

This is Your Brain on Hormones | Radiolab Podcast

40 MIN • YOUTUBE • [HTTPS://WWW.YOUTUBE.COM/WATCH?V=Z0KGZ-WW7JY](https://www.youtube.com/watch?v=Z0KGZ-WW7JY)

<https://www.youtube.com/watch?v=Z0kgZ-Ww7JY>

SUMMARY

The Radiolab episode explores the dynamic relationship between hormones and brain function, particularly focusing on how menstrual cycles influence brain structure and connectivity. Neuroscientist Emily Jacobs and graduate student Laura Pritschet conduct groundbreaking research to demonstrate that hormonal fluctuations lead to physical changes in the brain, affecting cognitive processes and emotional states.

- Hormones act as chemical messengers that influence communication between cells in the body, including the brain.*
- Recent studies show that brain structure and connectivity change throughout the menstrual cycle, particularly during ovulation when estrogen peaks.*
- Laura Pritschet's self-study involved daily monitoring of her hormones and brain activity over a month, revealing significant changes in brain connectivity.*
- The research indicates that both men and women experience hormonal cycles that affect brain function, with men having a daily rhythm and women a monthly one.*
- High estrogen levels can enhance neuroplasticity, while low levels may provide resilience against stress.*
- The findings challenge stereotypes about hormonal fluctuations being solely a female issue, highlighting that all individuals experience hormonal influences.*
- Future research may involve continuous hormone monitoring to better understand the impact of hormonal changes on brain function and behavior.*

oh wait you re listening

okay all right okay all right you re listening to Radiolab Radiolab from w n y c

MOLLY WEBSTER: One of the reasons that I come to you is maybe 10

or 15 years ago, I read a popular science book. I'm not even gonna say the title, because I

think that it was like somewhat controversial afterwards. And I remember this fact. And I think

since I read it, I have wondered if it was true.

And I've also told everybody this fact. [laughs]

So this is like my live fact check, which is I read that as you go through your menstrual

cycle, the size or shape or makeup of your brain changes. And I remember reading that and thinking,

wait, my brain actually physically is changing? Is that true?

EMILY JACOBS: Okay.

There's so much to unpack here.

MOLLY: Hey, I'm Molly Webster, this is Radiolab, and today ...

EMILY JACOBS: I can go real far back. MOLLY: We're going hard on a question that I have been thinking about for years. EMILY JACOBS: Totally.

MOLLY: It's funny, as I've been thinking about this topic, everyone's like, "Honestly, you should just talk to Emily." EMILY JACOBS: Oh!

MOLLY: Emily is a neuroscientist a neuroendocrinologist, to be precise and she is on one of the teams that has been struggling to understand how hormones affect the brain.

EMILY JACOBS: Because we had these like, these glimpses, these little flickers of what it could be doing, but to watch the full cinematic view of how this is unfolding, that was a breakthrough.

MOLLY: Very recently, Emily's lab came up

with an experiment so precise, so daring, it allowed them to pin down what hormones can do to our brains. And here's the thing: even though this story starts with menstrual cycles, it very quickly gets to the fact that women, men, whoever, we are all at the mercy of a crashing, swelling wash of chemicals inside of us the chemicals we call hormones.

EMILY JACOBS: So when we say "hormone" maybe we just define our terms. Like, when we say "hormone," that's a chemical messenger. It's a it's a chemical that is released from an endocrine gland like testes or ovaries. You have adrenal glands sitting on top of your kidneys. You have a thyroid gland.

And then once they start producing hormones,

those hormones use your circulatory system, your blood supply, as their superhighway. They hit, you know, almost every cell in the body, and that's when you think about, like, why do we even have hormones, like why is that a thing? MOLLY: Just to make it complicated.

EMILY JACOBS: Just to make it complicated. Like, why do we have hormones? Because if you're a multicellular organism, if you have more than two cells, those cells need to know how to communicate with one another, so that, like, everything's working together and in sync. And nature's figured out a really clever way to do that.

There's several ways, but hormones are one way.

MOLLY: It just seems like a sloppy way to communicate. Like, I'm gonna I'm gonna wash you in a liquid. Like, a synaptic connection where there's, you know, a fiber, a cable, and it's sending information from A to B feels like clean and directed and efficient. So why would we choose this bathing method? EMILY JACOBS: I think because you can't have wires connecting every single cell to every single other cell.

