





# Exercise and the brain- the crucial connection!

## SPARK

THE REVOLUTIONARY  
NEW SCIENCE OF EXERCISE  
AND THE BRAIN



Beat Stress, Sharpen Your Intellect,  
Lift Your Mood, Boost Your Memory, and Feel  
Better Than You Ever Have Before!

JOHN J. RATEY, M.D.,  
COAUTHOR OF *DRIVEN TO DISTRACTION*  
with ERIC HAGERMAN

**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)

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**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.

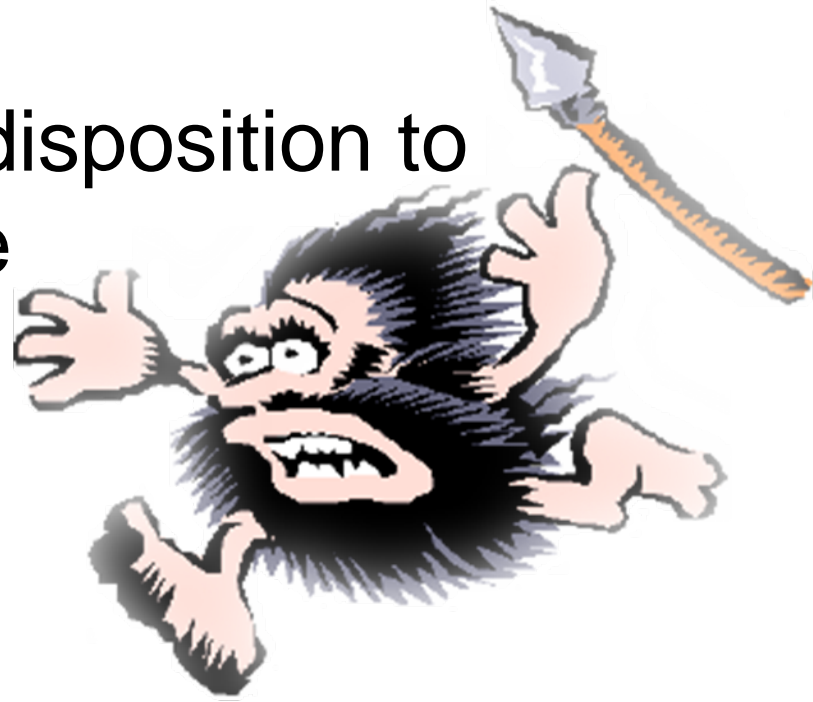
**ADDICTION:** Exercise is the perfect antidote to addiction, again because it increases dopamine and so improves the brain's ability to satiate.

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# The Running Man

An evolutionary predisposition to  
exercise





# No Morning walk



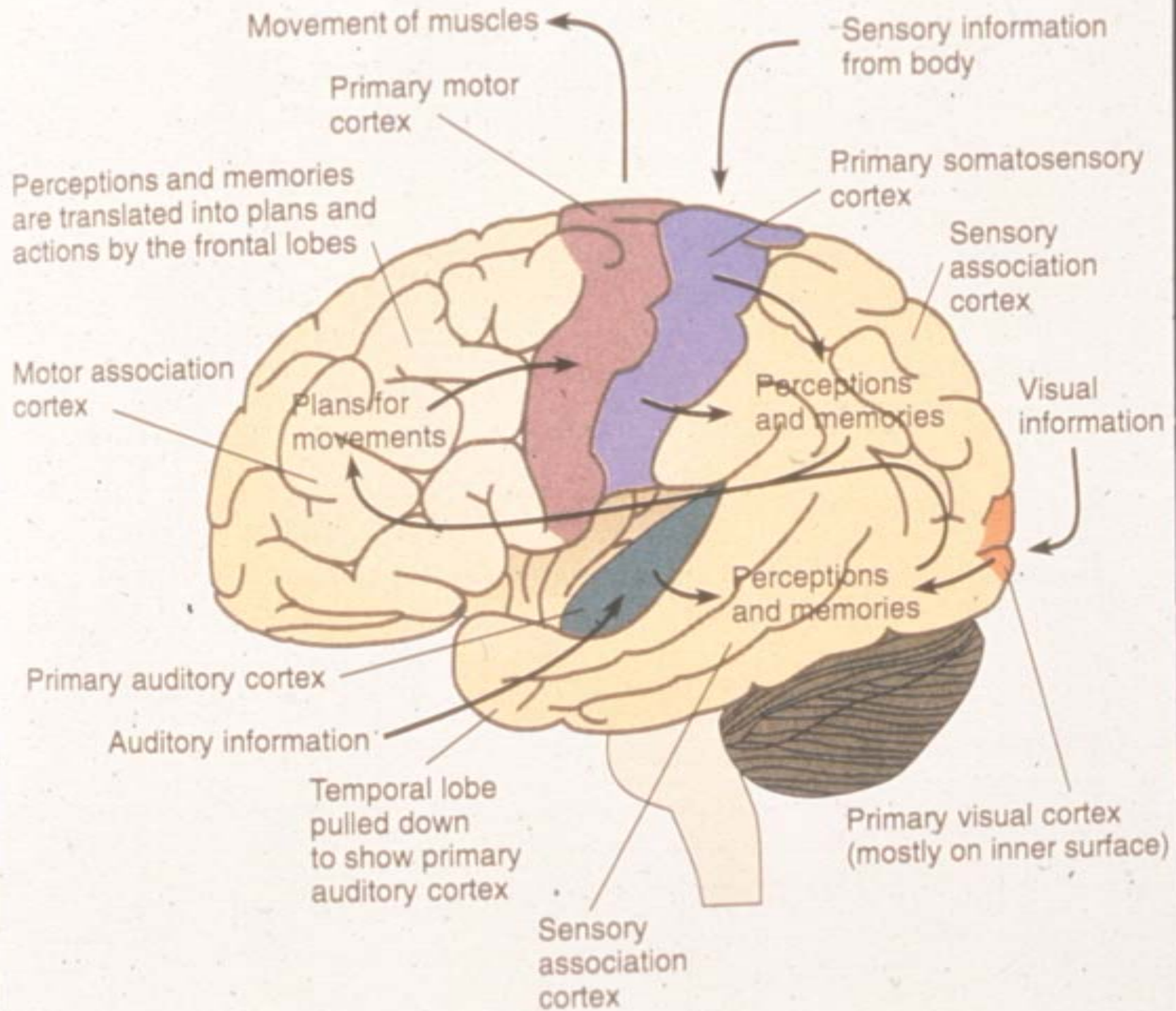


*“Early **mobile organisms** may have developed in complexity, incorporating **perception & predictions** as learning aspects, to **maximize motor operations** that **increased** the chances obtaining food and **survival.**”*

**Motricity**, may have provided the impetus for mental activity.

“Given that our **genome** is essentially that of our **active ancestors**, it is important to consider the **losses gained** by our **present sedentary** culture & the contribution of exercise to regulate systems that are critical for **synaptic & cognitive plasticity.**”





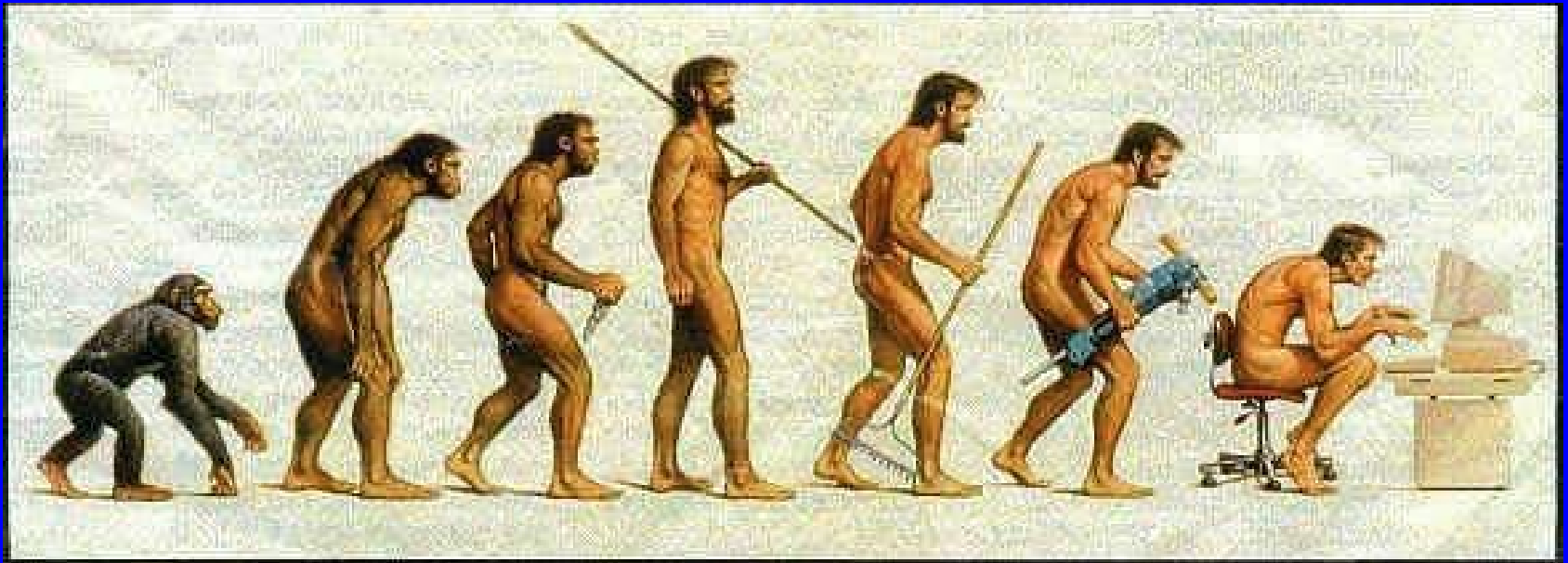
*“That which we call thinking is the evolutionary internalization of movement.”*

Lilinas, 2001



# The Human Body Is Designed for Activity

- Evolutionary history teaches us that early humans could not have survived without the ability to perform demanding physical work.



**Somewhere, something went terribly wrong**

# Hunters & Gatherers

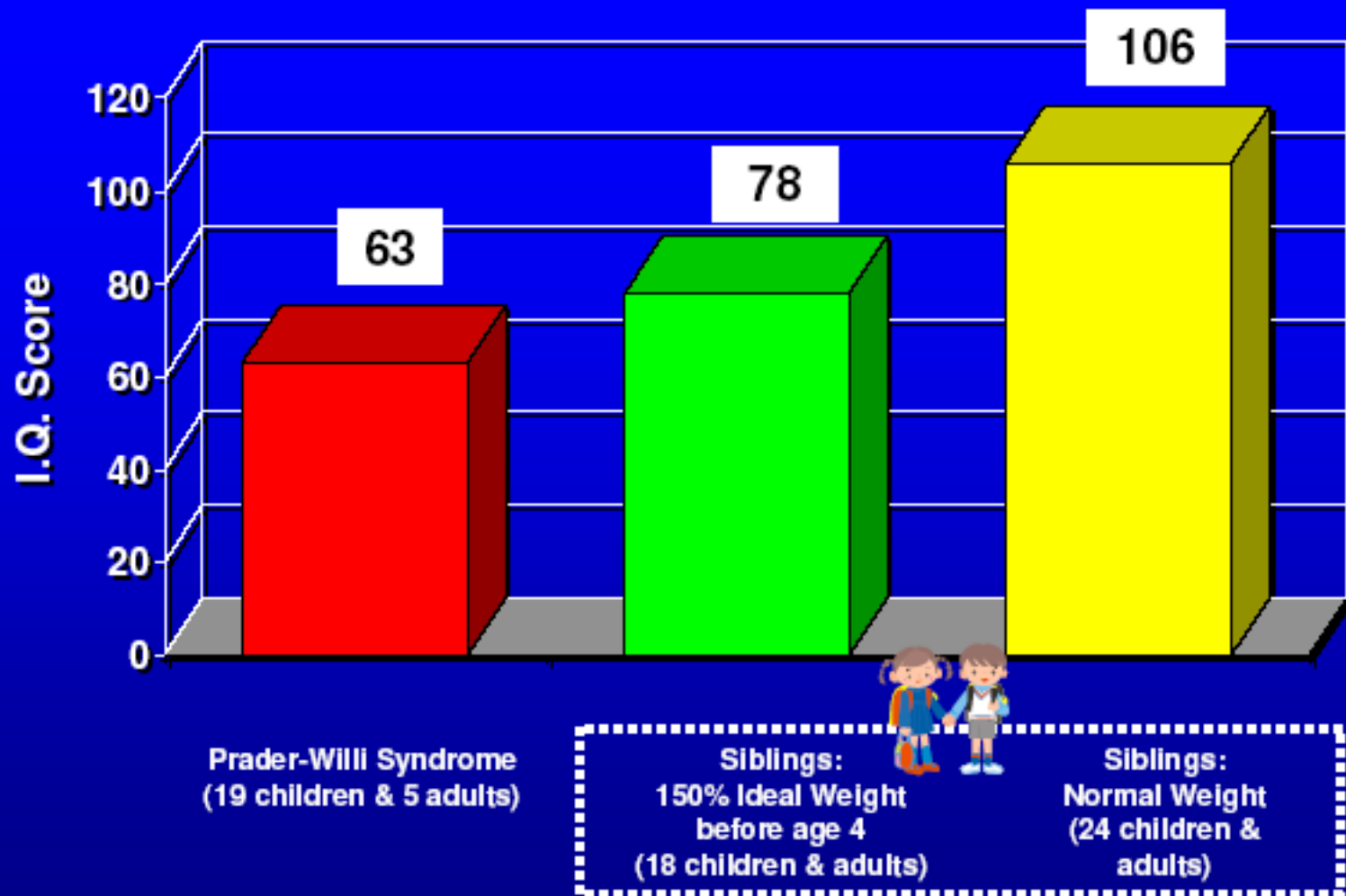
- Our early ancestors predominately consisted of **hunter-gatherer** types ensuring the “**Running Man**” as a standard of fitness for their survival.
- **If you did not run, you did not eat.**
- Individuals who could out-run & out-plan their peers would survive.



It has been found that a **high fat diet**, whose composition was formulated to closely parallel the “**all American diet**”, **decreased BDNF** levels in the hippocampus and **impairs learning and memory**.



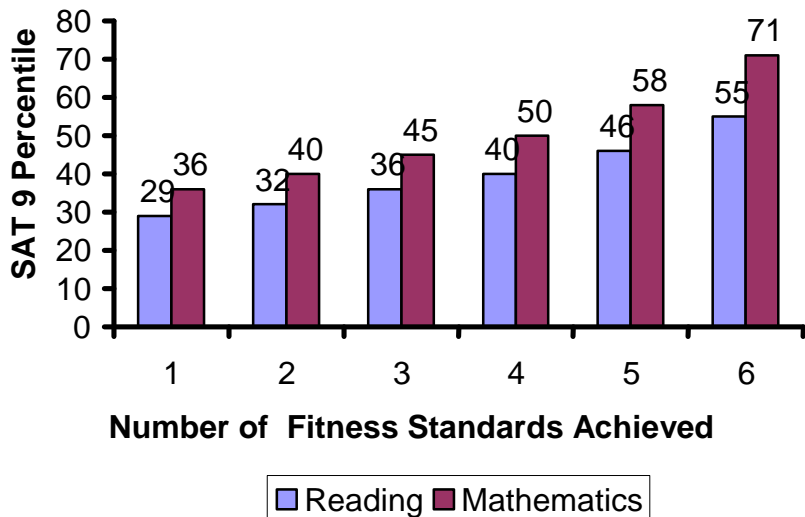
# Early-Onset Obesity and Its Effect on I.Q.





