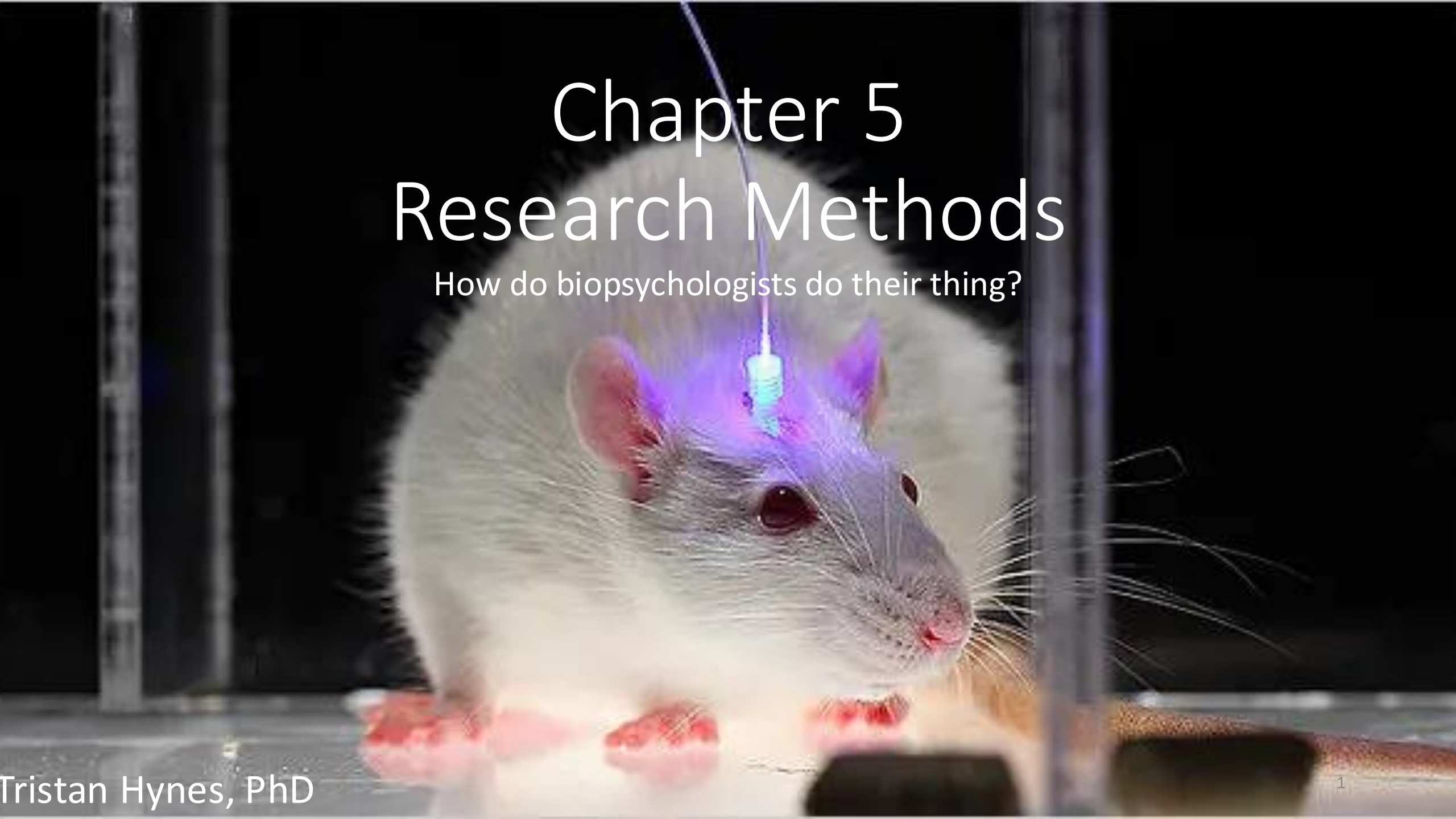


Chapter 5
Research Methods

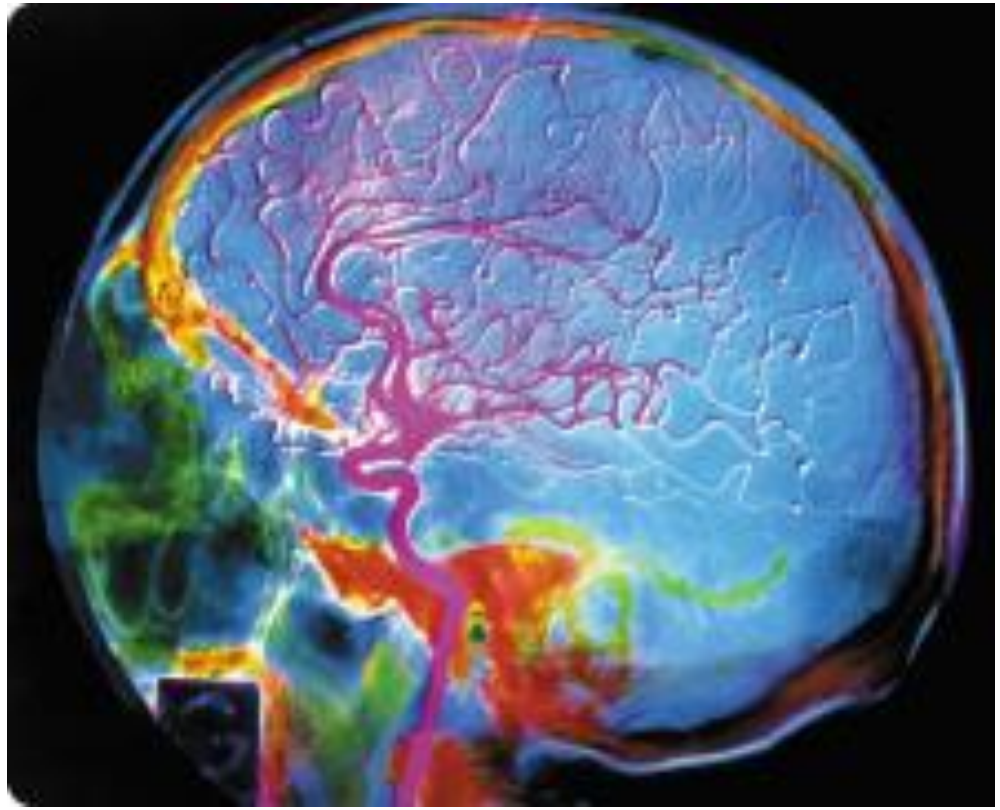
How do biopsychologists do their thing?

Tristan Hynes, PhD

X-Ray-Based Techniques

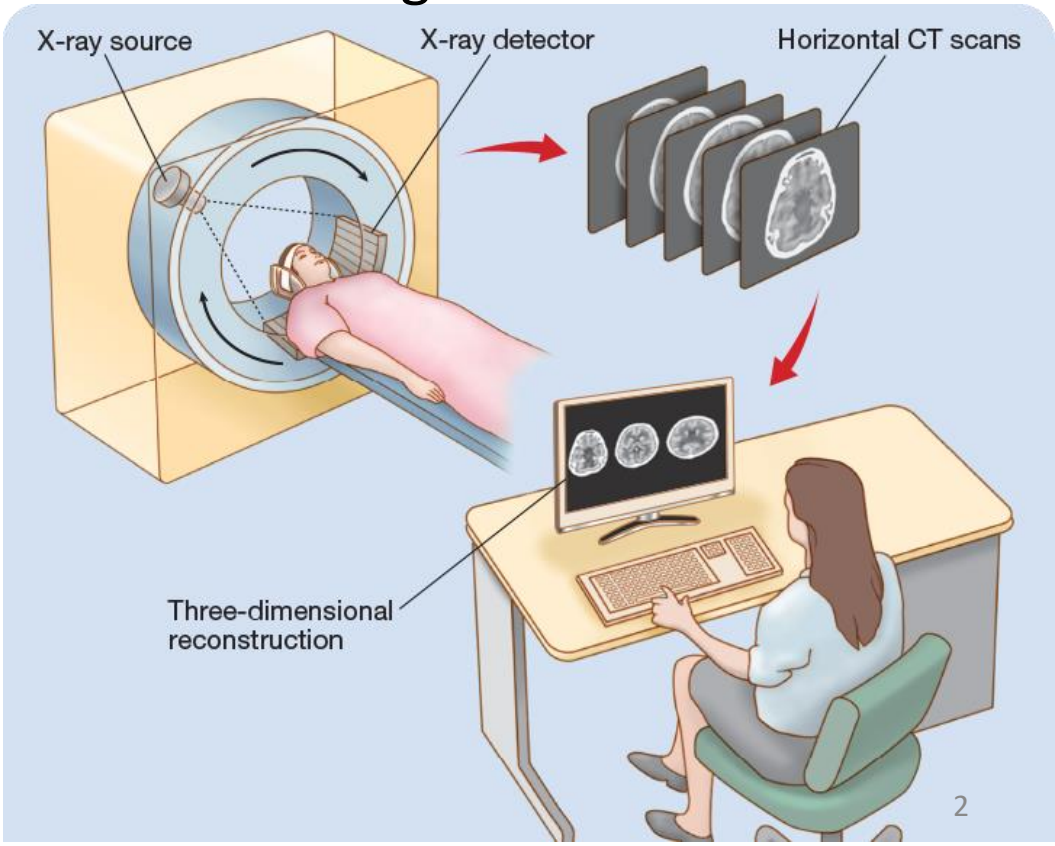
Contrast x-rays

- Inject radio-opaque material
- Cerebral angiography is an example



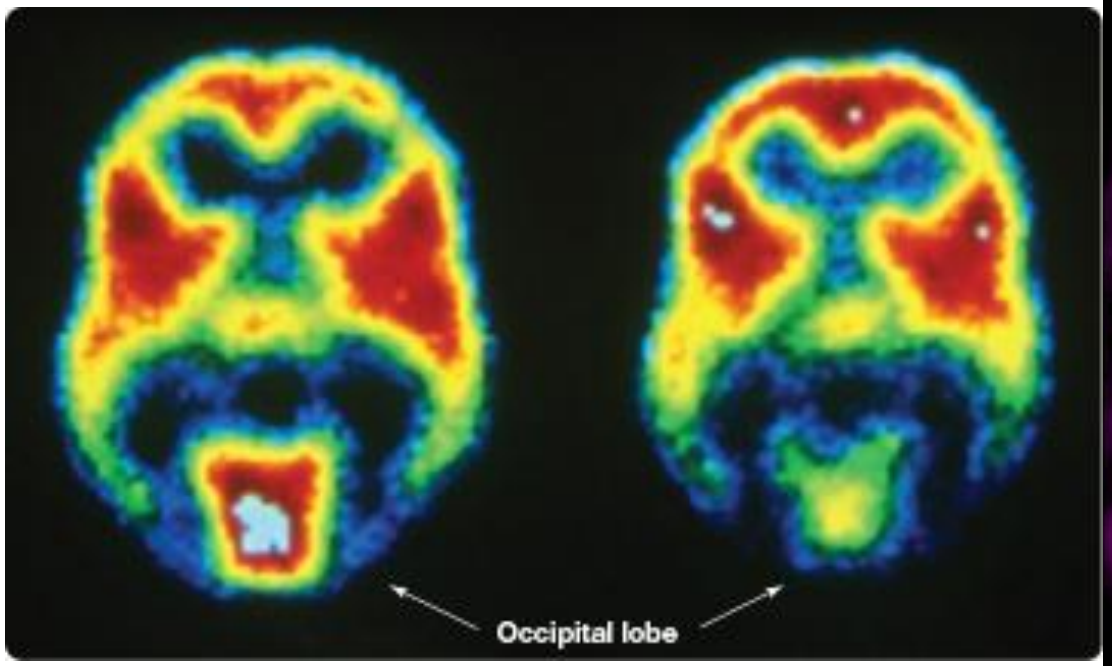
Computed tomography (CT)

