

# Syllabus

new frontiers of neurobiology  
and systems neuroscience

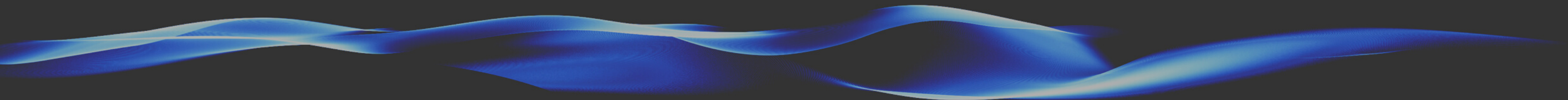
genetic engineering +  
applications to neurological  
disorders

novel therapeutics for  
treatments

ethical implications

## Week 4: Neuroscience and Computing / AI

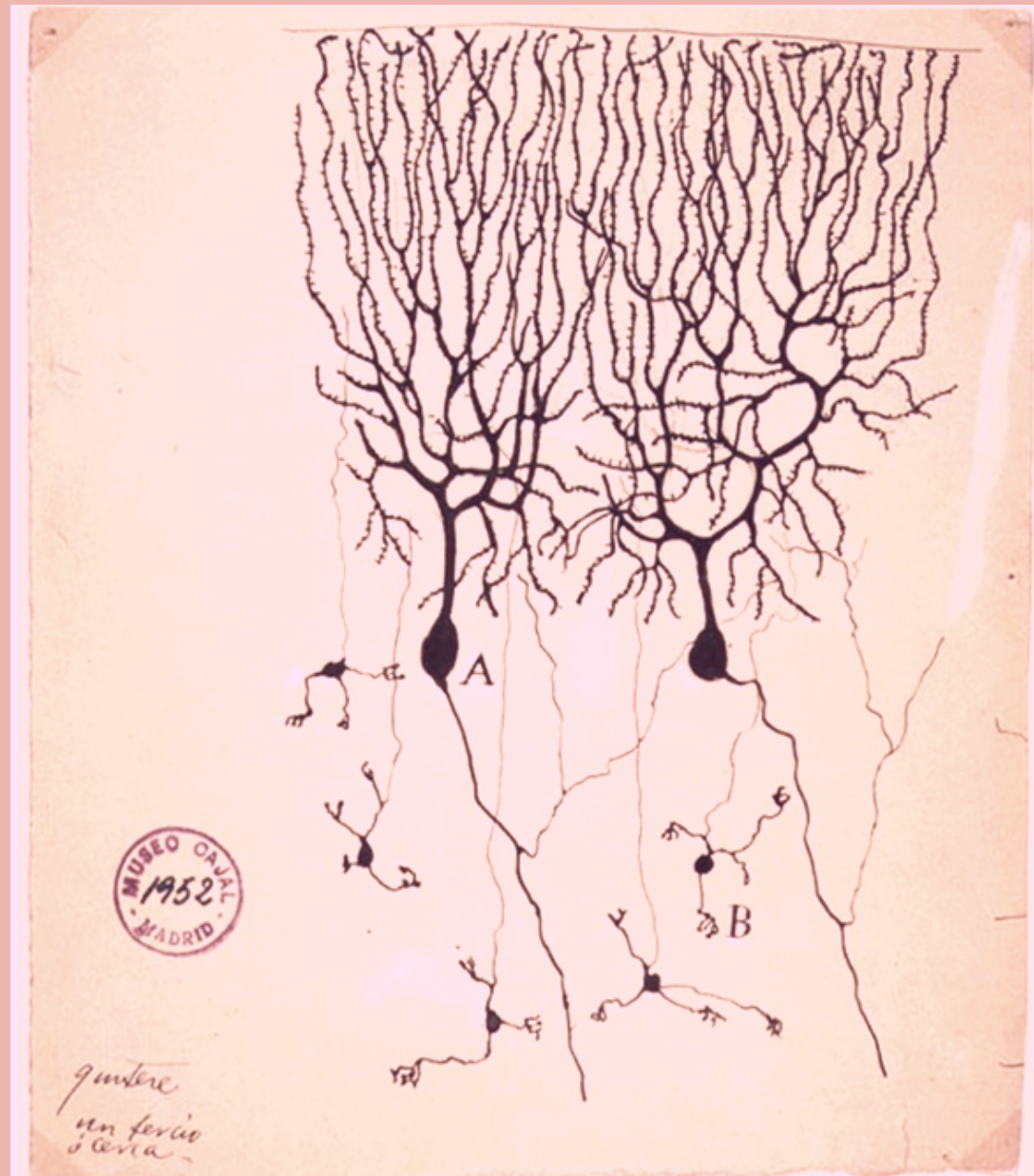
w/ Jay Iyer and Arvid Larsson



