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MAY 2012 \$2.50

HEALTH LETTER®
CENTER FOR SCIENCE IN THE PUBLIC INTEREST

Food & Addiction

Can Some Foods Hijack the Brain?

BY BONNIE LIEBMAN

Picture three random American adults in a room. Odds are, one is obese, one is overweight, and one is normal weight.

If the three were children, one would be overweight or obese. And obesity rates in children are still rising.

Clearly, there's no single cause of the obesity epidemic. Our 24/7 exposure to calorie-dense food and long hours at a desk or dashboard play a role. But new evidence suggests that some foods may keep us eating by hijacking the brain like an addictive drug.

"How much overeating in the population is attributable to these foods working on the brain so people keep coming back for more?" asks Kelly Brownell, professor of psychology at Yale University.

"It's possible that once people start consuming these foods, the brain changes in ways that make it very difficult to stop."

Here's what we're learning about food and addiction.

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Food & Addiction

Can Some Foods Hijack the Brain?

“The food industry obviously manipulates the qualities of its foods to maximize desirability,” says Kelly Brownell, who directs Yale University’s Rudd Center for Food Policy & Obesity. “That’s what they’re in business to do.”

“But if some foods start taking over the brain to create a biological demand, that’s a problem,” he adds. “Both animal and human studies suggest that an addictive process is profoundly possible.”

Here’s the evidence that some foods may alter the brain like an addictive drug.

SIGNS OF ADDICTION

What is food addiction?

“There is no clinically recognized definition,” says Marcia Pelchat of the Monell Chemical Senses Center in Philadelphia. In other words, you won’t find food addiction in the Diagnostic and Statistical Manual of Mental Disorders (DSM) that’s used by mental health professionals.

“However, the DSM does have a definition of substance dependence,” notes Pelchat. (Dependence is the clinical term for addiction.) “There’s a list of seven criteria, and you have to meet three of them within a year.”

In 2009, Brownell and his colleague Ashley Gearhardt adapted those criteria to food.

“We wanted to see if traditional criteria for substance abuse could be applied to the eating and obesity arena,” says Brownell. “And it’s pretty clear that the answer is yes.”

In a survey of roughly 350 Yale undergraduates, 11 percent of respondents met the criteria for “food dependence.” In particular, many reported a loss of control when eating, a persistent desire or effort to cut back, and heavy use despite deleterious consequences.¹

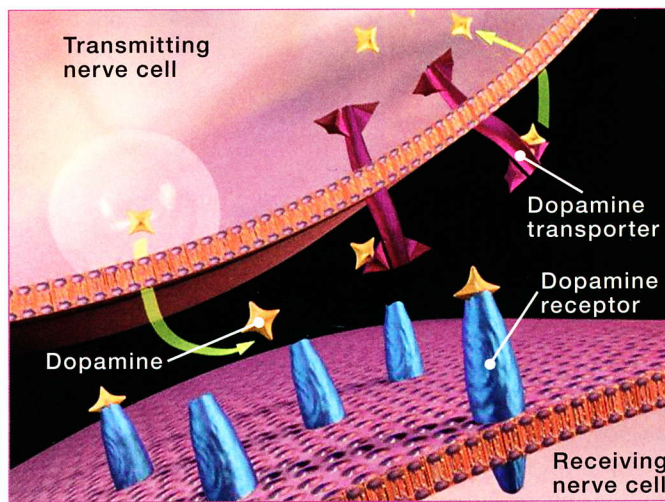
“Once the Yale Food Addiction Scale starts getting administered to large populations, we’ll know more about how common addictive eating is, its relationship to obesity, and its health consequences,” says Brownell.

However, relatively few people fall into that category, he notes. And although

those people need help, they’re not his main worry.

“We’re not as concerned about extreme cases, but the everyday cases of people eating an unhealthy diet,” says Brownell. “I’m less interested in the person who sits down and eats 15 doughnuts than the person who gets up in the morning and needs a sugared beverage to get the day going.”

The bigger question: “Can you make



How Dopamine Sends a Message. Food (or drugs, music, sex, etc.) causes nerve cells in the brain to send dopamine to receptors on neighboring nerve cells. Transporters reabsorb the dopamine that doesn’t reach the receptors.

a case that the brain is being hijacked enough by certain foods that you’ve got a public health crisis?”

