Brains On (APM) | Brains On! The tick-tock of our circadian clock 1QDE6ESE63Z7WYWGHH9PYN0YM8

SUBJECT 1: You're listening to *Brains On!* where we're serious about being curious.

[MUSIC PLAYING]

SUBJECT 2: *Brains On!* Is supported in part by a grant from the National Science Foundation.

[TICKING]

MOLLY BLOOM: You hear that?

ANNIKA RADER: Clocks.

MOLLY BLOOM: They are everywhere, and I don't just mean when you walk into a clock shop.

ANNIKA RADER: Even without alarms or watches, our bodies run on clocks.

MOLLY BLOOM: Down to the cellular level, we have tens of thousands of clocks in us.

ANNIKA RADER: Together, they make up our circadian rhythm.

MOLLY BLOOM: It's how our bodies know when to wake up in the morning.

ANNIKA RADER: When to eat.

MOLLY BLOOM: When to think about big problems.

ANNIKA RADER: And when to go to sleep at night.

MOLLY BLOOM: Our clocks are resynced each day by the rise of the sun.

ANNIKA RADER: Light and dark play a key factor by telling ourselves what to do.

MOLLY BLOOM: Today's episode of *Brains On!* is all about circadian rhythm.

ANNIKA RADER: And those clocks that tell us what to do.

[CLOCK CHIMING]

MOLLY BLOOM: You're listening to *Brains On!* from American Public Media. We take questions, big and small, from kids all over the world and track down the answers.

ANNIKA RADER: Along the way, we try to have a little fun, too.

MOLLY BLOOM: Oh, hey, Annika. I guess, I should give a proper introduction. I am your host, Molly Bloom, and joining me today from Stockholm, Sweden is 11-year-old Annika Rader. Hi, Annika.

ANNIKA RADER: Hi.

MOLLY BLOOM: So Annika, you are kind of the perfect guest for the episode on circadian rhythms because of where you live. Our circadian rhythms are set by the cycles of the sun, when it's light and when it's dark. And if you lived on the equator, those cycles would be pretty constant all year round, but you live very far North of the equator and the cycles are not constant. In fact, they change pretty dramatically throughout the year.

ANNIKA RADER: Yeah.

MOLLY BLOOM: So today we're speaking, it's mid-December, near the winter solstice. The day where the least possible amount of sunshine is present. So what time does it get dark?

ANNIKA RADER: It gets dark at, like, 2:25.

MOLLY BLOOM: And what time does the sun come up in the morning?

ANNIKA RADER: It comes up at about 8:30.

MOLLY BLOOM: Wow, so that's like six hours of daylight a day.

ANNIKA RADER: Yeah.

MOLLY BLOOM: So how does that change how you go about your day during this dark time of year?

ANNIKA RADER: Well, when it's darker, you just feel like you're going to fall asleep.

MOLLY BLOOM: Do you have any tricks that you use to sort of get your energy up in the winter when you feel more tired because it's so dark all the time?

ANNIKA RADER: My dad usually turns on the lights and then, it's kind of hard to fall asleep when the lights are on.

MOLLY BLOOM: But it makes you feel a little more awake?

ANNIKA RADER: It makes me feel more awake, but I still feel really tired, especially when we go out because sometimes, we bike to school, and it's really-- it gets, like, really dark.

MOLLY BLOOM: So you're biking to school in the dark.

ANNIKA RADER: Yeah.

MOLLY BLOOM: Wow.

ANNIKA RADER: And my sisters always fall asleep.

MOLLY BLOOM: On the bike ride to school. Are they, like, in a cart or something? I hope they're not physically biking.

ANNIKA RADER: Yeah No, they're in a cart.

MOLLY BLOOM: That makes sense. And I was reading that in summer, the sun rises a little before 4:00 in the morning and doesn't set until after 10:00 PM.

ANNIKA RADER: Yeah.

MOLLY BLOOM: So how do you go to sleep in the summer?

ANNIKA RADER: Well I just try to close my eyes and just try to fall asleep. And most of the times, I actually have one of those eye masks so I have less light coming into my eyes. It makes me fall asleep.

MOLLY BLOOM: Very smart.

MAN: (SINGING) Ba, ba, ba, ba, ba, ba, ba, ba, ba, ba, ba, ba, *Brains On!*

ANNIKA RADER: When the sun rises, it triggers our circadian rhythm to stop and start specific functions.

MOLLY BLOOM: Days here on Earth run a 24-hour cycle. Our circadian rhythm is close, but not exactly the same.

ANNIKA RADER: And not everyone has the same rhythm.

MOLLY BLOOM: Our body clocks can range from around 22 hours to 26 hours.

MARTHA GILLETTE: Circadian comes from the word circa and dian. Circa means about and dian means day.

ANNIKA RADER: That's Martha Gillette.

