

# EXERCISE & YOUR BRAIN



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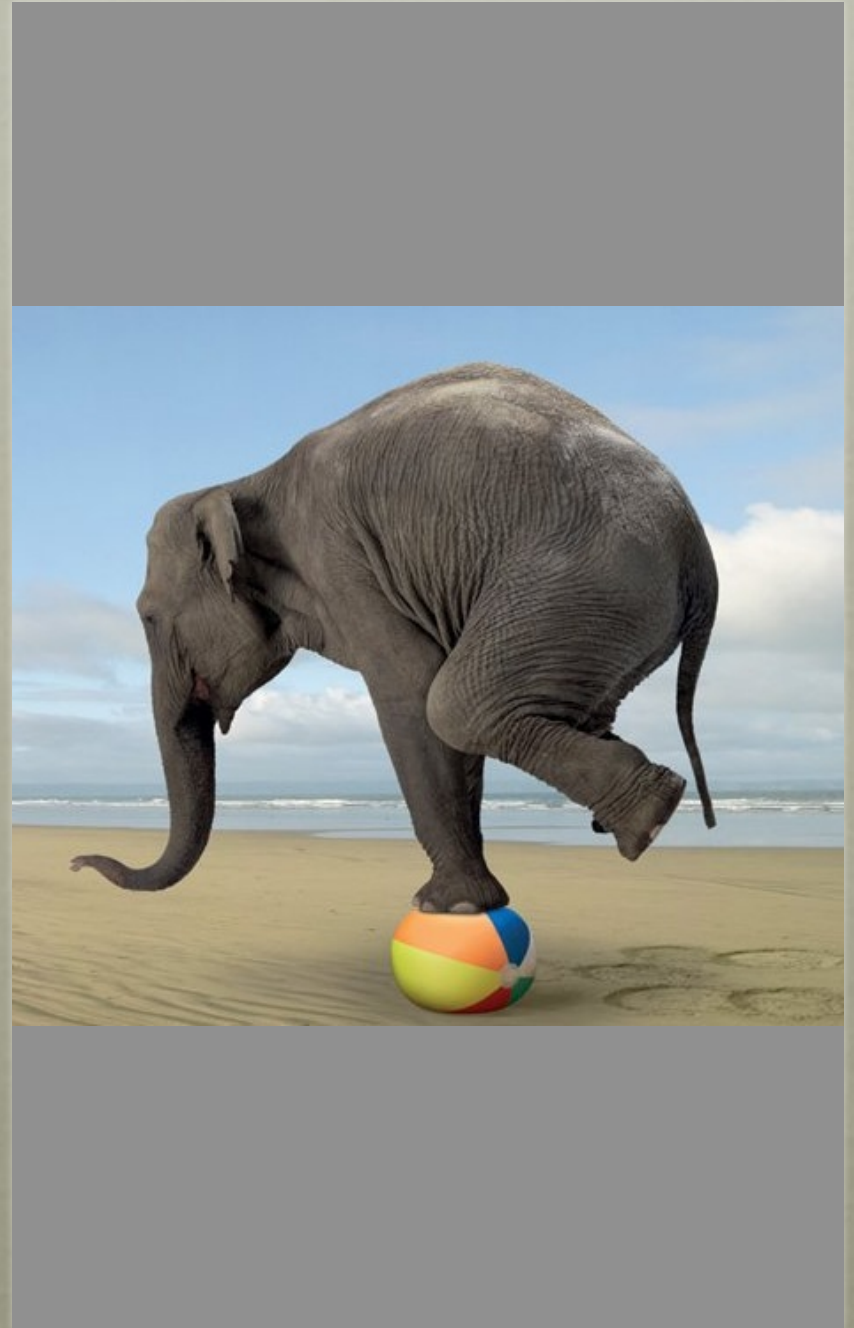
# EXERCISES TO START WITH