To find answers, some scientists have zeroed in on how the brain’s response to some foods can parallel its response to drugs.

DOPAMINE

In 2001, Nora Volkow and her colleagues at the Brookhaven National Laboratory published a groundbreaking study called “Brain Dopamine and Obesity.”

The results were stunning. Very obese people had lower levels of dopamine in the “reward” areas of their brains than did people who were normal weight (see illustration, p. 4).²

“These brain scans were game-changers,” says Pamela Peeke, assistant clinical professor of medicine at the University of Maryland School of Medicine. “Because this is precisely the same thing that happens in meth heads, cocaine addicts, alcoholics, and other addicts.”

Dopamine is a neurotransmitter that motivates us to eat (and engage in sex and other “rewarding” behaviors). It reflects *wanting* more than *liking*. Animals that lack dopamine starve to death because they have no motivation to eat.

“This is the mechanism that nature created to enable you as an individual and species to survive,” says Volkow, now the director of the National Institute on Drug Abuse. “If you ate a banana and it was delicious, the next time you were in the jungle and you saw it, you’d have this drive to eat it.”

Drugs like cocaine, heroin, and morphine can hijack the system.

“By the randomness of nature, certain chemicals are able to activate the same circuits,” explains Volkow. “And they do it in a way that’s much more potent” than anything natural.

Yet her brain scans are surprising. If dopamine makes you want to eat or take drugs, why would people who are obese or addicted to drugs have *less* of a dopamine response when they eat or take drugs?

“We used to believe that people were addicted because they were more sensitive to rewarding effects,” says Volkow. “We thought they had more dopamine release, that it would be more pleasurable. However, it’s the opposite.”



Less reward makes them want more. “It appears that people who don’t get much reward from food or drugs want more and more because they never are satisfied,” says Monell’s Marcia Pelchat. (Monell Chemical Senses Center is a scientific institute that does research on taste and smell.)

Chicken or Egg?

It’s a chicken-or-egg question.

Do some people overeat because they are born with a dopamine system that doesn’t respond? “Or do obese people have a low dopamine response because they overate and overstimulated their dopamine system?” asks Pelchat.

“There’s some evidence for both.”

To sort things out, researchers are trying to look at dopamine responses before obesity sets in. Some findings:

■ **Rats fed junk food.** Some studies see changes in dopamine release when rats are offered a so-called cafeteria diet.

“We gave animals access to foods that people might want to overeat—cookies, cheese, chocolate chips, marshmallows, and similar items,” explains Nicole Avena, assistant professor of psychiatry at the University of Florida College of Medicine.

After a few months, the rats became obese and had lower dopamine levels than rats fed ordinary lab chow.^{3,4}

“Once they have this history of overeating this highly palatable junk-food diet, their brains have changed,” explains Avena. “These changes are profound and long lasting.”

Could obesity itself weaken the dopamine system? To find out, Swiss researchers made sure that rats fed ordinary chow got as many calories as rats fed a calorie-dense diet that was high in fat and sugar.⁵

“Both groups gained weight, but the group fed the calorie-dense diet had a reduction of dopamine receptors while the other group did not,” explains Kyle Burger, a researcher at the Oregon Research Institute’s Eating Disorders and Obesity Prevention Lab, which is headed by Eric Stice.

“So it’s not necessarily weight gain—but the process of overeating calorie-dense foods—that changes dopamine receptors.”

■ **Less response after weight gain.** In a study of 26 young overweight and obese women, those who gained weight over six months had less response in areas of the brain targeted by dopamine when

they drank a milkshake than they had six months earlier.⁶

“They also showed a reduced dopamine response compared to the overweight women who remained weight-stable,” notes Burger.

A lower dopamine response may be a double whammy for weight gainers. First, it might make them more likely to overeat. And overeating may dampen the dopamine response even more.

food because you’re ‘chasing the high.’”

Burger and his colleagues are tracking the teens, “so we’ll know in a year or two.”

Cues & the Cortex

Researchers see another similarity between drug abuse and obesity.

Obese adolescent girls show less response in dopamine target areas when drinking milkshakes than girls who are normal weight. However, the heavier girls show a greater response to *pictures* of the shakes.⁸

“And the girls who respond most to food images are more likely to gain weight over the next year,” adds Burger.

