Meditation as a Modulator of Stress Effects on the Mind and Body

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Overview

I) Brief Review of Normal Structure and Function of Central Nervous System

II) Physiological Effects of Stress on the Mind and Body

III) Physiological Effects of Meditation on the Mind and Body

Brief Review of Normal Structure and Function of Central Nervous System

CNS Structure and Function

Structure – refers to “nuts and bolts” of the brain

Function – refers to inter/intra neuronal functioning

If we compare the brain to a computer, structure would refer to the hardware (computer, monitor, mouse, etc.) while function would refer to the software code while causes the computer to run smoothly

Really More of a Continuum (Sadock 2007, pg 70)

Neuron→Neuronal Network→Broadman Groups or Areas→Larger Structures→Whole Brain

*It is important to understand this continuum because changes at the neuronal level over time can actually effect change at a larger level (even whole brain volume)

Brain Structure
(Sadock 2007, pg. 86)

Broken Into 3 Major Groups:

1) Forebrain
2) Midbrain
3) Brainstem: Cranial nerves, vital centers (arousal, heart rate, origin of neurotransmitters), cranial nerves

Forebrain
(Sadock, 2007, pg 87, table 3.1-3)

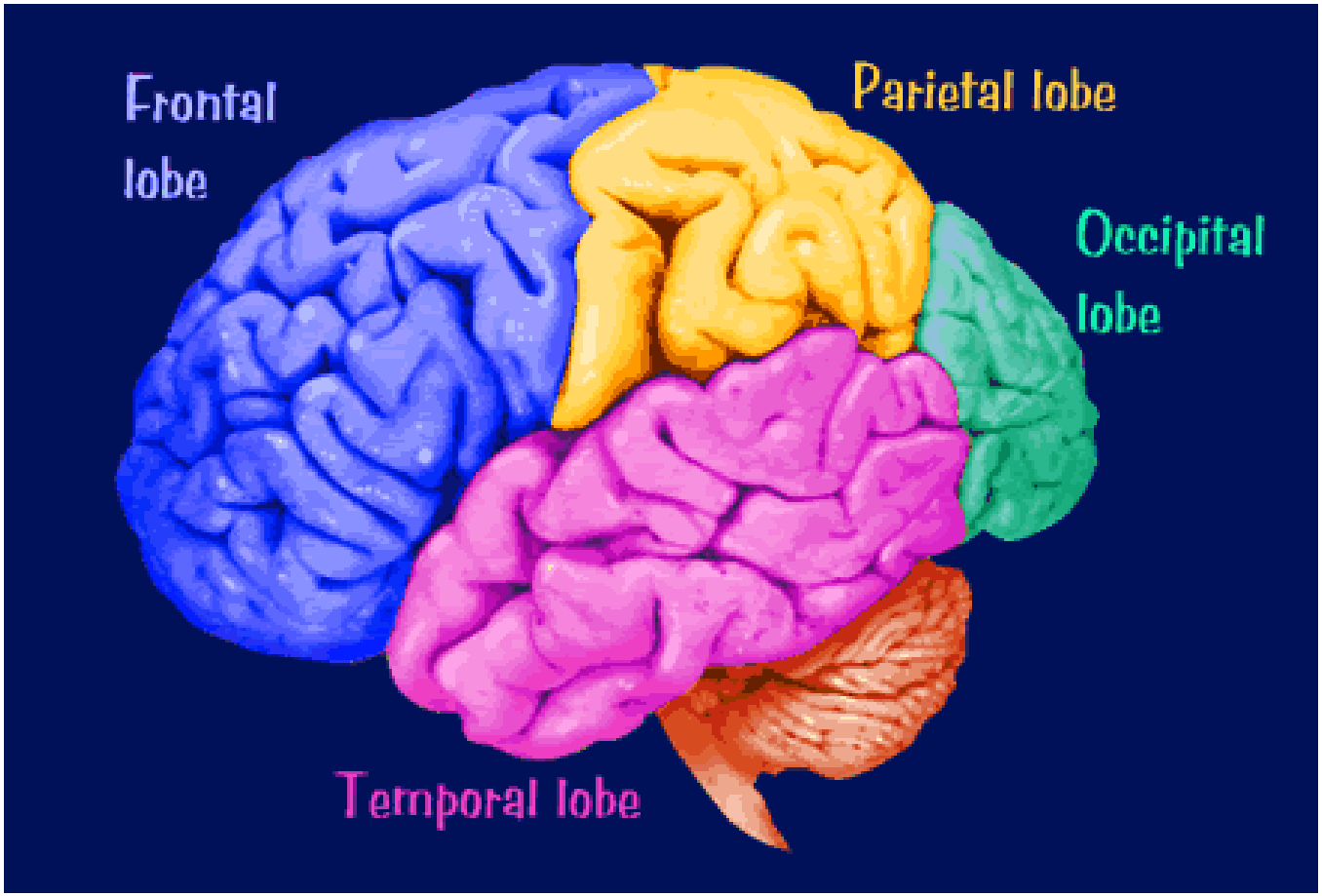
Telencephalon

- Cerebral Cortex
- Hippocampus
- Amygdala
- Striatum/Basal Ganglia

Diencephalon

- Thalamus
- Hypothalamus
- Epithalamus

Cerebral Cortex



http://psychlopedia.wikispaces.com/Cerebral+Cortex

Cortex (lobes)
(Sadock 2007, pg 85, table 3.1-1)

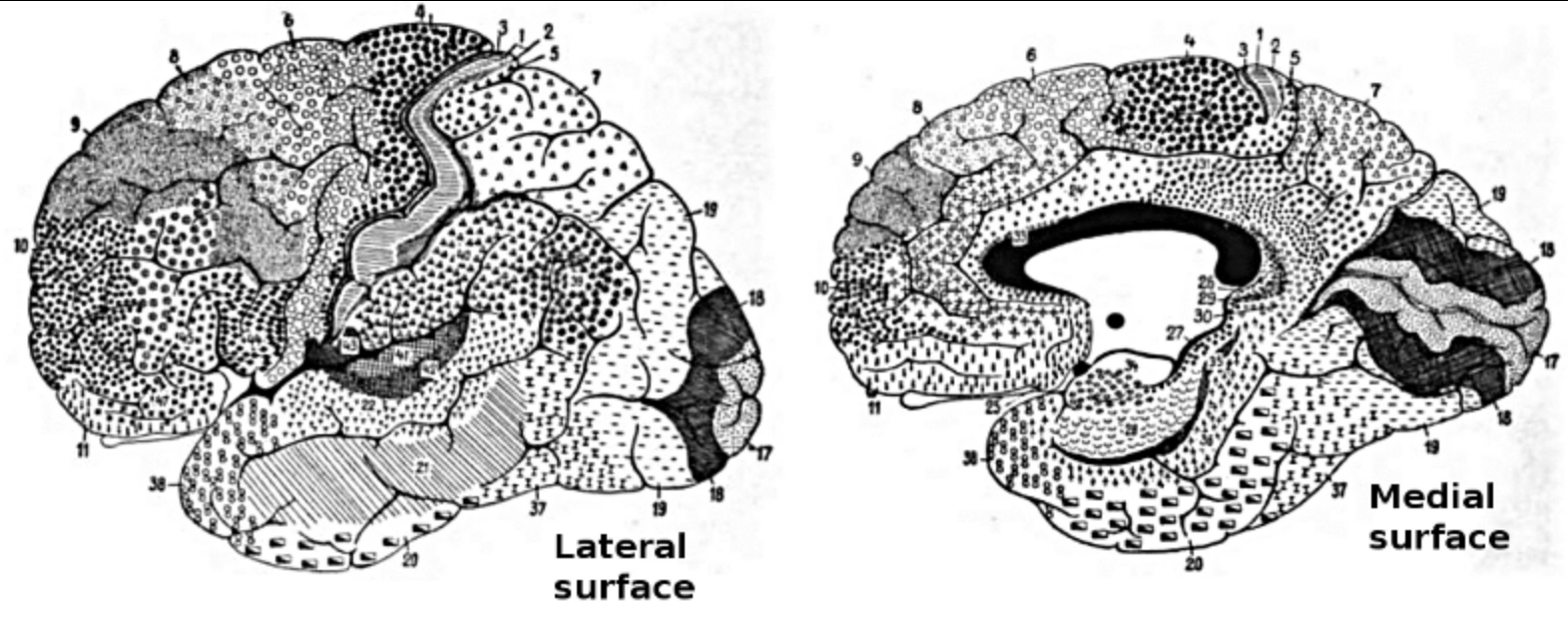
Frontal: language (left), movement (right), executive function, motivation, voluntary movement

Temporal: Audition, language (left), some memory and emotion given proximity to limbic system

Parietal: Tactile sensation, visuospatial (right), reading/calculation (left), sensory integration

