**NAME**_____ **PD**_____

**DIRECTIONS:** Write notes to the left margin (10), Underline important points (10), Circle things that you need clarification on (10), Write a summary, 2 to 3 sentences (20), Question for discussion (50).

# The Brain: *The Flavor Of Memories*

**By MICHAEL D. LEMONICK - Jan. 19, 2007**

Like just about every one of my contemporaries, I still remember exactly where I was and what I was doing when John F. Kennedy was shot. It's so vivid, it's almost like watching a movie: I was home sick from fifth grade, lying on the couch in the living room. My mother had a talk-radio station playing. Suddenly a newscaster broke in with the news that shots had been fired in Dallas and that the President had been rushed to a hospital. Then a few minutes later came these precise words, spoken in just the tone you would imagine: "Ladies and gentlemen, the President is dead," followed immediately by funereal music. My mother burst into tears, and I, profoundly embarrassed, fled the room.

That scene, which I have replayed many times since 1963, perfectly illustrates two crucial facts that neurologists have come to understand in the past few years about the workings of human memory--facts that have important implications for the treatment of a variety of mental disorders, from post-traumatic stress to obsessive-compulsive disorder. The first is that, despite its movie-like clarity, my memory of J.F.K.'s assassination is almost certainly wrong in some details, and maybe even some significant ones. That's because I'm not simply calling up the original memory laid down in November 1963. I'm recalling the last time I thought about it. Each time we retrieve and re-store a memory, it can be subtly altered by all sorts of factors. What goes back into our brains is like the new version of a text document, overwriting the old.

The second fact: memory and emotion are intimately linked biochemically, with hormones like adrenaline actively involved in forming the neurological patterns we call memories. "Any kind of emotional experience will create a stronger memory than otherwise would be created," says James McGaugh, a neurobiologist at the University of California at Irvine. "We remember our embarrassments, our failures, our fender benders."

On the face of it, that doesn't seem especially surprising: we feel strong emotion at important events, which are obviously more memorable than ordinary moments. But the connection is much deeper than that and dates back to our deepest evolutionary past. "The major purpose of memory," observes McGaugh, "is to predict the future." An animal that can remember the significance of that large, nasty-looking thing with the big teeth and sharp claws will survive longer and produce more offspring.

What happens biochemically, says McGaugh, is that when faced with an emotion-charged situation, such as a threat, our bodies release the stress hormones adrenaline and cortisol. Among other things, these signal the amygdala, a tiny, neuron-rich structure nestled inside the brain's medial temporal lobes, which responds by releasing another hormone, called norepinephrine. Norepinephrine does two important things. First, it kicks the body's autonomic nervous system into overdrive: the heart beats faster, respiration quickens, and the muscles tense in anticipation of a burst of physical exertion.

Second, even as it's kick-starting the body, the amygdala sends out a crackle of signals to the rest of the brain. Some of them put the senses on high alert, ready to deal with a threat. But these signals also tell the neurons that any memories recorded in the next few minutes need to be especially robust. One piece of evidence for this scenario: Lawrence Cahill, a colleague of McGaugh's at Irvine, showed subjects emotionally arousing film clips, simultaneously gauging the activity of their amygdalae using positron-emission tomography (PET) scans. Three weeks later, he gave the subjects a surprise memory quiz. The amount of amygdala activity predicted with great accuracy how well they remembered the film clips.

Imaging studies also make clear that it isn't just dangerous or tragic events that cement memory formation. Positive emotions, which are also mediated through the amygdala, have the same effect. Again, that's a perfectly reasonable evolutionary development. If eating or having sex makes you happy, you'll remember that and do it again, keeping yourself healthy and passing on your genes as well.

This is an oversimplification, of course. Other neurotransmitters, and even plain glucose-the sugar the brain uses for energy-may also play a part. And then there's the peculiar case of a woman who contacted McGaugh because she remembers absolutely everything. The stress-hormone model does not appear to apply in her case. Says McGaugh: "At one point I asked if she knew who Bing Crosby was. She's 40, so Bing Crosby doesn't loom large in her life, but she knew he died on a golf course in Spain, and she gave me the date, just like that." Imaging researchers are working to determine whether the woman's brain is structurally different from everyone else's.