Likewise, people who score higher on the Yale Food Addiction Scale show greater activity than others in the reward areas of the brain when they see pictures of a milkshake, but less activity when they drink it.⁹

It’s the same pattern seen with drugs. In fact, that’s what makes many people relapse after treatment for drug abuse.

“The moment an addictive individual sees a person they’ve taken the drug with or drug paraphernalia, dopamine release triggers an enormous desire to take the drug,” says Volkow. “And that’s why they relapse.”

When it comes to food, the cues are everywhere. “This hyper-response to the cues—and reduced response to the food—implies that obese people may not have a compromised dopamine response to begin with,” says Burger.

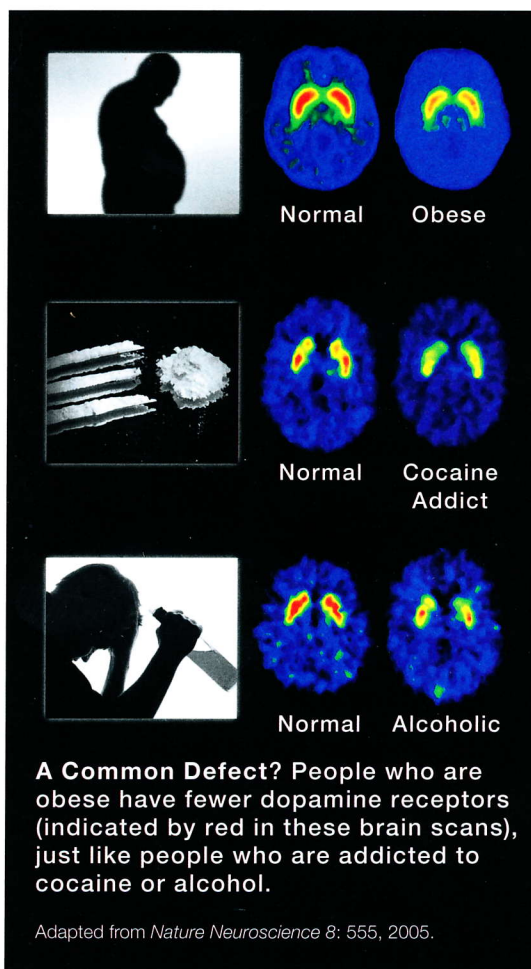
Of course, milkshakes aren’t cocaine. “If someone were to take an illicit drug, it would release far more dopamine than Häagen-Dazs,” he notes.

And, needless to say, rats aren’t people. “Rats are working off of their impulses,” says Avena. “Humans have highly developed cortexes so we can make decisions.”

That’s no reason to dismiss rat studies, she adds. “They illustrate that we might need to exercise a lot of control over the way we think about food because of what our primitive brains are telling us to do.”

When it comes to drugs, changes in the dopamine system may cause changes in the cortex. And in the obese, fewer dopamine receptors are linked to less activity in the cortex.¹⁰

“Repeated exposure to drugs disturbs a carefully calibrated balance in the frontal cortex that is needed to exert control, make decisions, and exercise judgment,” says Volkow. “This area is the brain’s brakes. Ad-



A Common Defect? People who are obese have fewer dopamine receptors (indicated by red in these brain scans), just like people who are addicted to cocaine or alcohol.

Adapted from *Nature Neuroscience* 8: 555, 2005.

■ **More response before weight gain.** To study obese people *before* they become obese, Burger’s colleagues compared 30 teenagers who were at high risk for obesity (each had two overweight or obese parents) to 30 teens at low risk. All were normal weight.

Those at high risk for obesity had a greater response in the dopamine target regions after drinking milkshakes than low-risk teens.⁷ So obese people may start out not with an insensitive, but an *over*-sensitive, dopamine response.

“We think this initial vulnerability is the hook that gets you in,” explains Burger. “Then you repeatedly consume the

“That’s How I’m Wired...”

“For a long time, I didn’t like the word addiction because it felt like it was a disease,” says Liz Gordon of Corpus Christi, Texas.

But she came to accept that her inability to resist sugar was more than just a sweet tooth.

