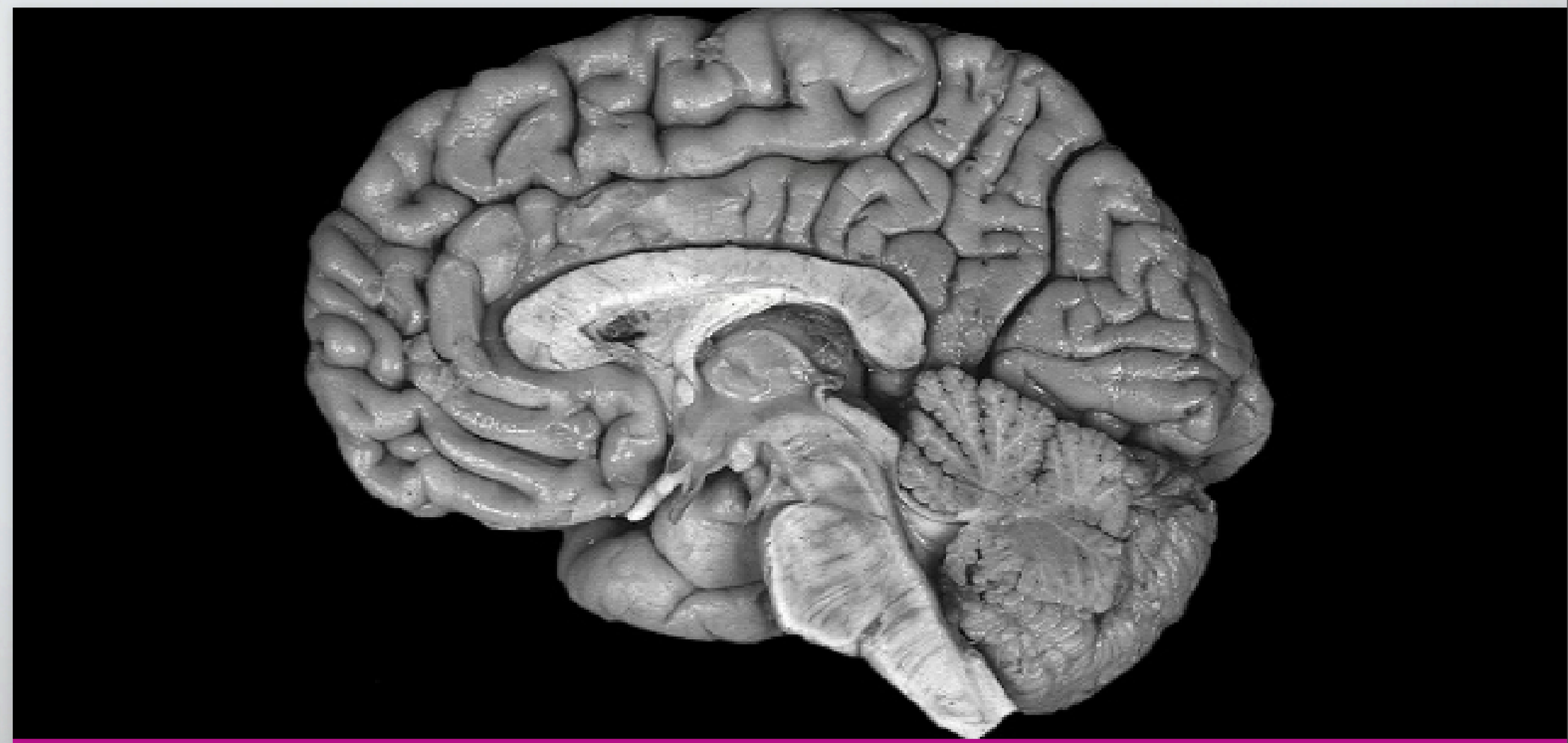
Lecture Two:
Building a New Brain



Every week we rebuild a significant portion of our brain

- Synapses (the connection between nerve cells in the brain) form and disconnect at about the same rate
- In visual cortex of monkeys this is at a rate of 7% per week
- Other areas of the thinking brain have shown similar rates of making and breaking connections
- Hippocampus (memory) and olfactory bulb (scent) actually make new brain cells–9000 per week in Hippocampus
- Brain cells average 10,000 synapses each