Back

Front

Side

EO / EC



# OUTLINE



1. Inspiration



2. Physiology of Exercise

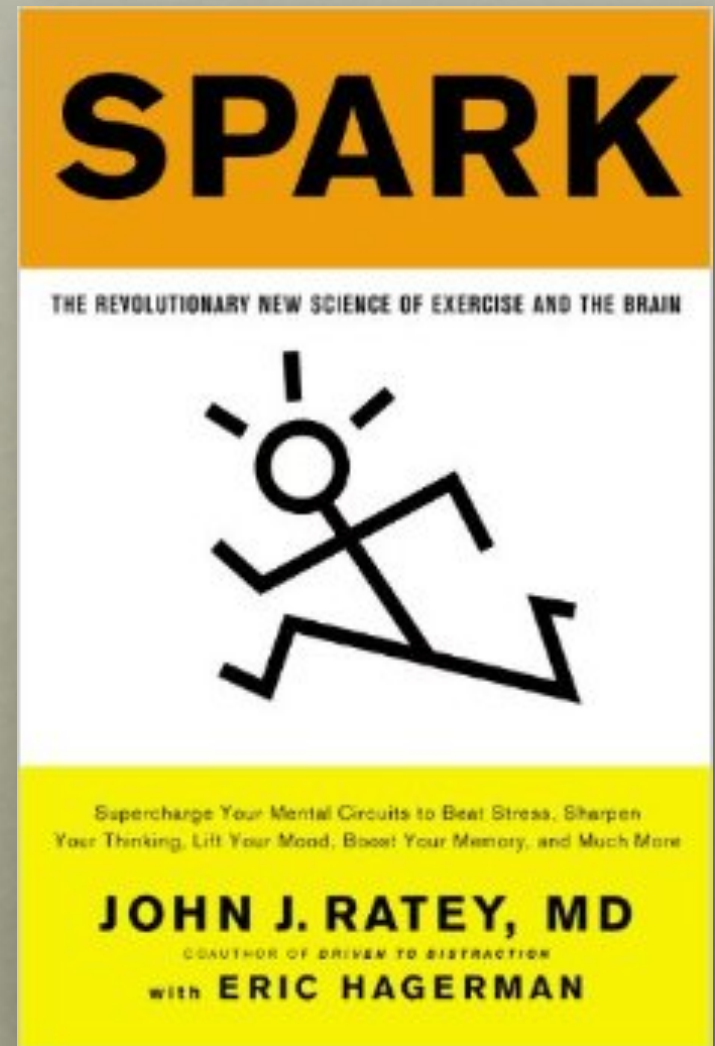
3. Exercise and How It Effects Common Presentations



4. How This Talk Should Change Your Exercise Habits  
(and your clients)

# 1. INSPIRATION

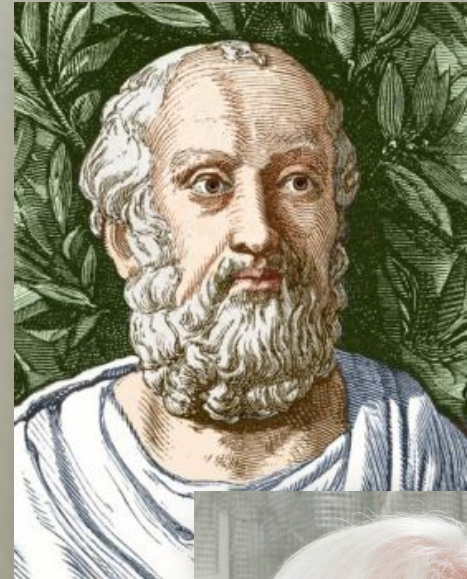
- Ratey, JJ. (2008). *Spark: The revolutionary new science of exercise and the brain*. NY, NY: Little Brown



# INSPIRATION

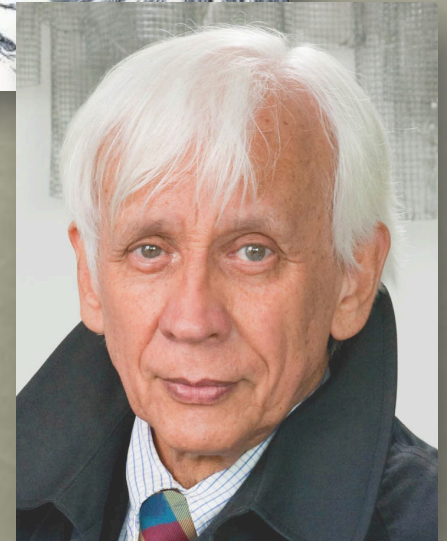
“In order for man to succeed in life, God provided him with two means, education and physical activity. Not separately, one for the soul and one for the body, but for the two together. With these two means man can attain perfection.”