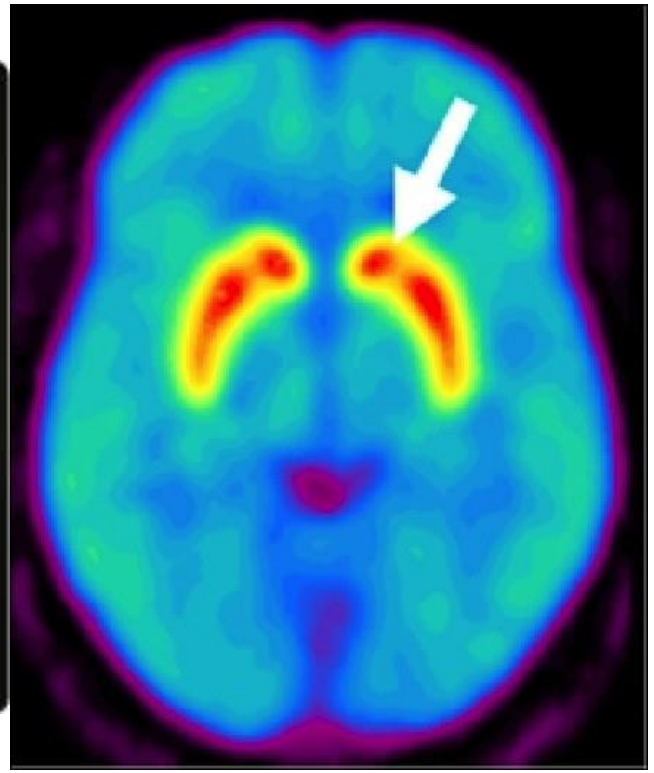
- 3-dimensional
- Not high-resolution



Radioactivity-Based Techniques

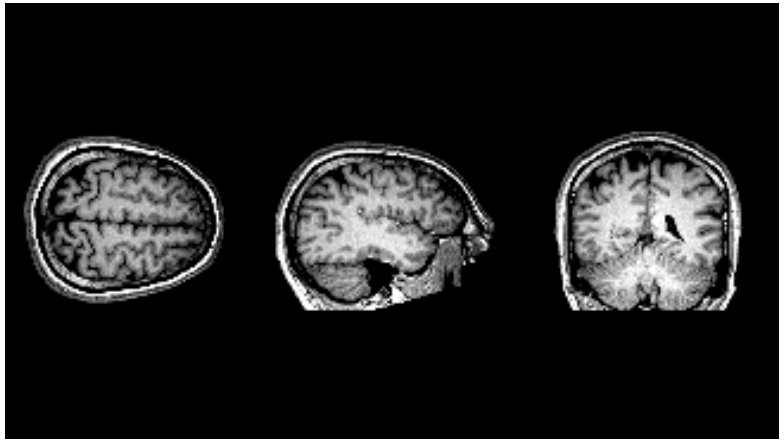
- Positron emission tomography (PET)
  - Highlights brain activity
  - Injection of flurodeoxyglucose (FDG)
  - Active neurons take up FDG
  - Radioactive cocaine

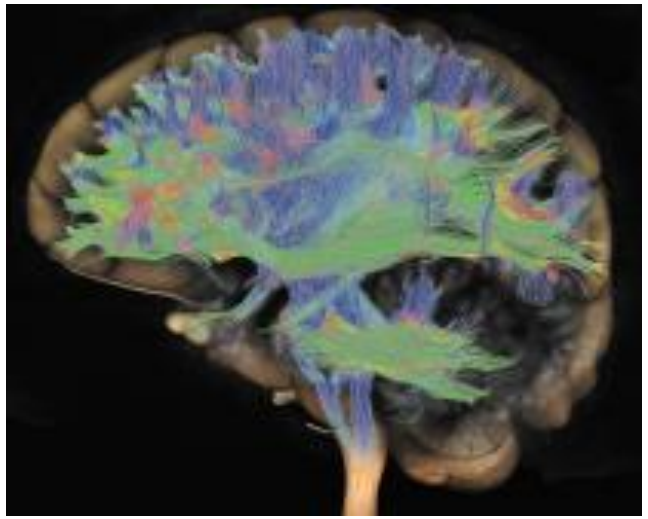


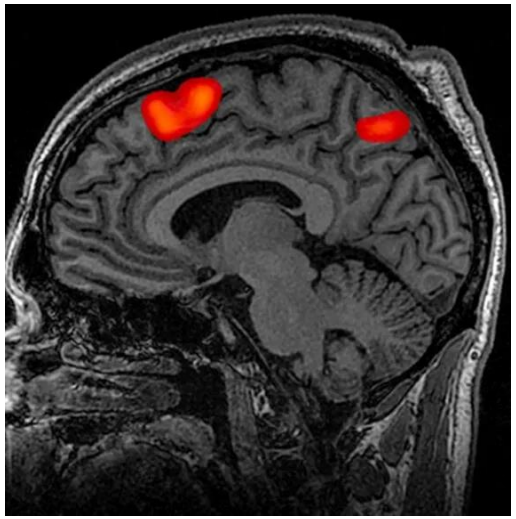


Magnetic Field-Based Techniques

- Magnetic resonance imaging (MRI)
  - Higher resolution than CT
  - Measures waves emitted by hydrogen atoms
- Diffusion tensor imaging (DTI)
  - Images axonal tracts
  - Based on rapid diffusion of water molecules
  - Allows viewing of interconnectivity
- Functional magnetic resonance imaging (fMRI)
  - More advantageous than PET
  - Signals are called “BOLD Signals”
  - Too slow to catch some neural activity