“It’s an obsession, a craving,” she explains. “I really have to be mindful to stop myself. Because if I start, oh gosh, it’s going to be hard to stop.”

Gordon, now 60, never was an out-of-control binge eater. And she was never quite obese. “I was always 5 or 10 pounds overweight.”

But in her 50s, the weight started to pile on. “I was almost up to 170 pounds as a 5-foot, 4-inch woman,” she notes. At 175 pounds, she would have crossed the line from overweight to obese.

Sweets were always her downfall. “I remember my mother hid chocolate in the cupboard when I was young,” says Gordon. “I remember enjoying it so much and wishing I could eat it like everyone else and not overdo it.”

But it was a constant battle. “For the moment it tastes good, and then afterwards, it’s like ‘Ugh...why did I do that?’ I’m not so addicted that I would go on a three-day binge. But I would get so discouraged and feel so defeated that I’d start to self-sabotage. I’d think, ‘Oh, forget it. Obviously, I can’t control this.’”

It’s not clear if a brain scan would show that Gordon has fewer dopamine receptors—a telltale sign of addiction. And there are no established criteria that doctors can use to diagnose food addiction in their patients.

In any case, she has turned things around. “I’ve lost 38 pounds in the last five years.” Gordon credits much of her success to Pamela Peeke, an assistant clinical professor of medicine at the University of Maryland School of Medicine who runs the Peeke Performance Center for Healthy Living. (Peeke’s latest book, *The Hunger Fix: The Three Stage Detox and Recovery Plan for Overeating and Food Addiction*, is scheduled to be published by Rodale in September.)

“It was helpful for me when Dr. Peeke said that there’s something called a sugar addiction,” says Gordon. “That validation is extremely important. It isn’t something that I can just control



“If I start, it’s going to be hard to stop.”

and it will go away. That’s how I’m wired. I’d like to say that someday I won’t have to work at this. Well, no, it’s never going to be like that.”

Peeke’s program consists of what she calls the three M’s—mind, mouth, and muscle. “I still do Weight Watchers online,” says Gordon. “That’s been my form of structural dieting.”

She doesn’t avoid sugar completely. “I can’t,” she says. “I’ve tried. It’s not possible because sugar is in so many foods. I try for moderation. I say, ‘Oh, I’ll just have one bite’ or ‘Oh, I won’t keep ice cream in the house so I’ll have to go out to get it.’”

But now she plans ahead. “If I’m going out for the day, doing errands or going to the gym, I’ll bring fruit or other snacks with me. If I don’t consistently eat meals and some sort of protein snack in between, that’s when I give in to a craving.

I think, ‘Darn, I’m in the store. I’ll just get that bag of licorice.’”

Fortunately, the “muscle” part comes easy for her. “I’ve always exercised. And I’ve gotten more into working out harder. Spinning class has been very successful. I feel good afterwards. I feel more in control, and now I can go about my life.”

Peeke counsels her once or twice a month by phone. “It’s having a person who reminds you to be mindful, vigilant, and accepting,” says Gordon. “Meditation has also become essential.”

And she has learned techniques to keep from sabotaging herself. “Last night, I was stressed about our upcoming move to Kansas. So what did I have for dessert? A fudge brownie sundae. When I’m worn down and tired, that’s when the demons set in. But I got up today and it’s a new day. I said, ‘Okay. Don’t go down the slippery slope.’”

Sometimes she passes up social events. “I say, ‘If I go to that party, I’m going to eat whatever I want.’ My husband says, ‘Just go and don’t do it. Why the drama?’ That’s because I don’t look like a person who has a problem. But I do.”

Denial takes a lot of mental energy, says Gordon. “I spent years thinking, ‘I don’t think I ate that much candy or dessert or whatever. How can I be gaining weight?’ Who was I trying to fool?”

Those days are over, she adds. “You feel a freedom when you’re not battling with yourself.”

dicted people don’t understand why they take the drug. It’s like they’re driving and they can’t stop. They have no brakes.”

WHICH FOODS?

Can any food be addictive?

“Sugar has been studied far more than anything else,” says Brownell. Is fat a player? What about salt or all the preservatives and additives that go into food?

“Or the flavorings or what the industry

euphemistically calls ‘flavor enhancers,’” adds Brownell. “What are those things doing in the brain? Nobody knows.”

