THE TRANSMITTER

Male and female brains, Proust, and Catherine Dulac

The 2021 Breakthrough Prize winner explains how reading widely shaped her worldview, and discusses the vomeronasal organ.

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This transcript has been lightly edited for clarity; it may contain errors due to the transcription process.

[opening theme music]

Brady Huggett
Here is a fresh episode of "Synaptic." This is our show that looks at the people, the research, and the challenges in the neuroscience space. These are the researchers of neuroscience, and this is the work that they do. Episode 16 today. Thanks for joining me.

[transition music]

Brady Huggett
Now, today, let's go back to 1996, and let's go to France. That year, France spent 2.22 percent of its gross domestic product on research and development. The United States that year spent 2.45 percent of its GDP on R&D. That is not a tremendous difference, and of course, France is a smaller country than the United States, with fewer scientists. Considering that the 1996 GDP of France was $1.6 trillion, according to the World Bank, and for the United States it was $8.07 trillion, one can understand the difference in the total amount of money that was floating around for research back then in those two countries.

That's one metric of the times. Also, the notable research institutes of France were struggling. For instance, in 1996, Inserm said it was freezing 25 percent of its operating budget for its labs. CNRS, the Centre National de la Recherche Scientifique, how was that? Had been in a critical financial situation for the past two years, according to a news article published in the journal *Nature*. That was the environment in France when Catherine Dulac was finishing her postdoc at Columbia. That's our guest for today, Catherine Dulac.

She had worked under Richard Axel at Columbia, and she'd published notable work while there. She'd seen other people leave his lab and go off and start their careers, and she wanted to do the same. She wanted to do it in France, in her home country. She had offers about everywhere in the U.S., she says. Harvard, for example, and MIT, UCSD, and UCSF, but when she went to seek a position in France, she was told she was too young, or she said she was offered maybe a corner of a bench in some lab. In essence, there were no independent positions for her in France, as she says on this podcast.

Catherine took Harvard's offer and she stayed in the U.S., and she has been there ever since. We talked about that on this podcast. We talked about her discoveries in mice and the vomeronasal organ around parenting and what suggestions that might have for our understanding of gender. We also talked about her love of world literature as a child, and how Marcel Proust's writing is related to neuroscience.

All that coming up in the next hour and a quarter. I interviewed Catherine in her office on the Harvard campus. It was a nice summer day in Cambridge. High sun, but less than 80 degrees. Her office has wooden wall shelves filled with books, and a sitting space centered around a kind of coffee table, and that's where I put the mics. Of course, just outside her office door, there were labs themselves, and the work was continuing out there, and so you can hear the low, constant hum of the equipment in the background.

OK, let's pick it up here, where Catherine is talking about the new dean of sciences at Harvard, Jeff Lichtman, and how he is the first overall dean of sciences with a life sciences background. I think you're ready, so here's your episode of "Synaptic" with Catherine Dulac, starting right now.

[transition music]

Catherine Dulac
OK. So the history is the concept of having a dean of science is relatively recent, which is that Jeff is, I believe, the third or the fourth one. Depends how you calculate. There was a little bit of an intermediate period where there was a dean of the physical sciences and a dean of the life science, so here there was a dean of life science, and then there were two deans of the sciences, and now Jeff is dean. He's the third dean of science.

Brady Huggett
And the first one in life sciences.

Catherine Dulac
Before that, the faculty directly reported to the dean of the faculty of art and science. Then that became a little bit too much, I think. Now there is a dean of social science, of humanities and other sciences.

Brady Huggett
Yes. OK, so you just mentioned you actually are not American by birth, though. You're French by birth. Yes?

Catherine Dulac
I'm French by birth and now have dual citizenship.

Brady Huggett
Where were you born?

Catherine Dulac
Montpellier. It's an old town in the south of France.

Brady Huggett
That's south. Yes, I was going to say.

Catherine Dulac
Yes. It's along the Mediterranean Coast.

Brady Huggett
How did you grow up? Were you interested in science as a young child? What was your childhood like?

Catherine Dulac
I grew up being interested in science, more generally just asking a lot of questions about how things work. Then my two parents actually were scholars in humanities. So, very different field, but they always encouraged me and my brother to read books on science because they thought there was no job available for their students in humanities, and they thought even in terms-

Brady Huggett
Oh, they were professors.

Catherine Dulac
Yes. In terms of finding a job and drawing, having a career, a scholarly career, if that's what we were interested in, then the sciences were a better bet. Overall, I think anything related to scholarship is of interest to me, or was of interest to me. We were living in this town, close to an area where there are a lot of caves, for example.

Brady Huggett
Caves?

Catherine Dulac
Caves, because it's a caustic geology, and so the water erodes and forms these big caves, and many of them had been inhabited by prehistoric or ancient habitants. For me, this was just fascinating, the idea of having these old, ancient people living there. We were also looking for fossils, always. There was a lot of old fossil, marine fossil, or others. For a very long time, I actually wanted to be a paleontologist.

Brady Huggett
Oh, you did?

Catherine Dulac
Then I realized that that meant being with a little brush, and then trying to uncover little things, and I said, "Maybe that's not that interesting."

Brady Huggett
These caves, they were historical. You could tour them. How did they know that they've been inhabited by prehistoric?

Catherine Dulac
OK, there are a lot of caves, of many different types. There are some that are just beautiful because there are all these formations, rock formations. So I don't know if they were inhabited or not-

Brady Huggett
Oh, I see.

Catherine Dulac
- but they were just these absolutely humongous spaces that were just beautiful. Then there were others that were on maps. One I remember was we went, we had our headlamps.

Brady Huggett
Your headlights, yes.

Catherine Dulac
We were complete amateurs. We didn't do anything very difficult. I remember, I was a kid, I don't know, maybe I was 8 or 10 maximum, and we came across some bones and some teeth. So I took them, and they look like bones or teeth from bears. I brought them-

Brady Huggett
Oh, the teeth were quite big then.

Catherine Dulac
- to my teacher. Yes, big teeth. The teacher was intrigued and looked, and they were from these prehistoric bears. I thought, "Oh my God."

Brady Huggett
Look what I've discovered, right?

Catherine Dulac
So cool. [laughs]

Brady Huggett
Obviously so exciting. Yes.

Catherine Dulac
Yes.

Brady Huggett
Your parents would take you and your brother out to do this?

Catherine Dulac
Yes.

Brady Huggett
Your parents were both in humanities. Did they meet studying or something?

Catherine Dulac
Oh, they met when they were students. They were students in Paris, and they met in whatever. When they were [crosstalk].

Brady Huggett
It's students. Yes.

Catherine Dulac
Yes.

Brady Huggett
In Montpellier, there's a university that they taught at?

Catherine Dulac
Yes.

Brady Huggett
So they were professors.

Catherine Dulac
Yes.

Brady Huggett
OK. So you did know what an academic life was like.

Catherine Dulac
Yes.

Brady Huggett
You knew your parents were professors. OK. So, you're growing up. You're interested in discovering things, it sounds like. The way things work. History, yes.