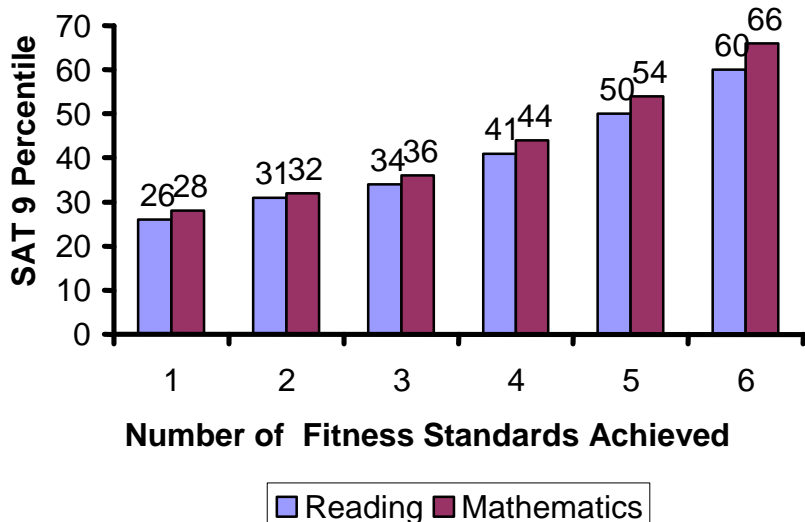


### 2001 Grade 5 SAT 9 and Physical Fitness Scores



<http://pe4life.org/research.php>

### 2001 Grade 7 SAT 9 and Physical Fitness Scores



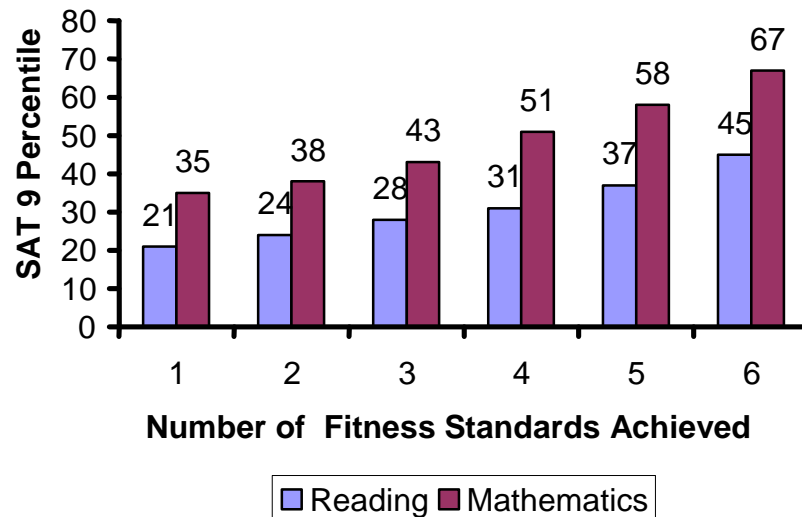
### California Department of Education Study December 10, 2002

The height of each bar shows the average (median) SAT-9 national percentile rank of those students with a particular fitness score.

The test that was used, *Fitnessgram*, uses criterion-referenced standards to evaluate fitness. These standards represent a level of fitness that offers some degree of protection against diseases that result from sedentary living. Achievement of the fitness standards is based upon a test score falling in the Healthy Fitness Zone (HFZ). Each of the six tasks measures a different aspect of fitness, and the HFZ represent minimal levels of satisfactory achievement on the tasks. **THE X-AXIS IS THE NUMBER OF FITNESS STANDARD REACHED BY EACH INDIVIDUAL.**

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.

### Grade 9 SAT 9 and Physical Fitness Scores



# EXERCISE OPTIMIZES LEARNING 3 WAYS

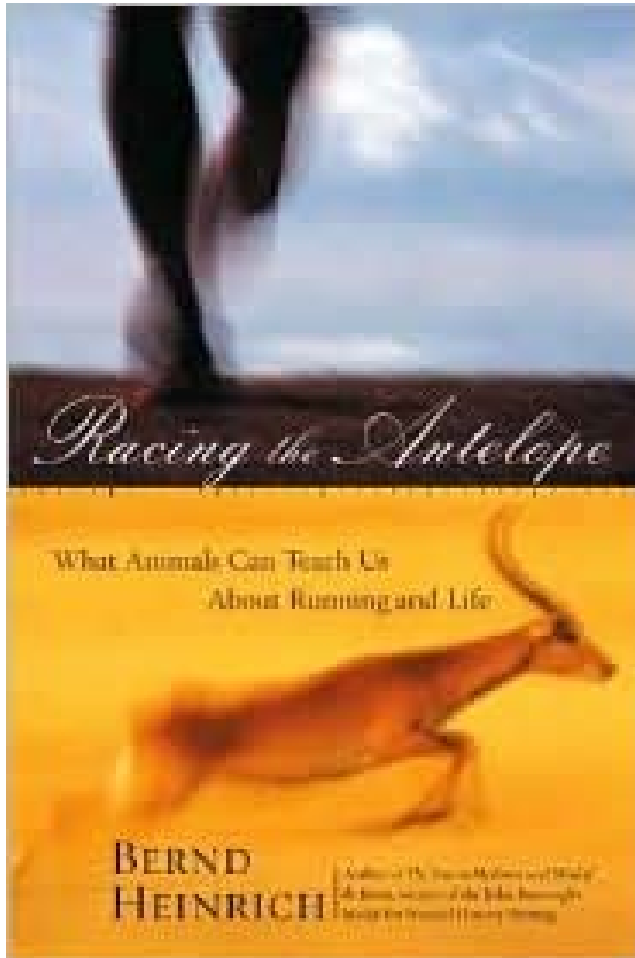
- Systems
- Cellular
- New cell growth

# Exercise Improves Learning 1

- Acts to make an active learner: improves attention, motivation, vigor, mood, memory, executive function skills and decreases anxiety, impulsivity, distractibility, “nudginesss” and “learned helplessness” (translation: if you have failed you can more easily approach it once again). Promotes neuroplasticity



# Keeping the child 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, and motivation to keep at it. All these traits are influenced by serotonin, dopamine, and norepinephrine

# Exercise Improves Learning 1a

## Biology is Psychology

### Exercise improves

- 1. Attention and Motivation: increasing levels of Dopamine and Norepinephrine**
- 2. Impulsivity: activates frontal inhibitory structures that stop random, divergent thoughts and actions, and help control rapid-fire reactions: increasing levels of Dopamine and Serotonin**
- 3. Mood is more positive, vigor is higher, anxiety is lower, self-esteem is higher: increasing levels of Serotonin, Norepinephrine**
- 4. Learned helplessness is overcome somewhat: improved resilience, better able to withstand stress and frustration, improved self-confidence**

# Chemicals

# Norepinephrine (NEP)

- Acute and chronic exercise increases brain NEP
- Norepinephrine linked to:
  - Improved Mood
  - Improved Arousal and Vigilance
  - Self Esteem
  - Improved Perception
  - Improved cellular learning
  - Exercise is like taking a little of Prozac and Adderall



# Serotonin (5-HT)

- Acute and chronic exercise increases brain 5-HT
- Serotonin linked to:
  - Mood Regulation
  - Impulse Control
  - Self Esteem
  - Combats toxic effects of high levels of stress hormone
  - Improved cellular learning

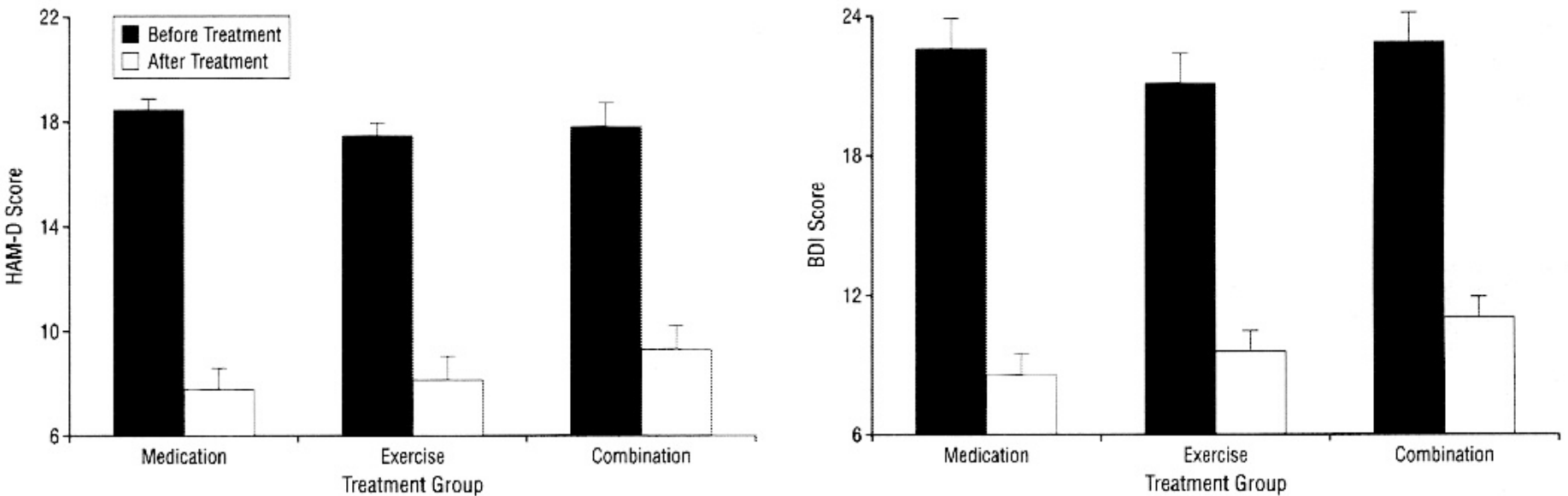
# Dopamine (DA)

- Physical Exercise is implicated in DA synthesis, release, and reuptake
  - Increased DA activity during motor behavior
  - The greater the intensity the greater the increase
- Regular exercise
  - Increases amount of enzymes that make DA
  - Alters the action of DA at the postsynaptic site

# Beta-endorphins

- Increases during and after exercise- in the body for sure, the brain's increase not so much!
- Runners high— after 45 minutes of full speed running  
????
- Endorphins linked to:
  - Mood Regulation
  - Self Esteem
  - Improves pain threshold- valuable in the body
  - Reward, motivation, satisfaction hormone

# ZOLOFT VS EXERCISE at 4 Months



**Figure 3.** Observed mean depression scores before and after treatment. All changes from pretreatment to posttreatment were statistically significant ( $P < .001$  for all). The treatment groups did not differ on baseline or posttreatment levels of depression. Error bars represent SEs. HAM-D indicates Hamilton Rating Scale for Depression; BDI, Beck Depression Inventory.

*From:* Blumenthal: Arch Intern Med, Volume 159(19).October 25, 1999.2349-2356

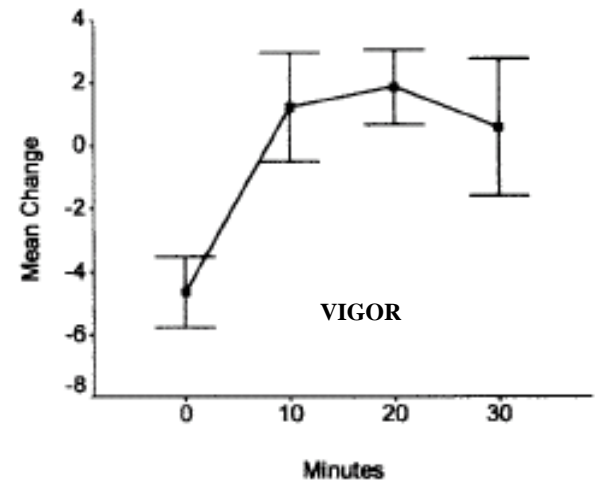
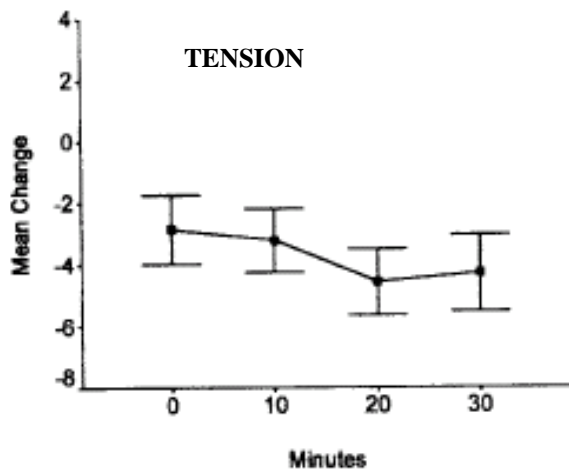


Figure 1. Pre- to postexercise changes in tension by duration of exercise. Negative scores indicate a decrease. The vertical lines represent  $\pm 1$  SE.

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

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

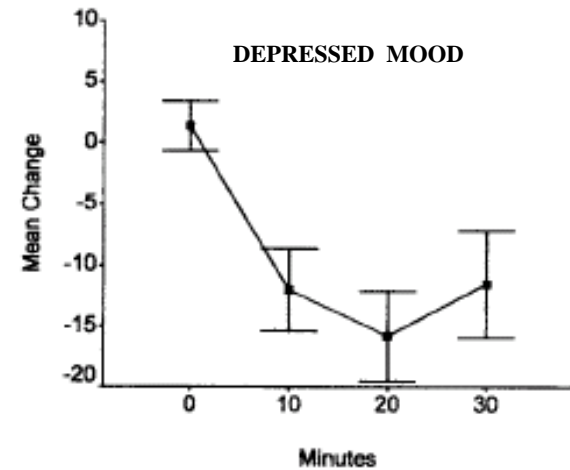
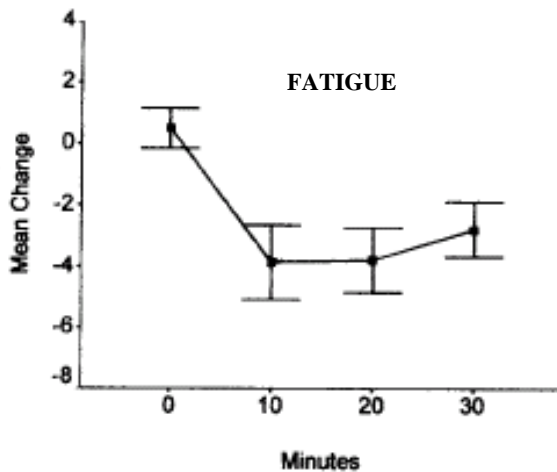
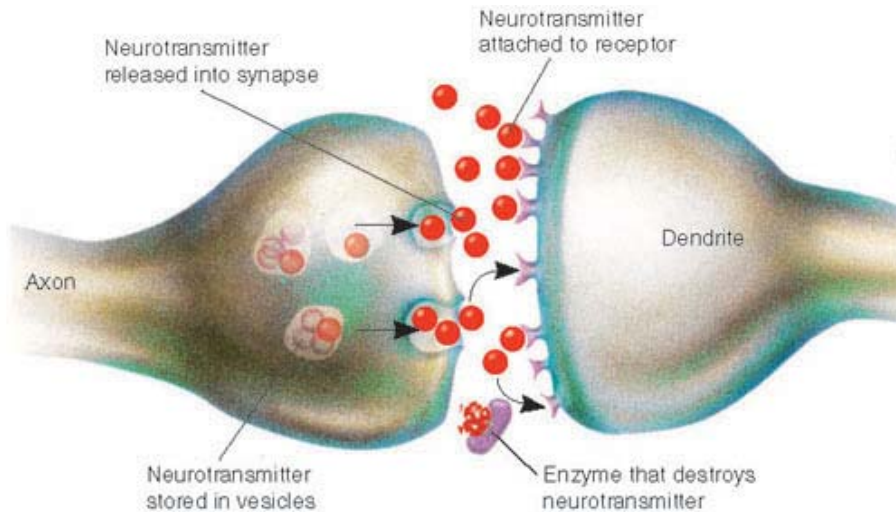


Figure 5. Pre- to postexercise changes in fatigue by duration of exercise. Negative scores indicate a decrease. The vertical lines represent  $\pm 1$  SE.