# The Frontiers of Neurobiology and Modern Biotechnology

*Jay Iyer, Ambassadour - Louisiana, US*

# Neurobiology



Santiago Ramon y Cajal (1899)  
Neurons in the pigeon cerebellum

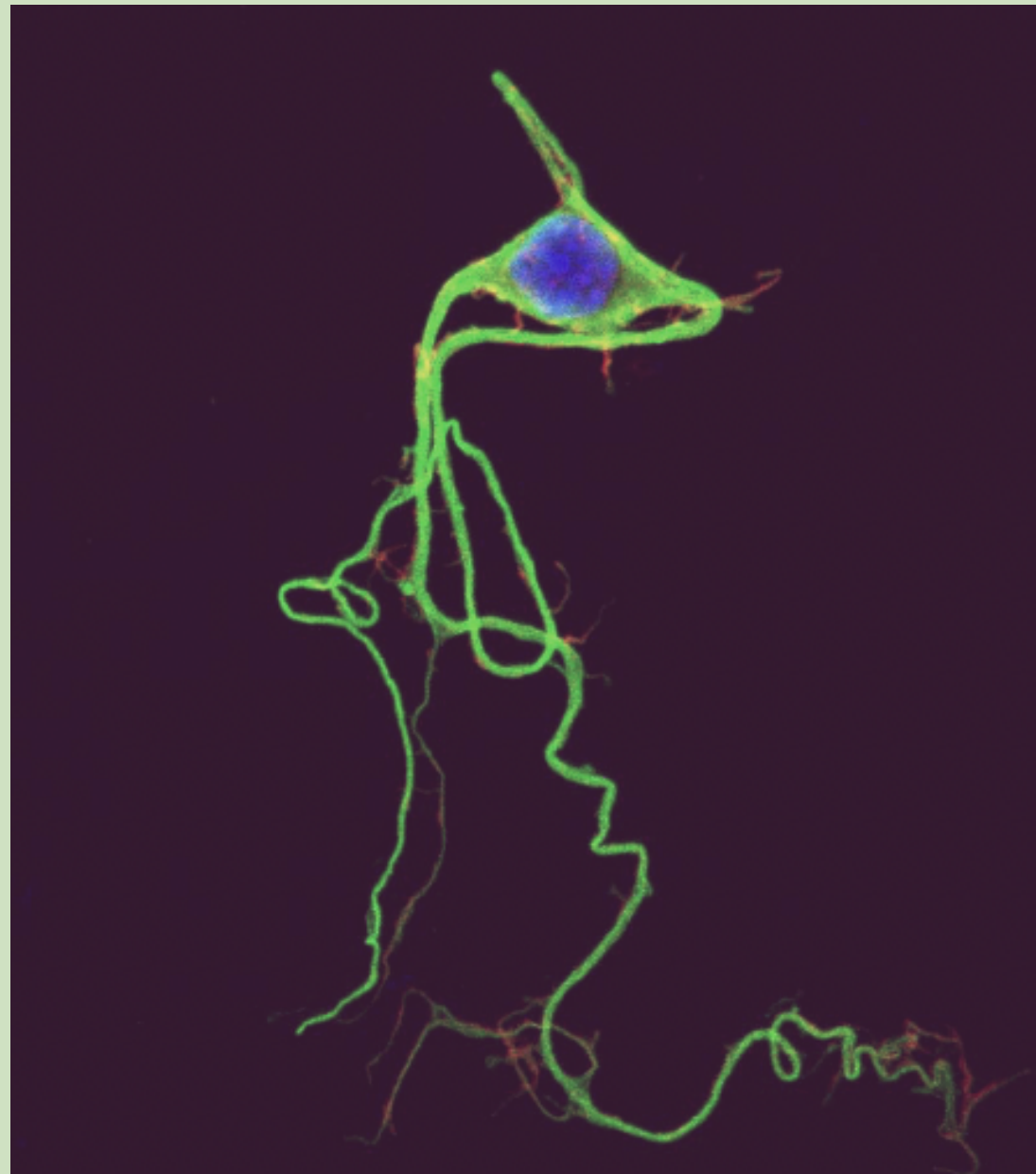


## WHAT AND WHY

- The scientific study of the nervous system
- Purpose is to understand properties of neurons and treat disease