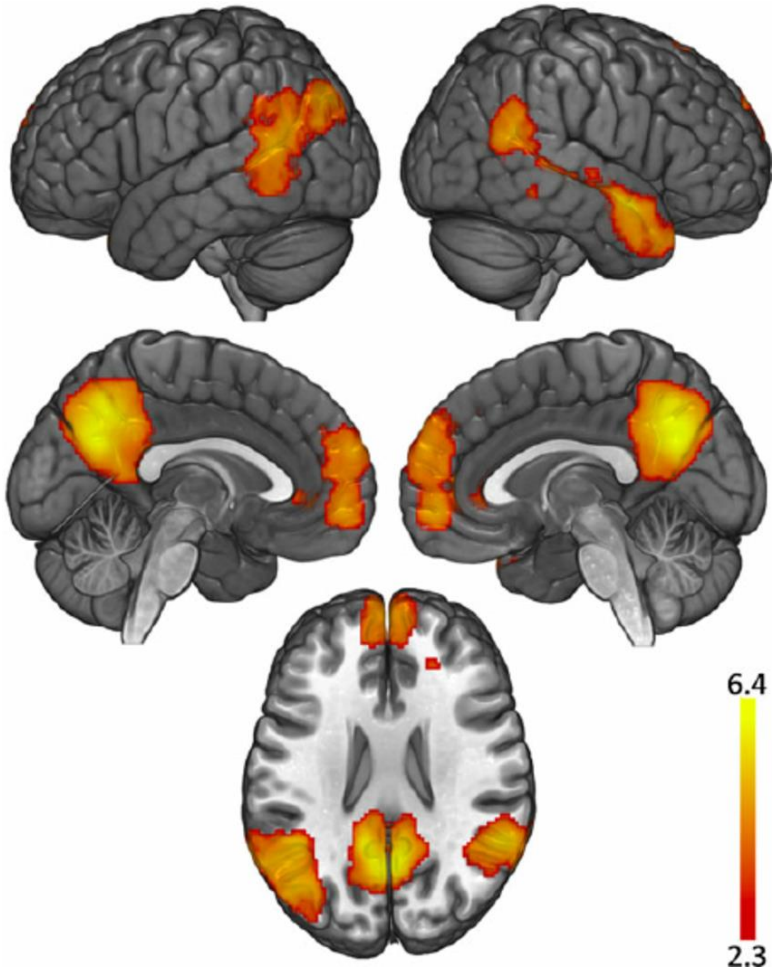




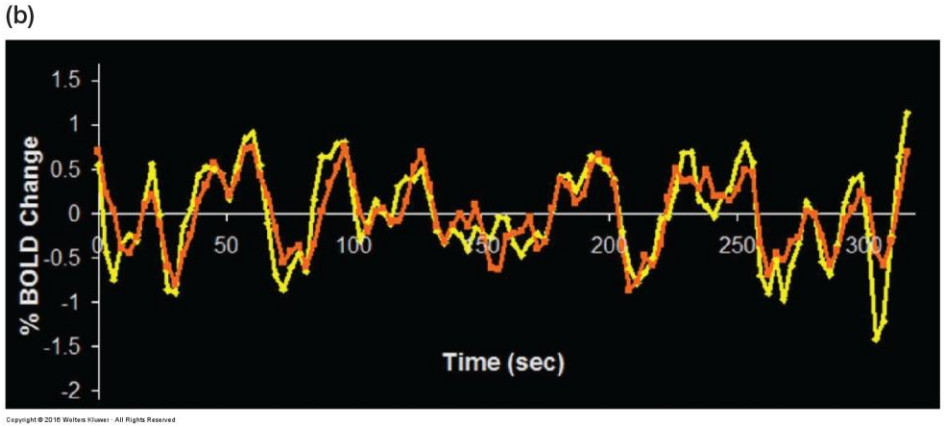


The default mode network

mPFC, posterior parietal cortex, PCC,
hipp, lateral temporal cortex

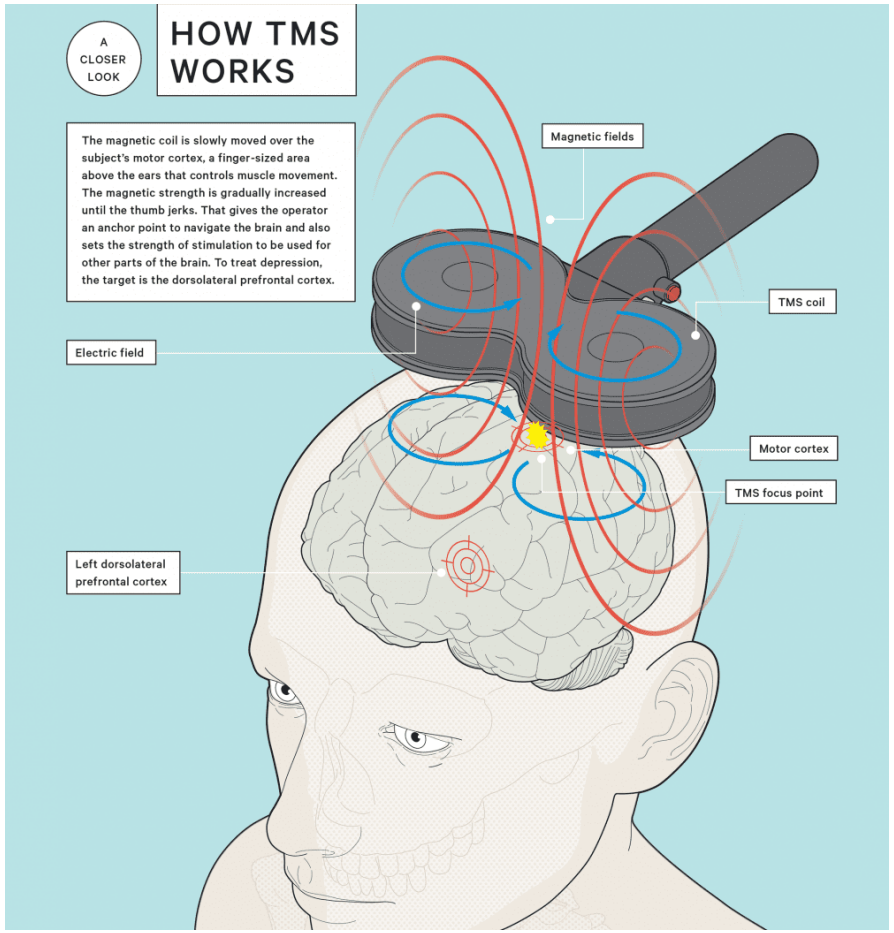


Resting state functional connectivity MRI

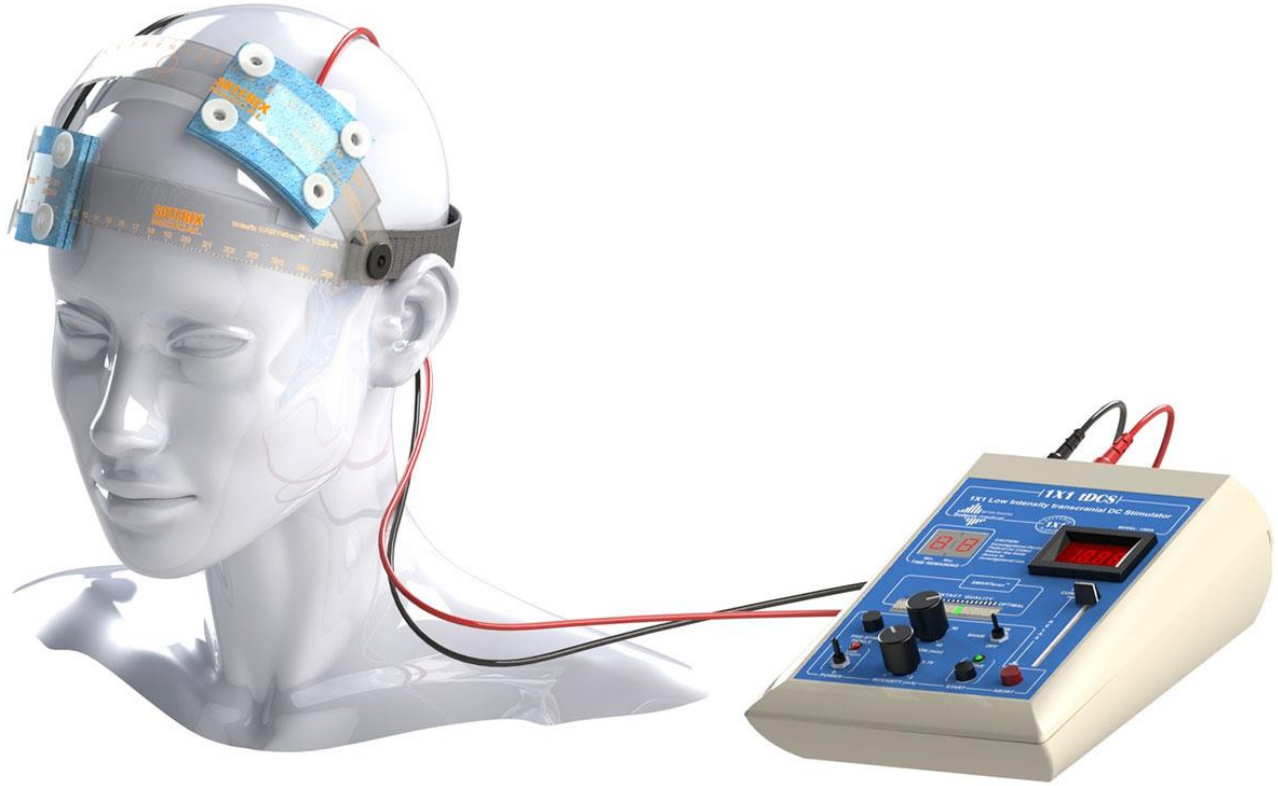


Transcranial Stimulation

Transcranial magnetic stimulation (TMS)

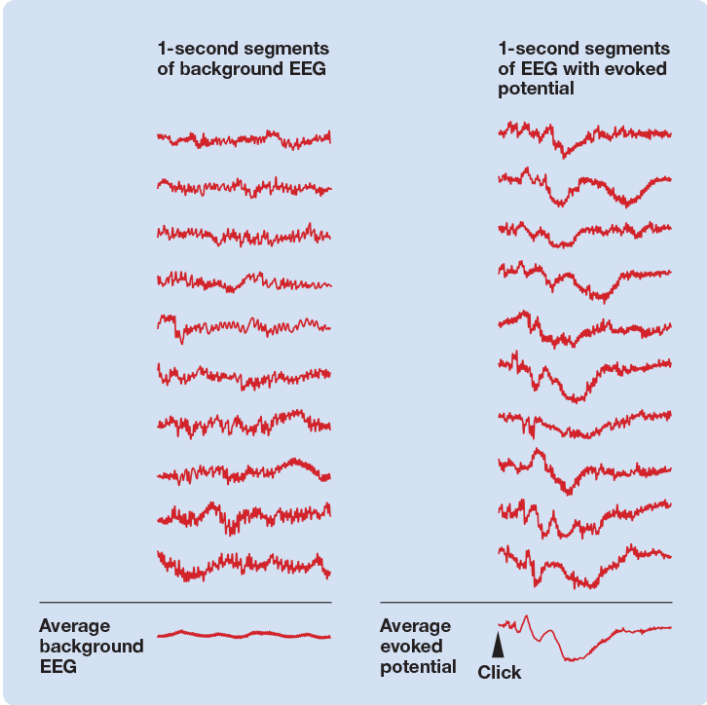


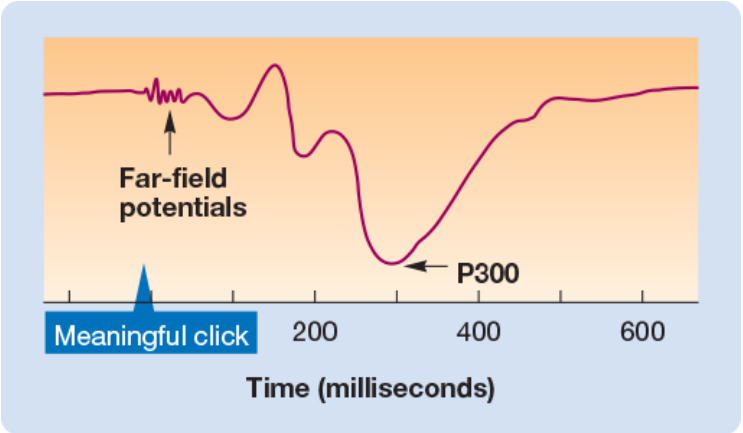
Transcranial direct current stimulation (tDCS)

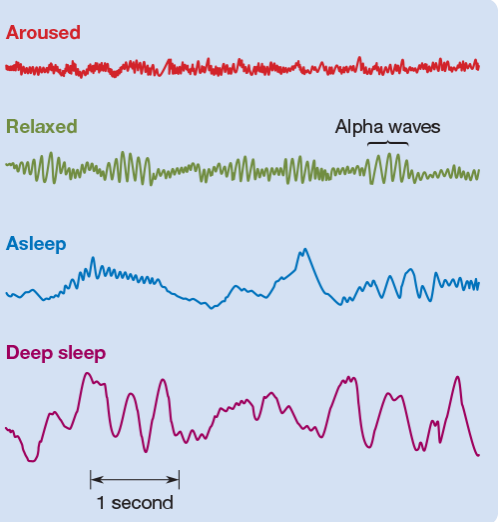


Psychophysiological Measures of Brain Activity

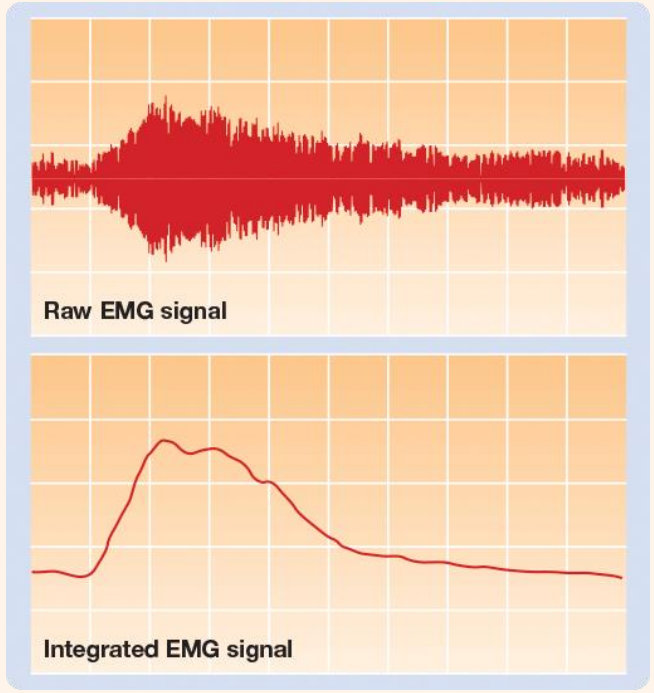
- Electroencephalography (EEG)
  - Measured by scalp electrodes
  - Event-related potentials (ERPs)
  - Sensory evoked potentials
  - Signal averaging
  - P300 wave