Catherine Dulac
Yes, asking questions. I was reading a lot of books, and always wondering why people were doing what they did. This was more, for the longest time, I just had this interest on how people think, and what they do, what they do. I was an avid reader. I was reading everything. Sometimes I would take a book and then I would go to my dad and say, "I don't like that book. What is it?" He said, "Maybe you're too young to read it." I would-

Brady Huggett
Are these biographies, or historical books, or fiction?

Catherine Dulac
Anything. My parents had books everywhere. We had bookshelves all around corridors, and I would just take books that seemed interesting. There was no age limit. That was my parents' books, and they had things of all sorts. Sometimes I would, yes, come across philosophers, or really complicated things, and would say, "I don't know this, that." [chuckles] I don't. Maybe you wait a little bit. [laughs]

Brady Huggett
Yes, you're not old enough. Were you reading like French authors? Were you reading fiction, too?

Catherine Dulac
My parents had books from literature, mainly, from all over the world. All in French, obviously, but they had section on French literature, on Russian literature, on Asian literature, on any type of literature. In fact, I came to realize, coming to the U.S., for example, that very few people in the U.S. have read foreign literature. For me, this was something completely natural. I had to read the French, I had to read the Russian, I had to read the Japanese, I had to read the Africans, all of that.

Brady Huggett
So, because it was all translated, you were getting fiction from all over the world.

Catherine Dulac
Yes. Yes. Yes. Growing up, I read all the key, yes, Russian, Japanese, British, whatever, American. For me, the fact that they were French or not French didn't really matter. Those were just absolutely fabulous books.

Brady Huggett
Do you think that had, as you said, you were wondering why people act the way they act, or behavior. I could see how you could get that from reading world fiction.

Catherine Dulac
Yes, totally. Yes, totally. In fact, this is an aspect that I always found very interesting, is that, why are you attracted to read novels? Well, it's about people. It's the life of people. It's the experience they have. It's their emotional reactions to events and also encountering other people. For me, it has always been very striking that a lot of our internal life has to do with how we interact with others. One author that was extremely important for me is Proust.

Brady Huggett
Oh, yes.

Catherine Dulac
Proust wrote these absolutely humongous books. I read them multiple times. It's like seven huge volumes, and I read it, I don't know, maybe three or four times.

Brady Huggett
As a child.

Catherine Dulac
As a child. Yes. For me, what was attractive is the introspection. Is the deep thinking of, why am I reacting in particular ways? Somehow you can view this as the equivalent of what a neuroscientist asks. Why are animals, how is our brain reacting to-

Brady Huggett
The world.

Catherine Dulac
- environmental events, but from that humanity side of things.

Brady Huggett
You're reading Proust, for instance. Are you asking the question, why are these characters doing the things they're doing? Or were you asking, why am I reacting to the story in this way?

Catherine Dulac
All of it.

Brady Huggett
All of it.

Catherine Dulac
Yes. All of it. It's that this internal life that we have, that others have, what are the guiding principles? Are there common principles? Why are some individuals reacting to a particular event, or a particular encounter in different ways? What are the rules?

Brady Huggett
Yes. I'm still struck by this. You read all of Proust, like three or four times as a child.

Catherine Dulac
Yes.

Brady Huggett
That's amazing. OK. Did you have any interesting-

Catherine Dulac
It depends what you call child, right? It goes up to-

Brady Huggett
Well, up to 18.

Catherine Dulac
Yes, absolutely.

Brady Huggett
Yes. In your childhood, you read Proust. Most people, if they get through one book of Proust, they're proud of themselves.

Catherine Dulac
I know. It's interesting because somehow what I encounter when I-- I read a lot of books here, but that's nothing compared to what I have home. [chuckles] I think a lot of people grow up and feel that they have to read things because their teacher is telling them what to read, right? Then, because it's an imposition, they may be not realizing that there's so much joy in discovering books. That's [crosstalk]-

Brady Huggett
You mean because someone's saying, "You have to read this," and then they don't?

Catherine Dulac
Yes, exactly. Then they don't like to do it. Then, therefore, they will never read anything else than what is being imposed to them. When I teach, here at Harvard, I always put examples of books that I think illustrate, in interesting ways, some of the concepts. For example, I have a lecture on schizophrenia, for example, and I cite a book on the family that has schizophrenia.

Brady Huggett
A fiction book?

Catherine Dulac
Yes.

Brady Huggett
Oh, you do?

Catherine Dulac
Or I talk about smell, and I mention a book in which smell is important. Actually, Proust is one of them, but I don't cite that because I know that people are not going to read it. Or a book about vision, and I cite a book from Saramago on blindness and seeing. I hope maybe even if one student take the book and read it, out of my entire class of Harvard students, that's a win.

Brady Huggett
That's a victory. That's a win. Yes. One more thing about Proust. Proust has that famous scene where the boy is dipping his cookie in the tea and it opens up all of his memory. That's a very neuroscience [crosstalk].

Catherine Dulac
Totally. In fact, it's repeated over and over and over again in the field of olfaction, as how evocative smell is of ancient memory. In fact, it's interesting because there are other examples of that type in Proust. For me, actually, the most striking one was not that particular example of, yes, dipping his madeleine in his tea, is there is an example of him walking around, I think, the house of his grandmother, and there are these bushes with flowers, and the smell of these flowers is also extremely evocative.

When I started to work in the field of olfaction, when I was a postdoc, and at the beginning here in my lab, people kept bringing the example of the madeleine. It's interesting because that's the example that is the public example, but actually there are many other ones, which I think are even better, but nobody has read those. [laughs]

Brady Huggett
So they don't know. Yes. One more thing. With all this reading, did you harbor any interest in being a writer before you went off to school?

Catherine Dulac
No, never. I am a consumer. [laughs]

Brady Huggett
You don't want to produce it. You want to consume it.

Catherine Dulac
It's interesting. I never thought about it. I love poetry also. I don't think I've ever even tried to write a poem. I don't think I would be very good at it, but I just enjoy it. [chuckles]

Brady Huggett
Yes. OK. I guess the question is, when you go off to college, and that's in Paris, right? That's the École Normale Supérieure.

Catherine Dulac
Normale Supérieure. Yes.

Brady Huggett
You were already thinking about being a scientist, or what?

Catherine Dulac
Yes. My interest in biology started in high school. Actually, yes, high school or mid school, I don't recall. I had a teacher, you know like many people, your attention, you get attracted to a field because you just have a fabulous teacher. There was this teacher in biology who was just describing something, I think about how the cells are organized, something like that. Some really basic biology. I asked, "Oh, why is it that way?" He said, "Oh, in biology, we never ask why, we ask how." I thought, "Oh, this is so interesting." [chuckles]

I don't know, somehow I remember that time as sort of almost switching something in me, and emphasizing that there's so little we understand in biology. We still have a lot of questions to answer of the how. How that works. I think I got attracted to biology because of that. From that time.

Brady Huggett
Yes, that was feeding your natural curiosity, that you had already up to that point. Yes.

Catherine Dulac
In fact, some of the knowledge that I acquired in becoming a biologist was not only strictly biology, it was also geology, and anything that is related to the world around us, I just loved it.

Brady Huggett
Yes. OK. Then when you finished your undergraduate degree, you rolled that right into a Ph.D., I think, right? University of Paris?

Catherine Dulac
Yes.

Brady Huggett
There you did study developmental biology.

