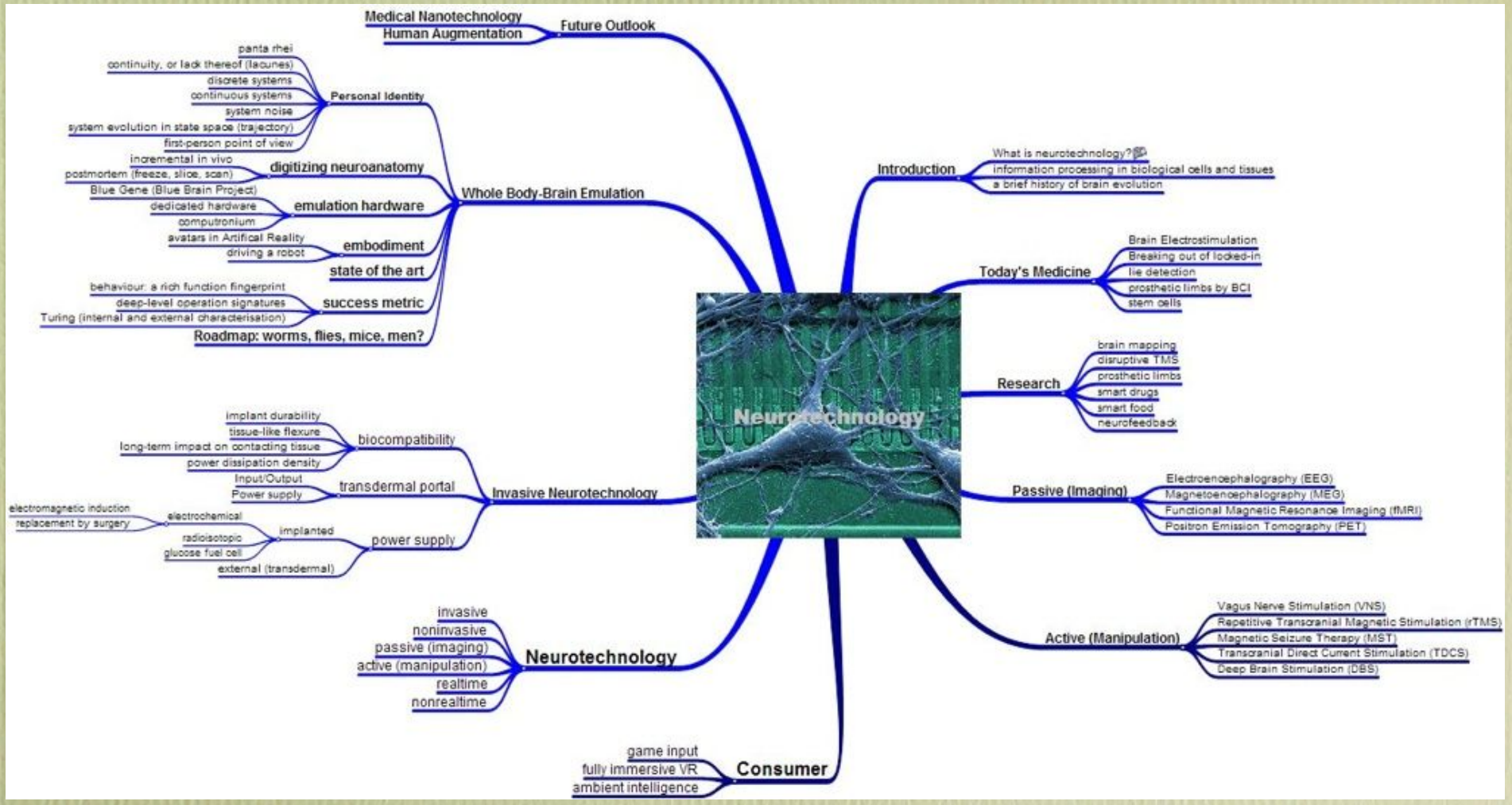

Neurotechnology


Neurotechnology
Future Outlook
Medical Nanotechnology
Human Augmentation
Whole Body-Brain Emulation
Personal Identity
panta rhei
continuity, or lack thereof (lacunes)
discrete systems
continuous systems
system noise
system evolution in state space (trajectory)
first-person point of view
digitizing neuroanatomy
incremental in vivo
postmortem (freeze, slice, scan)
emulation hardware
Blue Gene (Blue Brain Project)
dedicated hardware
computronium
embodiment
avatars in Artifical Reality
driving a robot
state of the art
success metric
behaviour: a rich function fingerprint
deep-level operation signatures
Turing (internal and external characterisation)
Roadmap: worms, flies, mice, men?
Introduction
What is neurotechnology?
information processing in biological cells and tissues
a brief history of brain evolution
Today's Medicine
Brain Electrostimulation
Breaking out of locked-in
lie detection
prosthetic limbs by BCI
stem cells
Research
brain mapping
disruptive TMS
prosthetic limbs
smart drugs
smart food
neurofeedback
Passive (Imaging)
Electroencephalography (EEG)
Magnetoencephalography (MEG)
Functional Magnetic Resonance Imaging (fMRI)
Positron Emission Tomography (PET)
Active (Manipulation)
Vagus Nerve Stimulation (VNS)
Repetitive Transcranial Magnetic Stimulation (rTMS)
Magnetic Seizure Therapy (MST)
Transcranial Direct Current Stimulation (TDCS)
Deep Brain Stimulation (DBS)
Consumer
game input
fully immersive VR
ambient intelligence
Neurotechnology
invasive
noninvasive
passive (imaging)
active (manipulation)
realtime
nonrealtime
Invasive Neurotechnology
biocompatibility
implant durability
tissue-like flexure
long-term impact on contacting tissue
power dissipation density
transdermal portal
Input/Output
Power supply
power supply
implanted
electromagnetic induction
replacement by surgery
electrochemical
radioisotopic
glucose fuel cell
external (transdermal)

Introduction

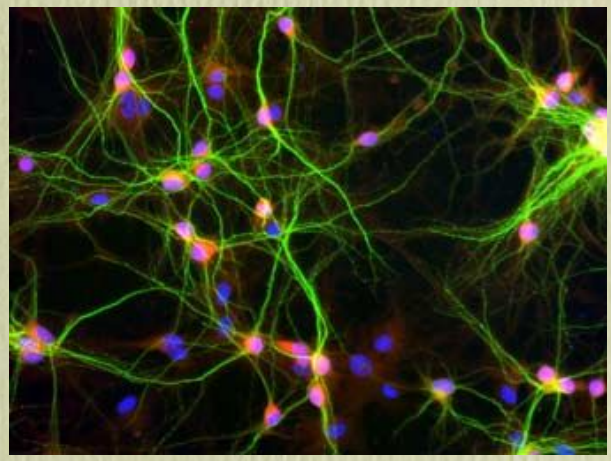
- What is neurotechnology?

  Neurotechnology: any technology to manipulate the Central Nervous System (CNS), especially the brain, to a desired effect.