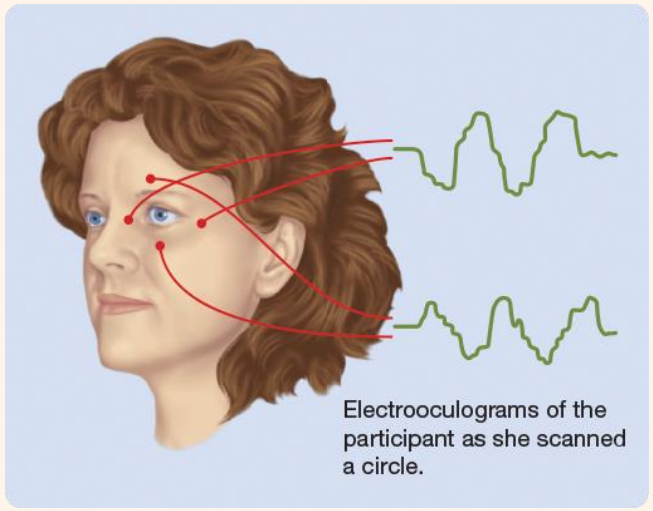




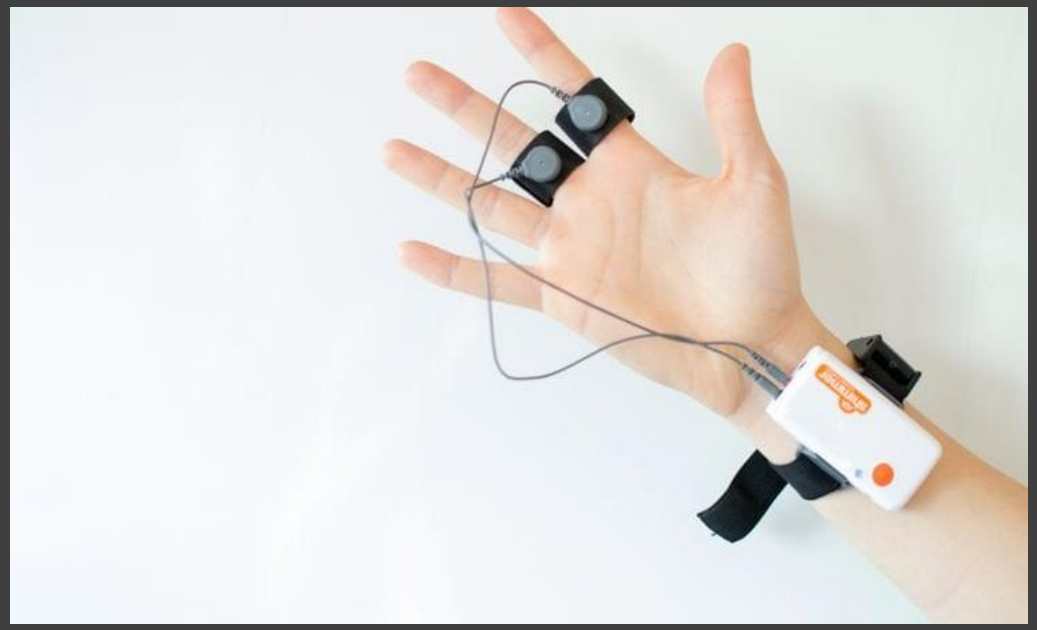


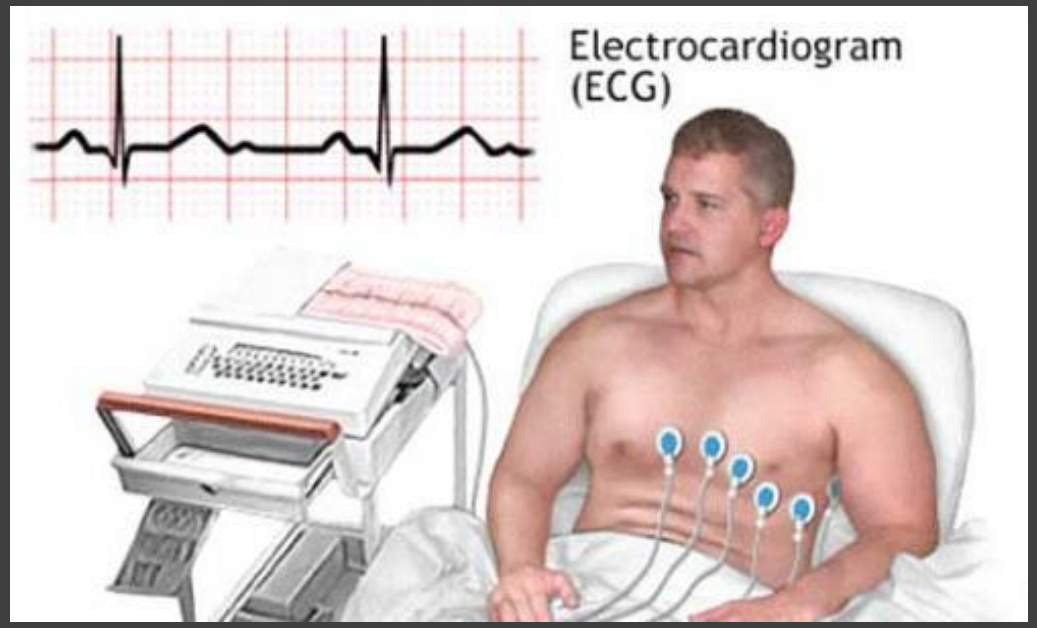
Psychophysiological Measures of Somatic Nervous System Activity





- Muscle tension
  - Measures level of tension in muscle
  - Called electromyogram (EMG)
- Eye movement
  - Measures eye movements
  - Called electrooculogram (EOG)



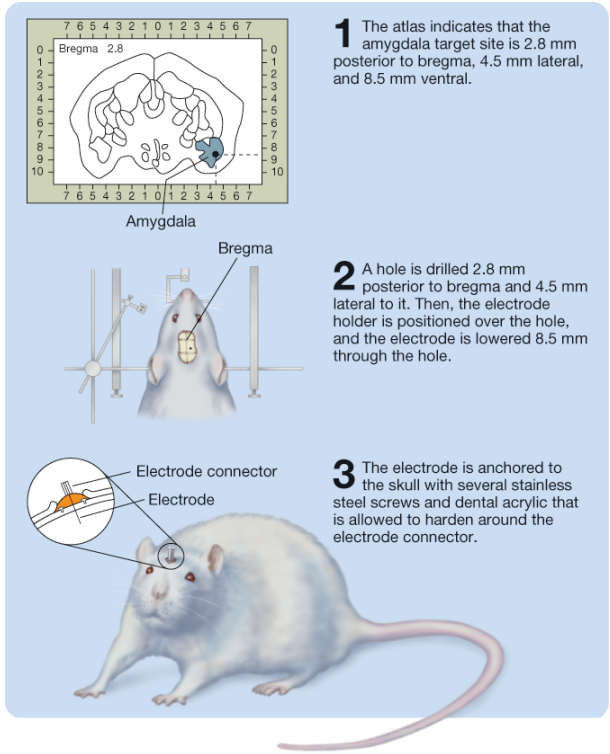


Psychophysiological Measures of Autonomic Nervous System Activity

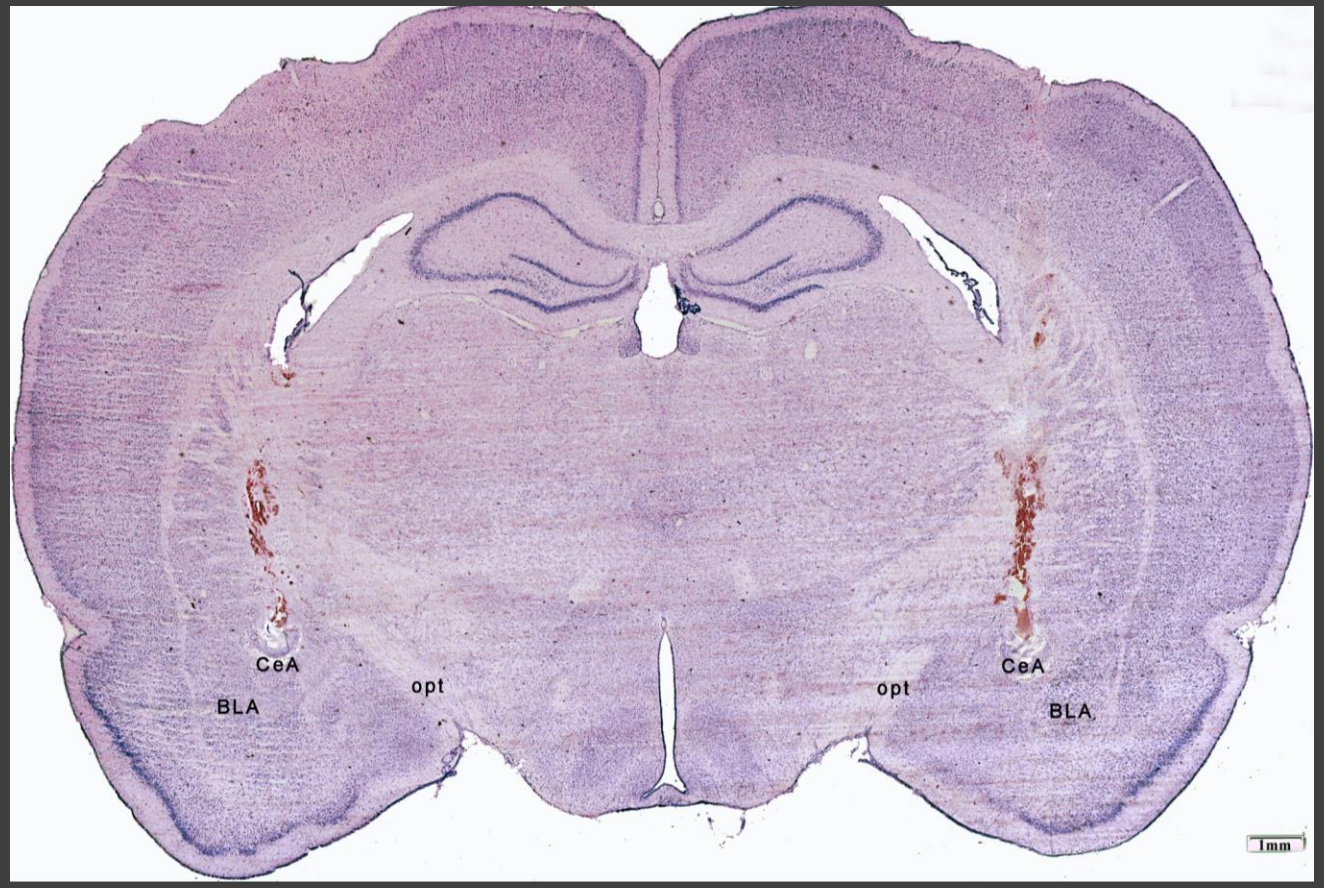
- Skin conductance
  - Skin conductance level (SCL)
  - Skin conductance response (SCR)
- Cardiovascular activity
  - Electrocardiogram (EKG) measures heart rate
  - Blood pressure: Systoles and diastoles
  - Plethysmography measures blood volume

