INTERVIEWER: Years ago. I mean, before the advent of microcomputers, there weren't any easy metaphors for what the brain did. As you were growing up, did you have any notion of what the brain actually was?

GRAYBIEL: Not a lot. But when, I will say, when I was, I guess I was in junior high school, I entered a little contest. And made a little poster. Use your brain, not your accident policy. It's the first money I ever earned by myself. Was winning that so. But yeah, I mean, your major point is that we've known nothing about it. It's, still is a mystery, right? Despite all these methods. But when I started out, we basically were in awe of all the big questions. You know, how do you see? How do you feel? What's the nature of thought? Is consciousness important and are we the only ones who have it? Right? All of those questions. And so the field, as you know, was, it was a certain things discipline, it's too early to look at all those questions. You know, theory of mind didn't exist in neuroscience. But it was okay to look at sensation. It was okay to look at movement. And people had worked out a lot about the spinal cord and reflexes and so on.

But I just hit, coming through here and going, you know, being born and all, at a time when everything changed. It just, so technique after technique opened up. And, you know, concept of the brain, I think, now, a lot of people have at least a rough idea that there's electricity in there. And lots of transmitters and chemicals, and imaging the brain. I mean, everyone would agree, is what put it in the New York Times and put it everywhere in front of everyone. More and more people have their brains imaged, for one reason or another. So the whole, it's really part of, the whole of biology has opened up to people now. At least in developed countries.

INTERVIEWER: And, in your time of study, in your lifetime, I mean, from the moment you were a child and began thinking about these sorts of things, the brain has gone from utterly opaque to the first hints of actually understanding the real structure. And it's an endeavor that involves more than just one science.

GRAYBIEL: Oh yeah. Yeah. Very much so. And so, I don't know whether we're going to talk more about MIT on this very subject, but MIT's been so special that way. Because early on, even before the kind of biologic, it's sort of like, the Greeks. They were very good in, they were pretty good in chemistry and physics. But they didn't really do a lot of biology. And MIT was outstanding in biology up to the level of the cell. But the biologists were not working on the brain. So, look what we had. I mean, we had Norbert Weiner. We had early artificial intelligence. We had all the different people who were basically using the human intellect to try to figure out how it might work. And lay some kind of computational restrictions on what we might look for. And so what's happened is that, interestingly, MIT's in a very good situation now. Because biology's now very interested in the brain. Many different disciplines have come to the work on the brain. And the computational people are more and more working with experimentalists. And the physicists who were the heart of MIT in a lot of ways, along with mathematicians, and engineers, of course, they now are interested in the brain.

So it's, it's a very curious time. It's a very interesting time when some people think the way to tackle it is still to look at the, at what would be the smallest computational unit, and then we'll go find it. So they're starting out with their ideas, and their concept and whatever brutal strength they've got as, their own brains. And then the other part are more kind of Darwinian people. Let's look, see what nature did and then apply those computational tools. And so there is a certain, there's a wonderful kind of, it's not attention. It's just a back and forth communication between those two different sets of ideas. And that is MIT now in neuroscience. And MIT was poised to do that. And it's, there are a few other places where this sort of thing goes on. But there aren't a large number. So.

INTERVIEWER: How did it did occur you as a young girl that you could have a career in science? At the time that you grew up?

GRAYBIEL: My my dad was a scientist and a physician. My mother would have been a physician, it was tough in those days for women. Especially, she was from northern Ireland. But they were of a medical family. And my father loved science. He loved medicine, he was very good at it. But he loved science, it was evident. And so I kind of poked around in there. And I quote, worked with him. He was nice and let a kid help him.

INTERVIEWER: Where? In what parts of his practice?

GRAYBIEL: Oh, no, no, not in a practice. But just when he was, for example, for writing papers or something. And so we talked a lot about things like that. And they both loved nature. Which I think is, it's fundamentally a part of why I do what I do. And I happen to think the brain is a mighty fine product of, of nature. So, it was for me kind of in a way easy. Except there was this, you know, female thing. That was, so I grew up in a redneck, northern Florida panhandle 13 miles from the Alabama border, little girls didn't do things like that, right? And so, anyways, we couldn't, we couldn't take science. That was too bad.

INTERVIEWER: What grade are we talking?

GRAYBIEL: Ninth grade, that was the first grade of science.

INTERVIEWER: And you couldn't take science.

GRAYBIEL: I wasn't allowed to, no. So we took home economics. And I sort of learned to sew. But then they, my parents had --

INTERVIEWER: Done a great job,

[OVERLAPPING VOICES]

GRAYBIEL: Thank you very much.

INTERVIEWER: That's stunning.

GRAYBIEL: My parents had to kind of ship us off to boarding schools. I have a brother who is a physician.

INTERVIEWER: How did your parents explain to you this restriction on science in ninth grade? What did they --

GRAYBIEL: Oh, are you too young to know? I mean, it was sort of, remember this is the Deep South. So, it's so different from now, it's almost hard to describe. Which is why I try to, anyway, show, help, girls to this day, but not by talking about the the way it was. Just by helping them. But, anyway, the way it was, was that women did one thing and men did another thing. Basically. And there was, it wasn't really, my parents were unhappy. I was, I was sorry but I wasn't a science wonk. I mean, I was just a student. But if people had parties, the women talked in one place and the men talked in another. And, the women took you to piano lessons. Or worked in the kitchen. And the men went out. So, how can I put it. It took long time. Really long time, in my case. To kind of to feel it's okay. So I was the only, it's funny, I was the only female faculty member in my building, for many, many years. Once we moved to a building called E-25, we're not in, we've moved out of it into this glorious science complex. But there was more to the department. It was in another building. But it was curious, you know, it's six stories. So, when I was at Harvard as an undergraduate, I realized, you made me think about these things. I hadn't really thought of them. But I never did, I never saw a female professor. I saw, I mean, I knew one woman, turned out she was an instructor. I never saw a female professor. I heard there was one in astronomy. So it was a different time.

INTERVIEWER: Yeah. How does that, how does that shape your discipline as a scientist? I mean, you're the only woman in the room. You're the only woman in the department. You're the only woman in a class, I mean.

GRAYBIEL: Oh, right. So, like, in well, it shaped things in certain ways. Like, we women were not allowed to go to the main library at Harvard, Widener. We were assigned seats. So, when we took organic chemistry, we were assigned seats in the front rows. So that was a great influence. We were way up front. It was easy to see. But, again, it was the way, how can I say this, there came upon all of us, and fortunately I was part of it, a time when it was okay to protest almost everything. And I lived right smack in the middle of that. And I went to Harvard Radcliffe, then Radcliffe, I had, we all had, 30 one o'clocks. So we had to be in by one o'clock. We were allowed to stay out until one o'clock 30 times in a semester. By the time I graduated --

INTERVIEWER: Wait, wait, let me explain that.

