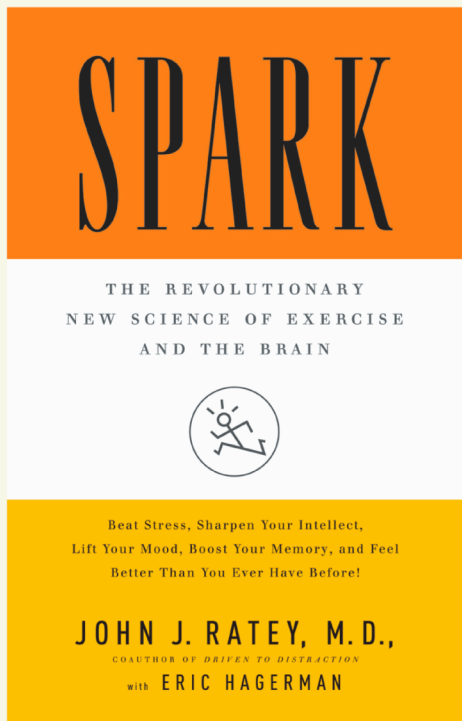




Exercise and the brain- the crucial connection!



**SPARK: The Revolutionary New Science of
Exercise and the Brain**

By Dr. John Ratey
with Eric Hagerman
January 10, 2008
Hardcover \$24.99 (In Canada: \$31.99)

—To receive updates on SPARK please register at
www.johnratey.com

—To purchase SPARK now go to:
www.amazon.com
www.barnesandnoble.com
www.powells.com

SPARK is a groundbreaking exploration of the connection between exercise and the brain's performance that shows how even moderate exercise will supercharge mental circuits to sharpen thinking, enhance memory, beat stress, and much more. Dr. John J. Ratey is a Harvard professor and author of the bestseller *Driven to Distraction*.

COGNITION: Dr. Ratey shows how exercise improves our ability to learn and in fact makes us smarter. After a new fitness program was instituted in an Illinois school district of 19,000, test scores soared—first in the world in science and sixth in math.

HORMONAL FLUCTUATIONS: Exercise is particularly important for women during each stage of the life cycle because it tones down the negative consequences of hormonal changes that some experience and enhances the positive effects for others.

STRESS: Too much stress can sever connections between neurons. Dr. Ratey explains how exercise counteracts this breakdown by increasing blood flow to the brain and creating a surge in protective neurochemicals.

ANXIETY: While anti-anxiety drugs stifle anxiety, they don't help you learn a different response to the underlying fear. Exercise has been proven not only to reduce anxiety but to rewire certain pathways and prevent anxiety.

MOOD: About 18 percent of adult Americans experience depression at some point in their lives. Using cutting-edge studies, Dr. Ratey shows that exercise is better than drugs like Zoloft in reducing depression. Exercise elevates endorphins, boosts dopamine, and regulates all of the neurotransmitters targeted by antidepressants.

AGING: Exercise can also help stave off memory loss and Alzheimer's and keep the mind sharp. New research illustrates that women who exercise decrease their chances of dementia by 50%.

ADHD: Exercise increases dopamine, which in turn improves focus and attention. Dr. Ratey explains why he prescribes exercise for treating ADHD in kids and adults.

ADDICTION: Exercise is the perfect antidote to addiction, again because it increases dopamine and so improves the brain's ability to satiate.

www.johnratey.com

www.PE4LIFE.org

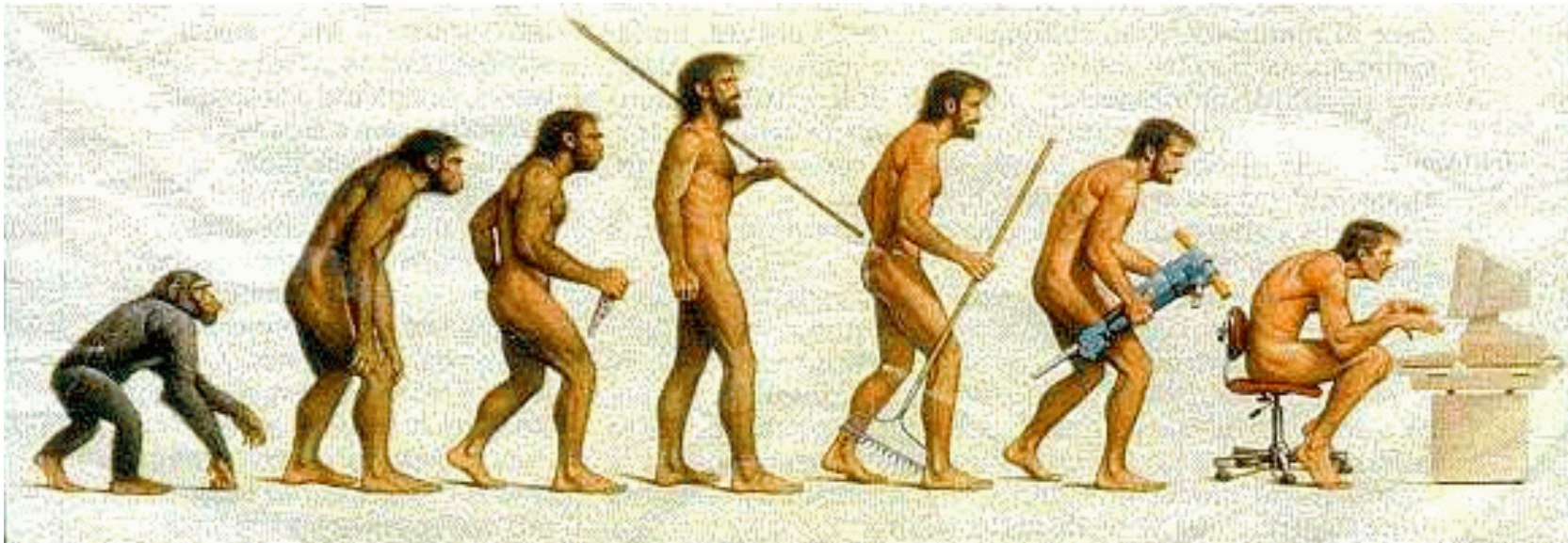
john@johnratey.com

Hunters & Gatherers

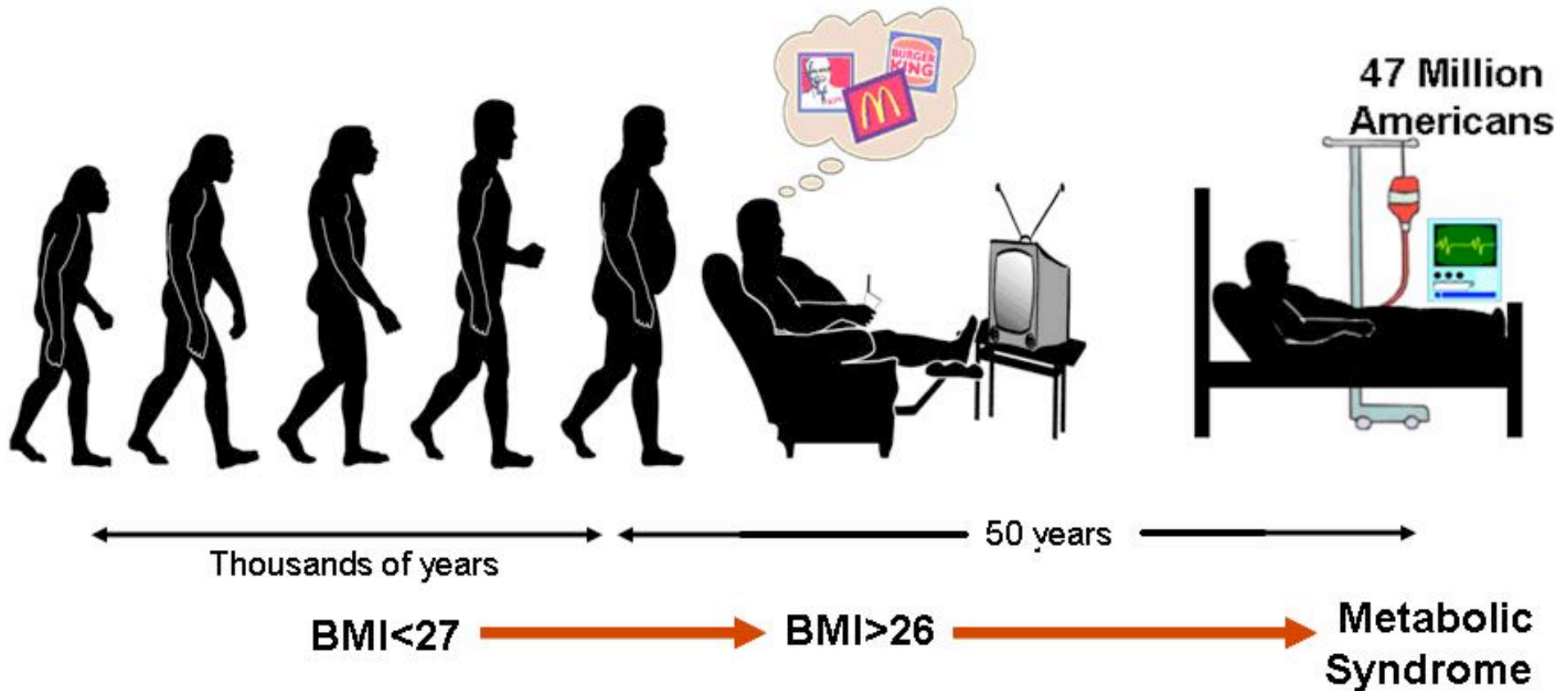
- Our early ancestors predominately consisted of **hunter-gatherer** types ensuring the **“Running Man”** as a standard of fitness for their



- # Learning From History
- Evolutionary history teaches us that early humans could not have survived without the ability to perform demanding physical work.
 - Individuals who could out-run & out-plan their peers would survive.