MOLLY: Yeah, it would be like a scary motel where it's like, yeah, you'd see the wires around the walls. Yeah.

EMILY JACOBS: Right. So but we have this blood

supply that feeds essential nutrients and oxygen to, you know, all parts of the body. And so it's

like hormones can just basically make use of what's already there in order to get your spleen talking to your heart talking to your brain. MOLLY: Hmm.

EMILY JACOBS: Think of it like a broadcasting system. They're

like the PA for the human body, and they go everywhere your blood goes, including your brain.

MOLLY: Which brings us back to the brain question.

What are hormones doing up there?

EMILY JACOBS: The science is really, I'd say, mile one of the marathon. No, inch one.

MOLLY: Inch one. Wow! EMILY JACOBS: We are using pretty archaic methods

to understand the function of hormones in the brain. And a lot of it is correlational. Like, most of the studies take large groups of people and take one snapshot of their brain and take one blood draw. But that snapshot in time, that's not how the endocrine system works. A fundamental feature is that it ebbs and flows over time.

It is not static. In fact, all of its power comes

from the dynamism of that system. Like, my body doesn't care if I'm at 20 picograms per milliliter of estradiol. It cares that I came from zero and I'm going to 200. So it's not the static level that matters, it's the change. And none of our experiments to date were capturing that change.

EMILY JACOBS: But something happened in the field of

neuroimaging about 15 years ago where somebody was like, wait a minute, I'm actually interested in how individuals change over time.

And so this is a friend and collaborator

at Stanford named Russ Poldrack, and he completed a project where he basically scanned himself over 100 times, and just collected everything you could possibly collect, like, how much caffeine did I have today and how well did I sleep? And, like, did I have an eczema flare-up? Like, literally everything. MOLLY: This is like my dream.

EMILY JACOBS: Yeah. Yeah. And he that study really launched this whole new way of thinking about the use of MRIs to understand dynamics of the brain.

And so we, my group, you know, here we are,

studying at sort of UC-Santa Barbara, and we're watching all of this great science unfold, and all of a sudden it unlocks this, you know, this it sort of solves this major problem for us, because we're like, wait a minute, we can study an individual and track this change. And so I had this brilliant graduate student in the lab ... LAURA PRITSCHET: [laughs] Yeah.

EMILY JACOBS: Laura Pritschet.

LAURA PRITSCHET: Yeah. Sorry, let me just

I'm gonna modify my headphones a little. EMILY JACOBS: And she was like, "Hey!"

LAURA PRITSCHET: I have normal cycles. I have a summer to kill. I don't really have a life.

EMILY JACOBS: "I volunteer to do this." Emily is a philosopher and I am a country

bumpkin. That's how I describe myself. [laughs] No better case subject than me.

MOLLY: So our girl Laura is actually Dr. Laura Pritschet now.

LAURA PRITSCHET: Now I'm in Philly for a postdoc.

MOLLY: But in 2018, she was a fresh-faced

grad student in Emily's lab. She had just started studying neuroscience in her undergrad, and she was left feeling dissatisfied.

LAURA PRITSCHET: I noticed for, like, week after week after week, the papers we were having to read only included male animals. And I would pose this question of, why is this only males? And I would always get this response of, oh, well, females have an estrus cycle, you know, akin to the human menstrual cycle, and that's just complicated and it's just a lot. And I was like, what the fuck? Like, we you're studying basic features of the brain. You're also taking these findings and applying them to males and females. So the logic's not there. This doesn't make sense. And that seems pretty wack. At the same time, I remember my boyfriend at the time in college, his mom was going through menopause. And I loved her, and she would just talk to me a lot about how she would walk into a room and forget where why she was there, where her keys were.

MOLLY: Oh. You put together, like, a human female going through menopause, and then at the same time, you're seeing study after study after study doesn't have females in it. Like, those two things connected for you?

LAURA PRITSCHET: Yes, exactly. Then that led

me to go, okay, well, how do sex hormones influence the brain in ways that I can measure?

MOLLY: And then you were like, "I know who can be the perfect study sample. Me." [laughs]

LAURA PRITSCHET: Yeah, I was like, I'll just to answer these questions, I'll just roll up my sleeve. And that's, you know, sort of how 28 and Me was born.

MOLLY: Laura named her experiment based on the 28 days it roughly takes to complete a single menstrual cycle. And for each one of those days, she would ...