- targets information processing in cells and tissues
- co-evolution drives better infoprocessing as a long-term trend

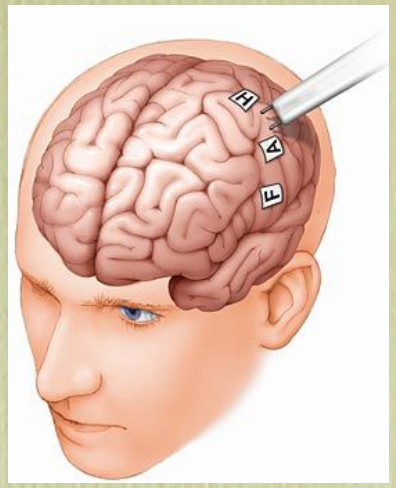
Today's Medicine

- brain imaging (passive)
- brain electrostimulation (active)
- breaking the ice of locked-in patients with BCI
- prosthetic limbs by BCI
- drugs
- stem cells contra degeneration
- genetic modification (GM)

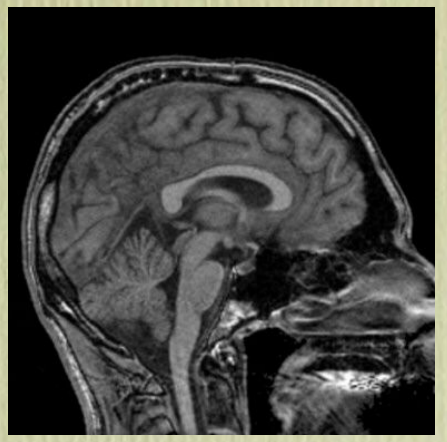


Research

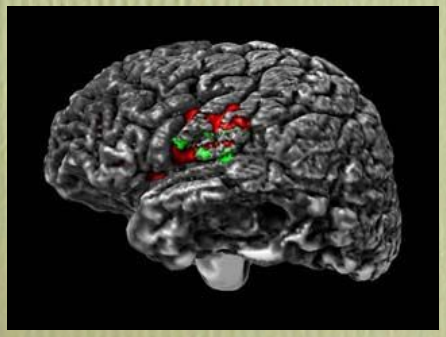
- brain mapping
- disruptive TMS
- prosthetic limbs
- smart drugs
- smart food
- neurofeedback

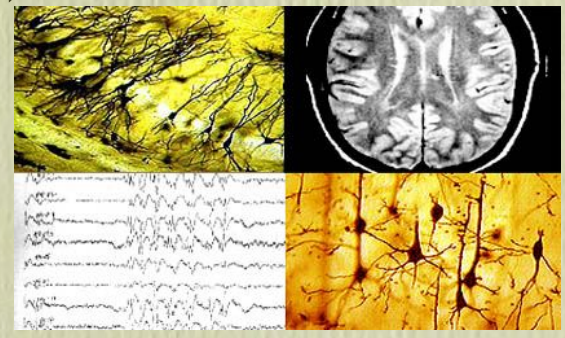


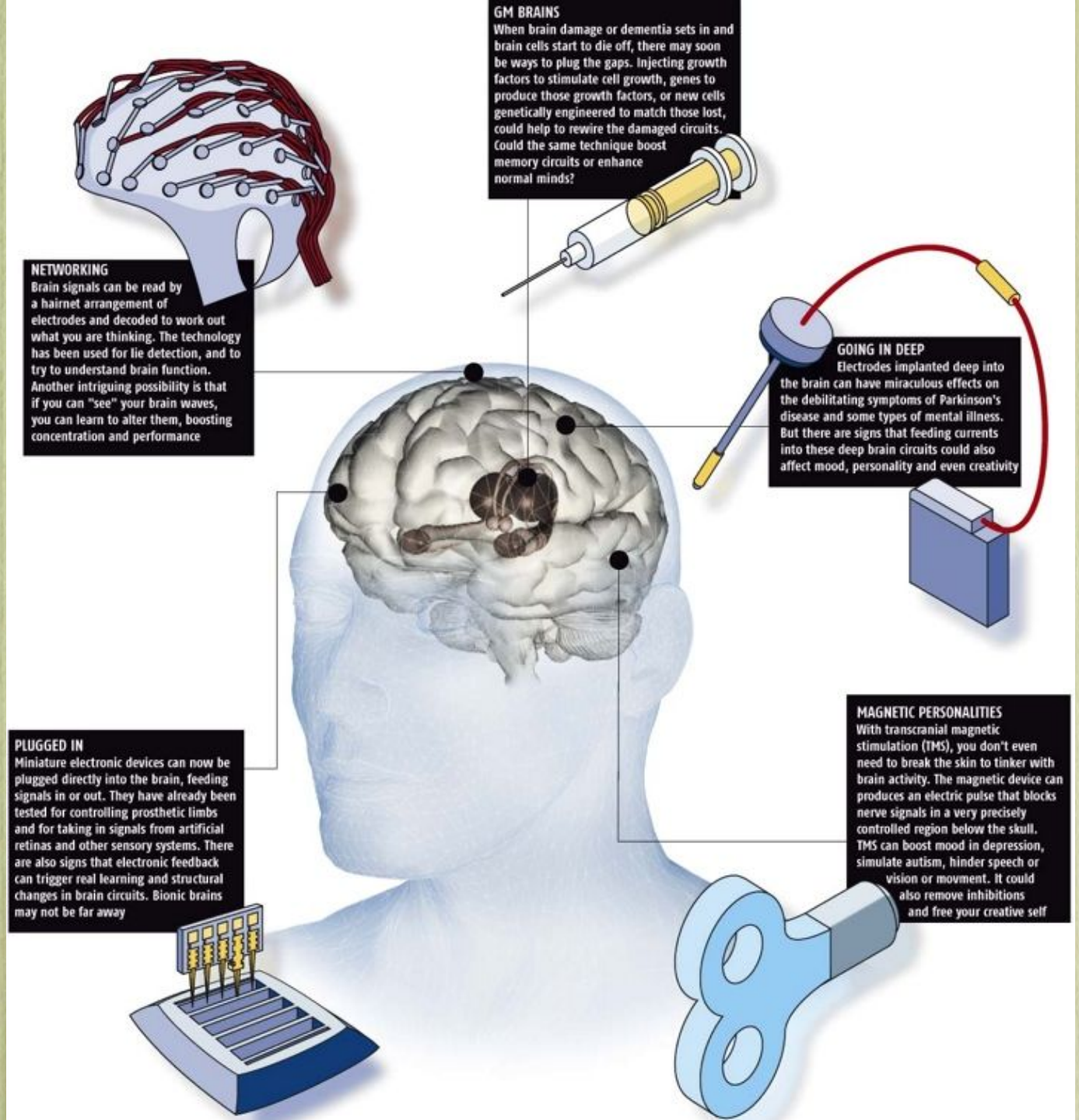
Passive (Imaging)



- Electroencephalography (EEG)
- Magnetoencephalography (MEG)
- Functional Magnetic Resonance Imaging (fMRI)
- Positron Emission Tomography (PET)






GM BRAINS
When brain damage or dementia sets in and brain cells start to die off, there may soon be ways to plug the gaps. Injecting growth factors to stimulate cell growth, genes to produce those growth factors, or new cells genetically engineered to match those lost, could help to rewire the damaged circuits. Could the same technique boost memory circuits or enhance normal minds?
NETWORKING
Brain signals can be read by a hairnet arrangement of electrodes and decoded to work out what you are thinking. The technology has been used for lie detection, and to try to understand brain function. Another intriguing possibility is that if you can "see" your brain waves, you can learn to alter them, boosting concentration and performance
GOING IN DEEP
Electrodes implanted deep into the brain can have miraculous effects on the debilitating symptoms of Parkinson's disease and some types of mental illness. But there are signs that feeding currents into these deep brain circuits could also affect mood, personality and even creativity
PLUGGED IN
Miniature electronic devices can now be plugged directly into the brain, feeding signals in or out. They have already been tested for controlling prosthetic limbs and for taking in signals from artificial retinas and other sensory systems. There are also signs that electronic feedback can trigger real learning and structural changes in brain circuits. Bionic brains may not be far away
MAGNETIC PERSONALITIES
With transcranial magnetic stimulation (TMS), you don't even need to break the skin to tinker with brain activity. The magnetic device can produces an electric pulse that blocks nerve signals in a very precisely controlled region below the skull. TMS can boost mood in depression, simulate autism, hinder speech or vision or movment. It could also remove inhibitions and free your creative self