Catherine Dulac
Exactly. Yes. As part of the École Normale Supérieure, I should actually back up a little bit. One thing that really interested me was the idea of doing research, of trying to explore something, discover something. Still this question of how instead of why. Everywhere I went, as a child, even my parents told me, it's very difficult to be a professional researcher. There are very few positions of that type. Don't get your expectation too high. You might succeed, but chances are it's not going to be possible. I think I just enjoyed so much learning, that I didn't really think about the career option in a very serious way. I just thought I'm going to do research and-

Brady Huggett
I'm enjoying myself.

Catherine Dulac
Yes. So that's what I did. I learned biology. I got lucky to enter into this very elite place, Ecole Normale Superieure, which is very totally geared towards research. That gave me an entry into a lab as an undergrad. I did already some research as an undergrad, and then I stayed in that lab to do my Ph.D.

Brady Huggett
Oh, you did? OK.

Catherine Dulac
Yes.

Brady Huggett
That was with Nicole Le Douarin, right?

Catherine Dulac
Yes.

Brady Huggett
Were you seeking her out? Did you know her work, or?

Catherine Dulac
No. I think that she contacted someone at the École Normale and say, "I'm looking for a graduate student, potentially, or an undergrad that would be interested. They are opening in my lab, basically." Then I went and I said I was super interested.

Brady Huggett
Well, that person suggested you?

Catherine Dulac
Yes.

Brady Huggett
They knew something about you they thought you might fit with Nicole.

Catherine Dulac
Yes. Well, you know, one thing is that she was one of the very few head of laboratory women. [laughs] She wanted also, was interested in having women students.

Brady Huggett
Yes. Smart. OK. When you finished your Ph.D., then you had some decisions to make.

Catherine Dulac
Well, you're going through the Ph.D. a little bit too quickly, because the Ph.D., first of all, was for me a revelation, because I was learning the job of being a scientist, and I just loved it. The French system is a little bit different than here. Because my Ph.D. was successful, I got a position right away. A lifetime position. That's it. I could stay in that lab forever.

Brady Huggett
Oh, I didn't know that. I didn't know that.

Catherine Dulac
I didn't feel I should do that, because I thought I had to go somewhere to learn something different. To just expand my knowledge. The other thing is, I had never learned English in school. I learned all sorts of language, Greek, and ancient Greek, and Latin, and German, and all of that, but not English. My parents said, "You're going to have to learn English anyway, so why don't you learn other things first?" [chuckles] I thought maybe I need to go to the U.S. or to the U.K. Being in an English-speaking country. This plus the American scientific system works so well, so efficient, so productive, I thought I had to come and see, experience this directly.

Brady Huggett
OK. You had an opportunity just to start a lab.

Catherine Dulac
Oh, no, no, no.

Brady Huggett
No, no. Not in the U.S.

Catherine Dulac
French system, you don't start a lab. You are in somebody else lab, but you have a lifetime position.

Brady Huggett
Oh, I see what you mean. OK. No wonder. No wonder.

Catherine Dulac
Well, you say no wonder because you're used to the American system, but in the French system, it doesn't work that way. Scientists are part of the-- These are government position, and starting your own lab is actually not easy.

Brady Huggett
Right. I'm saying, did you want to start your own lab, or you didn't even-

Catherine Dulac
Oh, so that's an interesting question, because in retrospect, I was just so oblivious. I never thought about starting my own lab. I thought this was completely out of my reach. Again, as with my studies, I was just enjoying myself doing research. When I was as a Ph.D. student, I was looking at the PIs around me and said, "Oh my God, this seems to be so out of reach, so difficult, and you need to find funding, and you need to find projects for people, and all of that. Oh, no." Then I went for postdoc, and I also had the same, I don't want to say fear, but I really thought that it seemed so incredibly difficult to be a PI, and I didn't think I would necessarily be able to do it.

It's only completely at the end of my postdoc when I made a big discovery, discovered genes encoding pheromone receptors, and that suddenly opened all sorts of new questions, new horizons. At that time, I thought I could do it.

Brady Huggett
We should say your postdoc was at Columbia.

Catherine Dulac
Yes.

Brady Huggett
You had not studied English at all, and you came over to the U.S. to start that postdoc?

Catherine Dulac
I had studied English. I had book and I had some tapes. Every day, for half an hour, I was doing my-- I was learning a lesson, when I was a Ph.D. student. Then my PI, my Nicole Le Douarin sent me for a collaboration at Cold Spring Harbor.

Brady Huggett
Oh, I see.

Catherine Dulac
I spent a summer there. I remember, I was like a fourth-year graduate student or something. I remember landing in New York, coming down the stairs of the plane, and thinking in my head, "I have never spoken English to anyone." Like in my head, on the tape, but never to-

Brady Huggett
A human.

Catherine Dulac
- a real person. It was actually quite interesting, because for some reason, I think I chose the right textbook or whatever, because it was American English rather than British English. I was with a lab mate who had learned British English in school. Actually, I could understand way better than he did. [laughs]

Brady Huggett
Oh, really. Oh.

Catherine Dulac
Yes. I could say things that were more, I guess, American. I remember actually staying, I think I stayed two months or a month and a half. So quite a long period of time. At some point, I realized that I was dreaming in English. It was super surprising to me. I thought, "Oh my God, I must be dreaming in terrible English. [laughs] Who cares, right?

Brady Huggett
Yes, it's a dream. **What does it matter.** OK. With your postdoc with Richard Axel.

Catherine Dulac
Yes.

Brady Huggett
Right? He later, I think later, right? He would go on to share the Nobel for odorant receptor genes, right?

Catherine Dulac
Yes.

Brady Huggett
He's working in olfaction as well. Did you know that going in?

Catherine Dulac
Yes.

Brady Huggett
OK. So that's what you wanted.

Catherine Dulac
Yes. I did my Ph.D. in developmental biology, in an absolutely beautiful system, experimental system, which is the quail and the chicken embryos are able to-- The cells are able to mix, and that enable to recognize the migration of cell types within an embryo. It was intellectually and experimentally a very beautiful system. Somehow I realized, when I was a graduate student, that I was very mechanistic in more molecular ways. There's no genetics in chicken and quail embryos. There's not a lot of molecular biology. In my Ph.D. lab, I was the first person to ever purify a protein, the first person to ever make cDNA library, the first person to clone a gene. I just want to continue along those lines.

In 1991, the paper from Buck and Axel came out, the cloning of olfactory receptor gene. I thought, "This is fabulous." Because here you recognize the identity of a particular olfactory neuron type based on the expression of its olfactory receptor. Every type of olfactory neuron expresses one particular type of olfactory receptor. I thought, "This is fabulous." It's like a new

sensory modalities now open up to molecular biology and to developmental studies using molecular tools. That's why I went to the Axel lab, because I was attracted to that.

I had two projects. I had a project that was my main project, that I thought was going to be very difficult, maybe impossible, and then a side project that I thought would be simple. Both of them ended up very difficult. The first one was to understand the development of olfactory neurons. The reason I knew this was going to be difficult is because the way people had understood how T cells and B cells in the immune system were able to choose a T cell receptor or an immunoglobulin is by making cell lines out of B cells or T cells.