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

# Exercise Improves Learning 2

NERVE CELLS WIRING TOGETHER ARE THE BUILDING BLOCKS OF LEARNING

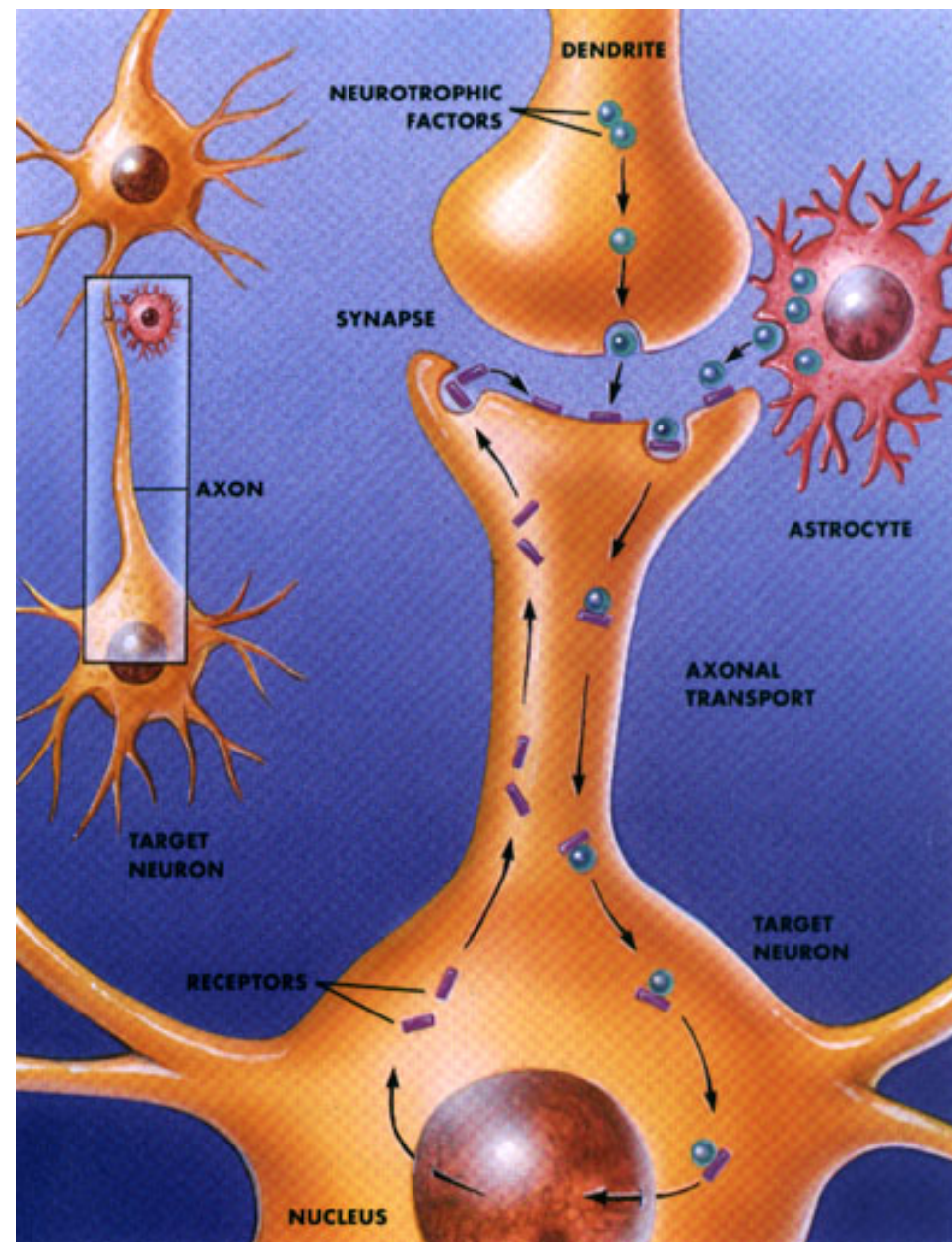


By increasing neurotransmitter activity, improving blood flow and producing Brain Growth Factors that I call Miracle Gro or Brain Fertilizers, exercise readies our nerve cells to bind more easily and stronger. Exercise does this better than any other factor we are aware of at the present time.



# The Plastic Brain

In the brain, a neurotrophic factor is released by a neuron or a support cell, such as an astrocyte, and binds to a receptor on a nearby neuron. This binding results in the production of a signal which is transported to the nucleus of the receiving neuron where it results in the increased production of proteins associated with neuronal survival and function, i.e the neuron is better able to bind thus learn, the animal is more adaptable.

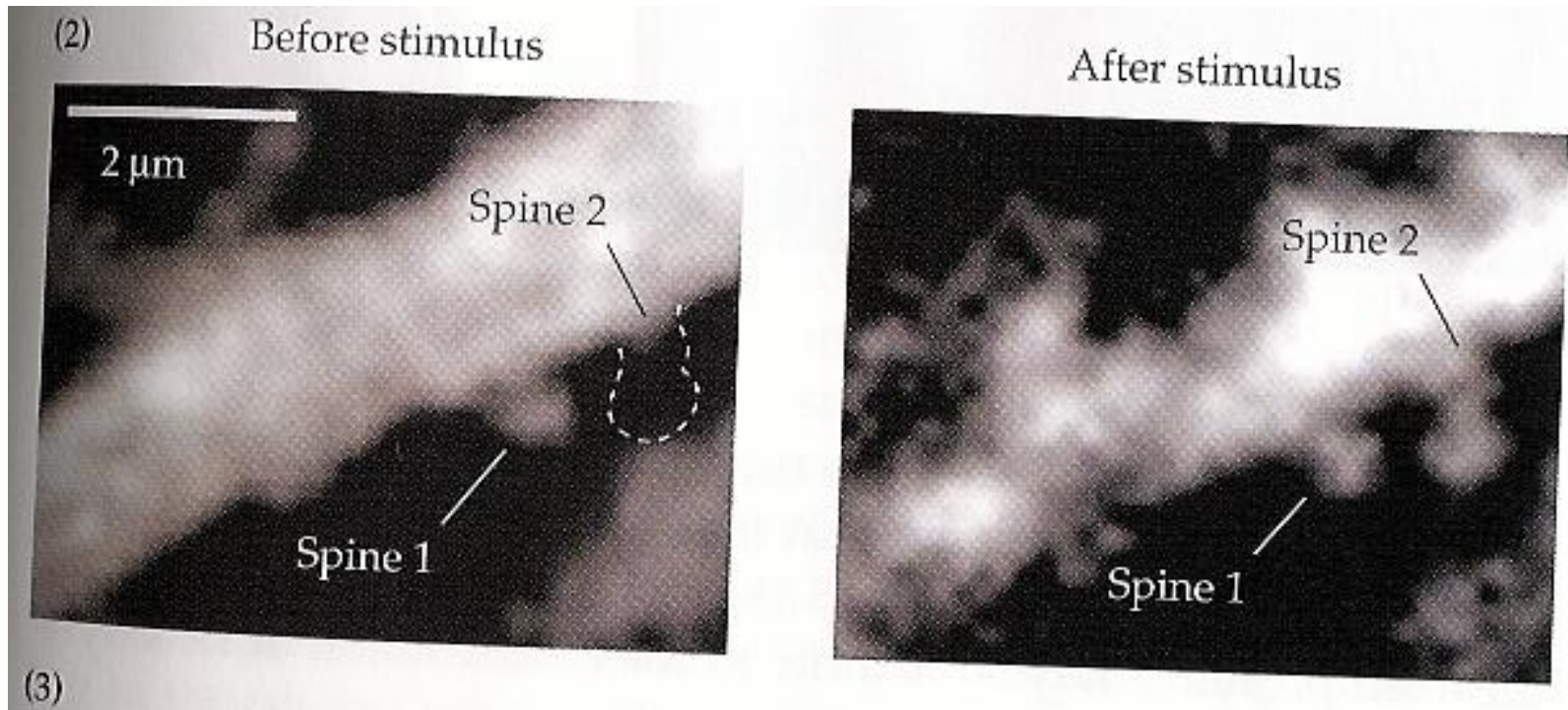


# Exercise Improves Learning 2a

## Cells optimally ready to bind

- **Increased Vascular Bed- more Oxygen, Glucose available, easier removal of the breakdown products.**
- **Increased Serotonin, Dopamine, BDNF and other nerve fertilizers (Miracle Gro) that strengthen the wiring of cells together**
- **Body/brain interaction: IGF-1, FGF, VEGF all come from the muscles acting and send off these messengers which impact the brain – potentates release of Neurotransmitters**

# ACTUAL GROWTH OF NERVE WITH PRACTICE

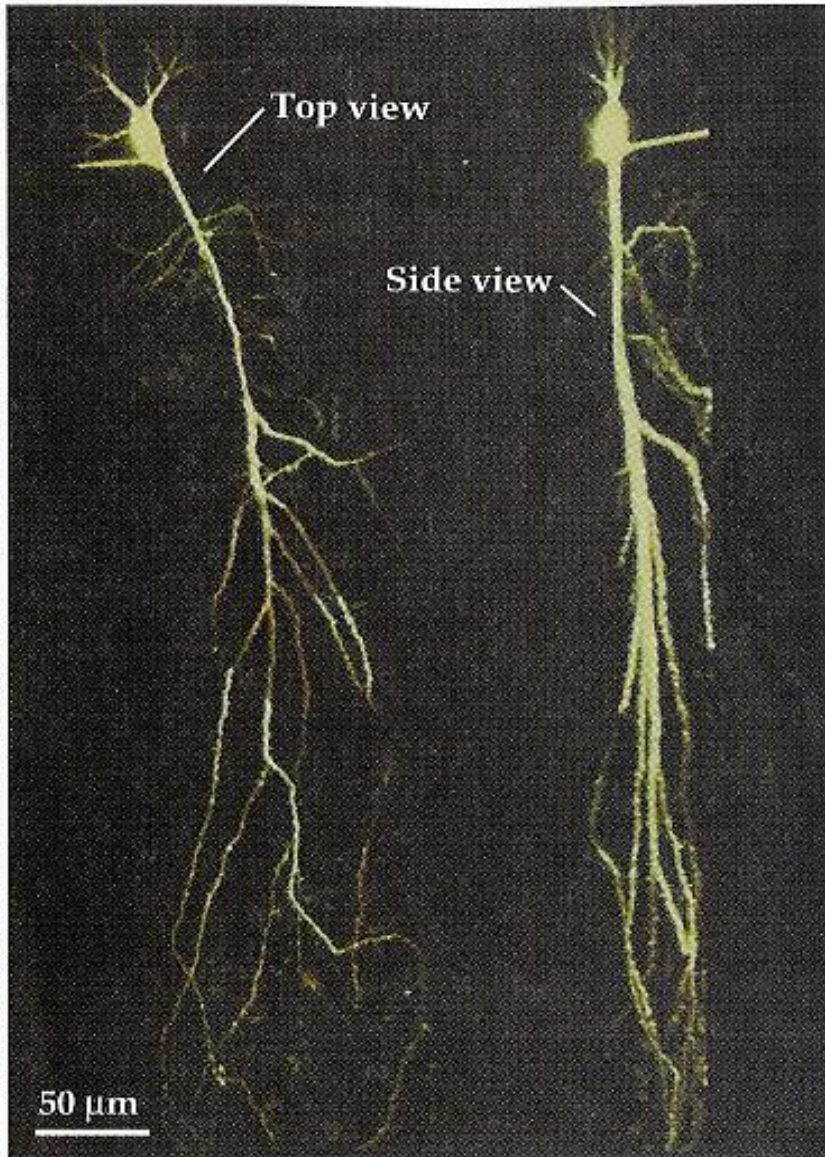


**Plasticity of the brain, a fact. Teachers are what I call:  
Plasticity Guides**

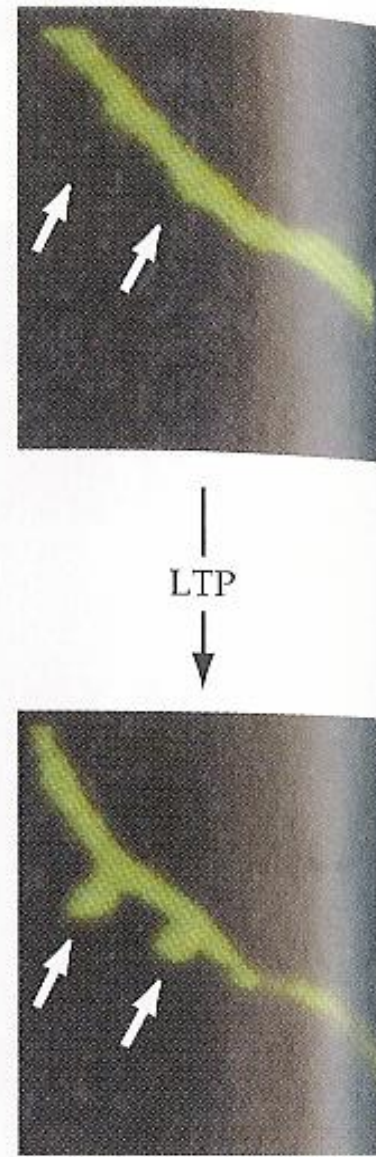


# A Neuroscientist's X-rated Movie

A)

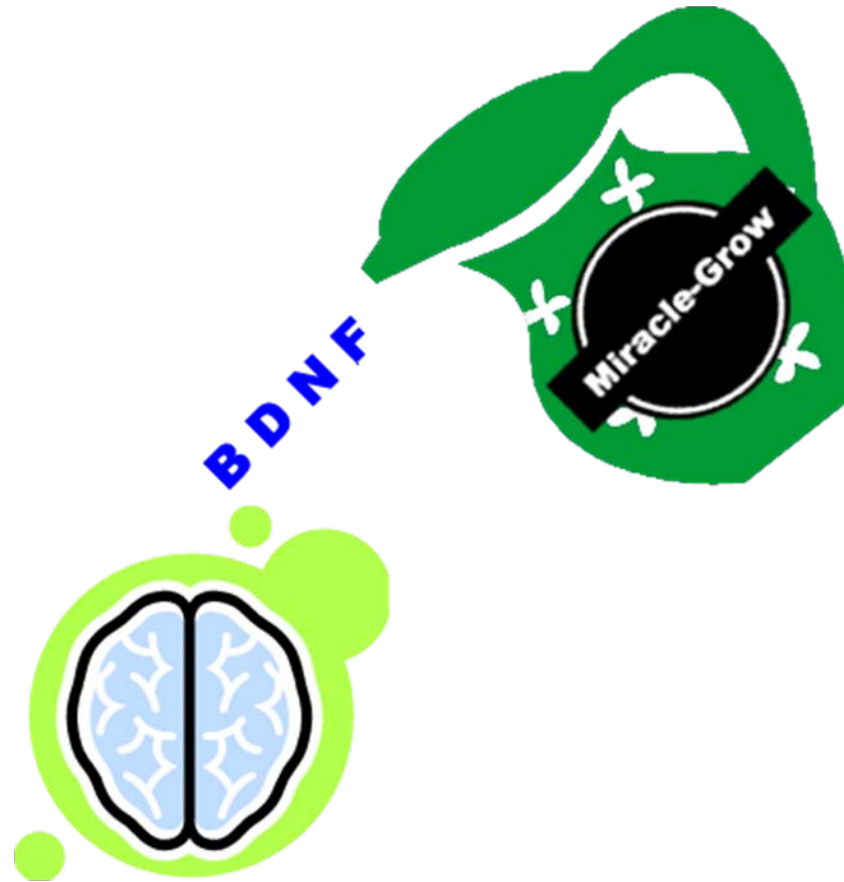


(B)



Structural Changes associated with LTP in hippocampus. The cells are filled with fluorescent dye. In B) one hour after stimulus see the sprouting of new dendritic spines to connect to neighboring nerve cells—this is a structural change that is part of the cellular basis of learning.

BDNF = Miracle-Gro



# Neurotrophic Factors

- Is what a nerve cell release during exercise.
- They are proteins.
- They buffer nerve cells against illness or injury.
- They prompt them to grow and multiply.
- Strengthen each neurons connection with other nerve cells.