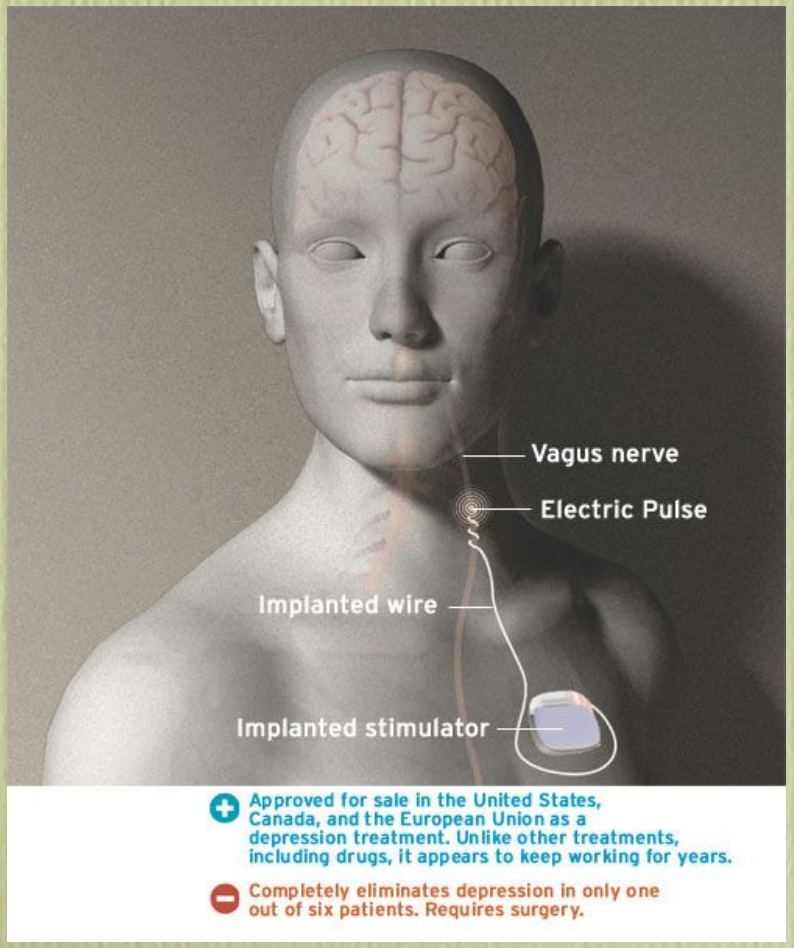
Neurotechnology

- invasive
- noninvasive
- passive (imaging)
- active (manipulation)
- realtime
- nonrealtime

Active (Manipulation)

- Vagus Nerve Stimulation (VNS)
- repetitive Transcranial Magnetic Stimulation (rTMS)
- Magnetic Seizure Therapy (MST)
- Transcranial Direct Current Stimulation (TCDS)
- Deep Brain Stimulation (DBS)

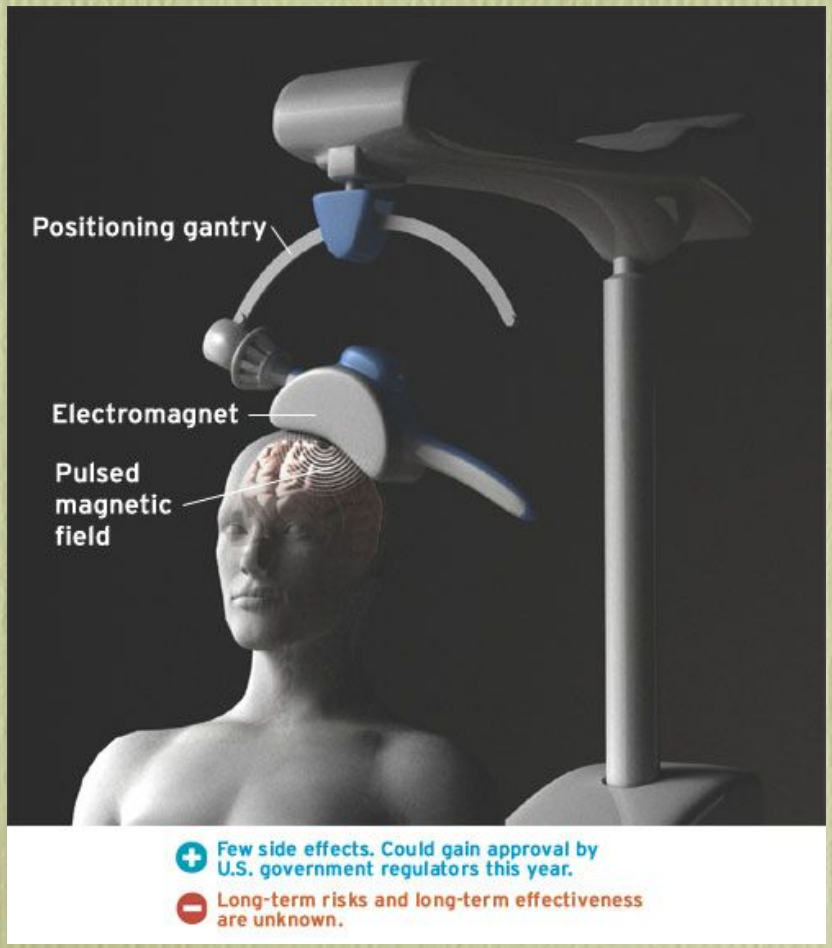
Vagus Nerve Stimulation (VNS)



A pulse generator implanted in a patient's chest sends electric pulses to the vagus nerve, one of 12 nerves that radiate from your brain rather than your spinal cord. The pulses send signals into the brain that may reduce or eliminate severe chronic depression.

IEEE Spectrum/Bryan Christie

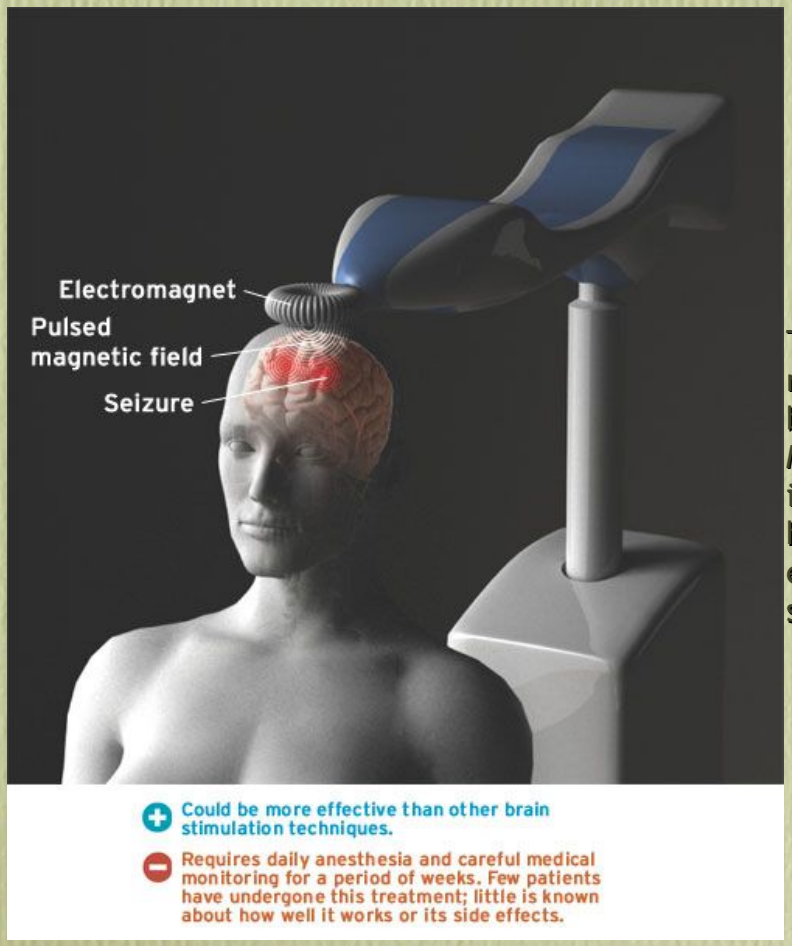
Repetitive Transcranial Magnetic Stimulation (rTMS)



A powerful pulsed electromagnet positioned over a part of the brain implicated in depression induces the flow of current in neurons locally. Though the stimulation is done only for minutes a day over a period of weeks, it alters the activity of the neurons long-term.

