for active virus, and so they're hoping to get a better picture of when somebody's infected, how far it spreads in a school. And in Berlin, and in the German state of Bavaria, also very similar projects have started.

15:12 SC: Alright, thank you so much, Gretchen.

15:14 GV: Thank you.

15:15 SC: Gretchen Vogel is a contributing correspondent for Science. You can find a link to her article and all of our Coronavirus coverage at sciencemag.org/podcast. Stay tuned for an interview with Kirstie Thompson about separating petroleum with membranes instead of heat distillation.

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15:35 SC: When it first comes out of the ground, petroleum is this crude mix of many different molecules. It has to be separated in order to get the useful things we need, like gas for cars or the building blocks for plastics. These days, the separation is done through distillation, and you probably remember this, maybe from Intro Chem or if you know something about making alcohol. You heat something up, collect that vapor, condense it back, and you've got separation by boiling point. You have to do this many times and use lots of energy to distill petroleum's many components. Kirstie Thompson and colleagues write this week in Science about a heat-free way of getting this separation by using a special membrane instead. Hi, Kirstie.

16:19 Kirstie Thompson: Hi.

16:20 SC: Okay. So separating petroleum is a very energy-intensive process, and we do it a whole heck of a lot around the world. Was that the motivation for this work, trying to reduce the energy cost involved in petroleum processing?

16:34 KT: Yeah, that was definitely one of the big motivators behind this work. If you actually look at the energy use of oil fractionation now, it actually accounts for 1% of the world's energy use alone.

16:46 SC: Wow.

16:46 KT: Which corresponds to 1100 tera-watt hours, which to break that down is the energy consumed by the State of New York in a whole year.

16:53 SC: Wow.

16:54 KT: There are definitely other motivations as well. There are many other liquid mixtures that need more energy-efficient ways to be separated other than oil, things like biofuels amid other renewable energies. So if you could think of anything that's a complex liquid mixture, currently those are primarily done through distillation.

17:14 SC: Why did you look to membrane technology to solve this problem?

17:18 KT: Membranes have been very extensively studied for gas phase separations.

17:24 SC: What's an example of gas-gas separation?

17:28 KT: Yeah, so I think a really good relevant example in the world today is the separation of carbon dioxide from air. So that's those greenhouse gases that are being released from factories.

17:37 SC: So this is carbon capture?

17:39 KT: Carbon capture, exactly. So there's so much literature and so much work and things that we know about different polymer materials and membrane materials for these gas separations. So it really was a good starting point for the separation of liquid mixtures.

17:55 SC: Membranes have been used to do things like desalinate water, which can also be done with heat distillation. Why has the membrane approach worked there, but there's been a lot more difficulty using membranes for things like oil?

18:11 KT: Seawater reverse osmosis is the separation of different salts and components from the pure water. When you look at things like oil or other more organic liquid mixtures, you have a lot more complexity in those mixtures.

18:28 SC: So there's a lot more components, and also the molecules are more complicated?

18:31 KT: Both fronts. So you're gonna have a lot more interactions with the membrane, you're gonna have a lot more variation in those compounds. You have a lot more to think about and a lot more interactions to try and overcome to get that separation.

18:44 SC: As you were setting up to explore the membrane options for separating out oil, what kind of properties were important for selecting the materials? What were you looking for?

18:55 KT: So we actually took a lesson that was learned in gas separations. And so one lesson that was learned by McEwan and colleagues was that a certain monomer in a classical polymer that is used for these gas separations, if you modify that monomer, you're able to more rigidify the polymer backbone or the material backbone that gave you higher permeability, which is what you want. You want these membranes to allow that liquid mixture through quickly. And it didn't result in changes in the separation, but we knew that with liquid mixtures we needed to kind of think about those different interactions that could be happening with the organic components of the mixture. So we wanted to address this by thinking of ways we could reduce swelling changes in the material to help us keep that high separation.

19:42 SC: So swelling is a problem because basically when you get things wet, sometimes they hang out in the membrane and change its physical shape, they distort the pores, all kinds of things like that?

19:53 KT: Yeah, so swelling is something where the solvent or liquid that you're using with these membranes change that pore size. So if you have a smaller pore to start, by the end, those pores are so large that you're gonna have very high permeances, but you're not gonna get that selectivity that you need to separate your mixture.