Occipital: Vision

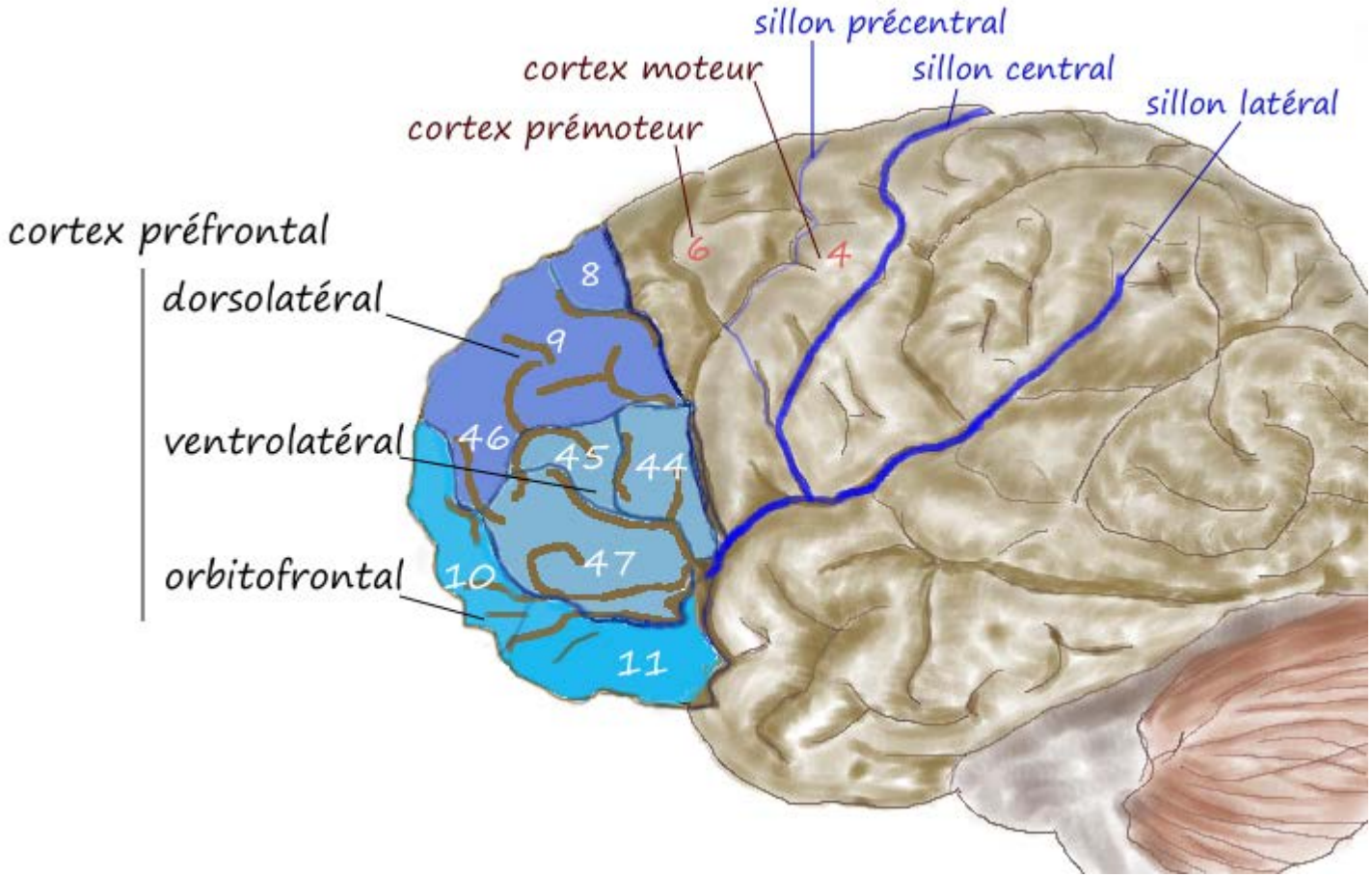
Cortex is also divided into 47 different broadman areas based on differences in cellular arrangements



Specialized Areas of Cortex (Sadock 2007 pg 90, Ngo 2013)

Prefrontal Cortex: anterior most portion of frontal lobe (many small divisions). Executive functioning, motivation, attention, sequencing of actions, planning. Can be involved in emotion regulation, cognitive re-evaluation, reconsolidation, and mental flexibility.

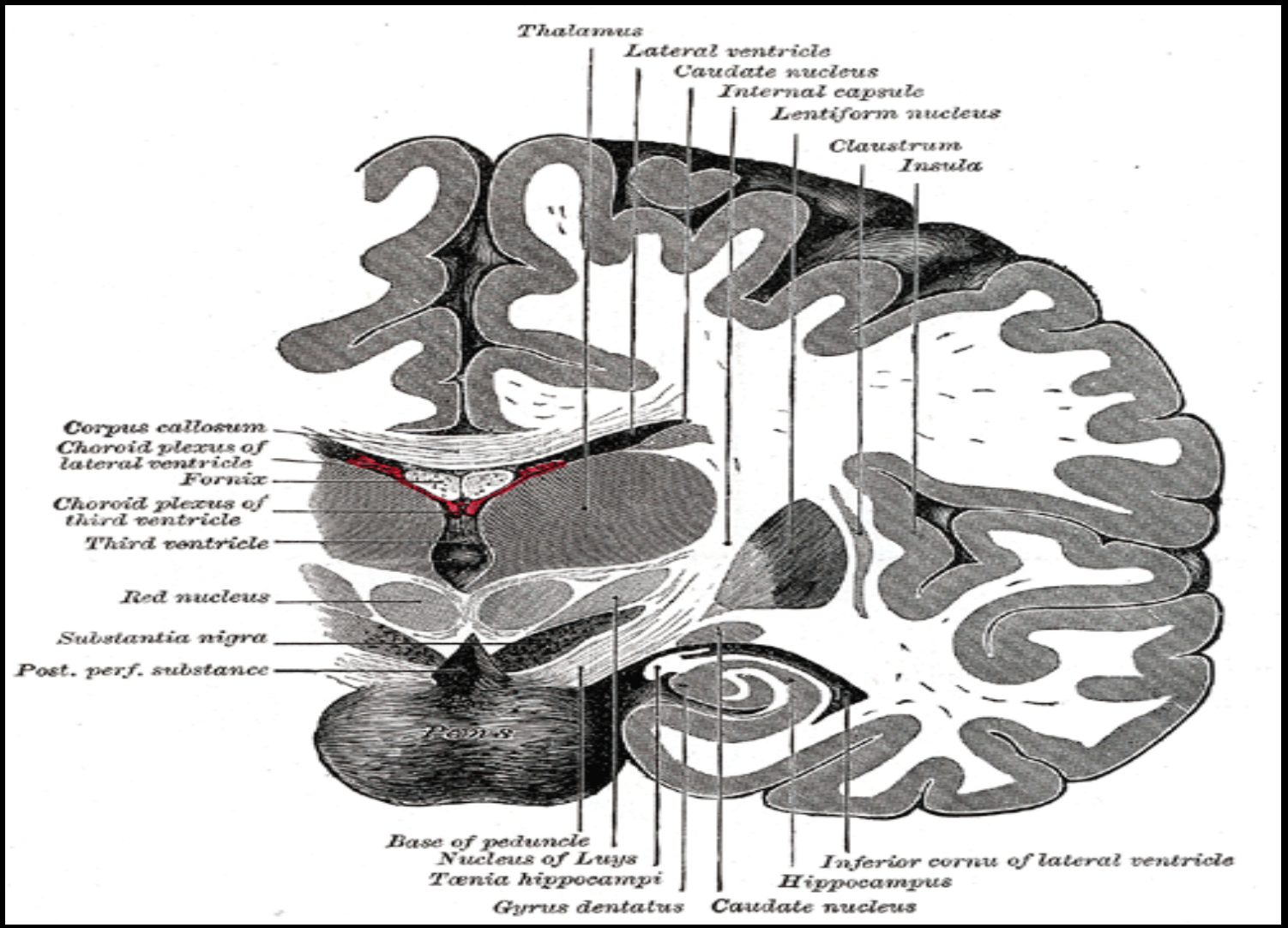
Prefrontal Cortex



http://en.wikipedia.org/wiki/Dorsolateral_prefrontal_cortex#mediaviewer/File:Prefrontal1.png. Courtesy of J'utilise *WK commons* pour mettre les illustrations dont j'ai besoin sur Wikipedia.

Specialized Areas of Cortex

Insular Cortex/Insula: Refers to deep cortex of the temporoparietal junction. Serves a role in body awareness, perception of visceral sensation, awareness of heart rate and respiratory rate, and response to pain (Ngo 2013)


Thalamus
Lateral ventricle
Caudate nucleus
Internal capsule
Lentiform nucleus
Claustrum
Insula
Corpus callosum
Choroid plexus of lateral ventricle
Fornix
Choroid plexus of third ventricle
Third ventricle
Red nucleus
Substantia nigra
Post. perf. substance
Pons
Base of peduncle
Nucleus of Luys
Tænia hippocampi
Gyrus dentatus
Caudate nucleus
Inferior cornu of lateral ventricle
Hippocampus

Forebrain
(Sadock 2007 pg. 89)

"Top" – Cerebral Cortex

"Bottom" –

Basal Ganglia (modulation of movement)
Limbic System/Cingulate Cortex

Limbic System/Cingulate Cortex (Ngo 2013)