Neuroplasticity rules: What is fired is wired; what you don't use you lose

- Everything we learn causes new connections to form and old connections to break based upon this principle
- The more we repeat something the stronger and more numerous the connections
- More connections means that we have become more skilled in the learned activity
- Every thing we do well has been improved by repetition and practice

Neuroplasticity rules: What is fired is wired; what you don't use you lose

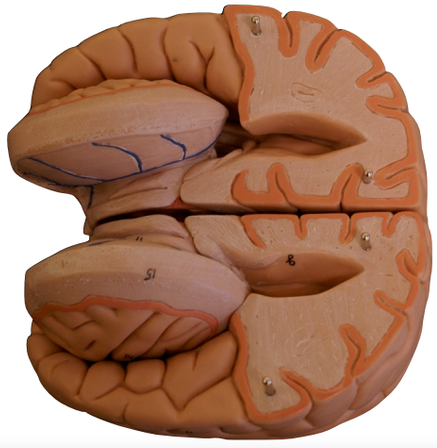
- When we stop doing something, the connections melt away
- The longer we stop doing something the more connections are lost
- Some things we repeat enough in our lives, that even if we stop, we maintain the ability to recapture the activity quickly when we start doing it again
- Riding a bike is an example

The brain in 7–D

- Remember, we need to look at the brain in seven dimensions
  - Anatomic: the physical layout of the brain
  - Physiologic: the ways the parts of the brain function with each other
  - Synaptic: the ways that nerves send signals to each other (chemicals)
  - Cellular: the actual nerve cell changes on a molecular and genetic level
  - Circuitry: the electrical circuits that determine mood, perception and behavior
  - Regional Functional Areas: brain maps
  - Neuroplasticity: the rate and extent of connections made and broken

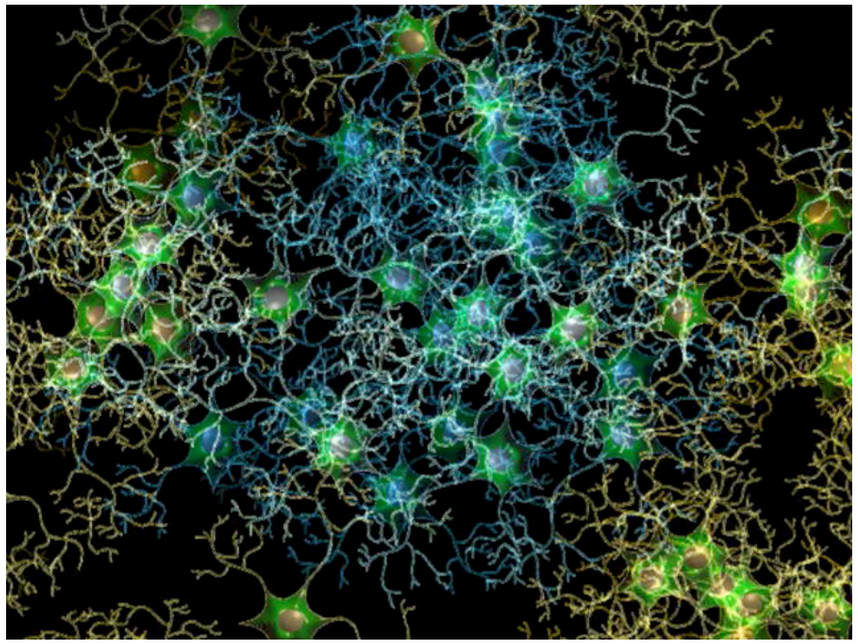
The naked brain

- To observe the brain this way, we must look at it from several perspectives.
- From a gross perspective there is the brain as it looks to the naked eye