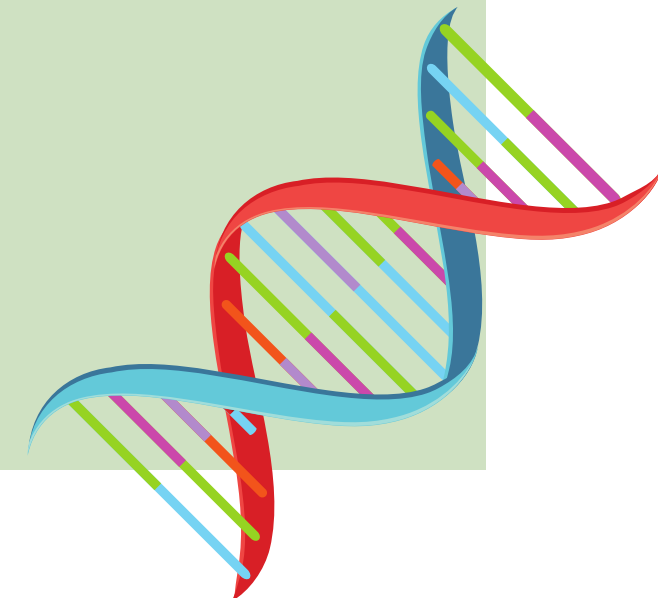
# Modern Neurobiology



Stained Neuron in a Chicken Embryo  
Creative Commons

## ADVANCEMENTS

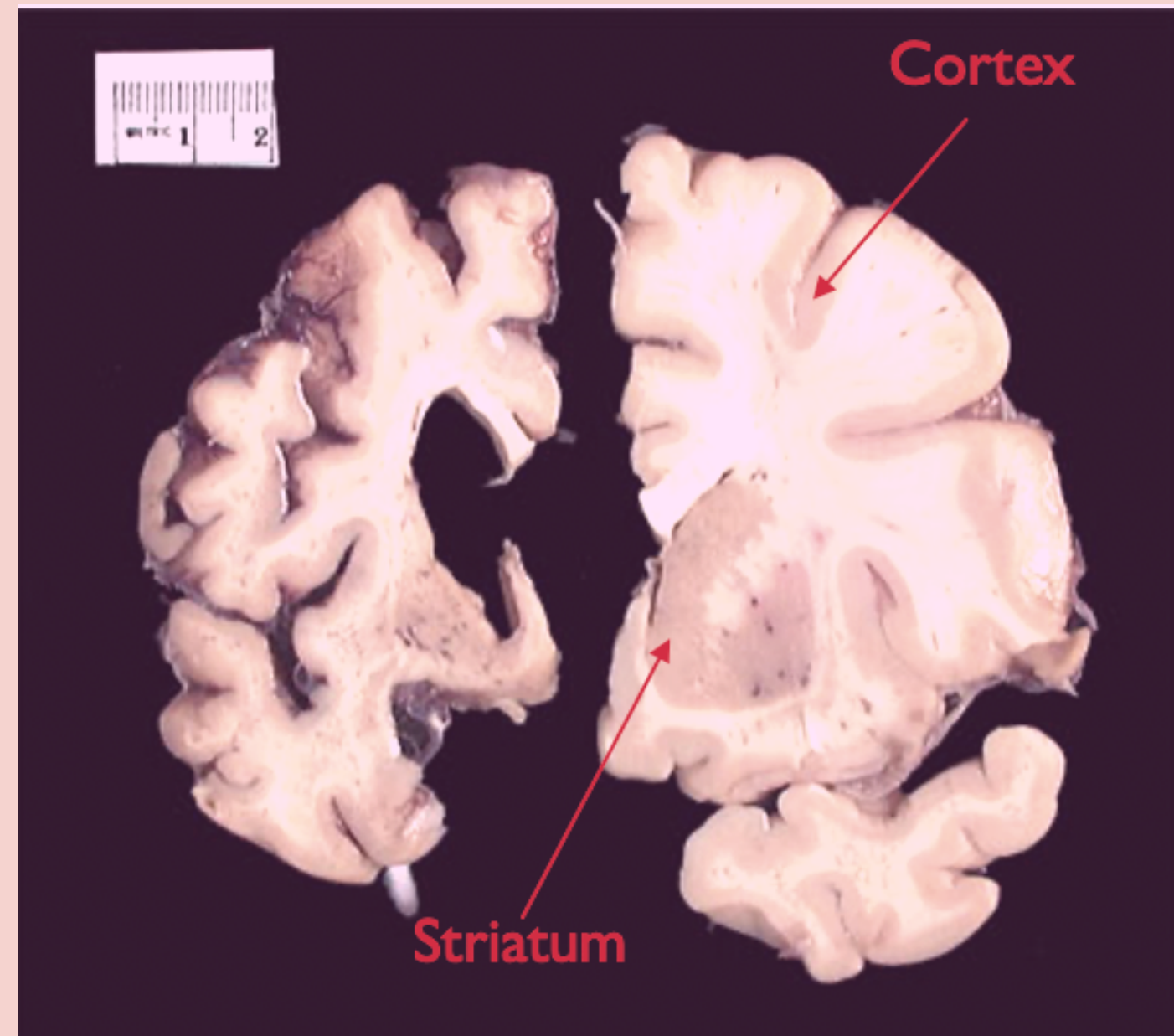
- Study of the nervous system has increased significantly in the 20th century
- Catalyst: Advances in molecular biology and biotechnology
  - Polymerase chain reaction (PCR)
  - Western Blotting
  - DNA extraction
  - Artificial synthesis of macromolecules