MOLLY BLOOM: She's a neuroscientist at the University of Illinois, and she spent decades studying circadian rhythms.

MARTHA GILLETTE: So circadian rhythms are rhythms, that is oscillations, that take place over the course of a day. They're not exactly 24 hour rhythms, but they're near 24 hour rhythms.

ANNIKA RADER: Scientists like Martha have helped determine when our bodies are most prepared to perform different functions during the day.

BOB: You mean like, when is the best time to organize my popsicle stick collection?

MOLLY BLOOM: Meet Bob. He's just your average guy.

ANNIKA RADER: With a giant popsicle stick collection.

BOB: I pride myself on being average.

MOLLY BLOOM: Here with a look at a day in the life of Bob is *Brains On!* producer Sanden Totten.

SANDEN TOTTEN: Like Molly and Annika just explained, Bob's day is influenced by thousands of cellular clocks in his body. So is yours. Let's find out more--

[MUSIC PLAYING]

[SNORING]

--but be very, very quiet. OK, it's 2:00 in the morning and Bob is in deep sleep. His internal clocks are on full on snooze mode and his body is flooded with a sleep hormone called melatonin. Now, let's fast forward a few hours. It's 4:00 AM, Bob's still asleep, and his body temperature is about 2 degrees lower than it would be if he was awake. This is a sign he's conserving energy while he dozes. Let's fast forward some more. OK, it's morning now, and Bob's alarm clock will go off in just a little bit. But even before he wakes up, his body clock is getting him ready for the day.

BOB: Did I forget my pants, again?

SANDEN TOTTEN: Those clocks are telling his body to start releasing a hormone called cortisol. It does a lot of things from helping your metabolism to regulating blood pressure, but it also fills the body with more glucose. Glucose is like food for cells. So Bob's body is already sending more energy to its cells before he even wakes. That way, he'll be ready when--

[ALARM]

BOB: What? Huh? I'm awake. I'm awake. What is it? Oh, yes, it's Tuesday. My favorite day.

SANDEN TOTTEN: Who loves Tuesdays? Whatever. As he gets ready, Bob's body temperature slowly rises and he stops producing so much melatonin.

BOB: Time for my black licorice-flavored mouthwash.

[GARGLING]

SANDEN TOTTEN: And now that he's up and at 'em, Bob's digestive tract is coming back online. Pretty soon, he'll have a bowel movement, which is a totally normal part of the circadian clock.

BOB: I'll be right back.

SANDEN TOTTEN: Let's just fast forward through this part.

[MUSIC PLAYING]

It's 10:00 AM now and Bob's at the office working hard.

BOB: These papers go here and these papers go there. I love filing things.

SANDEN TOTTEN: Not all, but most people are mentally sharpest in the late morning. That's especially true if you're a morning person like Bob here.

BOB: Bob, you genius. This might be your best filing work, yet. Do they give out awards for filing? The Golden Binder Clip, perhaps? I should win it.

SANDEN TOTTEN: Let's skip ahead. It's early afternoon now. Bob is back from lunch.

BOB: OK, back to filing. But maybe, I'll just rest my head on this nice, cushy desk for a second.

SANDEN TOTTEN: Most people typically see a dip in energy right after lunch. Your body is using energy to digest food so there's less energy for your work. But also, throughout the day, you build up levels of a hormone called adenosine. It makes you feel tired.

[MUMBLING]

BOB: Wake up, Bob, and get some coffee.

SANDEN TOTTEN: Cool fact. The caffeine in coffee actually counteracts adenosine. That's how it perks you up.

BOB: Back to filing. I've got the best job.

SANDEN TOTTEN: Wow, he sure loves filing.

BOB: (SINGING) Folders are the best. Paper clips, too. I've got a three-ring binder just for you.

SANDEN TOTTEN: Scientists don't exactly know why, but our muscles and cardiovascular system seem to work best in the late afternoon. So it's a good thing Bob exercises right after work.

BOB: Keep on trucking, Bob. One more mile on this puppy and you'll have run a mile.

SANDEN TOTTEN: It's evening now and Bob is relaxing.

BOB: This one goes here. This one goes--

SANDEN TOTTEN: Wait, is he filing for fun?

BOB: Oh, man. I love sorting my used popsicle sticks by size. Oh, maybe, I'll sort them by color stain next. Let's see, cherry red followed by strawberry

SANDEN TOTTEN: Wow, OK. That's a hobby, I guess.

BOB: And then tangerine.

SANDEN TOTTEN: Anyway, Bob doesn't know this, but his body clock is already getting him prepped for bed. The darkness around him has triggered his body to start releasing melatonin, again. That's that sleep hormone. Plus, after a busy day, Bob's full of adenosine making him tired. When he sleeps, his body will break that stuff down and clear it out.

BOB: I should turn in.