The microscopic brain

- Under a microscope the brain looks different than it does to the naked eye



The submicroscopic brain

- Under the extremely high power of the electron microscope, we get even a different picture

Synapses Color Electron Micrograph

NOVA, 2001

Regional Functional Brain

- The different parts of the brain have multiple functions
- Each part is different than another
- The rich interconnections between brain parts make the functions more and more refined and sophisticated
- When we fire one function's nerve cells a lot, it takes over cells and their connections from its neighbors
- That highly fired function becomes highly wired

Persistent Pain

- We only perceive pain in 9 regions of the thinking brain
- In each of those 9 regions only 5% of the nerve cells and their connections are dedicated to pain processing
- In chronic pain the constant firing and wiring leads to an increase of 15% to 25% of the cells in those regions being dedicated to pain processing.
- This steals from the other local functions

Stopping Persistent Pain

- To decrease pain we must increase other regional functions
- What gets fired gets wired. What you don't use you lose
- During pain spikes pain nerve cells fire and wire
- If this is countered by the firing of other regional nerve cells during pain spikes, then the population of firing pain nerves is decreased
- Eventually the brain rewires away from pain

Prefrontal

Pain, Executive Function, Creativity, Planning, Empathy, Action, Emotional Balance, Intuition, Morality

Anterior Cingulate

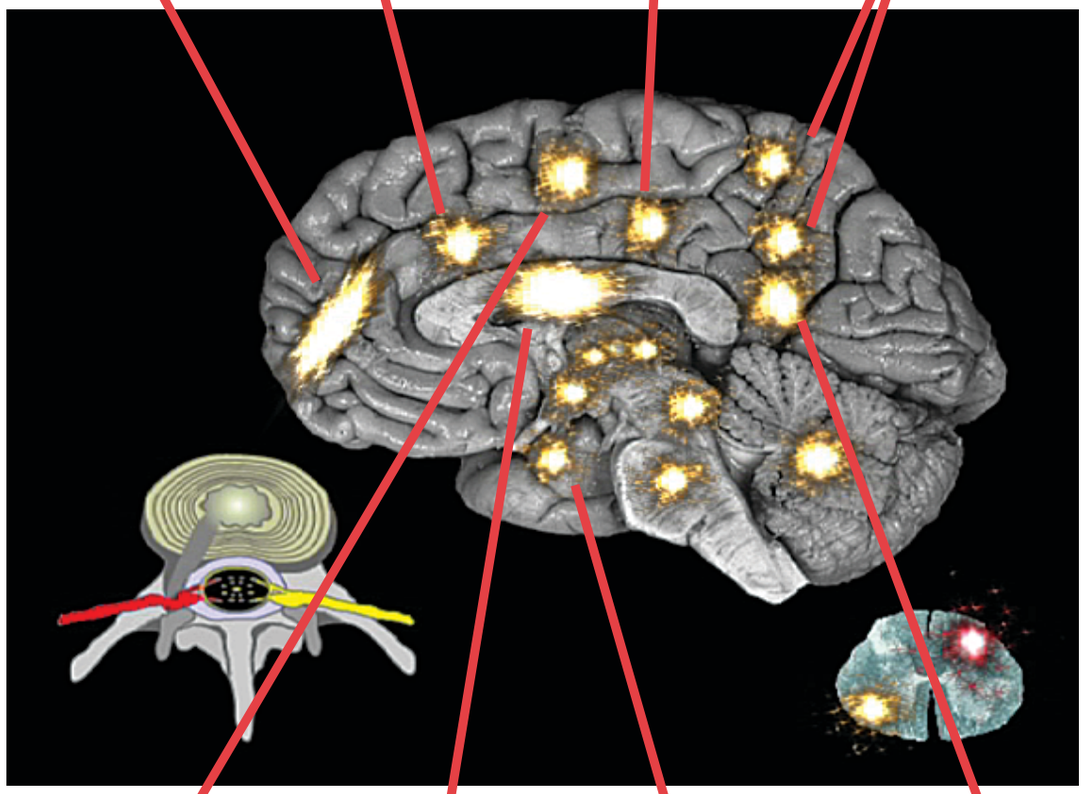
Pain, Emotional Self Control, SympatheticControl, Conflict Detection, Problem Solving