GRAYBIEL: We were allowed to go out after 10 o'clock.

INTERVIEWER: After 10. But you got --

GRAYBIEL: So you signed out. And you signed in. You don't know that? So when a girl went out, like after dinner or something, she signed out. Like, going to the library or wherever. Going out of her dormitory.

INTERVIEWER: That I understand.

GRAYBIEL: The girl had to be in by 10, except 30 times.

INTERVIEWER: She got 30 times to go wild between 10 and one.

GRAYBIEL: You got it. Right. And so, by the time I graduated there were no rules at all. None. So, you can imagine. People did go, I mean it was a very crazy time. Right.

INTERVIEWER: On the 30 one o'clocks, just for one second, did you, some evenings, kind of compare notes with other women friends? Oh, I've got three to go, or I've got six to go?

GRAYBIEL: Oh, no.

INTERVIEWER: No.

GRAYBIEL: Oh, no.

INTERVIEWER: Did everybody know how close they were to the 30, or? Was it just one of these --

GRAYBIEL: I'm sure I must have gotten in trouble. I can't imagine I only went out for one, 30 times. No. But MIT did, the first time I heard about MIT, it was really awful. They had this place called Bell's, which is where you signed out. And where phone messages were received. It's just such a different era. And the MIT guys would come around on Saturdays, call up on Bell's to anyone. Anybody want to go out? So, we had a very low opinion of MIT in those days, I'm sorry. I did marry an MIT undergrad, so. But.

INTERVIEWER: Although, experimentally and statistically, maybe that was a better way of solving the problem? Just go to where the women are and call on the phone and --

GRAYBIEL: No, I mean, now I think it's fine.

INTERVIEWER: Elegant solution.

GRAYBIEL: Exactly. Right, as usual.

INTERVIEWER: You said something really profound a moment ago. There came a time when it became okay to protest almost everything.

GRAYBIEL: That's right.

INTERVIEWER: How did that moment arrive?

GRAYBIEL: Do you mean in our country, in the world --

INTERVIEWER: No, in your, in just your community. Of, I mean, I've heard the story from political protesters. The point of view, from presidents' point of view. But from the point of view of a young scientist. Starting out.

GRAYBIEL: Okay. So now, all right, so now, like, President Johnson, for example was running this place during the Cambodian crisis. In all this, Vietnam, the whole thing. Not the whole thing, but part of it. And, you know, Harvard was almost in flames. And somehow, he managed to keep the lid on it, MIT. But I, and I've always admired him for that. But I think we, a lot people at MIT had the sense that, it probably is important that some people just keep, you know, going on and doing, doing the thing, that they were doing. But there was enormous tension. I mean, I remember very vividly being a student, in those days I used a microscope a lot. And sitting at my microscope at night, and a guy coming in and saying, how dare you work? How dare you do this? And so I thought about it a huge amount. We talked about it endlessly. When I was in college earlier than that, we were sure we were going to be blown up by the Soviet Union. And I'd say, sure. We just sat around and talked about it. You know, when will that happen. So, but the protest, I mean, it was all through this country. And many other countries. It was, it just kind of boiled up, didn't it? After all those wars. And people getting a bit fed up with it. So, I was, I did not go to Alabama to work with the blacks. But I did things other ways. I was, I would say I was quietly active. But I'd never go out and burn my bra for women, or something like that. Because I think there are, there are ways to be quite effective as a protestant, without doing that.

INTERVIEWER: So, in this period of time, relations between men and women are in play. Socially everything is in play. Scientifically, were things in play? That as a young scientist, you began to see things in ways that were --

GRAYBIEL: You know, I think, I was saying that this thing about big questions. Honestly, there was a sense of, at least with, certainly with me, and I think with many of my colleagues, we were very young. A kind of sense of reverence about, you know, how could the brain guide behavior and mind, brain, you know. Those questions. They were, they were looked at with a lot of respect. And so, part of the freedom that came was, one method after another opened up. Suddenly, in Hubbel and Weisel were recording with micro-electrodes. Jerry Lettvin was here. And they were finding cells that seemed to be related to perception. To actually how you see. You know. This was, this was somehow captivating. This was beyond a reflex in the spinal cord. Men, well, chemicals, where they had been, there's some chemicals, right? And I love that, I've always loved chemistry.

But, and it influenced me a lot. But suddenly you could say, well, no this is a neurotransmitter and the way a synapse works is, this stuff is spewed out. And if you have too little you might get Parkinson's Disease, right? So, again in the same time, it was a sense of empowerment. That bit by bit came. And, probably, another important thing is that how can I put it, I'll put it very directly. We were coached, almost, just short of being coached that pure science is, is the kind of science to do. Don't think about an application. Don't think about the consequence. You have to think about, you know, if it's not pure mathematics, at least it's with your whole being trying to explore some problem in nature. Physical nature. And, well, bit by bit it turned out that gee, one thing after another might have a heck of a practical application, and again MIT of course being MIT's technology, MIT was just poised.

So, took a long time in neuroscience. MIT was very slow. But in general, in spirit, MIT, I think has always been ready, willing, wanting to lead in turning some, some piece, some intellectual pursuit, to some output. Translational is now what it's called. So, that spirit, an entrepreneurial spirit, and you could call it partly, but not entirely, that's been around here. But bit by bit, as I say, that's liberating. Or at least, it makes you think, well, gee maybe we could ask. What is the nature of thought. And then bang, along came yet more methods and imaging and so on. So, it was, it's a great time now in this field. It's just awesome. It's wide open. Just open. And I can't tell you, I don't think anybody knows how the brain works. I don't think anybody, I don't care who you talk to. I personally wouldn't believe them. We don't even know, we don't even know the frequency of the signals that are important. I mean, I mean that literally. And 10 years ago, I would have wondered what to do, what does that sentence mean?

But what it means is that, we've become used to thinking that the main activity of the brain that's important are these little spikes. Little digital spikes. But we've always known, or we've known from the last century in the `30s, that there are these waves. And oscillations in the brain. That are like EEG and sleep-wakefulness patterns. And AI people have been very interested in them for a long time. But most people just kind of set that aside. Well, now, they're hot as fire. Because maybe they're another way the brain is signaling to itself. One part to another, by, kind of, like a carrier frequency. And then maybe, one of these little abrupt little spikes. If it hits a peak in the carrier frequency it's more potent.