But researchers have some clues.

Animals

■ **Sugar.** Working with the late Bart Hoebel of Princeton University, Nicole Avena found that rats showed signs of dependence when exposed to sugar for only a few hours a day.¹¹

“When animals get sugar, they’ll overeat,” she explains. “And they’ll show tolerance to it—they eat more and more each day, perhaps to feel the same euphoria.”

“If we take the sugar away, they’ll show signs of withdrawal—anxiety, tremors, and shakes,” she adds. “And they’ll show evidence of craving for the sugar. They’re willing to work harder to get at sugar, and they show behaviors to suggest that they’re seeking the sugar.”



What to Do



Exercise may boost brain volume and replenish dopamine receptors.

They also end up with fewer receptors for dopamine and opioids.¹² “With sugar, there’s neurochemical and behavioral evidence of dependence,” says Avena. “And the changes are similar to what you’d expect to see if the animals were dependent on drugs of abuse, not just eating a tasty food.”

■ **Fat.** Avena’s team has also tested high-fat diets on rats.¹⁰ “We see the same types of behavior emerging,” she notes, “except that when animals have access to fat, they don’t show signs of withdrawal.”

Researchers think that a brain chemical called galanin may explain why. “When an animal is eating fat, it releases galanin in the brain,” explains Avena. “And in other studies, galanin counteracted the effects of opiate withdrawal.”

No withdrawal doesn’t mean no addiction, though. “There are some drugs of abuse, like cocaine, that are addictive but don’t always result in clear signs of withdrawal,” says Avena. “We see withdrawal most clearly with opiate-based drugs like heroin or morphine.”

Another difference: When rats get just sugar, they eat less food, so they don’t gain weight. “But when we give them a combination of sugar and fat or even if they get fat alone, they do show signs of obesity,” she notes.

And that’s critical, because “people don’t eat sugar alone,” says Avena. “They eat sugar in combination with fat and salt and other things.”

■ **Restricted access.** Rats don’t show signs of addiction if sugar or fat is always available. “When they can have unrestricted, unlimited access to sugar, they snack on it all day,” says Avena. “They don’t binge, and they don’t show signs of addiction.”

But “there’s something about overeating that leads to changes in the brain and behaviors that suggest addiction,” she notes. “And to get the animals to overeat, we have to impose restrictions.”

In most studies, the rats get no food during the 12 hours when they typically sleep. Then they get no food or sugar for four hours after they wake up.

“It’s a bit like skipping breakfast,” says Avena. After a while, the animals start eating fewer, but larger, meals each day.

Does that mirror what happens to people? “Everyone overeats now and then,” observes Avena. “Thanksgiving is the classic holiday when everyone eats too much.”

“But what we see in some of our human patients who are overeating is that the

What may keep you from overeating?

■ **Avoid mindless eating.** “People tend to eat whatever’s on the plate in front of them,” says Monell’s Marcia Pelchat. “If you’ve eaten half the food on your plate at a restaurant, push the plate away.”

And don’t leave food around. “You’re more likely to eat food out on the counter than if it’s in a cabinet, even though you know it’s in there,” adds Pelchat. “It’s what Brian Wansink of Cornell University calls ‘mindless eating.’”¹¹

■ **Beware of cues.** “Smells can trigger desires for foods, like popcorn in a movie theater or cinnamon buns in the mall,” notes Pelchat.

“Think about walking into a movie theater. We’ve seen all the reports that movie-theater popcorn is bad for you. It’s stale, it’s popped in yucky fat, fake butter, and yet we all crave it because we’re used to getting popcorn at the movies.”

Smells aren’t the only cues. “If you have a cookie every time you walk into the house before you make dinner, you’re going to want a cookie when you walk into the house,” says Pelchat.

And then there’s advertising. “You see the biggest rise in dopamine release when people see cues,” says the University of Maryland’s Pamela Peeke. “That’s why marketing is so powerful.”

■ **Avoid the troublemakers.** Many people know which foods make them lose control, says Peeke. “One woman told me, ‘I have never in my life eaten a frozen Sara Lee cheesecake thawed.’ She just dives into it frozen.”

The answer, says Peeke, is a detox and recovery plan. “You can’t drop the weight and go back to cookies again. I tell patients, ‘I can give you something very rewarding, but it won’t include sugary, fatty, salty, processed glop.’”

