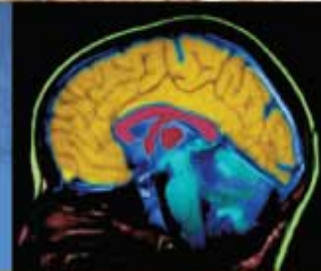


Nancy C. Andreasen, M.D., Ph.D.



The Creating
BRAIN



THE NEUROSCIENCE OF GENIUS



Iowa

What Is Creativity?

To see a World in a Grain of Sand
And a Heaven in a Wild Flower,
Hold Infinity in the palm of your
hand
And Eternity in an hour.



--William Blake

What Is Creativity?

- Intelligence?
- Talent or skill?
- The ability to perceive and produce novel ideas or products that are useful to society.....

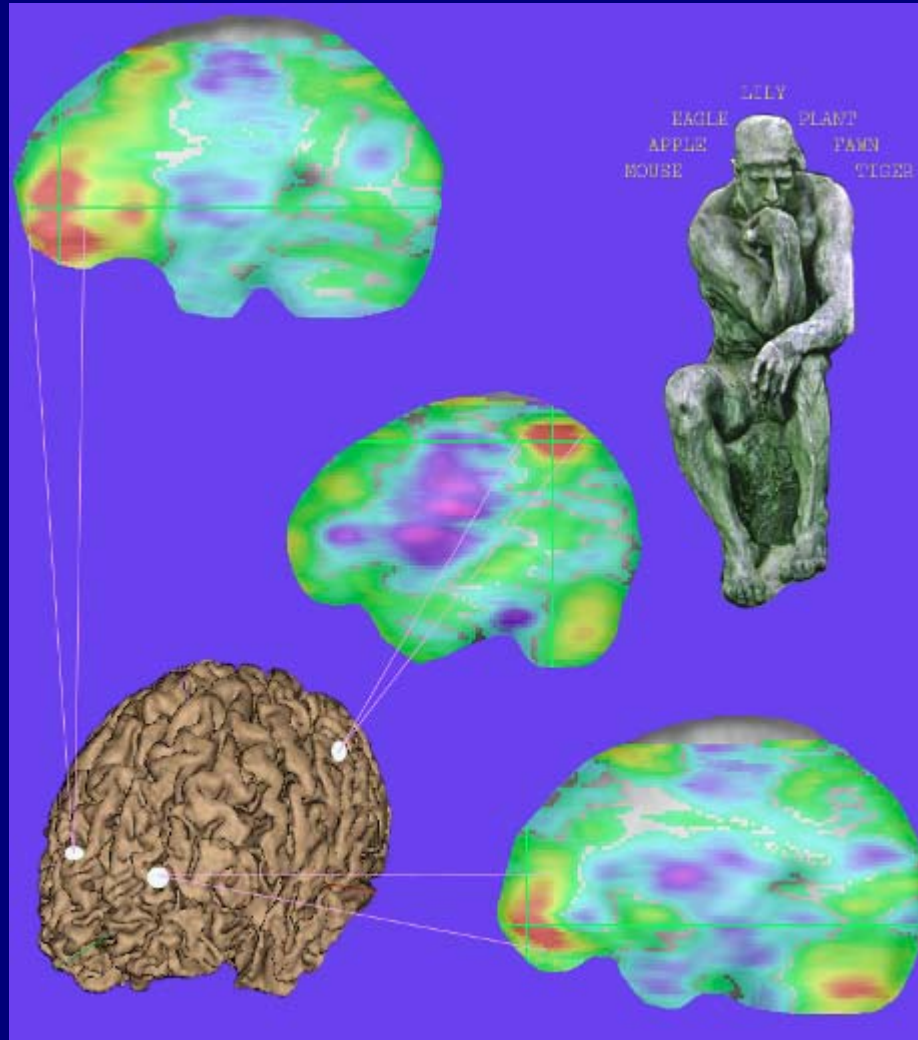


Lewis Terman's Geniuses: The "Termites"

- A landmark longitudinal study begun at Stanford in 1921
- Identified and followed children born in 1910 or later who had IQs in 135-200 range
- Tested the "early ripe, early rotten theory...and disproved it
- Measured in many ways—health, social function, etc
- Although highly intelligent, the "Termites" made few creative contributions
- Nobel Laureate William Shockley didn't even get included!



How Does the Brain Think?



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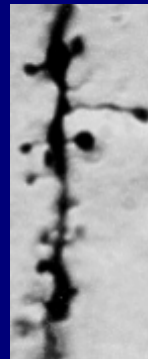
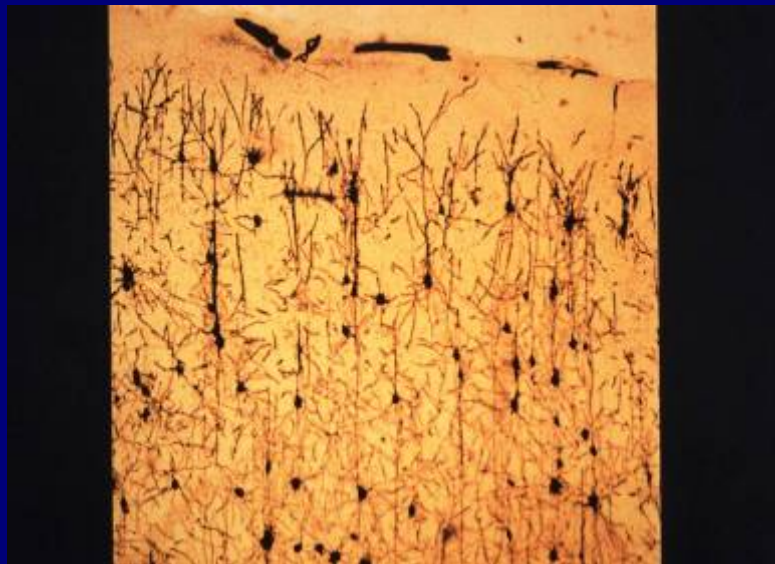
The Miracle of Human Brain Complexity

- 100 billion neurons in the cerebral cortex— as many as the stars in the Milky Way
- A trillion more neurons in the cerebellum
- Overall, more than a quadrillion neurons
- Then add on the dendrites, spines, and synapses (1000-10,000 synapses/neuron)
- Then ponder the number of interconnections that are possible through feedback loops
- It is not surprising that our brains have an enormous creative capacity



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Neurons, Dendrites, Spines, Synapses, Feedback Loops



All Human Beings Have Creative Capacities

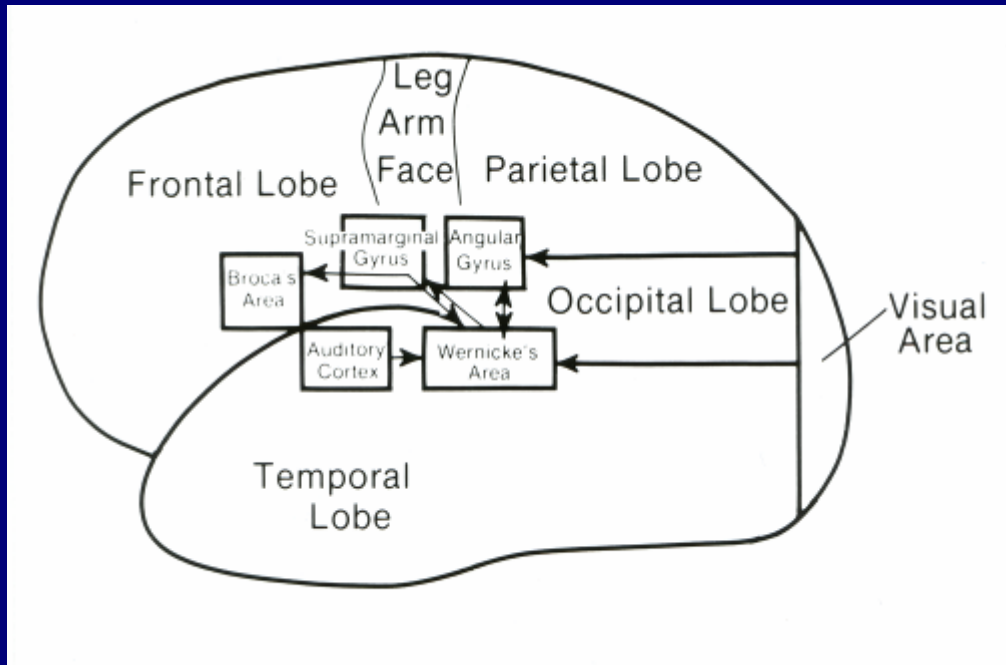


- Ordinary creativity
- Extraordinary creativity



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The Example of Language



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The Concept of Self Organizing Systems

- Draws heavily on chaos theory
- Process of self organization is not linear
- It is nonlinear and dynamic
- Nonlinear=not easily predictable, small causes can have large effects
- Dynamic=subject to frequent change, or “unstable”



The Brain as A Self Organizing System (SOS)

- The whole is greater than its parts
- Its parts spontaneously self organize to create something new
- Control is not centralized
- It is distributed throughout the whole system