You take these cells, you make them immortal, and then you see whether these particular molecular mechanisms that enable a B cell to express one type of immunoglobulin, or a particular T cell to express a particular T cell receptor. Because you have a clonal expansion out of a single precursor, you have a lot of material and you can see whether, for example, the genome has rearranged, which is the case of T cells and B cells. Because I was trained as a developmental biologist in the nervous system, I knew that it was almost impossible to make a cell line out of a neuronal precursor.

Either a neuronal precursor divide, but then it's not differentiated, it's very unlikely to express olfactory receptors, or it's differentiated, but then it cannot divide anymore. The idea of making and to have a clonal expansion of an olfactory precursor seemed impossible, but I was going to try. This was way before the iPS cells, so neural stem cells, et cetera. That was the difficult project. Then there was the easy project that ended up being not easy. That was the cloning of the pheromone receptors. The reason everyone assumed it was easy is, you have to imagine, this is just a few years after the discovery of the olfactory receptors, which was a magnificent discovery.

There was absolutely no doubt that the pheromone receptors would just be a subclass of the olfactory receptors. Therefore, all I had to do was make design primers or molecular probes that worked on olfactory receptors and find something that was a little bit on the side. It ended up being not this at all. [chuckles] At the beginning, that was my easy project.

Brady Huggett
You said when you first got there, too, you were looking around at the PIs, maybe at Richard, and thinking, "I don't know that I can do this." Did that feeling continue?

Catherine Dulac
Oh, yes. Continued up to basically the year before I went on **[unintelligible 00:31:37]** market, because it seems so difficult. Both my two PIs, Nicole and Richard, were people who were incredibly smart, incredibly successful, knew a lot of very important people, knew what to do, basically. I think that as a graduate student, as a postdoc, I thought, "Oh my God, how do I know all they know, what to do, all the people they know, all of this?"

Brady Huggett
How do they meet all these people, plus running the lab, right? I mean, having-

Catherine Dulac
Running a lab and having the intuition on what project to pursue, what project to stop, how to apply for grant, get funding for everyone. It seems very overwhelming. It turns out that seeing people who were more senior than me make that transition and being successful was actually very helpful, because if they can do it, maybe I can do it. [laughs]

Brady Huggett
Oh, you would see someone else in the lab leave and start their own lab and you'd think-

Catherine Dulac
Yes, well, because that's the American system, which is postdoc come, and they stay for a number of years-

Brady Huggett
Then go.

Catherine Dulac
- and as soon as they have a paper or two, then they apply for jobs and they are hired. Seeing this, that it's actually a normal cycle, made me more confident that I could do it.

Brady Huggett
Yes, it would happen to you, too.

Catherine Dulac
Yes.

Brady Huggett
Yes. You said both these projects end up being really difficult. So for a while, were you thinking, "I'm not going to make this. I'm not going to be able to--" Or no?

Catherine Dulac
Oh, yes. [chuckles] Yes, it was very stressful. Yes, nothing was working. Nothing was working for a number of years.

Brady Huggett
Oh, really?

Catherine Dulac
To some extent, that's also part of research. You try something, it doesn't work.

Brady Huggett
100 percent.

Catherine Dulac
So, you try again, it still doesn't work.

Brady Huggett
Did you know that, though? Did you know that it's OK to fail for a couple years and not get it to work, or were you worried about that?

Catherine Dulac
Oh, I was extremely worried, obviously. I think that Richard had a very nice way of reassuring people, because he was saying, "People in my lab try to tackle extremely difficult problems." He had confidence in himself, in his ability to pick people who could solve those difficult problems. He said, "I'm very confident you're going to be able to crack this open. I don't know when, but I think you can do it." It was interesting to hear, because if you think about his history, first of all, he has this incredible lineage of people who were trained in his lab. David Julius is one of them, but Linda Buck is another one.

He has these just amazing former trainees that each would come in his lab and publish on a different topic, and then take this over. Olfaction was the first topic he actually kept in his lab. In the past, people would just leave and he would switch to something else. This also was part of helping, is to think that he has confidence in me being able to solve that problem. This being said, what happened is that I was trying to clone the pheromone receptors, again, based on similarity with olfactory receptors. Everything I tried failed. So I would say, "OK. Well, maybe I didn't do that well, so let me try in a different way, and then in a different way, and then in a different way."

Then at the end, I thought, "OK, maybe I might be incompetent, but not that incompetent. I think there's something just fundamental that I'm not understanding." The fundamental assumption I was making is that these pheromone receptors were similar to the olfactory receptors. I thought, "Maybe this is just wrong." It's actually easy to test, because in the olfactory system, the signaling pathway that is triggered when an olfactory neuron detect an odorant, this was known. It was known that the exposure of olfactory neurons to odorants in frogs or other animals that were tested lead to an increase in cyclic nucleotides.

Therefore, the idea is that there is a cyclic nucleotide gated pathway, meaning the receptor has to be a GPCR. GPCR, 7-transmembrane domain receptors being activated, lead to the activation of adenylate cyclase, lead to the increase of cyclic nucleotides that open a channel, and da-da. Then you excite a neuron, you send the information to the brain. That was known for the olfactory system. That was the basis of the discovery of the olfactory receptors, because a lot of 7-transmembrane domain receptors were known. What Linda Buck did, in an extremely smart and ingenious way, is to design primers that would recognize any type of 7-transmembrane domain receptors.

All she asked, she had a number of criteria. One is that whatever she found had to have seven hydrophobic stretches. They have to be specifically expressed in the olfactory system, obviously. Then they had to represent a large family, because the olfactory receptor had to be very diverse. She found those receptors. Now, when I looked for the olfactory-specific adenylate cyclase, the olfactory cyclic nucleotide gated channel, all of that, all this olfactory signaling pathway was not expressed by neurons detecting pheromones.

In other words, I came to realize that these receptors could be of any type. They could be tyrosine receptors, they could be GPCR of a very different sort, they could be anything. All the strategy that I had used so far were based on having some intuition about the nature of these receptors. Now that was gone.

Brady Huggett
Is that because the nature of a pheromone is so different in the body? What a pheromone is meant to do in the body is different from a normal odorant.

Catherine Dulac
Yes. So, odorants is the sense of smell, right?

Brady Huggett
Yes.

Catherine Dulac
It's this information about volatile chemicals that provide information about food, about danger, about smoke, about all of that. Pheromones are semiochemicals. They are signals that are exchanged between animals to provide information that then lead to specific behaviors. Social behavior in particular, which is what I was interested in. In mammals, semiochemicals are typically not volatile, which is if you have a dog, or if you see what dog do, they put their nose in the butt of another dog. It's because they touch pheromones. The way they smell the sidewalk, they put their nose.

You need a contact, physical contact, because pheromones are water-soluble. They are in urine, they are in sweat, they are on the skin. There's a contact that is needed. You can imagine that the receptors for those molecules are completely independent. Have really evolutionary no similarity whatsoever with odorant receptors. Also, the pathway in the brains are completely different. The main olfactory system, the one detecting smell, goes to the olfactory bulb and then goes to five or more areas that overall comprise the olfactory cortex. That leads to the conscious perception of a smell. You smell a flower, you smell coffee, you smell wine. You have a conscious perception of it.