LAURA PRITSCHET: Wake up.

MOLLY: ... go to the lab, spit in a vial.

LAURA PRITSCHET: I did saliva, and then I would go get my blood drawn.

MOLLY: Mario the phlebotomist would poke her in the arm.

LAURA PRITSCHET: We tried once to get my foot, because I was a little too bruised up, and I almost kicked him in the face. Yeah, and then I would go straight to a two-hour or so MRI.

MOLLY: They put her in a brain scanner, and she had to lie totally still.

LAURA PRITSCHET: We 3D-printed a foam head case custom to me, and I actually had them put sandbags on my legs and take straps and strap me in almost like a straitjacket.

MOLLY: I can't believe that made you feel better.

LAURA PRITSCHET: Yeah, that's what I'm saying. I'm a weirdo.

MOLLY: So Laura was in there, she was under this, like, blanket of sandbags.

And they would scan her entire brain while she was doing a series of mental exercises.

LAURA PRITSCHET: We did a resting state scan, meaning recording my brain as I'm letting my mind

wander. And I would look at highly rewarding food for a block of, you know, a minute. I would look at very neutral images like a Q-tip.

We looked at still images of porn. I remember, there were, like, men taking selfies with a mirror, and I'm like, give me a romance novel. Like, this is not gonna do this for me. But I did that every day, which was ...
MOLLY: And Laura did this spit, stick, scan; spit, stick, scan again and again for a month.
LAURA PRITSCHET: The hardest part was halfway through, where you're like, I've done 15 days of this. Oh my God, there's 15 more?

MOLLY: And with every scan, they were taking a picture of what her brain looked like on each day of her cycle. And then with every task, they were looking at how her brain worked literally how it was firing as she moved through that cycle.
LAURA PRITSCHET: Exactly. MOLLY: Did you, like, look at your data every day? Or did you wait 'til the end to look at your data?
LAURA PRITSCHET: Yeah, great question. I waited 'til the end. So we actually decided to start blind in the middle of a cycle so that I would eliminate as much bias as possible. And I also didn't even know where I was at in my cycle. And I remember I didn't even know when I was gonna get my period. I remember a graduate student had to come and give me, like, a tampon. [laughs]
MOLLY: When it was all said and done, Laura and her team had all of these images of her brain. And then alongside that they had what her hormones were doing at the time the images were taken. And when they put those two things together ...

EMILY JACOBS: Her data were beautiful!
MOLLY: Hmm. EMILY JACOBS: When she started to look at sort of relationships between that period when estradiol peaks right around the time of ovulation, she saw this, like, massive increase in functional connectivity across most parts of the brain.
MOLLY: Wait, what is functional connectivity? Like, what am I visualizing when you say that phrase? EMILY JACOBS: This is really just a measure of brain regions that are talking to one another. Like, all the bits of the brain are talking to one another in a way that's that's more congealed. So it's like everything is just, like, hyperconnected.

Imagine, like let's say we wrapped the brain in a string of Christmas tree lights. I don't know where this analogy is going, but we're gonna try it. MOLLY: [laughs] Stay committed and keep going.
EMILY JACOBS: Okay, we're wrapping the brain in a string of Christmas tree lights. And when estradiol peaks, it's right around the time of ovulation. It's like all the lights go on, like, the green lights are, like, really connected to each other, and the red lights are all really connected to each other. It's like they're all, like, working in sync. And then, so to, like, walking through a menstrual cycle, like, right after ovulation, you get

this plummeting of estrogen, and progesterone starts to dominate the scene.

MOLLY: And during that moment, which is about a week before your period ...

EMILY JACOBS: You start to see, like, those lights dim a little bit. And it's not like the brain activity is dimming or, like, cognitive functions are dimming. It's just like this shift in the basic connectivity structure of the brain.

MOLLY: It's kind of like the structure of the

brain is the same, it's just not as in sync. EMILY JACOBS: But we also used a really high-resolution scan of the hippocampus. So this is the part of the brain that's, you know, really important for learning and memory. What we discovered is that this region of the brain and we can actually look at different subfields of the hippocampus, it's not actually one solid structure, it's got all of these little bits and bobs and that we could see these structures of hippocampus actually grow and shrink along with the menstrual cycle. I mean, like on a rapid time scale.