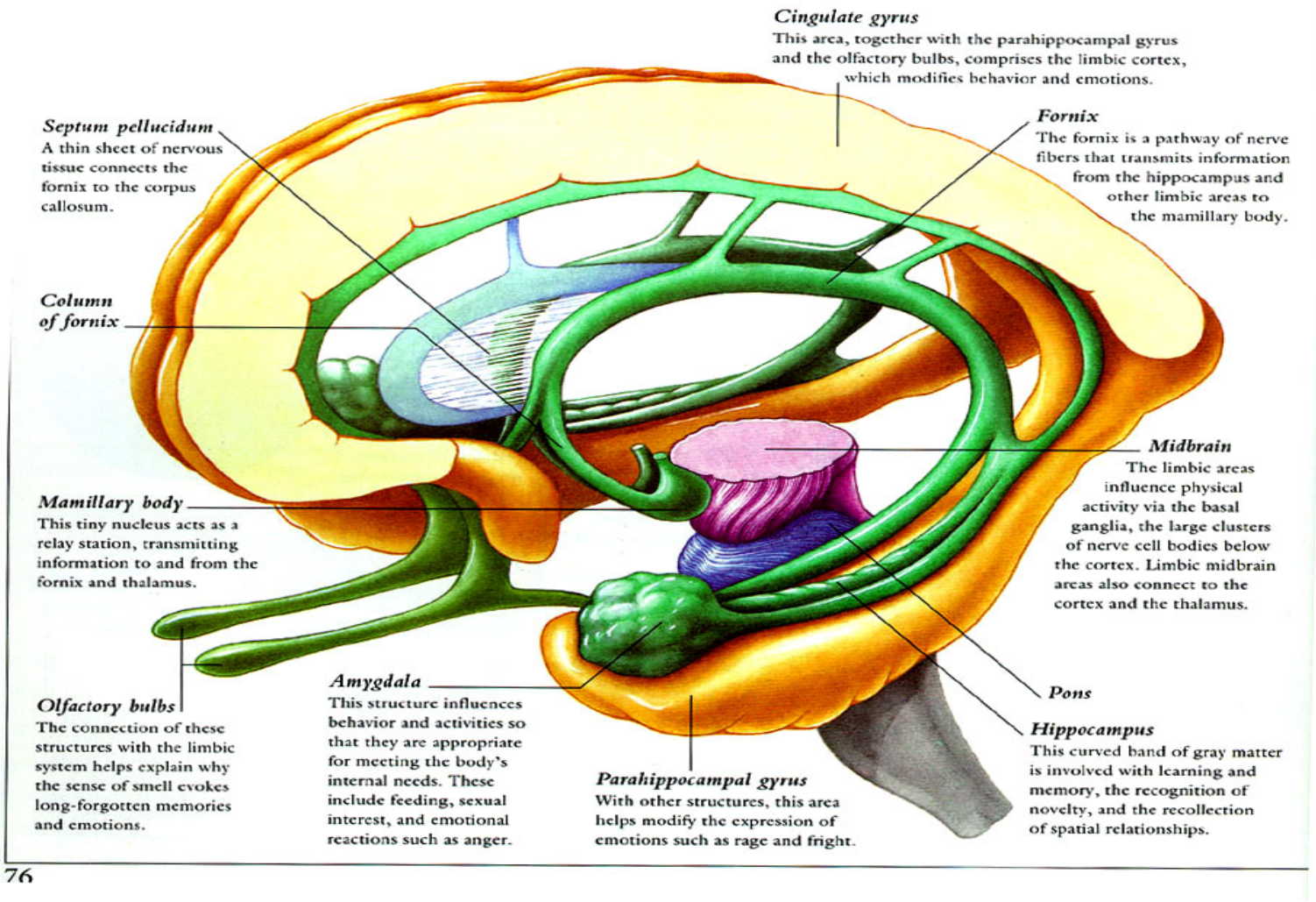
Limbic system

- Amygdala: Emotion Processing
- Hippocampus: Memory Processing

Cingulate Cortex: Known as “limbic cortex”

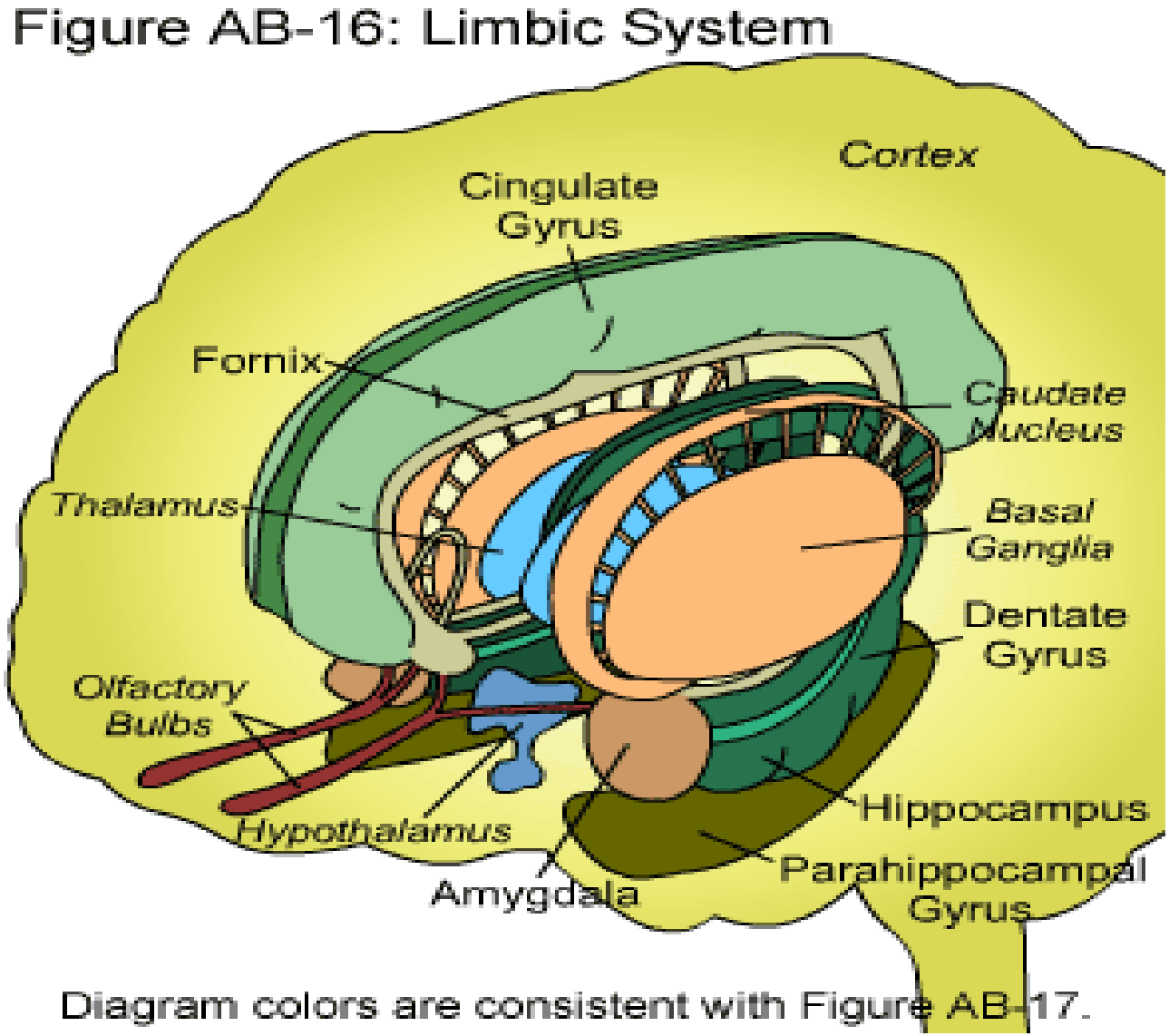
- Anterior Cingulate: Attention
- Posterior Cingulate: Understanding Context

Limbic System/Cingulate Cortex



http://163.178.103.176/Fisiologia/neurofisiologia/Objetivo_9/brain.html

Limbic System/Cingulate Cortex



http://education-portal.com/academy/lesson/what-is-the-limbic-system-in-the-brain-definition-functions-parts.html#lesson

Forebrain
(Sadock, 2007, pg 87, table 3.1-3)

Telencephalon

- Cerebral Cortex
- Hippocampus
- Amygdala
- Striatum/Basal Ganglia

Diencephalon

- Thalamus: relays sensory and motor signals/ information to cortex (Sherman 2000)
- Hypothalamus
- Epithalamus

Hypothalamus (Sadock 2007, pg 121)

Releases a multitude of hormones, including:

Corticotropin Releasing Hormone (CRH)