The vomeronasal organ, this set of neurons that detect pheromones, project to a particular area of the olfactory bulb, and from there, completely bypass cognitive areas. They go to the limbic system, to the amygdala, to the hypothalamus, and the idea is that they trigger instinctive behaviors. For me, this was the attraction to the pheromone world. Is to have access to-

Brady Huggett
Right. So this is-- We're beginning to touch on your work that you're doing at Harvard back in the early 2000s, right?

Catherine Dulac
Yes.

Brady Huggett
OK. All right. So then, when you finally do have your success here, at Columbia, and you had a big paper out of that, too, I think, yes?

Catherine Dulac
Yes.

Brady Huggett
Then it was your time to move on. Did you think about going back to France, or did you--

Catherine Dulac
I wanted to go back to France.

Brady Huggett
Oh, you did?

Catherine Dulac
In fact, when I started, when I went to the U.S., there was absolutely no doubt I was going to go back to Paris within a few years. I had absolutely no intention to stay in the U.S. I'm French. Why would I stay in a foreign country?

Brady Huggett
Yes.

Catherine Dulac
Then, first of all, the American system has something very special, I think. It's successful for very good reasons. Is the way it's organized. It was a difficult decision. I tried to find a job back in France, and there was no independent position for me. It was interesting because I had offers about everywhere here, that I applied to. MIT, and Harvard, and UCSD, and UCSF, all those places I had offers. Then I would go to France and would say, "Oh, you're way too young to be independent." Or, "You cannot have your own independent budget." Or, "Here's a little corner of a bench that you can have."

The discrepancy was like, what the heck? [laughs] There's no way I can go there. The American system is extremely attractive for me, as a way of being organized, because places like Columbia, or Harvard, or UCSF, these large academic institutions where there is this large number of scientists, there is this really interesting collegiality and collaboration. This is where I would say the academic world that I knew in France was quite different than here.

The scientific community in the U.S. is very large, and so it's very diverse-- Well, maybe not that diverse in certain ways, but anyway, there's a lot of different types of science occurring. It's very enriching to be part of this community. In France, maybe not only in France, in other countries in Europe, the communities are much smaller. The availability of funding is also very reduced.

Brady Huggett
Constrained. Yes.

Catherine Dulac
As a result, there's way less communal enterprise or collaboration compared to here. This is a very attractive academic environment for me.

Brady Huggett
You sort of made this bet that you sacrificed your own culture for science, for science life.

Catherine Dulac
Yes.

Brady Huggett
Yes. OK.

Catherine Dulac
Well, not really in the sense that everything went by step, which is that I came to realize that if I want to start a lab, and have my own project, I could not go back to France. Going back to France meant basically completely changing my plan. When you do a postdoc in the U.S. and you're successful, it means you have an entire new field that is opening up thanks to your

discovery. So, you're on a roll, and you want to do experiment along those lines. It was clear that that was not possible in France. There was no-- I needed to have transgenic animals, mice, large mouse facility, all of that. That just was not available to me.

I would have to completely change. To do what? Well, to probably work on the project of somebody else. That was not attractive. I thought, in the meantime, I had great offers in many places, including here. I thought maybe what I'll do is I start my lab as a junior faculty, I'll learn how to be a scientist as an independent junior faculty, and then I'll go back to France. What happened is that my lab worked really well. We had a lot of great publication almost immediately. So I got tenure very quickly.

Brady Huggett
That's like four or five years.

Catherine Dulac
Yes. Then, OK, I kind of got used to the good things. [laughs] It was just not possible for me to move out, because things were going so well here.

Brady Huggett
Yes. Where's your brother, by the way? Is he in France?

Catherine Dulac
He's in France. Yes. He's a physician.

Brady Huggett
Your parents were in France?

Catherine Dulac
Yes.

Brady Huggett
Yes. That's a big-- I'm sure you got to see them, but it meant a long flight, right?

Catherine Dulac
Totally. Yes. Being exiled, to some extent, is not always very easy.

Brady Huggett
Yes. You joined Harvard in '96 or something like that?

Catherine Dulac
Yes, fall '96. Yes.

Brady Huggett
Did you have postdocs or did you have grad students immediately?

Catherine Dulac
Yes.

Brady Huggett
Oh, so how big was your lab?

Catherine Dulac
Well, there was two postdoc who joined right away. Then the first year actually, I had three graduate students joining, and then two. My lab became 6 to 10 in the first four or five years.

Brady Huggett
Wow. OK. It's because you were, as you said, having these great publications, that's how you got tenure so quickly?

Catherine Dulac
Yes.

Brady Huggett
You just were producing?

Catherine Dulac
Yes.

Brady Huggett
Wow. OK.

Catherine Dulac
People got scared that I would leave. [laughs]

Brady Huggett
Oh, really?

Catherine Dulac
Yes. I think American institutions are terrific for that. Harvard really helped me. They want to keep me, they helped me buy a house, and they gave me this great lab, and funding. Why would I leave?

Brady Huggett
Were you being wooed? Were other schools coming at you saying, "Maybe, do you want to set up a lab here?" Harvard, if they were nervous-

Catherine Dulac
Yes, always. Yes, but not in a formal way, because the reality is, I was doing well here. I had no desire to go somewhere else.

Brady Huggett
They must have got wind of that, somehow. If they were nervous you were going to leave.

Catherine Dulac
Probably.

Brady Huggett
Yes. Yes. Well, must be glad you stayed.

Catherine Dulac
Yes, I'm glad.

[laughter]

Catherine Dulac
I'm very happy here.

Brady Huggett
Let's talk about the vomeronasal organ, right?

Catherine Dulac
OK.

Brady Huggett
That really took off in your own lab here at Harvard, yes?

Catherine Dulac
Yes.

Brady Huggett
Tell me about that work.

Catherine Dulac
I came to realize that a lot of assumptions that we had about the vomeronasal organ were wrong. I think this was some of the just great enjoyment also, of doing research, is to discover that all your expectations were wrong. Then, nature is always more interesting, that what you can predict. To start with, in Richard Axel, I discovered this family of pheromone receptors, and then realized that that was just taking into account a particular subset of the neurons. So, we discovered a second family of pheromone receptors. Now we have these two large families.

I think that there are a total of 300 receptors or something like this. These, to start with, was way, way many more, way more than what we had expected. Because the idea is that the vomeronasal organ triggers mating behavior, aggression, a number of stereotyped social behavior in rodents. Maybe, how many receptors do you need? I don't know, maybe 10-

Brady Huggett
10.

Catherine Dulac
- would be enough, or 20. Now we have 300. That was problematic, to some extent, because initially, the plan was, let's discover the mating receptor, or the aggression receptor, or the parenting receptor, and then let's do genetic manipulation of those receptors to know how they encode that particular information that lead to specific behavior. With 300 receptors, this is impossible, right?

Brady Huggett
Were you going to try to knock them out one by one in mice, or what were you going to do?

Catherine Dulac
Yes, for example, to knock them out, to look also where they project, try to understand what they do, how they do it, right?

Brady Huggett
Yes.

Catherine Dulac
With 300, this is impossible. It meant that the system was way more complicated than what we had anticipated. That led me to collaborate with Emily Lyman, who at the time was a postdoc with David Corey here at the medical school. She's a physiologist, and she had this really interesting idea on vomeronasal signaling. If it's not cyclic nucleotide-based, then it has to be of a different type. The only other type that was known was the one related to Drosophila vision, which used TRP channels, which is a different type of pathway.