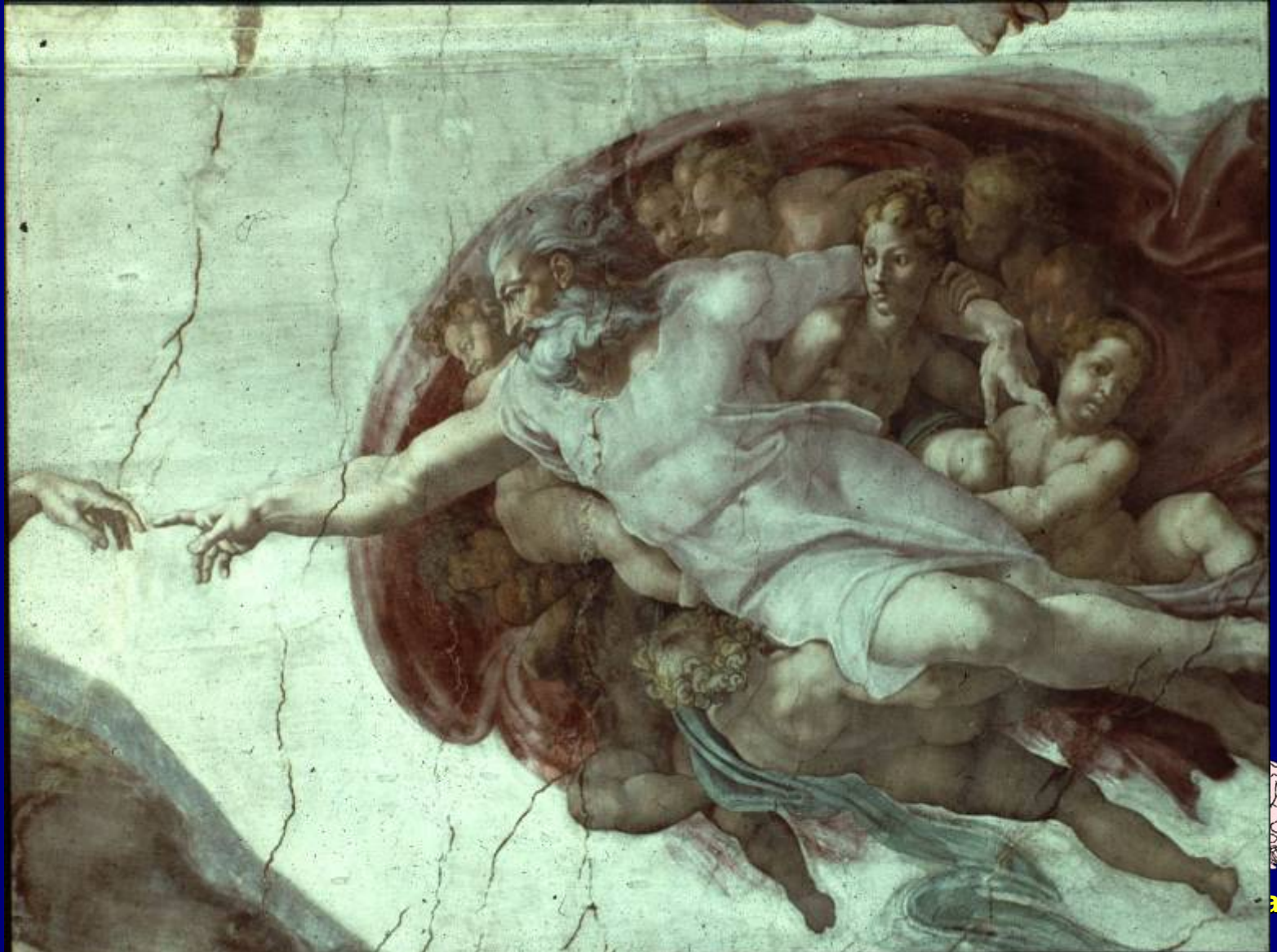
Examples of SOS



- Flocking of birds
- Schooling of fish
- Swarming of bees
- Changes in ecosystems due to climate changes, predators
- Changes in economy in due to changes in geopolitics or natural resources



How Does the Brain Think Creatively?



Coleridge

The Author continued for about three hours in a profound sleep, at least of the external senses, during which time he has the most vivid confidence, that he could not have composed less than from 200-300 lines; if that indeed can be called composition in which all the images rose up before him as *things*, with a parallel production of the correspondent expressions, without any sensation or consciousness of effort.



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Neil Simon

- I slip into a state that is apart from reality.
- I don't write consciously – it is as if the muse sits on my shoulder.



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Mozart

- When I am, as it were, completely in myself, entirely alone, and of good cheer — say traveling in a carriage, or walking after a good meal, or during the night when I cannot sleep; it is on such occasions that my ideas flow best and most abundantly. *Whence and how they come, I know not; nor can I force them. ...my subject enlarges itself, becomes methodized and defined, and in the whole, though it be long, stands almost complete and finished in my mind, so that I can survey it, like a fine picture or a beautiful statue, at a glance. Nor do I hear in my imagination the parts successively, but I hear them, as it were, all at once (gleich alles zusammen). What a delight this is I cannot tell! All this inventing, this producing, takes place in a pleasing lively dream.*



Poincare

- One evening, contrary to my custom, I drank black coffee and could not sleep. Ideas rose in crowds; I felt them collide until pairs interlocked, so to speak, making a stable combination. By the next morning I had established the existence of a class of Fuchsian functions, those which come out from the hypergeometric series; I had only to write out the results, which took but a few hours.



Exploring the Neural Basis of the Unconscious: "The Edge of Chaos"

Regular Articles

Remembering the Past: Two Facets of Episodic Memory Explored With Positron Emission Tomography

Nancy C. Andreasen, M.D., Ph.D., Daniel S. O'Leary, Ph.D., Ted Cizadlo, B.S.,
Stephan Arndt, Ph.D., Karim Rezaei, M.D., G. Leonard Watkins, Ph.D.,
Laura L. Boles Ponto, Ph.D., and Richard D. Hichwa, Ph.D.

Objective: This study used positron emission tomography to examine two kinds of personal memory that are used in psychiatric evaluation: focused episodic memory (recall of past experience, employed in "taking a history") and random episodic memory (uncensored thinking about experience, examined during analytic therapy using free association). For comparison, a third memory task was used to tap impersonal memory that represents general information about the world ("semantic memory"). **Method:** Thirteen subjects were studied using the [18 O]H $_2$ O method to obtain quantitative measurements of cerebral blood flow. The three conditions were subtracted and their relative relationships examined. **Results:** The random episodic condition produced activations in widely distributed association cortex (right and left frontal, parietal, angular/supramarginal, and posterior inferior temporal regions). Focused episodic memory engaged a network that included the medial inferior frontal regions, precuneus/retrosplenial cingulate, anterior cingulate, thalamus, and cerebellum. The use of medial frontal regions and the precuneus/retrosplenial cingulate was common to both focused and random episodic memory. The major difference between semantic and episodic memory was activation of Broca's area and the left frontal operculum by semantic memory. **Conclusions:** These results indicate that free-ranging mental activity (random episodic memory) produces large activations in association cortex and may reflect both active retrieval of past experiences and planning of future experiences. Focused episodic memory shares some components of this circuit (inferior frontal and precuneus), which may reflect the time-linked components of both aspects of episodic memory, and which permit human beings to experience personal identity, consciousness, and self-awareness. (*Am J Psychiatry* 1995; 152:1576-1585)

When to the sessions of sweet silent thought,
I summon up remembrance of things past. . . .

—William Shakespeare, *Sonnet 30*

Hysterics suffer from reminiscences.

—Sigmund Freud,
Studies on Hysteria (1)

Received May 3, 1995; revision received June 23, 1995; accepted July 11, 1995. From the Department of Psychiatry and Department of Radiology, University of Iowa Hospitals and Clinics. Address reprint requests to Dr. Andreasen, Department of Psychiatry, University of Iowa Hospitals and Clinics, Mental Health Clinical Research Center, 200 Hawkins Dr., Iowa City, IA 52242.

Supported in part by grants MH-31593 and MH-40856, Clinical Research Center grant MH-43271, and Research Scientist Award MH-00625 from NIMH and by an Established Investigator Award from the National Alliance for Research on Schizophrenia and Depression.