- Plato



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

- Llinás



# 2. PHYSIOLOGY OF EXERCISE

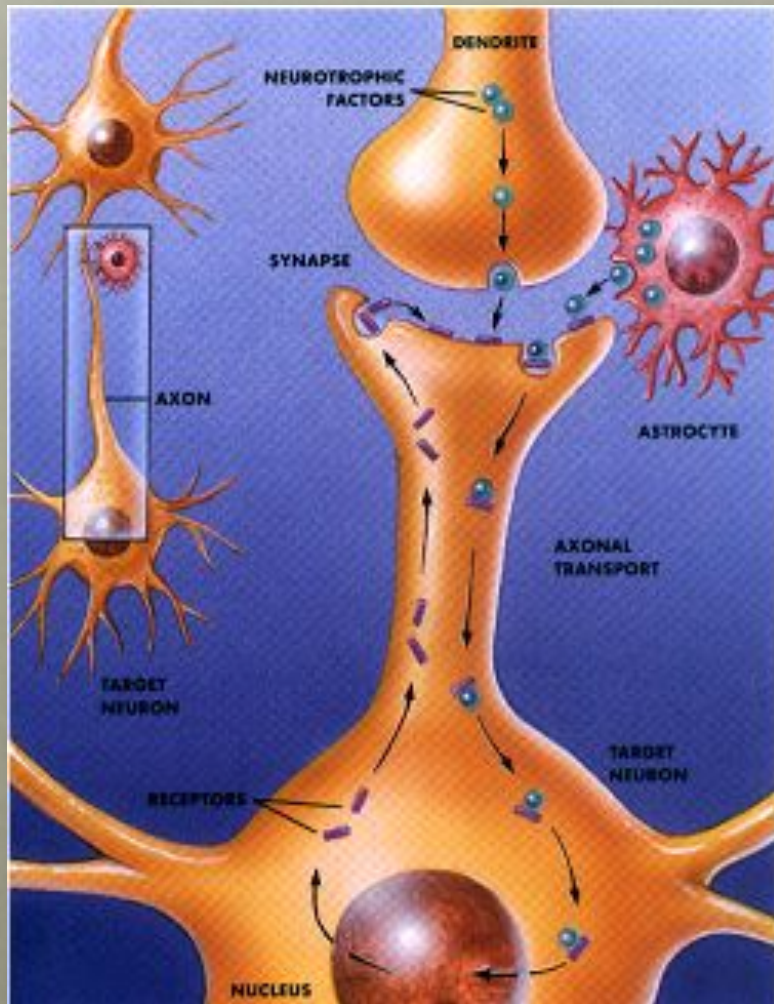


# MUSCLE MOVEMENT



- Without muscle movement, we don't need a brain (Llinás).
  - Example: Sea Squirt
- The cerebellum is intricately connected to the prefrontal cortex via basal ganglia
  - Automatic thinking and movement patterns are stored in the basal ganglia, cerebellum and brain stem
  - Thus, physical exercise invigorates mental exercise
- During exercise most factors cross the blood brain barrier and work in concert with BDNF

# GROWTH FACTORS



- When we move our muscles, they create peripheral and central proteins known as GROWTH FACTORS\*
- Physical activity leads to greater activation of cellular signaling pathways due to the growth factors, which is associated with cell survival, neurogenesis
- Largest concentration of this activity is found in the hippocampus (BDNF), which enhances hippocampal LTP induction.

\* Factors build and maintain brain circuitry

# GROWTH FACTORS

- Insulin-like Growth Factor (IGF-1)
  - Manufactured in liver when stimulated by human growth hormone
  - Essential for brain, liver and kidney health
  - Involved in all aspects of neurogenesis
  - Released by muscles when there is a need for more glucose
- Vascular Endothelial Growth Factor (VEGF)
  - Involved in vascular growth after injury (including from exercise)
  - Restores oxygen when depleted
  - May “relax” BBB during exercise so other important regenerative cells can reach the brain
- Fibroblast Growth Factor (FGF-2)
  - Involved in angiogenesis (formation of new blood vessels)
  - In body – helps tissues regenerate | In brain – involved with LTP
  - Low levels may be involved in anxiety