# Neurological Disorders

## DISORDERS

- Any disorder of the nervous system
- Brain and spinal cord highly susceptible if compromised
  - Neurodegeneration
  - Atrophy



HD

NORMAL

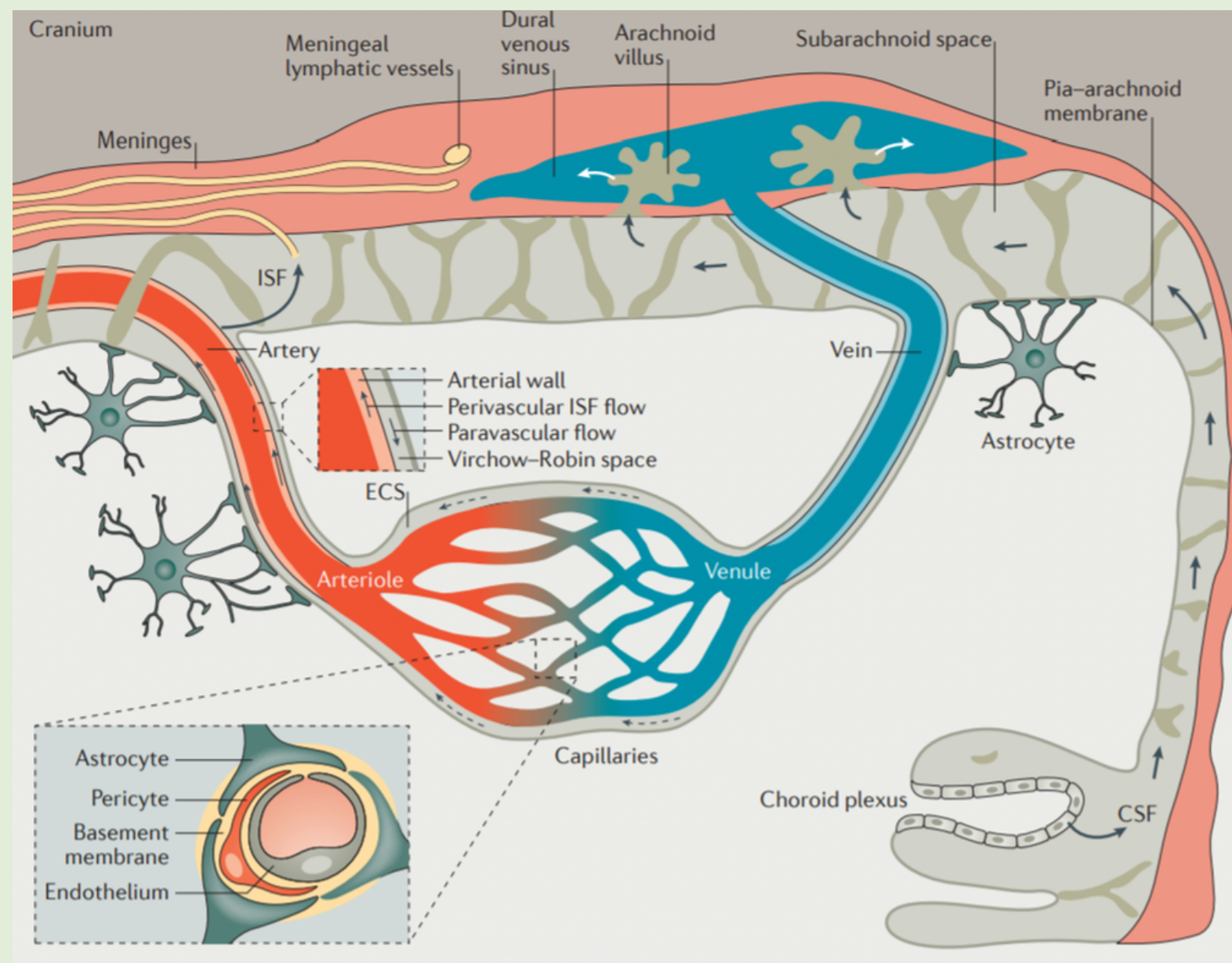
Image from the Harvard Brain Tissue Resource Center