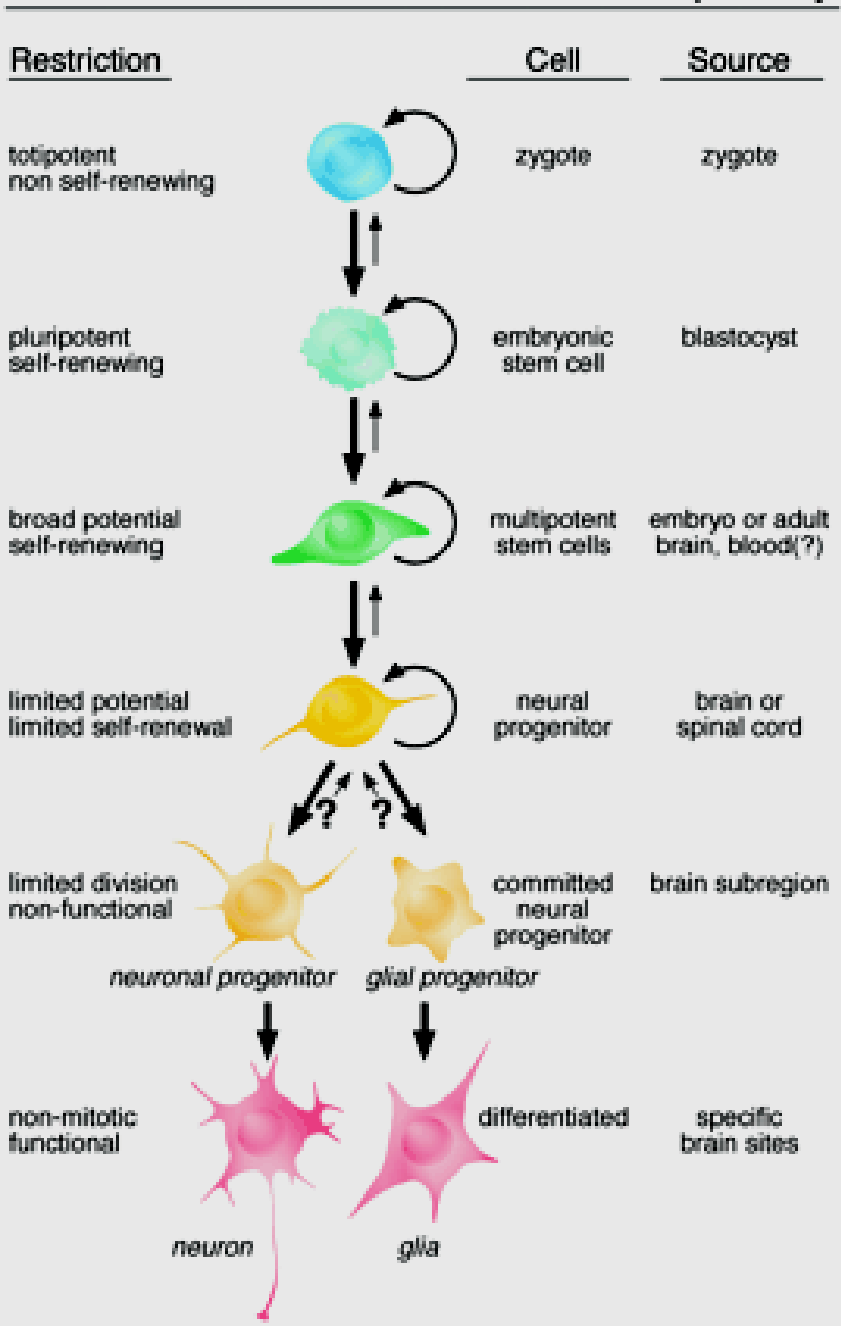
# BDNF

- 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-mediate synaptic transmission & long lasting potentiation of perforant path-dentate gyrus connection in vivo.

# Exercise Improves Learning 3

- Causes our stem cells in our brains to divide which is the beginning of the possibility of making a new nerve cell
- We add new nerve cells everyday to our memory control area- the Hippocampus and may also add to Frontal Cortex
- Muscle Contractions and increased brain activity add to the soup that promotes the growth and survival of new neurons.

# Potential Stem Cells with Neural Capability



A vast array of molecules are now known to exert neurotrophic actions on various neuronal populations. A veritable alphabet soup of neurotrophic factors contributes to the brain broth of chemicals that bathe and nourish nerve cells.

The demand to use neurons is met by keeping them fit and ready to function--a task accomplished by salting the brain broth with neurotrophic factors that keep the neurons healthy.

Only future research will teach us how the balance seasonings in the tender stew of the brain.

# Hippocampal neurogenesis

- Antidepressants, ECT, & physical activity → neurogenesis.
- Administration of BDNF (brain-derived neurotrophic factor) into dentate gyrus → antidepressant effects.
- Stress reduces hippocampal BDNF; this effect is reversed by antidepressants & ECT.

# Fred H. Gage & Henriette Van Praag Study, 1999

- Explored the question: whether the BDNF that exercising animals produced has similar effects on neurons in their brains. 1999 a study of two groups of mice:
  - One group had a running wheels
  - One group did not.
- Mice ran 4 to 5 kilometers every night.
- The **runners had twice** as many new brain neurons as the sedentary mice did.
- They discovered that **neurons** taken from the **runners** showed **greater signs of strength** and connections and Cellular learning.

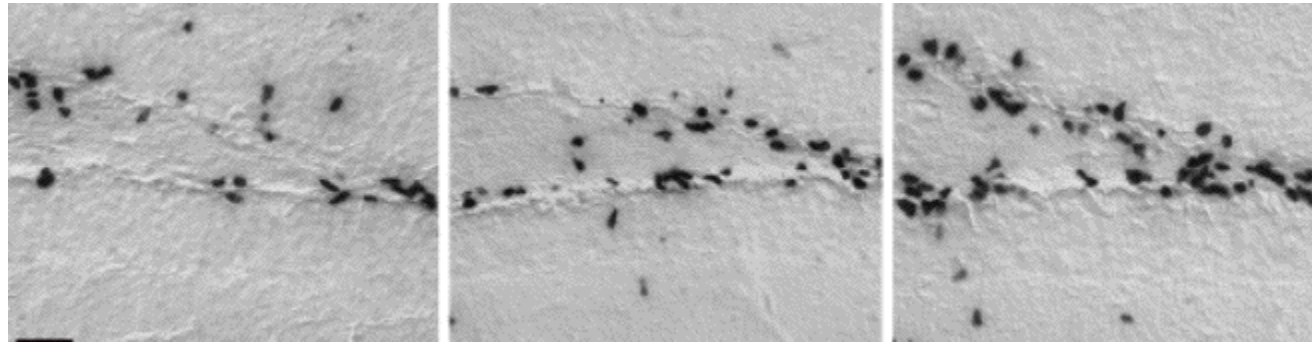


# Gage again, 2004

- Gage's team did it again this time with rats
- On average the runners voluntarily racked up 48 km per day over several weeks. (11 rats **averaging** 29 miles/day)
- The runners had more new neurons and stronger connectivity: this is key evidence for learning and that was not evident in the rats brains that had no wheel.
- Messenger RNA of both groups an indicator gene expression , found that the running rats had consistently high activity in the gene that codes for BDNF than the non runners did.



# Plasticity: Neural Growth



Control

Enriched

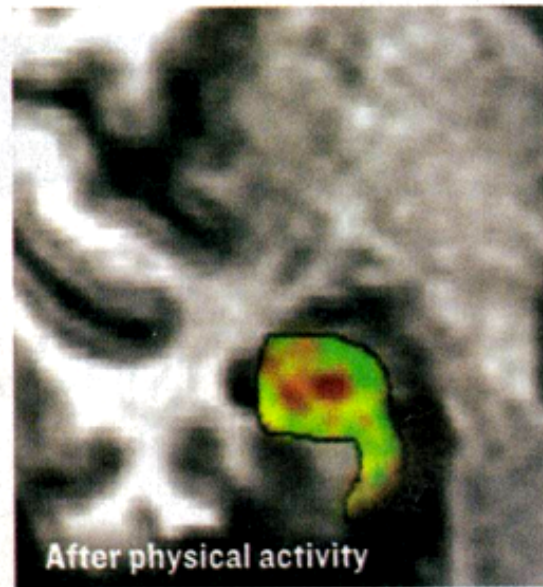
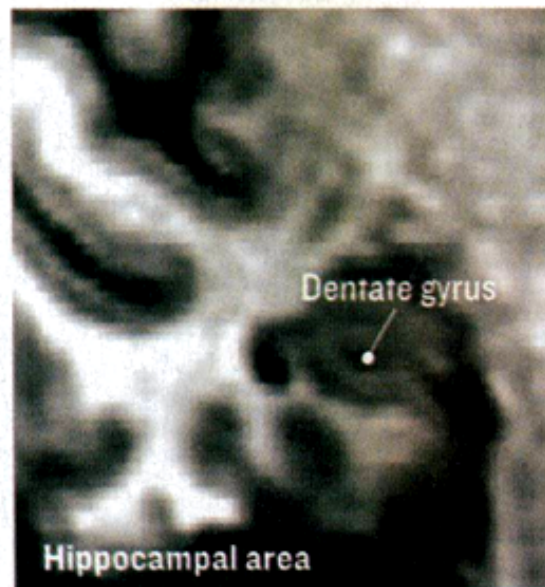
Running wheel

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

# How the Brain Changes

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

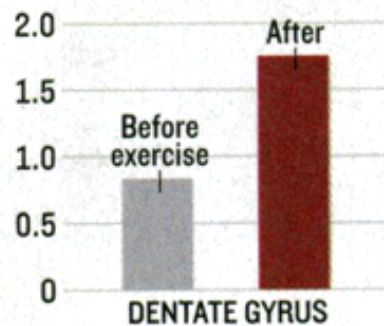
BLOOD VOLUME IN THE BRAIN: NEUTRAL  INCREASED



**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

# BODY SIGNALS STIMULATE BRAIN'S FERTILIZER

New, therapeutically interesting perspectives evolved from the observation that physical exercise evokes a marked increase in BDNF levels in the rat brain, in particular in the hippocampus and cerebral cortex<sup>29</sup>. These initial observations took an interesting turn when it was detected that the increased levels of BDNF are mediated by the enhanced production of growth hormone in the periphery, followed by increased synthesis of IGF-1 (ref. <sup>30</sup>). IGF-1 produced in the periphery is actively transported to the brain via the chorioid plexus, accumulated in the ependymal epithelium and further transferred to specific populations of neurons that exhibit prolonged enhanced electrical activity. This enhanced activity is transmitted to other neurons that are not directly responsive to IGF-1, which respond with enhanced production of BDNF. A causal relationship between the two events was documented by injection of blocking anti IGF-1 antibodies into the cerebrospinal fluid, which blocked not only the immediate effects of IGF-1 but also the increase in BDNF<sup>30</sup>. Clearly, these therapeutically attractive perspectives are no guarantee of clinical success of IGF-1 treatment, even if the concentrations can be adjusted to the same (low) levels as observed in experiments with increased physical activity. As a prerequisite for a prospective successful clinical treatment of aging-dependent memory deficits, including early stages of Alzheimer's disease,



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



# Stress and the Brain

- Stress demands adaptation: mechanisms evolved to help our plastic brain grow to meet these challenges. Neurotransmitters, Growth Factors (HGH included), adding to blood supply.
- Three major types of stressors: what we call **COGNITIVE OPERATIONS** (thinking and feeling), **DIETARY RESTRICTION** and **EXERCISE**. They stress nerve cells and if a **RECOVERY** period follows: then we see brain and nerve cell growth. Just like our muscles.

# Making new nerve cells with exercise

Recent evidence has suggested that over 9000 new cells are produced in the hippocampal DG of adult laboratory animals every day (Cameron and McKay, 2001). This process can also be dramatically enhanced by exposing animals to environmental enrichment (Kempermann et al., 1997) or allowing them access to voluntary exercise (Eadie et al., 2005; Farmer et al., 2004; van Praag et al., 1999).

- Glutamate- NMDA
- Serotonin
- BDNF Brain-derived Neurotrophic Factor
- GDNF Glial-derived Neurotrophic Factor
- VEGF Vascular endothelial factor
- IGF-1 Insulin-like Growth Factor
- FGF-2 Fibroblast growth factor



# EXERCISE OPTIMIZES LEARNING

- The biological becomes the psychological: improved attention, impulsivity, motivation, self-esteem, cooperativeness.
- The cellular level with increasing levels of the key neurotransmitters (Dopamine, Serotonin, Norepinephrine) and the increase in key neurotrophins (BDNF, IGF-1) one sees “cell wiring” occur easier and the bonds are more enduring.
- There is an increase in stem cell proliferation and also an increase in neurogenesis. A huge increase in BDNF, GDNF, IGF-1, FGF-2, VEGF all of which leads to an increase in neurogenesis or the actual growth of new nerve cells.



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

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

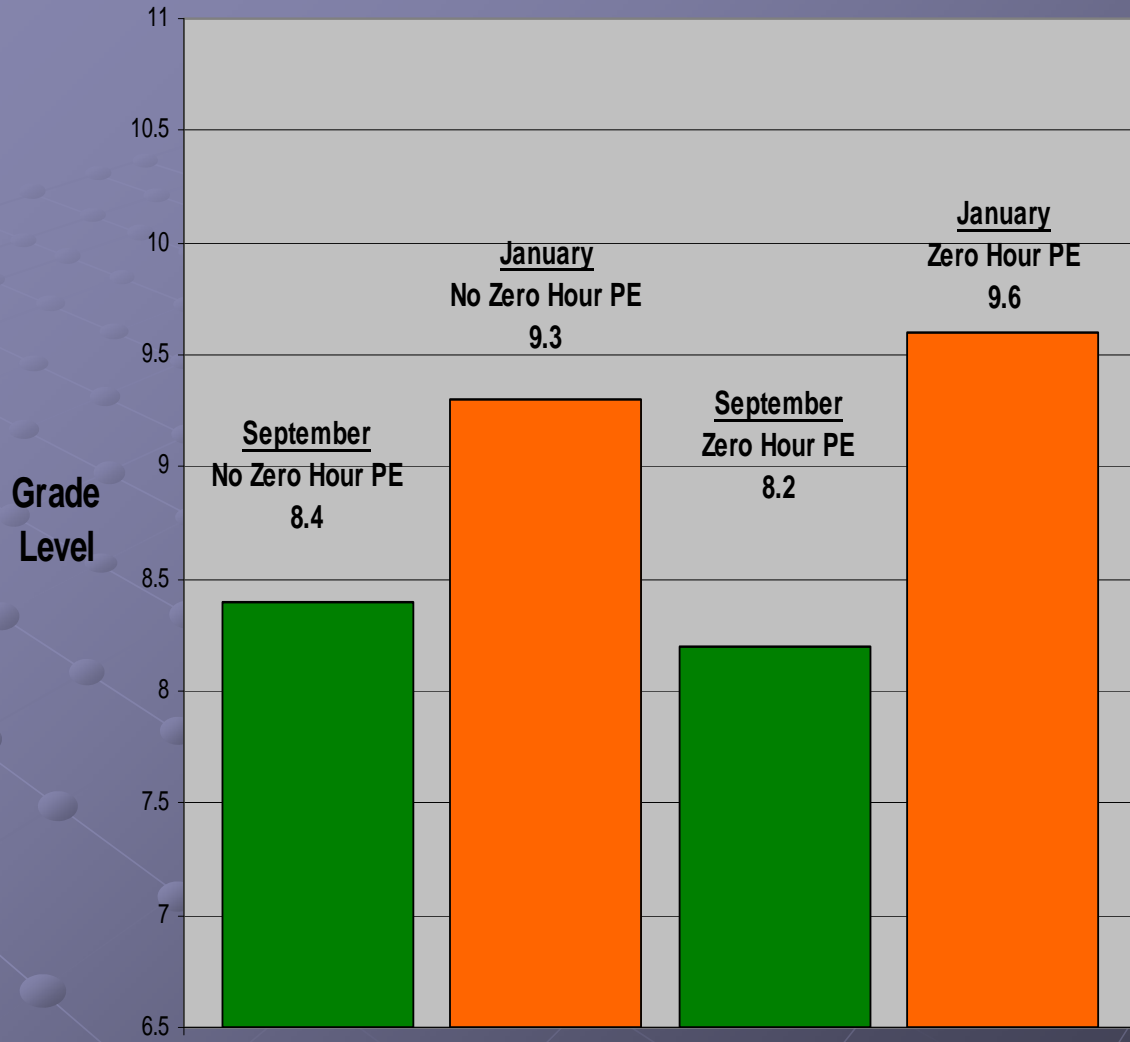
The results of a 2001 study by the California Department of Education showed 33 percent of freshmen in California were overweight or obese. When District 203 gathered its own data in a 2002 study of its own freshmen, only 3 percent were overweight or obese. 19000 children in the district.