Posterior Cingulate

Pain, Visuospatial Cognition, Autobiographical Memory Retrieval

Somatosensory

Pain, Temperature, Pressure, Touch, postion, vibration, sensation of movement



Supplementary Motor

Pain, Planned Movement, mirror neurons

Insula

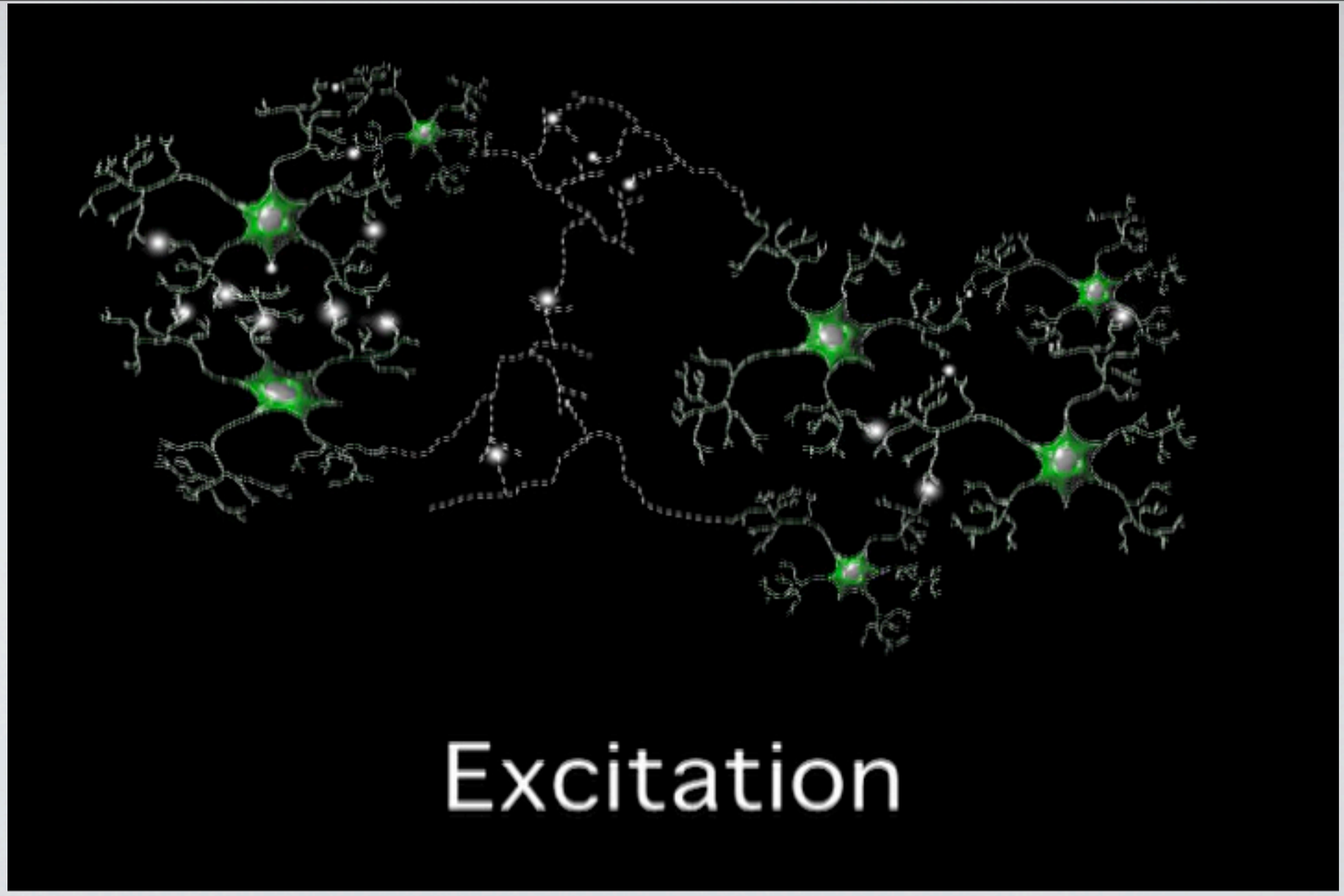
Pain, Temperature, Itch, Empathy, Emotional Self Awareness, Quiets the Amygdala, Sensual Touch, Connects emotion with bodily sensation, mirror neurons