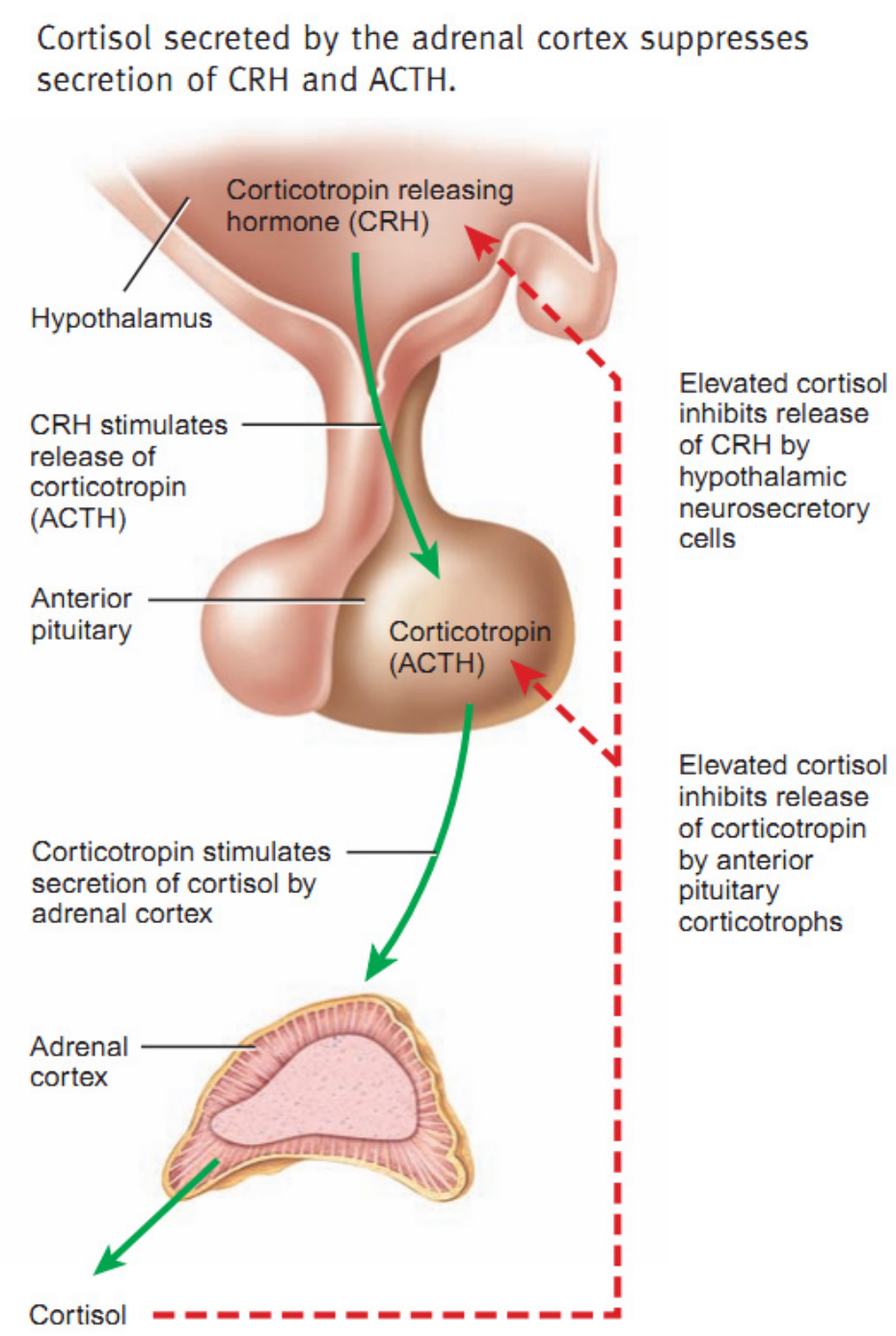
Adrenocorticotropic Hormone (ACTH)

Thyrotropin-Releasing Hormone (TRH) → Thyroid Stimulating Hormone (TSH)

Gonadotropin-Releasing Hormone (GnRH) → Luteinizing hormone (LH) and Follicle-Stimulating Hormone (FSH)

Growth Hormone Releasing Hormone (GHRH) → Growth Hormone (GH)

Typical Hypothalamic Feedback Loop



http://antranik.org/adrenocorticotropin-hormone-acth-including-cortisol/

Major Neurotransmitters (NTs) (Sadock 2007, pgs 100-109)

Dopamine: cardiac, movement, breast feeding (Schizophrenia)

Norepinephrine/Epinephrine: sympathetic, focus (anxiety, depression)

Serotonin: gut (anxiety, depression)

Histamine: allergy/inflammation, sedation, weight gain

Acetylcholine: movement, parasympathetic (anticholinergic toxicity)

Gamma-Aminobutyric Acid (GABA): major inhibitory NT

Glutamate: major excitatory NT

Physiological Effects of Stress on the Body

Stress

What does stress even mean?

Broadly defined as:

Physical/Pain

Grief or Loss

Mental Illness (Depression, Schizophrenia)

Early Childhood Adversity/Trauma

Largely defined as when demands in life outweigh our ability to cope with them

Stress and Pain

Pain is an incredibly complex phenomenon.

The way we perceive pain is multifactorial, from the objective cellular level (automatic reflexes) all the way to the very subjective emotional level

Even our cellular understanding of pain isn't complete. Why would a serotonergic medication help treat pain if in theory the only receptors for pain are opioid?

Goal with Stress and Pain

Much like with pain, our goal with stress is to help explain its relationship to the body and to then work towards learning to accept it and adjust ourselves to function with both stress and pain

A completely stress-free world is a fantasy. However, how we choose to respond to the stress in this world may make all the difference.

PsychoNeuroEndocrinology (Sadock 2007 pgs 122-125)

Hypothalamic-Pituitary-Adrenal Axis:

High levels of stress cause increased CRH, ACTH, and cortisol levels. Over time this leads to reduced hippocampal size and enlarged adrenal glands. Chronic hypercortisolemia results in reduced immune function.

Can lead to chronic fatigue, social withdrawal, impaired sleep, and decreased concentration. Can also lead to mood disturbance. Seen in anxiety and PTSD.

PsychoNeuroEndocrinology (Toufexis et al, 2014)

Hypothalamic-Pituitary-Gonadal Axis:

High cortisol levels, especially over time, also appear to inhibit testosterone and estrogen secretion

Testosterone: mood, energy, strength, sperm production

Estrogen: mood, libido, sense of well-being, fertility

Both of these hormones can impact the size of the hypothalamic nuclei and corpus callosum, the neuronal density in the temporal cortex, the organization of language ability, and the responsivity in Broca's motor speech area

PsychoNeuroEndocrinology (Ongphiphadhanakul 1994)

Hypothalamic-Pituitary-Thyroid Axis:

Stress has also been shown to decrease conversion of T4 to T3, which means you have less active thyroid hormone circulating in your body

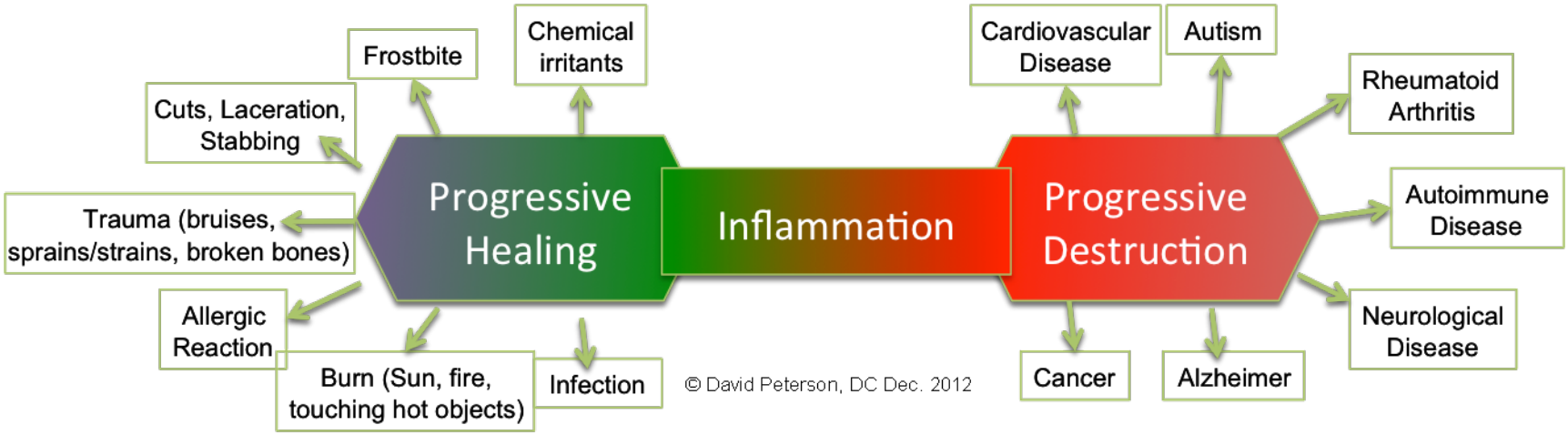
Signs of hypothyroidism include: fatigue, decreased libido, memory impairment, irritability, and depression

PsychoNeuroEndocrinology (Sadock 2007 pgs 122-125)

