# Why Teens Are Impulsive, Addiction-Prone and Should Protect Their Brains

This is FRESH AIR. I'm Terry Gross. We're going to talk about some neuroscience that will be of particular interest to the parents of teenagers and to anyone who's ever been a teenager. New research into how the human brain develops helps explain some of the reasons teenagers can be especially impulsive, moody and not very good at responsible decision-making. New research also explains why teenagers can be especially susceptible to addictions, including drugs, alcohol, smoking and, yes, cellphones.

My guest is neurologist Dr. Frances Jensen, author of the new book "The Teenage Brain." She's a professor and chair of the Department of Neurology at the University of Pennsylvania Perelman School of Medicine and was formally a Harvard professor and director of Translational Neuroscience at Boston Children's Hospital. She was the single parent of teenage sons. Her children are now in their 20s. Later, we'll talk about something that afflicts many adults - the feeling that your brain has been overloaded with too much information.

Dr. Jensen, welcome to FRESH AIR.

FRANCES JENSEN: Great to be here.

GROSS: So you point out we know now that the brain is the last organ to fully develop and that the teenage brain is still developing, and the part of the brain that's responsible for what's called, like, executive decision-making - judgment - isn't fully developed yet. It's still starting to develop when kids are in their teens. So which part of the brain is that and how underdeveloped is it?

JENSEN: Well, that's the prefrontal and frontal cortex - the very front of your brain. And teenagers are gaining increasing access as they go through their teens to that part of the brain. It used to be thought that children turned into almost adults - as we put in the book, adults with fewer miles on them - when they pass through puberty. And they kind of looked like adults. And you had the expectation that their brain - because their body looks like an adult - that their brain should also be structurally like an adult. Well, it's far from the truth. The teenage brain is not there all the way. It takes, often, into your early 20s and possibly late-20s and, you know, maybe even beyond for the brain to fully mature to adult levels. And one of the main drivers of this is the way our brain connects regions to each other inside the brain. These connection tracts have to be insulated for very fast signaling. And we have a natural insulation that's similar to the insulation around an electrical wire, which is usually a, you know, rubber insulation. We have something - a natural insulation - called myelin. It's a fat, and it takes time. Cells have to build myelin, and they grow it around the outside of these tracts. And that takes years. It's interesting. It goes from the back of your brain to the front, so the last place to be connected, to be fully myelinated, is the front of your brain. And what's in the front? Your prefrontal cortex and your frontal cortex. These are areas where we have insight, empathy. These executive functions, such as impulse control, risk-taking behavior, is suppressed by activity in your frontal lobes.

GROSS: So what does that explain about teenage behavior?

JENSEN: So it does explain, at least in part, why they are - their frontal lobes are there. They're there, and they're built. They're just not accessed in as rapid a manner because the insulation to the wiring to them isn't fully developed, so the signals go more slowly. Hence, teenagers are not as readily able to access their frontal lobe to say, oh, I better not do this. An adult is much more likely to control impulses or weigh out different factors in decisions, where a teenager may not actually have full online, in the moment capacity. And that's why we see this increased in risk - you know, classic sort of increase risky behavior. We've talk a lot about the downside of the limitations of, oh, the teen brain, you know, no insight, no judgment. Well, of course there's some. It's a gradual process. It's not - never all or none. But there's also wonderful - this is a wonderful time in life for teenagers. This is a time where because of their enhanced synaptic plasticity, which we can talk about, they can learn faster. They can absorb more information. They can...

GROSS: Well, on a related note, you say teenagers cannot only learn faster but the memories last longer. Like, they're more deeply ingrained. Why is that?

JENSEN: Well, the whole process of learning and memory is thought to be a process of building stronger connections between your brain cells. Your brain cells create new networks when you learn new tasks and new skills and new memories. And where brain cells connect are called synapses. And the synapse actually gets strengthened the more you use it. And especially if you use it in a patterned way, like with practice, it gets even stronger, such that after the practice, you don't need much effort to remember something. This actually has a scientific basis. This has been studied in slices of brain, for instance, in - from animal experiments, where it's called long-term potentiation - long-term meaning it's lasting a long time, potentiation meaning strengthening. Turns out that if you are stimulating one brain cell and recording from a second brain cell, if you do an initial stimulation, you get a small response from the second brain cell. But if you give a pattern stimulation, a fast-pattern stimulation akin to a practice session, from that point on, even if you go back to the little, small stimulus you used originally, you get a much bigger response on that second neuron. It's now remembered this, and it's - how is the response bigger? It's actually physically built a bigger synapse on the receiving end of that second cell. All the machinery of that requires more activation, more excitation of the brain. We are programmed, over development, to have more excitation, more molecules that subserve excitation during childhood and teen years than in adult.

GROSS: Teenagers are more prone to addiction. Why is that?

