

1. Dr. Knutson's lab's website is at www-psych.stanford.edu/~span. It includes many .pdf files of his publications. Also at this site are articles in the lay press citing Dr. Knutson's research, some of which are mentioned below.
2. As of this writing, there are two internet video postings of Dr. Knutson discussing his work. The earliest is on decision making, and was delivered at the "Beyond Belief: Candles in the Dark" conference in October 2008: video.google.com/videoplay?docid=-5145313645738206463#

The second is from a lecture at Stanford in January 2009 and is entitled "Visualizing Desire" It gives details on the shopping experiment briefly portrayed in *The Emotional Brain* film: www.youtube.com/watch?v=CUK8D-kX0fE
3. *Affective Neuroscience: the Foundations of Human and Animal Emotions* by **Jaak Panksepp** (Oxford, 1998 ISBN: 0-19-509673-8) is a wonderful resource, written by a very scholarly and humane scientist. Dr. Panksepp is now at the College of Veterinary Medicine at Washington State University, after a long career at Bowling Green State University, Ohio. Highly recommended!
4. The German social scientist **Wilhelm Wundt** (1832–1920) is considered by many to be the founder of experimental psychology. He had several American students who brought his teachings and methods to the United States. His work separated psychology as a field from its purely biological and philosophical origins. It is said that he wrote 53,000 pages of text!
5. **Charles Darwin** (1809–1882) published *The Expression of Emotion in Man and Animals* in 1872, thirteen years after *On the Origin of Species*. **Paul Ekman** wrote an introduction, afterword, and commentary in an edition published by Oxford in 1998 (ISBN 0-19-515806-7). It is a delight, illustrated with engravings and photographs that were in the original editions and more. Both the Darwin text and Ekman's commentary upon it are written in a very engaging way. There is a new "anniversary" edition of the paperback edition, released to celebrate the 200th anniversary of Darwin's birth. There are versions of the book without Ekman's commentary, including online digital ones. We suggest you seek out the Ekman version with its added features, but for an example, visit etext.virginia.edu/toc/modeng/public/DarExpr.html.
6. The *valence/arousal* model in this film is called the "circumplex model of affect," and was inspired by the theory of Wilhelm Wundt, initially developed by Harold Schlosberg, and elaborated by James A. Russell in a paper published in 1980. It has been much discussed since that time. A detailed graphic of it can be found at www.ac.wvu.edu/~culture/altarriba2.htm. It may be interesting to have your students plot their own versions and compare them to Russell's.
7. **Paul Ekman**'s work on facial expressions has been very useful, and widely applied. He is currently involved in interpreting micro-expressions to determine when someone is lying or concealing truth. This work has inspired a prime time television drama on the Fox network called *Lie to Me*. Dr. Ekman's website, www.paulekman.com, includes the offer of a free newsletter and clips of him discussing his work.
8. This film illustrates the uneasiness of our culture on the balance of *reason versus emotion* by mentioning Plato and Descartes, and referencing classic behaviorists. Your students might be

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interested in exploring this issue by considering popular expressions about emotion. The phrases “stay cool,” “don’t blow your top,” “keep a stiff upper lip,” and “take it like a man” provide dated examples. Are there fresher ones, or are we more accepting of emotional expression?

9. **William James** (1842–1910) is associated with the **James-Lange** (along with Carl Lange, a Danish physiologist) theory that emotions result from peripheral physiological reactions to a stimulus. We see a bear and run, raising heart rate and adrenaline levels, etc., which results in fear. Subsequent research has discounted this theory. It is perhaps interesting to note that James himself suffered from depression and many seemingly psychosomatic illnesses, as did other members of his family. Despite his ill health, he accomplished an enormous amount of work—establishing psychology as a respectable discipline in the United States.
10. **Walter Cannon** (1875–1941) was a physiologist at Harvard’s medical school. He coined the phrase “fight or flight” and is credited with the development of the concept of homeostasis. Much of the work on emotional stress has been built on his research.
11. **Paul MacLean** (1913–2007) was also a physiologist who spent much of his career at Yale (His brother Norman wrote the novel *A River Runs through It*, and made it into a movie.). The triune brain scheme of Maclean, based on the idea that evolution added layers to the brain, has not stood up well to scientific investigation, since cortical and subcortical regions are strongly interconnected. However, it provides a useful framework for introductory students in pointing towards specializations of different brain regions. By implying that lower brain regions are more conserved across the phylogenetic line, it also relates human behavior to that of other species.
12. **Walter Hess** (1881–1971) was a Swiss physiologist. He won the Nobel Prize in 1949, sharing the Medical-Physiological prize with Egas Moniz, the developer of the now infamous prefrontal lobotomy. Hess’s research establishing that emotional responses could be generated by stimulating certain brain regions has inspired further research methods and questions. Hess did not work with Moniz—instead, they were paired by the Nobel Prize Committee.
13. **Panksepp**’s original “blue ribbon” emotional circuits include SEEKING, FEAR, RAGE, and PANIC. To highlight links with other emotion literatures (particularly neuroimaging), Knutson has made the substitutions “excitement” for *seeking* (referring to an emotional state rather than a behavior), “anger” for *rage*, and “sadness” for *panic*. He also has explicitly stressed anticipatory aspects of excitement and fear although theorists like Panksepp and LeDoux implicitly stress it.
14. **Animal research** such as Hess’s work with cats can be a touchy subject, and some of your students might be dismayed by the concept of invasive brain research. Animal research has become much more humane in recent years, with tighter controls for limiting the discomfort of the animals involved. Yet many people still have problems balancing the benefits of lesioning and stimulating lab animals with their predispositions towards seeing the animals as cuddly pets. A discussion with your students might involve talking about the ethics of using animals for research and for food, as well as the benefits and costs of each. One interesting related point is that similar invasive procedures are also implemented on humans in clinical situations—without the animal research, many of these interventions would be impossible.