# BDNF

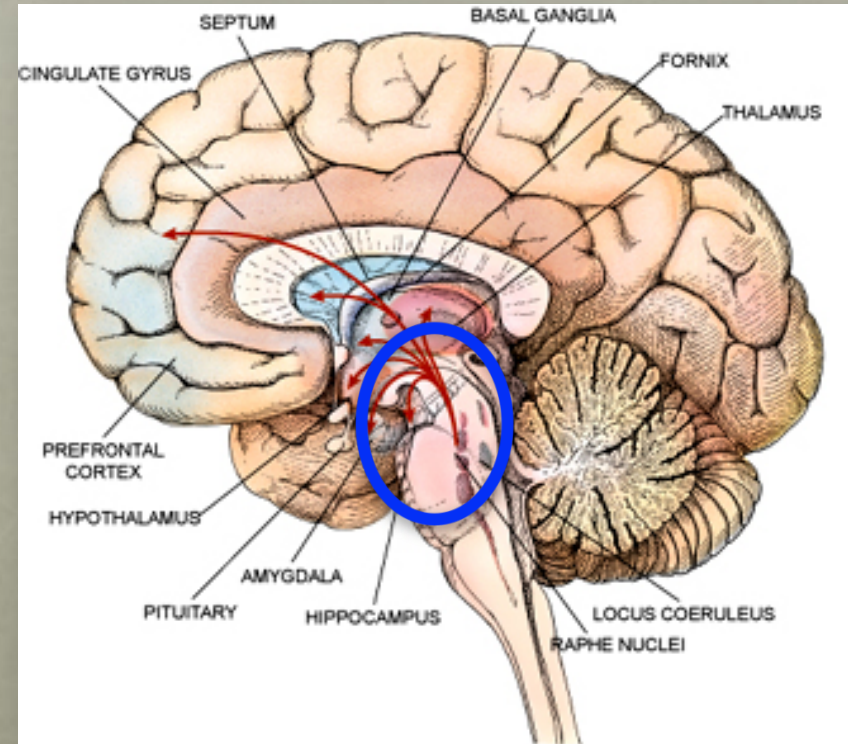
## BRAIN-DERIVED NEUROTROPIC FACTOR

- Considered neuron “fertilizer”
- The hippocampus is the control board for BDNF
  - Stimulating LTP increases BDNF expression in mice\*
  - Important in memory function, neuronal survival and differentiation during neurogenesis
- Experimental reductions in BDNF activity significantly impair LTP. BDNF is found near synapses throughout the brain, but highly concentrated in the hippocampus\*\*
- Brain damage recovery is faster in mice who are exercising
  - \*Cotman, CW. & Berchtold, NC. (2002). Exercise: a behavioral intervention to enhance brain health and plasticity. *Trends in Neuroscience*:25(6); 295-301. Showed that the increased BDNF levels from exercise were found in the hippocampus in mice.
  - \*\*Vayman, S., Ying, Z. & Gomez-Pinella, F. (2004). Hippocampal BDNF mediates the efficacy of exercise on synaptic plasticity and cognition. *Eur J neurosci*:20(10); 2580-90. Showed exercise enhanced memory-based cognitive function in mice using the water maze paradigm.

# BDNF

## BRAIN-DERIVED NEUROTROPIC FACTOR

- Too much of a good thing?
  - Exercise dramatically increases hippocampal BDNF levels and produces consistent behavioral effects.
  - However, BDNF plasticity renders the hippocampus more vulnerable to hyperexcitability and/or excitotoxic damage possibly causing seizure activity.
  - The neuropeptide **galanin**, produced in the locus coeruleus\*, modulates exercise-induced hippocampal hyperexcitability.



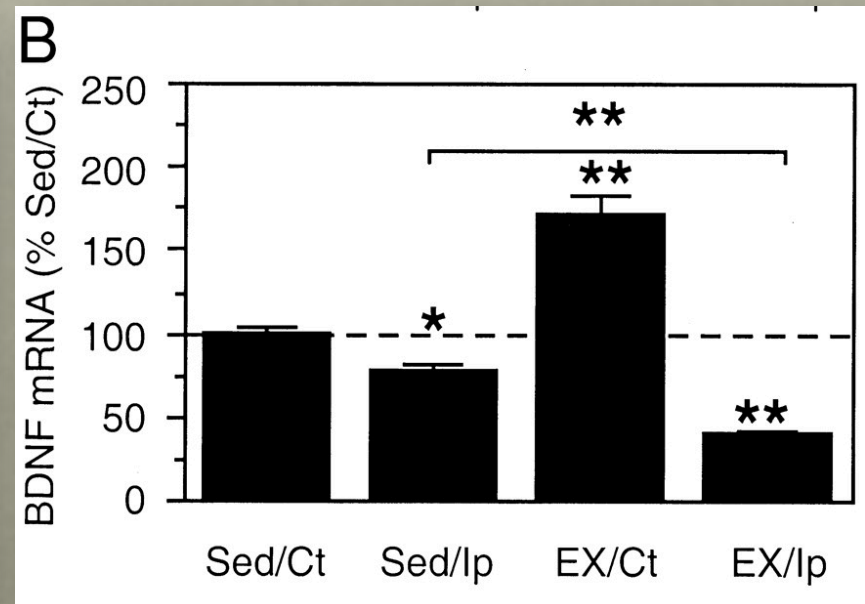
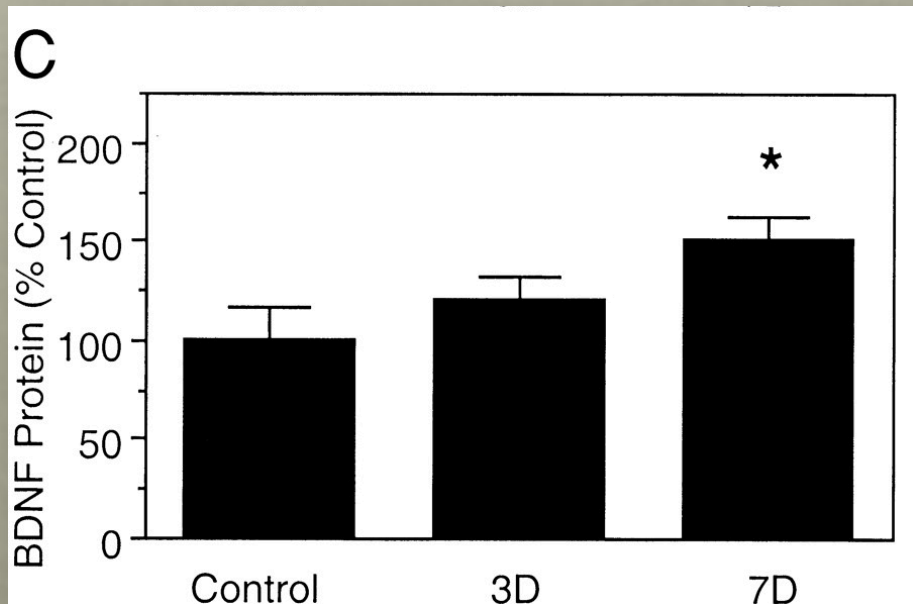
Murray, PS. & Holmes, PV. (2011) An Overview of Brain-Derived Neurotrophic Factor and Implications for Excitotoxic Vulnerability in the Hippocampus. International Journal of Peptides Volume 2011