Each day most psychiatrists "take a history" from someone, perhaps from many people. In addition, some psychiatrists use techniques of free association, in order to examine spontaneous and uncensored thinking as a means for understanding the dynamics of mental processes. Through these two methods of exploring past experiences, psychiatrists are tapping into two potentially different kinds of "episodic memory" (2). The conscious remembering of past experience during history taking requires a focused search into the events of the individual's past. The unfocused expression of whatever comes to mind, or free association, occurs in the crucible of the psychoanalytic relationship and situation; it distills neurotic themes manifested in transference and interpersonal relations, fantasies, dreams, and recollections; one component includes retrieval of memories interlinked in ways that reflect primary proc-



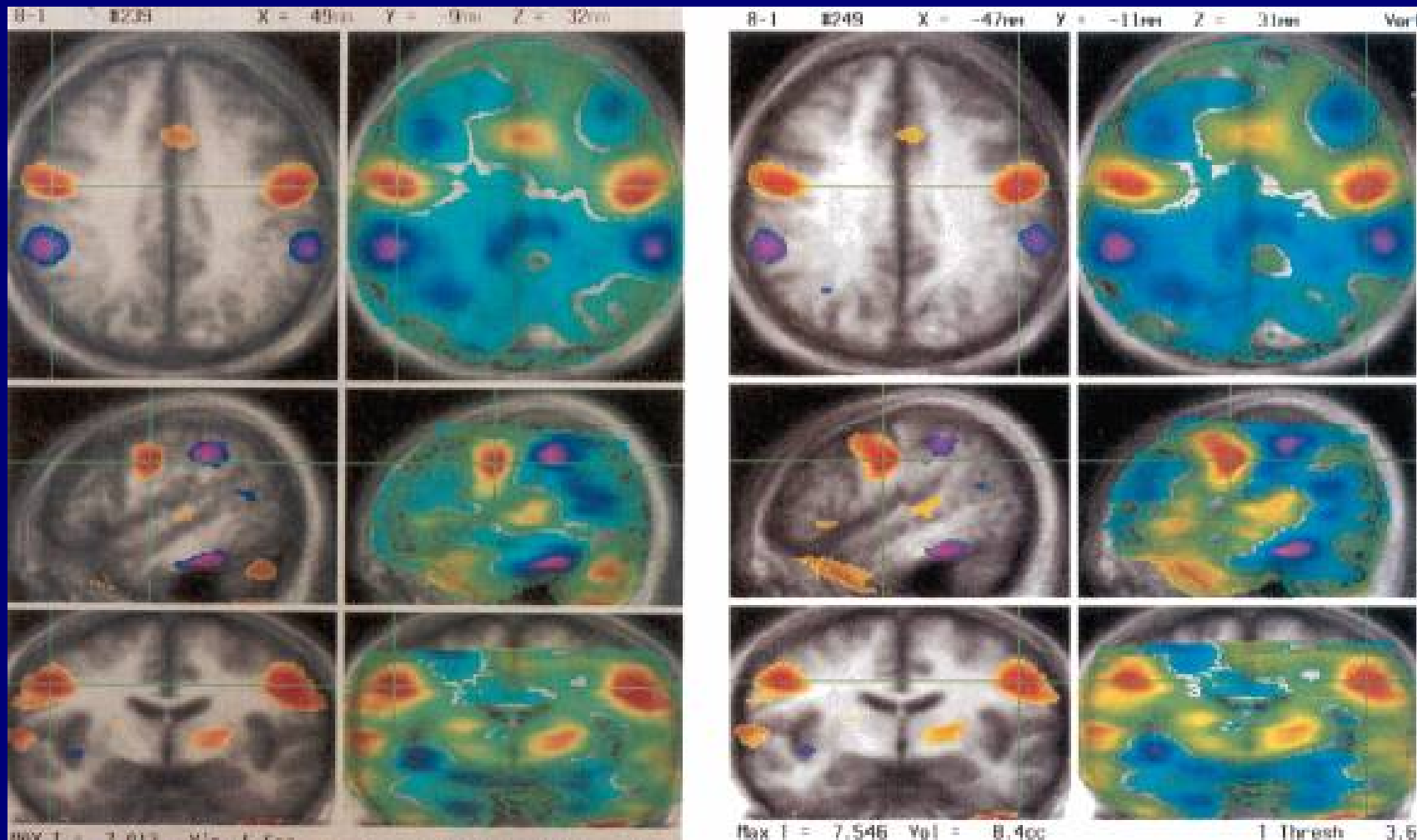
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Random Episodic Silent Thought (REST)

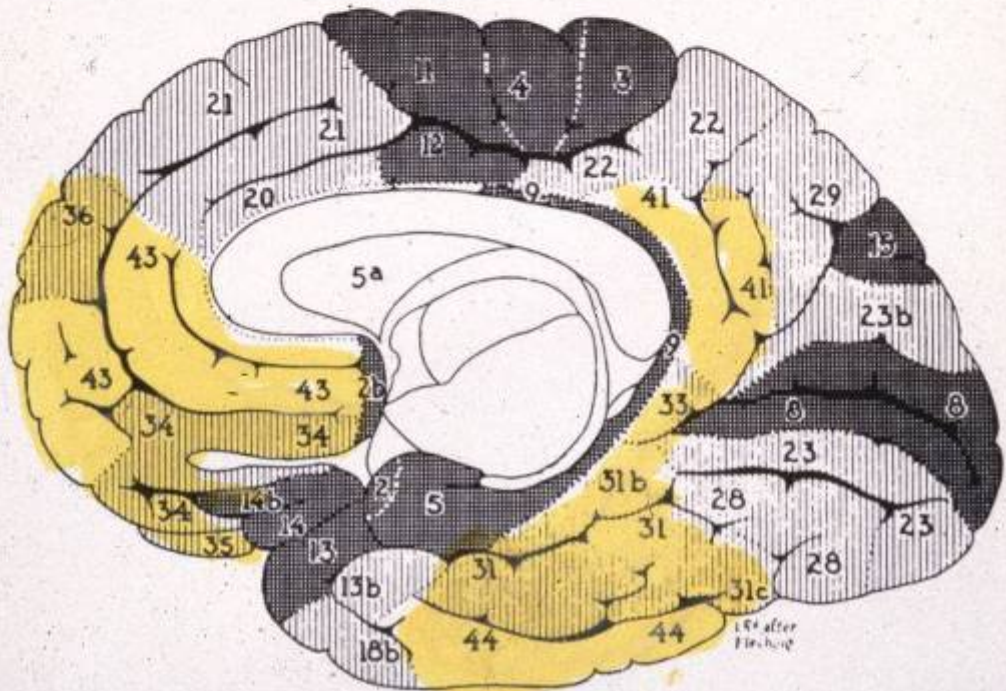
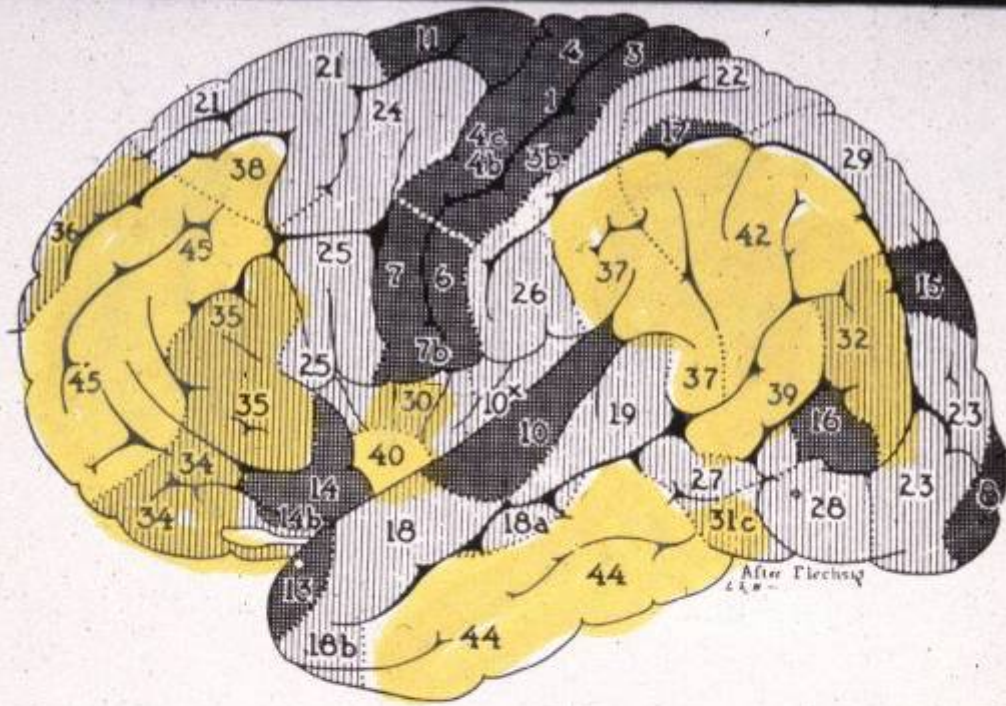
- Evaluated through free association in the psychoanalytic tradition
- The literary basis for *A Portrait of the Artist as a Young Man* or *The Sound and the Fury*
- Primary process thinking—free and uncensored
- The resource for creativity, dreams, and religious experiences



The Brain during REST: Association Cortex



**Ontogenetic
map of human
cortex: the
regions that
are the last to
myelinate—
the
association
cortices**



How Does the Brain Create?