I mean, we don't know whether that's true, it's an idea. But it just shows, or another, let me give you one more example. So, a long debate in neuroscience from way, way, way back when we knew almost nothing, in fact a classic debate, was whether the nervous system is a sensation where there are the cells are physically continuous with one another through some little strand of cytoplasm. Or whether they're discrete entities and their only interactions are through the circle of synapse, where electrical impulse comes down the end. Chemistry occurs. Molecules are shipped out, into this space. The next cells receives the molecules, by adapter molecules. And more chemistry occurs. And so on, and so on. And more electricity. Well, now it turns out that probably a lot of the communication goes on not in the synapses. But maybe near them, but not in them. Well, that's got to be a totally different kind of communication. Again it's going to be more punctate, or digital, or more analog. And on and on, I could go. People are debating, is the vasculature important for the brain's work? Because all these imaging studies are based looking at blood flow. They're not looking at what the brain does. At where the blood flows. So, this is all part of the freedom that, at least, freedom to fiddle around. And freedom to think that maybe you could solve anything.

INTERVIEWER: Are those stories and the focus on the problem that you described as being coached into basic research, if you look at that problem and see what comes out, does that in any way mirror or remind you of the way that your dad particularly approached nature, and the way that he would explain to you what was going on? Was there, is there, sort of a continuity in approach to science that goes back to his training?

GRAYBIEL: No. See, he was a physician as well as a scientist. And so I think he represented both sides, both the pure and the applied. And he got interested in, he worked in the heart. He worked here in Boston. The MGH. But then in the war was sent to Florida. And that's where I grew up. And down there he found that, or it was found, that pilots were crashing. And my father had worked at the Harvard fatigue lab, and they figured the pilots were tired. So they said, please solve the fatigue problem. But it turned out they were disoriented. Because of their vestibular systems were being stimulated in unusual ways, due to changes in gravitational levels. As they flew around. And so, he ended up doing a lot of work under the vesibular system. Which led to a lot of work in the space program. So one of the fun things I got to do when I was little was to go to Cape Canaveral. And I was there when John Glenn lifted off. And, I was kept, again, it's a women's thing. I was the daughter of the physician to them. So I stayed with the wives. Because it was very exciting. It was wonderful. It was wonderful.

INTERVIEWER: That's amazing.

GRAYBIEL: Stay up all night and then it doesn't go. Stay up all night and it doesn't go. Day after day.

INTERVIEWER: You didn't want to be an astronaut, though.

GRAYBIEL: There weren't any. I mean, stuff like that never came to my mind. That's what, maybe I'm just backward or something. But women weren't astronauts, you know what I mean? It just, so I'm afraid. So no, I never wanted to be an astronaut.

INTERVIEWER: Again, I'm not holding that against you. Or the not burning your bra thing. That's perfectly okay with me. It's just interesting, this, this journey from one way of looking at things to seeing the world as completely open as you describe it. I mean, in the course of two minutes we've gone from, there is one way of looking at things, to also saying, it's completely wide open. If you're thinking about --

[OVERLAPPING VOICES]

GRAYBIEL: Yeah. And this is just, I mean this is so old hat. Because now everything is open. That's what I love about now. I mean, internet, you know. YouTube, the whole bit. It's just, it's fabulous. So, so I mean, I guess it's very good, historically, to document all of this. But it's going to seem so bizarre. I mean, anything that you and I are talking about to anybody who's under, I don't know what age, but, it's just unimaginable, isn't it?

INTERVIEWER: How did you find a way to MIT?

GRAYBIEL: So. I had decided to go to Tufts. Because I was working on a project as an undergrad. And I wanted to follow the project. And then I heard about MIT. I heard they were working on the brain. And I was extremely -- by then, passionately interested in learning about brain and behavior. In fact, at Harvard I tried to get them to let me do a combined major, in biology and psychology. But they wouldn't let me do it. It was, no. Now everybody does that, but it was --

INTERVIEWER: Which did you choose?

GRAYBIEL: Biology.

INTERVIEWER: Why not psychology?

GRAYBIEL: It was very soft. At that point. It was. But I did, I mean, I heard fantastic people. George Miller and Jerry Bruner. And Roger Brown. And many people like that. But there were, I was pretty busy. I mean, I took a lot of, in those days, we had labs, I had lab every afternoon. So, by the time you got done with classes all morning and labs, there wasn't a lot of time. But, so I heard, and I heard about Teuber. This phenomenal guy who had this young department, you know. And I started going to the colloquia, here, on Fridays. And I don't know whether you've ever heard of them. If you've visited. But, they were awesome. People from all over came here on Friday afternoons to a little room, in a little ex-automobile factory building to hear these people speak. He had everybody. He gave long historical introductions about the field and about the person, and so they were, it became clear, this is pretty interesting.

But, I had thought I might study insect nervous system. Because they're at least invertebrate somewhere in there. Because it might be a simpler situation. Might be able to solve something. And, so I got in here twice, actually. But I didn't go. I stayed at Tufts for a while. But I'm very glad I came. But it was just the force of what that, what that fellow did. And it was, you know, MIT had been so strong in physics and math. And as I was trying to say earlier, there was brewing this fantastic group of people interested in the brain. And in computation, really. But they were quite separate from the people who worked on the brain. Or in psychology.

So it was good to have a psychology department. But then to, I mean Jerry Lettvin. He and I have done experiments together. Again, an older person being awfully nice to a little one. But, I mean, these guys were, they're fabulous people. So I learned a lot through them. And, Walter Rosenblith, I hold the chair in his name. It's a tremendous honor. These are, these are people who really thought about what, what is the essence of communication. And I, for a long time, have thought of the brain as a communication system. I was caught up short by somebody from the old Bell Labs, saying, no the brain is not a communication system. But, a lot of communication goes on in there. And, again, this very attractive about MIT, this blending of a more formal computational, or, if possible, mathematical approach.

And then biology. That's, I'm sure, it's the way to do it. Not sure exactly how, but, put a lot of smart people together, you know. And, I think actually that's what's going on now.

INTERVIEWER: A lot of people who conducted brain research did choose to go the invertebrate route. Kandel, you know, finding giant neurons in sea slugs, and those kinds of things. You chose to go straight at the human brain.

GRAYBIEL: With, I was very worried about doing that. Because I had, I was very lucky. I was exposed to a man named Kenneth Roeder, a German. I would say that three quarters of people to whom I was influenced or exposed, and became influenced by them were Europeans of one sort or another. And this man, he had discovered that the moth has two sense cells for hearing. Just two. And he tried to go from those two cells into the thicket, the invertebrate nervous system is, it may look nice in a picture but it's really actually very hard to work with. And then you go out and, you know, the bird will eat, I mean, a moth will either come avoid a bat, or go toward a mate. So, he was trying to solve that problem. And had the idea of this extreme simplicity would help. And just almost did it. But, the human brain is such a mystery. And, I don't know about you. I think studying gravity would be another big one. Or in general, studying the universe, would, maybe that's even better than studying the brain. But the brain, I would put those almost on the level in terms of interesting and very, very important things to study. So, it became clear.