# Challenges in Their Treatment

## PROBLEMS

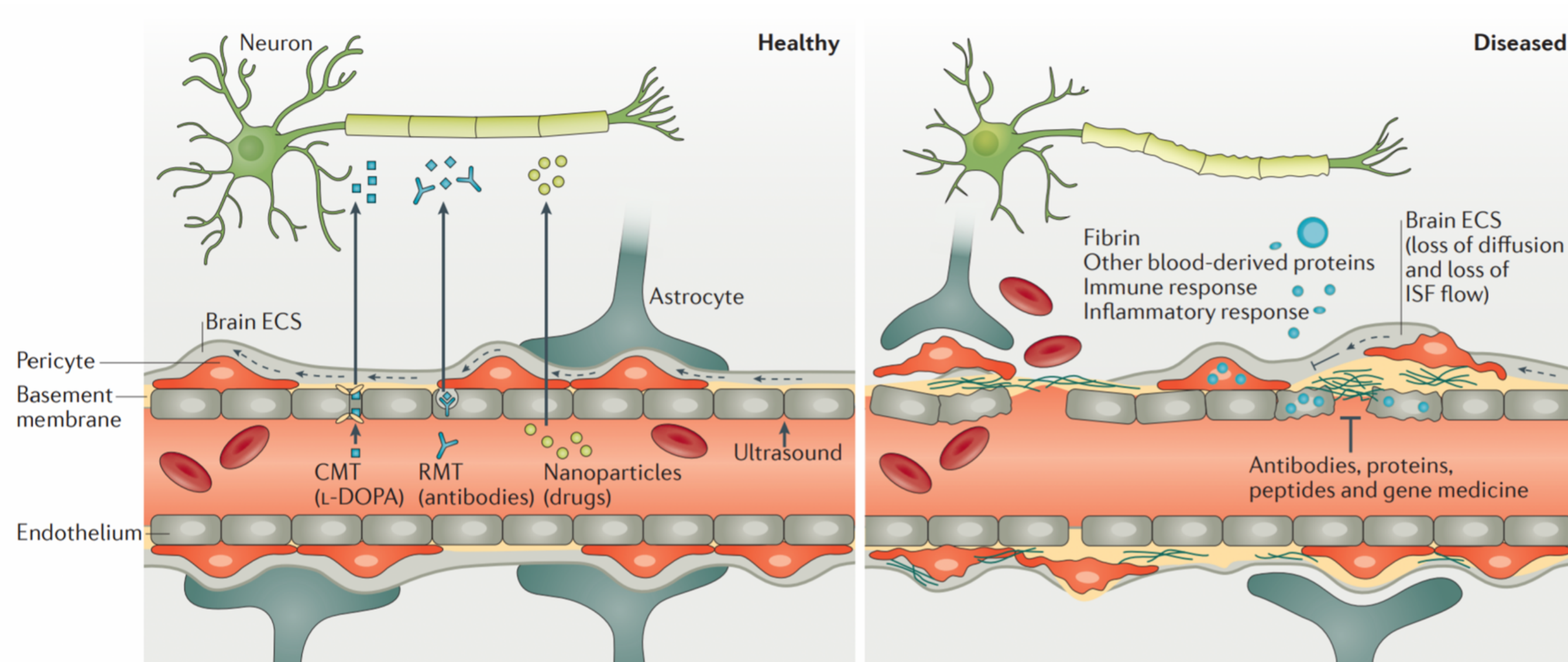
- Blood-brain barrier
- Complexity of the brain
- Over 100 trillion neuronal connections