- Thought is not just dynamic and nonlinear; unconscious processes play a role
- Association cortices are freely communicating back and forth, without being subject to reality principles
- Associations may initially be meaningless and unconnected, but then a new connection emerges that is creative
- The brain *disorganizes* in order to *self organize* and produce a totally new idea



The Iowa Study of Creative Genius

- Some of my most exciting work in progress
- The study compares neural activity in 30 highly creative artists, 30 highly creative scientists, and 30 noncreative individuals matched on IQ
- Working hypothesis: creative people will have more activity in association cortex while performing 3 tasks that require “making associations” in an fMR study
- The 3 tasks: word association, picture association, and pattern detection

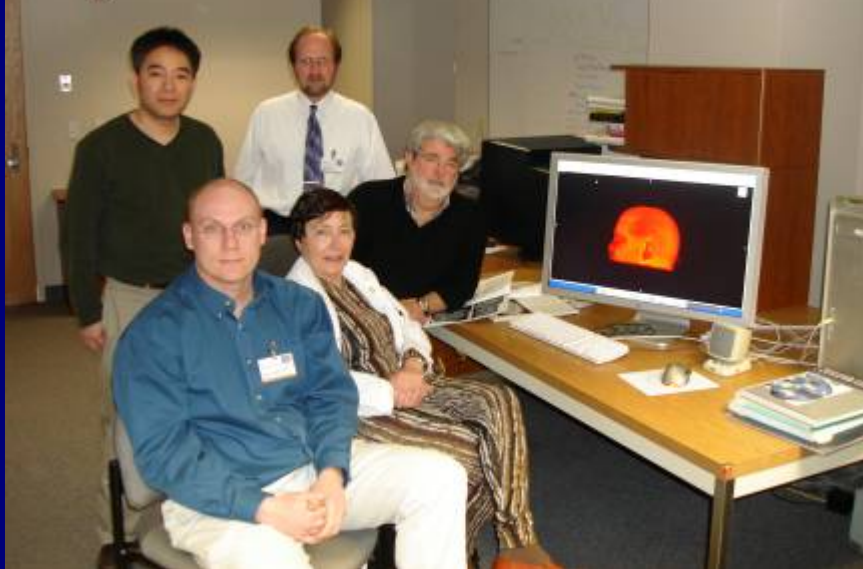


The Subjects Are Highly Creative



Iowa

The Nature of the Study



- Interview about the creative processs
- Anatomic MR
- Functional MR
- Cognitive Tests
- Debriefing
- Personal “brain book”
- Personal brain model



Iowa

What Have We Learned, So Far?

- The 3 tasks strongly activate association cortex, with some task-related differences
- The creative people have much more prominent activations
- Patterns are essentially identical in artists and scientists

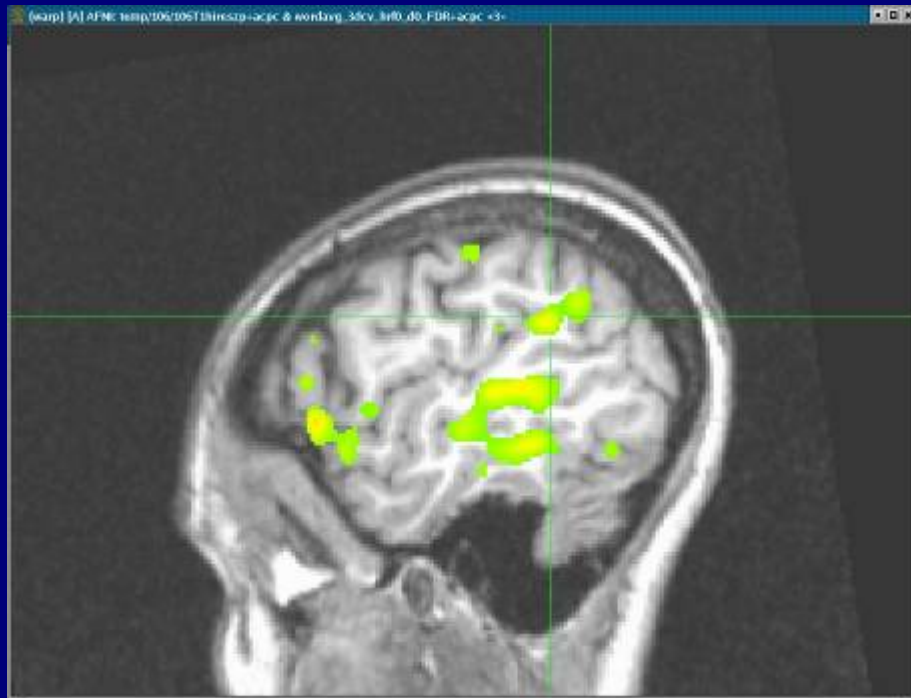


Word Association

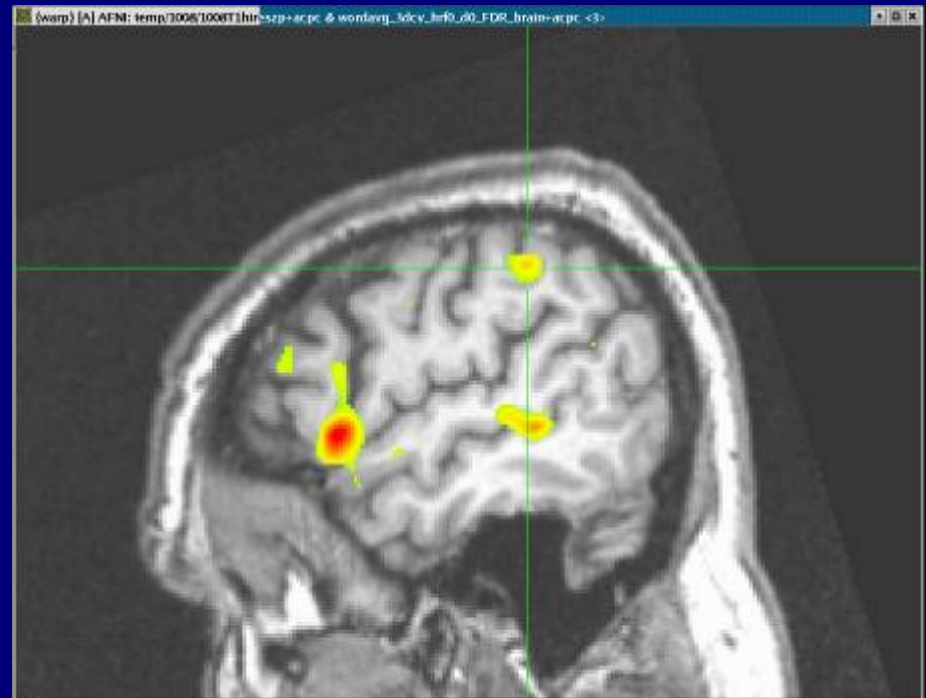
Eat

Wealth

Forget



Control subject

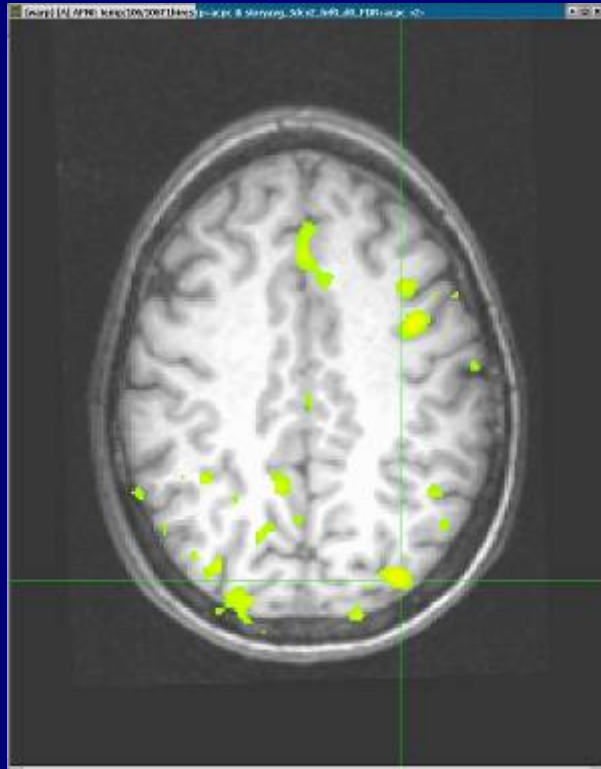


Creative subject

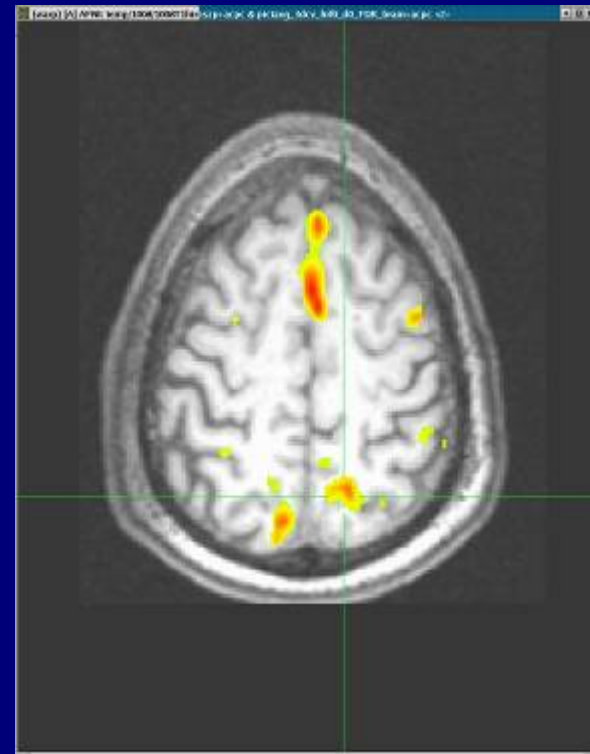


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Picture Association



Control subject



Creative subject



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Why Should Artists and Scientists Have Similar Brain Activations?

