[MUSIC PLAYING]

MOLLY BLOOM: You're listening to *Brains On* where we're serious about being curious. I'm Molly Bloom. What's that in the sky? Is it a bird? Is it a plane? It's a total solar eclipse. That's right. Here in the United States we have total solar eclipse fever. That's because on Monday, August 21, a total solar eclipse will be visible on a path from Oregon on the West Coast to South Carolina on the East Coast. And the rest of the country will get a glimpse of a partial eclipse. This is the first solar eclipse to go across the US since 1979.

And just in case you don't listen to the end of this episode, we need to say right now up front, do not look at the solar eclipse without protection. And no, your regular sunglasses won't cut it. More on that later. Just remember--

SUBJECT 1: (SINGING) Do not stare at the sun. Don't do it.

MOLLY BLOOM: But first, why are we so excited about this astronomical phenomenon? Jordan Fields is a young astronomer from Northfield Minnesota. She joined me to help explain the basics of what an eclipse is and how she got interested in the night sky.

JORDAN FIELDS: So the moon is going to come in between the sun and the Earth. They're going to be all in one line, very temporarily. But the moon will block the sun's light and cast a shadow on the Earth. So that's what we'll be seeing down here.

MOLLY BLOOM: So why is it that you can only see the total eclipse in like some parts of the United States?

JORDAN FIELDS: Because for us like in Minnesota, we'll only see a partial eclipse because the moon won't be completely aligned with the sun up here because we're at a different longitude--

MOLLY BLOOM: So that makes sense.

JORDAN FIELDS: --and latitude. A total solar eclipse happens-- is visible somewhere on Earth about every 18 months. But it's usually over the ocean, because that covers so much of the Earth. So normally you can't see it. And then sometimes it happens in places like Asia where there's nowhere near us, so we can't see it either. Bu--

MOLLY BLOOM: This is an opportunity.

JORDAN FIELDS: It's really cool to be able to have it in the United States, so close to home.

MOLLY BLOOM: So what is your plan for the eclipse?

JORDAN FIELDS: I think I'm going to go down to Lincoln and yeah, because that'll be in the path of the total eclipse.

MOLLY BLOOM: Like, let's say there's a kid out there who's interested in astronomy and is thinking about maybe learning more, what would you say to them?

JORDAN FIELDS: I would say start looking at the night sky as much as you can, viewing stuff is easier in a small town like Northfield where there's not a ton of lights, because in the big cities, light pollution blocks out all the stars, basically. You can only see the brightest ones. So everything else is just washed out. And download an app, and it'll tell you what the names of stars and constellations are.

And it'll also show you where planets are. It's really cool to be able to tell people things about the sky that they don't know, like to be able to tell them about the phases of the moon and how it works and like, why eclipses happen because most people don't realize how it works.

For the eclipse, definitely, go out and see it. Get some solar glasses or make a pinhole projector. Definitely go and see it because there's not going to be another one for a while. And it's going to be one of the coolest things you see in probably this year.

MOLLY BLOOM: Well, thank you so much for talking to me today.

JORDAN FIELDS: Of course, it was my pleasure.

SUBJECT 2: *Brains On!*

MOLLY BLOOM: So a total solar eclipse happens when our view of the sun is blocked by the moon. When these three bodies, the Earth, the moon, and the sun are perfectly aligned, there's a cool astronomy word for this, syzygy, spelled S-Y-Z-Y-G-Y. That's right, no vowels.

A syzygy occurs when astronomical bodies are aligned. So lunar eclipses are also syzygies, as are the full moon and new moon. The Earth is constantly orbiting around the sun. And the moon is constantly orbiting around the Earth. Even though these orbits have different lengths, the time of the syzygies as can be predicted.

Humans have been able to predict when eclipses would happen since about the year 150, even though we didn't have the orbits of the planets figured out quite yet. We thought the sun orbited around the Earth. Whoops. Chinese and Greek astronomers started keeping very careful records of the movements of the sun, the moon, the planets, and stars about 3,000 years ago.