IEEE Spectrum/Bryan Christie

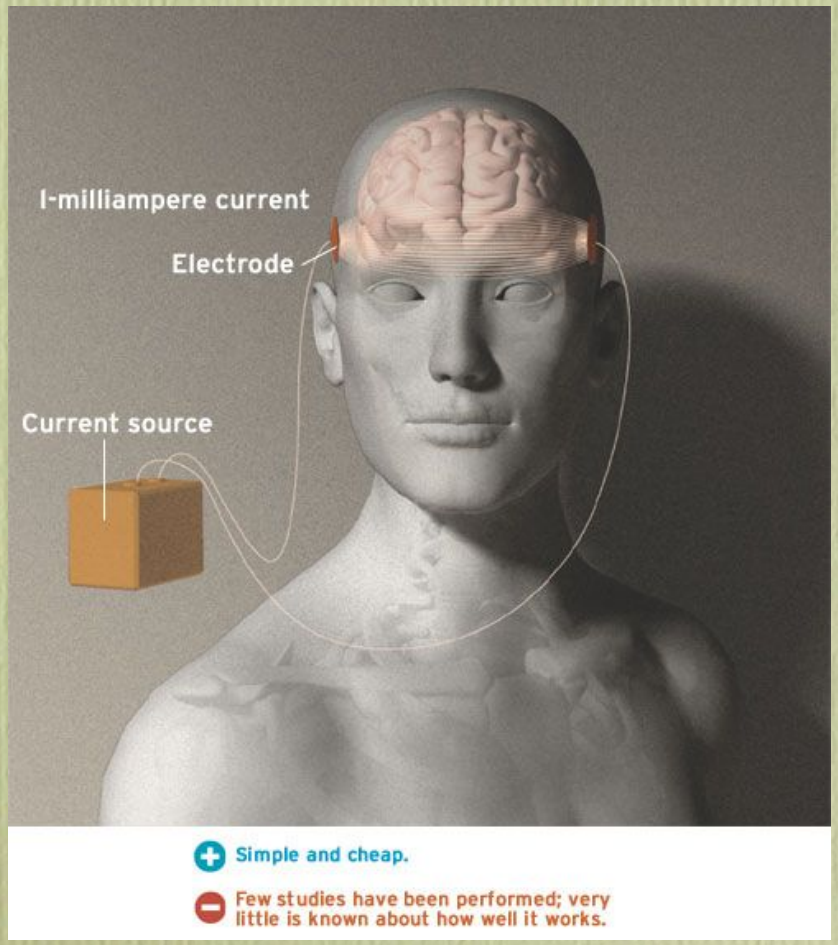
Magnetic Seizure Therapy (MST)



This therapy uses a more powerful electromagnet than repetitive transcranial magnetic stimulation does; it is basically a magnetic version of electroconvulsive therapy. Magnetic seizure therapy induces a high-frequency current in a small portion of the brain until it sparks a seizure. The hope is that a magnetically induced seizure will be as effective at treating depression as an electrically induced seizure while causing less memory loss.

IEEE Spectrum/Bryan Christie

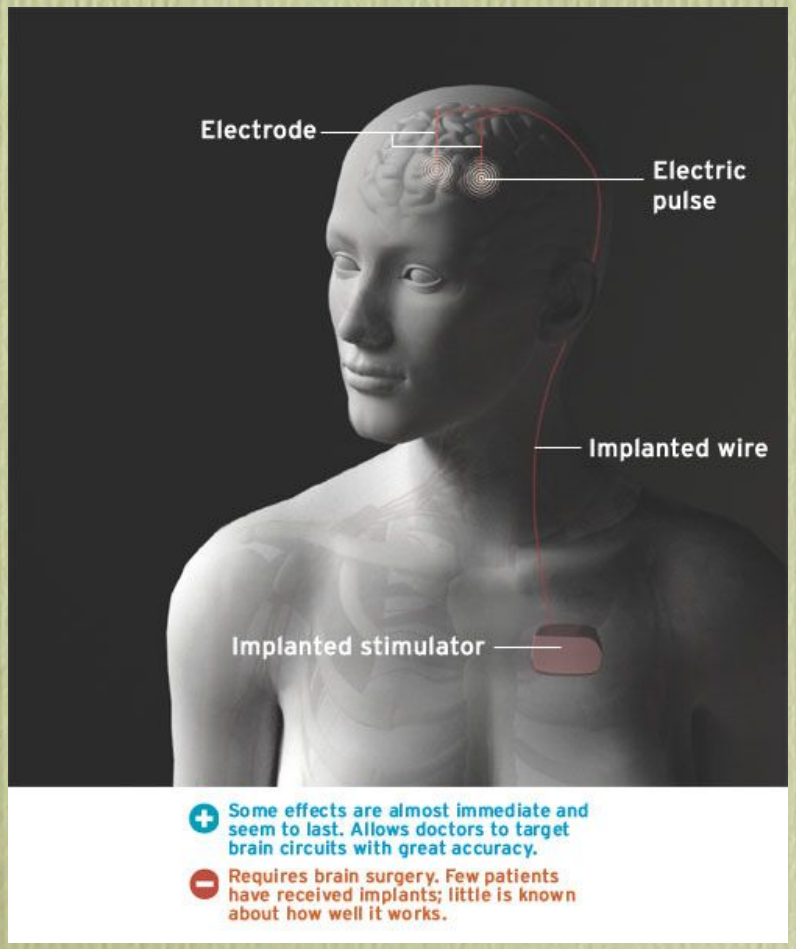
Transcranial Direct Current Stimulation (TDCS)



A device drives a small direct current through the front part of a patient's brain. Though the stimulation is done only for minutes a day over a period of weeks, it appears to alter the activity of neurons in the long term.