So why didn't I go right onto brain of human. Was there, was no adequate method. But I had learned anatomy here. And I was interested in chemistry. And it dawned on me that if you could see the distribution of the chemicals in the brain, you know what you could do, you could go from an experimental animal to a human brain. And so, that's what I set out to do. And I actually did it for some time. I would do an experiment. Find something in the animal brain. Try to figure out a neurotransmitter that might mark that phenomenon. And then get a human brain. And try to do that, get the same stain to work. Which would then, you know, it's indirect but it's better than nothing. So that was a, that was an amazing time. Because there were no rules. And, so I was just this person at MIT.

I would go, it was amazing. I'd go over to the MGH. I found out where the diener was. And I went and I asked if I could have a human brain. And pretty soon we became friends. And I went over there a fair amount. And was able to obtain very, very, very fresh human brain specimens. And that's where I began to see, I saw autopsies. And did my dutiful fainting spell stuff. But that was, that was really incredible. Because we did, I mean we did find, some things in human brain that I'm very much hoping will be useful in human, trying to help human disorders of certain parts of the brain. So, but, so there wasn't a way to actually go all the way then. Now I don't know now how far human brain imaging is going to take us. But we're only at the very first wave of that. So, I think, I think we're there. We're just there. So.

INTERVIEWER: Eventually your research began to focus more narrowly on a particular location in the brain that was as mysterious as everything else. But possibly narrowed the problem for you, simplified it, made it more manageable. How did you come to fall in love with the basal ganglia?

GRAYBIEL: So. How could anybody not?

INTERVIEWER: Yeah, I know, it's like certainly, yeah.

GRAYBIEL: I got it bad. I've really got it bad. It was this, I'd been working on sensory motor things. And I'd gotten closer, I've always liked to be in the middle. Like, not fully sensory, not fully motor in what I study. So I had always before worked kind of in the middle. But in the sensory motor middle. And then I found some things that, actually implicated basal ganglia, or some pathways related to the basal ganglia. In the control of eye movements. That was interesting. And I knew I'd been trying to get this. Can you use, kind of, chemical neuroanatomy which didn't exist, to get at the human brain. So I did some, around then, dopamine had been found to be implicated in that transmitter, in Parkinson's Disease.

So the big idea then was that dopamine is fought by acetylcholine So they're in a balance. So, you have too much of one, you get one thing, you have too much of the other, you get the other thing. For example, schizophrenia or Parkinson's. So I went after acetylcholine and stained human brain and a ton of different, the animal kingdom, of brains for cholinergic markers. And again, it was very exciting. Because see, our concept of brain has been, and still is, that we had this outer rind, the neocortex. Which is the stuff of higher cognition. That's where we do our math, that's all the high-level stuff goes on out, in, in the outer rind. And then, deep down, underneath that, either things are serving the cortex to prepare to, for action or they're serving the cortex to prepare the information so that this cognitive machine can take over. And what was discovered when I was a student was that this beautiful cortex has a magnificent architecture. It's divided up not only into layers, that's been known for a hundred years, but little columns like Greek columns, and at the intersections important things went on. And you could have columns that saw things from one hemi-field of the right eye and the left eye and so on.

So what we found, down in the deep brain, was sort of like that. It was in effect that, my goodness, the deep brain isn't just a homogeneous little ball of low-level cells. It actually is a magnificent architecture. It's just nobody had ever seen it before because they didn't use these chemicals. So that was a trick. To see it. And then once we saw it, it was, gee, our lab and many many other labs started staining for everything. And it turns out that just about every molecule we've got in there there, and there are a lot of them, are divided into this kind of architecture. So that was, that was exciting. And then the, but the hooker was that we still had, it's the deep brain. So it's hard to get the microelectrodes in there. You can't see this part. With any method, this architecture is too small, to this day to be seen with fMRI.

INTERVIEWER: Really?

GRAYBIEL: Yeah. It's really, you know, it's. But we're almost there. So we are, you know, we're trying. We're trying to push it as far as we can. As best we can. But then it turned out that, again, MIT's so special. There are, a lot of computational people who were interested in learning architectures. Okay? And that's what I meant by, I mean, that's one way to figure out what the brain does. But we saw connectivity patterns in relation to this architecture that for all the world looked like certain computational models. At least in their schematized views. So I talked with Mike Jordan and some other people, and I got, I completely fell for it, and decided that the striatum and the basal ganglia, the input side, great big structure, huge, in a human, this is a learning, maybe, maybe it's a learning machine. And I actually still think that. But that then meant we had to change. We could not simply know where there was this architecture. We had somehow to get in there and get at what it does. And the way to do that, the only way that we really have so far is with microelectrodes or doing imaging. Which can give you an idea function but without this fine detail that maybe to catch the whole thing.

INTERVIEWER: The trajectory of your research was, first of all, you found this complexity. This anatomical complexity, which suggested this is important. Then you began to look at the disposition of the chemistry.

GRAYBIEL: Right.

INTERVIEWER: And began to see patterns that suddenly were familiar to some of the computational people across campus.

GRAYBIEL: Right.

INTERVIEWER: You began to discuss whether that similarity was real. A theory emerged about this sort of communication, learning system.

GRAYBIEL: Right.

INTERVIEWER: And now you're just getting to the point where you may be able to actually experimentally, on a broad basis, test that theory.

GRAYBIEL: Right. So, let me just say, this, instead of narrowing, this all started with a question of, well, you've narrowed down on no, it turns out that when you go deep you go broad. And so, first we've had to develop and borrow these multiple microelectrode methods. It's very exciting. You try to get as many electrodes in as you can. To record simultaneously from lots of neurons and record over a lot of different frequency ranges. So you get all this, you know, digital stuff and all the oscillatory activity. And because of the learning, and because of, I mean, the basal ganglia also, I must interrupt myself, the basal ganglia are also interesting is, I hope we can talk more, because on the one hand it is turning out, as I've learned more, the basal, and as the field has it, the basal ganglia are mixed up in many, many, human disorders. Many --

INTERVIEWER: Let's list some of those.