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.

# Analysis of Data Gathered on Freshman Literacy Students During the 2005-2006 School Year

- Not all Freshman Literacy students were enrolled in Zero Hour PE
- All Freshman Literacy students were tested using the Nelson Denny reading test in both September 2005 and January 2006
- Results
  - Vocabulary
    - Regular PE students – .6 GE Improvement
    - Zero Hour PE students – 1.0 GE Improvement
  - Comprehension
    - Regular PE students – 1.2 GE Improvement
    - Zero Hour PE students – 1.4 Improvement
  - Vocabulary and Comprehension Combined
    - Regular PE Students – .9 GE Improvement
    - Zero Hour PE Students – 1.4 GE Improvement

# Reading Growth From Sept. '05 - Jan. '06



.9 GE Improvement

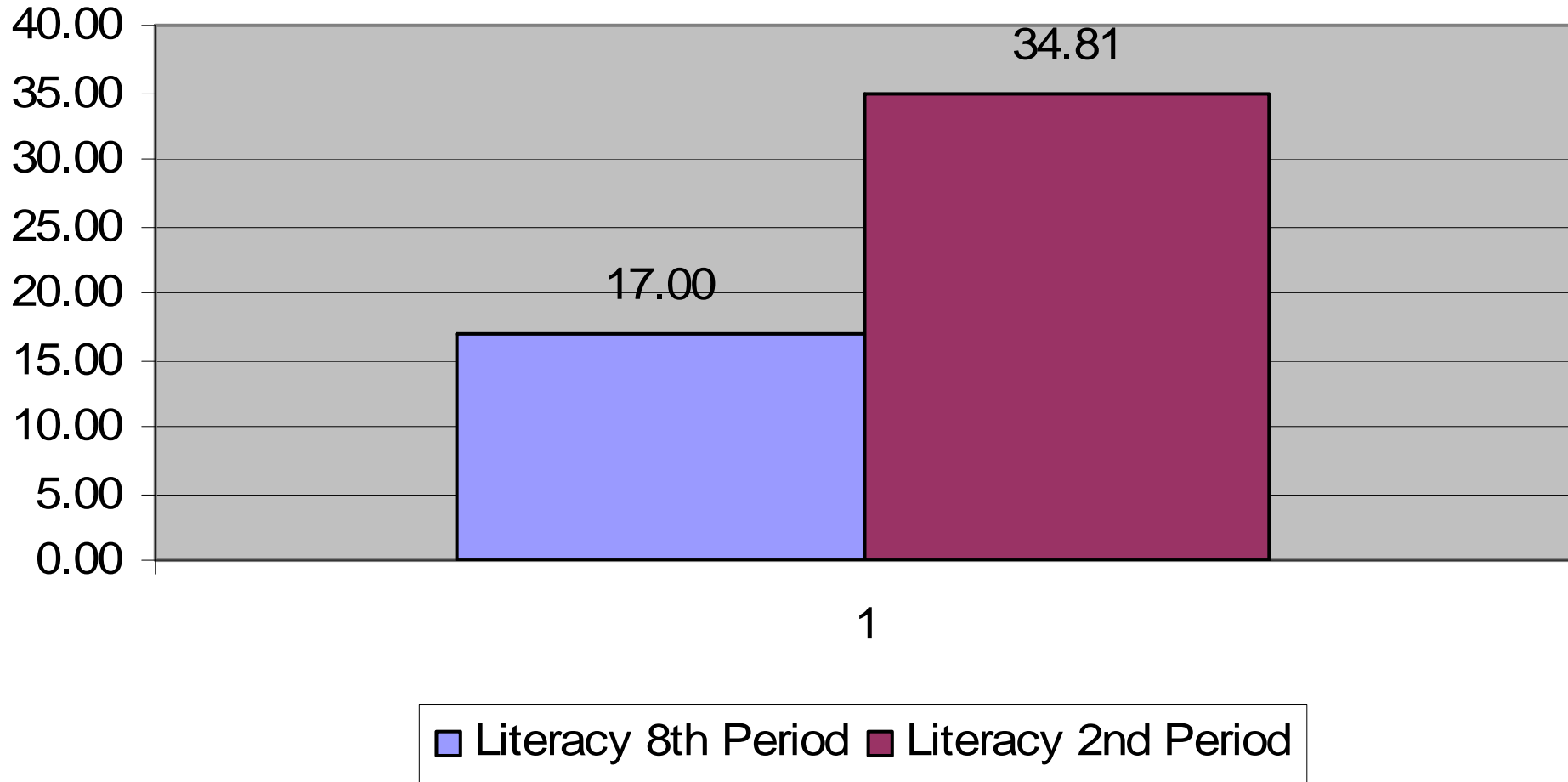
1.4 GE Improvement

# Analysis of Data Gathered on Freshman Literacy Students During the 2006-2007 School Year

- ❑ ALL Freshman Literacy students were enrolled in 1<sup>st</sup> hour LRPE
- ❑ All Freshman Literacy students were tested using the Nelson Denny reading test in both September 2006 and January 2007
- ❑ Half of the Freshman Literacy students were in 2<sup>nd</sup> hour Freshman Literacy and the other half were in 8<sup>th</sup> hour Freshman Literacy
- ❑ Results
  - Vocabulary
    - ❑ 2<sup>nd</sup> Hour FL students – .73 GE Improvement
    - ❑ Hour FL students – .24 GE Improvement
  - Comprehension
    - ❑ 2<sup>nd</sup> Hour FL students – 1.78 GE Improvement
    - ❑ 8<sup>th</sup> Hour FL students – .90 GE Improvement
  - Vocabulary and Comprehension Combined
    - ❑ 2<sup>nd</sup> Hour FL students – 1.34 GE Improvement
    - ❑ 8<sup>th</sup> Hour FL students – .60 GE Improvement



# Naperville 2007 results

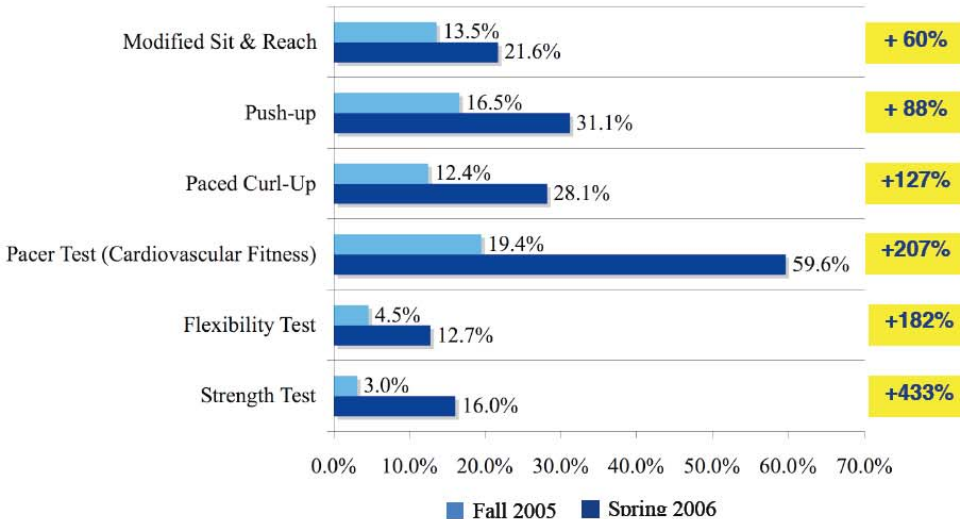


Comparing Nelson Denny improvements for 9<sup>th</sup> graders in reading readiness classes. Blue are students who took special PE but had reading class 8<sup>th</sup> period; while those having their class immediately following special PE improved twice as much. The weak conclusion drawn from this is that special PE had a greater effect on learning if the students took the class immediately after PE.

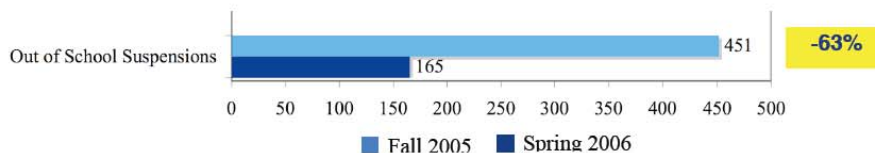


**GROUP REPORT**  
Grades 4 and 5  
Fitness Gram Results: Fall 2005 – Spring 2006

**Percent of Students in Healthy Fitness Zone**



**Percent Reduction in Disciplinary Issues**



In the fall of 2005, this elementary school had PE one day per week of 50 minutes. This year Jan-June 2006 a PE4life Program was offered five days a week at 45 minutes.

The changes are remarkable. This is an inner city school with 80% of kids on free lunch program, mostly Hispanic and African American heritage.

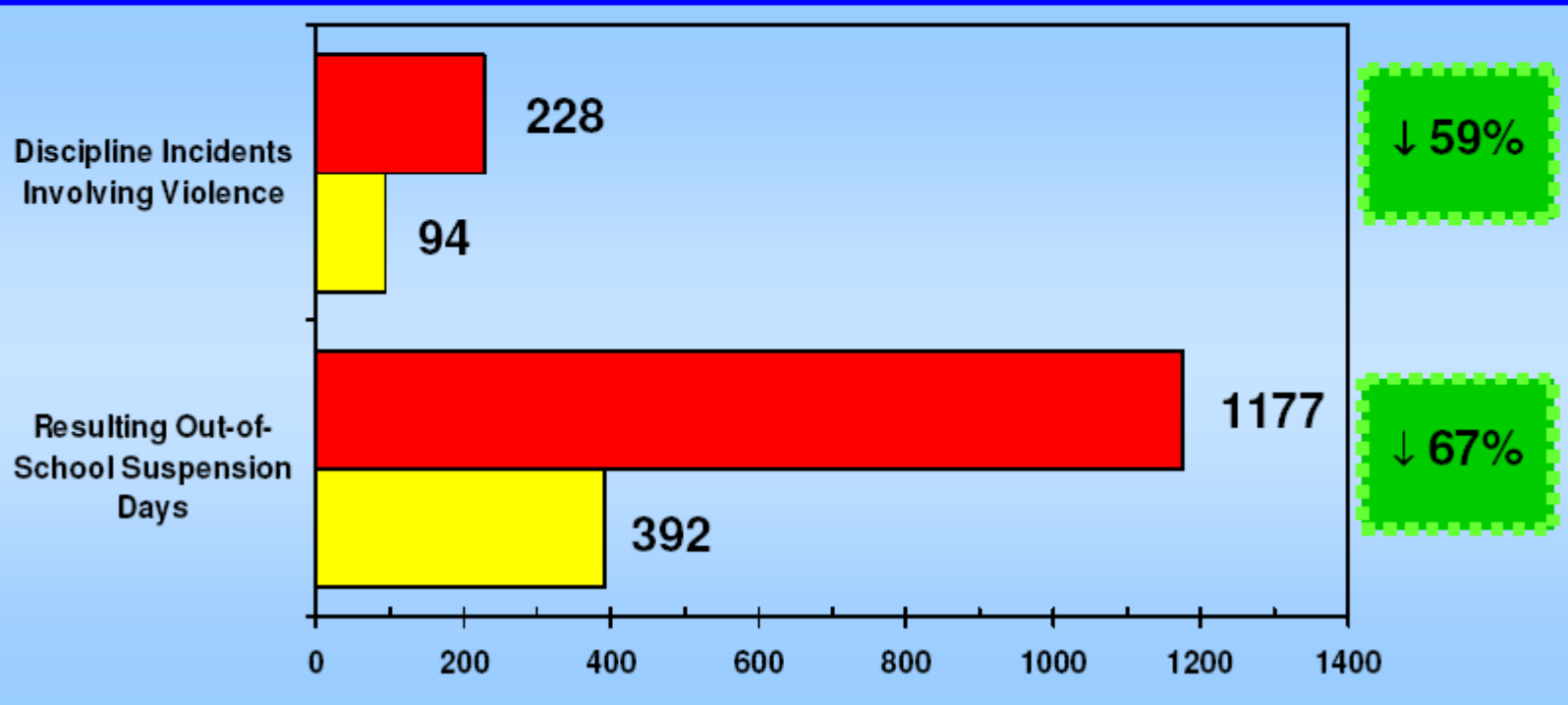
The PE4LIFE added elements were cardiac monitored watches, Dance Dance Revolution, a few exercise bicycles, and a small number of fitness machines. Mostly what was added was a new attitude.





# ***Fitnessgram Results: Percent Reduction in Disciplinary Issues***

***Woodland Elementary School, Kansas City PSD #33  
Fall 2005 – Spring 2006, Grades 4 and 5***



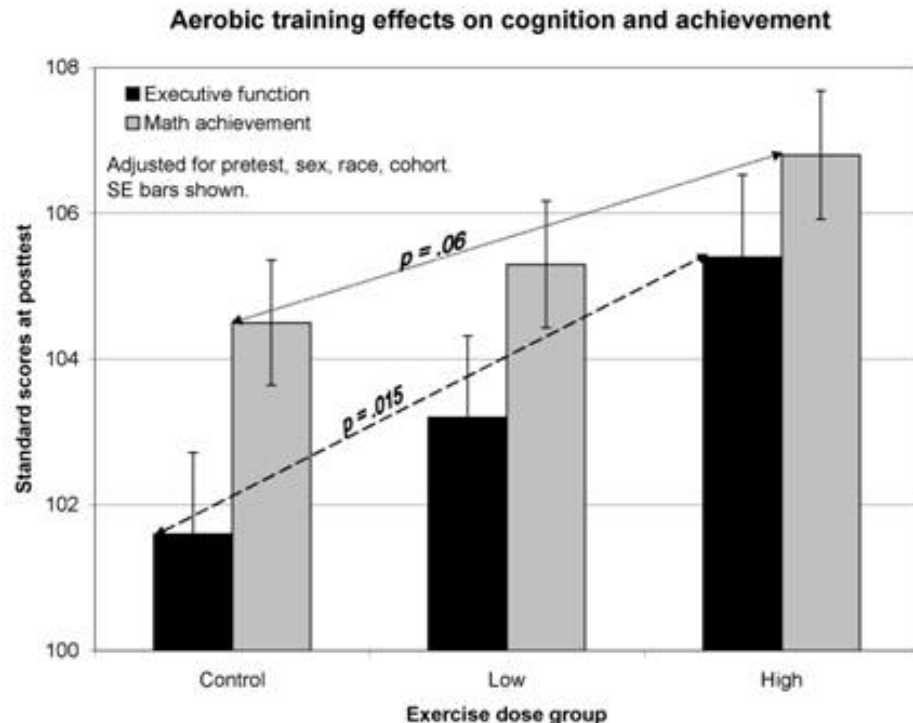


## Results

*“PE4Life has had a tremendous influence on the lives of our students. It’s not just the increased levels of fitness we are seeing in our kids which has everyone excited. Students are also more motivated throughout the day, their enthusiasm is way up, and discipline issues are way down.”*