IEEE Spectrum/Bryan Christie

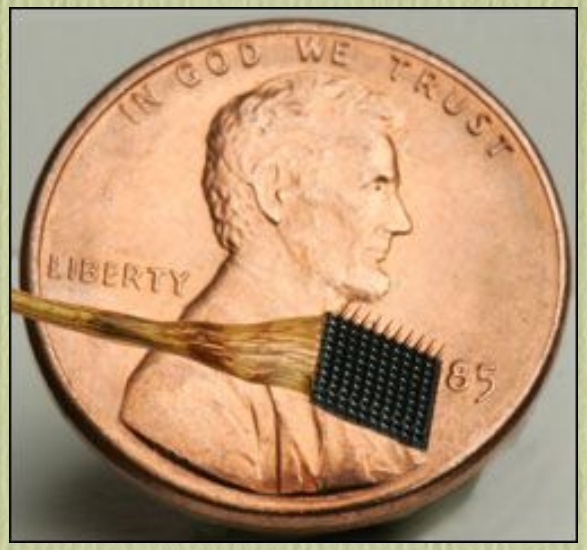
Deep Brain Stimulation (DBS)

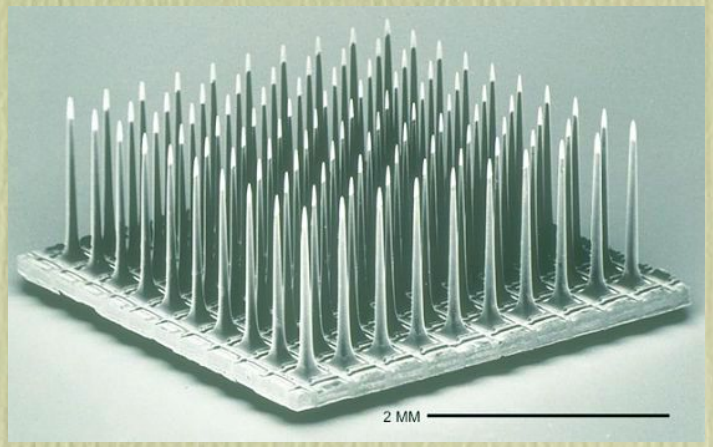


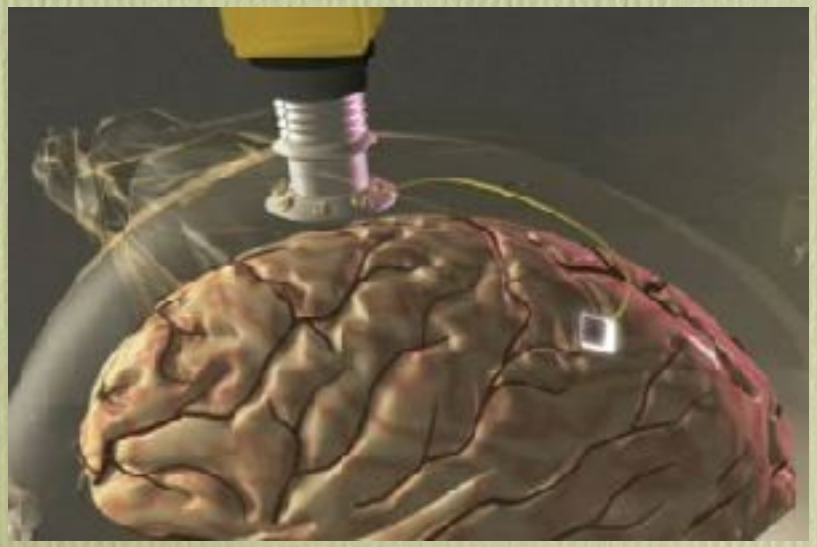
A stimulator implanted in a patient's chest sends pulses of electricity to electrodes embedded deep within the brain. The stimulation switches off neurons within a few millimeters of the electrodes. It can cure severe depression by interrupting malfunctioning brain circuits implicated in the disease.

IEEE Spectrum/Bryan Christie

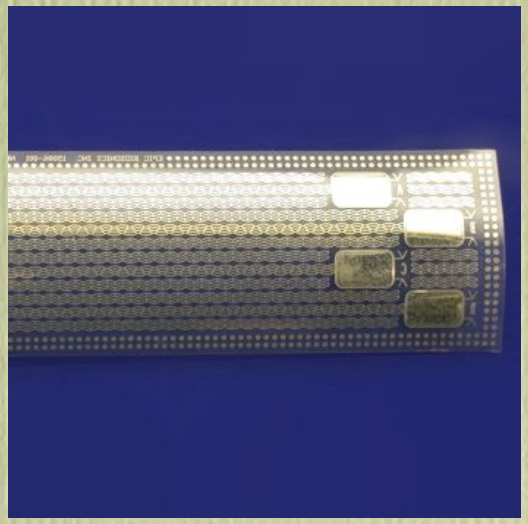
Invasive Neurotechnology



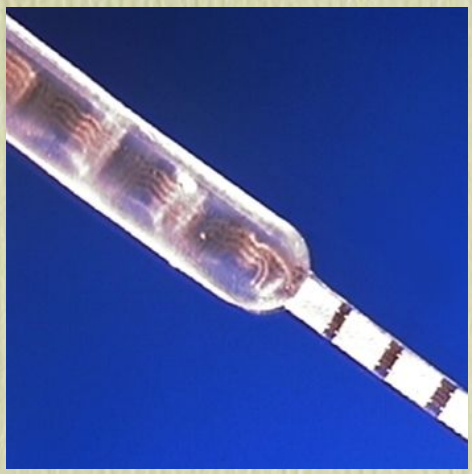




biocompatibility



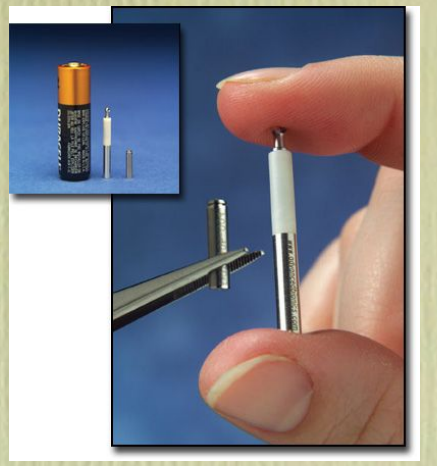
- implant durability
- tissue-like flexure
- long-term impact on contacting tissue
- power dissipation density



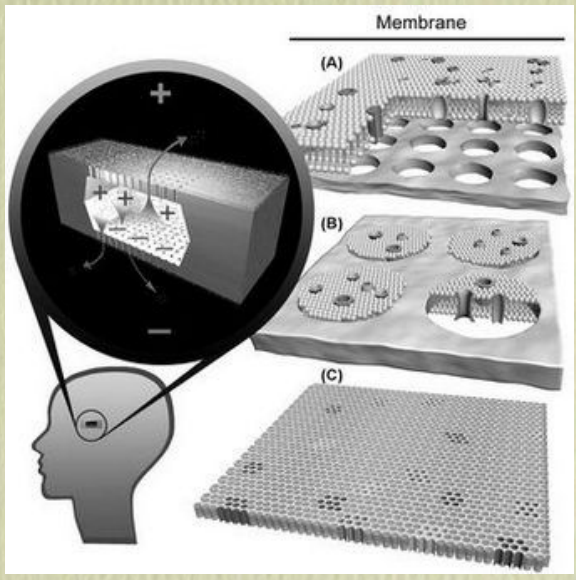
transdermal portal

- Input/Output
- Power supply
- surgery
- infections
- Frankenstein F.