GRAYBIEL: Well, there are the ones most people know about. Kind of movement plus disorders. So, Parkinson's. Huntington's Disease, Dystonia are the three great ones. And then neuropsychiatric disorders. Obsessive-compulsive disorder, Tourette, ADHD, or ADD, Autism, maybe depression, probably depression, and unmedicated schizophrenia, maybe. We're going down the list of certainty now. But, in other words, not only neurological disorders that have to do with movement control, which basal ganglia used to be thought of as one half of the movement control system, that isn't the cortical control system, which is the kingpin. So, the pyramidal track, as you well know, controls the spinal cord and so on. But then there are two great brain systems. The cerebellum and the basal ganglia that help that. Well, they help it, yep. But they may help it in ways that have to do with plasticity. Which is so key to any kind of action.

So for the basal ganglia, what's really happened is that the, one whole side of basal ganglia work has blossomed as more and more it's been realized that, well, I mean, they are in, these loops with the cortex, I haven't told you what they're like. But the cortex and basal ganglia are constantly communicating with one another. It's just a set of massively connected circuits. And the one influencing the other. And so these, now, we would accept, I think the whole field would, are involved in these kinds of disorders. Bipolar, probably as well. So then the other part of the field, which was ignored for a long time. There were psychologists, old-fashioned psychologists, saying that if they made lesions in the basal ganglia, then the animals had trouble with something they call habit learning, or learning mazes, or something like that.

And so, a couple of really amazing things have happened. One is that people discovered, not at MIT at all, that this dopamine's so important for Parkinson's and so on, it is a transmitter in a system that basically responds either to primary rewards like chocolate, or to some conditioned stimulus, it represents a reward. Or it's a predictor of a reward. Or maybe to, and is, but that signaling is influenced by how certain one is about a reward. So it's become the, so now we know that, the place I work on which is heavily influenced by this dopamine system, for example, will light up in fMRI studies when someone sees a picture of someone they're in love with. As opposed to someone they're just friends with. And so, there's a whole, there's a whole side of that that now we can appreciate the basal ganglia is somehow very sensitive to, maybe it's reward and punishment, most people think mainly reward, but somehow to reinforcement. So you could imagine a system that, if you're constantly monitoring and then kind of adjusting the gain on, on pathways that, that help you decide what you're going to do. Whether you're going to do it again, or which path you're going to choose, you know. At a decision point. That if that happened over and over and over, then you might develop a habit or a pattern. And that's become quite a central focus of what we do now. And it's unbelievably closely related to these clinical conditions. Which is what is, it's really seriously exciting. It's just, it's very, very exciting.

INTERVIEWER: Addiction is suggested.

GRAYBIEL: Yeah. So that, so what happened with me is, it went from these chemical architecture stuff, I figured it might be a learning thing, architecture. I found that was generalizable to not just the neurochemically identifiable parts of the system, which was a big step up, and then I had heard that someone in England working in the spinal cord had made a stimulation that would excite the spinal cord. And he had used a method to look at very rapidly activated genes. They're very rapidly activated when the cell surface is stimulated, or even a single cell. And that was the beginning of, of a method that now is used by many people. But this fellow had been early on doing it. And I just happened to see it and thought, oh my goodness. So I tried. We gave an animal a shot of, a rat, a shot of amphetamine. Then we chopped up the brain and did more of this chemical anatomy type visualization. But this time of genes. And darned if we didn't find these compartments that we had discovered all those years before.

So that was, that was exciting. So that began a line of work that, it's curious, things are coming together. Live a long time or something. So, that was absolutely cool. So then, which I knew nothing about drugs, I'm still, I'm no expert. But, obviously you get addicted if you're exposed over and over and there are beautiful routines for studying that. So, we picked up those and did this to animals. And we found it, we've now found it in mice and rats and monkeys. That if an animal's given this drug more and more and more, cocaine, amphetamine, we've used a number of different ones, that this pattern, which emphasizes the stuff we discovered way on back, that pattern, that emphasis gets greater and greater. Well, that's interesting. But then I was very lucky.

Because a fellow came to the lab, as a postdoc, and he had studied what behaviors are induced when animals are given such drugs. And so we did more experiments to see whether, when you give these drugs, of course, to animals, they get hyper. They develop what are called stereotypes, or repetitive behavior. So a little rat may rear, over and over endlessly. Or chew on something endlessly. And monkeys do it. We do it. We all do it. And in experiment after experiment, how repetitive, how stereotypic the animals were, seemed to be correlated quite amazingly closely to how much this pattern was emphasized, the striosomes. And so, that was interesting.

INTERVIEWER: Wow.

GRAYBIEL: So suddenly we had a situation where, see, I had been trying to stain human brains right along. And we still have not, well, anyway, I don't get too sidetracked. But it became apparent that, so we did some more old-fashioned tract tracing. The last I did with, long time ago. We, we wanted to know what parts of the cortex in a monkey would preferentially target this, these compartments that we called stridal bodies or striosomes. It turned out of all things, the only two places we found were the two places that are especially activated in drug addicts, on the one hand, and in people with OCD. So they have abnormal activity in this far interior singulate cortex, caudo-orbito frontal, and the striatum, especially the head end. Of course, striosomes, or these compartments, are very big. In a human. So, it all, you know, it's very enticing. All of it may just fall apart and it's just a dead end but maybe, I hope it's not. So.

INTERVIEWER: But it does seem as though patterns of movement, and patterns of behavior are localized in the basal ganglia --

GRAYBIEL: Yeah.

INTERVIEWER: To some extent. And the brain appears to consider them at least at that level, equivalent. They're different pieces of information.

GRAYBIEL: That's right. That's right. I think patterns of thought and patterns of movement are controlled probably in much the same way. And exactly what you said. So, a propos of what you said, when we first, we have not yet with microelectrodes, been able to find these compartments. But we're trying. We're trying as hard as we can. And we've got, I've got some wonderful new people who are, we actually have a, I think a real, I don't know, we're all excited about it. Trying, again. But what we did find, we did this very simple, it's just what you're talking about. We put rats in a T-maze, just like psychologists use. And they have to, a little door opens and they run down this maze. And then they either feel one of two textures under their feet. Or they hear one of two sounds, through loudspeakers. And depending on what their cue is, they should turn either right or turn left to get a reward. And we literally just put electrodes in the sensory-motor striatum of these animals. And did that chronically, as they learned. And oddly enough, it's so hard to do, was, it's not any more, but it was so hard to do that very few people had done that. Chronic, day after day recording. You know, bring them up. Put them, take them to school every day and record.