Amygdala

Pain, Emotion, Emotional Memory, Emotional Response, Pleasure, Sight, Smell

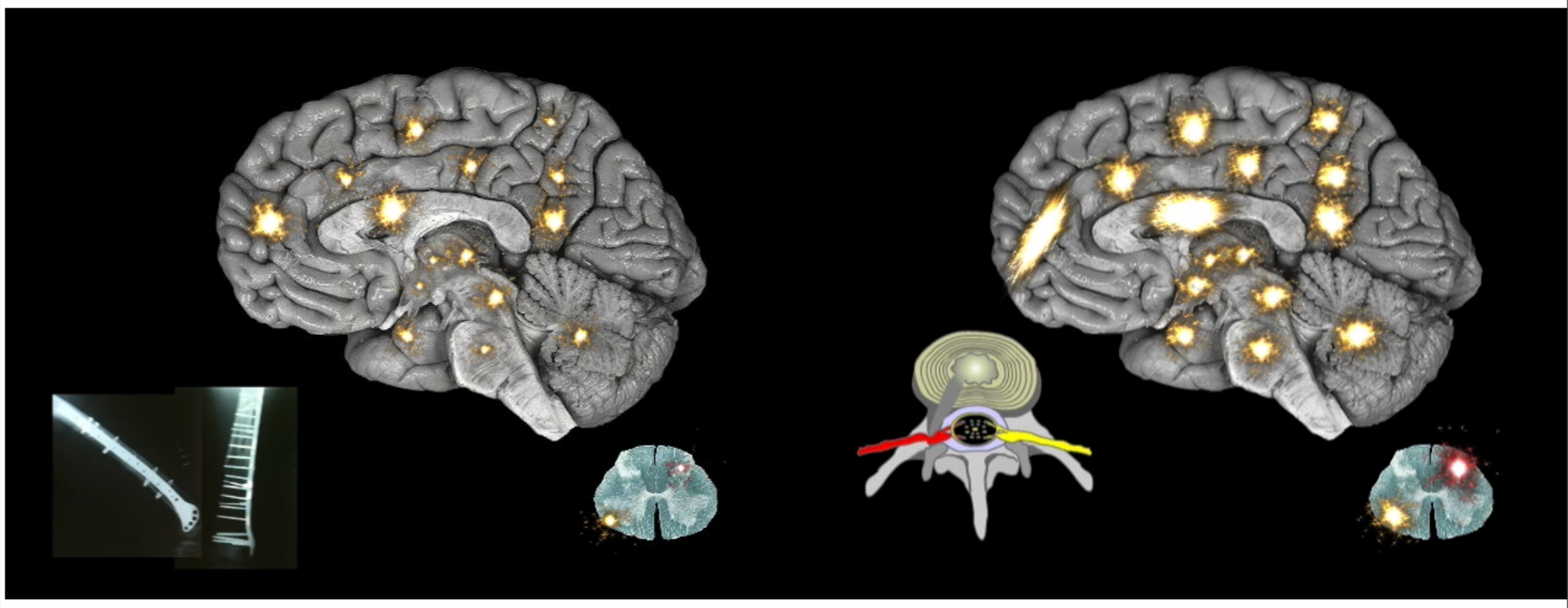
Posterior Parietal

Pain, Sensory, Visual, Auditory Perception, mirror neurons, internal location of stimuli, location of external space