Stereotaxic Surgery

- Employs stereotaxic atlas and instrument
- Allows accurate placement of lesions, probes, electrodes, or other instruments
- Reference point used is bregma



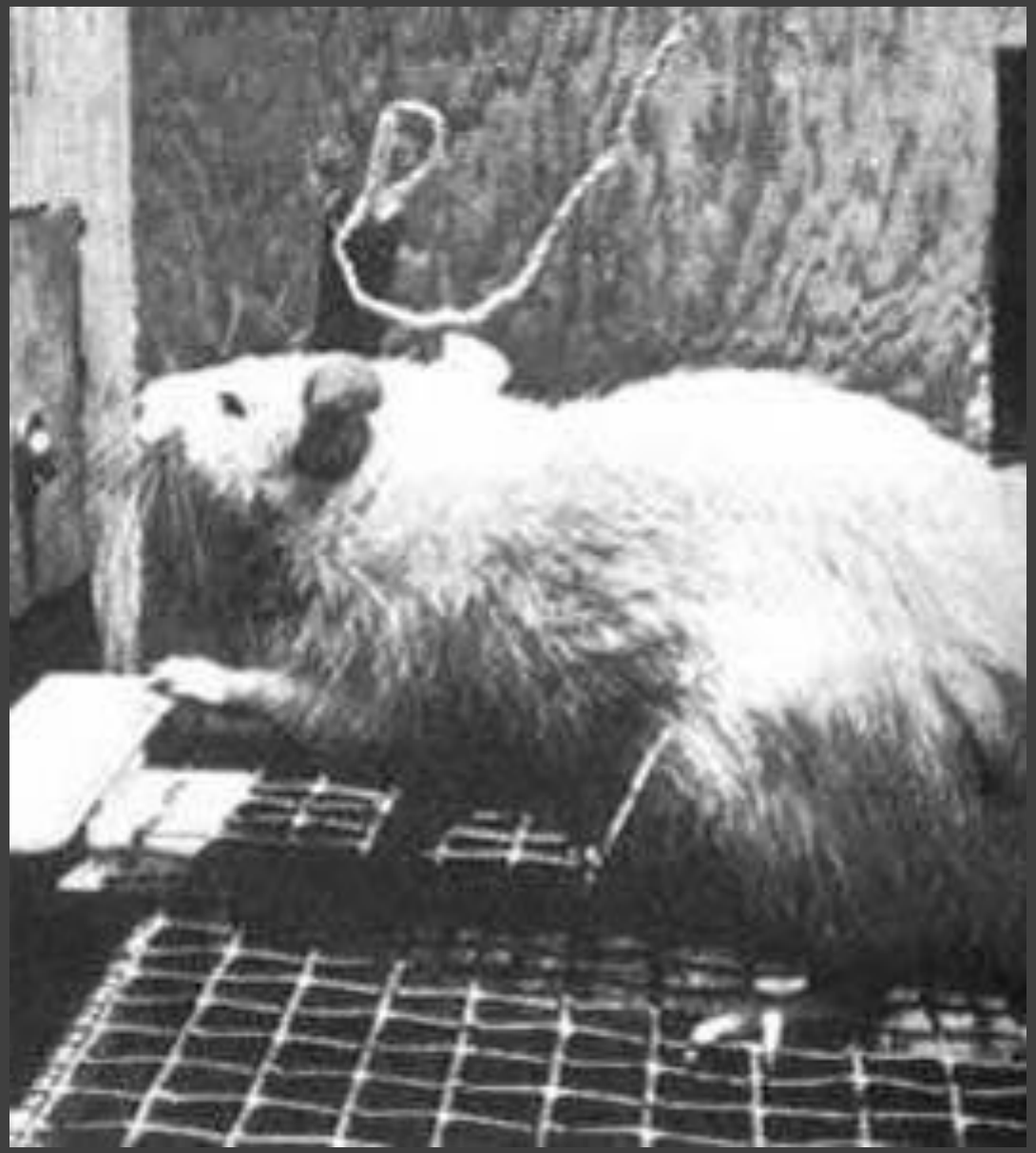
Lesion Method



- Non-selective lesions
  - Aspiration
  - Radio-frequency
  - Knife cuts
  - Reversible lesions
- Selective Lesions
  - Example: 6-hydroxydopamine is a chemical that destroys dopaminergic and noradrenergic neurons
- Interpreting lesion effects
- Unilateral and bilateral lesions

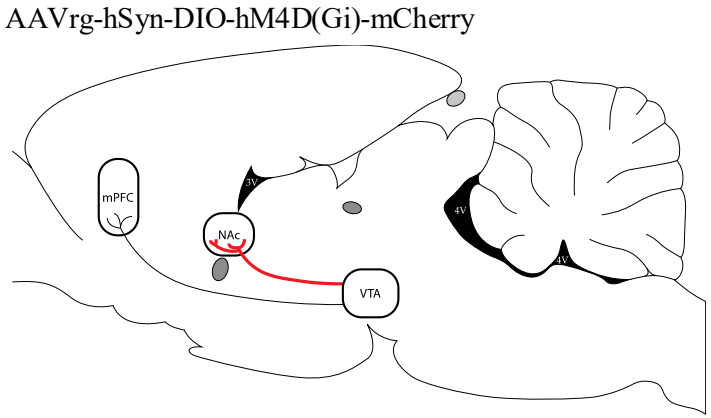
Electrical Stimulation

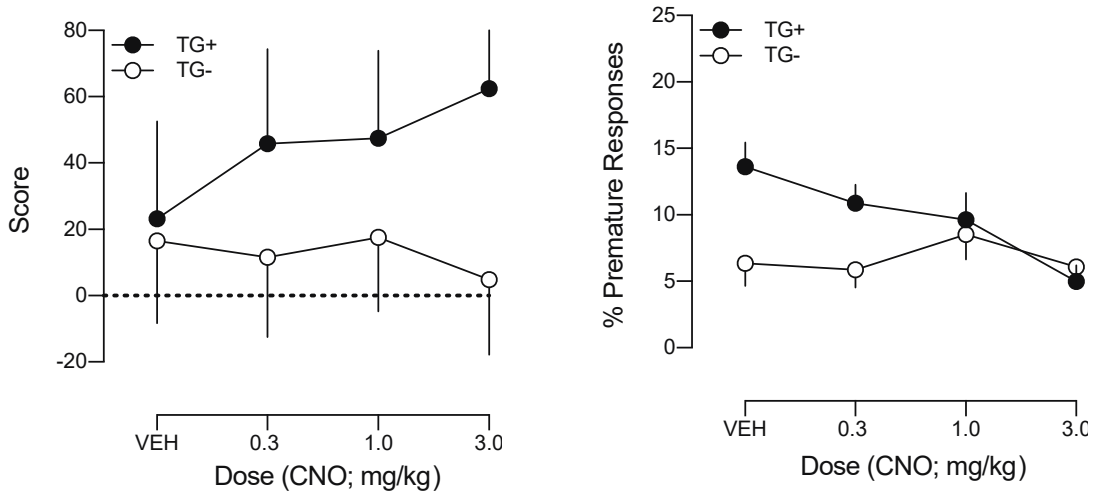
- Effects opposite of lesions
- Usually done prior to lesioning



Drug “Challenge”

- Potential Routes
  - Intramuscular (IM)
  - Intravenous (IV)
  - Subcutaneous (SC)
  - Intraperitoneal (IP)
    - Perhaps most common
  - Intraventricular
    - Overcomes problems with drugs passing the blood-brain barrier
  - Multiple doses is best (e.g. saline only, then low, med, high)
    - Within-subjects design





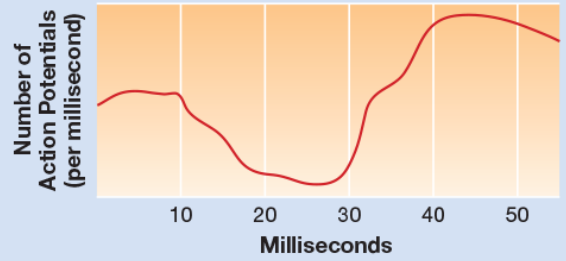
(Hynes et al., 2020)

Invasive Electrophysiological Recording

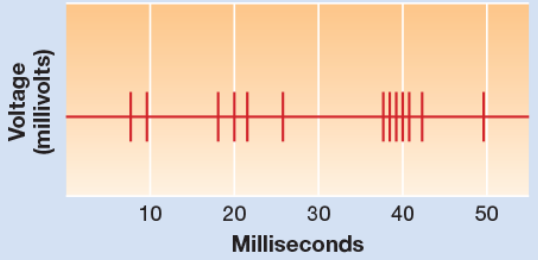
- Four invasive electrophysiological recording methods
  - Intracellular unit recording
  - Extracellular unit recording
  - Multiple-unit recording
  - Invasive EEG recording

An Intracellular Unit Recording
An intracellular microelectrode records the membrane potential from one neuron as it fires.