- Perhaps the creative process is very similar in art and science—both show sudden flashes of insight and intuition
- Many creative people have interests and skills in both fields—e.g., Einstein played the violin, Watson writes books
- Being a “polymath” (good at many things) enhances creativity because such people can see a “big picture”



The Example of George Lucas



- **Writer**
- **Film director**
- **A winner of the national Medal of Technology for digital imaging and computer graphics**
- **A very successful businessman**



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Creativity and Mental Illness



- Is there a relationship
- If so, to which illness?
- Are different types of creativity related to different types of illness?



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Genius and Insanity

- Those who have become eminent in philosophy, politics, poetry, and the arts have all had tendencies toward melancholia.

--Aristotle

- Great Wits are sure to Madness near ally'd:
And thin Partitions do their Bounds divide.

--John Dryden



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Joan Miro



Iowa



Michael Faraday




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The First Modern Empirical Study of Creativity and Mental Illness

Creativity and Psychiatric Illness

By NANCY C. ANDREASEN, M.D., Ph.D.



"In short, by these analogies, and coincidences between the phenomena of genius and mental aberration, it seems as though nature had intended to teach us respect for the supreme misfortunes of insanity; and also to preserve us from being dazzled by the brilliancy of those men of genius who might well be compared, not to the planets which keep their appointed orbits, but to falling stars, lost and dispersed over the crust of the earth."

— Cesare Lombroso¹

People have wondered for centuries whether creativity should be dreaded as well as prized.

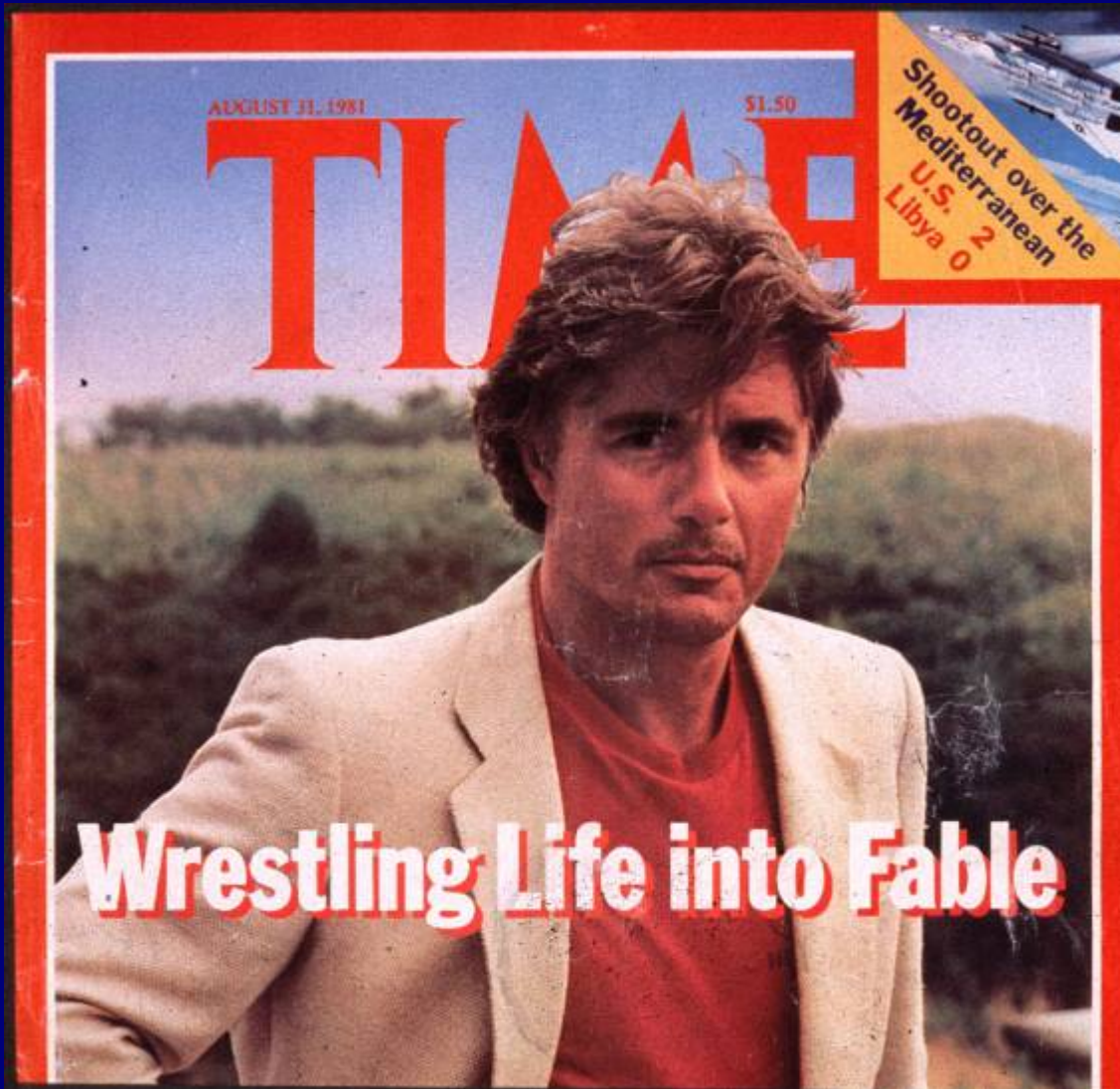
The mantle of prophet, poet, seer, or leader has rested heavily on the shoulders of its wearers. In both literature and life, genius has been viewed with ambivalence, seen as both a curse and a blessing, because it has so frequently been attended by physical and mental suffering. Tiresias was a lonely, crippled outcast as well as a revered sage. Columbus heard a voice condemning him when he reached the shores of Jamaica: "What happens to you today is a deserved punishment for having served the masters of the world and not God." Newton's later years were troubled by recurrent persecutory delusions. Samuel Johnson, Abraham Lincoln, and a host of others experienced terrible bouts of melancholy. Throughout the centuries, the

continued



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The Iowa Writers' Workshop: The Oldest and Most Famous Creative Writing Program in the World



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For Example...

- Kurt Vonnegut
- John Irving
- Robert Lowell
- Jorie Graham
- Gail Godwin
- Phillip Roth
- John Cheever
- Current faculty: two McArthur “geniuses” and two Pulitzer prizes



Iowa

OZARK AIR LINES

flighttime

MARCH

Featuring
The Top Of The Hill
by Irwin Shaw

Iowa's School for
Prize-Winning Writers
Hollywood Hits the Road:
The Boom in Location Shooting
Voyage of the
Space Shuttle



John Cheever



Kurt Vonnegut



Gail Godwin



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Design of Study

- **Structured interview designed to examine creative, social, psychiatric, and family history**
- **Diagnostic criteria applied to both subjects and family members**
- **Specific criteria used to define level of creativity**
- **Cognitive and personality tests also given**
- **Control group: educationally- matched individuals from “noncreative” professions**



History of Study

- Began in early 1970s
- Facilitated by my prior career in the Iowa English department
- Permitted me to recruit 30 writers, most of them well-known, over the next 10-15 years



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James Joyce and Family



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Hypotheses

- **Writers would not have an increased rate of psychiatric illness in comparison with educationally matched controls**
- **Their first degree relatives would have an increased rate of schizophrenia**
- **Cognitive testing would show differences in cognitive style**



Psychiatric Illness in Writers vs. Controls

Writers

Controls

| | N | % | | | | |
|-----------------------------|-----------|-----------|----------------|-----------|--------------|-------------|
| | | | X ² | P | | |
| Bipolar I | 4 | 13 | 0 | 0 | - | ns |
| Bipolar II | 9 | 30 | 3 | 10 | 2.60 | ns |
| Unipolar | 11 | 37 | 5 | 17 | 2.13 | ns |
| Any Bipolar Disorder | 13 | 43 | 3 | 10 | 6.90 | .01 |
| Any Mood Disorder | 24 | 80 | 9 | 30 | 13.20 | .001 |
| Alcoholism | 9 | 30 | 2 | 7 | 4.01 | .05 |
| Drug Abuse | 2 | 7 | 2 | 7 | - | ns |
| Suicide | 2 | 7 | 0 | 0 | - | ns |



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Psychiatric Illness in First Degree Relatives of Writers vs. Controls

Writers **Controls**

| | N | % | N | % | X ² | P |
|--------------------------|-----|----|-----|---|----------------|--------------|
| Total Relative N | 116 | | 121 | | | |
| Bipolar II | 4 | 3 | 0 | 0 | - | .056 |
| Unipolar | 17 | 15 | 3 | 2 | 9.84 | .01 |
| Any Mood Disorder | 21 | 18 | 3 | 2 | 14.21 | .001 |
| Alcoholism | 8 | 7 | 7 | 6 | 0.01 | ns |
| Suicide | 3 | 3 | 0 | 0 | - | ns |
| Any Illness | 49 | 42 | 10 | 8 | 34.77 | .0001 |



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Creativity in First Degree Relatives of Writers vs. Controls:

| | Writers | | Controls | | X ² | P |
|----------------------------|---------|-----|----------|-----|----------------|-----|
| | N | % | N | % | | |
| Total Relative N | | 116 | | 121 | | |
| All relatives + creative | 20 | 33 | 11 | 18 | - | ns |
| All relatives + + creative | 12 | 20 | 5 | 8 | 4.85 | .05 |
| Total creative relatives | 32 | 53 | 16 | 27 | 9.10 | .01 |



Iowa

Conclusions

- **Contrary to the initial hypothesis, writers have an increased rate of mood disorder**
- **Their family members also have an increase in both mood disorder and creativity**
- **They appear to share a diathesis that predisposes to both mood disorder and creativity.**



Is There a Relationship with Schizophrenia?