power source

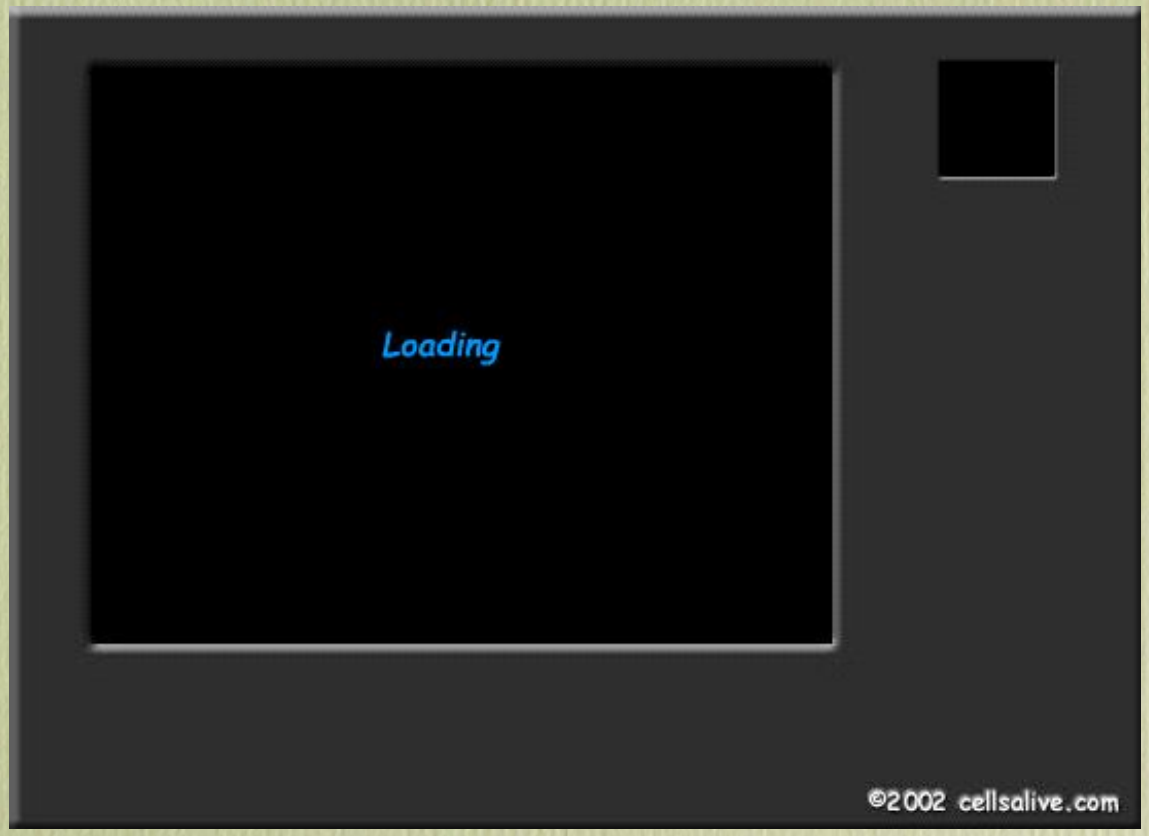


- implanted
  - electrochemical
    - electromagnetic induction
    - replacement by surgery
  - radioisotopic
  - glucose fuel cell
- external (transdermal)