SANDEN TOTTEN: Pretty soon, Bob's clocks will lull him back to sleep and the whole thing will start over, again.

BOB: Good night, sticks.

SANDEN TOTTEN: Every day for Bob and for you, it's a cycle of ups and downs controlled by our circadian cycle.

[SNORING]

Perfect time to sneak out and get back to the show.

MOLLY BLOOM: Another good night's sleep for Bob, and he'll be ready for his next busy day of filing. Oh, and Sanden, before you go, can you help me out with one more question?

SANDEN TOTTEN: Sure. Sure, what's up?

MOLLY BLOOM: What's the best time of day to answer the Mystery Sound?

SANDEN TOTTEN: Well, in my non-scientific study group of one, I'd say, right now.

MOLLY BLOOM: OK.

[DIFFERENT SOUNDS]

SUBJECT 3: Mystery Sound.

MOLLY BLOOM: Here it is.

[MYSTERY SOUND]

SANDEN TOTTEN: Wow, OK.

MOLLY BLOOM: So do you have any guesses?

SANDEN TOTTEN: Well, it sounds busy, whatever it is. I think, maybe, it's a jungle? And I'm picturing lots of, like, monkeys in trees kind of, like, laughing because maybe another monkey slipped on a banana peel, which is entirely plausible because monkeys are constantly eating bananas.

MOLLY BLOOM: There's a lot of peels around.

SANDEN TOTTEN: And there would be a lot of peels, yeah.

MOLLY BLOOM: OK, well, I think that's a really good guess, and we're going to let you think about it just a little bit more. So stick around for the answer to this one a little later in the show.

[SCRATCHING]

[INAUDIBLE SHOUTING]

ANNIKA RADER: If your clock runs shorter than 24 hours, you're a morning person.

MOLLY BLOOM: You don't stay up too late and you like getting up early.

ANNIKA RADER: Those of you who have circadian clocks that take longer than 24 hours to turn over--

MOLLY BLOOM: You're night owls. You like staying up late and spending more of your mornings in bed. Annika, are you more of a morning or a night person?

ANNIKA RADER: Well, I'm more of a night person. My body makes me stay up late and most of my morning, I just like sit in bed.

MOLLY BLOOM: Me too. I think you and I are on the same page. It's hard to get up in the morning.

ANNIKA RADER: So what type of person are you, morning or night?

[MUSIC PLAYING]

SUBJECT: I think it's better to be a morning person because when you're awake at the night, you would be tired and you won't want to do fun stuff and you would just want to stay home.

SUBJECT: I like to have dance parties in the morning.

SUBJECT: I think it's better to be a night person because then you won't fall asleep watching fireworks on the 4th of July.

SUBJECT: I think it's better to be a morning person because at night, you can't see much things and you get creeped out. shadows don't look like what they are. Some look like zombies and ghosts.

SUBJECT: I wake up when the sun comes up.

SUBJECT: And I'm a night person because whatever my mom turns out the light, I want to stay sleeping.

SUBJECT: We have a morning and night people in our family.

SUBJECT: I'm a night person, but I think it's better to be a day person because it's when we're meant to be awake and active.

SUBJECT: It's better be a night person because you get to have a sleepover and stay up almost all night.

SUBJECT: I like being a morning person because I can get up and read while everybody else is asleep.

SUBJECT: And we are morning people so we can focus on breakfast.

SUBJECT: You get to play for a long time before breakfast.

SUBJECT: And so I can get up early in the morning to go skiing.

SUBJECT: The early bird gets the worm, and you would have more time to get dressed and get ready.

SUBJECT: I choose mornings because you can see a lot, not like seeing blind.

SUBJECT: I would like to be a night person because I would get to see nocturnal creatures like owls, some wolves, or raccoons. It would be so fun!

MOLLY BLOOM: Thanks to *Brains On!* listeners Audrey, Micah, Ellen, Keith, Maia, James, Rowan, Julia, Henry, Masha, Eleanor, Claire, and Reece for sharing their thoughts on morning versus night.

ANNIKA RADER: Figuring out whether you're a morning or night person can get tricky when you're in space. Astronauts on the International Space Station orbit the Earth every 90 minutes.

MOLLY BLOOM: Which means they see 16 sunrises and 16 sunsets every day every 24 hours.

ANNIKA RADER: So what affects do all those signals of light and dark half on their circadian rhythm?

[MUSIC PLAYING]

MOLLY BLOOM: Doug Wheelock is a NASA astronaut. He spent six months in space orbiting the Earth on the International Space Station.

DOUG WHEELOCK: We're traveling pretty fast-- 17,500 miles per hour, which is about 5 miles per second. So we orbit the Earth once every 90 minutes, and every 45 minutes, we get a sunrise and a sunset. If you're looking out the window and it's light outside or it's dark outside, it can be very confusing to your normal circadian rhythm. We operate the Space Station on Greenwich Mean Time. So it's 6:00 in the morning Greenwich is when the crew usually awakes on the Space Station, and then they begin their work about 7:30 in the morning Greenwich. And then, our go to bedtime is 9:30 in the evening.