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John Nash

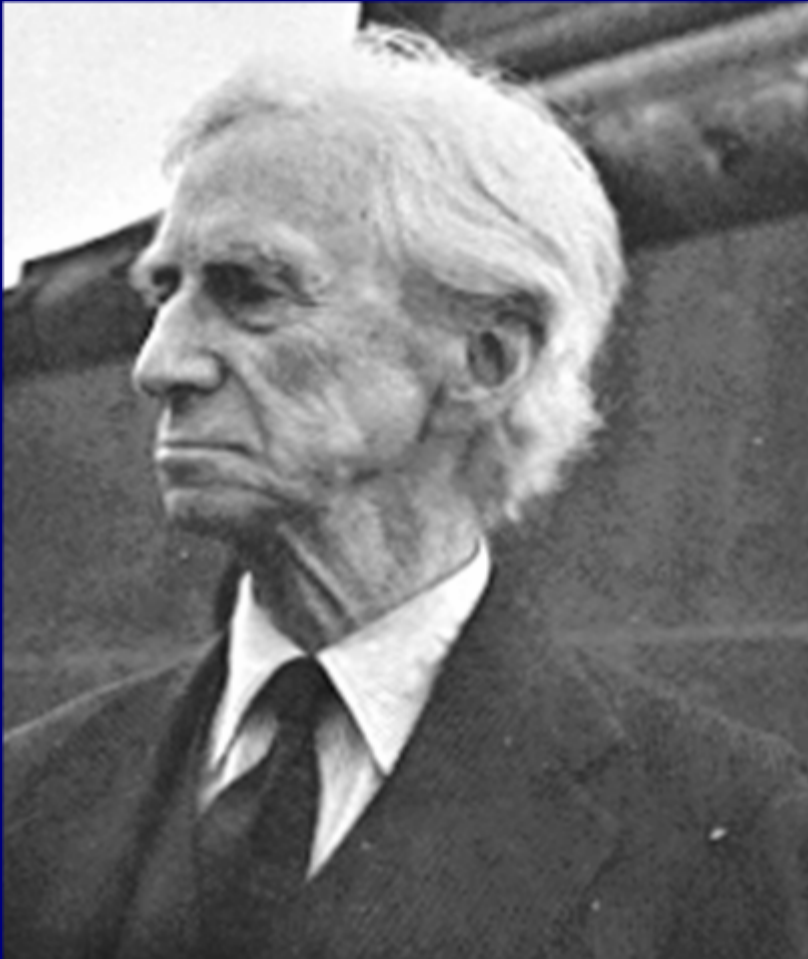


- **Nobel laureate: inventor of game theory**
- **Developed schizophrenia at age 30**
- **Son Johnny: also suffers from schizophrenia**



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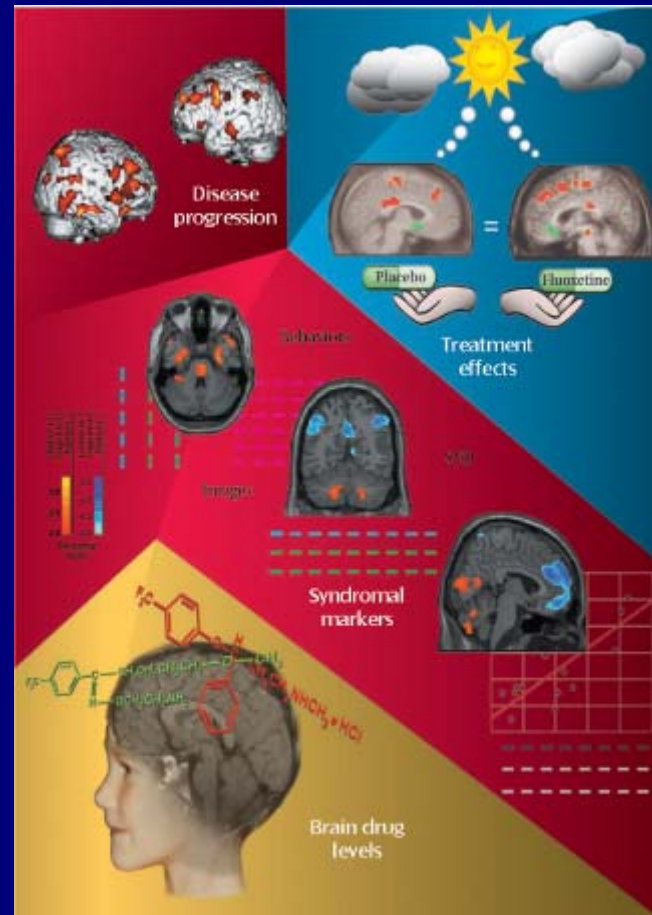
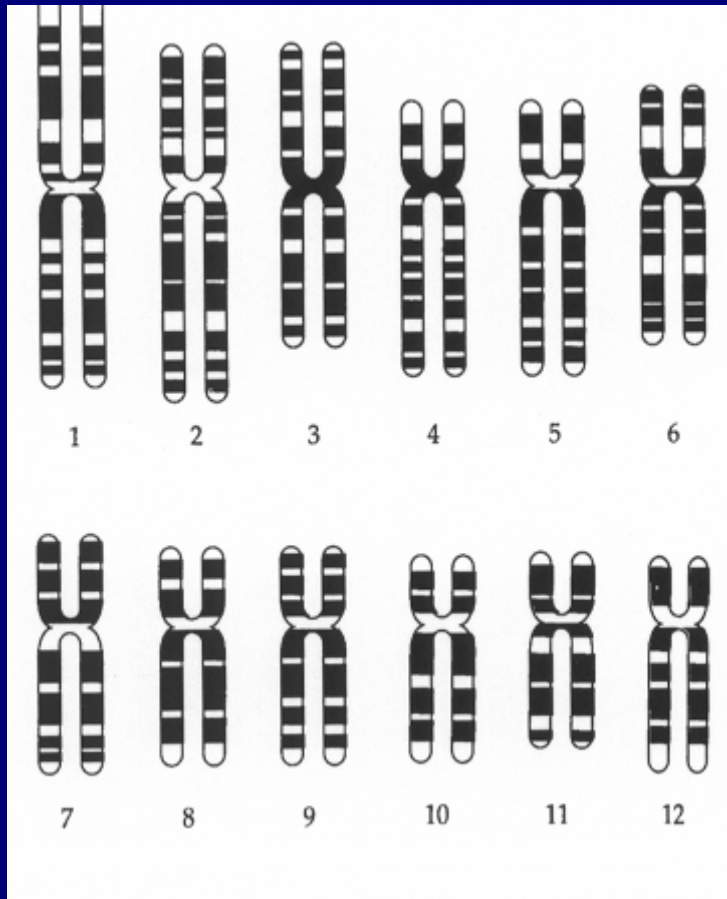
Bertrand Russell



- **Uncle William:**
“insane”
- **Aunt Agatha:**
delusional
- **Son John:**
schizophrenia
- **Granddaughter Helen:**
schizophrenia and
suicide



Is There Empirical Evidence?



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**What Have Been the Most
Important Scientific
Discoveries Since the Dawn of
Modern Science?**



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The Dawn of Modern Science

- Arose in the world of the Renaissance, when the absolute authority of the church and the Bible was called into question
- Arose because people attempted to **know** (science=to know) about the world through observation, testing, and empirical proof
- Francis Bacon and the Novum Organum: the first statement of the modern philosophy of science



Man can act and understand no further than he has observed, either in operation or in contemplation, of the method and order of nature.