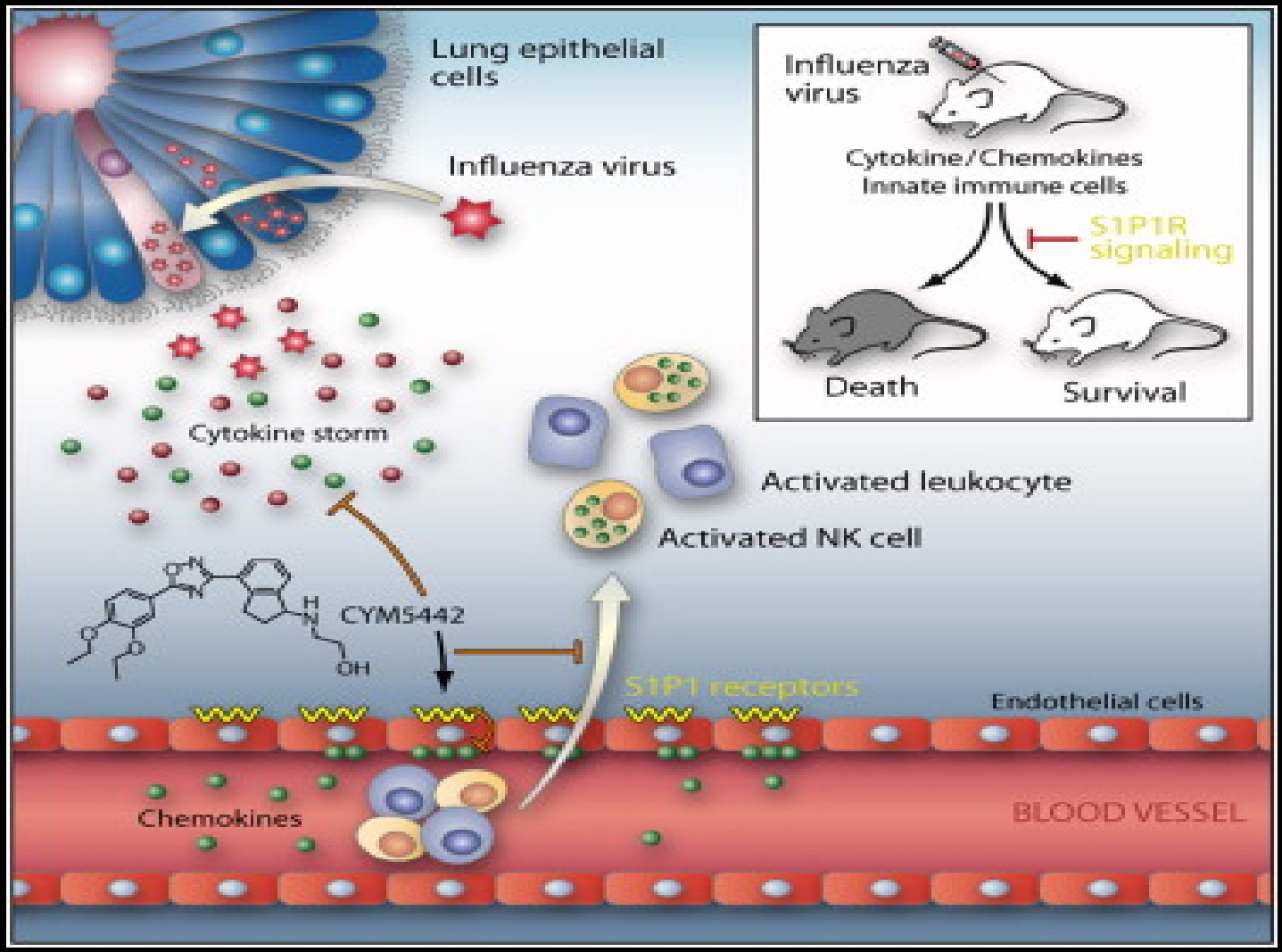
Severe psychosocial stress can cause growth hormone deficiency and delay puberty, and this can be severe enough to result in significant short adult stature

Children with Growth Hormone Deficiency see improved cognitive functioning when growth hormone is supplemented

INFLAMMATION



http://livingwellnessblog.wordpress.com/2012/12/11/inflammation-where-there-is-smoke-there-is-fire/



http://www.cell.com/abstract/S0092-8674(11)00941-X

PsychoNeuroImmunology (Sadock 2007, pgs 125-126)

Numerous effects of stress on immunology (cortisol known to cause immunosuppression)

One study assessed medical students prior to examination and during final examination. Examination stress resulted in less natural killer T cell activity, decreased numbers of T cells, and decreased interferon production.

PsychoNeuroImmunology (Sadock 2007, pgs 125-126)

Caregivers of people with chronic illnesses have been found to have impaired antibody responses, more days of illness, and longer latency for wound healing

HIV patients who rate severe stress experience lower CD*+ T Cell numbers and lower natural killer cell counts

PsychoNeuroImmunology (Sadock 2007, pgs 125-126)

Mental Illness:

Schizophrenia: increased interferon (helps generate immune response), lower interleukin-2 (pro-inflammatory).

Depression: increased proinflammatory interleukin-1 and interleukin-6, increased CRP.

Chronic Fatigue Syndrome: alternating overactive immune activation and suppression

PsychoNeuroImmunology (Sadock 2007, pgs 125-126)

TAKE HOME: Stress simultaneously

1) Creates chronic, low level inflammation in the body which promotes systemic inflammation (linked to cancer, heart disease, autoimmune conditions, and depression)

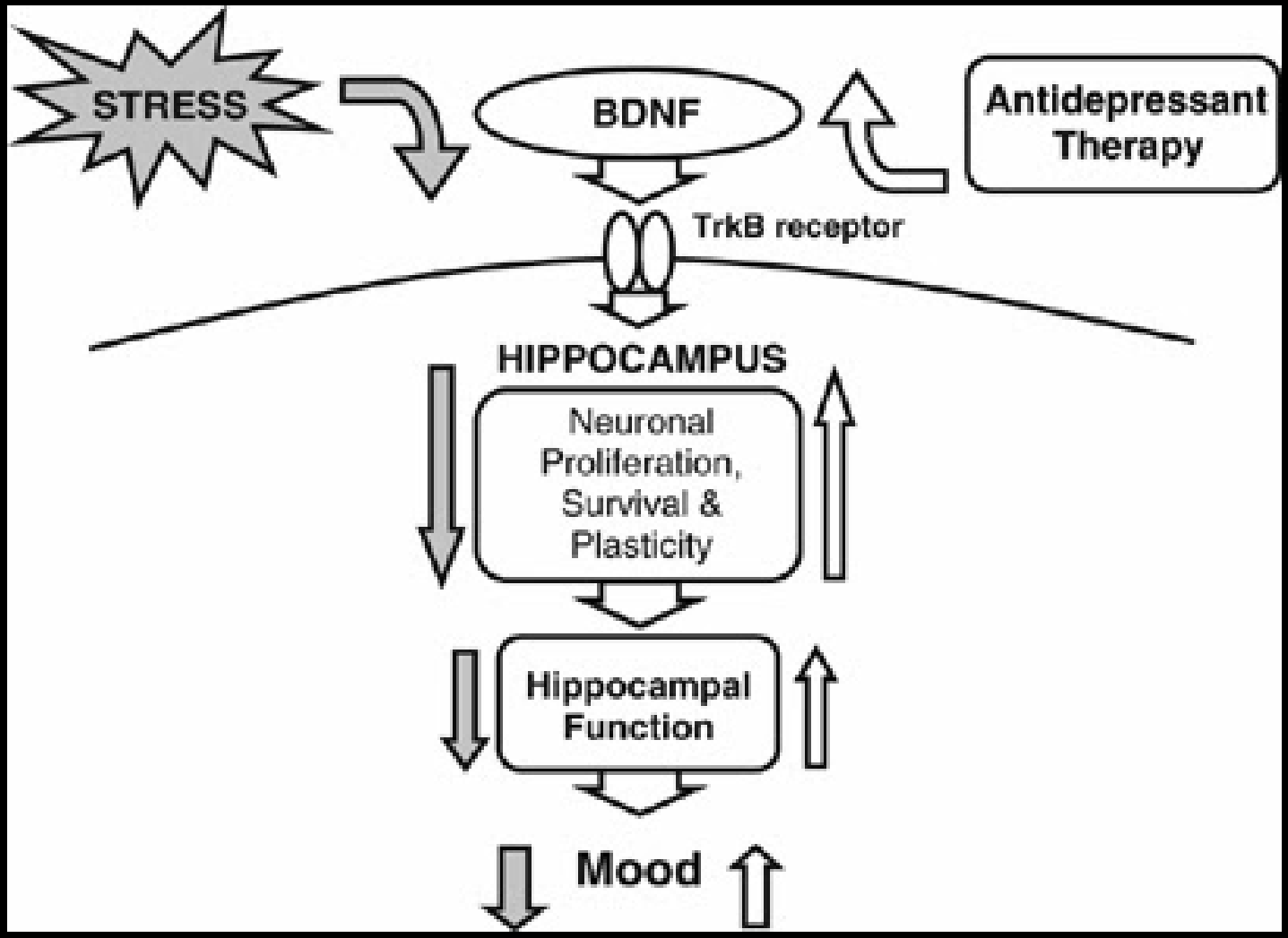
AND

2) Suppresses acute inflammation needed to fight off infections

Physiological Effects of Stress on the Brain

Effects of Hypercortisolemia (Issa 2010, Gray 2013)

- Chronic elevated levels of cortisol in the cerebral vasculature and CSF
- Reduced level of Brain-Derived Neurotrophic Factor (BDNF)
- Decreased volume of hippocampus