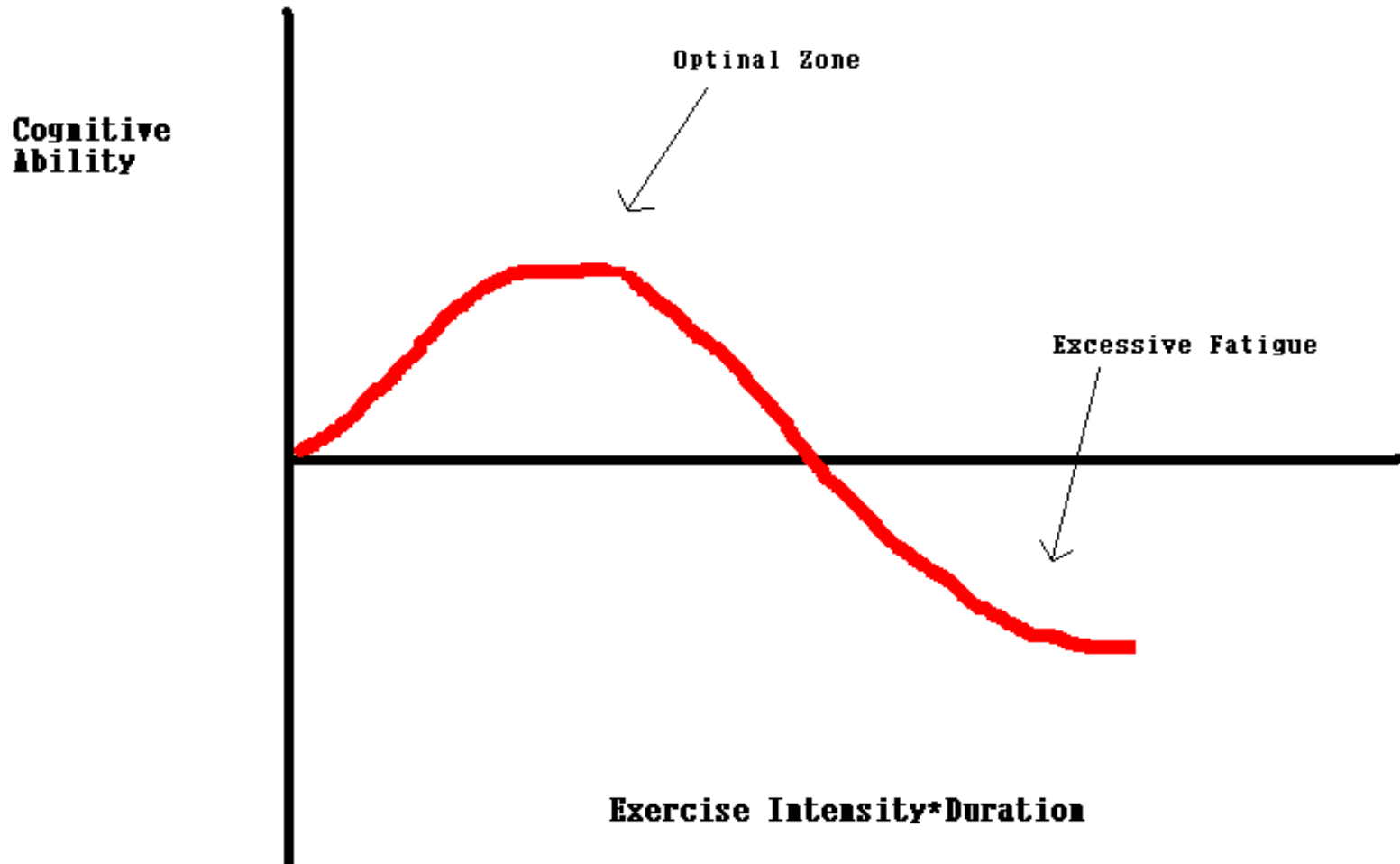
*— Craig Rupert  
(Principal, Woodland Elementary School)*

# Improving Executive Function



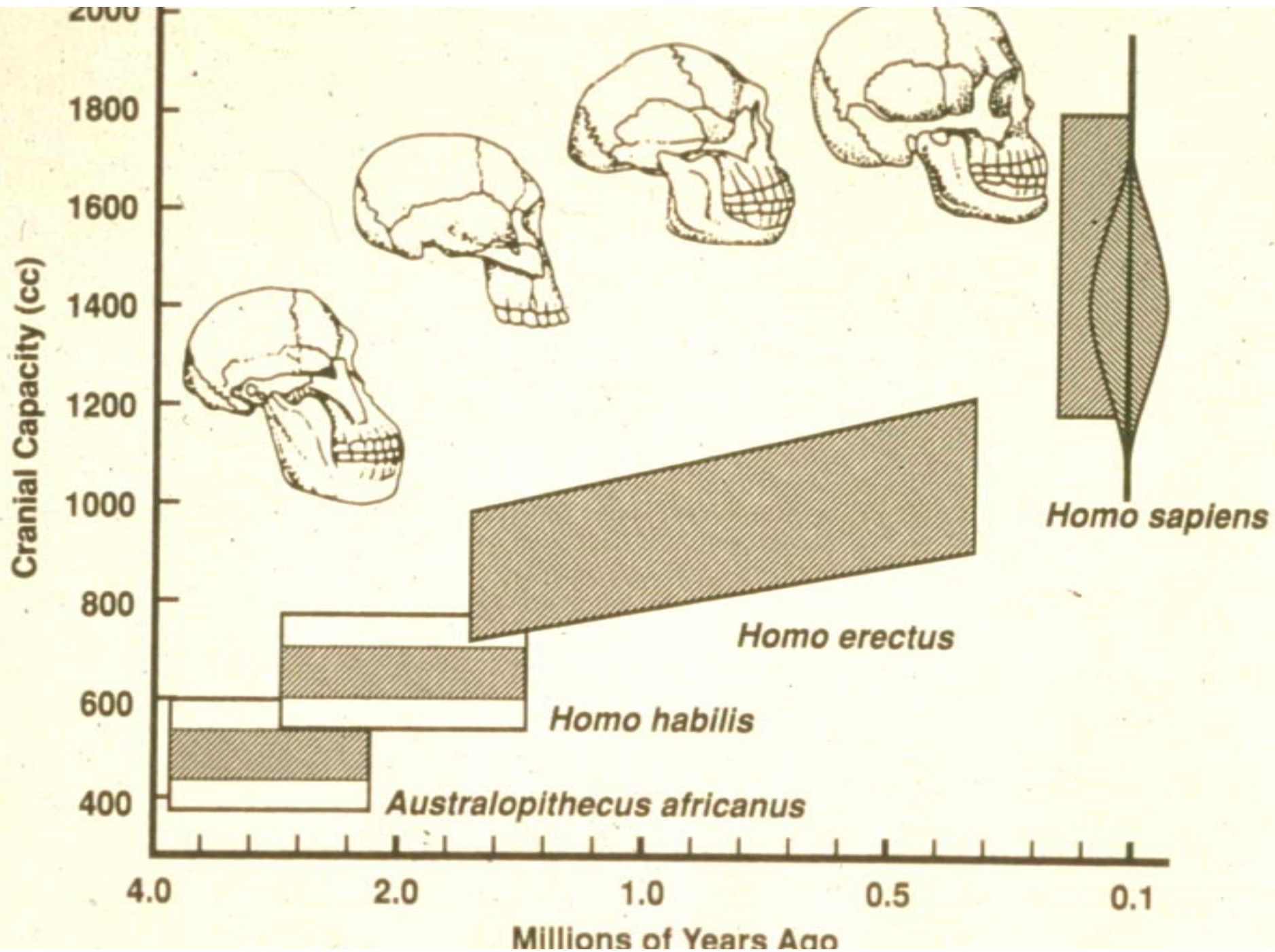
Dr. Catherine Davis, clinical health psychologist at the Medical College of Georgia and lead investigator had 200 overweight, inactive children ages 7-11 learn about healthy nutrition and the benefits of physical activity; one-third also exercised 20 minutes after school and another third exercised for 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.

# Cognitive Ability as a Function of Exercise Intensity times Duration



**Figure 1:** Proposed curve for the relationship between exercise intensity x duration and cognitive ability, as measured immediately following an exercise session.





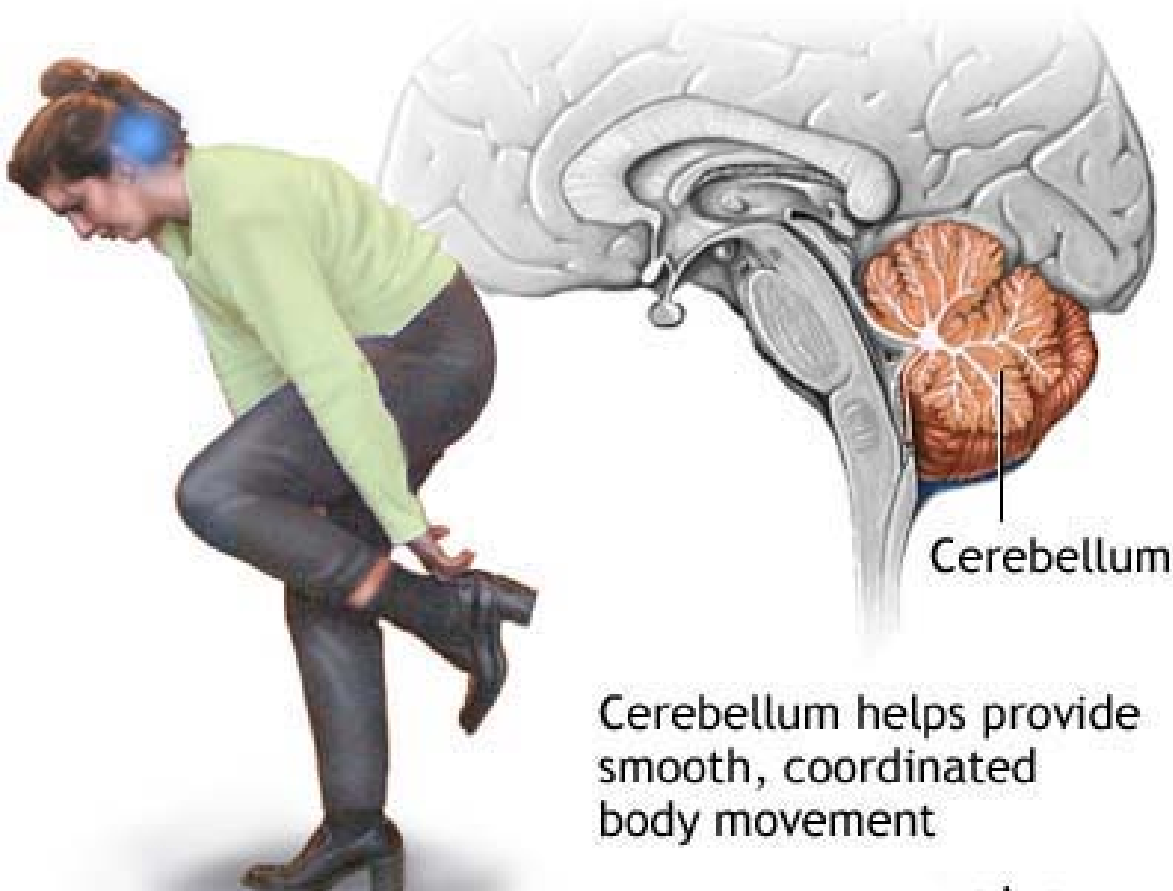
# Cerebellum: mood, schizophrenia, autism, memory, dyslexia, ADHD

Balance board, Core

Karate, ballet,  
dance, gymnastics,  
yoga, sports in  
general

DDR, Wii,

DORE Program???



Cerebellum helps provide  
smooth, coordinated  
body movement

# Math Balls



Colorado teacher Lisa Witt studied a dozen of her sixth-grade students in 2001 to demonstrate the benefits of the balls to a skeptical principal. Video studies of the students showed improved posture, more time spent on task and less squirming while they sat on the balls, she told the newspaper. “People are not meant to sit still.”

Mrs. Raabe’s fifth-grade class in Charlotte, North Carolina recently embraced ergonomic innovation in an attempt to increase attention spans and facilitate good posture. The classroom is now a sea of motion in which children bob and weave, sway and bounce their way through lessons perched atop brightly colored fitness balls.

Turns out, the balls do have a wellness significance. A Mayo Clinic study found that the balls can be used to burn calories, in effect attacking the growing problem of childhood obesity. With the balls, fidgety students or those with attention deficit disorder have an outlet for their excess energy. Concentration increases for everyone because of the noise reduction. And physical conditioning is improved because of the work involved in staying on top of the ball.







# Exercise and the brain- the crucial connection!

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JOHN J. RATEY, M.D.,  
COAUTHOR OF *DRIVEN TO DISTRACTION*  
WITH ERIC HAGERMAN

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By Dr. John Ratey  
with Eric Hagerman  
January 10, 2008

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**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](http://www.johnratey.com)

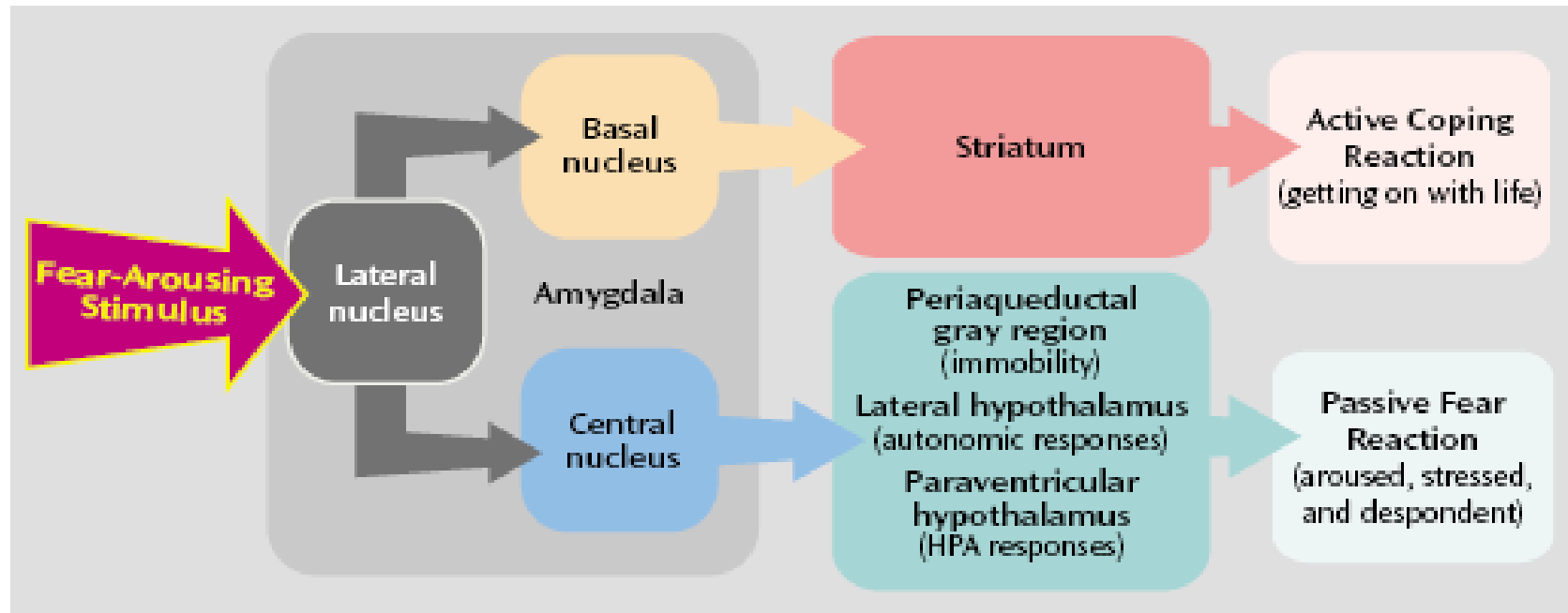
[www.PE4LIFE.org](http://www.PE4LIFE.org)