But aside from such odd cases, virtually no expert doubts the connection between the hormones of emotion and memory--and nobody doubts that memory can be enhanced artificially. It's not necessarily a good idea, though. Give someone a shot of adrenaline, and memory temporarily improves. But it also drives up the heart rate, so it could be dangerous for the elderly. Other memory enhancers, like Ritalin or amphetamines, used by college students to cram for exams, are highly addictive. And some of the experimental drugs McGaugh is testing in rats can cause seizures. Unfortunately, he says, for people with truly serious memory problems, "existing drugs are not yet powerful enough or nice enough."

For people haunted consciously or unconsciously by painful memories, there may be hope. Roger Pitman, a professor of psychiatry at Harvard medical school, is working to understand post-traumatic stress disorder (PTSD). The syndrome, he believes, is the result of brain chemicals reinforcing themselves in a cerebral vicious circle. "In the aftermath of a traumatic event," he says, "you tend to think more about it, and the more you think about it, the more likely you are to release further stress hormones, and the more likely they are to act to make the memory of that event even stronger."

That's consistent with McGaugh's ideas, but there are only a few bits of hard evidence so far to support it. One bit comes from Israel: researchers found that of people who showed up at emergency rooms after traumatic events, those admitted with the fastest heartbeats had the highest risk of later developing PTSD. Another is the surprising fact that after an accident there's a much higher rate of PTSD in those with paraplegia (paralysis of the lower body) than in those who suffer quadriplegia (paralysis of all four limbs). "It doesn't make any psychological sense," says Pitman. But it makes physiological sense because quadriplegia severs the link between the brain and the adrenal glands.

To test his theory, Pitman went to the the emergency room at Massachusetts General Hospital in Boston and intercepted patients who had suffered serious traumas. He gave some of them propranolol, a drug that interferes with adrenaline uptake. The rest got placebos. He also had them tape-record accounts of the traumas. When he played back the tapes eight months later, eight of 14 placebo patients developed higher heart rates, sweaty palms and other signs of PTSD. None of the patients on the real drug had such responses.

Encouraged by his results, Pitman is entering the third year of a much larger trial--one that has stirred some controversy. The President's Council on Bioethics recently condemned his study as unethical, saying that erasing memories risks undermining a person's true identity. Pitman rejects such notions as a bias against psychiatry. After all, he says, no one suggests that doctors should withhold morphine from people in acute pain on the grounds it might take away part of the experience.

Other researchers are looking at PTSD as well. Michael Davis, a professor of psychiatry at Emory University in Atlanta, is about to launch a study of at least 120 soldiers returning from Iraq to see whether a compound called D-cycloserine could help prevent PTSD. This compound activates a protein that helps the mind form new, less emotional associations with the original trauma, letting patients tolerate the memory better. Studies in rats and humans have shown that it can work--and, says Davis, "psychologists are very excited by it."

That's because the theory behind D-cycloserine's action is totally consistent with old-fashioned talk therapy, and especially with cognitive behavioral therapy (CBT), currently the most effective non drug technique dealing with phobias, PTSD and obsessive-compulsive disorder. The idea behind CBT--which first appeared in the 1950s, long before neuroscience could explain such things--is that the patient examines upsetting ideas and consciously assigns new, more positive associations to them.

Even old-fashioned Freudian psychotherapy might fit in with this model. By dredging up forgotten memories, it may achieve the same thing, albeit in a much less efficient way.

Medications like D-cycloserine may simply streamline the process. Indeed, says Davis, at least one study showed patients on D-cycloserine getting as much benefit in two sessions as would normally take about eight. "That's exactly what they're finding in obsessive-compulsive trials too," he says. There are, moreover, a number of other brain receptors and chemicals that show promise in accelerating the formation of new associations. Says Davis: "People are now working on different targets because we know so little about the process. What we have now could be the tip of the iceberg."

And that's hardly surprising. Even without anything approaching a complete understanding of the complexities of the human brain, neurologists and psychopharmacologists have come up with dozens of medications to treat schizophrenia, depression and other disorders. The next batch of psychoactive drugs could provide ammunition against the even more mysterious disorders of memory.

**SUMMARY:**

**QUESTION ABOUT THE TEXT FOR DISCUSSION:**