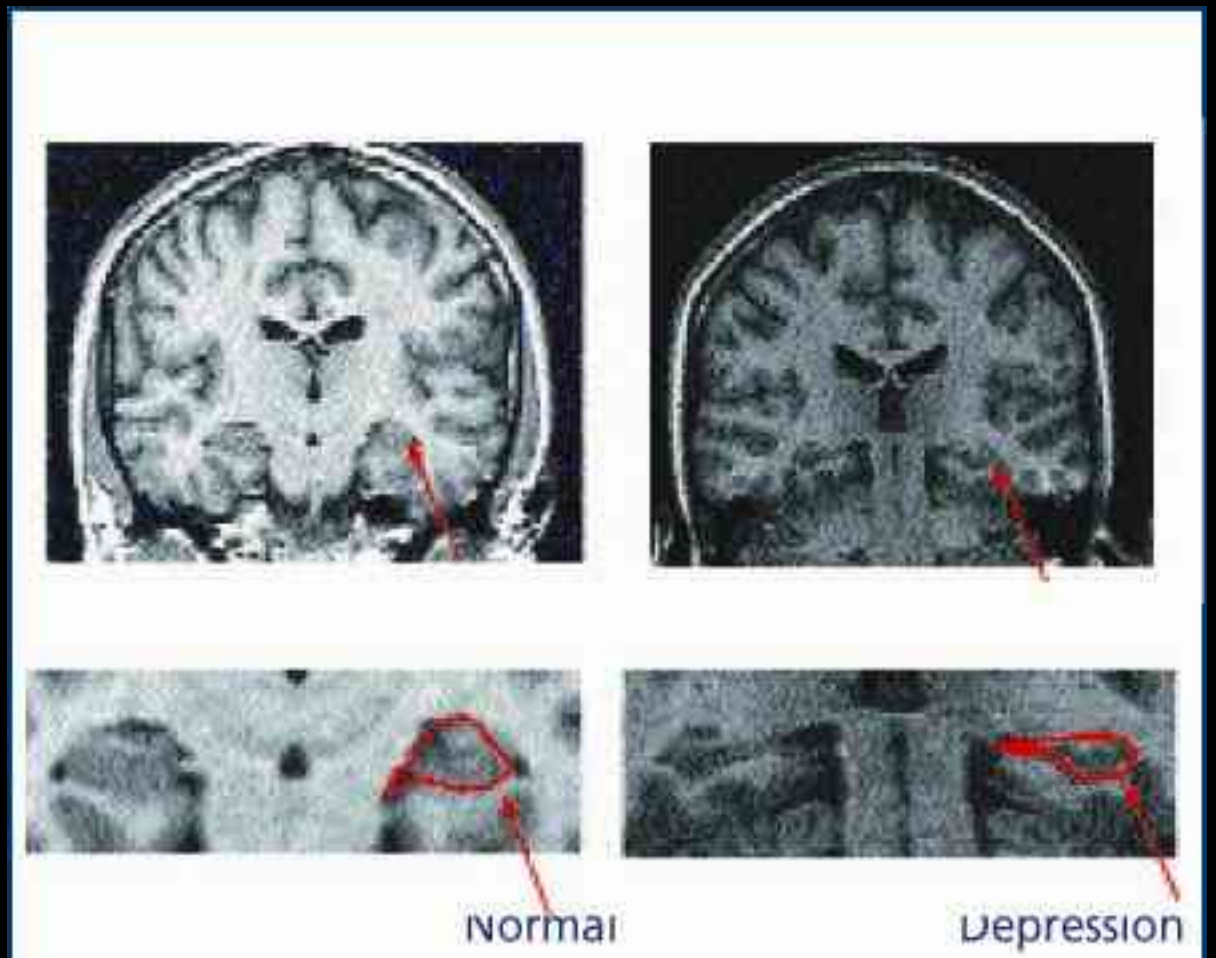


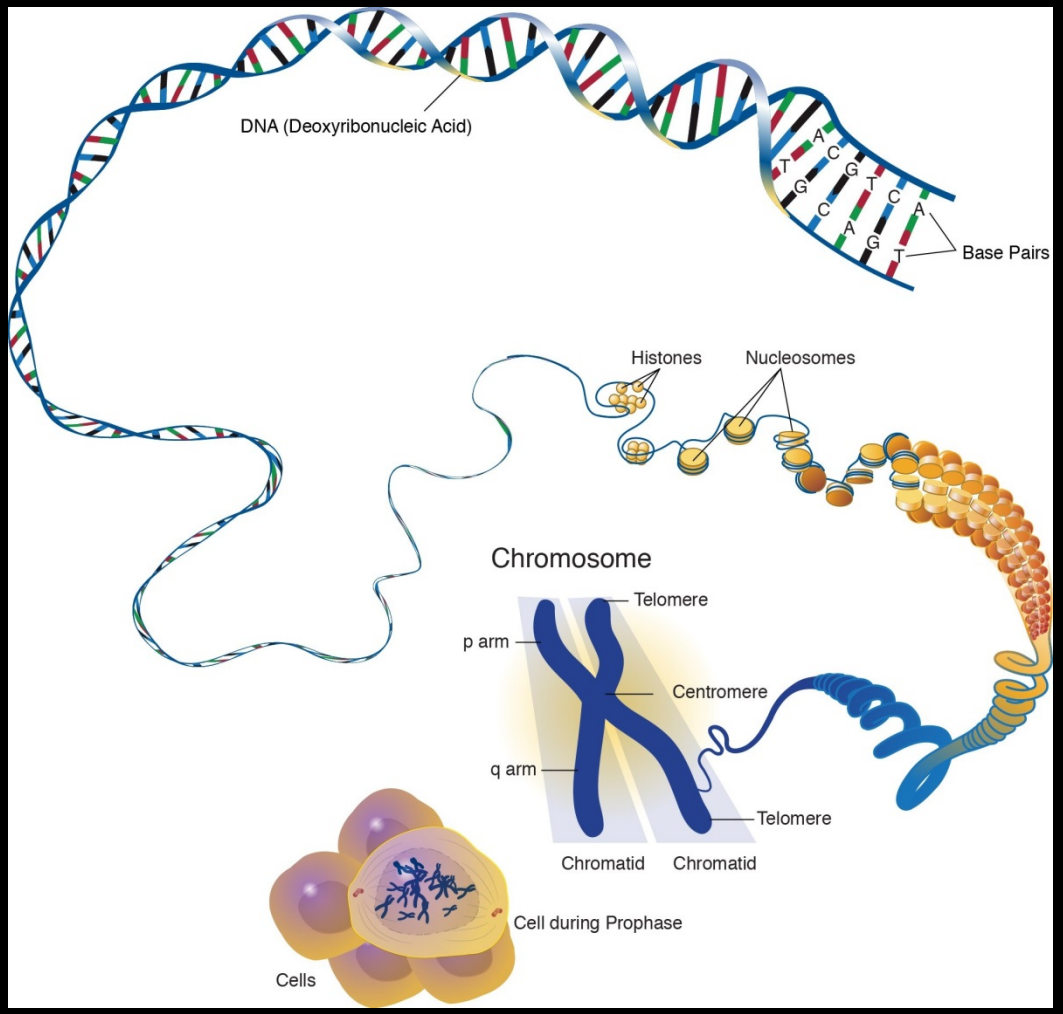
FIGURE 1. Atrophy of the hippocampus in depression.

Bremner JD. *CNS Spectrums.* Vol 7, No 2. 2002.

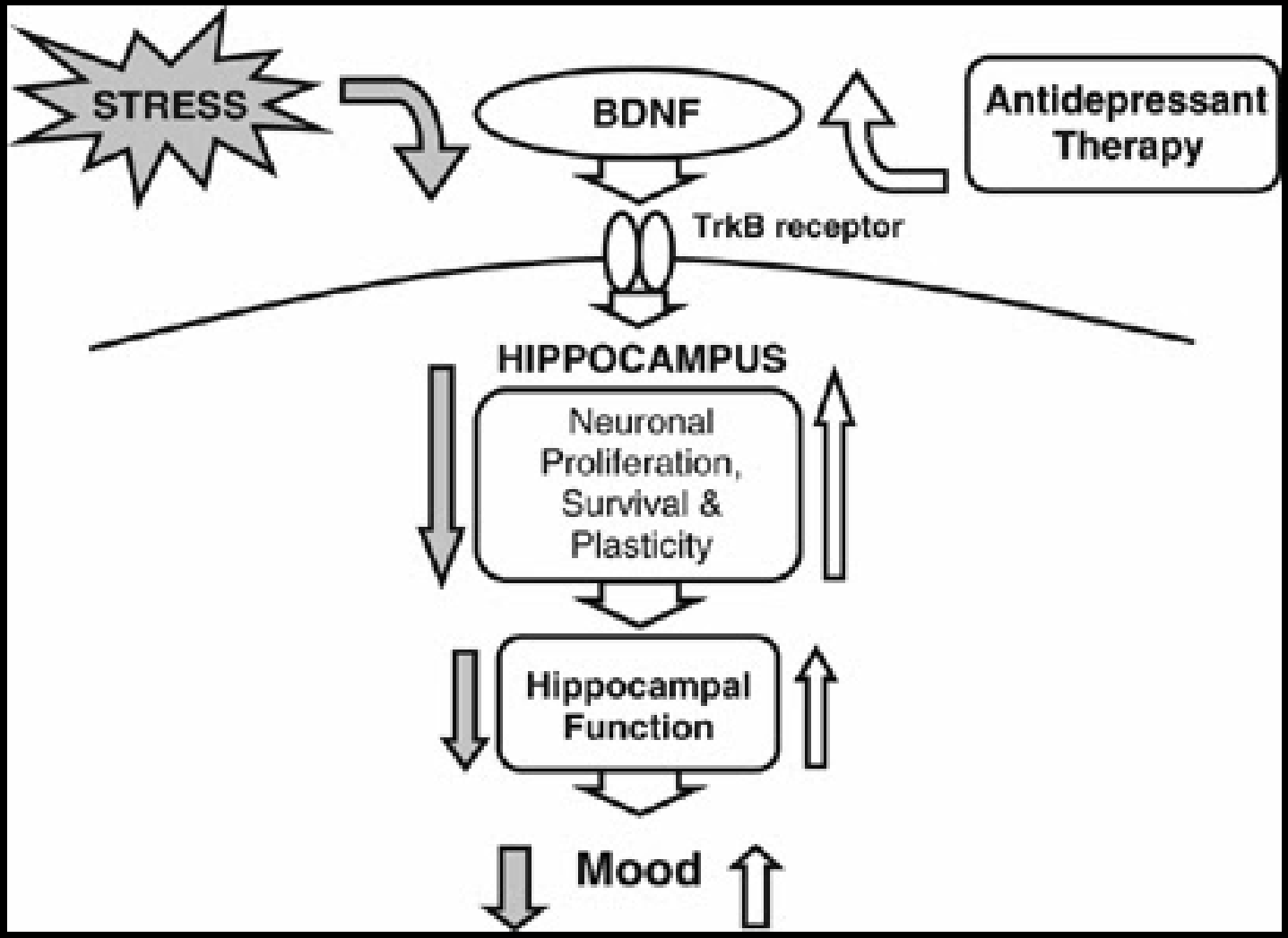
Chronic Stress Effects on CNS Structures