# West Virginia DDR Obesity

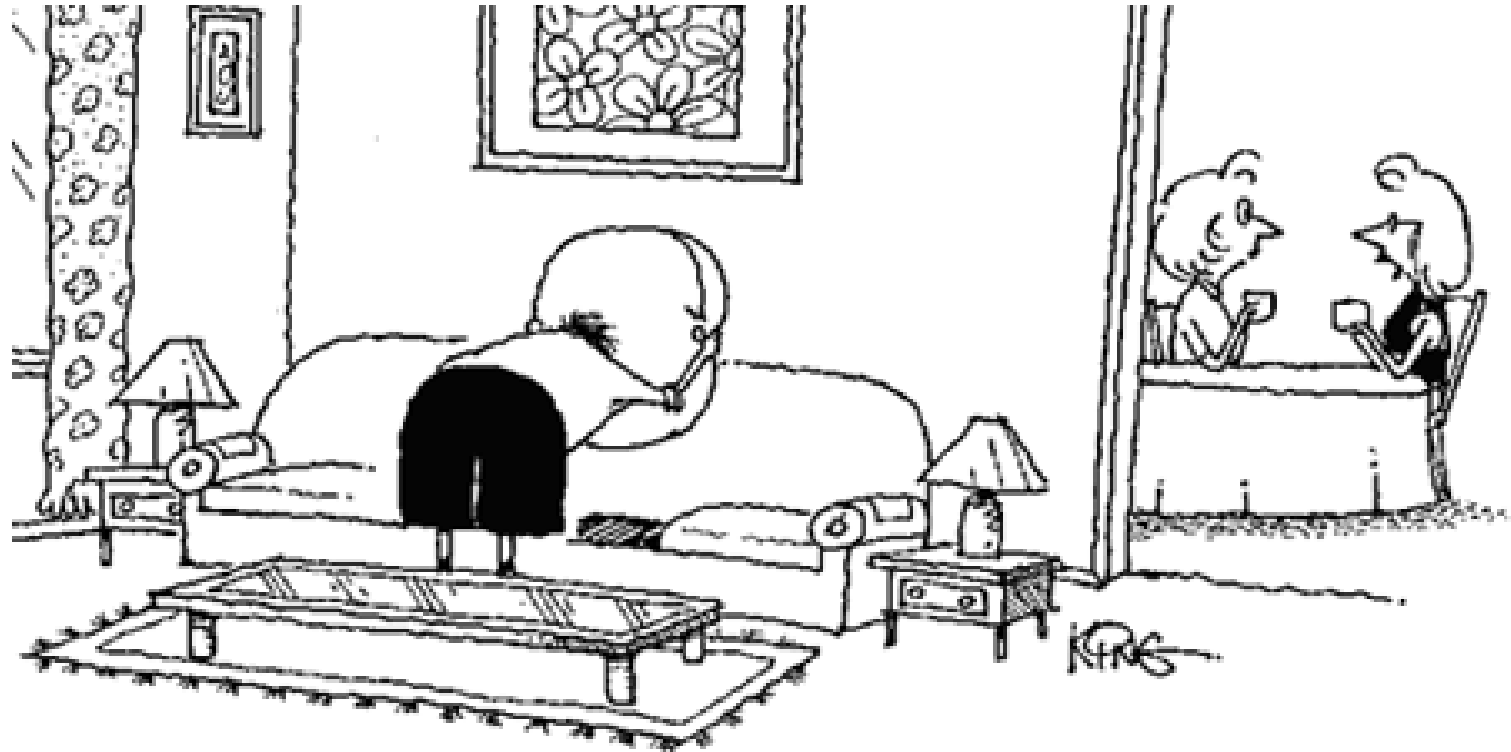
- Last April, 85 children in West Virginia received a gift from a local health insurance company - a Sony PlayStation 2. The machine came with a game called Dance Dance Revolution in which the player follows a fast-paced dance routine using an interactive mat that feeds foot movements back to the console. It's a dream toy for most children, but the insurance company wasn't being purely altruistic.
- In West Virginia, more than a third of children are overweight. These are the next generation of clients for the West Virginia Public Employees Insurance Agency, which provides health insurance for 215,000 public employees and their dependents. "We have an obesity epidemic in West Virginia," says Nadia Henderson, a spokeswoman for the agency. "Giving them PlayStations is good business sense if it helps them lose weight."
- It's part of a study to see if this type of computer game can reduce obesity. So far, results seem positive. For example, one 11-year-old boy weighing 80 kilograms lost 4.5 kilograms in two weeks
- Then, a decade later, a computer game called Dance Dance Revolution - or Dancing Stage in Europe - began to appear in arcades around the world. Created by the Japanese gaming company Konami, DDR uses a set of pressure pads which the player must press with their feet in response to on-screen commands. This time it was a huge success. DDR has become a global craze with its own subculture and tournaments. In Norway, DDR is registered as an official sport. Today there are over 90 variants of the game and many offspring offering similar features



FIGURE 1. Shift From Passive Fear to Active Coping in the Brain<sup>a</sup>

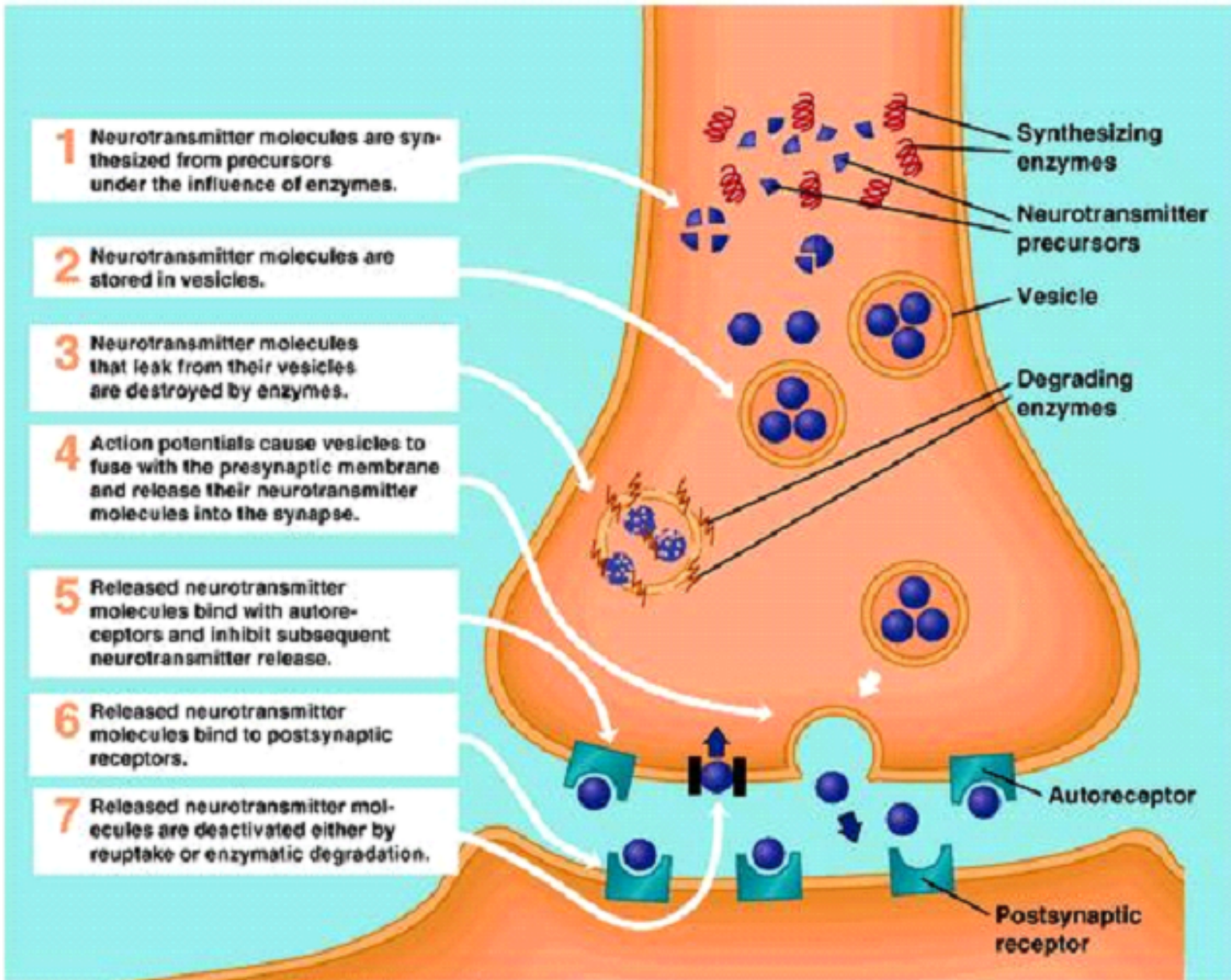


<sup>a</sup> Fear-arousing stimuli elicit a constellation of fear responses that include freezing or immobility and activation of autonomic and neuroendocrine responses. These responses can be coupled to otherwise meaningless events through a process of associative learning. Studies of rats over the past 20 years have implicated the amygdala in this process of learning (1, 2). Specifically, the lateral nucleus of the amygdala is where the conditioned stimulus and unconditioned stimulus are integrated. Subsequently, exposure to the fear-arousing conditioned stimulus enters the lateral nucleus, where its meaning is encoded. The lateral nucleus in turn activates the central nucleus of the amygdala, which activates brainstem areas involved in controlling specific components of the fear reaction. Connections with the periaqueductal gray region control the freezing or immobility response, connections with the lateral hypothalamus control autonomic responses, and connections with the paraventricular hypothalamus control endocrine responses of the hypothalamic-pituitary-adrenal (HPA) axis. Animals and people involuntarily (passively) express these responses to fear-arousing stimuli. However, through a process of active responding, the flow of information can be diverted to the basal nucleus of the amygdala and from there probably to motor circuits of the striatum, which allows the rat to successfully avoid the fear-arousing event.

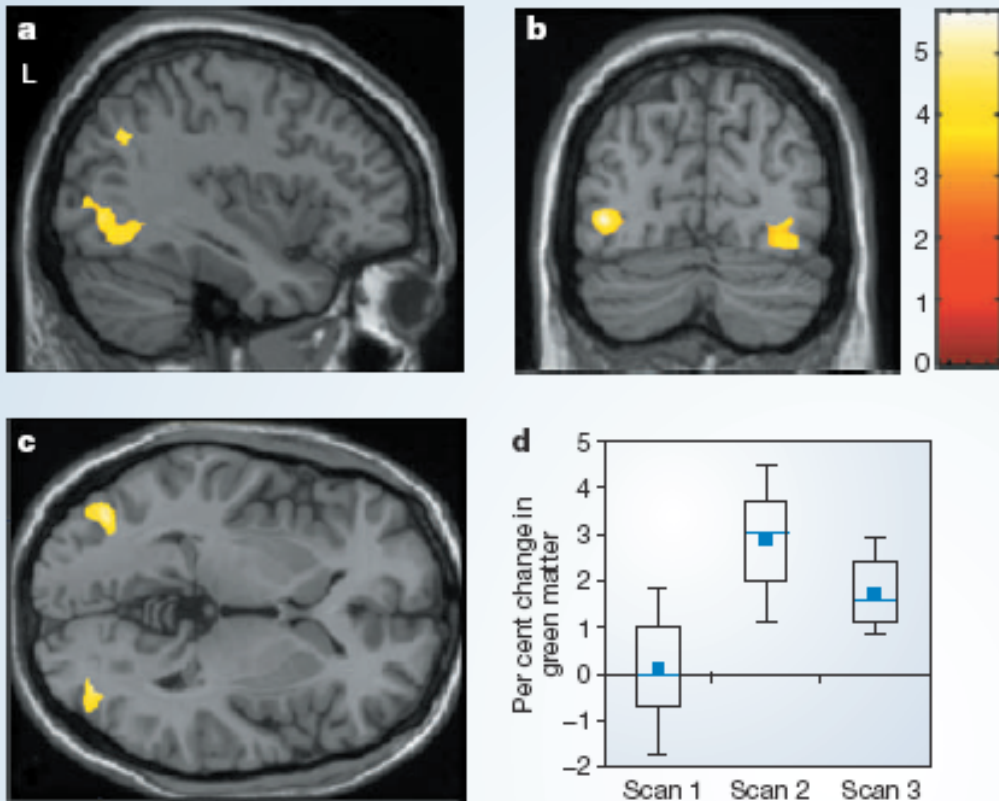


The doctor said he needed more activity. So I hide his T.V. remote three times a week.

# CELLS THAT WIRE TOGETHER, FIRE TOGETHER



# JUGGLING CHANGES THE BRAIN

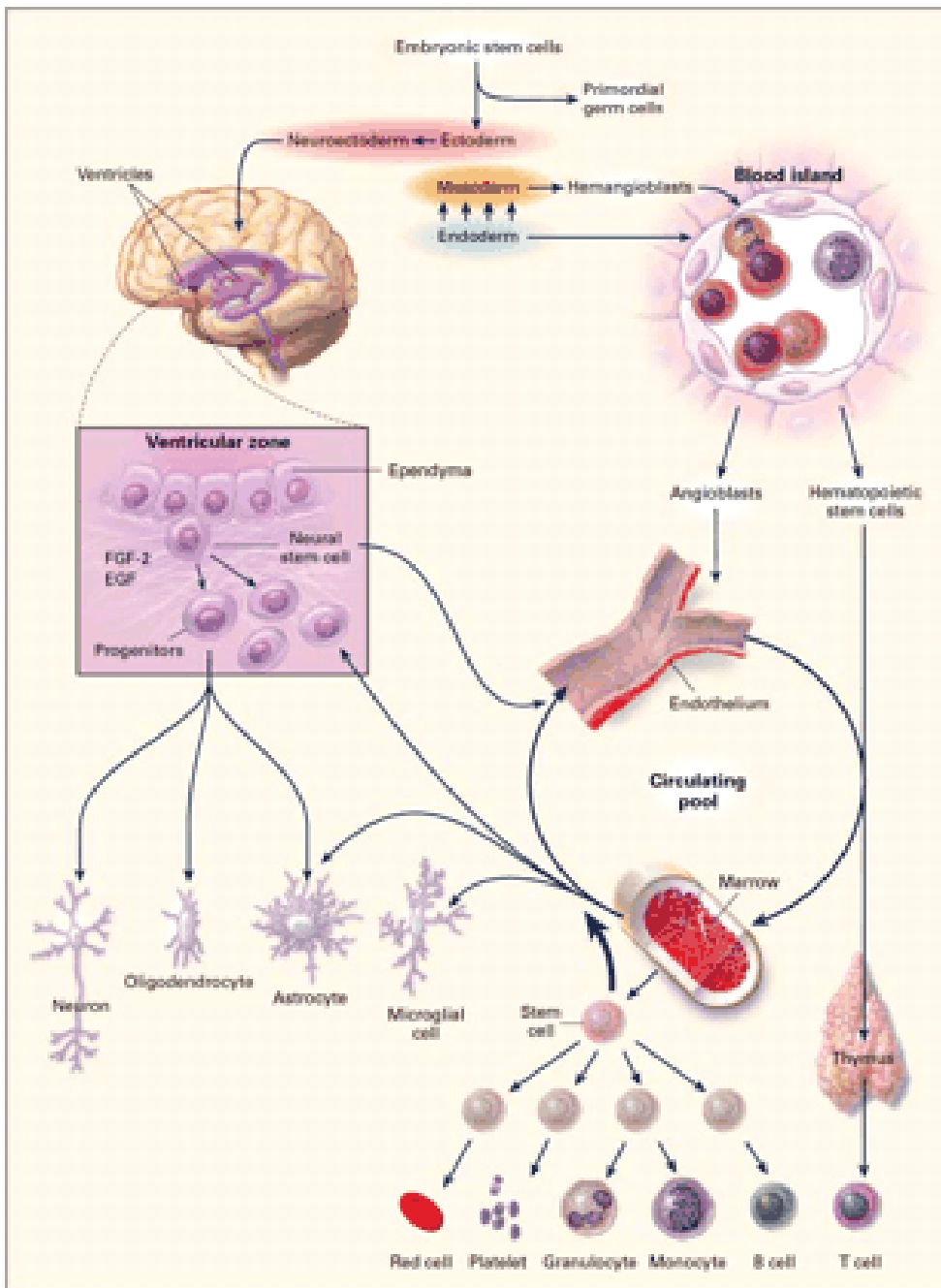


They **divided a homogeneous group of 24 volunteers**, who were matched for sex and age, into two groups, designated as jugglers and non-jugglers. Both groups were inexperienced in juggling at the time of their first brain scan. Subjects in the juggler group were given **3 months to learn a classic three-ball cascade juggling routine**. A second brain scan was performed when they had become skilled performers (that is, when they could sustain juggling for at least 60 seconds). A third scan was carried out 3 months later; during the intervening period, none of the jugglers practiced or attempted to extend their skills — for example, by learning a four-ball or a reverse cascade. In fact, most subjects were no longer fluent in three-ball cascade juggling by the time of the third scan.