Brain Learned and Unlearned Persistent Pain

Acute vs Chronic Persistent Pain: Brain Maps



Acute Pain Brain Map

Chronic Pain Brain Map

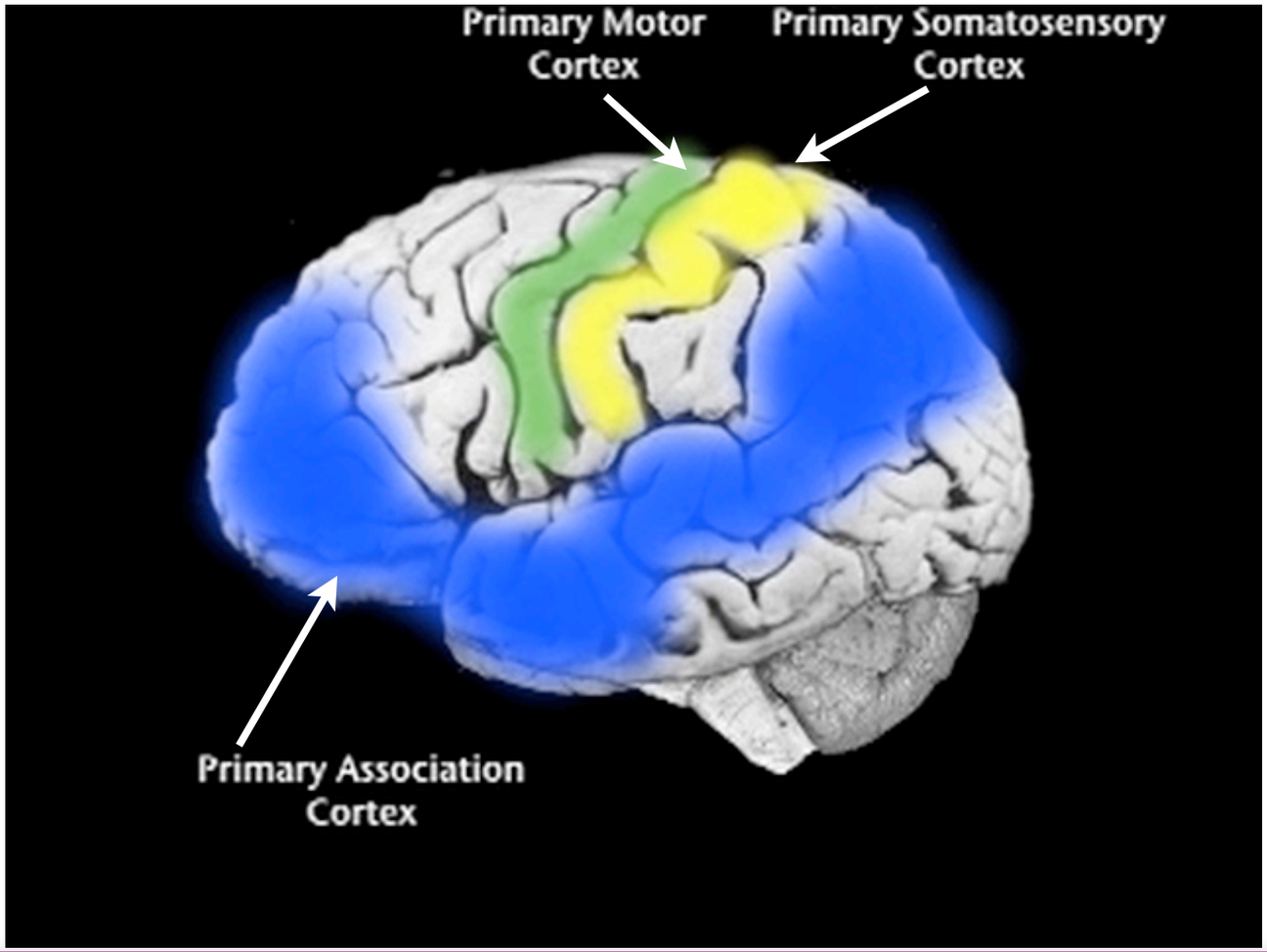
Access to the Brain

- You don’t need to be a brain surgeon
- Seven holes and the biggest organ we have
  - Eyes, Ears, Nose, Mouth, Skin
- Sensation comes from billions of receptors in skin, muscle, bones, joints, etc
- The thinking brain makes decisions based upon sensory input
- Touch, position, vibration, movement, temperature, pressure, itch, pain, vision, scent, taste, sound