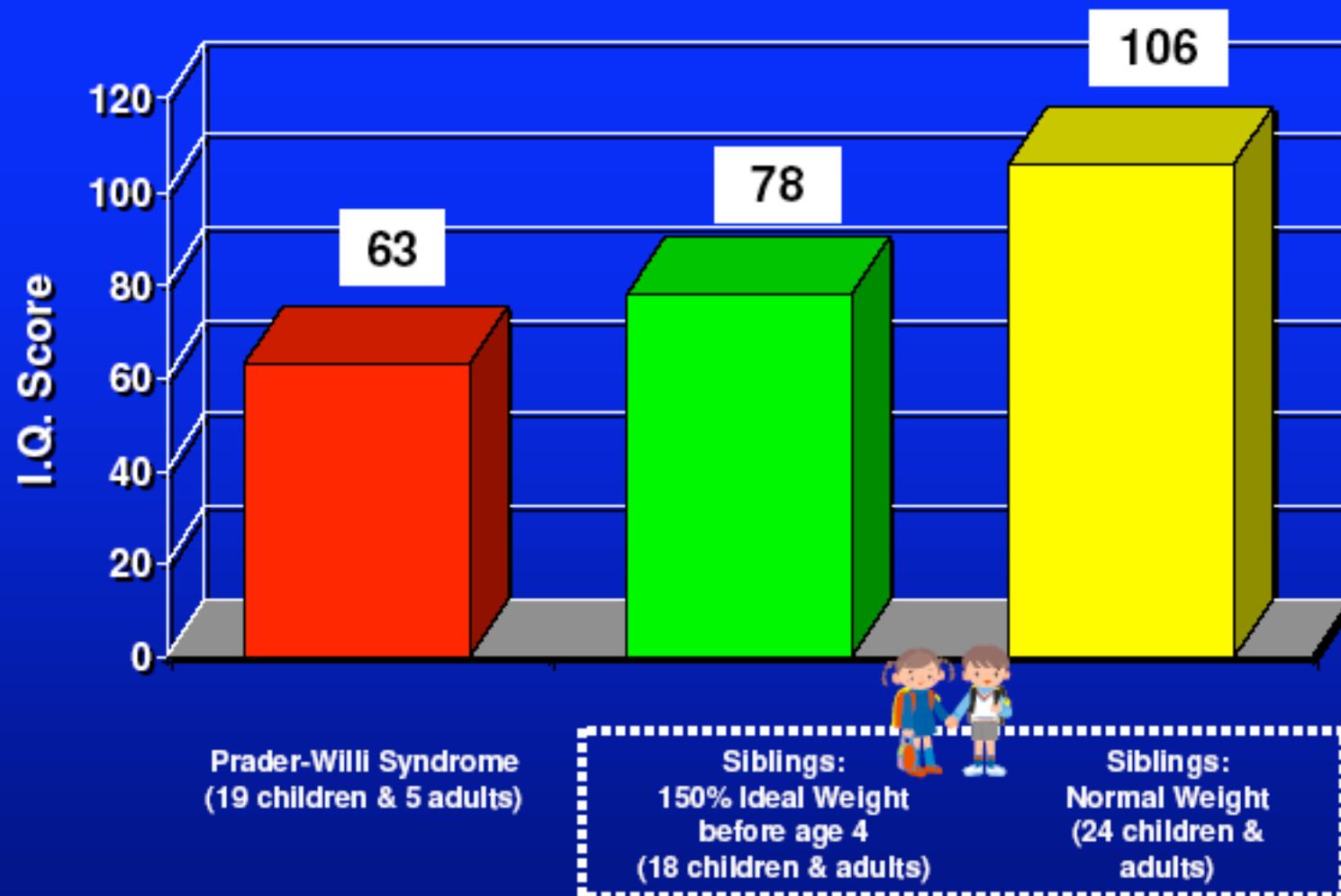
EVOLUTION OF MAN



Most Americans will become overweight, 90% of men and 70% of women.

An email from a German doctor who had gone to a conference in Illinois: 'One afternoon I decided to go for a walk. I noticed there were hardly any sidewalks on this road. On two occasions people stopped their car and asked if I was OK. The second stopper was a police car. The policeman found it hard to believe I was just going for a walk.'

Early-Onset Obesity and Its Effect on I.Q.



MY GENES MAKE ME DO IT

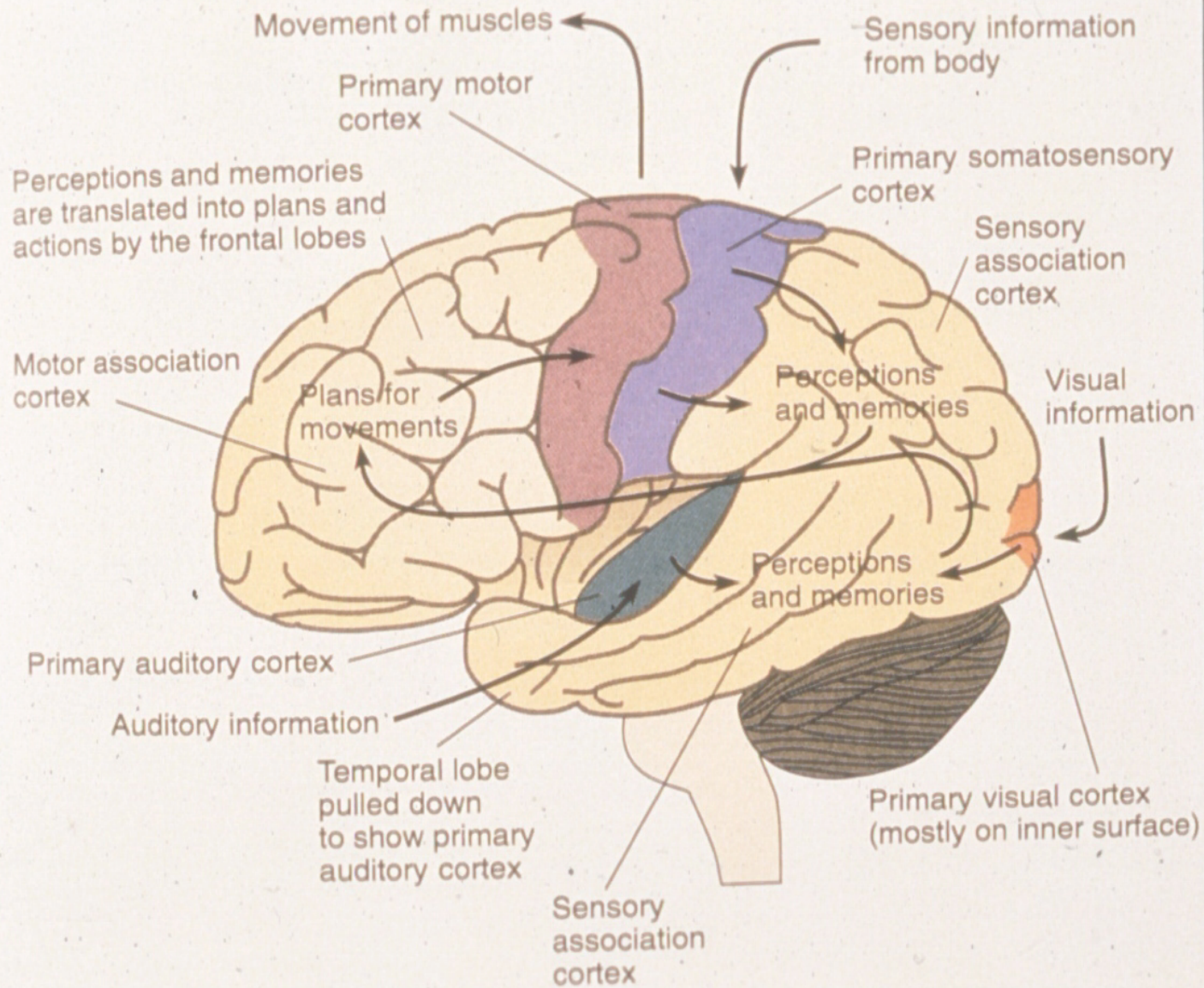


Thrifty Genes Evolved

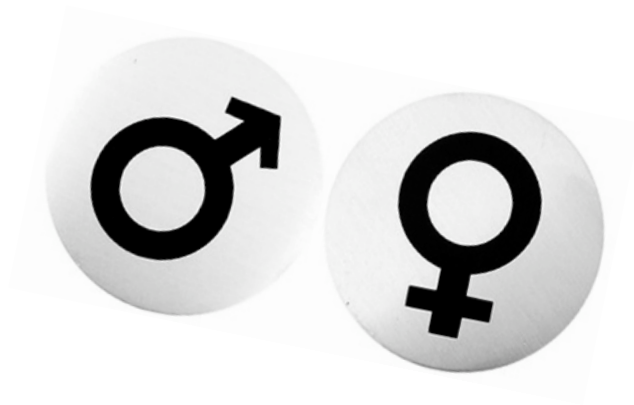
They drive us to load up on **calories** and **take it easy**