If you fall asleep in space, you actually kind of float there, but you'll end up kind of moving with the air stream in space. And so we have sleeping bags that we just kind of crawl inside, and it keeps us attached to the wall or to the ceiling or to the floor, wherever you want to hook your sleeping bag to.

Right after we wake up, we have a period of what's called post-sleep activity and then before we go to bed, it's pre-sleep activity. And we try to incorporate in those times, the very same things we do on Earth. When you first wake up, they might go to the bathroom. They'll wash their hands. They'll brush their teeth. They might take a shower. Some people do their exercise in the morning. And so we encourage our astronauts to do those things that you normally do on the ground that are signals that you do that the body is just waking up and getting ready for the workday.

Also, before you go to bed you, like here on Earth, we don't stay in school, we don't stay at work right up to the point where we're going to go to bed. We'll go home. We'll relax. Maybe, we'll kick our shoes off. Maybe, watch a movie or something or read a book. We try to keep those same routines, very familiar routines, for each crew member. And that helps us maintaining our circadian rhythm with sleep.

ST. OLAF CHOIR: (SINGING) *Brains On! Brains On! Brains On! Brains On!*

MOLLY BLOOM: Up next on the *Brains On* circadian rhythm special--

ANNIKA RADER: What looks like two tiny footballs--

MOLLY BLOOM: --is located in the brain's hypothalamus.

ANNIKA RADER: It acts like a conductor.

MOLLY BLOOM: --the suprachiasmatic nucleus?

ANNIKA RADER: Yeah.

ST. OLAF CHOIR: (SINGING) Suprachiasmatic nucleus.

MOLLY BLOOM: We'll meet this circadian conductor after the break.

[MUSIC PLAYING]

ANNIKA RADER: *Brains On!* is powered by the curiosity of kids all over the world.

MOLLY BLOOM: If you want to send us a question, send in a Mystery Sound, draw us a picture, or just give us a high five--

ANNIKA RADER: Email us hello@brainson.org.

MOLLY BLOOM: That's how we got this question.

ADDIE: Hello, my name is Addie, and I'm eight years old.

DYLAN: Hi, my name is Dylan, and I am 11 years old. We live in Zebulon, North Carolina.

ADDIE: And our question is, why do people put salt on the road when it snows? Why does the salt melt the snow and ice?

MOLLY BLOOM: We'll answer that question and hear the latest group to join the Brains Honor Roll at the end of the show. And a special note for our listeners in Boston, you can come see us live. *Brains On!* is proud to be a part of the Cambridge Science Festival taking place in April. We have a special robot show planned on the 15th. Check out brainson.org for tickets and more details.

ANNIKA RADER: While you're there, why not sign up for our newsletter? There's always interesting experiments, books, and videos to go along with our episodes. From American Public Media, I'm Annika Rader

MOLLY BLOOM: And I'm Molly Bloom.

ANNIKA RADER: Today, we're talking about what makes us tick.

MOLLY BLOOM: That's right, our circadian rhythm.

MAN: Good morning to Nobel Forum and this press conference for the announcement--

ANNIKA RADER: Three scientists studying these near 24-hour cycles were honored with the 2017 Nobel Prize for Physiology or Medicine.

MAN: Jeffrey C. Hall, Michael Rosbath, and Michael W. Young for their discoveries on molecular mechanisms controlling the circadian rhythm.

MOLLY BLOOM: Jeffrey C. Hall, Michael Rosbath, and Michael W. Young shared this prestigious prize for their work that shows just how the circadian clock works. They studied clock genes in fruit flies, but guess what? We have very similar genes in our bodies.

ANNIKA RADER: Thanks to their research, we know millions of cells in our body each have their own clock, and they all need to stay in sync with each other.

MAN: This year's laureates, they wish to peek inside the clock and figure out how it actually works.

MOLLY BLOOM: And there's this tiny part in the brain that is responsible for telling all these millions of clocks what to do. It's the suprachiasmatic nucleus or SCN. It gets cues from light.

ANNIKA RADER: Specifically, blue light, which is part of the visible light spectrum that our eyes can detect. The sun is full of blue light.

MOLLY BLOOM: Parts of our eyes called photoreceptors take in this slide and signal the SCN to reset our cellular clocks. This is what keeps our circadian rhythm in sync with the day.

MARTHA GILLETTE: The suprachiasmatic nucleus is actually two clusters of brain units, we'll call them neurons. That's what a brain cell is.

ANNIKA RADER: Again, neuroscientist Martha Gillette.