And using this treasure trove of data about 2000 years ago, Greek and Chinese astronomers were able to make calculations that allowed them to predict when solar eclipses would occur. But Greek and Chinese astronomers were not the only ones with their eyes to the skies. There are stories and beliefs connected to solar eclipses from all around the world.

Many cultures have tales of dogs or other creatures like dragons or demons eating the sun. Many of the native tribes in the US have long astronomy traditions and their own perceptions of the solar eclipse. Nancy Maryboy is the president of the Indigenous Education Institute. She is Navajo and Cherokee and is working to share tribal stories about the eclipse.

NANCY MARYBOY: Some of them have been lost to time and sometimes when some of the knowledge holders pass away, that knowledge is lost. Every community and every tribe has their own perceptions of the eclipse. Navajo, for example, is really interesting. Navajos feel that an eclipse is a bad omen also. And not all tribes do but, but Cherokee does and so does Navajos.

There's a very traditional protocol you follow. So you go in your house and everything would stop. And you'd go in there and you'd sit there for the whole time of the eclipse and you wouldn't-- you'd be very quiet, very reverent. You wouldn't eat anything. You wouldn't drink anything. You sing certain songs that traditionally about the eclipse. You just talk in very quiet voices and you wait it out.

And you might be wondering, OK, there's a lot of other tribes that think it's fine to go out, look at it, enjoy it, as something to be awestruck with. But why do you think there's so many that are thinking of it in a negative way? And here's one answer I've heard.

A lot of tribes think of the universe, the Earth, and the sky worlds as needing to be in balance. And when something out of the traditional order the process of the universe happens like an eclipse, that eclipses disrupting the order of nature. And so that's why a lot of tribes want to make sure the eclipse is corrected, and the sun is out again. So they have their different ways of behaving to ensure that will happen.

All over the world, there are many different people, different societies, different tribes. And everybody sees the sky in a different way. And it depends on where you are on the Earth and the society, the community you live in. But there's not just one size fits all. It's-- there's many different stories that are told. And the more you know, the more it enriches your understanding of the sky.

[MUSIC PLAYING]

I think it's really, really helpful to learn what scientists say. And I think it's also equally important to learn what different tribal people say because it just adds to what your understanding is of eclipses.

MOLLY BLOOM: It makes sense these epic sun swallowing stories would arise around eclipses because it is a truly awe inspiring phenomenon.

[CHEERING]

That's the sound of people witnessing a total solar eclipse in Svalbard, Norway in 2015. So why does something that is essentially just a shadow make people so excited? A solar eclipse starts out slow, hopefully on a clear, sunny day where there are no clouds to get in the way of your eclipse viewing. And I will say again that I mean viewing with protection for your eyes. More on that later.

The sun starts as a nice big circle. Then a small bite is taken out. After this initial nibble, the moon starts to cover more and more of the solar disk until all that's left is a Crescent. It can take over an hour to reach this point. The sky is pretty dark now.

And then things start to happen faster. As totality approaches, only a few spots of the sun's light peek through. These are called Bailey's beads. What's happening is we're catching a glimpse of the sun seen through the low lying valleys on the moon's surface. Then there's a bright flash of light. This is known as the diamond ring effect. And it means totality will begin in a few seconds.

Then it begins, totality. The sun has been completely covered by the moon. The sky has darkened. The corona of the sun, the outer layer of the sun's atmosphere suddenly becomes visible. It looks like wisps or plumes of light coming off the dark circle where the sun used to be.

This total eclipse will last a couple of stunning minutes before the sun starts to be revealed again. A crescent of the sun will be visible, and the sky will grow lighter as the moon continues its transit out of the sun's way. Pretty cool, right?