Because tomorrow we will have to **walk for days without food.**

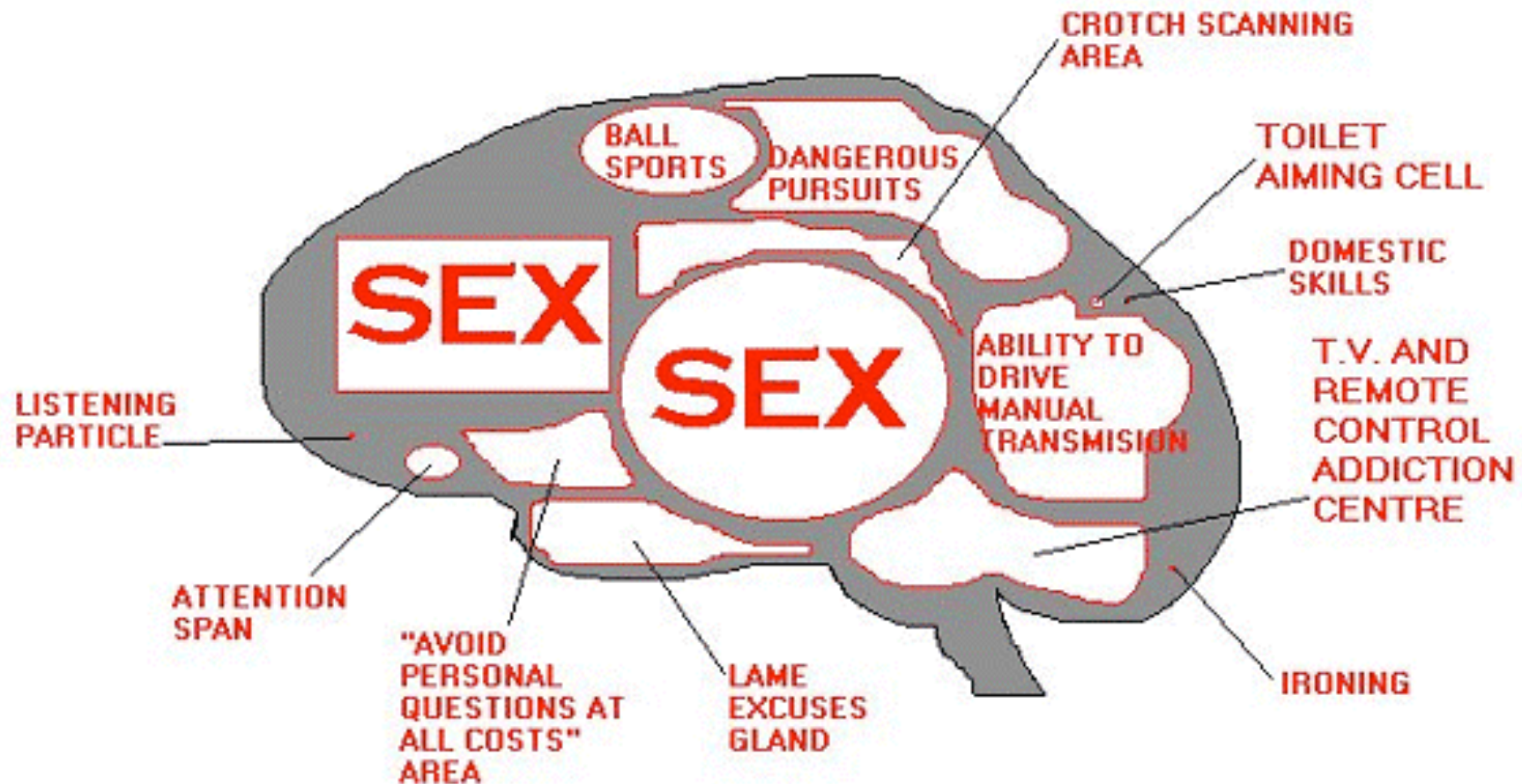
ADAPTATION, MOVING, LEARNING



GENDER DIFFERENCES

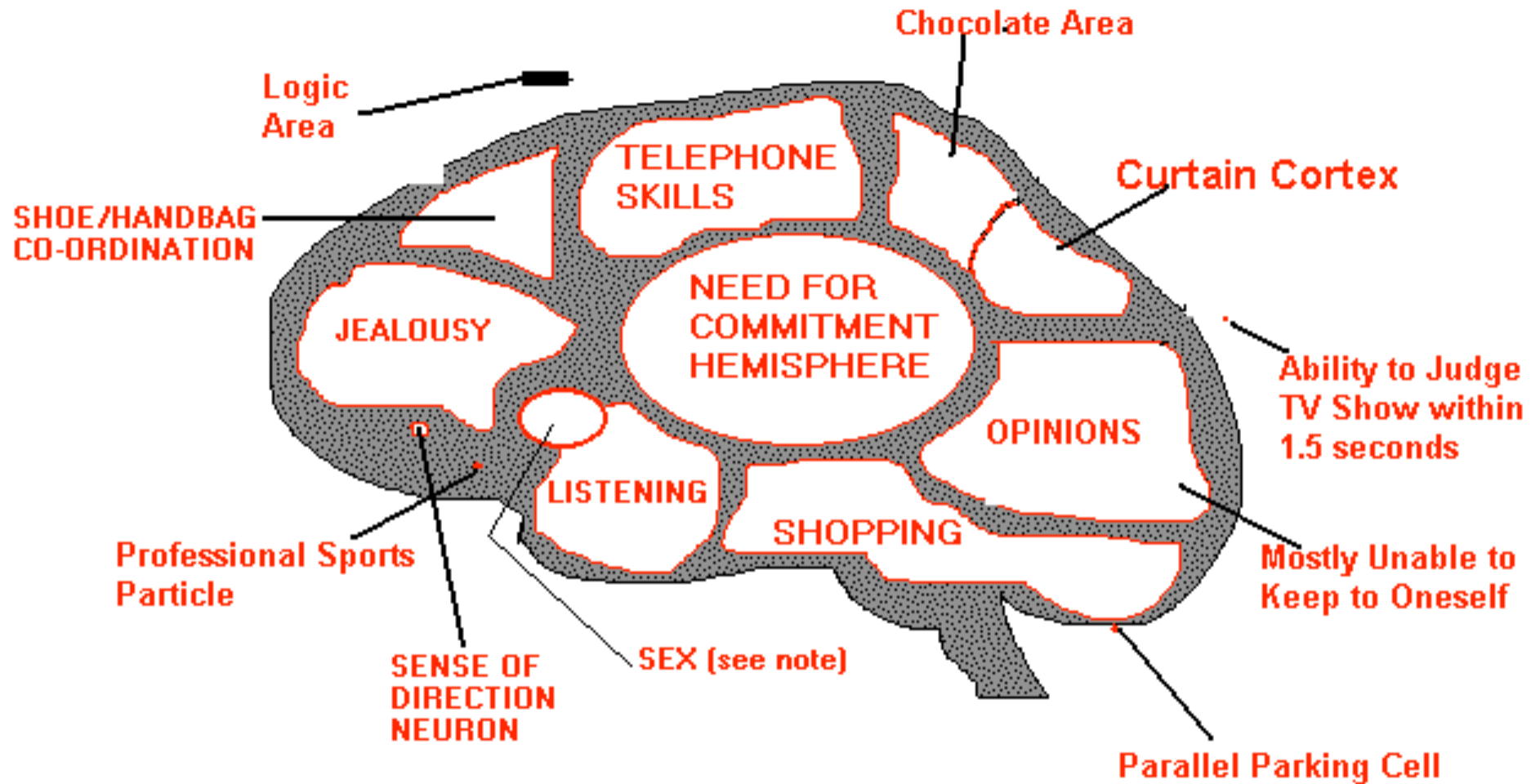


THE MALE BRAIN



Note: The "Listening to children cry in the middle of the night" gland is not shown due to its small and underdeveloped nature. Best viewed under a microscope.

THE FEMALE BRAIN



FOOTNOTE: Note how closely connected the small sex cell is to the listening gland.



Every student at Madison Junior High completes a computer-based fitness test.



Students spend one day a week in the school's state-of-the-art fitness center.



The results of a 2001 study by the **California Department of Education** showed **33 percent** of freshmen in California were **overweight or obese**. When District 203 gathered its own data in a 2002 study of its own freshmen, only **3 percent** were overweight or **obese**. 19,000 children in the district.

TIMSS (Trends in International Mathematics and Science Study) is an international benchmarking study comparing the achievement of eighth-grade students . In 1999, Naperville District 203 scored **#1 in science** and **#6 in math** . An amazing 94.1% of Naperville parents were satisfied with the PE curriculum.

The Board Meeting of the Future

BY JOHN J. MEDINA If you wanted to create a work environment in direct conflict with what the brain is equipped to do, you'd design the standard cubicle. Instead, imagine a brain-friendly workplace where board meetings are conducted on treadmills, desks are equipped with stationary bicycles, and people wear gym clothes, not suits.

AT BOARD MEETINGS, people wear gym clothes and walk on treadmills at about 1.8 miles per hour—to cool down right after a period of intense physical activity.

TREADMILLS are installed in the office. Morning and afternoon exercise breaks are encouraged.

WORKSTATIONS include stationary bicycles that fit under the desks. Employees keep their legs moving while answering e-mail.

IN A COMPETITIVE climate, exercise is as close to a magic productivity bullet as you'll get.