MOLLY: Really? Okay, so that

one is actually physical. EMILY JACOBS: That one is physical. It's morphological. It is a change that literally, like, the brain structure is changing across the cycle. MOLLY: Really?

EMILY JACOBS: That's a thing people can wrap their head around.

MOLLY: My takeaway here is that these liquid chemicals in my body are washing my brain and changing it monthly, weekly, daily. But to be sure ...

EMILY JACOBS: You need to essentially squash the endocrine system. And if you squash it, you don't allow those rhythmic endocrine changes to occur anymore, then let's see what happens.

MOLLY: So they basically do the entire experiment all over again, but this time, Laura ...

LAURA PRITSCHET: I went to our student health center, and I said, "Prescribe me the most common birth control packet you're giving the undergrads."

EMILY JACOBS: She went on a drug that suppressed progesterone levels by 97 percent.

MOLLY: The birth control basically wiped out the hormones in the back half of Laura's cycle, so that progesterone rise, and then she went back to the lab. Spit-stick-scan. And ...

EMILY JACOBS: The progesterone-dependent changes that we saw in the hippocampus across the cycle were completely obliterated.

MOLLY: So it did give you a chance to say, like,

look at the data. These bumps we're seeing are because of estrogen and progesterone cycling.

EMILY JACOBS: Exactly. Yeah. MOLLY: Okay, so you're telling me I can keep telling people that at different points in your cycle your brain changes.

EMILY JACOBS: Yes. MOLLY: Wow!

EMILY JACOBS: But I think where we need to be careful is in the interpretation of that fact. So we don't know what it means in terms of behavior. So that's where we have to draw the line. It's like, I don't know if this is good or bad. It's just different.

MOLLY: Well, it's funny, it's like, I can tell you what that feels like [laughs]. In my body, it

feels like you're making all these connections, and you're going so fast and, like, the world is like a little brighter and I'm quicker. Like, I'm like, send send give me an improv troupe.

EMILY JACOBS: [laughs] MOLLY: Like, I will "yes, and" the shit out of this show, you know what I'm saying? And then when the what you're saying, the progesterone takes over and estrogen decreases and when I'm like, right before I'm bleeding, I'm like ...

EMILY JACOBS: "Give me a sec."

MOLLY: Oh, like, yeah. "Like, what was your name?" Like, oh, yeah. LAURA PRITSCHET: There were tears.

That was a note. I was crying in the parking lot for some reason.

MOLLY: As part of the study, Laura was tracking her mood each day.

LAURA PRITSCHET: Like, I was seeing the negative affect rise with progesterone rising, so I was seeing it across multiple days. And I was like, "Wow! Like, this is real." And maybe for me, and maybe not for the female across from me.

MOLLY: Laura and Emily did say they can't peg any particular person's mood or cognition to these hormone changes. I mean, the body is freaking complicated. Like, estrogen affects dopamine. For me, that might feel really good to get that extra hit of dopamine, but if you're a person who already has a lot of dopamine, it could make you feel awful. So ... EMILY JACOBS: Like, I think we still need the data to, like, understand how that is tied to those aspects of cognition.

MOLLY: If you're like a Molly brain, when you first hear this research, you're like, "Oh, wow, it's so cool!" Like, every day that I have had my cycle since doing this story, I'm like, "What's my brain doing today?" [laughs] But it also feels like, oh my God, this is the exact thing that people have been saying for millennia.

Women are hormonal. Women change.

Unlike men, women aren't reliable. EMILY JACOBS: When you, like, call somebody "hormonal," it's, like, almost always directed at a woman, right? Like, it's like a pejorative. But, like, that belies the fact that, like, hormones are in all of us. These are ancient molecules. Every vertebrate have them. [laughs] Like, these are essential. And, you know, men have them, too.

MOLLY: But it sort of comes from the fact of, like, ours females' are changing on this 28-day cycle. It's like, I'm not saying, like, men don't have hormones, but I think there is a cycle that women are running through.

EMILY JACOBS: Right.

MOLLY: I'm not sure if you're about to tell me, like, well, guess what, men are going through a cycle, too.

EMILY JACOBS: Yeah, guess what? Men are going through a cycle, too. [laughs]

MOLLY: Wait, really? EMILY JACOBS: Yes!

MOLLY: That's right. We're not getting out of this episode without ...

PAVEL SHAPTURENKA: The trending thing is boy kibble, right?