[MUSIC PLAYING]

If you won't be in the US for this solar eclipse, there are plenty more coming up in 2019 and 2020. A total solar eclipse will be visible in Chile and Argentina. In 2024, Mexico, US, and Canada will get the treat. In 2026, it will be Greenland, Iceland, and Spain's turn. 2027 brings the phenomenon to Morocco, Spain, Libya, Saudi Arabia Algeria, Egypt, Yemen, and Somalia. And 2028 will bring the show to Australia and New Zealand.

And if you happen to be in any of these places during the eclipse, please remember--

SUBJECT 1: (SINGING) Do not stare at the sun. Don't do it.

MOLLY BLOOM: Solar eclipses are a delight for the protected eyes, but now it's time for a delight for the ears. It's time for the mystery sound.

SUBJECT 3: Mystery sound.

MOLLY BLOOM: Here it is.

Any guesses? We'll be back with the answer right after this.

[MUSIC PLAYING]

Are you planning on watching the eclipse? We'd love to see your photo showing how you safely witness this awesome phenomenon. You can post them to Instagram and Twitter and tag us. We're @brains_on, or you can send those photos by email to hello@brainson.org.

Speaking of email, you can send us questions, mystery sounds, drawings, and high fives to that same email address. That's hello@brainson.org. We really couldn't make this show without our amazing listeners. So we started the Brains Honor Roll to thank all the amazing kids who share their energy and ideas with us, like Emery from New Mexico who sent us this question.

EMERY: Why are bugs attracted to light?

MOLLY BLOOM: We'll be back with the answer during our Moment of Um, and the latest group to be added to the Brains Honor Roll all at the end of the show.

[MUSIC PLAYING]

Before we get back how to treat your eyes well during an eclipse, let's go back to that treat for your ears. Here's that mystery sound one more time.

Here's a hint. These celebratory orbs are filled with an invisible substance. Any new thoughts? Here's the answer.

GABRIEL: I'm Gabriel from Denver, Colorado. That was the sound of me blowing up a balloon, and letting it go. And you're hearing the air coming out of the balloon. My favorite thing about a balloon is that once you finish tying up the balloon, you've get to play with it.

SUBJECT 4: (SINGING) Ba, Ba, Ba, Ba, Ba, Ba, Ba, Ba, Ba, Ba, Ba, *Brains On.*

MOLLY BLOOM: I know we're all hoping for clear skies on August 21, so we can get a glimpse of a full or partial eclipse. But, but, but you cannot just go out and stare at the sky. Nope. Please don't. Really don't do it. Here to explain why is optometrist and astronomer Dr. Ralph Chou from the University of Waterloo in Ontario, Canada.

RALPH CHOU: We are hardwired in our brains not to look at a really bright object.

MOLLY BLOOM: And there's a good reason for this. Bright light like the light from the sun can seriously damage our eyes.

RALPH CHOU: It's not the light inherently that's bad because our eyes are evolved to take the light energy, turn it into a nervous signal that our brains interpret as vision. The problem with looking at the sun is that it's just too much light entering the eye. It just overwhelms the light sensitive cells, the photoreceptors at the back of the eye.

MOLLY BLOOM: When these photoreceptors get overwhelmed, they start to break down. And when they start to break down, this process generates chemicals. And these chemicals cause further damage to the cells in our eyes that help us see. You know how when you sometimes look at a bright light like a lamp or flashlight, afterwards you'll have a dark spot in your vision?

RALPH CHOU: Yeah, that's what we call an afterimage. And what it is an indicator that the photoreceptors that actually originally picked up the signal, that part just isn't responding.

MOLLY BLOOM: Let's say you overcome your aversion reflex because you want so badly to look at this really cool solar eclipse, you'll be doing damage and you won't even know it. If you burn your finger, you'll know it's burned because you'll feel pain.

RALPH CHOU: But in the eye, the problem is there are no pain receptors at the back of the eye. You don't feel it. And you go to sleep, everything's fine. You wake up the next morning, and all of a sudden you realize you can't see the face in the mirror. You can't see the face of the person across the table at breakfast. You can't read your newspaper.