\*An important homeostatic control center

# BDNF

## BRAIN-DERIVED NEUROTROPIC FACTOR

- “These results indicate that basal levels of neuromuscular activity are required to maintain normal levels of BDNF in the neuromuscular system and the potential for neuroplasticity”



- Gomez-Pinilla, F., Ying, Z., Roland, RR, et al (Voluntary Exercise Induces a BDNF-Mediated Mechanism That Promotes Neuroplasticity. *Journal of Neurophysiology* Published 1 November 2002 Vol. 88 no. 5, 2187-2195 DOI: 10.1152/jn.00152.2002



# RUNNER'S HIGH

- Running stimulates endorphin and endocannabinoid release
  - Endorphins are endogenous pain killers or analgesics (**endo**genous **mor**phine)
    - Produced in pituitary gland and hypothalamus
    - Expressed in periaqueductal gray (PAG)\* in reaction to pain, stress and/or fear
  - Endocannabinoids are natural THC
    - Created in every cell
    - Reaction to cortisol, which is spiked during exercise
    - Endocannabinoid levels are highest in the morning, and even more so after a good night's sleep (as is cortisol levels)
- **Hypofunction** (Dietrich, A. (2005). Transient hypofrontality as a mechanism for the psychological effects of exercise. *Psychiatry Research*:145(1), 79-83)

\*PAG is involved in efferent tracts through spinal cord to ANS to mediate pain

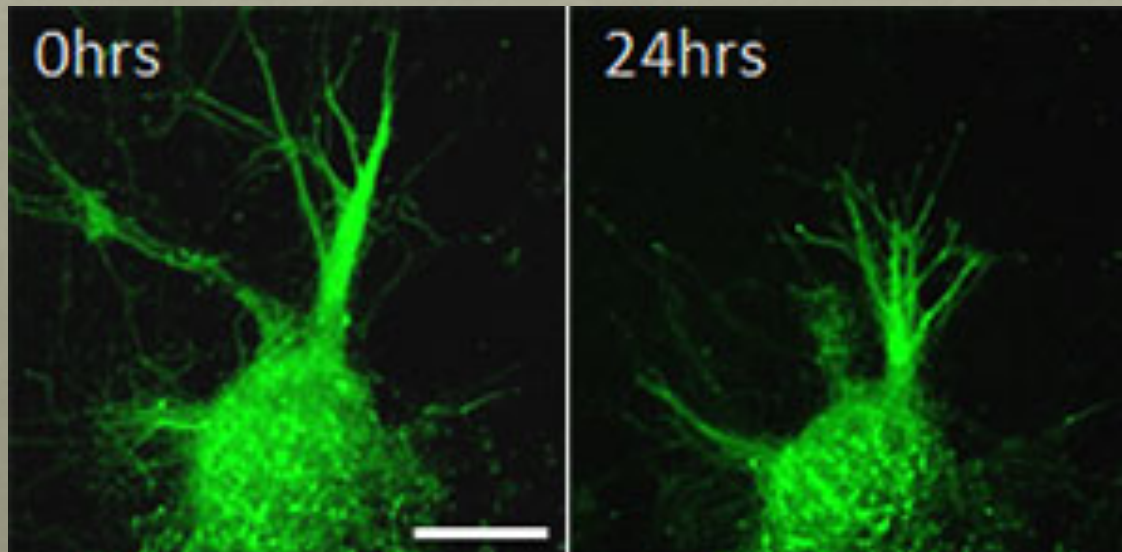
# LET'S NOT FORGET:

- Cells that fire together, wire together
  - 'A' becomes more efficient when firing to 'B' if 'B' is receptive
- OR
- Neurons that fire out of sync, lose their link
  - 'A' becomes less efficient and finds another group of neurons that are receptive



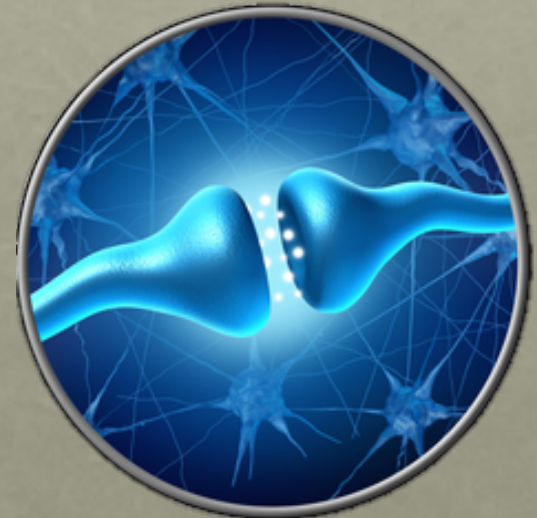
# AND ALSO:

- It takes approx. 28 days for a neuron to firmly connect to a network
- While exercise promotes neurogenesis, neurons that don't get connected will die off. Thus exercise and learning are important TOGETHER.



# NEUROTRANSMITTERS INVOLVED

- Neurons respond to “instructions” from growth factors to regulate the flow of information. Neurotransmitters targeted include:
  - Glutamate
    - Learning, memory
    - Involved in neurogenesis
    - Most prolific neurotransmitter and can cause damage when not regulated
  - Serotonin
    - Mood, impulsivity, anger, aggressiveness, happiness, circadian rhythm
    - Responsive to exercise
  - Norepinephrine
    - Mood, **attention**, perception, motivation, arousal, flight/fight
  - Dopamine
    - **Learning**, reward, motor control, movement, satiety
  - GABA
    - Calming (inhibitory neurotransmitter)
    - Motor control, vision, relaxation, focus



# HORMONES INVOLVED

- Endorphins
  - Exercise, pain, excitement, euphoria, sexual satiety, response to spicy foods and chocolate  
“Endogenous Morphine”
- Growth Hormone
  - The more you exercise, the more you excrete
  - The more often you exercise, the more you excrete
  - Indicated in muscle growth
- Testosterone
  - Muscle repair after exercise
- Thyroid Hormones
  - Convert amino acids while exercising
- Epinephrine
  - Quick increase in metabolism
- Insulin
  - Increases blood sugar levels after a workout

3.

# EXERCISE AND HOW IT EFFECTS COMMON PRESENTATIONS

- ✧ ADHD
- ✧ Autism
- ✧ TBI
- ✧ Stress
- ✧ Anxiety
- ✧ Depression
- ✧ Pain & Arthritis
- ✧ Aging
- ✧ Alzheimer's and Parkinson's
- ✧ Hypertension, CVD, Diabetes

# ADHD



- Prefrontal hypofunction
- Cerebellum exercises
- Interactive Metronome
- Increases BDNF, which has been shown to be reduced in ADHD
- There are deficits in the dopamine precursor *tyrosine hydroxylase* in ADHD. Exercise compares to methylphenidate in increasing dopamine

# AUTISM



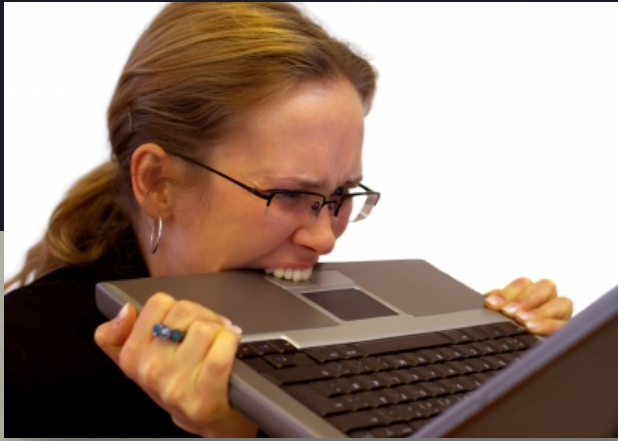
- BDNF is over-expressed in children with Autism, especially in basal forebrain.
  - Reportedly 3X as much
  - Children with autism tend to have larger brains
  - BDNF expression levels off in teen years
- Rigorous exercise reduces instances of rocking, spinning, hand-flapping, head nodding, and other stereotypic behaviors.