MOLLY: ... a man. We're going inside the male cycle after the break.

EMILY JACOBS: One of the reasons we did 28 and He were just like ...

MOLLY: Oh, is that what it was called? 28 and He?

EMILY JACOBS: Yeah. [laughs] MOLLY: Oh, that's hilarious!

EMILY JACOBS: Fun fact, this was actually Laura's then-partner, now husband.

PAVEL SHAPTURENKA: I met Laura first in intramural softball in graduate school.

MOLLY: [laughs] Okay. EMILY JACOBS: His name is Pavel.

PAVEL SHAPTURENKA: Pavel Shapturenka. I am a scientist.

EMILY JACOBS: Shout out to Pavel. PAVEL SHAPTARENKO: The summer that we met, she had done, prior to that summer, this study on herself.

And I was just taken aback that someone would do that for science, would just stick themselves in a huge magnet for a whole month, every day.

I mean, immediately I was kind of like, wow, I'm in love, you know? [laughs]

MOLLY: So when Laura said ... PAVEL SHAPTURENKA: "Hey, so how do you feel about climbing into the MRI?" MOLLY: Pavel said yes.

PAVEL SHAPTURENKA: She would always be there by my side.

MOLLY: Every morning they'd get in the car.

PAVEL SHAPTURENKA: I'd be pooling my saliva.

MOLLY: Like, collecting it in your mouth? PAVEL SHAPTURENKA: [laughs] Yeah.

MOLLY: Like, don't talk, just gather spit. PAVEL SHAPTURENKA: That's right, yeah.

MOLLY: He'd walk into the lab, deposit his spit, and ...

PAVEL SHAPTURENKA: Mario would come and take some blood.

MOLLY: I just love this character of Mario the phlebotomist.

PAVEL SHAPTURENKA: [laughs] MOLLY: Then, just like Laura, he would lie in the scanner, still as can be. But for his experiment, he did double duty.

PAVEL SHAPTURENKA: The first 15 days we had a morning scan and a morning blood draw.

And then 10 days into that 30-day period, we also started a 15-day nightly scanning.

MOLLY: Why were you getting scanned twice a day?

PAVEL SHAPTURENKA: Whereas, you know, the main fluctuation of estrogen happens on a monthly time scale, testosterone has sort of a daily rhythm, so it's diurnal. It's super high in the morning.

MOLLY: I did not know that. Okay, super high in the morning.

PAVEL SHAPTURENKA: And then it drops by anywhere from 30 to 70 percent at night.

EMILY JACOBS: So for Pavel, we really kind of capitalized on this known circadian rhythm where testosterone and progesterone and estrogen are peaking in the morning, they're dipping in the evening. And we said, "Huh, let's study him ..."

MOLLY: Wait, men have progesterone?

EMILY JACOBS: Oh yeah. Yeah. They have all the bits that we do, just at different concentrations. And they you know, these hormones cycle in men, and so we wanted to understand that, like, is the male brain undergoing kind of a similar degree of change? MOLLY: After all Pavel's data was collected,

Emily and Laura had their team comb through it. And they saw ...

EMILY JACOBS: The punchline is that essentially we see the exact same thing that we saw in Laura, that, like, when these hormones are peaking, you see the brain become, like, more interconnected with each other.

And then when the hormones dip in the evening, the brain becomes less interconnected. And we see, you know, the brain is pulsing on this 24-hour scale. So when hormones are high, it's a little bit bigger. At evening, it sort of like tightens up a little bit. And the crazy part is that we can literally see this periodicity, this wave if you will, happening every single day throughout the entire and he did 40 sessions across 30 days. So it's just like this, like, beautiful rhythm that exists, and we can measure that.

MOLLY: That's crazy!

EMILY JACOBS: So it's like that these hormones are having the same size effect whether it's happening on a 24-hour time scale or across the 28-day menstrual cycle. MOLLY: Huh! But wouldn't women

also be doing this circadian? EMILY JACOBS: Yes, that is true.

MOLLY: So we're getting circadian 24 and 28 across time.

EMILY JACOBS: That's right. MOLLY: And men are more locked in to the 24.

EMILY JACOBS: That's right. That's right. MOLLY: I feel contradictory then, because somehow in you trying to be like, "Look, men are part of this equation, too," it actually just leaves me feeling like, wow, my hormones are even more up and down than I thought. Yeah.