You can't look outside and see fine detail because that part of the eye that is responsible for all those tests has been damaged and is no longer functioning. And you've got this big blur spot instead.

MOLLY BLOOM: OK. So now you're thinking, great, I'll wear my sunglasses, problem solved. Wrong.

RALPH CHOU: Unfortunately, regular sunglasses don't block enough light to make it safe to look at the sun.

MOLLY BLOOM: Normal sunglasses block 80% to 85% of visible light. But there is so much visible light coming from the sun that you need to block out 99.9996% of it. That's practically all of it. So in order to do that, you'll need special eclipse viewing glasses that are able to block out that much light.

Many local public libraries will be giving these out at eclipse events across the country, or you can order them online. And since these glasses block out so much light, remember you can't really do anything in them besides look at the solar eclipse, like don't try to walk while wearing them. You won't get very far. Ralph Chou has seen 26 solar eclipses in his life.

RALPH CHOU: I was 12 years old when I first saw my first eclipse back in the 1960s. It was totally unexpected, but it was a life altering event for me.

MOLLY BLOOM: Ralph went on to study astronomy and then optometry and then got to combine both of his loves in his study of eye safety during eclipses. Ralph says to remember to put your eclipse glasses on first and then look at the sun, not the other way around.

And if you're in the path of totality, you can take your glasses off briefly during totality. But please put them back on as soon as it ends. You can also look at the eclipse through a telescope fitted with a special solar lens or you could make a pinhole projector that lets you look at it indirectly. We have instructions on how to do that on our website brainson.org.

But even if you don't have eye protection that will allow you to look directly at the eclipse, you can just go outside and look at the rest of the world around you. There's some cool stuff that will happen.

RALPH CHOU: When it's close to totality, there tends to be a little bit of a breeze that sets up because the shadow of the moon causes the air to cool down. Just watch what happens to the birds and the flowers around you during the eclipse as it gets dark. There are some plants where the flowers will close up at night. You'll see this happening as the eclipse proceeds and it gets darker.

And the interesting thing is that the quality of the light changes. And again, it's really hard to describe. But the spectral content of the light actually from a scientific view is now more red dominant than we are used to. So the world looks really, really strange because of the different color balance.

The other thing is that the crescent being so narrow, all of a sudden you start getting effects on how you see things around your world because in that zone of totality, you've got this very, very thin light source illuminating the world. You get different appearances to the sharpness of edges and what shadows there are look really weird.

MOLLY BLOOM: So get out there and observe what's happening. We'd love to hear what you see. You can tell us on Twitter or Instagram. Tag us @brains_on, or send us an email at hello@brainson.org. While the whole country is going eclipse crazy, there's another group very excited for this upcoming eclipse, NASA scientists. One of these scientists is William Dean Pesnell. It's his job to keep tabs on the sun by taking pictures of it. Lots of pictures.

WILLIAM DEAN PESNELL: I'm the project scientist for NASA's solar dynamics observatory which we call SDO, which is a mission that we sent up about seven years ago to take pictures of the sun. We've taken approximately 270 million pictures of the sun since we got up there. And we look at those pictures to try and understand what the sun's magnetic field is doing and what the inside of the sun is doing.

Magnetic fields are very weird things. They cause particles that have an electrical charge like an electron or a proton to move in circles. So we're used to forces that make us start and stop, like we get in a car and we sit down, and your parent pushes on the gas pedal. And when you go forward and you kind of press back against your seat, you understand that force.

But a magnetic field is weird because if you take an electron and send it into a magnetic field, the electron, instead of moving straight, will start to circle around in the magnetic field. So when they first started seeing magnetic fields, they were just weird things. We now understand that the magnetic fields are an important and essential force to understand what's going on at the surface of the sun.

MOLLY BLOOM: And so as someone who studies the sun, what will you be able to learn about the sun or do during the solar eclipse that's coming up?

WILLIAM DEAN PESNELL: So we're all going out to Oregon and look at how the sun's corona appears from the ground. So you're actually able to watch the bulk of the material flow and move along the arches of the magnetic field.