# TBI



- To be administered after a period of healing or it will interrupt the process
- Non-bouncing or sweat-inducing exercise may be best to start
- Exercise and virtual reality
- CIMT (constraint-induced movement therapy) and exercise increases motor agility and balance

# STRESS



- Increases dopamine
- Increases BDNF
- Increases cardio-vascular health
- Increases feelings of well-being and self-esteem
- Reduces oxidative-stress
- Shift of body fat concentration



# DEPRESSION

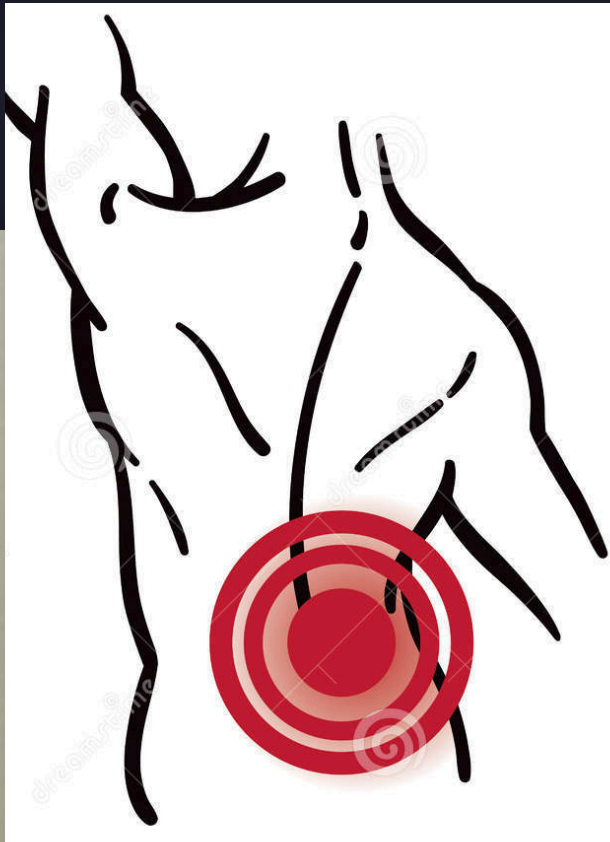
- Studies show the effect of exercise is equal to that of some antidepressants. And that antidepressants work faster than exercise. However, exercise effect lasts longer than medications.
- Monoamine hypothesis: long-term, adaptive changes to receptors of serotonin, dopamine and norepinephrine



# ANXIETY

- Regular exercise
- HPA effected
- Warmer bodies
- Benson's relaxation response
- When BDNF is activated, GABA is also activated
- Voluntary and forced exercise result in the same brain activations

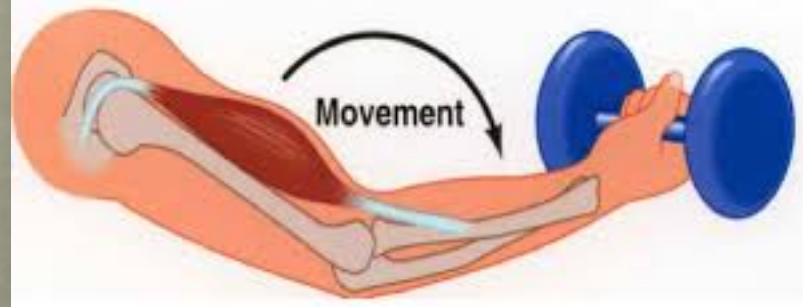
# PAIN & ARTHRITIS



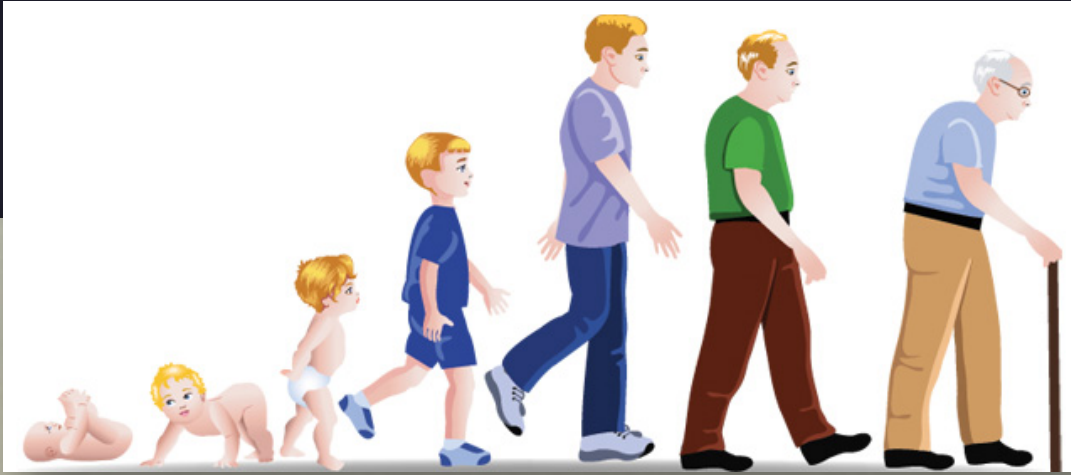
- Exercise releases endorphins, which reduce perception of pain
- Avoid DOMS (delayed onset muscle soreness) by avoiding “eccentric muscle contractions”