She had the idea that maybe, and the idea, it is really coming from her, that maybe the vomeronasal signaling was based on TRP channels. So, because she's a physiologist, I'm a molecular biologist, we decided to collaborate. We indeed identified specific TRP channels, particular TRP channel called-- At the time we called it TRP-2, now it's called TRPC2, that was extremely highly expressed in the vomeronasal organ. When we made an antibody, it was nicely expressed. The protein was nicely expressed at the sensory terminals of the vomeronasal neurons. Emily went on in looking at the physiology of the neurons, and I used a gene to knock out, to impair genetically vomeronasal signaling. That was a huge surprise. The VNO was actually, the vomeronasal system was not doing what we expected it to do. The expectation, again, was that this is the trigger for mating behavior and aggressive behavior. When we look at mutant males for the vomeronasal system, vomeronasal organ, males were able to mate perfectly normally. In fact, it was interesting because Richard Axel, also in his lab, had also done that knockout and couldn't find any phenotype, and so the student who was doing the work basically left the lab and went to medical school.

I was very lucky to have, as a postdoc, Lisa Stowers, who is now at the Scripps in California, at UCSD, in San Diego, who said, "Well, if the removal, the genetic impairment of the vomeronasal system does not affect mating, let's look at another behavior that we think is thermo-mediated." That's male-male aggression. She put two males together. One is a wildtype, one is a type 2 mutant. We want to see whether they would fight or not. Da-da, the mutant male tried to mate with the other one. [laughs] I said, "Oh, my God, what's going on here?" We realized that the mutant male was basically unable to discriminate between a male and a female, which is if you put a male and a female in a cage, the male mutant would try to mate with the female, and then the male and the female and then the male.

What the vomeronasal system does is not to trigger mating behavior, it's to discriminate between males and females and basically tell the animal either you mate or you attack or you do other things. It's more like a switchboard rather than a simple trigger.

Brady Huggett
A trigger.

Catherine Dulac
That was super, super interesting. Then there was this really interesting period where I would describe this work, and then when I would give a seminar, there would always be somebody raising their hand and say, "OK, so this is the phenotype of the males, but what about the females?" Here I came across a really interesting phenomenon that surprised me at first. Now I think that this is well-recognized. It's that actually people had strictly no interest in the behavior of females. There was very little in literature. I was lucky because here again I had a terrific postdoc, Tali Kimchi, who is now a professor at the Weizmann, who said, "I'm going to look at the behavior of females." She was used to the behavior of wild animals, and so she thought she could discern if there were even subtle differences. She looked at the mutant female, and she just wanted to do a very simple test to see whether that mutant female was sexually receptive or not. She put the mutant female together with the male.

Brady Huggett
The wildtype.

Catherine Dulac
Yes. Da-da, the female mutant tried to mate with the male, with a male-typical mating behavior. It's like the female was behaving like a male. Wait a minute. Check the female. Yes, it's a female, not a male, but it was behaving like a male. We thought, maybe the circuitry is developed abnormally because the animal is a mutant, never had vomeronasal input. [clears throat] We did an experiment that ended up being very difficult, which is to remove the VNO surgically-

Brady Huggett
Of an adult.

Catherine Dulac
-of an adult. We found exactly the same phenotype as the genetic mutant. In the meantime, we also discovered something that explained a lot of the old literature that said that the VNO is essential for mating, which is that when you remove surgically the vomeronasal organ, so the VNO is in the septum, in the cartilage, in the middle of the nose, when you remove it, what happens is that there is a lot of bleeding. What Tali discovered is that in the majority of the surgery that she did, the nasal cavity was basically full of blood. It was completely clogged by blood. She had to do all sorts of trickery to clean up the nasal cavity after the surgery to make sure that the VNO was removed, but the main olfactory system was excessive. When people had done the surgery in classical work, they didn't check that. What happened is that these animals were both deficient in the main olfactory system and vomeronasal system.

It turns out that if you look at an olfactory mutant, they have great difficulty of mating. The olfactory system, the main olfactory system, is actually essential for mating behavior. People never realized that because they were so focused on odor and perception. The VNO does the instinctive social behavior. The main olfactory system does smell. People had olfactory mutant lines that were extremely difficult to breathe, but they never associated both. Oh, maybe the olfactory system is essential for breathing. They never did because it was known, that was the assumption, that the olfactory system was essential for smell, not mating. It's interesting how we get stuck in these preconceived ideas that end up being completely wrong.

This idea that females now behave like males if they don't have vomeronasal input was very influential for my own thinking because first it indicated that if a female is now able to switch to a male behavior just because we remove a piece of the nose, it means that the central circuitry is there. People hated that idea when I first published it because the textbooks say young males have a surge in testosterone that makes the brain circuitry male, and that's it.

Brady Huggett
Right, so once the hormones come in, they develop differently from that point on.

Catherine Dulac
Exactly, you have a male brain and a female brain, and that is not the case. There's a brain, and that brain is suddenly influenced by hormones in very significant ways, but the hormones act on circuitry that do exist in males and females.

Brady Huggett
When this work is done, when you read it, you can't help but think of humans, right?

Catherine Dulac
Yes.

Brady Huggett
Do you think that's why people get resistant to ideas like that?

Catherine Dulac
Well, people get resistant of ideas because first that contradicts a lot of work in animals. The problem is there was a lot of reluctance to accept some work that we're basically challenging ideas that had been in the field for over 50 years. Those ideas were done in a particular experimental paradigm. I was invited at the time we made this discovery in 2007, 2010, I was invited to give a seminar in the endocrinology department here at the medical school at the Grand Run. There was a lot of physician endocrinologists over there. Somebody came at the end of my talk and said, "Oh, I thought your talk was really interesting," because that person was the director of the transgender clinic. He said that he was just starting in that position and said that he was very surprised because he had assumed people who would go to his clinic would be teenagers that have these usually fluctuating hormones and don't feel good in their body, et cetera. He said, "No, the patient I see are kids that are four or five years old. They barely speak and they already say, I know I'm not a boy or I know I'm not a girl." This has nothing to do with sex. It has to do with your gender identity. Something that way, way precedes any type of sexual behavior.

If you think that there is a male brain and a female brain, then this transgender phenomenon is a little difficult to understand. If you think that *there's a* brain, that then there are also the regulatory mechanisms that makes a male to behave mostly like a male and a female mainly like a female, then the phenomenon of transgenderism is a little bit easier to understand because you can understand these differences and whatever phenomenon occurs. It was interesting because I remember, I still have the slides, and I found that really interesting. I was invited to give the keynote lecture in the big endocrinology conference in 2008. I presented those data. I remember how much of a cold shoulder I got. [laughs]

Brady Huggett
Oh, really?

Catherine Dulac
Yes, clearly. Two-thirds of the people just didn't buy what I had to say.

Brady Huggett
You mean afterward?

Catherine Dulac
During the conference, and then when we published our paper, I got some letters, very condescending letters from endocrinologists who were telling me that they would be happy to explain to me how to do behavioral experiments because clearly I didn't know how to do them properly. It was very offending. Then I got also invited, 10 years later, 2018, I still have those slides, also to give the keynote lecture at also this big ANDO Meeting. This time there was three keynotes. There was me

talking about the control of sex-specific behavior. There was a physician who was treating transgender patients, and then there was a transgender person who was a physician and was talking as a transgender.