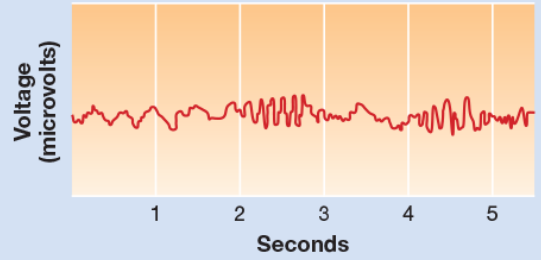
A Multiple-Unit Recording
A small electrode records the action potentials of many nearby neurons. These are added up and plotted. In this example, firing in the area of the electrode tip gradually declined and then suddenly increased.



An Extracellular Unit Recording
An extracellular microelectrode records the electrical disturbance that is created each time an adjacent neuron fires. In this example, each vertical line represents an action potential.



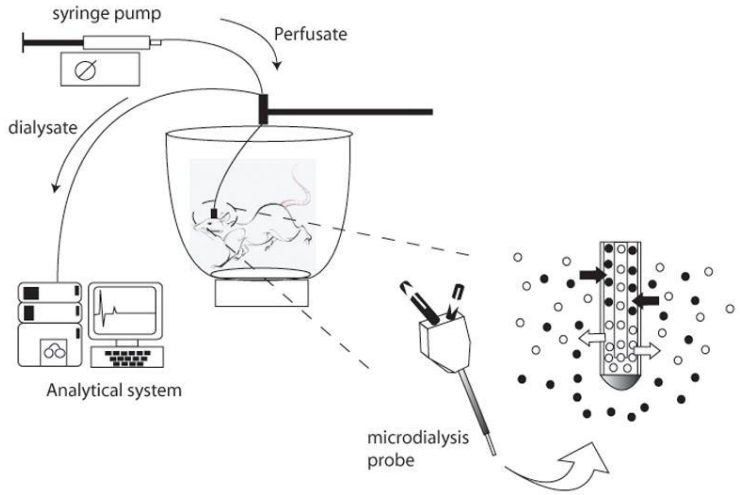
An Invasive EEG Recording
A large implanted electrode picks up general changes in electrical brain activity. The EEG signal is not related to neural firing in any obvious way.

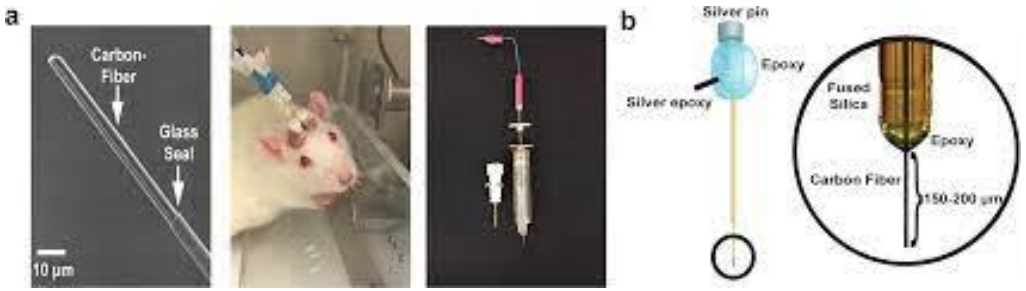


Measuring Chemical Activity in The Brain

- Cerebral dialysis
  - Directly measures specific neurotransmitters
  - U-shaped tube gathers sample
  - Analyzed by chromatograph

- Fast-scan cyclic voltammetry
  - Infers the presence of neurotransmitters
  - Use a carbon fibre (recording) and gold (reference electrode)
  - Analyze voltammogram





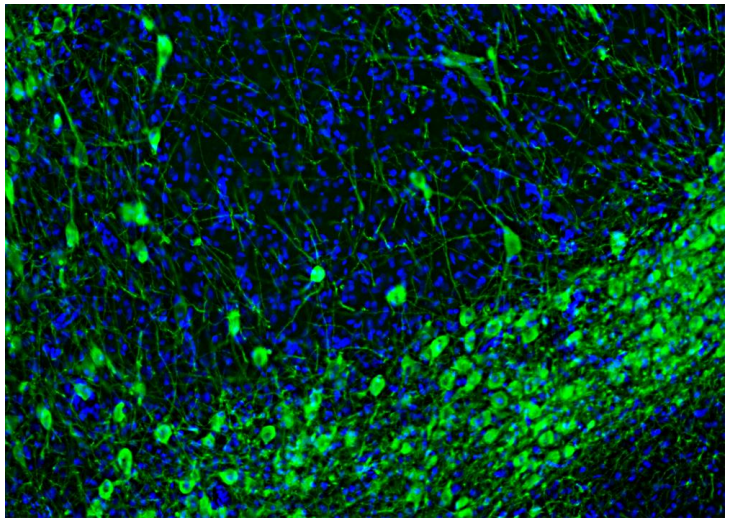
Locating Neurotransmitters and Receptors

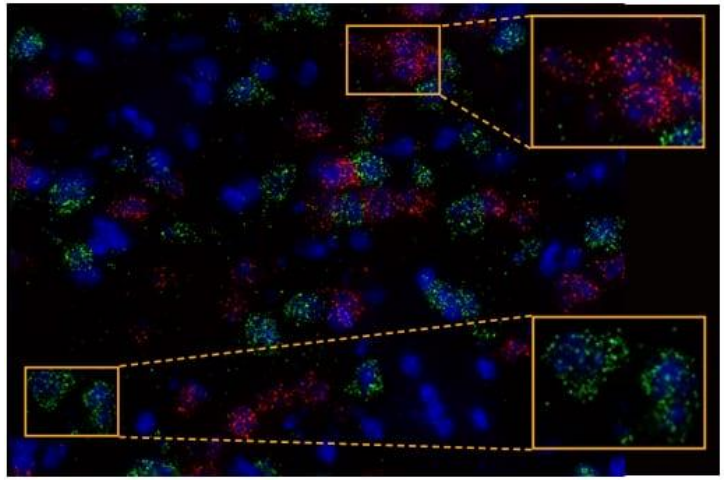
Immunocytochemistry

- Create antibodies to desired neurotransmitter or receptors
- Label antibody with dye or radioactivity
- Look for specific neuroproteins in brain slices

In situ hybridization

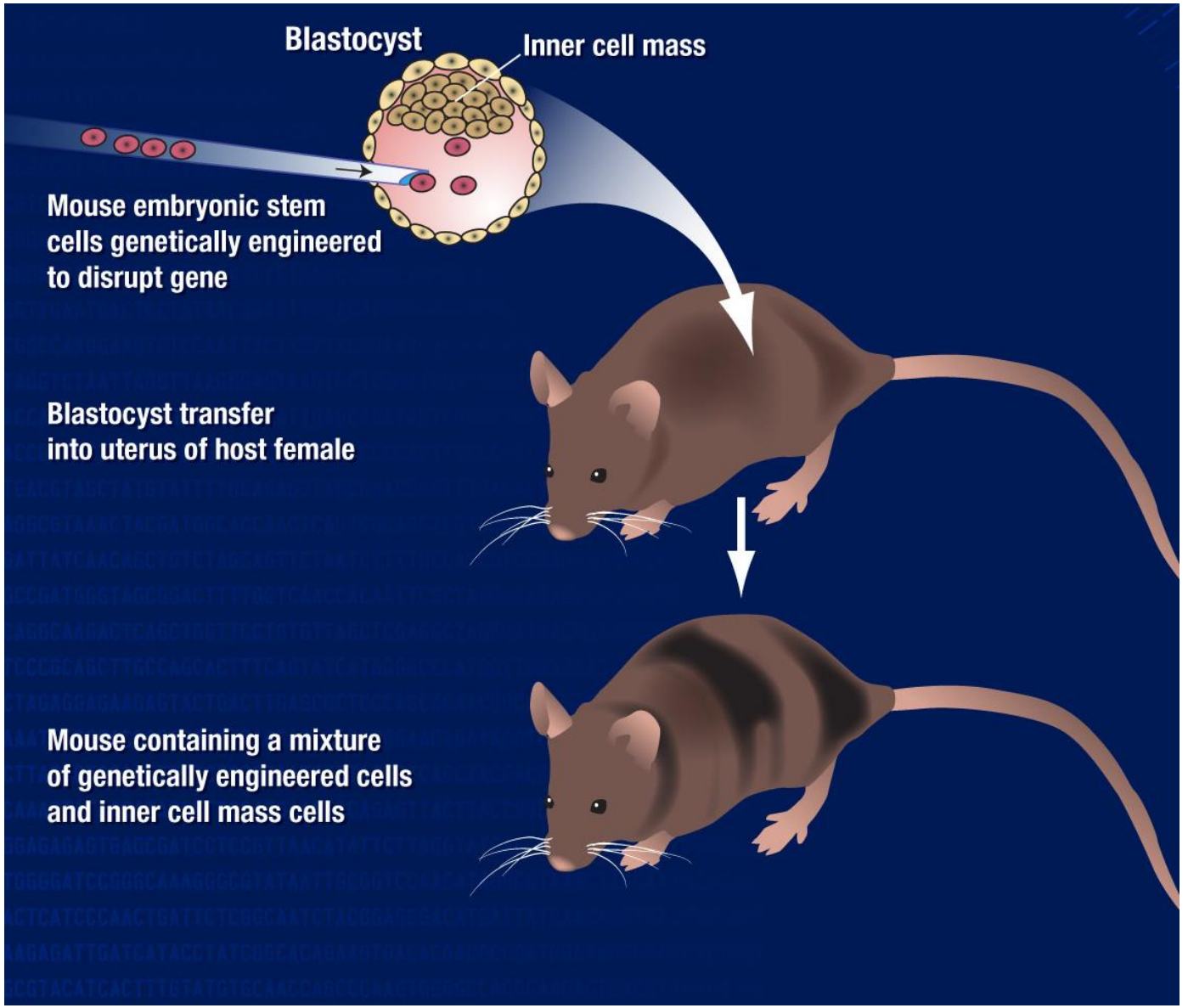
- Locates peptides and proteins in the brain
- Labeled hybrid RNA that complements mRNA is administered
- They bind and allow scientists to locate the neuroprotein of interest