The Brain's Active History

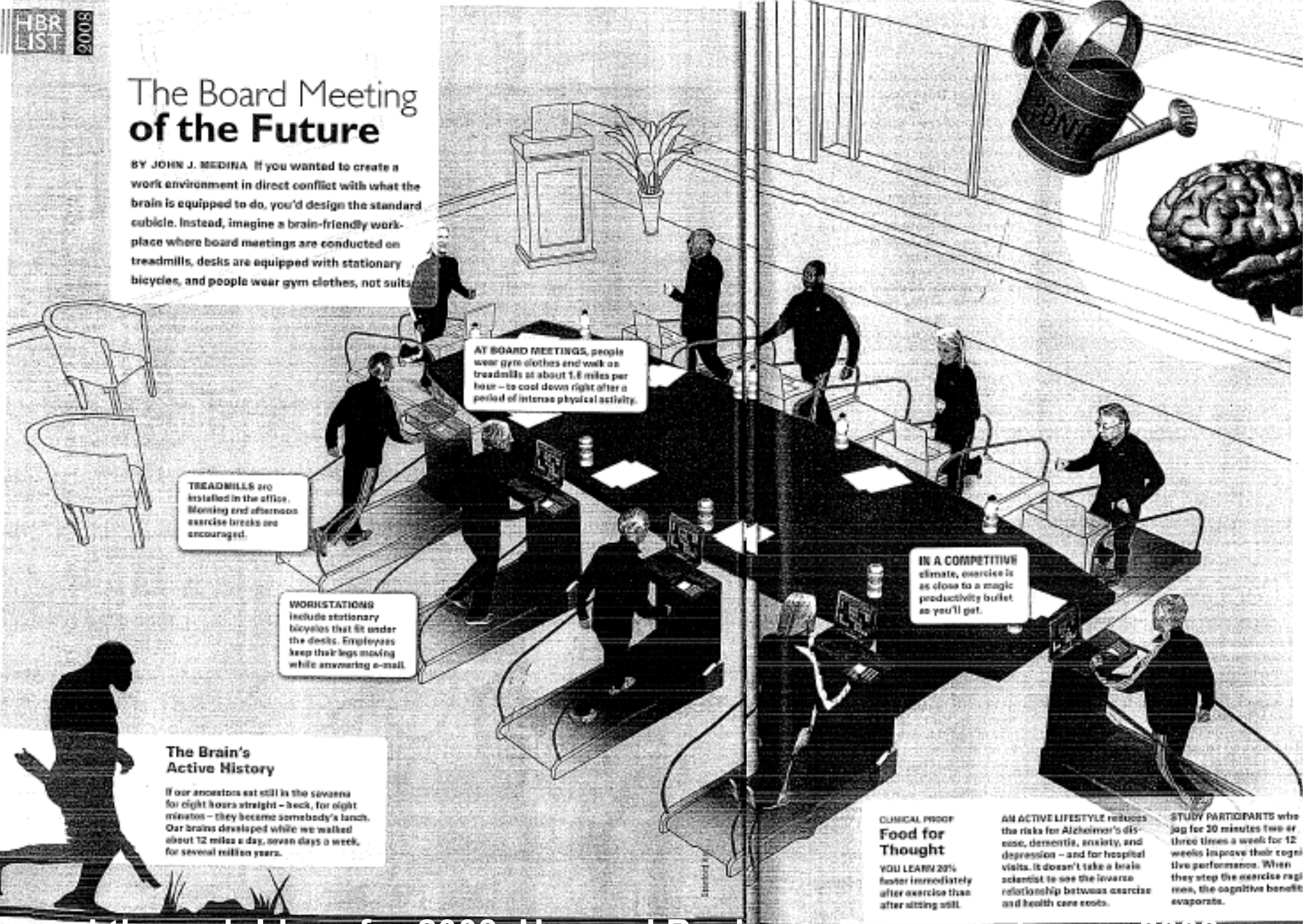
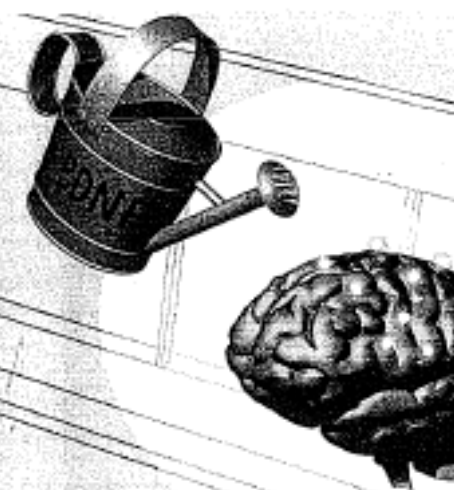
If our ancestors sat still in the savanna for eight hours straight—back, for eight minutes—they became somebody's lunch. Our brains developed while we walked about 12 miles a day, seven days a week, for several million years.

CLINICAL PROOF Food for Thought

YOU LEARN 20% faster immediately after exercise than after sitting still.

AN ACTIVE LIFESTYLE reduces the risks for Alzheimer's disease, dementia, anxiety, and depression—and for hospital visits. It doesn't take a brain scientist to see the inverse relationship between exercise and health care costs.

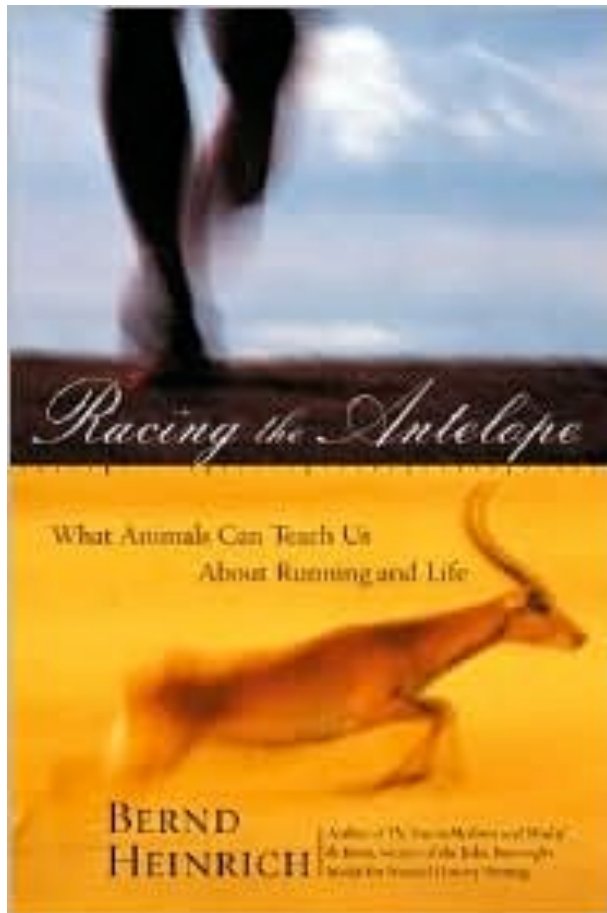
STUDY PARTICIPANTS who jog for 30 minutes two or three times a week for 12 weeks improve their cognitive performance. When they stop the exercise regimen, the cognitive benefit evaporates.



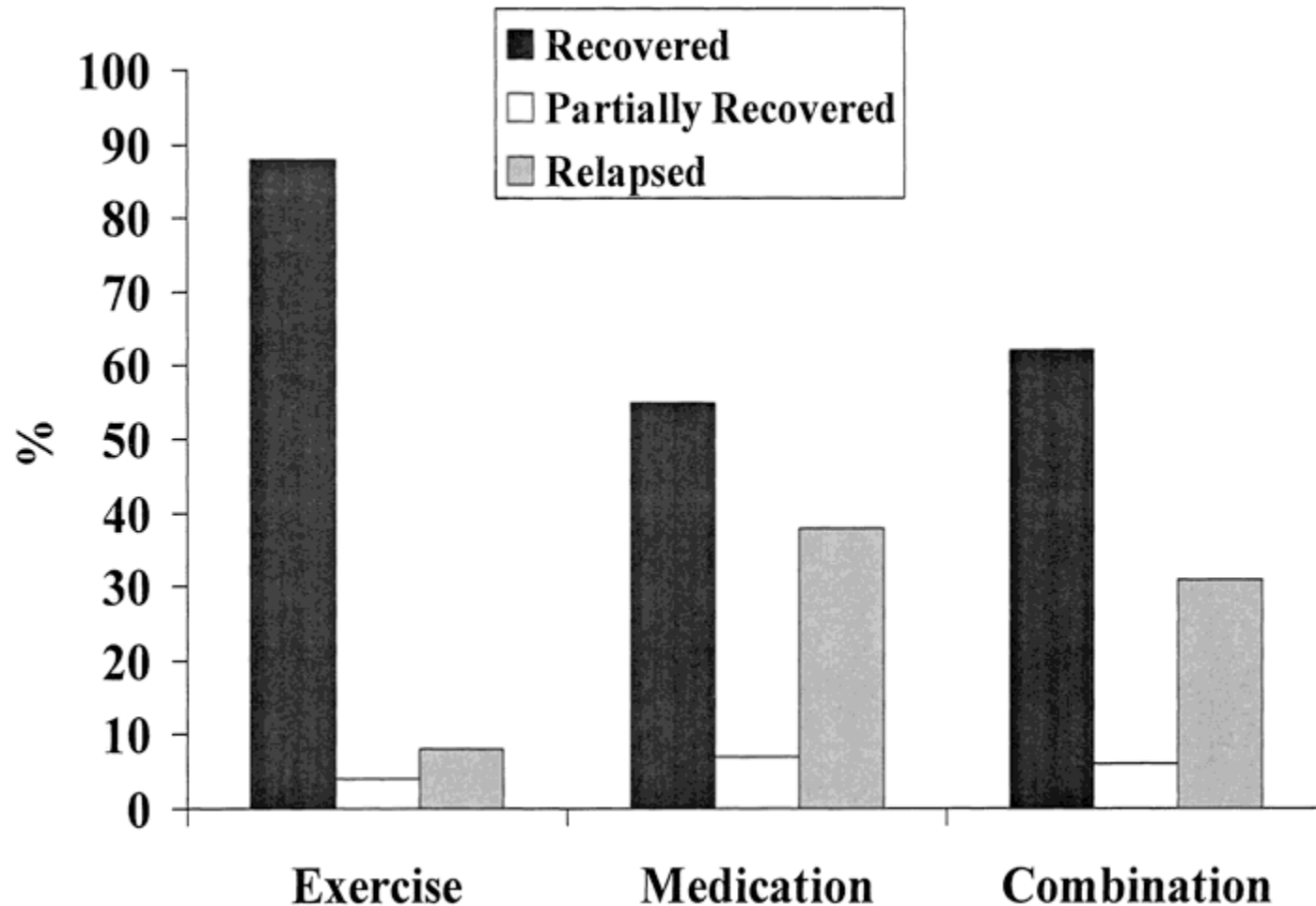
Keeping Children In Their Seats

When you look at this in the evolutionary context of Heinrich's endurance predator, it makes elegant sense:

While tracking their prey our ancestors needed to have the patience, optimism, focus & motivation to keep at it.