Structure	Effect of Stress	Source
Prefrontal Cortex	Decreased OFC activity	Dedovic 2009
Cingulate Cortex	Decreased ACC volume	Meng 2014 Baldacara 2014
Amygdala	Decreased volume	Hanson 2014, Stratmann 2014
Hippocampus	Decreased volume (GM) Deactivity	Issa 2010, Gray 2013, Dedovic 2009
Temporo-Parietal Junction Insula	Decreased volume	Stratmann 2014, Meng 2014

“Activation” refers to increased blood flow and/or increased metabolism

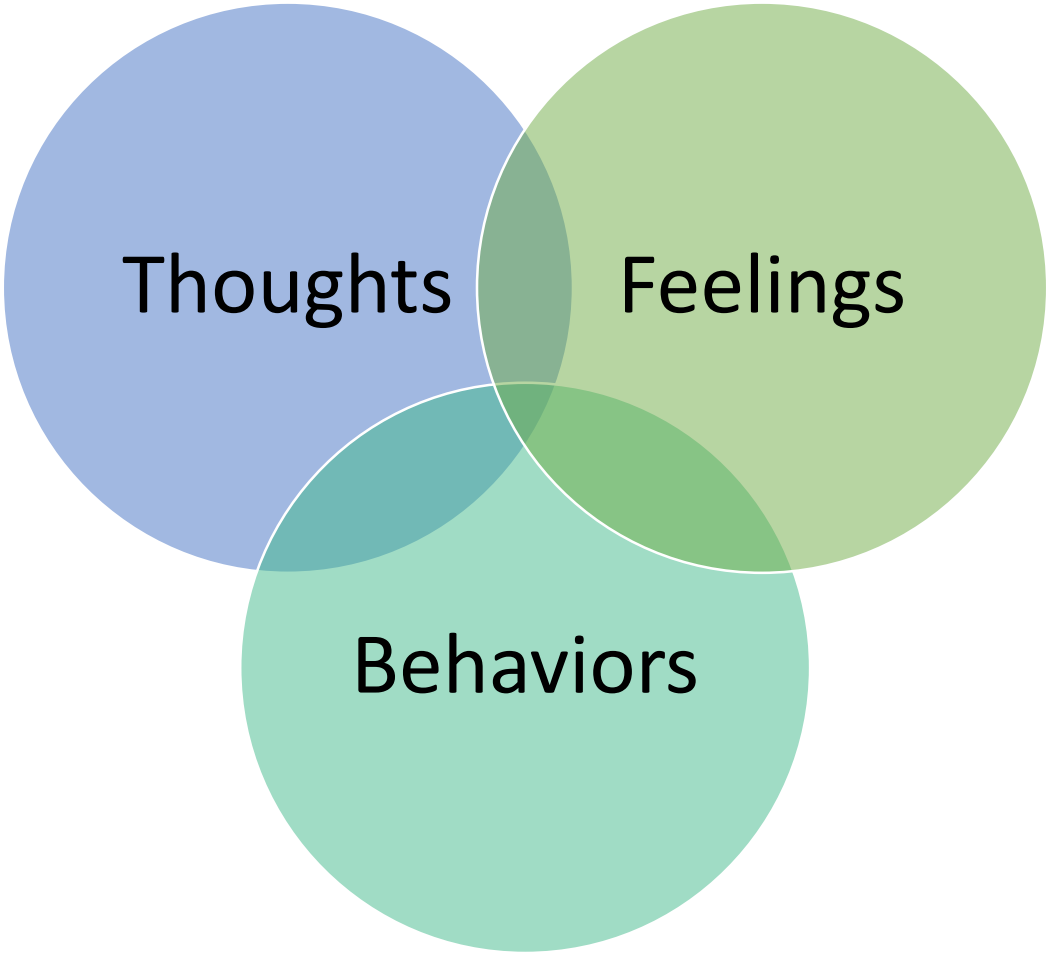

DNA (Deoxyribonucleic Acid)
Base Pairs
Histones
Nucleosomes
Chromosome
Telomere
p arm
Centromere
q arm
Telomere
Chromatid
Chromatid
Cell during Prophase
Cells

Physiological Effects of Meditation on the Mind and Body



Cognitive Behavioral Therapy

Sadock, 2007, pgs. 953-961



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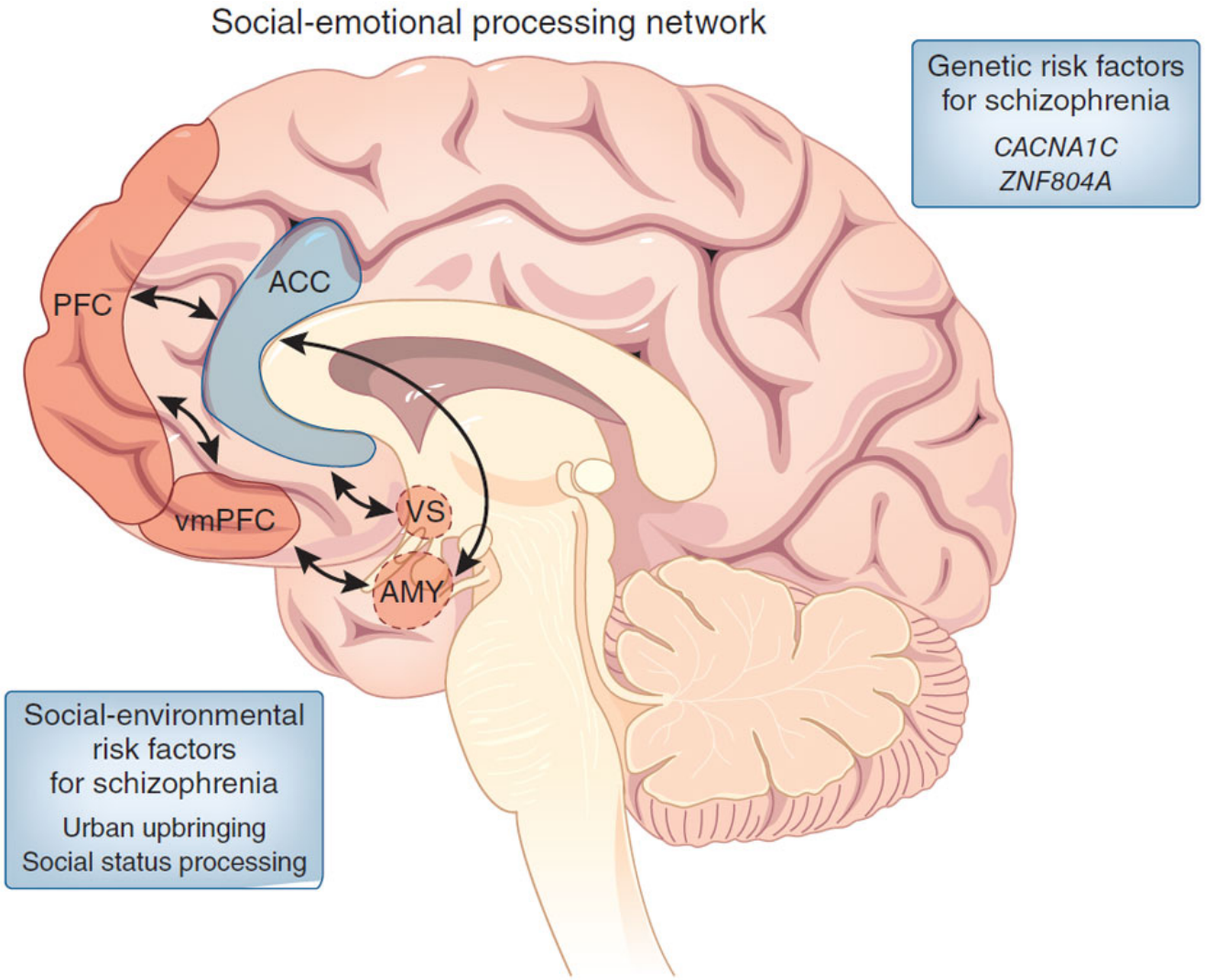
Prefrontal Cortex "Top-Down" Control Over Amygdala (Kumar 2014)