Sensory Input/Motor Output Circuit

- The signal travels through multiple synapses in the spinal cord and brain
- Signals all arrive at the primary somatosensory cortex (second highest order of brain nerve cells), where the pain signal is separated from other sensory input and its location in the body is determined
- Output is sent via primary motor cortex through multiple synapses signaling billions of individual muscles cells to contract or relax
- Three areas of the brain look over this process (This is the highest order of brain nerve cells), known as the association cortex and can turn the pain up or down through multiple connections to primary sensory and motor cortex

Sensory Input/Motor Output Circuit



Key principles of intentional brain change: **Mirror**

- **M**otivation- The patient must be highly motivated to work on reduction of pain without immediate result- ability to delay gratification- start with Doidge's book
- **I**ntention- activity must be focused on changing back the neuroplastic changes of chronic pain brain map to acute pain brain map
- **R**elentlessness- every action must have an equal and opposite reaction- no pain spike goes by without an attempt to reduce it
- **R**eliability- Count upon the tool that has always served to learn new things: The Brain
- **O**pportunity- Using pain spikes to challenge brain pain map converts fear of pain to opportunity to change brain's ability to control it
- **R**estoration- Initial opposition may be ineffective in reducing pain spikes, but diligent unrelenting opposition will reduce spike frequency, then intensity, then start to result in better regional and baseline pain control

How do we shrink the map?

- *Brain is a learning machine: Learn self-efficacy*
- *Flood the brain with other input during pain spikes with intention of changing brain. Connect peripheral pain to the brain.*
  - *Thoughts: Opposition to pain, no pain, shrinking pain map*
  - *Images: brain maps, brain clear of pain, pleasant imagery*
  - *Sensations: touch, temperature, pressure, auditory, visual, olfactory, taste, movement (proprioception)*
  - *Memories: Pleasant and strong memories other than pain*
  - *Calming emotions: mindfulness, pleasure, peacefulness, serenity*
  - *Movement or thoughts of movement*

Shrinking the Pain Map:

During pain spikes flood the brain with:

Thoughts, Images, Sensations,Memories, Calming Emotion, Movement

- Develop 15 to 20 strategies
- Have simple strategies useful in everyday life: repetitive phrases, simple images, sensory input (scents, photos, touch, music, taste)
- Use more complex strategies for times of rest, pre-sleep, etc
- Use of updated newsletter of what patients in the practice are doing with success- e.g.
  - **JB:** *I picture the Gray Matterhorn and all of the spots are lit up. As I go past them on my snowboard, I spray them with snow and the lights go out and my pain becomes better.*
  - **CR:** *I go into my brain, not just visualize it, but go into it to and change pathways to decrease my pain and improve my mood. I actually feel myself in my brain and connect and disconnect electrical circuit boards. I make lights go out and lights come on. If I have pain in a part of my body I touch it and see what part of my brain lights up. Then I turn off the circuit.*
  - **KH:** *When pain comes up I say "no pain," then "I own this body. I'm the master here. Go back to the shadows." I visualize pushing it out of wherever the pain is in my body.*

What do you Experience?

- Change of pattern of treatment from passivity to activity: Pain trains us to be passive
- Initial treatment may fail or cause flare. Persistence reduces pain episodes, location, intensity and baseline pain
- Repetition changes conscious learning into unconscious learned expertise
- The act of opposing chronic pain each time it floods the map mimics normal brain function in acute pain and eventually reactivates brain spinal cord synergy, i.e. the alarm turns on, the brain responds and shuts off the alarm
- The patient gains mastery with pain reestablished as a signal of going beyond limits, needing to be respected and dealt with, rather than heralding unrelenting punishment

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