All these traits are influenced by serotonin, dopamine, and norepinephrine



Clinical status at 10 months (6 months after treatment) among patients who were remitted ($N = 83$) after 4 months of treatment in Exercise ($N = 25$), Medication ($N = 29$), and Combination ($N = 29$) groups. Compared with participants in the other conditions, those in the Exercise condition were more likely to be partially or fully recovered and were less likely to have relapsed.

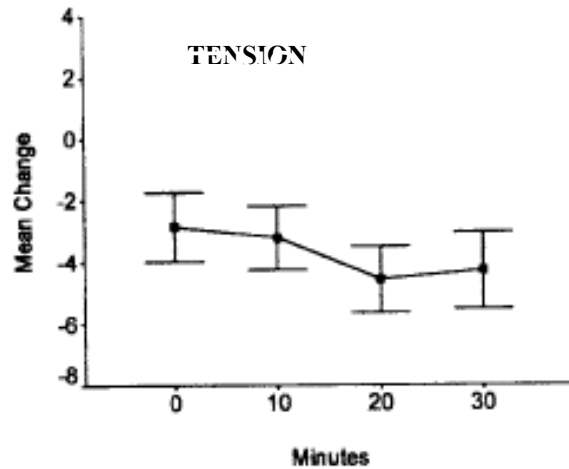


Figure 1. Pre- to postexercise changes in tension by duration of exercise. Negative scores indicate a decrease. The vertical lines represent ± 1 SE.

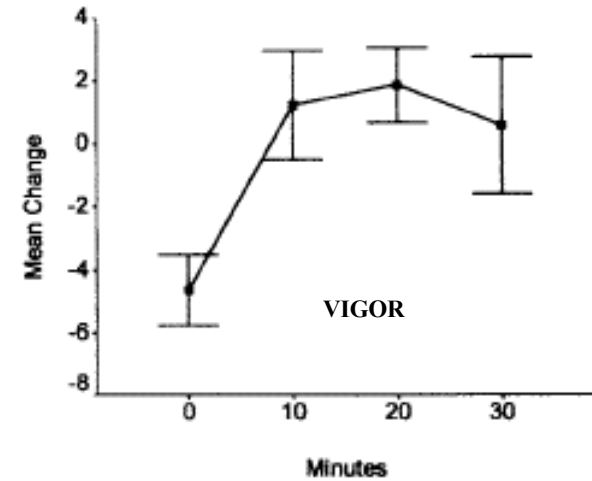


Figure 4. Pre- to postexercise changes in vigor by duration of exercise. Negative scores indicate a decrease. The vertical lines represent ± 1 SE.

21 COLLEGE STUDENTS: 4 WEEKS- 1st week. SITTING FOR 30 MINUTES 2nd week. 10 MINUTES ON BIKE TO 60% OF Vmax 3rd week. 20 MINUTES ON BIKE TO 60% OF Vmax 4th week. 30 MINUTES ON BIKE TO 60% OF Vmax.

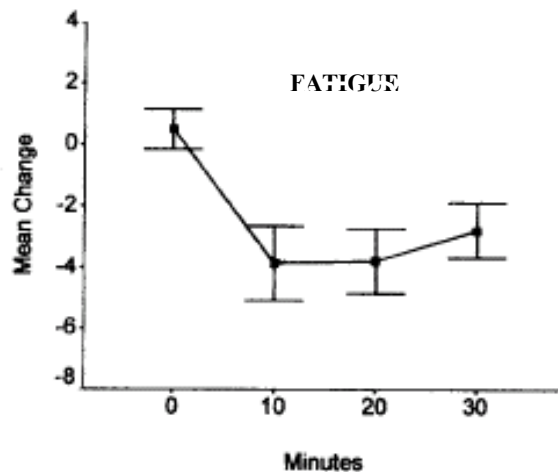


Figure 5. Pre- to postexercise changes in fatigue by duration of exercise. Negative scores indicate a decrease. The vertical lines represent ± 1 SE.

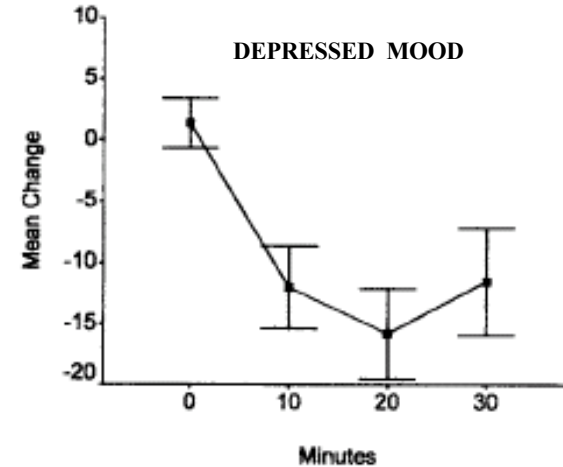


Figure 7. Pre- to postexercise changes in total mood by duration of exercise. Negative scores indicate a decrease. The vertical lines represent ± 1 SE.

PTSD or LEARNED HELPLESSNESS

FAILURE

EMBARRASSMENT

SELF-HATE

GIVING UP

CLASS CLOWN



**I'M NOT COMPLETELY
WORTHLESS
I CAN ALWAYS
SERVE AS A BAD EXAMPLE**

P1SD OF LEARNED HELPLESSNESS WEEKS VS 6 WEEKS

2

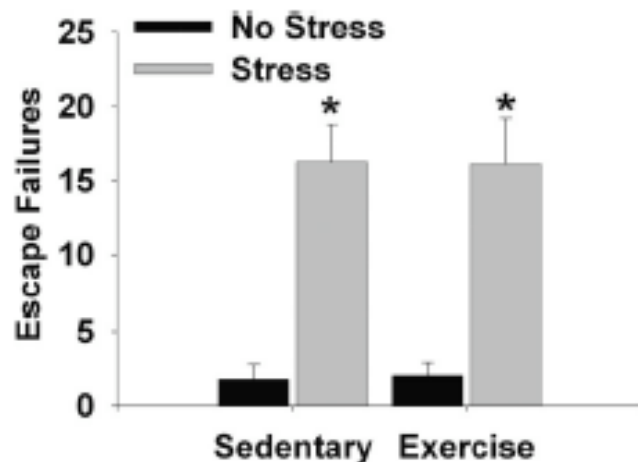


Figure 5. Effect of 2 weeks of exercise on the number of fixed-ratio 2 (FR-2) escape failures. Sedentary rats and rats allowed 2 weeks of voluntary access to running wheels (Exercise) were placed back into shuttle boxes 2 weeks after exposure to uncontrollable foot shocks (Stress) or control treatment (No Stress). The number of FR-2 escape failures (defined as the failure to perform the escape response within 30 s) was recorded during 25 FR-2 escape trials. Prior stress increased the number of escape failures, regardless of the availability of a running wheel for the 2 weeks between stress and testing. Data represent group means \pm SEM. * $p < .05$, compared with no-stress groups.

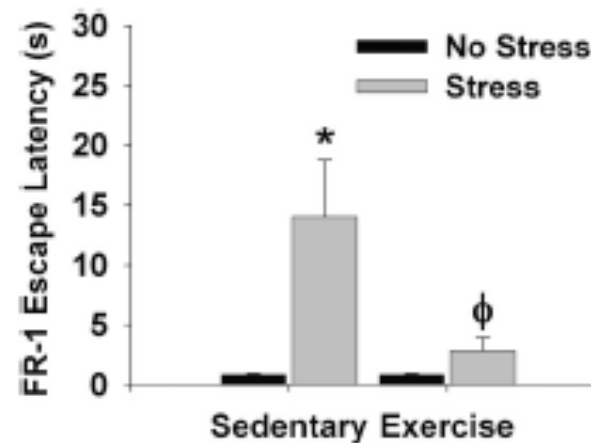


Figure 8. Effect of 6 weeks of exercise on fixed-ratio 1 (FR-1) escape. Rats were given voluntary access to running wheels (Exercise) or no wheels (Sedentary) immediately after exposure to uncontrollable foot shock (Stress) or no stress. Six weeks after stressor exposure, rats were placed back into shuttle boxes and the latency (in seconds) to cross once through the shuttle box door (FR-1) was recorded. Prior stress increased FR-1 latency in sedentary rats. Exercise reversed the effect of stress on FR-1 escape performance. Data represent means \pm SEM. * $p < .05$, compared with no-stress groups. ϕ $p < .05$, compared with the sedentary-stress group.