■ **Eat healthy foods.** “It hasn’t been documented, but when people go on a diet and start eating a lot of fish and vegetables, they eventually start craving those foods if they stick to it long enough,” says Pelchat.

“Don’t think about depriving yourself. Just think about adding a serving of something to your diet once a day for two weeks. If you’re eating, say, five servings of fruits and vegetables a day, you’ll have less time to eat other things.”

And don’t assume that you have to banish calorie-dense foods from your diet. Oils, nuts, and avocado are calorie dense. But sprinkle them on a big bowl of greens and the calorie density plummets. (See “Don’t Be Dense,” March 2012.)

■ **Distract yourself.** “Dieters say, ‘It won’t matter if I give in just this once,’ but the behavior-modification people say it does matter,” says Pelchat. “You have to practice breaking the automatic response.”

How? “Some people recommend engaging in another absorbing or enjoyable activity when you have a food craving,” she suggests. “Listen to your favorite music, read a book, tap dance. Anything you can do to put a delay between thinking of the food and reaching for it will make it more likely that you’ll forget about it.”

■ **Beware of stress.** “When you are stressed, you’re much more likely to fall into the pattern of eating more food than you wanted to,” says the National Institute on Drug Abuse’s Nora Volkow.² “Food can reduce anxiety. It’s no coincidence that we talk about comfort foods.” And don’t get too hungry. That intensifies the drive to eat.

■ **Exercise.** In rats, running on a treadmill can increase dopamine receptors.³ And in sedentary people in their 60s and 70s, an aerobic exercise program increased the volume of the brain’s cortex.⁴

“We now have brilliant data that shows an increase in prefrontal cortex nerve cells,” says Peeke. “That’s extremely important because this is where you have executive function and rein in impulses. And guess what? It doesn’t have to be extreme activity.” Brisk walking is good enough.

¹ *Physiol. Behav.* 100: 454, 2010.

² *Physiol. Behav.* 103: 157, 2011.

³ *Neurosci. Lett.* 79: 138, 1987.

⁴ *J. Gerontol. A Biol. Sci. Med. Sci.* 61: 1166, 2006.

person has to feel that they have little control over their eating. They can't stop even though they want to."

How common is binge eating? No one knows for sure. "But the numbers are growing," says Avena. "More and more patients report it to us at clinics. It's the most common eating disorder, and it can be seen in people who are obese, normal, or underweight."

And although most people have access to food all day long, there are some parallels for dieters.

"Many people restrict themselves from eating," says Avena. "They wake up every day and decide that they're not going to eat anything because they're starting a diet. Anyone who goes on a diet is restricting their calories."

And that may make it harder to stick to the diet. "Restricting food promotes the intake of the palatable food when it becomes available," says Avena.

Humans

■ **Calorie-dense foods.** In its studies on people, Kyle Burger's research team started with milkshakes because they're not just sweet and fatty, but calorie dense. That is, they have a lot of calories per swallow.

"It looks like the habitual consumption of food—specifically calorie-dense food—can elicit changes in brain responses that mirror drug addiction," says Burger.

Studies on craving also point to calorie-dense foods.¹³

"We ask people, 'Have you craved any food in the last year?'" notes Monell's Marcia Pelchat. "And we give them a definition of craving, which is an intense desire to eat a particular food."

Craving isn't addiction, she adds. "The vast majority of people have cravings, and that wouldn't qualify as having an addiction."

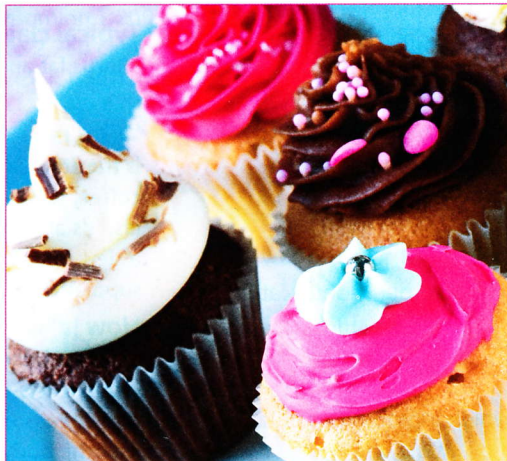
What do people crave? "About 95 percent of the foods are calorie dense and high in fat," says Pelchat. "Fat is more calorie dense than carbohydrates or protein. One guy told me he craved Belgian endive, but he was thinking of it sautéed in cream sauce."