--Francis Bacon, Novum Organum



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The Most Important Discoveries of Modern Science

- Newtonian mechanics
- The theory of relativity
- The structure of DNA



Newtonian Mechanics

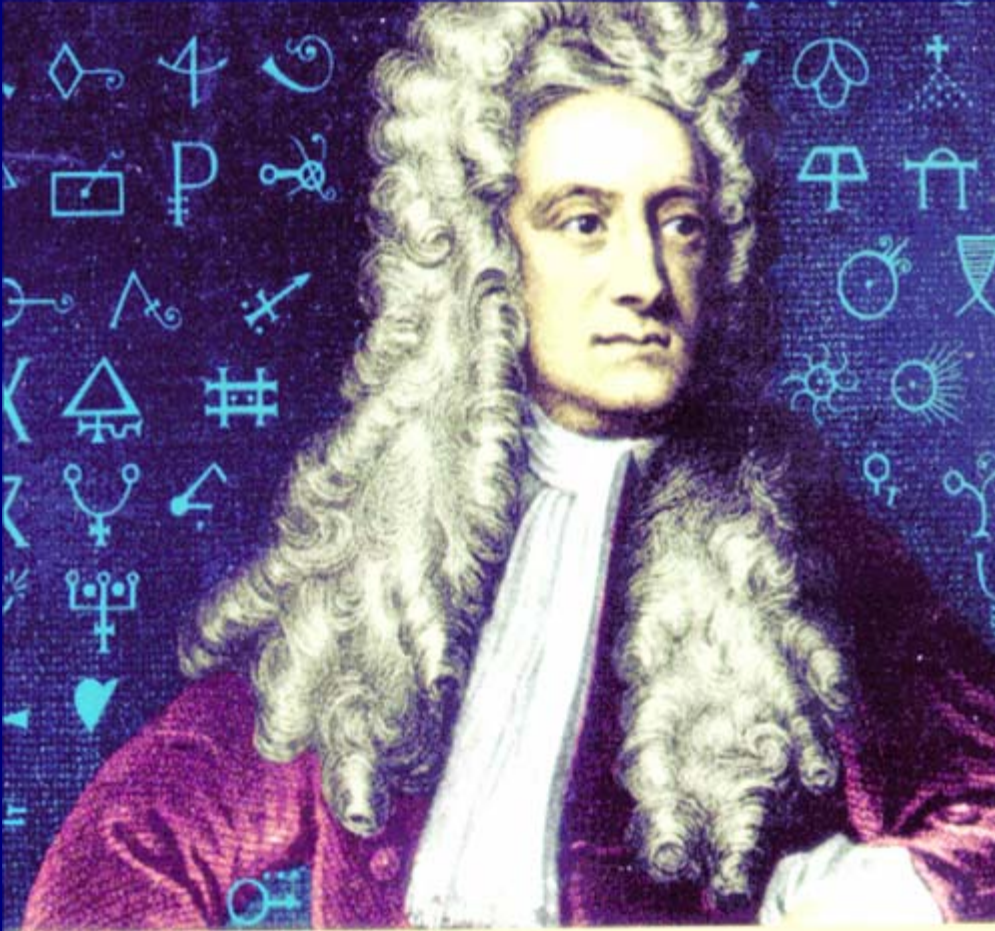
Nature and Nature's laws lay hid in night.
God said "Let Newton be," and all was
light.

--Alexander Pope



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Isaac Newton



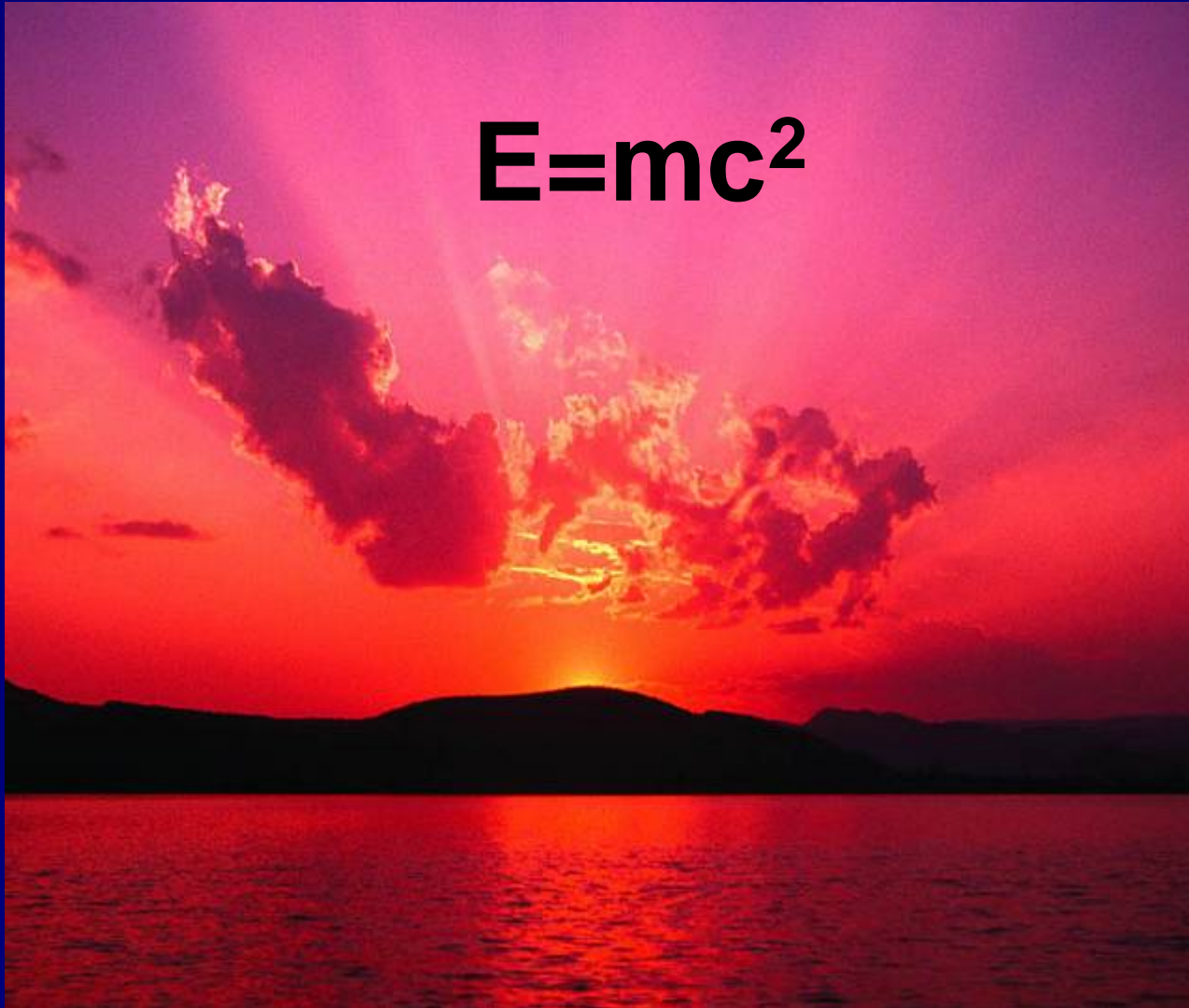
- Born a “preemie”
- Chronically suspicious
- Psychotic break at age 40
- Unusual interests and beliefs



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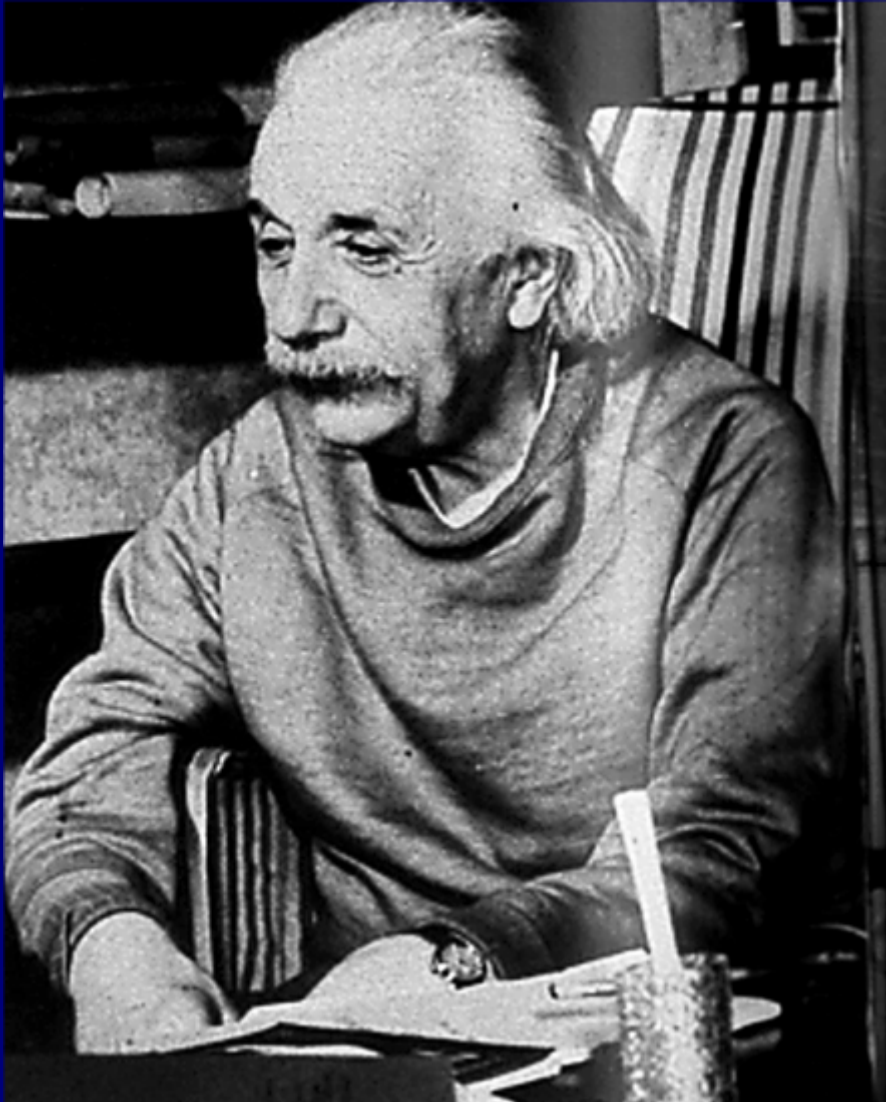
Theory of Relativity