Gene Knockout Techniques

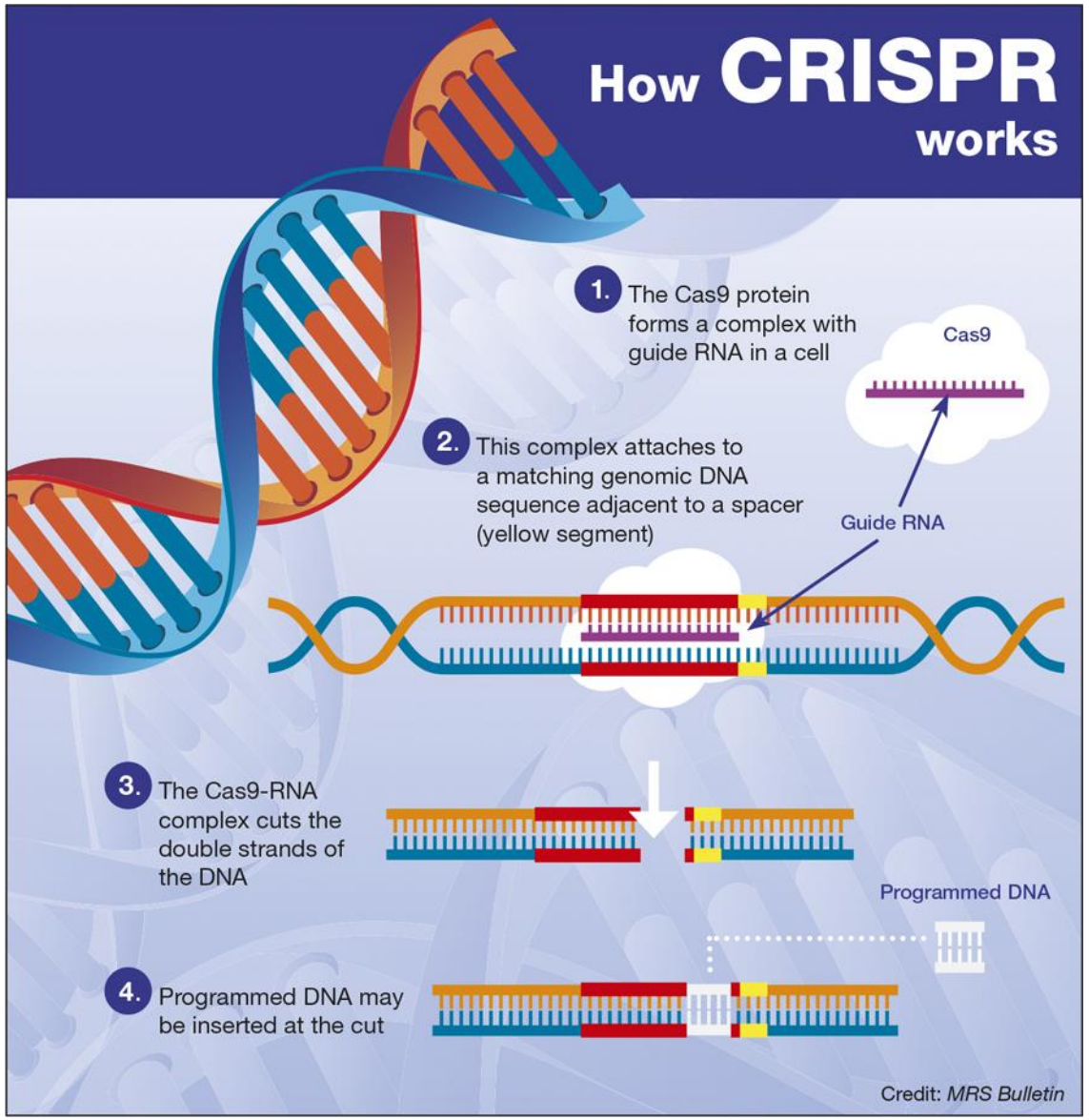
- Melanopsin Knockout Mice
  - Protein found in retina
  - Implicated in circadian rhythms
  - Did not eliminate rhythms, so it is not the only factor



Gene Editing Techniques

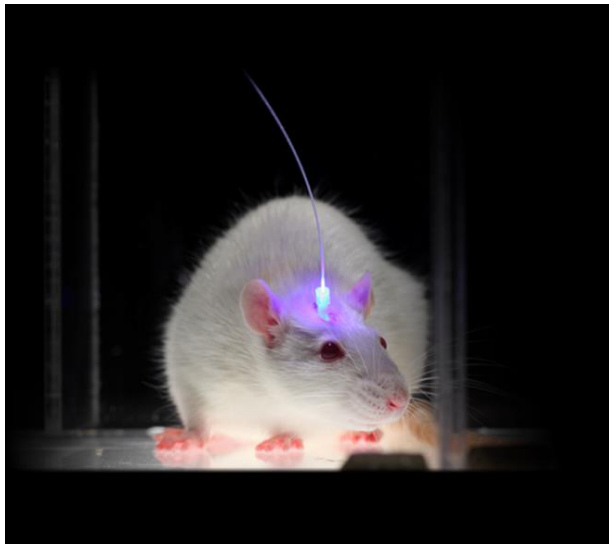
- CRISPR/Cas9 method shows exceptional promise
  - Cas9 protein is linked to guide-RNA
  - Integrated into a virus
  - Injected into an organism
  - Ethical implications:

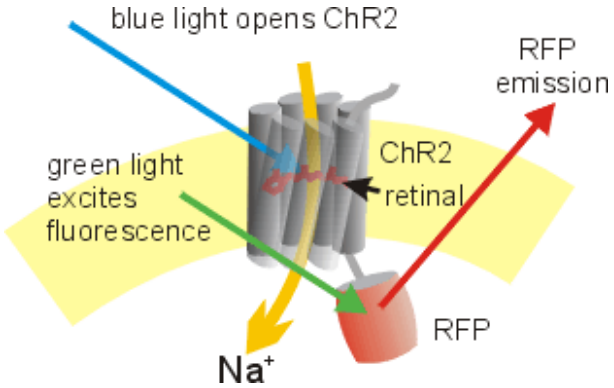
https://www.youtube.com/watch?v=SuSP-tzogyY



Optogenetics

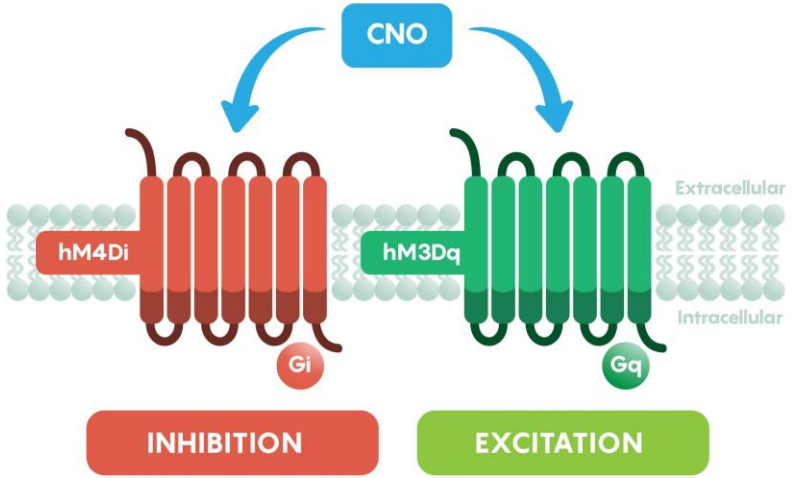
- Introducing: light-sensitive ion channels!
  - Channelrhodopsins
- Use system-specific transcription factors
- Can be used for both recording/mapping and manipulation

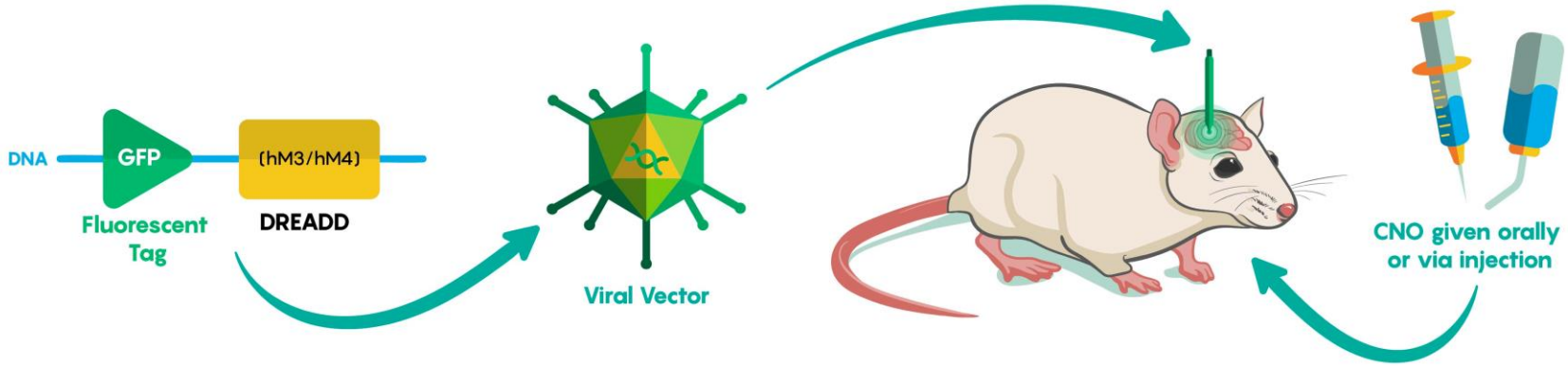




DREADDs

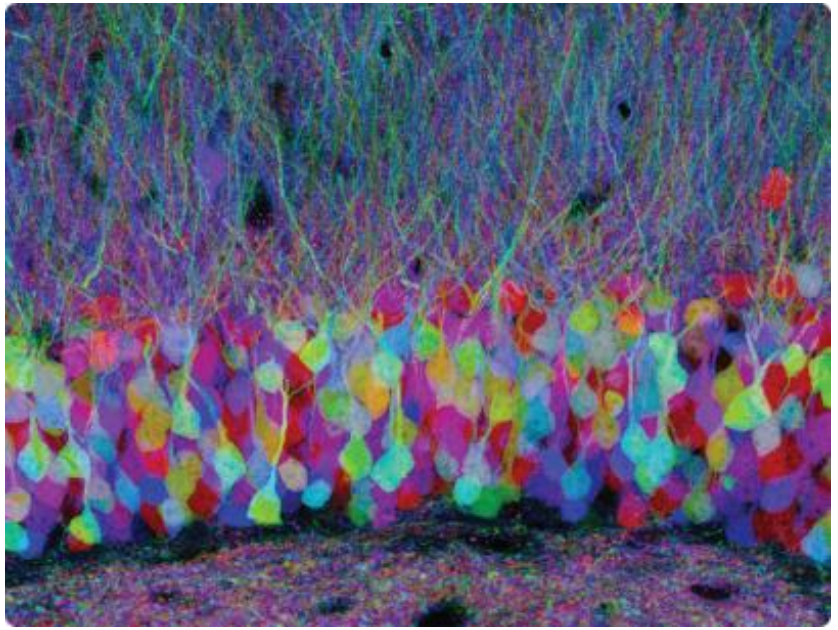
(Designer Receptors Exclusively Activated By Designer Drugs)