- Running downhill
- Lowering weights
- Lowering down your body

**Eccentric contraction**



# AGING



- Cotman study showed education, self-efficacy and exercise were the three factors that contributed to the least cognitive decline.
- Chronic inflammation and infection diminishes BDNF

# ALZHEIMER'S & PARKINSON'S



- 2015 study: BDNF deficit may be one cause of AD
- \*\*Exercise slowed the process of E4 gene expression and hippocampal shrinkage in AD
- Dancing, boxing, bike riding, Tai Chi have best effect on PD
- Better dopamine attachment to receptors

\*Zhang, L, Fang, Y, Lian, Y, et al (2015). Brain-derived neurotropic factor ameliorates learning deficits in a rat model of Alzheimer's disease induced by  $\beta$  1-42. *PlosOne*:10(4).

\*\* Smith, J, et al (2014). Physical activity reduces hippocampal atrophy in elders at genetic risk for Alzheimer's disease. *Frontiers in Aging Neuroscience*;Apr 23, 2014. doi: 10.3389/fnagi.2014.00061

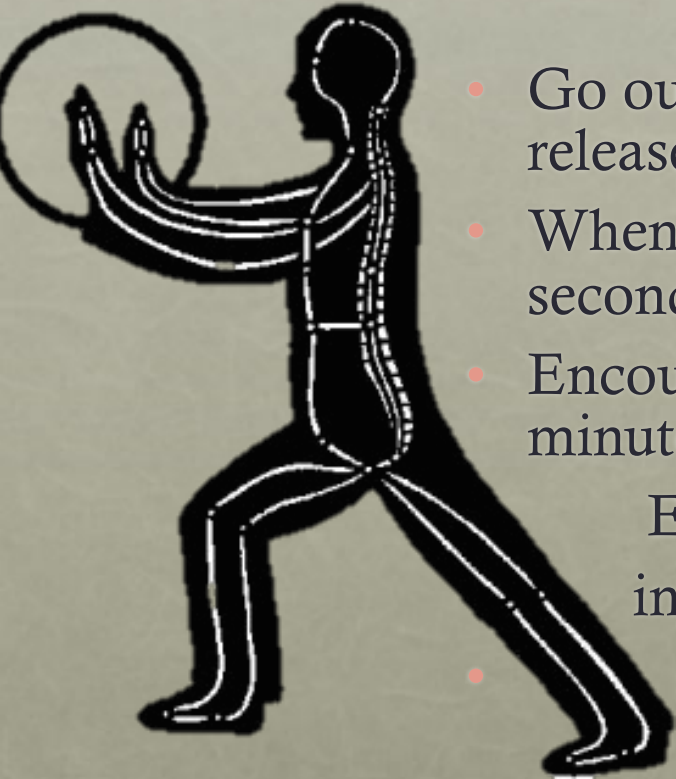
# HYPERTENSION, CVD, & DIABETES



- These diseases cause reduction in vascular supply, inflammation, which will lead to neurodegeneration because growth factors are inhibited.
- Galanin is released from the locus coeruleus to modulate exercise excitability and to facilitate glucose transport.
  - Insulin channels become more effective allowing glucose to move freely into muscles (be careful of hypo- or hyperglycemia)
  - Lag effect = low blood sugar after exercise

# 4. HOW THIS TALK SHOULD CHANGE YOUR EXERCISE HABITS

(AND YOUR CLIENTS')



- Go outside for lunch, even a 15 minute walk in the sun releases endorphins that increase brain activity
- When exercising, push yourself – sprint at least 20-30 seconds. Weight is relevant to time.
- Encourage your clients to go for a quick stroll for 10 minutes before starting their NFB sessions

Encourage exercise (along with sleep and diet improvements) while undergoing NFB

- Don't try to learn new things while exercising due to shunted blood from the prefrontal cortex
- More complex exercise (synchronized dance/Tai Chi/team sports) involve more complex networking

# 4. HOW THIS TALK SHOULD CHANGE YOUR EXERCISE HABITS

## (OXIDATIVE STRESS)

- An imbalance between the production of free radicals and the ability of the body to counteract or detoxify their harmful effects through neutralization by antioxidants.
- Free radicals stimulate production of endogenous antioxidants.
- Too much intense exercise can cause oxidative stress by resulting in more free radicals than can be combated.





**“What fits your busy schedule better, exercising one hour a day or being dead 24 hours a day?”**

# THANK YOU!



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