Blood-brain barrier: Brain capillaries are a key site

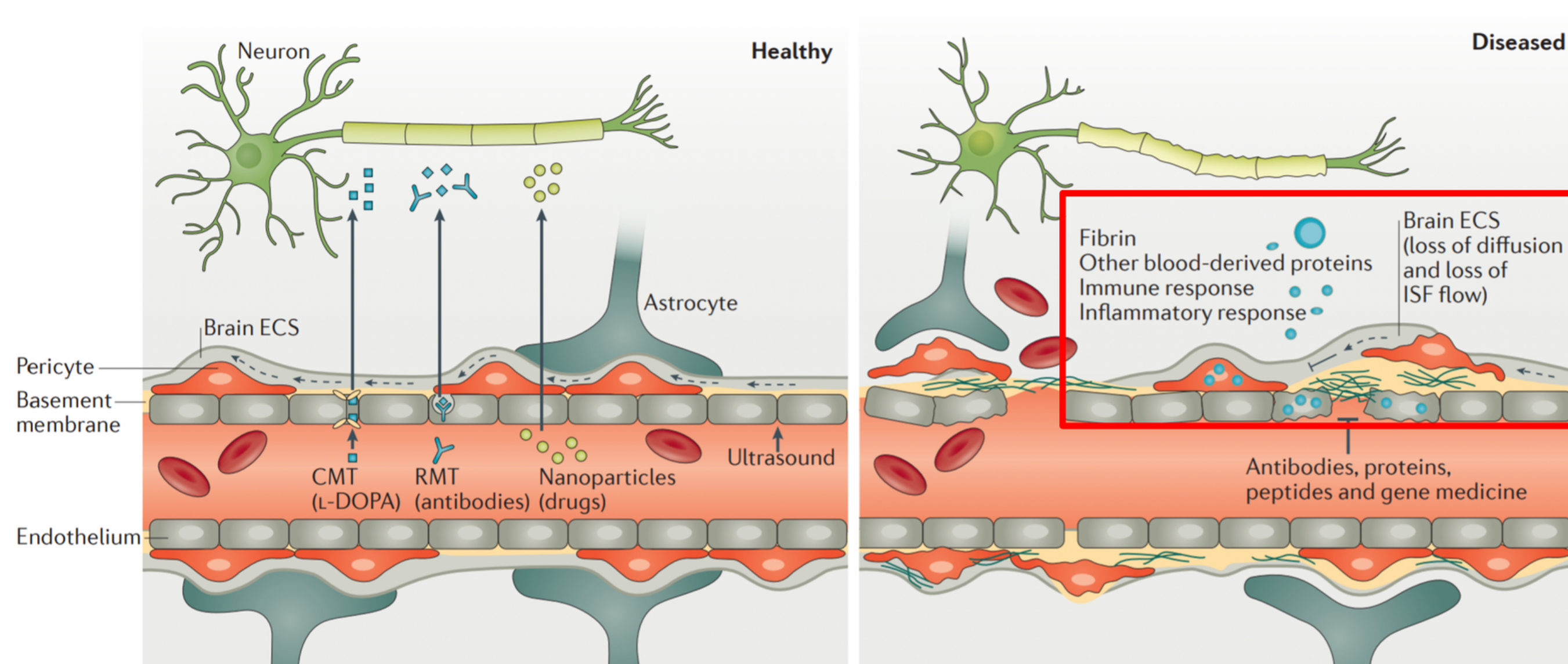




# Challenges in Their Treatment