EMILY JACOBS: Meaning, like, it's a surprise that you have a circadian cycle on top of ...?

MOLLY: Yeah, yeah.

EMILY JACOBS: Like, you're absolutely right in that this myth of female variability and this idea that we have this ...

MOLLY: Emily said that even though females have these two cycles, studies have shown that they're not inherently more variable than males. In fact, it might be the opposite.

EMILY JACOBS: Here's where stuff gets, I think, funny. It's like, you know, women have this menstrual cycle. And for most women, for most of our lives, it's as steady as the tides, right? Like, maybe until we start to get to menopause or if there's like a reproductive

condition. Like, short of that, like, it is, you know, this sort of rhythmic event.
MOLLY: Predictable, yeah.

EMILY JACOBS: It's this kind of predictable thing. That is not so true for for male-dominated hormones like testosterone, which are famously capricious. So testosterone can, like, spike and dip and it's, like, super responsive to social stimuli. So you can study this, you know, in animals who get in a fight and you get these, like, testosterone surges. And then if they're they lose a fight, you get, like, testosterone suppression. It's true in humans who aren't even engaged in, like, you know, fist-to-fist combat. If they're just watching TV and their favorite team loses, you can see testosterone suppression. So ...

MOLLY: But that's not happening with, like, estrogen? EMILY JACOBS: Yeah, not as much. It's really you know, again, every sex has every hormone, it's just the proportions that are different, but in, you know, testosterone, which is, like, on average, higher in men, it's much more fickle.
MOLLY: Wow. EMILY JACOBS: So it's just funny to me that women are the ones deemed as this, like, unknowable you know? [laughs]
MOLLY: It turns out all of our brains are oscillating with these hormones. Whether it's monthly or daily or fickle or regular, all of us have estrogen and testosterone flowing in, and the brain gets bigger and more connected.

And then estrogen and testosterone flow out, and the brain gets smaller and less connected. EMILY JACOBS: Brains are built to change. They're built to learn. They're built to adapt. And here we have this mechanism this hormonally-mediated mechanism that's allowing our brains to do that. If brains did not change, that would be the pathology of interest.

MOLLY: Okay, can I just ask a question?
EMILY JACOBS: Yeah. MOLLY: I think my takeaway is that the brain is opening in some way when it's bigger, or when it's firing in that stronger Christmas tree light, like, analogy you gave. Like, when it's speaking to itself better that it's opening.
EMILY JACOBS: Yeah. So, like, these estrogen rhythms are opening up these windows of of enhanced neuroplasticity, and that's a good thing.
MOLLY: Neuroplasticity, you probably know this, is this idea that the brain is malleable, it's open to change. And Emily said all sex hormones, including estrogen, can go into the brain, down to the level of the DNA and open it up.

EMILY JACOBS: So DNA is organized in this chromatin structure, right? So it's actually, like, pretty tight and closed up.
MOLLY: Like wound tight. EMILY JACOBS: It's tightly wound.

MOLLY: ... the helix, and then the helix is it's tight.

EMILY JACOBS: Exactly. It's really tight, right? MOLLY: Yeah.

EMILY JACOBS: But there but estrogen is one of the factors that that can actually, like, loosen up the DNA. It's like it just relaxes a little bit, and it can promote, you know, the production of proteins. And then that's the pathway by which learning and all of these great things happen.

MOLLY: Okay.

EMILY JACOBS: But this paper

that I just sent you ... MOLLY: I got it, like, five minutes before the interview, so I have no idea what it said. EMILY JACOBS: I know. [laughs]

MOLLY: Okay. EMILY JACOBS: So this is work from Tallie Baram.

And oh my God, it's blowing my mind, because this is what the study asked: What happens if during that brief fleeting window where estrogen is flooding the system, your chromatin is all loosened up, it's like it's getting ready for its massage, it's on the table, it's warm, it's like "Let's go!" and then you introduce a severe stressor. You know, blasting loud music, you know, you're sort of shaking the animal, you know, are introducing it to odors of its predator. If that happens during this period, you create a PTSD-like phenotype in these animals.

MOLLY: Wow!

EMILY JACOBS: And it is long-lasting.

MOLLY: This study, which was done in both female and male mice was an attempt to understand why some people record more trauma than others. And one of the takeaways was high estrogen plus stress can produce PTSD. Then they asked the question: Okay, well what happens in moments of low estrogen?