AT END OF WEEK ONE, RATS RAN 8 KM, WEEK TWO 12.5 KM, WEEK SIX 19.2 KM

[Greenwood BN](#), [Strong PV](#), [Dorey AA](#), [Fleshner M](#). Therapeutic effects of exercise: wheel running reverses stress-induced interference with shuttle box escape. *Behav Neurosci.* 2007 Oct;121(5):992-1000

EXERCISE OPTIMIZES LEARNING



1. SYSTEMS

2. CELLULAR

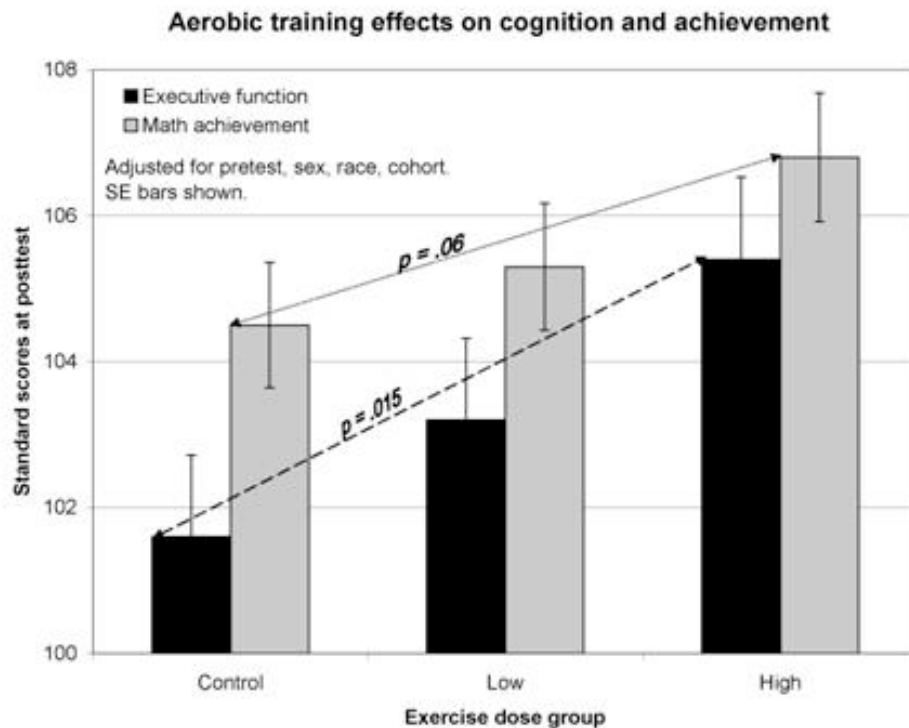
3. NEW CELL GROWTH

BIOLOGY IS PSYCHOLOGY SYSTEMS

- **Attention and Motivation:** Due to increasing levels of **Dopamine and Norepinephrine**
- **Impulsivity:** Frontal Inhibitory Structures Activate Increasing levels of **Dopamine and Serotonin**
 - ✓ Stops random, divergent thoughts and actions
 - ✓ Helps control rapid-fire reactions
- is Positive is
Lower

Improving Executive Function

Dr. Catherine Davis
Clinical Health Psychologist
Medical College of Georgia



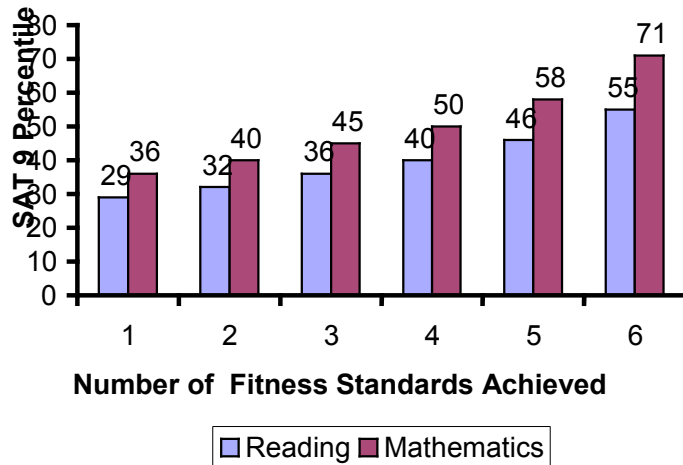
200 overweight, inactive children
Ages 7-11 learn about
Healthy Nutrition
Benefits of Physical Activity
And

1/3 Exercised 20 minutes after school
1/3 Exercised for 40 minutes

Children played hard, with running games, hula hoops and jump ropes, raising their heart rates to 79 percent of maximum, which is considered vigorous. They met for 15 weeks, 5 days/week.

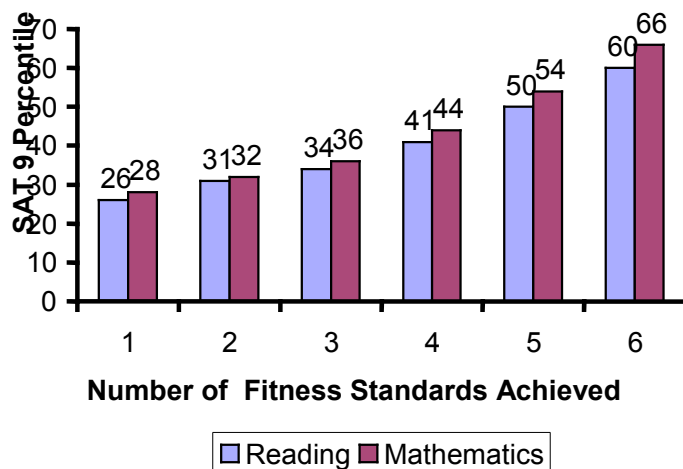
California Department of Education

2001 Grade 5 SAT 9 and Physical Fitness Scores

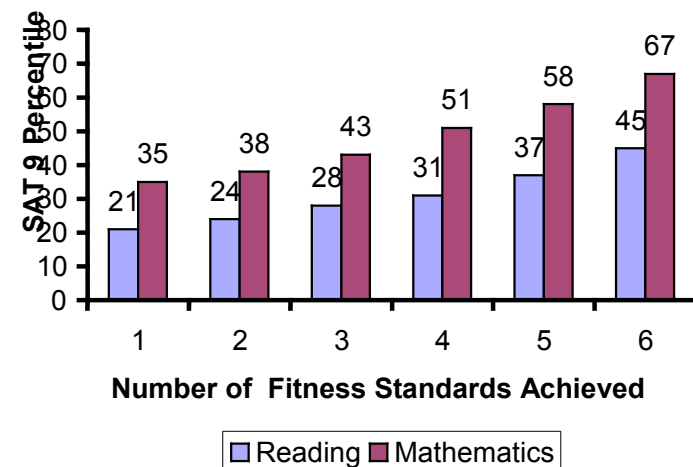


- Higher academic achievement is associated with higher levels of fitness in grade 5,7,9.
- The relationship between academic achievement and fitness in grade 5,7,9 was greater in mathematics than in reading, particularly at high fitness levels.

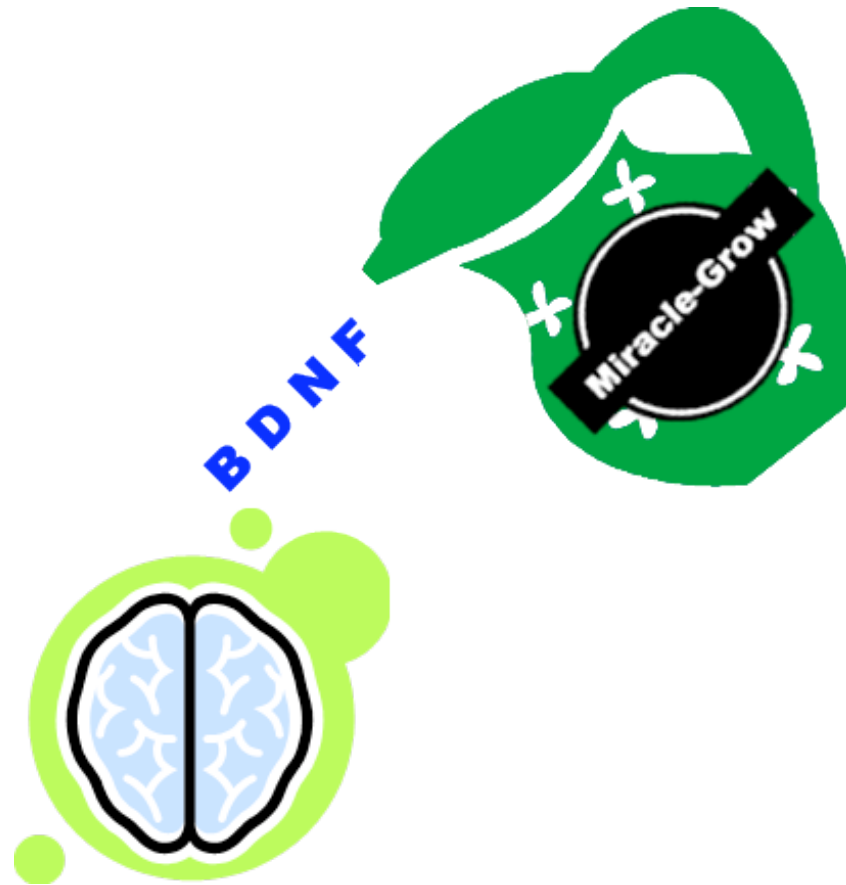
2001 Grade 7 SAT 9 and Physical Fitness Scores



2001 Grade 9 SAT 9 and Physical Fitness Scores



BDNF = Miracle-Gro



BDNF

- **BDNF** is a **neurotrophin** whose status as a **regulator of the survival, growth & differentiation** of neurons during development has matured to include the **adult nervous system**.
- **BDNF** functions **translate activity into synaptic & cognitive plasticity** in the adult animal.
- In the **Hippocampus** it is capable of **inducing a rapid potentiation of glutamate mediated synaptic**