Brady Huggett
Both as a physician and lived experience.

Catherine Dulac
Yes, and so things have turned entirely that now this concept that the circuitry in the male and the female brain are largely shared instead of being distinct was becoming attractive because it made so much sense.

Brady Huggett
The other thing is that we don't have a VNO.

Catherine Dulac
no.

Brady Huggett
These things that you were seeing in mice, they don't actually translate to humans because we don't have that.

Catherine Dulac
Yes. This is a very important point, and thank you for bringing this up. I think what is extremely important to realize is that there are different levels of information that give rise to specific behavior. One is the sensory information, the external information. What is extremely important to realize is that every animal has its own idiosyncratic ways of understanding the world. If I'm a mouse, I rely on olfaction and on the vomeronasal system. If I'm a bird, I rely mainly on sound or vision. A mouse is not a rat, a rat is not a human or not a primate. Every animal has its own idiosyncratic way to receive signals, and you want this because you want to be able to recognize signals that matters to you from the ones that don't.

Brady Huggett
I see what you're saying.

Catherine Dulac
For sure, the vomeronasal system has nothing to do with human or primates in general, but neither with birds or neither with a lot of animals. Every animal detects their species in particular ways. It's interesting, if you look at the brain of a mouse or a rat, about two-thirds of the brain is occupied by olfactory-related areas. If you look at the brain of a human or a higher primate, about two-thirds of the brain is dedicated to visual processing. The importance is not the specific sensory information that comes, the importance is the circuitry within the brain. Here, again, the circuitry of a mouse is not the circuitry of a primate or human. There's absolutely no doubt, but the template is the same. Whatever we learn in the mouse probably can at least inspire research or finding in humans.

The finding we had made with these females that mated like males when they were mutant, then raised the immediate question about, "Well, if the female has male circuitry, does male have female circuitry?" That's how we turned to parenting behavior because parenting was considered to be the female, the mother, the female-specific behavior. We thought, "Well, if we can show that the vomeronasal system is essential for female to be parenting and male not to be parenting, then our reasoning might be correct. In mice, virgin males are typically non-parenting. They basically attack and kill mice, whereas virgin females, they are parenting. They are not extremely parenting. They are not like mom, but typically after a few trials, they will retrieve pups and bring them to the nest.

Brady Huggett
Right. Pups that are not their own, they will nurture them-

Catherine Dulac
Pups that are not their own.

Brady Huggett
-but the males will go after it.

Catherine Dulac
Yes, and kill them.

Brady Huggett
That's like an evolutionary thing, we want to remove it from the gene pool.

Catherine Dulac
Yes, exactly. Sarah Hardy, who was actually a Ph.D. student here at Harvard in the late '60s, discovered this, not only discovered, actually, because it was described already, but she gave an evolutionary explanation to the phenomenon of infanticidal behavior. She was observing langurs in India, and she found that each time a male would enter a social group, a foreign male, then all the infants would disappear or be killed or wounded. She never actually observed an actual attack, but she inferred that the male were actually getting rid of all the infants. Then the female, now no longer having offspring, then would be sexually receptive again, and the male would be able to mate. Her theory was encountered with a huge uproar [laughs] because she was basically saying infanticidal behavior is a normal behavior. People say, "Ah, no, there's just no way. Why?" Well, it's interesting because she was in the psychology department.

There are two types of people who study primates. There are people in zoology department who look at primates for primates, and the people in psychology department who look at primates as a proxy to look at the evolution of human behavior. Here somebody was saying, "Oh, infanticidal behavior is a normal behavior. No way." [laughs] There was this huge uproar. This can't be real, male attack infant because they are loud or because they are hungry or, all of that. Then people actually confirmed her data, found infanticidal behavior. I think the next species were lions. When there's a foreign male entering the pride of lion, first thing they do is to kill all the cubs. Then rodents. This became an accepted fact that infanticidal behavior is a normal behavior in some species. About, I don't know, maybe 40 percent to 50 percent of mammalian species are infanticidal.

Brady Huggett
OK, a couple of things I want to ask you still. One is, you won the Breakthrough Prize in 2021, right?

Catherine Dulac
Yes.

Brady Huggett
This is basically for the work we just discussed.

Catherine Dulac
Yes. The work I got the Breakthrough Prize was the discovery of neurons driving parenting behavior. Again, we haven't really discussed that yet. Basically, once we knew that males could be parenting if you remove the vomeronasal system, so that's exactly what happened. The vomeronasal system was, again, enabling the animal to behave either as a male or a female. If you remove the vomeronasal system, then male can be parental. There has to be neurons driving parenting behavior both in the male and the female brain. We look for them based on activity markers. We found a population of neurons in the hypothalamus expressing galanin. We did all sorts of genetic manipulation to show that these neurons do indeed are both necessary and sufficient for parenting behavior, both in males and in females. That made us realize something that had been described in the literature in some obscure journal is that indeed males do become parenting after they mate with a female. There's this extremely interesting switch in behavior where males mate with a female and then three weeks later are actually paternal.

Brady Huggett
It's in this short period while they're preparing for their own pups.

Catherine Dulac
Exactly.

Brady Huggett
Yes. Then that goes away after the pups reach a certain age.

Catherine Dulac
Yes.

Brady Huggett
OK. I was looking at that. That was 2021. I know a little bit about the Breakthrough Prize and the ceremony and stuff. On that note, do you-

Catherine Dulac
Actually, I got the Breakthrough Prize during the pandemic.

Brady Huggett
I was going to ask.

Catherine Dulac
I never went to the ceremony. [laughs]

Brady Huggett
They didn't have it.

Catherine Dulac
I have that thing. Where is it? Oh, it's here.

Brady Huggett
Oh, that's it.

Catherine Dulac
Yes.

Brady Huggett
Wow.

Catherine Dulac
They send it to me. [laughs]

Brady Huggett
Part of the goal of that is to mix science and celebrity and them, them all—I know, but it's a shame that they didn't get to mix anybody.

Catherine Dulac
I have to say they gave me a chance.

Brady Huggett
What do you mean they gave you a chance?

Catherine Dulac
Well, during the pandemic, there was no ceremony. Then last year, I could go and get my ceremony.

Brady Huggett
Oh, I see.

Catherine Dulac
That was the one-year anniversary of the passing of my mom, and so I went to France to stay with my dad.

Brady Huggett
OK, I think you made the right choice there.

Catherine Dulac
Yes, [laughs] I think so, but that's OK.

Brady Huggett
You're doing often behavior work. It looks like behavior work, but you're coming at it from a biological standpoint. I think that's a little uncommon and that might give you some uncommon insights. Do you think that that's true at all?

Catherine Dulac
It's true in multiple ways. Thanks for asking the question. One of them is that it's true that behavior has traditionally been looked at from two completely different angles. The one from psychology that is interested in behavior in trying to get insight into animal behavior, to get insight into animal behavior. The other one from ethology, which is just to try to understand the rules of animal behavior. I come from a standpoint of a biologist using biological tools that enable to gain insight into mechanism, cellular mechanism, molecular mechanism, trying to find causality in behavior in ways that is never achieved or even sought after, neither by ethologists, neither from psychologists.