And I have to tell you, what we found was absolutely amazing. Just, and we found it over. I know it's true. I think it's true. So when they start out, and they're running, you do it, like, these, 40 times every day, every day. The cells in the striatum, the nerve cells, are firing on average, kind of all through those runs. They just, as though everything is interesting and everything is, you know, important or somehow they're going to respond to just about everything. Not every cell, but on average, take the whole population, try to record from thousands. Okay? And then as they learn, the activity, right when they start out and right when they get to the end, it's pretty strong. And the activity in the middle gets weaker and weaker. So it's like a, like a, get it going, and then don't worry about it. And then get it stopped, or get to the reward. It's as though you bracket the whole behavior. It's exactly what you said. And so, then I begin to think, well, maybe one of the things the basal ganglia do for the cortex is, they help decide if this is looking good. You know, I get rewarded when I do this, so I want to do this more. Basal ganglia help whole behaviors get kind of packaged or chunked. And then they ship the information off. Then the cortex is the grand master and can execute it however the cortex wants to do that. But this guy is constantly kind of helping make more probable one or another, whole stream of behavior. Or a whole stream of thought. And so if you think of it that way, that's interesting. So we are, we're trying very hard to track down what is it that exactly that makes that pattern happen. And we're doing that in different kinds of animals.

INTERVIEWER: Your lab has a lot of undergraduates. Is that because -- well, what is that because? You're known as a popular lab, on campus.

GRAYBIEL: Good. I didn't know that. I'm very happy. So, well, we like, they're great kids, right? So I mean that -- I actually have been told that, it's stupid that we do that. Because it takes some time. But I always have done it, as a matter of fact. And partly it's, I just don't want to sound, sort of, I don't want to sound, the way I don't want to sound. I don't want to say that, you know it's really nice to help people. But it really is nice to help people. And that's the way my folks were. But it's more than that. It's that, some kid comes in, and he's fascinated, you know. Gee, I'm interested in the brain or something like that. And so, why can't they at least get exposed to it?

And I will say, we've had a lot of girls. Because that's one of the ways I've tried to help, so I've had even high school, had a fair number of high school girls. And when I was very young, at the lab was really silly. Because we had different age girls. Who, see, I told you, I was never exposed to any of that, except through the privilege of my particular advantaged upbringing. But why not let them see what it's like. And so, in the end I was so surprised. They had to get me to tote up all the UROPS and I guess we have had a lot of undergraduates. And a lot of women undergraduates in the lab. And I can't believe them. They're all beautiful, they're all brilliant. And they're all able. And almost every single one of them comes in and does something just fantastic. It's just, it's really great. So I love doing that. I love, I used to do it all by myself. But now, it's only in the last little bit, we kind of like, one just works with one person sort of thing. That's the way labs usually do it. But, I used to do it with them myself. I don't, I can't say I'm actually working with an undergraduate. But I talk with them and, you know. I think it's just, and again, it's when I was an undergraduate, there was very, very little of that. But it was just a pure fluke. But the year I went to Harvard, they started the freshman seminar program. Which is a laugher at MIT because, you know, it's everybody does that sort of thing. But not at Harvard. And so I was accepted into the freshman seminar program in chemistry. And it was bizarre because I'd never had chemistry. I didn't know chemistry from Adam and --

INTERVIEWER: Home Ec. There's a little chemistry in there.

GRAYBIEL: Exactly. I love to cook. But, there was this wonderful man, Eugene Rockell. Bless his soul. And he took me in. Everybody else, I think I was the only girl. I'm sure I must have been. But they were like, you know, basement chemistry setups. And then, I'd never even seen a crystal. I was dazzled. Oh, I loved it. I just adored it. Just, so, maybe that's also part of it. I just, it's really great to let them get excited. You know?

INTERVIEWER: Young undergraduate, young --

GRAYBIEL: Yeah, yeah. But I mean, any student.

INTERVIEWER: So you said something on, like, it took you a really long time to feel as though it was okay that you were a woman doing science. Maybe you misspoke, but was a point after a while when you looked back and said, oh, I'm comfortable with this now, and maybe I wasn't so comfortable with it earlier on.

GRAYBIEL: Well, I don't want to paint a one-sided picture. I mean, how can I put this, it also can be fun to be the only woman in a, I had a a lot of fun at a lot of different occasions. No, it's more that all I meant to say, really, was that it was unusual to see what, especially when I was an undergrad, and then even here. There are a lot more men in the faculty than women, when I came. No, I mean, I've always felt as though I could do that. But.

INTERVIEWER: When did you notice it wasn't unusual? Any more?

GRAYBIEL: It's very field-dependent. I mean, it's still unusual. I'm amazed at, I think, in math at MIT, there's so many women. It's just great. I just found that out. But I don't know. I've never, I'm sorry, I haven't kind of made, being a woman kind of like the main thing in my identity. I've been pretty interested in just doing whatever I was doing.

INTERVIEWER: Were you, --

GRAYBIEL: Except trying to, I feel very strong, this business of helping the young ones. Because my, I'm sorry to interrupt you, but my view is, it's certainly with me, but I think with many, many other women at least in my era, and I still see it, is that they don't really have that fundamental self-confidence. You know, I can do anything kind of attitude. And so, I try to, the ones who need it, I try to give it to them. Because I think that's -- Talk about, now that is empowering. If you just, and I think a lot of women are to this day timid. At least in some fields.

INTERVIEWER: Were you conflicted when Nancy Hopkins came to you, wanting to know, first of all, your experiences and secondly if you'd participate in this report?

GRAYBIEL: Oh, no, I think it's terrific what she did. It's, I think she's done a, she did an amazing job. And I was one of that group. And I, I mean, I think she, I've had, she's had women all over the world come to her and write to her and invite her and so on. But I had a fair number of women, myself, all over the world who've come to, you know, how do you guys do it. And can you really do it, and I think it's magnificent but she was able to. It's awesome, what she did, actually. Is, we never even knew, I mean, I didn't know that I was that underpaid. Or. I knew certain things about space, but she did a lot of good.

INTERVIEWER: How did the institution of MIT either hinder or help the process of solving this problem of gender equity? And how has it changed the institution.

GRAYBIEL: I think, honestly speaking, MIT has come around. I think ex-president, Chuck Vest, really embraced the issue. Kind of, said this was one of the main achievements of his administration. So I think MIT's tried very hard. And now, I mean, we have Susan, so that's very good. It takes time to, you know, it does take time. Because you have to go, you have to find enough people. To fill the slots. But, I don't know. I think it's okay, that I think it's going to take a little more time. I'm afraid I'm cynical about it. We're going to have to see. I'd like to see how many people, or how many women starting out now, stick it in the field. And, you know, become accomplished professors or whatever. Businesswomen or something. After a while. But gee, the Institute has changed radically. There are huge numbers of women now, and as I said, they're doing wonderfully. And they don't seem depressed, and working all day and all night. And sitting in a corner, you know they just seem like they're out doing all kinds of other stuff too. It's just, it seems, it's just great.