MARTHA GILLETTE: And there's very small football-shaped structures that are too small for the naked eye to see. You can see them with a microscope. They have this very clear appearance because they're very tightly packed with cells. And these cells are some of the smallest cells in the brain and the body. And they have this very interesting function, and that is they keep time like a clock. And the cells work together so that the whole suprachiasmatic nucleus keeps time. And it can even keep time if the suprachiasmatic nucleus is taken out of the brain and kept alive with life support in a dish. You could do this for months, even a couple of years, if you take very good care of it.

MOLLY BLOOM: The suprachiasmatic nucleus is located at the base of the brain.

ANNIKA RADER: Open your mouth and tap the roof of it. That's your hard palate. And just above that is the SCN.

MOLLY BLOOM: So, like, right up here. So like right up here. Martha says, you can think of the SCN like a conductor and your body as an orchestra or choir. From your heart and liver down to your hair follicles, none of them would know how to sing without their SCN conductor.

MARTHA GILLETTE: Absolutely. The different clocks in the heart, the liver, the lungs, the blood, the muscles, the cells that grow your hair, all of them are coordinated so that they have highs and lows in their activity that's appropriately timed with, guess what? That original signal that came into the SCN day and night or the orchestra of our body really works around the day/night cycle.

ANNIKA RADER: And it's a conductor's job to make sure all the pieces of an orchestra or choir stay in sync.

[CHOIR SINGING]

ANTON ARMSTRONG: My name is Anton Armstrong. I'm the Tosdal Professor of Music and Conductor of the St. Olaf Choir at St. Olaf College in Northfield, Minnesota. All music has rhythm. All music does not have pitch. There is music that doesn't always have harmony, but there's rhythm. Because music is sound in a time and time factor. It's how you're using that time. So rhythm is 100% to me. Absolutely important.

MARTHA GILLETTE: The SCN is the only region in the body that if it's damaged or removed causes all those other elements in the orchestra to lose their conductor, and they slide out of synchrony.

ALL: Synchrony. Synchrony.

MARTHA GILLETTE: And they slide out at different rates. And so, the rhythms in the heart will change, but it'll change differently than the rhythms in the liver or the intestines. So they're all their own local unit of the orchestra, but they're all drawn to play together by the SCN, which is appropriately thought of as a conductor.

ALL: Synchrony.

ANTON ARMSTRONG: I'm a right-handed conductor so that might be the hand that primarily is keeping the time, is showing the basic pulse. Then, my left hand becomes more of the descriptor. So if I want to increase, I might do a gesture that allows my left hand and arm to extend out towards the ensemble.

[VOCALIZING]

Conversely, if I want them to be softer, my palm would go down and I would recede in that gesture and bring my hand closer to my body and lower.

MOLLY BLOOM: So the suprachiasmatic nucleus not only tells each cell what to do, but it tells groups of cells when to become more or less active.

[VOCALIZING]

ANNIKA RADER: The SCN is also great at getting cells ready for a particular job like when your body senses light in the morning.

MARTHA GILLETTE: There are chemicals that your brain releases to say to your body, hey, I haven't eaten all night. It's time to go out and eat some breakfast.

ST. OLAF CHOIR: (SINGING) Hey, I haven't eaten all night. It's time to go out and get some breakfast.

MARTHA GILLETTE: Those chemical signals rise before each of the meals that we eat. They anticipate the arrival of the meals.

ST. OLAF CHOIR: (SINGING) Mm, hungry.

MARTHA GILLETTE: Anticipation that is being prepared before you need a certain state in the body is one of the advantages of having a clock system. So you anticipate the need for food, you go out and eat, and then your feeding drive is satisfied.

MOLLY BLOOM: The suprachiasmatic nucleus--

ANNIKA RADER: This body clock conductor.

MOLLY BLOOM: --it controls everything.

MARTHA GILLETTE: The SCN changes your interest in eating.

ST. OLAF CHOIR: (SINGING) Eat, eat, eat.

MARTHA GILLETTE: It changes your interest in sleeping.

ST. OLAF CHOIR: (SINGING) Sleep, sleep, sleep.

MARTHA GILLETTE: It changes your body temperature.

ST. OLAF CHOIR: (SINGING) Heat, heat, heat.

MARTHA GILLETTE: It changes your interest in running around outside.

ST. OLAF CHOIR: (SINGING) I'm beat, beat, beat. Let's rest.

MARTHA GILLETTE: And interestingly, when you're sleeping at night, it changes your sensory systems. And those are the systems by which you bring information about the world into your brain. For instance, you have much less robust color perception at night. Your eyes see much more black and white, and the SCN controls that. You're less sensitive to sounds at night, and that helps you stay asleep when you're asleep. So it tunes down the sensitivity of the auditory system. In other words, the SCN doesn't just control our active state. It also controls our sleeping state.