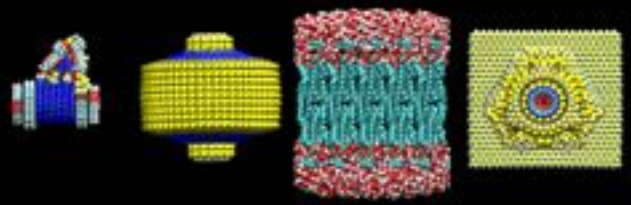


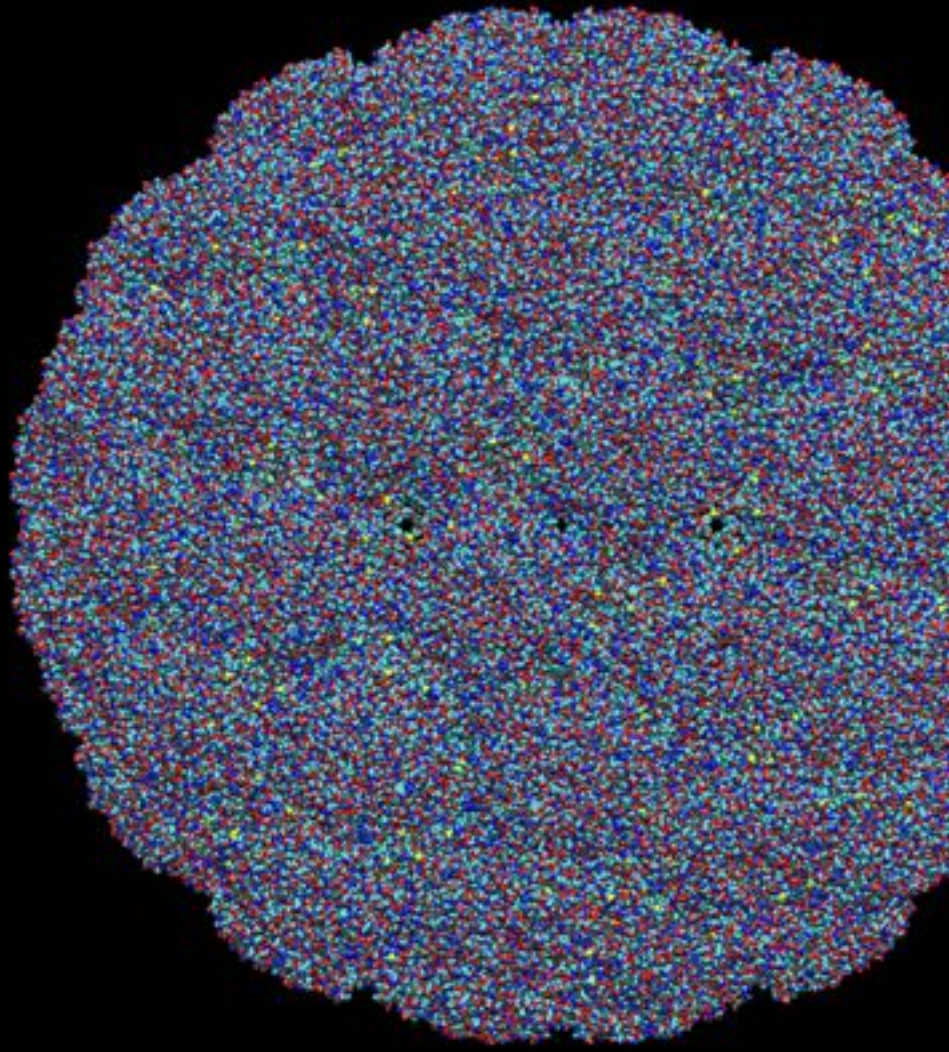
Consumer

- control of...
- game input
- fully immersive VR
- ambient intelligence

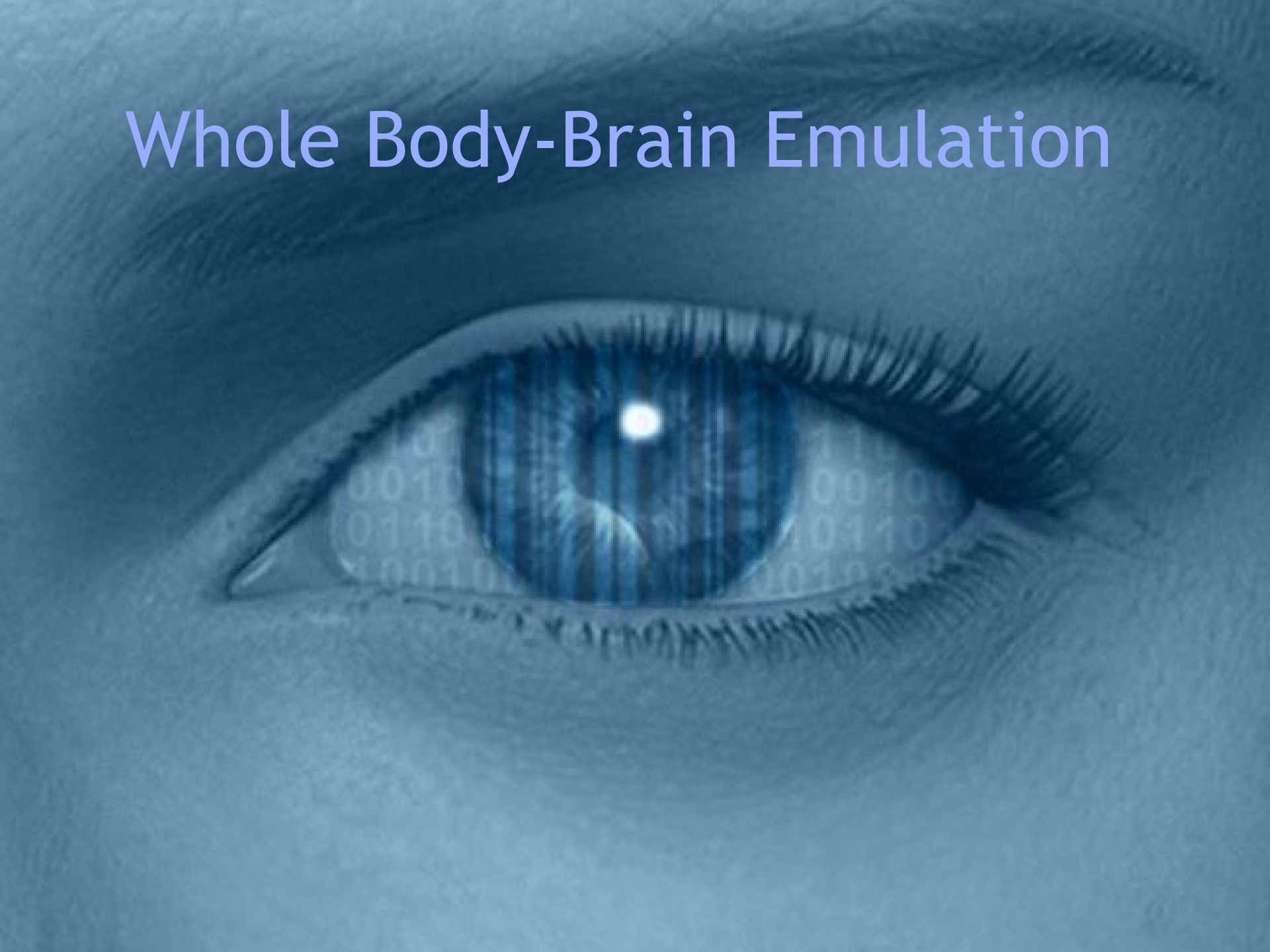


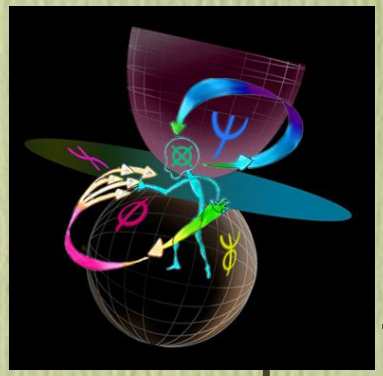
(A working interactive version of the above illustrative flash animation can be found at http://leitl.org/docs/nano/howbig.htm)





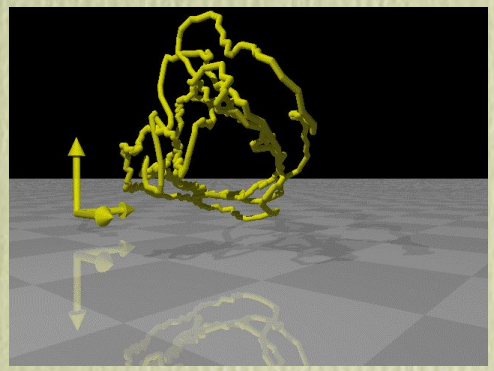
Whole Body-Brain Emulation





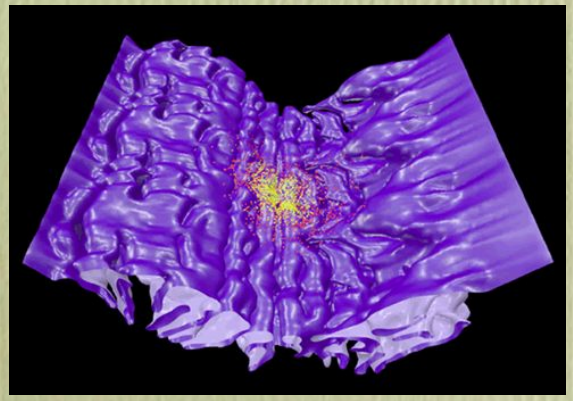
Personal Identity

- panta rhei
- continuity, or lack thereof (EEG lacunes)
- continous systems
- discrete systems
- nonlinearity/system noise
- system evolution in state space (trajectory)
- first-person point of view



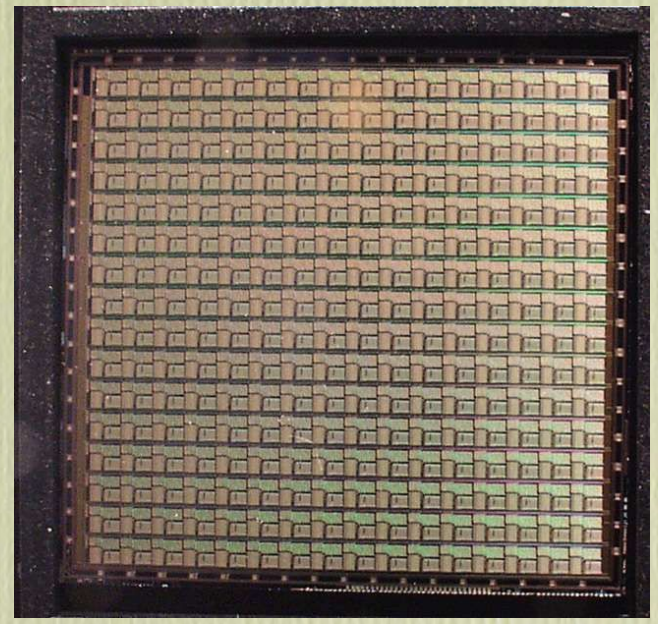
digitizing neuroanatomy

- incremental in vivo
- postmortem (freeze, slice, scan)



emulation hardware

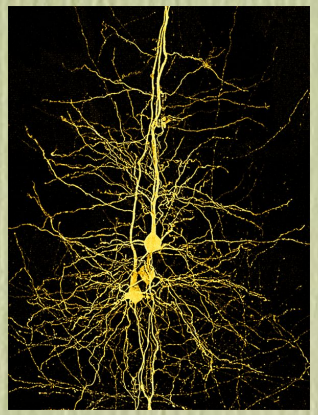
- Blue Gene (Blue Brain Project)
- dedicated hardware
- computronium