JENSEN: Well, addiction is actually a form of learning. And just like when I was talking about learning requires synaptic plasticity and enhancement of a synapse based on repeated exposure to facts in a memorization task, what happens in addiction is there is also repeated exposure, except it's to a substance. And it's not in the part of the brain we use for learning. It's in the reward-seeking area of your brain - the limbic system, someplace called the nucleus accumbens and the ventral tegmental area you read a lot about. And it's involving dopamine and other neurotransmitters. It's happening in the same way that learning stimulates and enhances a synapse. Substances do the same thing. They build a reward circuit around that substance to a much stronger, harder, longer, stronger addiction. Just like learning a fact is more efficient, sadly, addiction is more efficient in the adolescent brain. That is an important fact for an adolescent to know about themselves - that they can get addicted faster. It also explains why - and it also is a way to debunk a myth, by the way, that, oh, teens are resilient. They'll be fine, you know? He can adjust go off and drink or do this or that. They'll bounce back. Actually, it's quite the contrary. The effects of substances are more permanent on the teen brain. They have more deleterious effects and can be more toxic to the teen than in the adult.

GROSS: It's easier to turn off to what you just said and say, oh, all moralistic people talk that way about drugs. So are you coming at this from a moralistic, preachy perspective?

JENSEN: Absolutely not. And that's exactly why the book contains lots of facts and graphs from actual research that shows this very fact that drugs and alcohols, other substances have different effects on the teen and adolescent brain than they do an adult. This is still a very imprintable, impressionable period of brain development. So it, you know, is kind of common sense when you think about it. Good things can have a good effect on the brain in a stronger way than later in life, and bad things can have a bad effect on the brain.

GROSS: There's an interesting paradox you point out when it comes to alcohol in the teenage brain. The teenage brain is more resilient when it comes to, like, the sedative effects of alcohol. Like, you know, they're not going to get tired as quickly. At the same time, that means they might drink more (Laughter). So would you talk about that paradox?

JENSEN: Yes, so the alcohol actually - because it's affecting critical machinery in the brain that is actually at higher levels in the teenager than in the adult, there is more of target material for alcohol in the developing brain than later in life. And hence, it can have a more toxic effect. There are studies that show that binge drinking - which is probably the worst scenario actually - binge drinking can actually kill brain cells in the adolescent brain where it does not to the same extent in the adult brain. So for the same amount of alcohol, you actually get - you can actually have brain damage, permanent brain damage, in an adolescent for the same blood alcohol level that may not - may cause, you know, bad sedation in the adult but not actual brain damage.

GROSS: What about drinking's effect on memory? You know, teenagers are so good at learning and remembering. Does alcohol reverse that at all?

JENSEN: Yes.

GROSS: Or impede it?

JENSEN: Yeah, well, so one of the things that we go through in the book is to talk about how do we learn? What is learning? And what are the targets for learning? And how do drugs lock on to those targets and impair them? Well, alcohol is one of those

drugs. And it will actually cause - counteract the effects of learning, so that it will certainly impede learning. And there isn't as much of a bounce back from alcohol exposure in the adolescent brain when there's - you know, looking at experiments, looking at animal tissue, we see that there's a more permanent effect on learning in the adolescent compared to the adult.

GROSS: So is alcohol likely to impair your ability to learn new things? Or will it unravel the things you have already learned?

JENSEN: That's a very good question. Alcohol will impair you from even laying down a memory because it has a sedative effect. And it's actually causing more inhibition and blocking excitation. So we need excitation to learn. And it's actually diminishing that. So the process of learning doesn't even get started. And I think in the most extreme case, of course you know after a binge drinking, there is complete amnesia around the - often - the event and even for the hours after having had a binging episode.

GROSS: Let's look at marijuana. First of all, you point out that the marijuana of today is a lot more potent than the marijuana of the 60s or the 70s. So, like, things have really changed in terms of what teenagers are getting exposed to. But does marijuana have a particularly potent effect on the teenage brain?

JENSEN: Yeah, marijuana actually does have a different effect on the teenage brain than the adult. And this is one of those things that you want to let kids know about, that because they have more plasticity, more substrate, a lot of these drugs of abuse are going to lock on to more targets in their brains than in an adult, for instance. And it's interesting because we have natural cannabinoids - they're called - in the brain. We have kind of a natural substance that actually locks onto receptors on brain cells. It has, for the most part, a more dampening sedative effect. So when you actually ingest or smoke or get cannabis into your bloodstream, it does get into the brain, and it goes to these same targets. It turns out that these targets actually block the process of learning and memory, so that you have an impairment of being able to lay down new memories. Now, what's interesting is not only does the teen brain have more places for the cannabis to actually land, if you will, it actually stays there longer. It locks on longer than in the adult brain. So there were studies done that showed that several days out, there's still impaired learning and memory, say, in experimental adolescent animals compared to adults, where it's a more fleeting effect. So this is important for teenagers to know. For instance, if they were, you know, to be - get high over a weekend, the effects may be still there on Thursday and Friday later that week. An adult wouldn't have that same long-term effect.