ST. OLAF CHOIR: (SINGING) Sleeping state.

[YAWNING]

ANNIKA RADER: A good night's sleep is important for everyone, especially kids because that's when the SCN let's your body know it's time to grow.

MOLLY BLOOM: If you're going to grow, you've got to sleep.

ANNIKA RADER: Special thanks to St. Olaf Choir for helping us out with this interview.

ST. OLAF CHOIR: (SINGING) You're welcome.

MOLLY BLOOM: OK, Annika, I want to bring Sanden back in to see if he's got a chance to identify the Mystery Sound. Sanden.

SANDEN TOTTEN: Hi, again. Can we hear that Mystery Sound just one more time?

MOLLY BLOOM: Sure, here it is, again.

[MYSTERY SOUND]

SANDEN TOTTEN: I'm thinking now, maybe, it's birds in a tree in the forest or in a jungle somewhere? Like, some colorful birds that have lots of many colors, and this time they're all talking about some great fruit tree.

MOLLY BLOOM: I like how you think. All right, here is the answer.

TULSI: Hello, my name is Tulsi. I'm from Australia. The sound you heard was little red flying-foxes.

SANDEN TOTTEN: Little red flying-foxes?

MOLLY BLOOM: Here to tell us more about what a flying-fox is exactly, is Tulsi's granddad, Hugh Ford. He's a zoologist.

HUGH FORD: No, a flying-fox isn't a fox at all. It's actually a great big bat or what they call mega-bats. They're little red flying-foxes. They're not actually red. They're a reddish brown and can weigh about a pound. Their wingspans probably about 3 feet. And the other species we have here, the gray-headed flying-fox, which have dark, grayish, black almost on the back on the front with a yellow to orange ring around the neck, can weigh up to 2 pounds.

So they're pretty big beasts. And they're quite a bit bigger. Maybe, the big males get to about 5 feet across the wingspan. So they're a little bit scary when they get close to you. And some of them do get pretty close.

[RED FLYING-FOXES SQUEAKING]

MOLLY BLOOM: So Sanden, you were close. There are a bunch of flying things in a tree talking to each other, but they're bats, not birds.

SANDEN TOTTEN: They are bats. They're still talking about fruit trees probably, though.

MOLLY BLOOM: Probably.

SANDEN TOTTEN: I'm pretty sure, I heard one of them say, fruit tree.

MOLLY BLOOM: You speak bat.

SANDEN TOTTEN: Well, we're both mammals.

MOLLY BLOOM: True. You have a lot in common.

HUGH FORD: They're nocturnal, and they're resting during the day when, of course, we're not. So what happens in the evening about 7 o'clock in the summer, they start this chattering together. And they sort of talk away to each other for half an hour and then they start flying around in circles and then they leave. And they go off, say, 8:00 and they travel 20 miles or more to get to their food source because they feed on the nectar of trees and they also feed on fruits in the rainforest.

And then, in the morning, they come back. And this is one of their big impacts on us because you can imagine, 3,000 bats flying back in and they're all screeching away about 4:00 AM. And you're sound asleep, or you were sound asleep, and you get this horrendous racket going on all around the house. And they finally settle down about 7:00 when we're just sort of getting up and starting to make noise ourselves. And the other thing, of course, is they've been out there feeding all night and they come back out, hang in the trees here, and of course, all the poo comes down. And so we get this terrible stink and mess everywhere.

[RED FLYING-FOXES]

The first 1,000 turned up beginning of October, and they increased a bit during October. They increased a lot in November. There was something, like, 30,000 gray-headed flying-foxes, maybe 20,000 of the little reds.

(SINGING) *Brains On.*

ANNIKA RADER: You're listening to *Brains On!* The science show for curious kids.

MOLLY BLOOM: And adults.

ANNIKA RADER: All right, adults. They're kind of the source of the problem we're about to talk about.

MOLLY BLOOM: Hang on a second, Annika. I just need to finish this text.

[TEXT SWOOSHING]

What were you saying?

ANNIKA RADER: Well, I was about to introduce Samar Hattar. He's a biologist and neuroscientist at the National Institute of Mental Health.

MOLLY BLOOM: All right, he's been looking into the effects that screens have on us. Oh, wait, hold on. My mom just sent me a cat video. This is important. Can you take it for a sec?

ANNIKA RADER: OK, then. Let's get a little help from *Brains On!* producer Marc Sanchez. He spoke with Dr. Hattar about screens and circadian rhythm.

MARC SANCHEZ: Smartphones, tablets, laptops, e-readers, they're everywhere these days. And their shiny little screens can be really helpful. I mean, did you know that bubble wrap was originally invented as wallpaper? It's true. And I know that important fact thanks to looking at a screen. But we need to give our eyes and brains a break, especially at night, because light coming off these screens is in the blue spectrum, and as you heard earlier in this episode, the sun also gives off a lot of this blue light. When special photoreceptors take in this light, we get a daytime signal and that can be tricky for our circadian clocks.