Some friends of mine are flying in a jet high up in the sky. And one of their goals is to keep up with the shadow of the moon as it moves across the United States, so that they can get more time in the eclipse. The maximum length of totality of the eclipse on August 21 is about 2 minutes and 40 seconds. And that's not a whole lot of time to test out your equipment, but if you get into a very fast jet and fly very high, then you can extend that up to about 8 minutes.

They're doing that to take these instruments that want to look at the atmosphere of the sun just above the surface. We call that the chromosphere because it's pink. And they want to look at that very thin layer, and moon just happens to block out the disk of the sun just below it. So there's just this little tiny thin layer of the sun's atmosphere. And they're able to look at it during the total phase of the eclipse.

Understand that this is the only place in the solar system that you can see a total solar eclipse like this. Other planets and other moons, the moon will block the sun from the surface of the planet. This is the only one where the moon fits very closely to the size of the sun. And it allows us to see a part of the sun that is otherwise invisible from the ground because the moon blocks all that bright light from the disk of the sun and allows us to see the corona and chromosphere.

The moon fits very tightly inside. And it's part of the sun that is always there. it's just that you can only see it from the ground during this very special time of a total solar eclipse. So we have a unique circumstance. And if at all possible, you should take advantage of this.

It has been a life changing event for many people. Of course, people that I know, because we're all science nerds.

MOLLY BLOOM: Has it been that way for you?

WILLIAM DEAN PESNELL: Right. To me, it's always amazing to look at the sun because every day I look at images of the sun and it's like, wow, how do you do this? But I think this one, especially in the path of totality is something that once you see you'll never forget.

MOLLY BLOOM: Dean gave us some other fun ideas for activities to do during the eclipse. You can head to our website to find out about them. That's brainon.org. Here's to hoping for clear skies for all of you trying to see the solar eclipse on August 21. We'd love to hear about your eclipse viewing experiences. You can send emails, drawings, and photos to hello @brainson.org, or you can post them on Instagram and Twitter and tag us. We're brains_on. And remember--

SUBJECT 1: (SINGING) Do no stare at the sun. Don't do it.

MOLLY BLOOM: Now before we go, it's time for our Moment of Um.

PEOPLE: Um.

EMERY: My name is Emery Whitaker from Las Cruces, New Mexico. My question is why are bugs attracted to light?

PAM WELISEVICH: Well, there's a lot of different thoughts on this question. It's been asked many, many times. Hi, my name is Pam Welisevich. And I'm a naturalist here at Dodge Nature Center. One of the ideas is that insects learned to navigate or find their way around by the natural light far in the stars. And when we put fake lights that people use out, it confuses the insects and they fly towards them, thinking that they're the stars.

There's another reason that people think it might happen because they think the boys might be thinking that the lights are girl insects, and they're flying towards the girls. The third reason that people think insects fly towards the light at night is a flight or fight action. And what happens is if they sense movement from people, they are frightened and they will fly towards the light, thinking it's the natural starlight in the sky. So those are the ideas that people have on why insects fly towards the light at night.

[MUSIC PLAYING]

SUBJECT 5: Um.

SUBJECT 6: Um.

MOLLY BLOOM: I'll try not to get distracted by this beautiful glowing light as I read the most recent group to be added to the Brains Honor Roll.

[MUSIC PLAYING]

[LISTING HONOR ROLL]

[DRUMS]

That's it for this episode of *Brains On. Brains On* is made possible in part by a grant from the National Science Foundation. Many thanks to--

[LISTING HONOR ROLL]

You can contact us any time by sending emails to hello@brainson.org, or you can send us physical mail. You'll find our mailing address at our website, brainson.org. Thanks for listening.

SUBJECT 1: (SINGING) Do not stare at the sun, no. Do not stare at the sun. Don't do it. Do not stare at the sun. Do not stare at the sun. Do not stare at the sun, seriously. Don't do it.