20:11 SC: When you tried this out with, I guess it's like a light crude, so it's not "right out of the ground" petroleum, but some down sampled version of this, were you able to separate some different fractions, and was it similar to what you do with a boiling point distillation?

20:28 KT: Yeah, so this was actually one of the most exciting things in this work. We actually observed a fractionation, similar to what is observed from distillation columns, where there's actually a really sharp cut-off at a certain boiling point, which corresponds to molecular size. So this is actually really important, especially in the purification of crude oil, because those different classes and different sizes, as you mentioned in the beginning, that come out of the crude mixture correspond to different products, so you really need that sharp cut-off.

20:56 SC: Why were you conducting these experiments at different temperatures? What were you hoping to find out with that?

21:01 KT: We did this at different temperatures because crude oil is purified at higher temperatures because it's a really thick, viscous mixture, and so they have to heat it up to keep the mixture flowing quickly through membranes or that's the way we're thinking about it. So the membrane needs to able to hold up to hot mixtures.

21:20 SC: Would that also help it be part of a hybrid system where you're doing some distillations and some membrane separation?

21:26 KT: That's actually, I would say, the more realistic application of membranes where you could think about membranes being incorporated with those distillation columns where you could think of a membrane taking one large mixture and separating into two mixtures, and then those two mixtures are purified through distillation columns. And even that one cut by a membrane drastically reduces the energy consumption.

21:52 SC: We've talked a little bit about scale already, 1% of all energy used planet-wide is for refining petroleum. It's astounding. If using membranes could save even a fraction of that energy, it would be a big win, but the technology needs to be scalable, easy to make in big batches. Were you able to do that in this study?

22:14 KT: We were actually able to scale up this polymer synthesis and were able to, like we did in the rest of the paper, make those thin film composites where you have our material on top of a robust support that supports that thin material. And we were able to do this in a very large scale, actually made three meters of membrane, and we were able to show that we could take this large membrane and roll it up into a membrane module that could actually separate much larger amounts of these mixtures.

22:46 SC: What else might you need to optimize to be able to use this at the industrial level. You need to consider speed, right? So something has to flow through really small pores. Is this a fast process?

22:58 KT: That is definitely something that we need to work on. Currently, the permeances from these membranes are lower than we would like to see, but we mentioned in the paper, that's due to the thickness of this coating that we have on these thin films not being optimized. So that's definitely something that we need to look at.

23:15 SC: Crude oil is very crude. It's kind of a messy, gloppy substance. Wouldn't it clog up pores in a membrane if they're very fine?

23:25 KT: Yeah, that is definitely a worry. It's called membrane fouling. And that is definitely one reason why we didn't look at that nasty crude that you initially think of. We looked at a little bit more cleaned up cut of crude, and I think it would be more realistic for membranes to be applied to this light crude, as opposed to that dirty crude you're thinking of.

23:47 SC: Would you have to have a bunch of different tuned membranes to do a full breakdown of all the petroleum products? Would you have to line up a bunch of different sized pores or different kinds of chemical properties of the membranes?

24:00 KT: That's really our end goal. We really have to get a better understanding of the material properties that give you specific separation, but we really would love to build a library of different polymers, different materials, different types of membranes, maybe one day, that are able to have different cut-offs due to different pore sizes or different interactions that they have. And by having these different membranes that have different cut-offs, you could actually think of fully replacing the various distillation columns used to purify crude oil, but really, this is one of the first papers coming out that even looks into this. We really need other people to come in and then also explore different materials for this to get to that large scale.

24:44 SC: Thanks, Kirstie.

24:45 KT: Thanks. It was so nice talking to you.

24:47 SC: Kirstie Thompson is a PhD student in the Department of Chemistry and Biochemistry at the Georgia Institute of Technology. You can find a link to her science article and a related perspective at sciencemag.org/podcast. And that concludes this edition of the Science Podcast. If you have any comments or suggestions for the show, write to us at sciencepodcast@aaas.org. You can listen to the show on the Science website at sciencemag.org/podcast. On the site, you'll find links to the research and news discussed in the episode. And of course, you can subscribe to the podcast anywhere you get your podcasts. The show is edited and produced by Sarah Crespi with production help from Podigy, Meagan Cantwell and Joel Goldberg. Jeffrey Cook composed the music. On behalf of Science Magazine and its publisher, AAAS, thanks for joining us.