EMILY JACOBS: What she is suggesting in her data is that actually if you look at the low estrogen periods of the female menstrual cycle, that they were immune to these stressors.

Like, they had almost like this armor on. What this work is suggesting, which is so profound, is that actually there may be sort of these protective mechanisms of having these beautiful but fleeting windows where you can drive plasticity, but then estrogen levels get a little bit lower and you are more resilient to these stressors.

Again, pure speculation at this point,

because the science is so young. MOLLY: I think for me the thing with this study is that when I think about my period, the moments of high estrogen are the ones that I feel really good in, and the moments of low estrogen are the moments I want to get out of as fast as possible. But maybe at a deep biological level, those moments when we feel our worst so for me, during my period, maybe for you at the end of the day those might be moments that are worth sitting in.

LAURA PRITSCHET: If you have really high connectivity between regions of your brain, that's really energy-dependent.

MOLLY: That's Laura again.

LAURA PRITSCHET: You could be exhausted. MOLLY: It is funny. Maybe part of what it is opening up for me is like there is so much about, you know, "I just finished my period," there's, like, so much about it where you're like, "Mah!" But so but I'm just thinking about it in a different way, like as it it's like a way my body is, like, taking care of itself.

LAURA PRITSCHET: Yeah. I think that's a beautiful way of thinking about it. And I think, you know, if I teach a class or guest lecture, I say, "What comes to mind when I say 'estrogen'?" And it's like, Zooey Deschanel's character in New Girl crying and, you know, eating ice cream. And it's like, we can move from those stereotypes and be like, wow, hormones are just fucking powerful, and they serve a purpose and they're neuroprotective.

EMILY JACOBS: And if anything, you know, why are we trained to think of the cycle as a source of noise, when, in fact, I think it's a source of stability? You know, hormones guide behavior, and they do so through this rhythmic action, whether it's across the circadian cycle for males and females or whether it's across something like the menstrual cycle for females.

MOLLY: Geez! Are you ever like, "Damn! Our brains!" 24 hours a day it's going up and down, up and down, and then every other day it's going up and down, up and down.

EMILY JACOBS: But I think it's like an organizing principle of the brain. It's like, it's creating ...

MOLLY: It sounds tiring.

But you're saying it's not. EMILY JACOBS: I don't know! Like, is it tiring for the waves to, like, you know, happen on this rhythm? I don't know. Or is it like organizing the system in some really helpful way? I don't know. Those are the questions that I want to dig into that, like, man, we have just scratched the surface on scientifically.

MOLLY: So what make like, just the fact that you could even suggest something like is it organizing us in a certain way? I'm like, "Ooh, why did you choose the verb 'organizing'?" Like, why would brain changes be organizational?

EMILY JACOBS: The brain likes prediction.

It likes rhythm. It likes, you know ... MOLLY: It likes rhythm.

EMILY JACOBS: You know, like, it's, like, providing a scaffolding or a structure. It's the same thing, like, if you have kids and you let them just, like you know, there's no rules in the house, and they can put themselves to bed whenever they want, or they can eat whatever they want. Like, it is high chaos in the house, and nobody's happy and nobody functions well. But, like, you put a little bit of structure, you put a little, like, organizational structure, and then all of a sudden, like, shit[00:33:06.21] flows better.

And maybe that's what hormones are doing. It's, like, laying down these, like, fundamental rules, these organizing principles for the brain that can, like that help it function at its most you know, at its highest level. I don't know, I'm totally speculating here, but ... MOLLY: Yeah. Yeah, yeah.

EMILY JACOBS: But now we get to at least ask the question of,

like, is that pulse doing anything that the brain likes or that, like, helps us in some way?

MOLLY: Yeah. Wow. That's a cool word, "pulse."

Like, brain pulse. Like, it's it's

working out up there. [laughs] EMILY JACOBS: Yeah, it's like the heartbeat of something, right? It's like the vital sign. It's like, you think of, like, the cha-chunk, cha-chunk, cha-chunk of the heartbeat monitor. Like, maybe this is the endocrine system. It's like it's pulsing on these different rhythms, and then it's creating these echoes throughout the rest of the body that's like, oh, cool! Like, here's the rhythm we get to dance to. And that's what I mean when I am thinking about this sort of organizational framework. It's like, I think it's creating that rhythm for then the whole body to get in sync to.