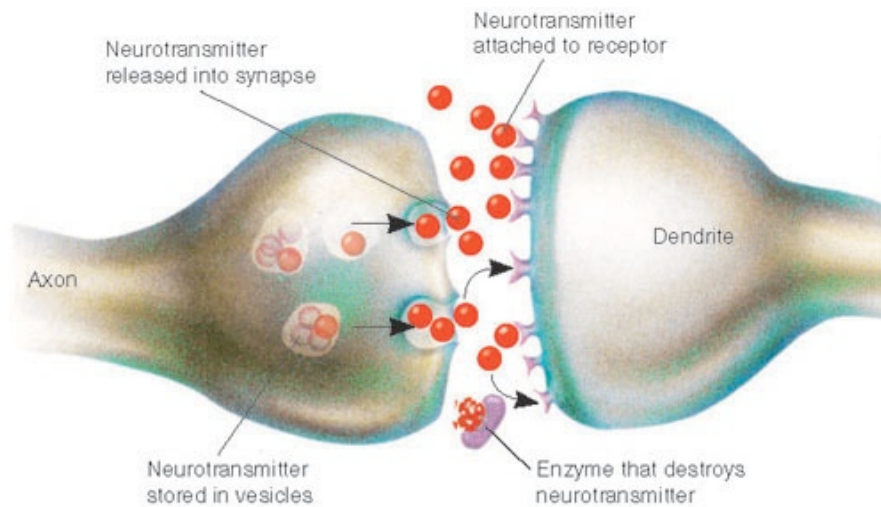
Exercise Improves Learning by Increasing

NEUROPLASTICITY

- **Increased Vascular Bed** - More Oxygen & Glucose available; Easier removal of the breakdown products.
- **Increased Serotonin, Dopamine, BDNF (Miracle Gro)** and other nerve fertilizers that strengthen the wiring of cells together.
- **IGF-1, FGF, VEGF - Body/Brain Interaction:**

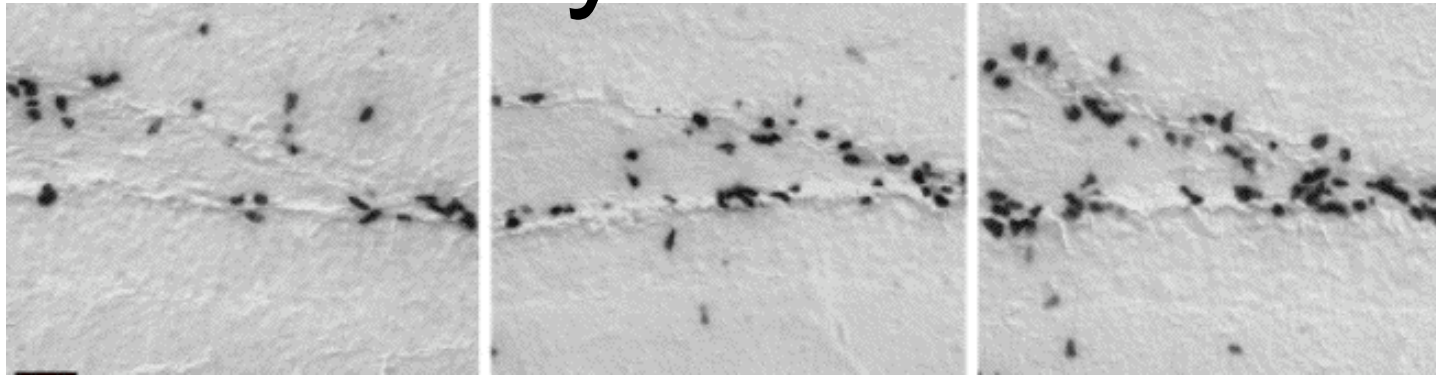
Muscles send off these messengers which travel to and impact

Nerve Cells Wiring = The Building Block of Learning



- By increasing neurotransmitter activity, improving blood flow and producing Brain Growth Factors that I call Miracle Gro or Brain Fertilizers, exercise readies our nerve cells to bind more easily and stronger.

Plasticity: Neural Growth



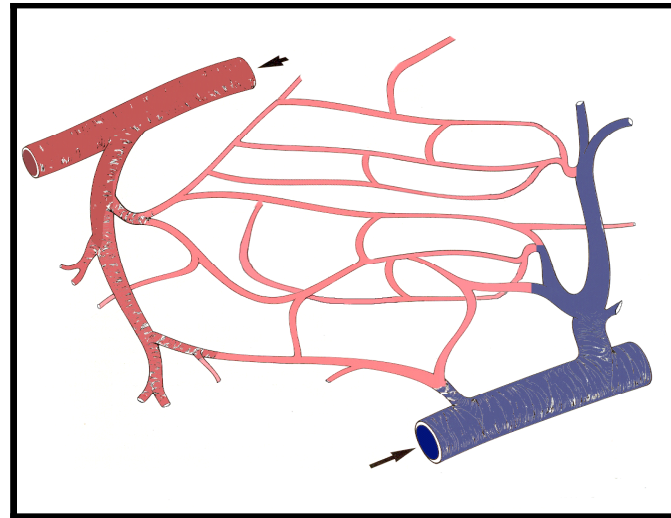
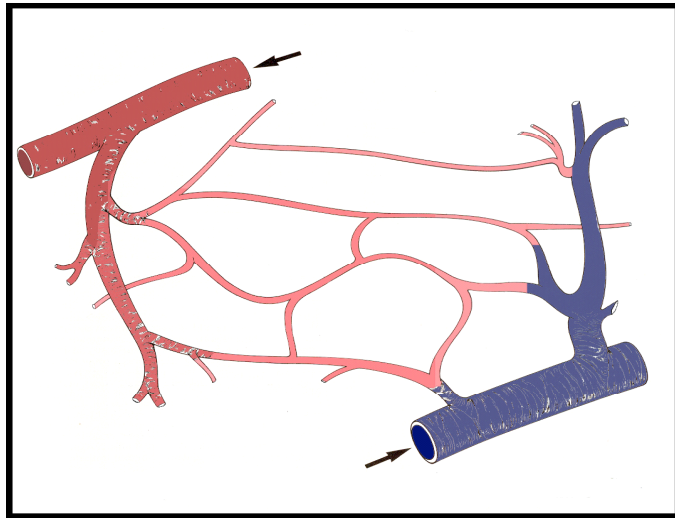
Control

Enriched

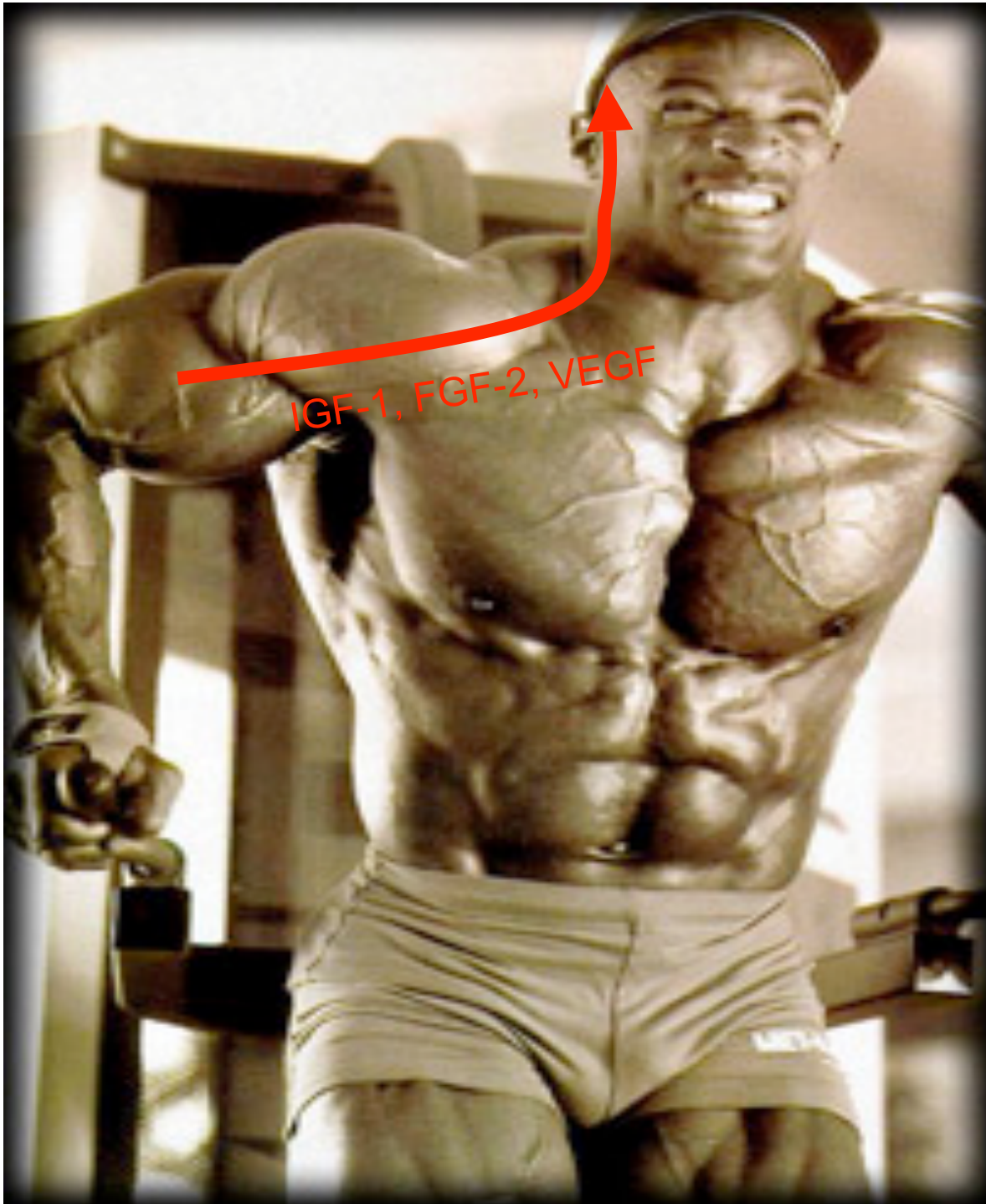
Running wheel

Brown, Jason, Cooper-Kuhn, Christiana M., Kempermann, Gerd, Van Praag, Henriette, Winkler, Jürgen, Gage, Fred H. & Kuhn, H. Georg. Enriched environment and physical activity stimulate hippocampal but not olfactory bulb neurogenesis. *European Journal of Neuroscience* **17** (10), 2042-2046

THE BRAIN IS A MUSCLE AND TO ADD NEW CELLS STRESS MUST OCCUR



Angiogenesis is the process of formation of new blood vessels; It is generally a rare occurrence in the adult, although it is a common adaptive response to exercise training in skeletal muscle. This kind of Collateral Circulation happens in the muscles, the heart , and the brain.