SAMAR HATTAR: What you are doing when you're using these very high intensity light devices, like iPads, iPhones, is that now you're giving a confusing signal to your brain, and your brain thinks it's the day already. And this will affect your sleep cycle. And if your sleep cycle is affected, then many other physiological functions are affected.

MARC SANCHEZ: Darkness is a cue for melatonin-- that sleep hormone-- to start peak production. And light from the sun or your screens helps keep melatonin from being released the way it is when it's dark.

SAMAR HATTAR: So what happens when you stimulate yourself by light at night, your melatonin levels are going to go, your alertness level is going to go up, and you're going to have problems going to sleep.

MARC SANCHEZ: In 2002, Dr. Hattar helped discover special photoreceptors that are sensitive to blue light. They're called intrinsically photosensitive retinal ganglion cells. Oh, that's a mouthful. Let's just call them IPRGCs like everybody else. Unlike the photoreceptors in our eyes that help us see images, IPRGCs send signals straight to the conductor of our circadian rhythm.

ST. OLAF CHOIR: (SINGING) Suprachiasmatic nucleus.

MARC SANCHEZ: Yep, our old pal the suprachiasmatic nucleus. If you went into a completely dark room and stayed there for, let's say, a week or two, your circadian clock would fall out of sync with the day and night cycle. Your IPRGCs wouldn't be sensing blue light.

[DOOR OPENING]

OK, back to our screens. One way to make sure we get a good night's sleep is to not look at our devices for a few hours before bedtime.

SAMAR HATTAR: Yes, I would say minimum two hours. And the other thing is you really should use the new features that Apple, for example, have added to their phones where they use this Night Shift where they change the color and the intensity of the emittance from these tablets. Because one thing about the photoreceptors in the retina that detect light for the circadian clock, they are not very sensitive to light. So if you decrease the amount of light at night, you have less probability of activating them. So you could actually, not affect yourself if you're-- as much. If you have to read the phone, at least have it at a very low intensity.

MARC SANCHEZ: In general, Dr. Hattar thinks most people rely on too much light, and he issued a bit of a challenge.

SAMAR HATTAR: You go home at night, put yourself in a dark room, not completely dark, and just wait in this room for 10 minutes, and then go outside to the lights you were under. And what do you notice is that you always use so much light than you really need. What I really like about this experiment is to show you how sensitive your visual system is. So you really-- my advice to a lot of people is try to cut 50% as a minimum, as a start, of how many lights you put at your home at night. And then you will find that you could even cut even more later once you allow yourself to adapt. Because vision is very sensitive, but it needs to dark adapt before you appreciate the sensitivity of vision.

[MUSIC PLAYING]

And once you start cutting your light out at night, you're actually helping your adjustment to the circadian rhythm and the day/night cycle.

MOLLY BLOOM: Dr. Samar Hattar is a biologist and neuroscientist at the National Institute of Mental Health. Throughout history, light and dark have played an important role in people's lives.

ANNIKA RADER: Winter and summer solstice celebrations.

MOLLY BLOOM: Dances to honor the sun.

ANNIKA RADER: And holidays based on the idea that light will shine.

MOLLY BLOOM: Annika, are there any celebrations in Sweden that celebrate the light?

ANNIKA RADER: We have, in the summer, we have Midsummer, which is basically, a celebration on the longest day of the year. And then we also have Lucia, which is in winter. It's, like, about this saint who brought light to Sweden.

MOLLY BLOOM: What are the traditions that go along with that holiday?

ANNIKA RADER: In schools, there's somebody who served like Lucia. She has candles on her head and then she has a candle-- like, it's a candle wreath on her head. But most schools actually don't use real candles. They use fake candles because it's safer, but it looks like candles.

MOLLY BLOOM: Well, candles and fire play a big part in winter celebrations all over the world, and for good reason. Winter is dark, and we miss the light. In fact, most of the celebrations occur around the winter solstice, the shortest day of the year. Anthony Aveni is a Professor of Astronomy and Anthropology at Colgate University. He says, throughout history, we see cultures celebrate light during these dark days.

ANTHONY AVENI: In medieval times, in Europe, people would beckon to the sun by making huge wheels out of straw and wood and place it at the top of a hill and light it on fire. And then, men with sticks would roll that wheel down the hill toward the river, imitating the movement of the sun. And it's just the way the sun moves. At noontime, it starts to roll down and then finally, it hits the horizon. And then, they would take some of the remaining flames and light their sticks with that fire, and then carry that new fire into their household. And they would use that to light the fire in the fireplace. By doing that, it would symbolize that they would take this new fire that comes from the sun when it turns around and comes back into the sky in the springtime, and they would take a part of that fire and bring it to their hearth. They would own a part of the sun.