INTERVIEWER: Nancy describes that it was fairly clear to her that to have a life in science she would have to forego other aspects of life.

GRAYBIEL: Right.

INTERVIEWER: Did you see that tradeoff?

GRAYBIEL: No. I'm, well, in one way yes. I mean, it took a long time to decide about children. I was scared that we couldn't. I couldn't do both. But we wanted children, we didn't have children, but we sure wanted children. I very much wanted children. Didn't have any. But, I'm happily married to the same guy an MIT undergrad himself. And I don't, it's, but and so I have, another thing my lab became noted for was the number of children born to members of the lab. Certainly including almost every woman. And so we have a rogues' gallery of kiddie pictures. And the water down the hall was called fertility water, all of those things. So, I, I think it's, why shouldn't people be able know manage all this? And the actual, I mean, the thing is that for families where the they both try to help and especially if they, I don't know. It's still difficult.

It is -- I mean, Nancy's got a point. And I think anybody who, again, it's field-dependent. If you don't have to be in a lab. If you can sit with a laptop. Do math, you know. Something like that, then I would think it's an easily-doable thing. But if you're really a research scientist, you have to be in a lab, then it's difficult. But women are more and more doing it. Their husbands are more accommodating. Maybe we're getting better childcare. I mean, that's one of the things MIT's trying to do. Has done. That's great. I mean, I know women who work in the building I'm in, and pop their child in the daycare center in the next building. You know, can visit the child at noon. Pick it up at 5. And that's it. So, oh, it's tough. But a lot of things are tough.

INTERVIEWER: Is it personally vindicating to your choice of study and the big questions that you decided to embrace that the president of the university is a brain scientist?

GRAYBIEL: Personally vindicating. I celebrated. I think it's just wonderful, but personally vindicating, no. But she's fabulous. And, --

INTERVIEWER: Certainly biology's not as much of a fringe as it was when you first came here.

GRAYBIEL: No, no. So I guess, I didn't emphasize that enough. I mean, the changes at MIT are really, are profound. It was a place for math and physics. Engineering, architecture, and so on. And then biology became so successful. So successful in the new wave of biology is neurobiology, right. And neuroscience, more in general. And so, if it's a vindication of anything that she's here, it's a vindication of the success of that field. And then her own, her own incredible ability. This is one talented lady. So, that was a good move. And it, to me anyway, it seems very natural. But do I notice it every time, that wow, you know, there she is? Of course I do. But I think it's great. It's true everywhere, right? I mean, it's true at Harvard. Maybe true in the United States.

INTERVIEWER: Right. How important is your relationship with Walter Rosenblith?

GRAYBIEL: Oh, he was, as I said, I'm so honored to have that chair. He, he was the, he man, thinking about the brain as a communication system is sort of, Center of Communication was a book he edited. It was very famous at the time. And so, he sort of stood in my mind for that hard, more engineering or computational side of things, early on. And signal analysis. And then, as he and Jerry Wiesner came to run the place. They were terrific to me. They were, trotted me out to talk a lot. So I gave a number of talks. And Walter was always very funny. And teased me a lot. So I thought I enjoyed him personally. He's a very, very talented man. But he was not, kind of, among the group in the department that led to this neurobiology part. He was the other side. And now the two have come together, which is, almost come together. Coming together. So he was an important man.

INTERVIEWER: You won the National Medal of Science in 2002. You were also the recipient of the Killian award, aside from 2002 being an exciting year, how do you evaluate your recognition? Partially in those awards, but in terms of the field, what is it about your work that you think is worthy of recognition? That answers a specific question, that is a contribution, that it's clear and discrete?

GRAYBIEL: Clear and discrete. So I told you we discovered some things and that is ongoing with the gene work we're doing. To tell you the truth, I was absolutely amazed at each award. And beats me, you know.

INTERVIEWER: Oh shucks, Florida Panhandle coming right out there.

GRAYBIEL: I'm very lucky. So, it's, I haven't solved, I'm on the way, really I'm very, very excited about what's going on right now. So, we've added. I mean, there's no doubt, our lab has added something to this, we've added a brick, right? But there are very few single discoveries that, we all know that, right, which completely transform a field. I've not to my knowledge made such a discovery. However, I am extremely interested in whether the relation between this kind of architecture and some of these human disorders can come together. And that may not be so much a, I don't know how you'd put it in terms of a discovery, but it might be very helpful. So we're hard at work. That's where we're going now. I'd like what we do, I now embrace the idea of that pure science can be applied science. That's exactly what it can be, that's my new idea. And so, that's what we're gunning for. I want to get some of these disorders. I'd like to work on genes, or work on all these things I've told you about. Seeing if we can really hit something that will help.

INTERVIEWER: Do you think these fast transforming genes are a key to understanding a whole mechanism of communication in the brain?

GRAYBIEL: Why not? Yes, I do. And that's a general idea by now in the field. That there's a whole cascade of genes that act in different time domains. And that ones can set off others that can then go back and influence the ones. Biology is multiple control systems. One on the other, it's just, it really is, it's profoundly, it's, again, awesome. It is awe-inducing. Yeah. And, actually, one of the little things we've found that we're pretty interested in now, at the Broad, one of those early genes. But we have now found, I decided that if we had to clone genes, it's funny coming in my lab, not being raised as a micro-biologist but I did go to school. And learn some. And we now, in collaboration with some terrific people David Housman is one. We've cloned some genes, we wanted them selected for this, the basal ganglia. And the striatum. And, gee, we've hit on some real doozies. I hope. So they turn out they're expressed, again, in this compartmental way.

And amazingly enough, if you knock them out which a wonderful young woman in the lab is doing, if you make these knockout mice, they have abnormal stereotypic behavior. Or perseverative behaviors. So, can we help in autism, I don't know. Can we help in OCD, I don't know. But we are really at it. And the other funny thing, it's funny how these things are all, it's just as though, just have a wonderful sense that things are coming together. Because these two that I'm particularly talking about, they're regulated oppositely in Parkinson's models where, you know, in people if you give them levodopa therapy, Sinemet, then a lot of the people unfortunately develop abnormal movement patterns, called dyskinesias. So you'll see a Parkinson go from unable to move to waking up, to having all kinds of choreoathetotic movements called dyskinesias. They're awful. They're the biggest problem in therapy. And in a dyskinesia model, the amount our genes are regulated, the two of them, each one of them, actually, is correlated with the amount of dyskinesia which is perilously close to the amount of stereotypy related to, you know. them.