BODY  BRAIN

IGF-1 Insulin-like Growth Factor

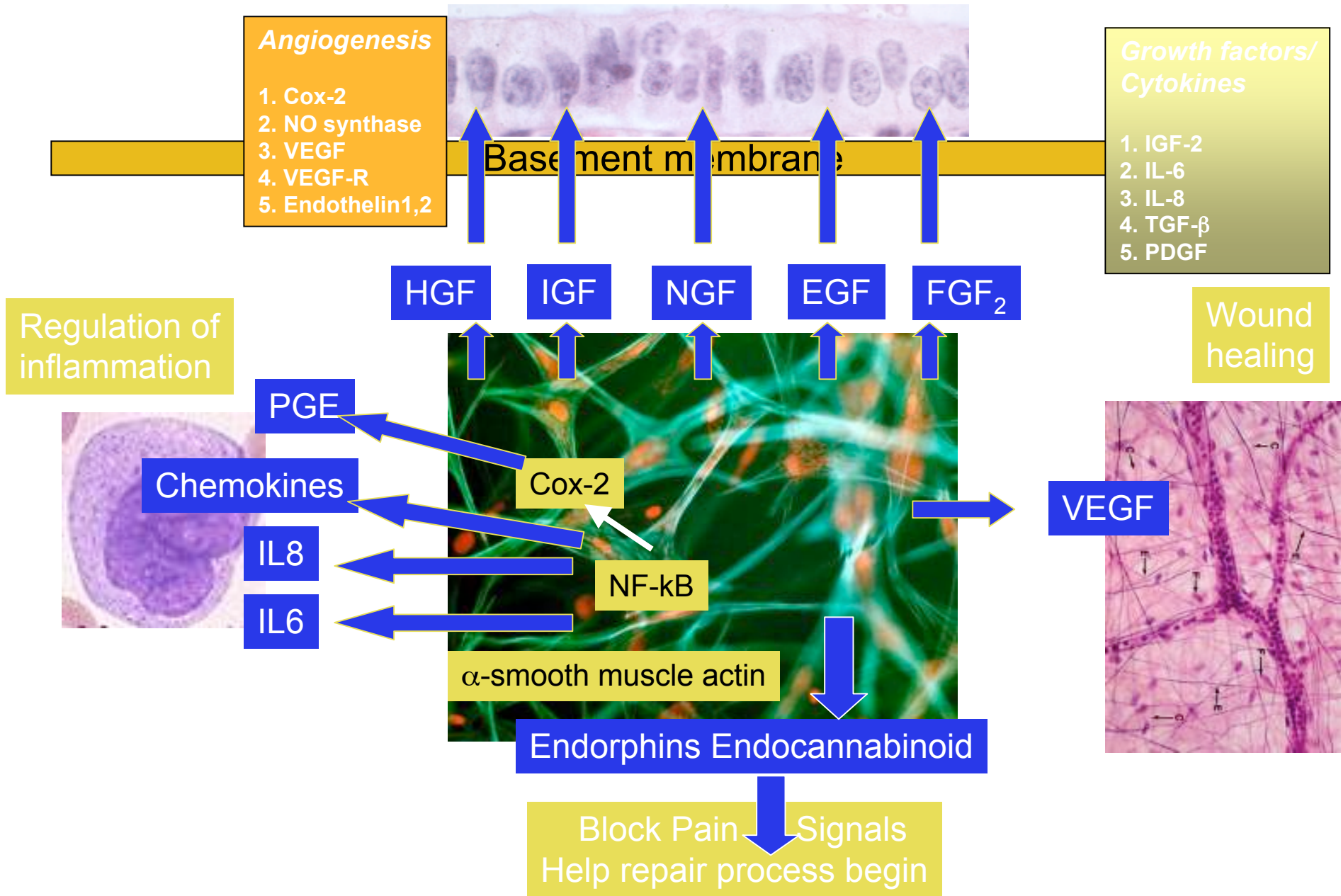
VEGF Vascular endothelial factor

FGF-2 Fibroblast growth factor

ANP- Atrial Natriuretic Factor

ALL THESE COME FROM MUSCLE CONTRACTION AND TRAVEL TO THE BRAIN AND HAVE AN EFFECT ON LEARNING AND BRAIN CELL HEALTH AND GROWTH

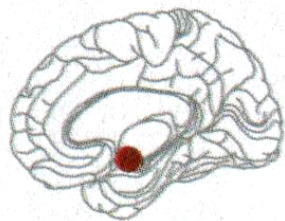
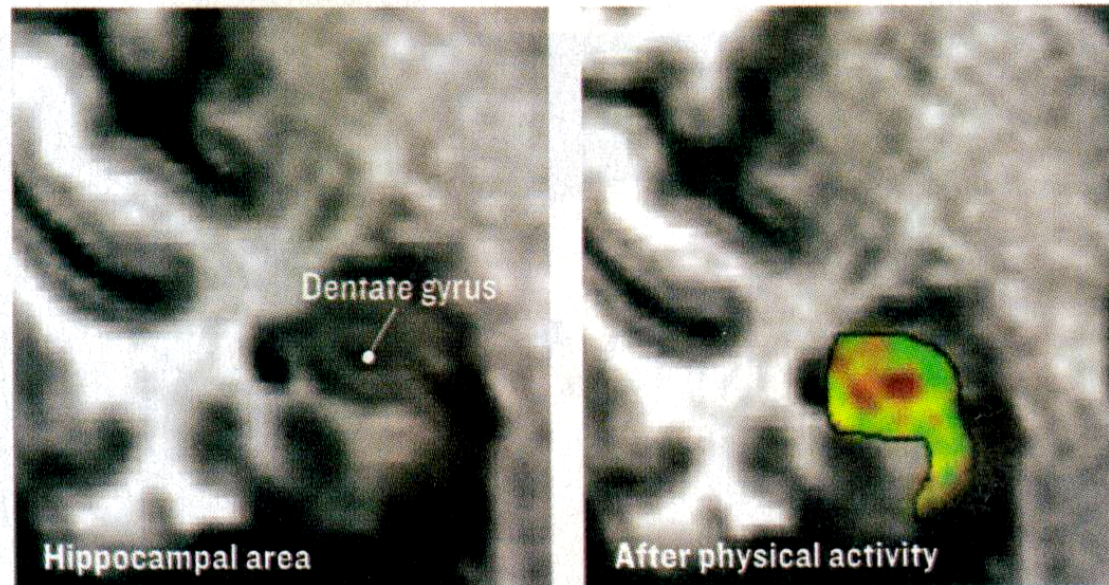
Repair and Recovery: Stress then Growth



How the Brain Changes

Research suggests exercise spurs growth in a brain structure associated with memory, possibly leading to improved function. An overview:

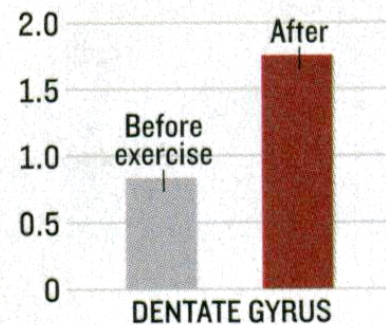
BLOOD VOLUME IN THE BRAIN: NEUTRAL  INCREASED



THE EVIDENCE: When new nerve cells form in the brain, their growth is accompanied by the creation of blood vessels.

Researchers found that exercise increased blood volume in the dentate gyrus (a region of the hippocampus, which is used in memory), implying new cells were forming in the area.

Relative blood volume in the brain with exercise



-MARC BAIN

SOURCES: NATIONAL ACADEMY OF SCIENCES OF THE U.S.A., COLUMBIA UNIVERSITY

Here we rely on the coupling between neurogenesis and angiogenesis and test whether MRI measurements of cerebral blood volume (CBV) provide an imaging correlate of neurogenesis.

Eleven healthy subjects (mean age 33, ranging from 21–45 years; two males and nine females) participated in the study, completing a 3-month aerobic exercise regimen.

Cognitively, individuals performed significantly better on trial 1 learning ($F = 7.0, P = 0.027$) after exercise, with a trend toward improvement on all-trial learning ($F = 5.0, P = 0.053$) and delayed recall ($F = 5.0, P = 0.057$). There was no effect on delayed recognition ($F = 0.19, P = 0.67$) or source memory ($F = 0.15, P = 0.25$) (Fig. 4a). To test that cognitive improvement was related to exercise *per se*, we found that individual changes in trial 1 learning were correlated with individual changes in VO_{2max} ($r = 0.660, P = 0.037$).

Pereira AC, Huddleston DE, Brickman AM, Sosunov AA, Hen R, McKhann GM, Sloan R, Gage FH, Brown TR, Small SA. An in vivo correlate of exercise-induced neurogenesis in the adult dentate gyrus. *Proc Natl Acad Sci U S A.* 2007 Mar 27;104(13):5638-43.