And the Aztecs in Mexico had a similar ritual. They say that on New Year's Eve, they would all take sticks and contribute to a central fire. They would call it the New Fire Ceremony. They would break their cups and saucers and dishes and throw away their forks and knives. They would get rid of all the impurities from the previous cycle of the sun. Then, they would renew the fire. They would get new mats to replace the old mats in their house that they sat on and slept on. And they would begin things anew.

And if you really think about this, it has a little bit to do with our New Year's resolutions where we take out the old and bring in the new. In other words, we start a new cycle of the sun coming back into our world for the next year. So there's really some very deep meaning to all of these things we do during Christmas and Hanukkah and all of the other holidays that all seem to take place-- these important holidays-- right around the turn of the year, right around the time of the winter solstice when the sun is going far away.

MOLLY BLOOM: That's archeo-astronomer Anthony Aveni. So not only does the cycle of light and dark rule the clocks in our body, but it plays an important role in our holidays and celebrations, too.

[MUSIC PLAYING]

ANNIKA RADER: Circadian rhythms are around us and in us every day.

MOLLY BLOOM: Our bodies run on near 24-hour cycles.

ANNIKA RADER: But we depend on the sun to sync our clocks each day.

MOLLY BLOOM: The great conductor of our clocks is called the suprachiasmatic nucleus.

ANNIKA RADER: Looking at screens too close to bedtime can confuse our bodies into thinking it's time to be awake.

MOLLY BLOOM: That's it for this episode of *Brains On!,* but we will be back in your feed very soon with more on circadian rhythms. We'll find out how they affect plants and animals, too. Hibernation, nocturnal animals, salad-- do not miss it.

ANNIKA RADER: *Brains On!* is produced by Marc Sanchez, Sanden Totten, and Molly Bloom.

MOLLY BLOOM: We had production help this week from Jon Lambert, Emily Allen, Lauren Dee, and Annie Baxter. Our engineers were Michael Osborne, Corey Schreppel, Johnny Vince Evans, Stell Klein, and Mark Schultz. Many thanks to Eric Ringham, Gwen Holtmann, Lindsey Henning, Tracy Mumford, Dr. Alon Avidan, Rowena Orr, Stacy Maison, Karina Rader, Nathan Rader, Carl Reichert, and Tara Whitfield *Brains On!* is supported in part by a grant from the National Science Foundation.

ANNIKA RADER: You can find more episodes of *Brains On!* at brainson.org or wherever you get your podcasts.

MOLLY BLOOM: We're also on Instagram and Twitter. We're brains_on. And we're on Facebook, too.

ANNIKA RADER: If you have any question you'd like to hear answered on *Brains On!,* email it to us any time.

MOLLY BLOOM: The email address is hello@brainson.org.

ANNIKA RADER: Before we go, it's time for the Moment Of Um.

PATRICK HAMILTON: My name is Patrick Hamilton and I'm the Director of Global Change Initiatives at the Science Museum of Minnesota.

[MUSIC PLAYING]

ADDIE: Why do people put salt on the road when it snows? Why does the salt melt the snow and ice?

PATRICK HAMILTON: That's a good question about how does salt actually melt snow and ice. So if we were able to look at ice at a really close microscopic scale, we would see that it isn't as solid as it appears. That even when it's below freezing oftentimes, there's a surface of liquid water on top of that ice. This water and ice are very dynamic. Some of the molecules of water are becoming crystalline ice and some of that crystalline ice is reforming as water.

And when we put salt on that thin layer of water, it dissolves. And the ions of sodium and chloride in that liquid water interfere with the ability of the liquid water molecules to link up with the ice and form additional ice crystals.

Now, we certainly all benefit by applying salt to our roadways and highways and streets, but there's a long-term consequence because salt dissolves into our waterways. The sodium and chloride are elements that never go away. And especially, chloride is building up in our freshwater ecosystems. And those lakes, those streams, rivers, the organisms in them, the fish, they are adapted to living in freshwater, not salt water. So as the chloride level increases, it becomes increasingly hazardous for the health of aquatic ecosystems.

MOLLY BLOOM: The roads look clear, and I'm ready to zoom through this list of names. It's the most recent group to be added to the Brains Honor Roll. These are the excellent listeners who help us out by sharing their ideas, Mystery Sounds, and questions with us.

[MUSIC PLAYING]

[LISTING HONOR ROLL]

MAN: (SINGING) Brains Honor Roll.

MOLLY BLOOM: Getting to hear your name on the Brain's Honor Roll is easy. Just send in a question, drawing, or Mystery Sound. Let your curiosity guide you. You can email them to hello@brainson.org and you can also find our physical mailing address at our website brainson.org. OK, we'll be back soon with more answers to your questions.

ANNIKA RADER: Thanks for listening.