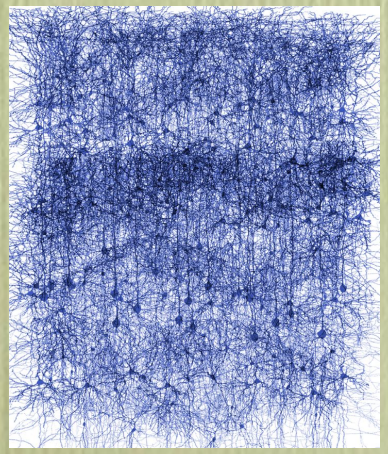
embodiment

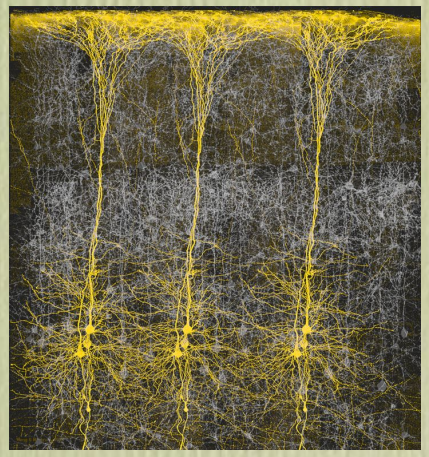
- avatars in Artifical Reality
- driving a robot

state of the art



- Blue Brain Project



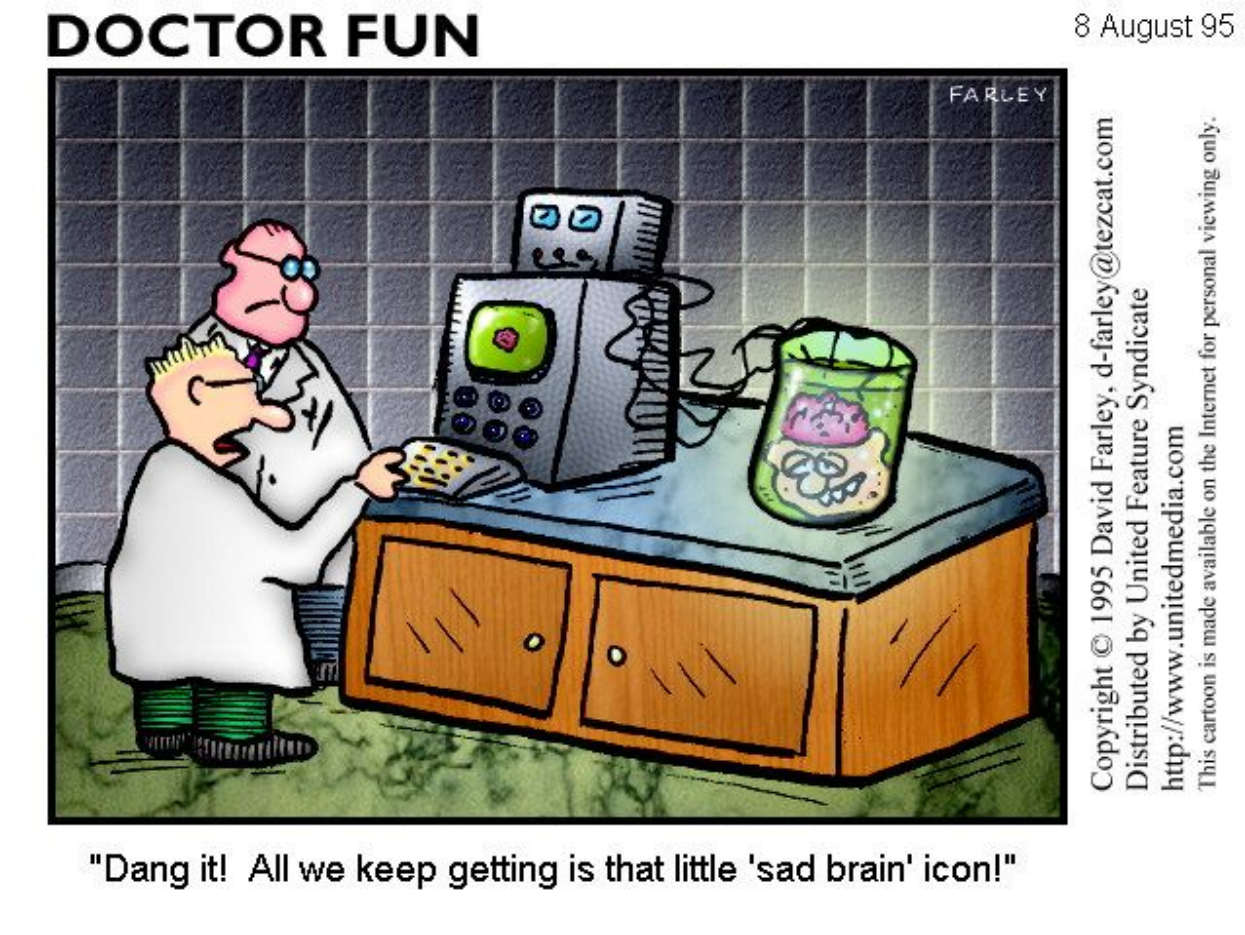


Henry Markram, EPFL

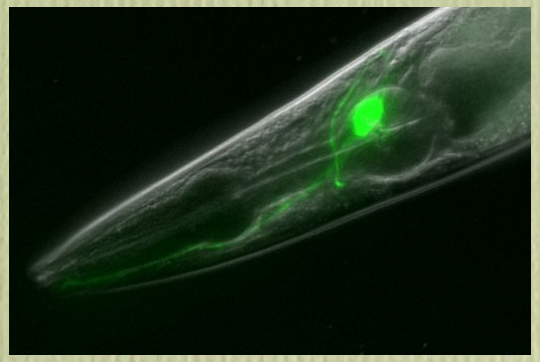
success metric

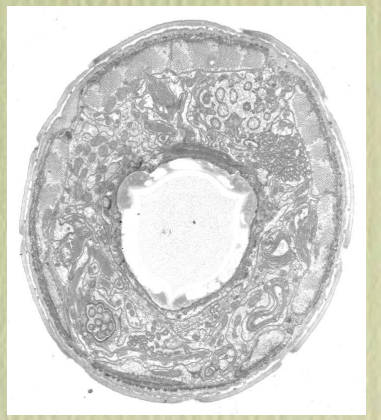
- behaviour: a rich function fingerprint
- deep-level operation signatures
- Turing (internal and external characterisation)

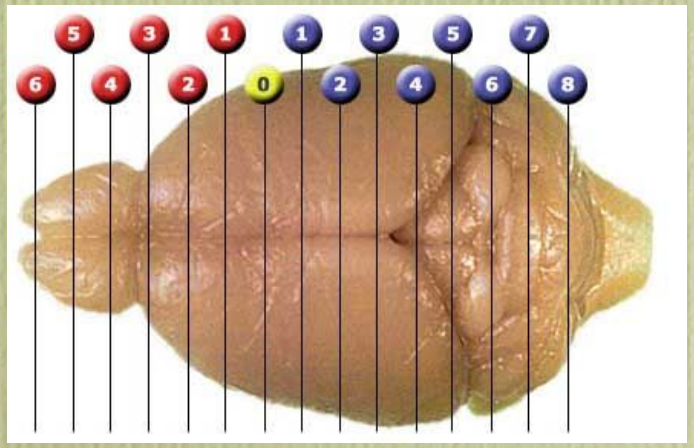
terrible importance of QA



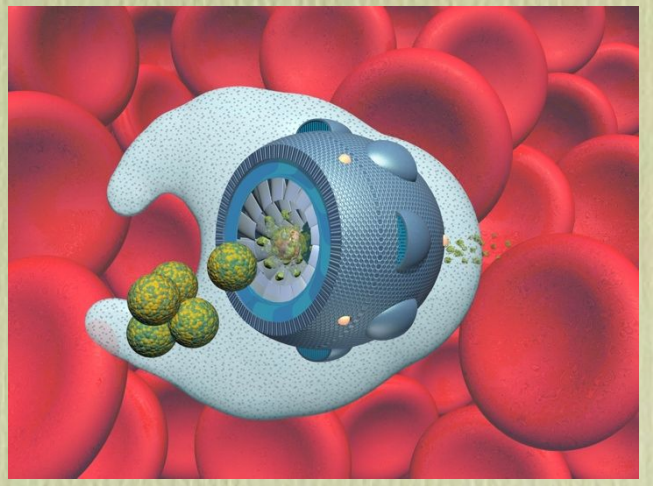
Roadmap: worms, flies, mice, men?







Far Future



- medical nanotechnology
- human augmentation
- Whole Body/Brain Emulation
- speciation and radiation of postbiology
- expansion into space