Transient changes in brain structure induced while learning to juggle. **a–c**, Statistical parametric maps showing the areas with transient structural changes in grey matter for the jugglers group compared with non-juggler controls. **D** shows grey matter changes scan 1 is baseline, 2 is after six weeks of training, 3 shows regression after six months of no juggling

# History of BDNF

Synaptic Plasticity, Learning,  
Memory, & BDNF

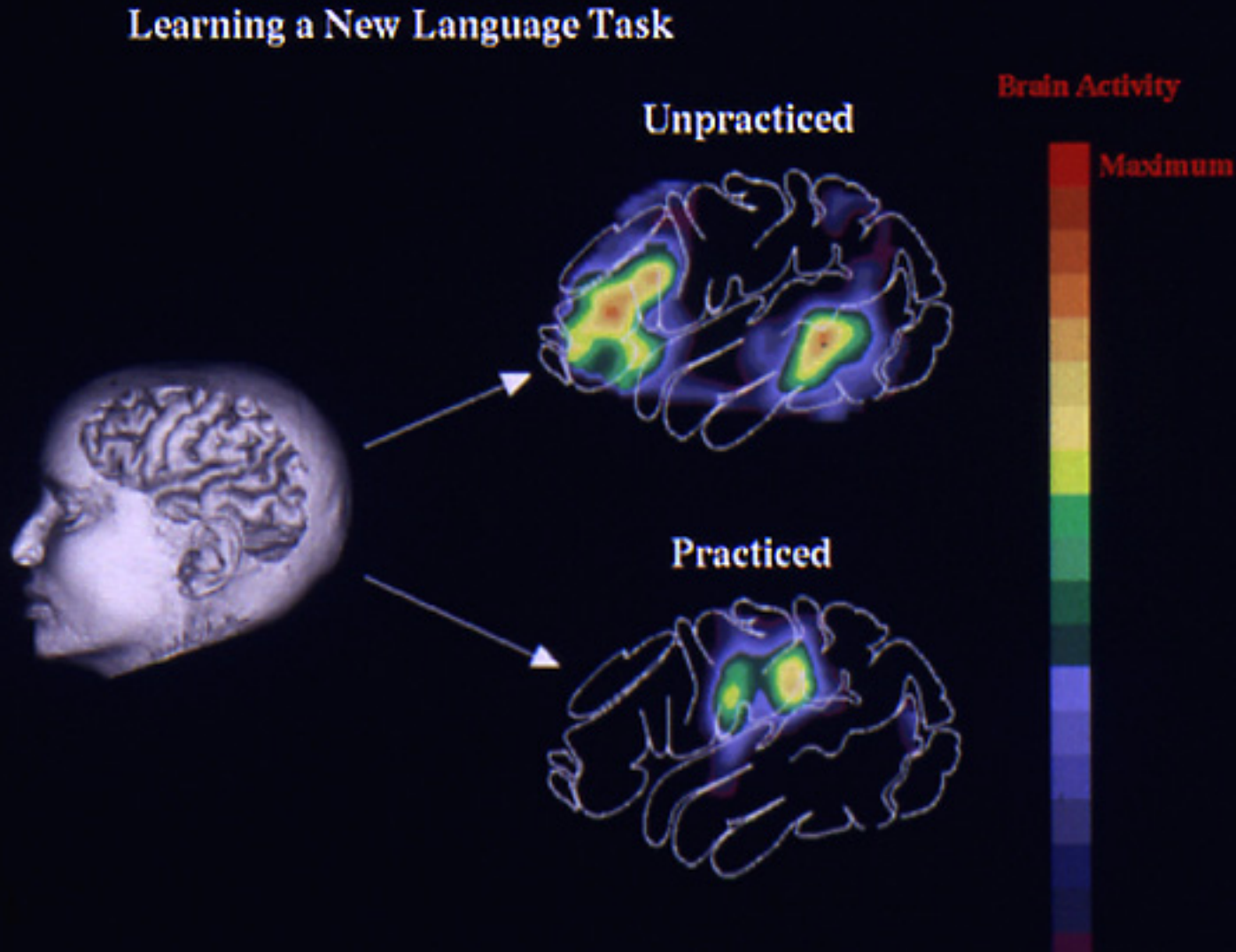


NEUROGENESIS -MAKING  
 NEW NERVE CELLS, IS  
 SUPPORTED BY BDNF  
 AND IS INHIBITED BY  
 CHRONIC STRESS AND  
 INACTIVITY.

BDNF IS MIRACLE GRO  
 AND IS INCREASED BY  
 BOTH PHYSICAL AND  
 COGNITIVE ACTIVITY



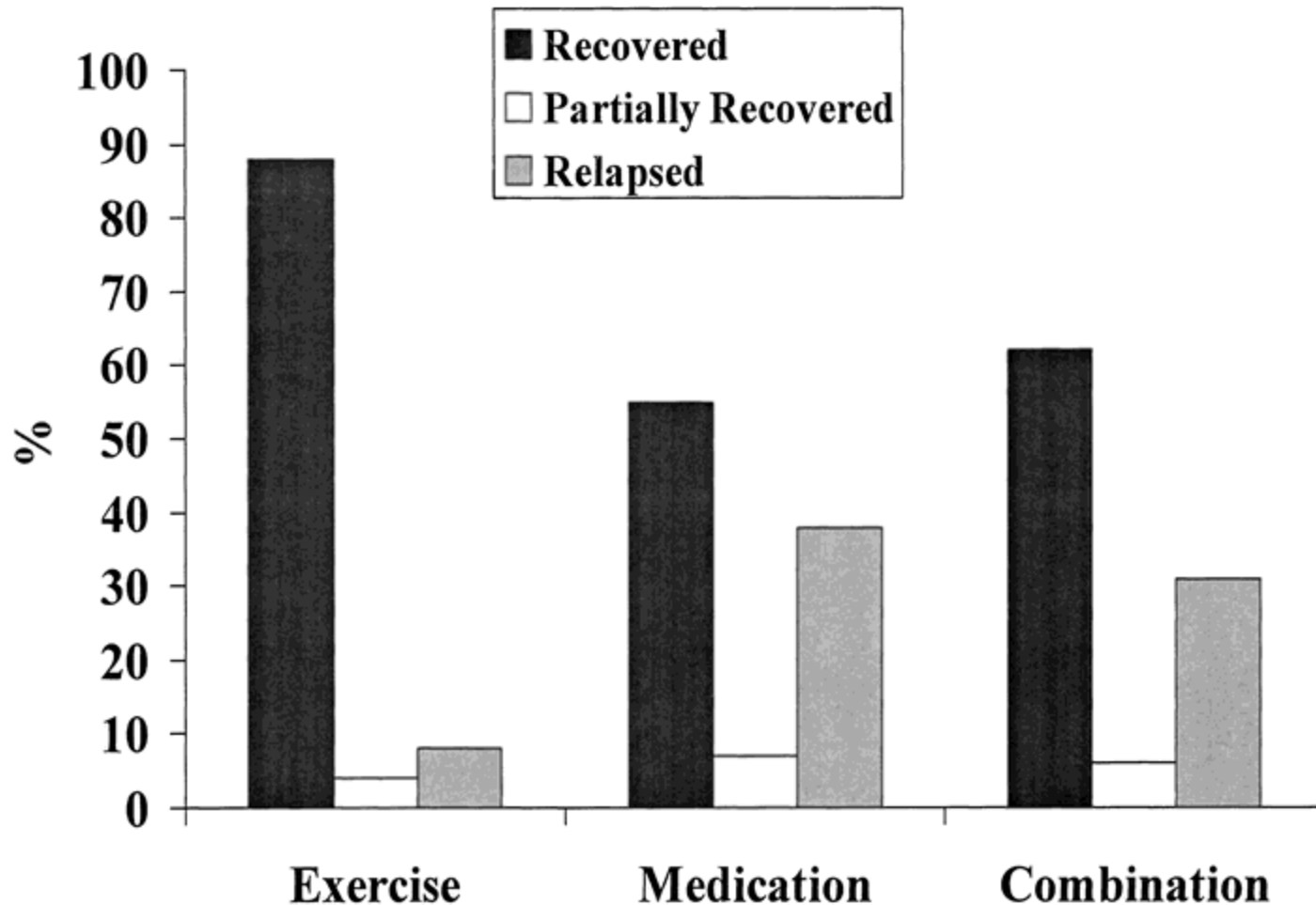
Nerve cell activity when learning is a stressor on the cells; they are requested to do more. This causes a release of Miracle Gro. The cells involved are bigger and healthier.



# Eating, exercise, and “thrifty” genotypes: connecting the dots toward an evolutionary understanding of modern chronic diseases

- **“On a superficial level, many would consider it intuitive to make the statement that exercise in general is a good thing. However, when the layers of the exercise onion are peeled, the answer to the question of how exactly at the mechanistic level is exercise beneficial for human health does not seem that obvious to the general scientific community, although there is extensive literature at a descriptive level documenting the precise benefits of exercise for many aspects of human health.”**  
Manu V. Chakravarthy and Frank W. Booth
- **“Modern society is remarkably sedentary, with at least 70% of the US population undertaking less than 30 min/day of moderate-intensity physical activity”**  
US Department of Health and Human Services. Physical Activity and Health: A Report of the Surgeon General. Atlanta, GA: U.S. Dept. of Health and Human Servs., Centers for Disease Control and Prevention, National Center for Chronic Prevention and Health Promotion, 1996.
- **As asserted by Trevathan et al. “A better understanding of many modern health problems will emerge when we consider that most of human evolution took place when our ancestors were hunter-gatherers.”**  
Trevathan WR, Smith, EO, and McKenna JJ. Introduction. In: Evolutionary Medicine, edited by Trevathan WR, Smith EO, and McKenna JJ. New York: Oxford Univ. Press, 1999, p. 3–6.

# Zoloft versus Exercise at 6 months



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.

# INTENSITY/DOSE

- Dr. Catherine Davis, clinical health psychologist at the Medical College of Georgia and lead investigator had 200 overweight, inactive children ages 7-11 learn about healthy nutrition and the benefits of physical activity; one-third also exercised 20 minutes after school and another third 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.
- After 3 months, aerobic exercise training showed dose-response benefits on executive function (decision-making) and possibly math achievement, in overweight children.” “Regular exercise may be a simple, important method of enhancing children’s cognitive and academic development. These results may persuade educators to implement vigorous physical activity curricula during a childhood obesity epidemic.”
-

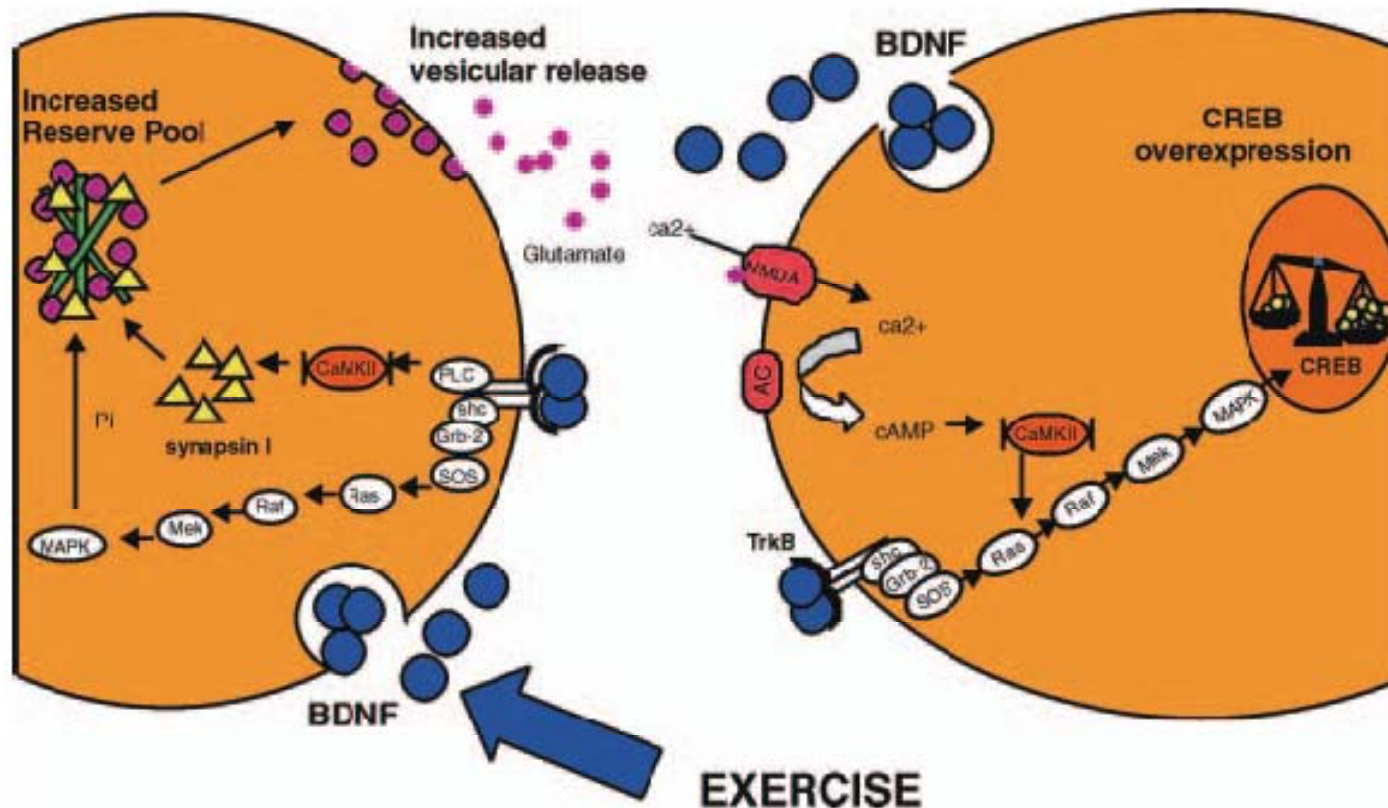
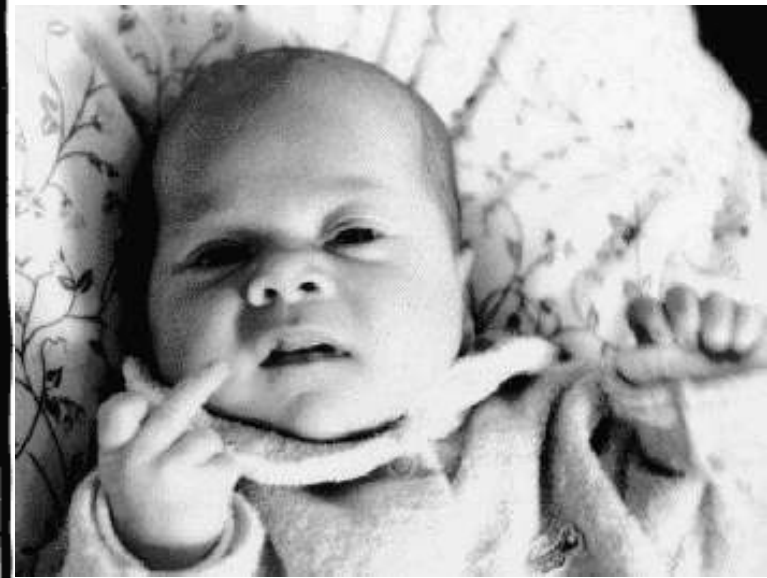


Figure above shows: Potential mechanism through which BDNF may enhance learning and memory in the hippocampus under the action of exercise. Exercise-induced BDNF levels are depicted activating signal transduction cascades that lead to synapsin I and CREB mediated plasticity. BDNF activation of its TrkB receptor may increase the synaptic reserve pool by activating a PLC-CAMK-II cascade to increase synapsin I levels. Additionally, BDNF may increase neurotransmitter release by phosphorylating synapsin I via the MAP-kinase cascade. Postsynaptically, BDNF activation of the MAP-Kinase cascade, supplemented by additionally interaction with the NMDA receptor and CAMK-II, can lead to CREB overexpression that is necessary for implementing long-term structural and functional changes supporting long-term memory.

# NO CHILD LEFT BEHIND





# Darwin: “Cooperative nervous system”

- The ability to **acquire food and remember where and how to do it**, was a major force in the evolution of humankind. This **soldered together** cooperative molecular mechanisms underlying activity, cognition & metabolism.
- Individuals who could outrun & out-plan their peers would survive.

# History of BDNF cont.

- Learning, memory, & long term potentiation (LTP), considered an electrophysiologic correlated to learning & memory.
  - Selectively increase BDNF & mRNA levels in the hippocampus.
- Blocking anti-BDNF antibodies has been shown to impair learning & memory.
- Blocking endogenous BDNF significantly reduce LTP.
- Replenishing the depleted hippocampus with exogenous BDNF seems to improve these deficits.