Among college students, who are most often surveyed in eating studies, "maybe 60 percent of what women write down are sweet foods, and they're usually also high in fat," says Pelchat. "Among men, 40 percent of the foods they crave are sweet."

Why do calorie-dense foods appeal

to us? Because as humans evolved, those foods gave us the best chance of staying alive when food was scarce.

Eating too much wasn't a threat to our survival. "Our bodies are built to regulate rigorously when deprived of calories," says Pelchat. "So when we feel hungry, we go after food, and we're really aware of it."



When foods are sweet, fatty, calorie dense, and varied, we want to eat more.

But when we overeat and food is stored as fat, the brain doesn't necessarily see it.

"Once food is stored away as fat, it's gone," says Pelchat. "You don't walk around saying, 'I'm not hungry because I've got 20 pounds on each thigh.' You get hungry because that fat isn't really accessible."

"So the system makes us eat a lot when we have a calorie deficit, but doesn't do much when we have an excess."

■ **Variety.** "We are conditioned to a diversity of extraordinarily appealing food everywhere," says Volkow.

It doesn't matter if we've just eaten.¹⁴ "We can overcome the body's normal satiety signals if we see food that we remember tastes very good," she explains.

After dinner, "no more dopamine will be triggered by seeing a piece of chicken, but it may be triggered by dessert," says Volkow. "You see some Godiva chocolates and you want them."

And it's not just one piece of chocolate. "I can eat one chocolate and get satiated, but then I turn around and there's all these other varieties, and they're novel and intriguing."

■ **Hyperpalatable foods.** "Our theory is that if the body gets normal food found in nature, most people won't overdo it," says Yale's Kelly Brownell.

"The body's satiety mechanisms will activate and behave in a reasonable way. But when you process the foods so much that they become hyperpalatable, it thwarts the body's ability to regulate."

It's like coca leaves and cocaine, he suggests. "When you get the coca leaf in nature, it's mildly reinforcing but people don't overuse it. But when you process the coca leaf into cocaine, all hell breaks loose, and it overrides good judgment, wisdom, and responsibility."

Brownell says that "you can make the same argument for these hyperpalatable foods. The body just doesn't know how to handle them."

Clearly, research on food and addiction is just gathering steam.

"We need studies that follow people over time," says Brownell. "What exist now are snapshots in time."

But if the early clues pan out, people may look more carefully at how much and how often they "indulge."

Says Burger: "The take-home message is that the frequent consumption of calorie-dense food may be altering your brain responses in a way that's going to make you consume more." 🍌

The Bottom Line

■ Research on food and addiction is in its infancy. But studies suggest that overeating may dampen your dopamine response. That weak response may make you overeat even more.

■ You may be more likely to overeat foods that are calorie dense, fatty, or sweet.

■ Stress and dieting can lead to overeating.

■ For more information, see the Rudd Center for Food Policy & Obesity at Yale University (www.yaleruddcenter.org). You can watch parts of a 2009 Food Addiction Summit at www.foodaddictionsummit.org/agenda.htm

¹ *Appetite* 52: 430, 2009.

² *Lancet* 357: 354, 2001.

³ *Neuroscience* 159: 1193, 2009.

⁴ *Nat. Neurosci.* 13: 635, 2010.

⁵ *Neuroscience* 171: 779, 2010.

⁶ *J. Neuroscience* 30: 13105, 2010.

⁷ *J. Neuroscience* 31: 4360, 2011.

⁸ *J. Abnorm. Psychol.* 117: 924, 2008.

⁹ *Arch. Gen. Psychiatr.* 68: 808, 2011.

¹⁰ *Neuroimage* 42: 1537, 2008.

¹¹ *Physiol. Behav.* 104: 87, 2011.

¹² *Neurosci. Biobehav. Rev.* 32: 20, 2008.

¹³ *Physiol. Behav.* 76: 347, 2002.

¹⁴ *Am. J. Clin. Nutr.* 92: 697, 2010.