The other point you're making is that basically I come to the field of behavior as an outsider, which I think is super important. In fact, it even is a guiding principle of my own lab, which is people who come from my lab all come as outsiders of the field of social behavior. There are people who have worked on copper metabolism, or in immunology, or in *C. elegans* motor behavior, people from my lab all come from very different horizons, and they come as outsiders and because of this, they ask tough questions.

Brady Huggett
You're choosing that.

Catherine Dulac
All right. This is on purpose.

Brady Huggett
Specifically, I want people like that.

Catherine Dulac
Exactly.

Brady Huggett
Yes. Do you think that's why your lab is so productive?

Catherine Dulac
I don't know if it's the reason my lab is productive. I think I have very good people, but at least that's the type of environment I want to have. I want an environment where people are challenging ideas, including my own ideas. I think that's enabled us to make a lot of progress.

Brady Huggett
Yes. OK. I don't know that this is true, but it seems like growing up you had two parents who were both working, both had active careers, and both did parenting to you.

Catherine Dulac
Yes.

Brady Huggett
Do any parallels between that and the work that you're doing in mice and parenting?

Catherine Dulac
it's an interesting point. The influence of my dad and my mom having the same job, basically, for me, I phrase in a slightly different way, but what you say might be correct. I think that my mom and my dad had the same job. They both were parenting. My dad was the person doing the groceries and doing the cooking at home. There was really sharing of both

intellectual, professional, as well as personal pursuits. For me, I think, was very influential in feeling that I could do whatever I wanted. There was no real impairment in me desiring to do anything I wanted in the same way my brother would. The reason I think this was very influential is that a lot of my classmates had a mom who stayed at home, and there was no equilibrium, no balance between the achievement of the father and the achievement of the mom. I remember several times when I went to visit my classmates when I was a child, mom would say, "Oh, I think it would be great if we could buy this or that." The child would say, "Mom, you don't have a salary so it's not to you to decide." I thought, "Oh, [laughs] this is not right." Right?

Brady Huggett
Yes.

Catherine Dulac
I think I never experienced that because my two parents had the same salary, the same job, and the same duties at home. I felt as entitled to do whatever I wanted with my life as anyone else. In fact, it didn't even come to my mind that there would be a difference between a boy and me in terms of ambition and achievement. In fact, I was always the best in class, so why would the boy who was not as good as I am would do better than me later? There's just no way. It's only when actually I became a PI that I realized that, yes, things were not that fair. [chuckles] I never suffered from it myself personally, but I could see that going to conferences, for example, the expectation of women giving good talks was not the same as a man. In fact, it has happened to me many, many times, that I would go to a conference and was the first day and nobody knew each other and I would sit close to a famous guy, and the guy had no interest in talking to me, and would talk to whoever other guys were at the table. Oh, and it just turns out that I was the one giving the keynote lecture. The next day that man would come to me and look at me in a sheepish [way] and say, "Oh, that was very interesting." I'm like, "Well, yes." [laughs]

Brady Huggett
Did he acknowledge that he was sitting next to you at lunch the day before?

Catherine Dulac
Yes, totally, and would come to me apologizing because he absolutely did not pay attention, didn't expect that I would have anything interesting to say.

Brady Huggett
Yes.

Catherine Dulac
Oh, and I was the one giving the keynote lecture. Oh, and he thought my keynote lecture was really good. [laughs] I think, for me, being here at Harvard and being a teacher, an instructor, an educator, I think this is something I always keep in mind, which is that it's fascinating that I have a lot of undergrads in the lab. I have men and I have women and they are all super excited by science. I feel it's my duty to make sure that everyone feel equal and equally confident on what they want to do. It's super important that men, women, people of color, whoever their ethnic background or they come from underprivileged background or whatever, feel that the world belongs to you.

Brady Huggett
Yes. If you're in my lab and we're going to do science in here, you're all going to do it.

Catherine Dulac
Exactly. Absolutely. I want everyone excited. I think that what is hard is that, is this thousand cuts, right? If you're a young woman or maybe if you're African American or come from an underprivileged background and don't have all the cues of what's around you, it's that you're being penalized.

Brady Huggett
Death by a thousand cuts, you're saying?

Catherine Dulac
Exactly. That's what I worry about. I remember something that I didn't realize, I discovered when I read the book from Sonia Sotomayor on her biography, on her coming from an extremely underprivileged background from Puerto Rico where her parents didn't even have a bank account and that, she was this spectacular student. Then all the doors opened to her and, she

was accepted at Harvard, she was accepted at Yale and all these places. She went to Yale and then she had no clue on how the academic environment works, and then she had some guidance. It made me realize that-

Brady Huggett
You knew that anyway.

Catherine Dulac
Yes, I had that privilege, basically.

Brady Huggett
Yes. One final question. I actually don't know the answer to this, so you've got all this work, you won the Breakthrough Prize, and your work has been tied to both the male and female brain, but also parenting, right?

Catherine Dulac
Yes.

Brady Huggett
I don't know whether you have any kids or not, but if you do, has that influenced the way you think about work? If you don't, has it influenced the way you think about parenting?

Catherine Dulac
I don't have children. I have a niece and two nephews. [chuckles] No, I don't think it influenced me. The fact is, parenting was recognized by the Breakthrough Prize, but my interest is way more general about social behavior and instinctive behavior. Similarly, I'm similarly interested in aggressive behavior. Similarly, we've made some really interesting findings recently on the brain response to social isolation, which I think is super, super interesting. Why do we have an urge to be together? I think more broadly about instinctive social behavior. For me, this is what's driving me.

Brady Huggett
Yes, you do. Then when the prize comes out, people think, "Oh, she's working on parenting."

Catherine Dulac
That's true. Then now they have a chance to hear-

Brady Huggett
Hear the rest of it.

Catherine Dulac
-more and more. [laughs]

Brady Huggett
OK. All right. That's it. Thank you.

Catherine Dulac
OK.

Brady Huggett
Appreciate it.

Catherine Dulac
Yes. You're welcome.

[transition music]

Brady Huggett
We had been trying to get our schedules aligned for a while, but I'm glad we finally got it done. Super interesting person, great science. Thank you, Catherine, for making time and letting me set up in your office. This podcast will be archived on the

transmitter.org, where we have also supplied a transcript, which includes some links for more information. You can find this podcast on YouTube, Spotify, Apple, and wherever you get your podcasts. You can subscribe there and you can rate this show. Some of the information for the intro was taken from Trading Economics, which supplies historical economic indicators for 196 countries, including France. Also in the intro, I quoted from an article titled "Budget woes cast chill on French research, published in 1996 in *Nature*. If you'd like to comment on this show or whatever we do with the transmitter, you can find us on the social media platforms X, BlueSky, Mastodon, and LinkedIn. Our theme song was written and performed by Chris Collingwood. Thank you for listening to Synaptic. Until next time.

[ending theme music]

Brady Huggett
You know what? I could pile stacks of books up.

Catherine Dulac
Yes. Well, you have plenty of books here. We can pile up. Do you want to make a pile of these?

Brady Huggett
Let's try that.