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15. Lesioning certain areas caused animals to become tame, first demonstrated by Heinrich Klüver and Paul Bucy's temporal lobe resection of rhesus monkeys (Klüver and Bucy, 1939, Archives of Neurology and Psychiatry). David Amaral's group at UC Davis later localized fear-reducing effects to lesions of the amygdala in 2001 (Emery et al., 2001, Behavioral Neuroscience).
16. **James Olds** (1922–1976) and **Peter Milner** (an emeritus professor at McGill in Canada) discovered what they called the “pleasure center” of the brain while working under Donald Hebb at McGill in 1954. James Olds, a psychologist and US citizen, returned to the states and had a distinguished career at the California Institute of Technology. Actual footage of James Olds and his self-stimulating rat is part of an older educational film, *The Mind*.
17. **Joseph LeDoux** teaches at New York University. He is the author of two books for non-scientists: *The Emotional Brain: the Mysterious Underpinnings of Emotional Life* (1996, Simon and Schuster ISBN 13-978-0694-80382-1) and *The Synaptic Self: How our Brains Become Who We Are* (2002, Penquin ISBN 14-20-0178-3). He leads a rock band called the Amygdaloids. His website, www.cns.nyu.edu/ledoux, contains slide shows on various aspects of his fear mechanisms research.
18. **LeDoux's** distinction contrasting the “high road” and the “low road“ suggests not only that emotions can be conditioned without conscious awareness, but also that our emotional state may sometimes conflict with our conscious goals. Students may want to identify personal situations where they experienced similar conflict (e.g., flying in spite of fear).
19. Many fMRI studies have implicated the amygdala in humans' ability to learn to anticipate a shock using arbitrary cues (for an early example, see LaBar et al., 1998, Neuron). However, a follow-up study illustrated that, while the amygdala signal diminished after learning, insular activation continued to increase when shock cues were presented (Buchel et al., 1998, Neuron).
20. Patients with anxiety disorders show more activation in the amygdala and insular cortex; one of the most promising applications of fMRI is to better diagnose and treat psychiatric disorders. For instance, investigators have recently been able to identify hyper-responsiveness to negative stimuli in anxiety prone subjects (e.g., Stein et al., 1997, Archives of General Psychiatry).
21. In the 1990s, parallel to improvements in the temporal resolution of brain imaging in humans, methods (e.g., in vivo cyclic voltammetry) began to confer second-to-second resolution of dopamine release in specific brain regions. This allowed investigators to observe dopamine release in the nucleus accumbens not just in response to food and drug rewards, but also in anticipation of food and drug rewards (Garris et al., 1999 Nature; Roitman et al., 2004, Journal of Neuroscience).
22. **Brian Knutson's Research** utilizes financial behavior to better understand the emotional basis of decision making. As he states in the film, money is a very useful research tool, as it evokes emotional behavior and is easily quantifiable. The lay press has reported on some of Dr. Knutson's research, and the articles may be useful to your students by demonstrating that this research can extend to real-life situations. A brief review can be found at [www-
psych.stanford.edu/~span/Publications/bk07jn.pdf](http://www-psych.stanford.edu/~span/Publications/bk07jn.pdf).

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A particularly compelling article from SLATE, www.slate.com/id/2224932/pagenum/all, entitled “Seeking,” tells why we may sometimes be more satisfied in looking for things (in this case on the internet) rather than in actually finding them. The article cites *Olds*, *Panksepp*, and *Knutson*.

Other articles include an article from Oprah’s magazine about the role of anticipatory affect in shopping: www.oprah.com/money/Why-We-Shop-6-Shopping-Traps-to-Avoid, and an article from the Edge website about the role of uncertainty in financial decision making by Knutson: www.edge.org/3rd_culture/brown08/brown08_index.html#knutson

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Related Films Also Available from Davidson Films

This is one of four films in Davidson Films' "Neuroscience" series. The other titles are:

- *Discovering the Human Brain: New Pathways to Neuroscience* (2006) 30 Minutes
- *Human Brain Development: Nature and Nurture* (2007) 30 Minutes
- *Making Sense of Sensory Information* (2008) 30 Minutes

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