$$E=mc^2$$



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Albert Einstein

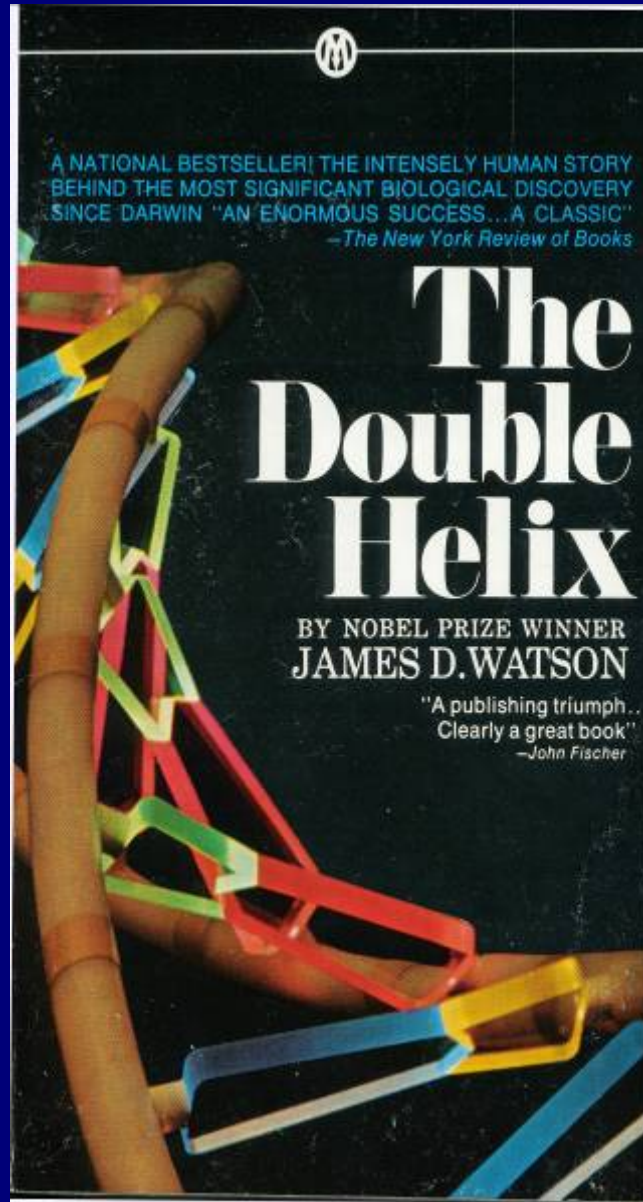


- **Nobel laureate**
- **Schizotypal traits**
- **Son with schizophrenia**



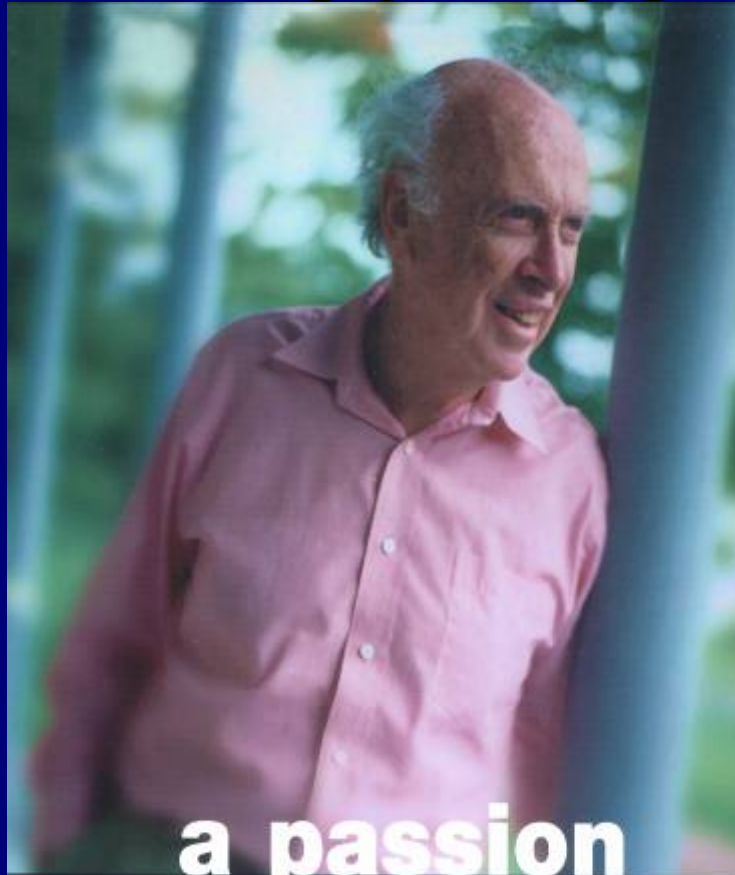
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The Structure of DNA



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James Watson



a passion
for DNA
Genes, Genomes,
and Society
James D. Watson

- Nobel laureate
- Son with schizophrenia



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The three most important discoveries of modern science were all done by men who have an association with schizophrenia.

What are the odds of that association occurring by chance?



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Genius and Schizophrenia

- Does the illness (or carrying the diathesis) confer an ability to perceive and think in a highly original way? To perceive new and different relationships?
- Is the thinking style related to the cognitive dysfunctions of schizophrenia?
- Are the original insights of Newton or Einstein a mild/useful variant of “associative loosening?



A Question and Nash's Answer

- “How could you believe that you are being recruited by aliens from outer space to save the world?”
- “Because the ideas I had about supernatural beings came to me the same way that my mathematical ideas did. So I took them seriously.”



Some Thoughts and Ideas

- Creativity is a mental gift that permits people to perceive in original and novel ways...to see things that others can't
- It is shared across disciplines such as math and literature
- It makes its possessor "different," and sometimes vulnerable to mental illnesses such as schizophrenia or mood disorder



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***Kubla Khan: Or, A Vision in
A Dream***

Beware! Beware!

**His flashing eyes, his floating hair!
Weave a circle round him thrice,
And close your eyes with holy dread,
For he on honey-dew hath fed,
And drunk the milk of Paradise.**



Iowa

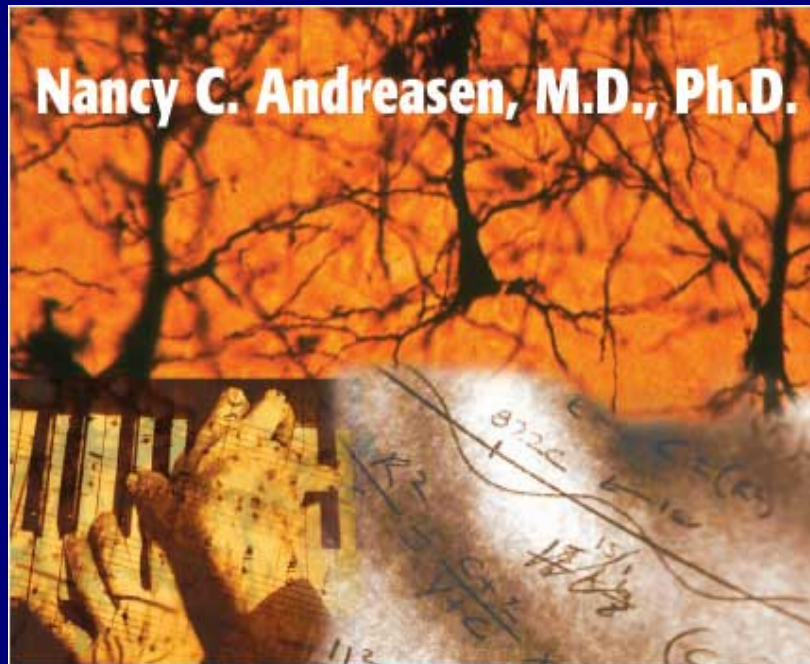
William Blake

To see a World in a Grain of Sand
And a Heaven in a Wild Flower,
Hold Infinity in the palm of your
hand
And Eternity in an hour.

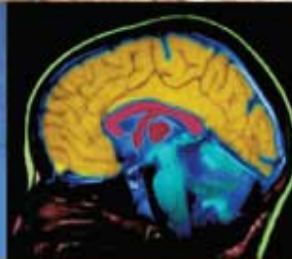


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The Creating
BRAIN



THE NEUROSCIENCE OF GENIUS



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