INTERVIEWER: So it's trigger meets trigger meets trigger.

GRAYBIEL: So, yeah. In men we find in Huntington's brains. I actually worked on the brains of Huntington's patients. These compartments are differentialy affected, depending on whether the major symptom is a mood or a motor symptom. In our model of Parkinson's now we're just beginning to see, these genes now differentially regulated. So, and now the bipolar community is interested in this. So, to my utter amazement, we're giving animals lithium. It's just, this field is bubbling. It's just bubbling. And so I'm very, I mean, there is a sense in, aren't we lucky. People who get to do this kind of work. I mean, I just, what I want to do now, I want to help people. And my tools, my ammo, is to do this kind of work. And I don't know whether we'll get there, but we're, so many things are coming together that I sort of think if we don't, you know, money's nice, girls. Well. It's great.

INTERVIEWER: Is that what's kept you at MIT all these years?

GRAYBIEL: That's strange you ask. I have a terrific guy in the lab. Who made that picture. And he said, so you're going to go get interviewed. But the central question is, what has kept you at MIT. And I hadn't really thought of that. But I have been offered some other places I might, as you can imagine. But for no other reason than they needed a woman. But MIT is just too cool. It's really, it's the, what is the essence of MIT. It is a place where you can go ahead and be smart, you know, you can go ahead, I think for a lot of people, go ahead and be you. And just kind of go for it, you know? Just, I had a kid who came in the lab and said, gee I have an idea, you know. It's, I want to make a better robotic wheelchair. And then, people are doing that, so I want to get in an automobile and then I want. He's this little kid, he's running rats in our mazes. And he's thinking these thoughts. And I could pick up the phone and say, why don't you go see, you know, the head of instrumentation lab. And find out what they're doing. It's these kinds, this is MIT. But so is music.

I mean, MIT's a very interesting place. So I think it attracts people who are, smart. A lot of them are smart. A lot of us are rough diamonds. But, that's okay. That's okay. So it's a, I think that there's a sense of energy at MIT. Something's always going on. And a sense of excellence. A kind of expectation of excellence. And of course, every university aspires to that, I'm sure. But this is, there's a kind of high concentration of that kind of person. And it makes it interesting. We're all a little bit odd, right? At least a lot of us. I would certainly include myself. That, but that makes for being interesting.

INTERVIEWER: Is there a way to answer the question, what is MIT's role in the world?

GRAYBIEL: Gah. Its role is always going to be changing, right? But I think this, it's nice to have a few places in the world that do have that set of standards. And so openly declare it. You know, if you can think anything you want here. You can do anything, right? You can put a car on top of the dome. Literally, you can do just about anything. And so I think that attitude, put in the context of some intellectual framework, I'm big on you know, pushing the intellect. I think we don't use our brains anything like, I just, that's the big question. Why we don't. Why aren't we more motivated? So I think part of what's good about MIT is it keeps a very high level of motivation in its people. And I'd like to see that spread. I think that's a giant problem with human beings. And it brings about a lot of our difficulties. And it's, of course I always can relate that to what we do. Because there is this apparent disconnect between what we think and want and intend. And, you know, I promise today I'll be different or better or whatever, and then what actually comes out of us.

And I don't know the degree to which it's different parts of the brain unable to talk to each other. Why is it that some people work feverishly? You know, why is it? I can't believe it's just that they're smarter than other people. Or some people are passionate. Passionate to paint, passionate to write music. Or whatever. Play the banjo. You name it. Why? And then other people just kind of, they just can hardly get through a day. And wouldn't it be wonderful to have them come up. Have them experience more of what the other people are experiencing. And so MIT, it represents that. In a very real sense. And I think it's great for kids to say, gee, could I ever get into MIT? I think it's wonderful. So.

INTERVIEWER: You know, you've enumerated in the course of this hour and a half, probably about 30 or 40 fairly big questions about the brain, how it works, what is thought. Is there one question in particular that you would love to have a part of answering, that is one of the big Ann Graybiel questions about the brain?

GRAYBIEL: Any one would be fine, thank you. But I think this one I just was talking about. That we are, there are disconnects between some level of thinking and planning, and deciding. Disconnects between some of that and some of this deep, core stuff that, that actually ends up driving our behavior. So I don't think, how many people do you know who actually do what they think they ought to do? Or want to do? Or, you know, decide to do. How many people like that do you know? So, I have a, a feeling probably shared by many people in brain work, that there may be just small, little adjustments that we need to make. In either motivational systems, or somewhere in those little neurotransmitters that are connecting the cortex with other parts of the brain. Just minor little changes that would have the machine kind of work optimally. And, although some aspects of our machine and our brain do work optimally. It's amazing, they're actually studying that. It's amazing that you can put a monkey to a little task that he has to learn all by himself. You never teach him a thing. Not anything. And he will learn that simple little task, ours is an eye-movement task, to what a high-level physicist computational guy, my colleague, tells me is the optimal solution. The brain just does it. So, Norbert Wiener said that all, any early learning, all early learning, is a miracle. It's a miracle that we can get these different aspects of brain-controlling behavior to gel as well as they do. But, so I would like to, I'd like to up the ante. I'd like to get them to work together just a little bit better.

INTERVIEWER: Everybody knows how competitive people are at MIT. GRAYBIEL: Tell me about it.

INTERVIEWER: In the sense of --

GRAYBIEL: I know also.

INTERVIEWER: Let's, your what?

GRAYBIEL: I also know.

INTERVIEWER: Yeah, I'm sure you know. If there was a competition between the people who experienced the first 50 years of MIT, the second 50 years of MIT and the third 50 years of MIT, I suspect you would say that your 50, this coming in this third period of 150 years, is the best?

GRAYBIEL: Oooh, best. What do you mean best? They are so different. I mean, war years, right? MIT was central and crucial to the whole United States effort, in, right? For a lot of years. Right, MIT's been crucial all along. In so many different ways. But --

INTERVIEWER: Most exciting 50 years in those 150 years.

GRAYBIEL: Man, when --

INTERVIEWER: You've got to make a choice.

GRAYBIEL: What would a physicist tell you? He'd say, my God, that physics department was huge. Then it got to be tiny. You know, and now we're trying to get it to grow again. These are the bad years.

INTERVIEWER: For the physicist.

GRAYBIEL: Yeah.

INTERVIEWER: But what about Ann?

GRAYBIEL: So, when you said for all of MIT.

INTERVIEWER: Well, what about for Ann?

GRAYBIEL: So it depends on the part of them. But I mean, hands down for anything to do with studying biology and brain, it's just razzle-dazzle, this is the time, go for it.