MOLLY: Hmm. I think I'm having this question of, the brain is such a regal and, like, commanding object, right? Like, you kind of know how much work it's doing in your body. Even though it's part of you, it kind of feels like other.

Like, there's a way in which it just has a

it's all-powerful. And so then when I hear something about the brain changes, I'm, like, immediately like, "Wow!" Like, awestruck. EMILY JACOBS: Yeah. Oh my God. I think that that idea that the brain is like this regal thing is a myth. I actually think it's an organ like every other part of our body. Like, I think the the way we can show that hormones influence aspects of the brain suggests that, I don't know, we're all just kind of these, like, you know, big buckets of chemicals walking around. And we think we have control but, like, no, we don't! Like, I yelled at that person because I'm hangry. And I don't even know if I buy into free will if I'm being totally honest. I don't know. I mean, I think that there's ways we can gain free will. But, like, by and large, we are also just, like, big biological sacks of stuff. And anyway ...

MOLLY: I'm hoping that I'm a big biological sack, but if I know that, if I say it out loud, then I could maybe do a little bit more with the sack. Like, I could push it to the left and push it to the right, even if only an inch.

EMILY JACOBS: Maybe.

MOLLY: That's my that's my ... EMILY JACOBS: I hope.

MOLLY: That's my wish. EMILY JACOBS: I do think an understanding of the system allows us to control it. In fact, I was just on a call earlier this week talking to there's this incredible researcher out of Caltech, and he's developing continuous hormone monitors. So, you know, we have the glucose monitor where we can track ...

MOLLY: No way! EMILY JACOBS: Yes! And now they're starting to develop technology where either from sweat, which seems difficult, but even in, like, interstitial fluid, you can create a glucose-like monitor that can just give us this kind of constant readout of hormones. I mean, imagine if we could get, like, a second-by-second or even just hour-by-hour readout. We can just watch and observe and see the patterns play out. But that's so huge! I mean, think about the images of Pluto that we had 100 years ago where it's this grainy little blip in the sky, and now we can see the individual, like,

craters and this idea of let there be light. Like, being able to see a phenomenon in, you know, incredible detail is the start where all of the breakthroughs happen.

MOLLY: This episode was produced by Mona Madgavkar and me, Molly Webster. It was fact-checked by Diane Kelly. I want to thank Soren Wheeler, Pavel Shapturenka, Emily Jacobs and Laura Pritchett.

Emily hangs out at the University of California, Santa Barbara. You can find Laura and Pavel at the University of Pennsylvania in Philadelphia. And you can also find all of Laura and Pavel's data online. Go to OpenNeuro.org. That's Open-N-E-U-R-O.org. Props to Laura for making all of her data public. Also, a huge shout out to Catherine Woolley, whose original research on sex hormones and the brain was foundational to all the stuff we're talking about today.

MOLLY: If you find yourself with some spare time, go to Radiolab.org/thelab and sign up for our member's-only access. You'll get ad-free listening, special content. It's fun over there! And that's it. I'm Molly Webster. This is Radiolab, and the next time I see you, I'm gonna ask where are you at in your cycle?

[LISTENER: Hi, I'm Gabby. I'm from the Bay Area, California, and here are the staff credits.

Radiolab is hosted by Lulu Miller and Latif Nasser. Soren Wheeler is our executive editor. Sarah Sandbach is our executive director. Our managing editor is Pat Walters. Dylan Keefe is our director of sound design. Our staff includes: Jeremy Bloom, W. Harry Fortuna, David Gebel, Maria Paz Gutierrez, Sindhu Gnanasambandan, Matt Kielty, Mona Madgavkar, Annie McEwen, Alex Neason, Sarah Qari, Natalia Ramirez, Rebecca Rand, Joanna Strogatz, Anisa Vietze, Arianne Wack, Molly Webster and Jessica Yung, with help from Gabby Santas and Maia Appleby Melamed. Our fact-checkers are Diane Kelly, Emily Krieger, Natalie Middleton, Angely Mercado and Sophie Sanahee.]

[LISTENER: Hi, I'm Aubrey, calling from Salt Lake City, Utah. Leadership support for Radiolab's science programming is provided by the Simons Foundation and the John Templeton Foundation.

Foundational support for Radiolab was provided by the Alfred P. Sloan Foundation.]