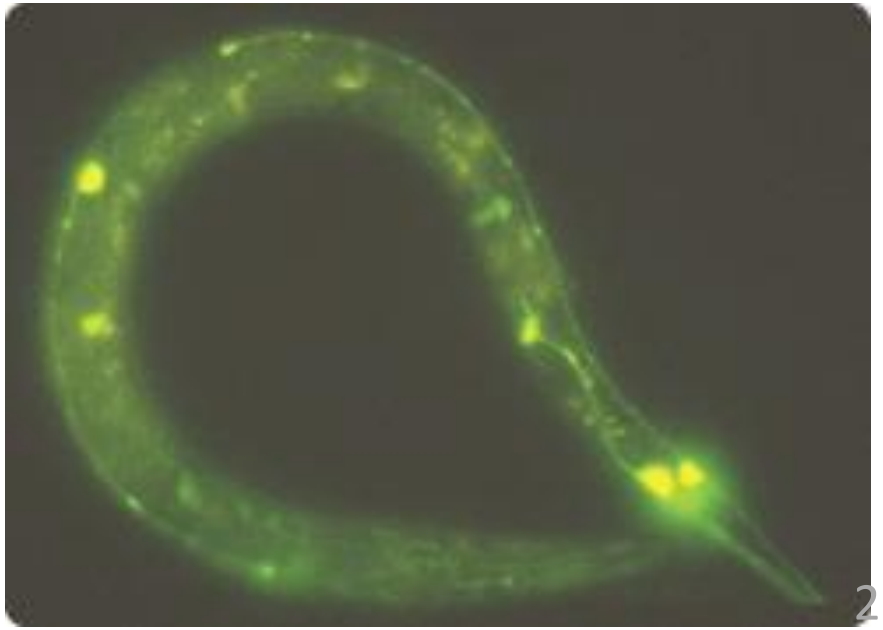




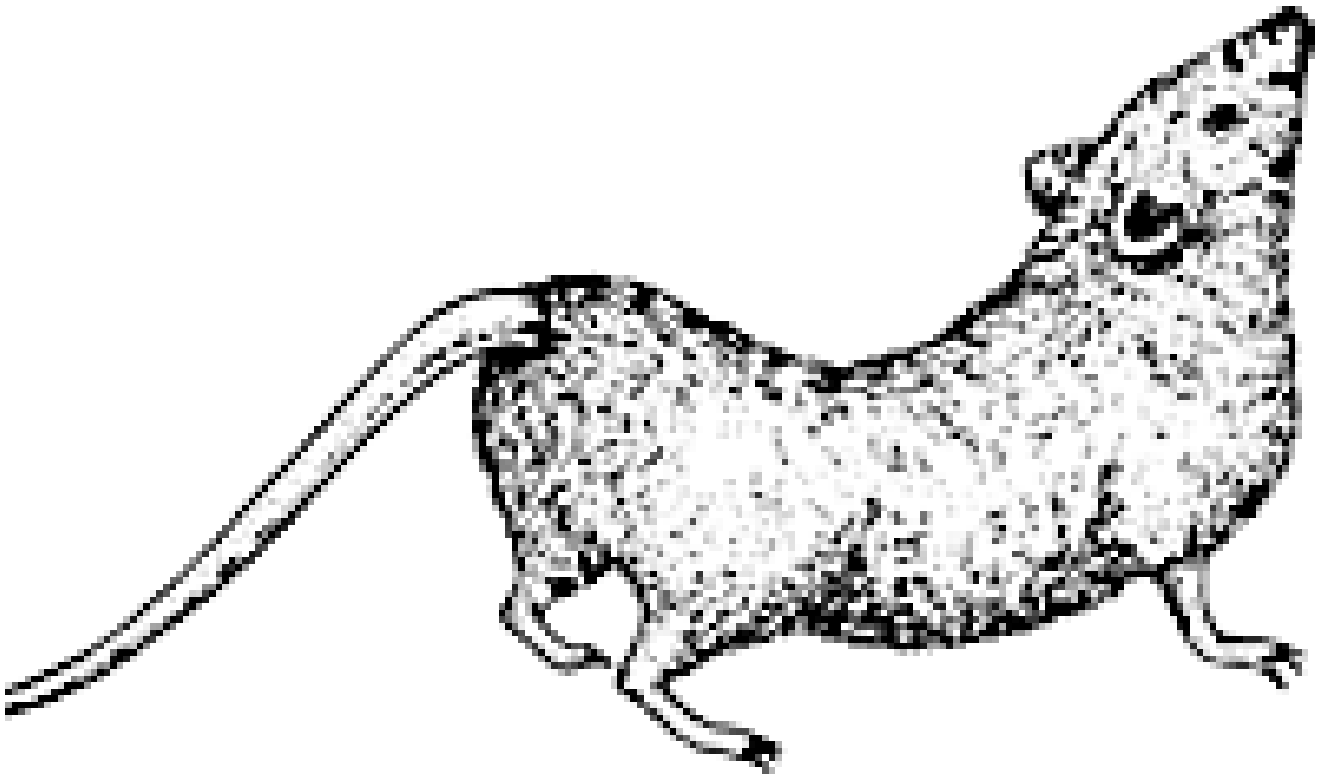
Fantastic Fluorescence and the Brainbow

- Green fluorescent protein
  - Inserted into target cells
  - Expose to blue light
  - Bright green fluorescence
  - Can be altered to fluoresce in different colors





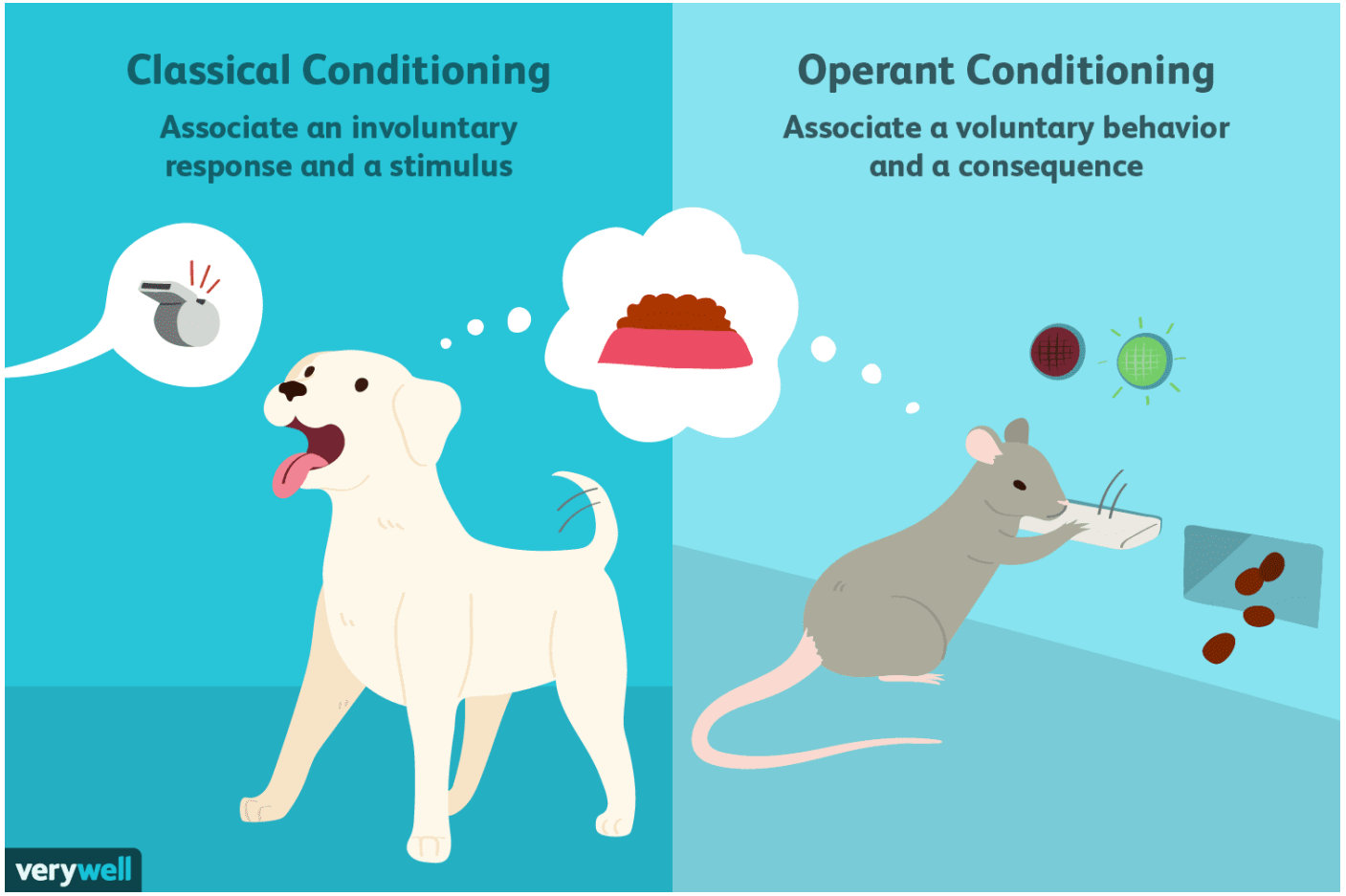
Paradigms for the Assessment of Species-Common Behaviour



- Open field test
- Tests of aggressive and defensive behaviors
- Tests of sexual behavior
  - Females
    - Lordosis
  - Males
    - Mounts to intromission
    - Intromissions to ejaculation
    - Time to remount

Traditional Conditioning Paradigms

- Pavlovian conditioning
  - UCR, UCS, CR, CS
- Operant conditioning
  - Reinforcement
  - Punishment



Seminatural Animal Learning Paradigms

- Conditioned taste aversion
  - One-trial learning
- Radial arm maze
  - Studies foraging behaviors
- Morris water maze
  - Studies rat spatial ability
- Conditioned defensive burying
  - Studies anxiety treatments