http://www.nature.com/nm/journal/v18/n2/fig_tab/nm.2671_F1.htm

Benefits of Meditation for the Brain

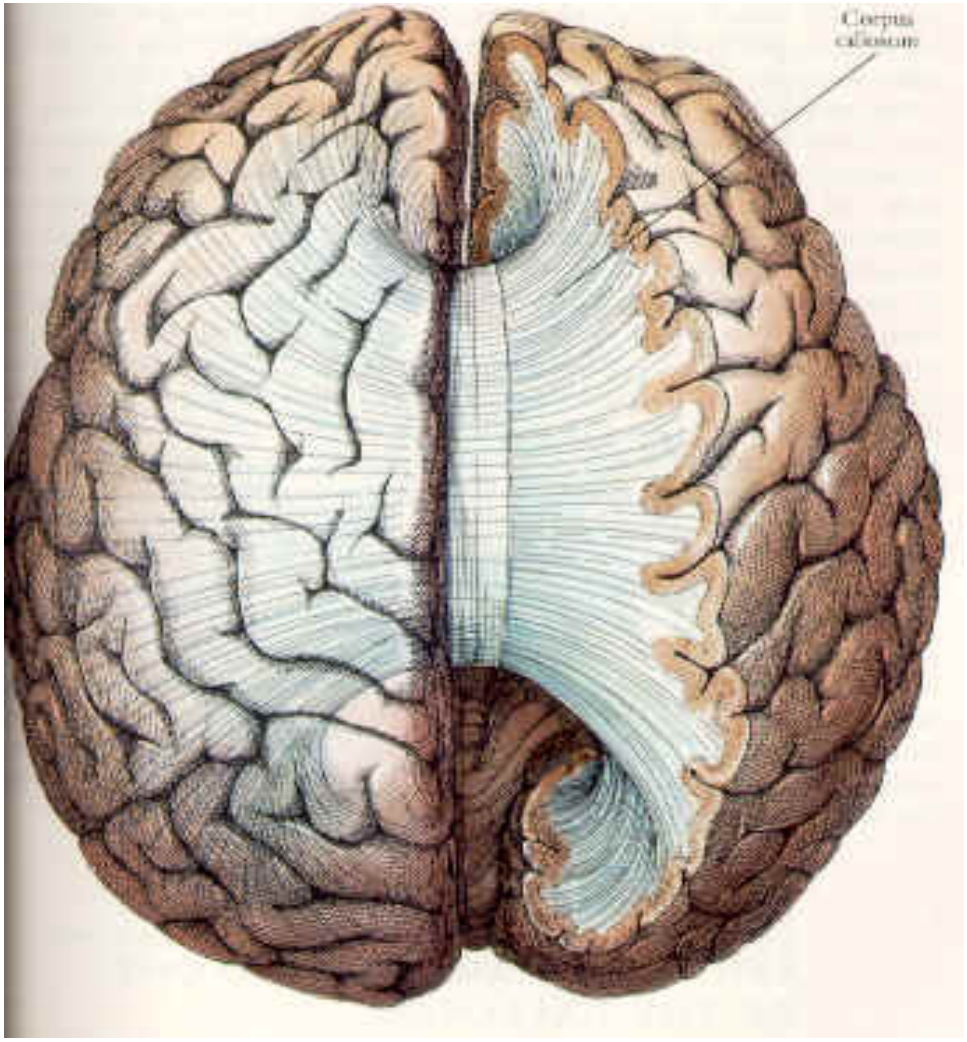
Simultaneously providing both “top-down” and “bottom-up” rewiring of the brain (comprehensive total brain exercise)

“Top-Down” by concentrating and focusing very hard while attempting to minimize impulses from lower brain

“Bottom-Up” by increasing our awareness of our body and in particular our heart rate and respiratory rate, which in turn allows the cortex to calm, decrease extraneous noise, and focus/concentrate

Maybe Also “Side to Side?” (Kurth 2014)

Meditation thickens the corpus callosum, increasing “cross talk” between left and right cerebral hemispheres

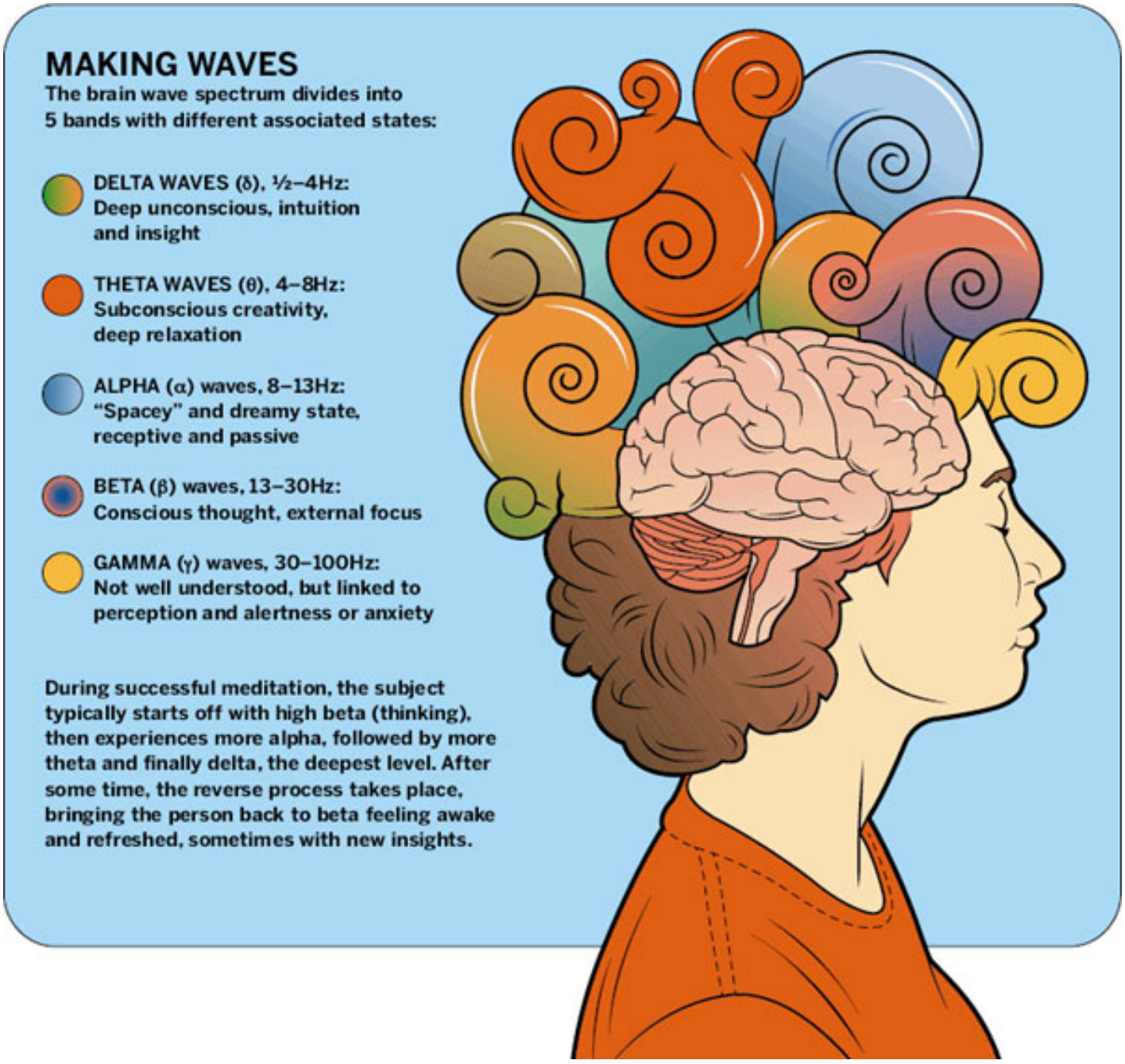


http://apbrwww5.apsu.edu/thompsonj/Anatomy%20&%20Physiology/2010/2010%20Exam%20Reviews/Exam%204%20Review/CH%2012%20White%20Matter%20in%20the%20Brain.htm

Frontal Brain Asymmetry on EEG
(Keune 2013, Moynihan 2013)

Meditation can impact frontal asymmetry. Keune reported that mindfulness meditation helped change the asymmetry pattern from withdraw to approach/motivation.

Moynihan reported that meditation helped to maintain left frontal asymmetry (where slipping to the right was undesirable)



http://makezine.com/projects/make-10/the-brain-machine/

Can Meditation Reverse the Effects of Stress on the Brain?

Meditation Reverses Effects of Chronic Stress

Structure	Effect of Stress	Source
Prefrontal Cortex	Decreased activity **Increased activation**	Dedovic 2009 **Guleria 2013**
Cingulate Cortex	Decreased ACC volume **Increased volume**	Meng 2014 Baldacara 2014 **Lu 2014**
Amygdala	Decreased volume **Increased volume**	Hanson 2014, Stratmann 2014 **Lu 2014**
Hippocampus	Decreased volume (GM) Deactivity **Increased volume**	Issa 2010, Gray 2013, Dedovic 2009 **Lu 2014**
Temporo-Parietal Junction Insula	Decreased volume **Increased activation**	Stratmann 2014, Meng 2014 **Zeidan 2014**

What About Meditation and Immune Function?

Meditation Improves Immune Function

Witek-Janusek 2008:

Women newly diagnosed with early stage breast cancer who were given mindfulness meditation had higher levels of healthy immune markers (interferon, interleukins) than controls. They also experienced improved coping skills and quality of life

Meditation Improves Immune Function

Rosenkranz 2013:

Subjects were given a small “burn” with capsaicin cream. Those who partook in mindfulness had a much smaller post-test inflammatory response

How About the Endocrine System?

Meditation and Cortisol

Turakitwanakan 2013:

Medical students given a four day mindfulness meditation course had significantly lower serum (blood) cortisol levels

Kang 2012:

Breast cancer patients received three hours of mindfulness meditation instruction per week for eight weeks, resulting in lower salivary cortisol, not to mention decreased perceived stress, improved coping, and decreased psychological stress

Other Organs/Diseases?

Park 2014:

Mindfulness meditation resulted in reduction in systolic and diastolic blood pressure, mean arterial pressure, heart rate, and muscle sympathetic nerve activity, all critical to health in chronic kidney disease (population of study)

Manchanda 2014:

Meditation can improve outcomes in individuals with coronary artery disease by reducing adverse cardiovascular events (heart attacks) by 48% over a 5 year period.

The benefits to meditation for the mind and the body are plentiful. That being said, is it possible that there can be too much of a good thing?

QUESTIONS/THOUGHTS???

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