GROSS: If you're just joining us, my guest is Dr. Frances Jensen. She's a neuroscientist who's the author of the new book "The Teenage Brain." Let's take a short break, then we'll talk some more. This is FRESH AIR.

GROSS: This is FRESH AIR. And if you're just joining us, my guest is neuroscientist Dr. Frances Jensen. She's the author of the new book "The Teenage Brain." She's a professor and chair of the Department of Neurology at the University of Pennsylvania Perelman School of Medicine. She's a former Harvard professor.

You recommend keeping cellphones and computers out of your teenager's bedroom, to which I say, good luck...

JENSEN: That's right.

GROSS: (Laughter) ...With that. Why do you recommend that?

JENSEN: Well, you know, that is - it may or may not be enforceable. I think the point is that you - when they're trying to go to sleep, to have this incredibly alluring opportunity to network socially or be stimulated by a computer or a cellphone really disrupts the sleep patterns. Again, it's also not great to have multiple channels of stimulation while you're trying to memorize for a test the next day, for instance. So I think I would restate that and say especially when they're trying to go to sleep to really try to suggest that they don't go under the sheets and have their cellphone on and be tweeting people. First of all, then the artificial light can affect your brain. It decreases some chemicals in your brain that help promote sleep such as melatonin. So we know artificial light is not good for the brain. That's why I think people - there have been studies that show that reading books with a regular warm light doesn't disrupt sleep to the extent that using a Kindle does.

GROSS: You suggest that maybe teens and people in their 20s now - these being the first generation to actually grow up with devices - that they were exposed to electronic distractions from the start...

JENSEN: Right.

GROSS: ...That no one else in history has been exposed to. So their brains might be different in some fundamental way. What are your thoughts about that?

JENSEN: Well, it's all very speculative at this point in time because of course the experiment hasn't completed itself. This generation hasn't fully made it to, you know, full-fledged adulthood, which I would say would be sort of your mid-30s. So I think that if we look back and see how well the human brain adapts to so many - has adapted to so many different things over the centuries - I mean, think about reading. Until about three or four centuries ago, it was very uncommon for humans to read. It was just the religious community and the academia that read. And most of the populations in even Western countries were not reading. So we've developed a reading brain over just those few centuries. And we've come to rely on it very, very heavily. So we hope that there are new skills being embedded in these brains as they learn how to deal with all this input. I guess my concern is that the teen period is rather vulnerable because the input's out there. We can't control it. We can't really control their access to it. But what is more concerning to me is that they are not mindful of how to manage this input.

GROSS: So in talking about some of the things teenagers are prone to because their brain is still developing, one of the things is stress. So how does the development of the teenage brain figure into the possibility of being more stressed?

JENSEN: Right. So the teenage brain, like the childhood brain, is a very impressionable brain. The environment is molding it by the minute, right? So stress, just like substances, just like good experiences, are changing the wiring diagram of the brain and changing the chemistry of the brain and setting it up for future life. So stress, just like any other kind of stimulus, has been shown to have an effect on long-term brain health. Stressful situations in adolescence have been shown to increase the risk of depression, for instance, as adults. So we have to think about, you know, what is in our environment during the teen years.

GROSS: So does the ability to learn more quickly figure into the stress, too?

JENSEN: I think...

GROSS: Like, why are teenagers more prone to stress or to being moody?

JENSEN: Well, I think...

GROSS: I don't know if those are the same thing.

JENSEN: Well, they're not actually, so...

GROSS: OK. Let's stick with the stress then.

JENSEN: More prone to stress because they have more plasticity. Their synapses are being conditioned by whatever is in their environment. If stress is in their environment, they build synapses in a different way than they would without stress. And in the case of stress during the teen years, it can increase your risk of depression. So you are altering areas of your brain that would be - that are not functioning normally in depression.

GROSS: So a stressed teenager is more likely to have depression as a teenager or into later life as well?

JENSEN: Later life as well. Now, interestingly, your mental state is very dependent upon how mature your brain is. Most mental illnesses, such as depression, bipolar, schizophrenia, tend to have their onset at the end of the teen years or early adult. This is not a coincidence. It is because to be able to actually manifest depression or schizophrenia, you need your prefrontal and frontal lobes. They are not connected yet until late teens. So it helps us understand why they these diseases are actually quite silent earlier in life. And the person can appear completely normal and then have this onset in the early college years - usually it is - or, you know, late high school. We know there's an increased risk of suicide in this window of development - probably related to this. It's a time where you have enough of your systems working in order to actually manifest a depression, yet you don't have your frontal lobes for the impulse or risk-taking behavior, and suicide in part, for instance, is an impulsive act. So there isn't that gating that's like maybe I shouldn't do this. But it's done.