# Challenges in Their Treatment





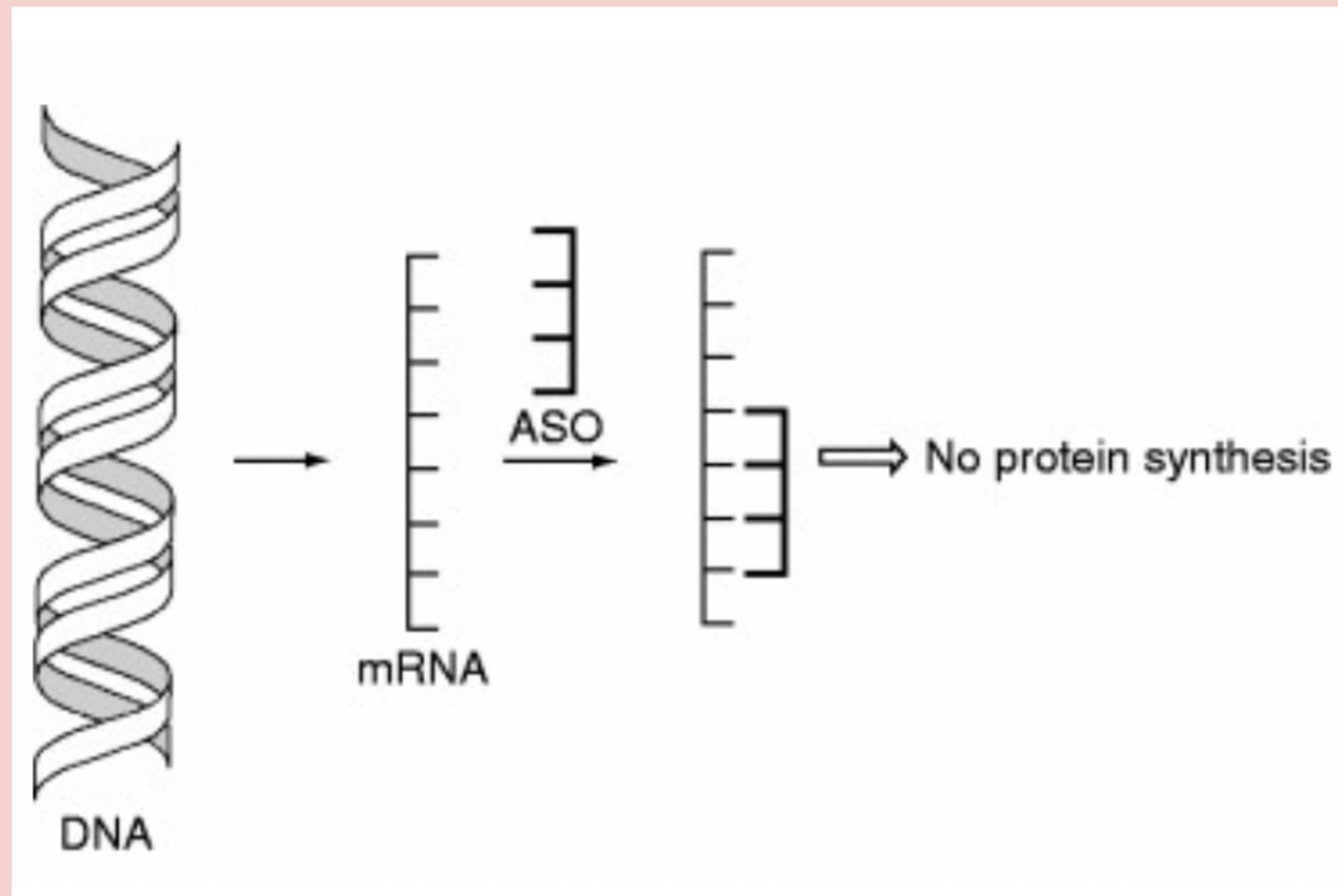
# Antisense Oligonucleotides

## WHAT DO THEY DO?

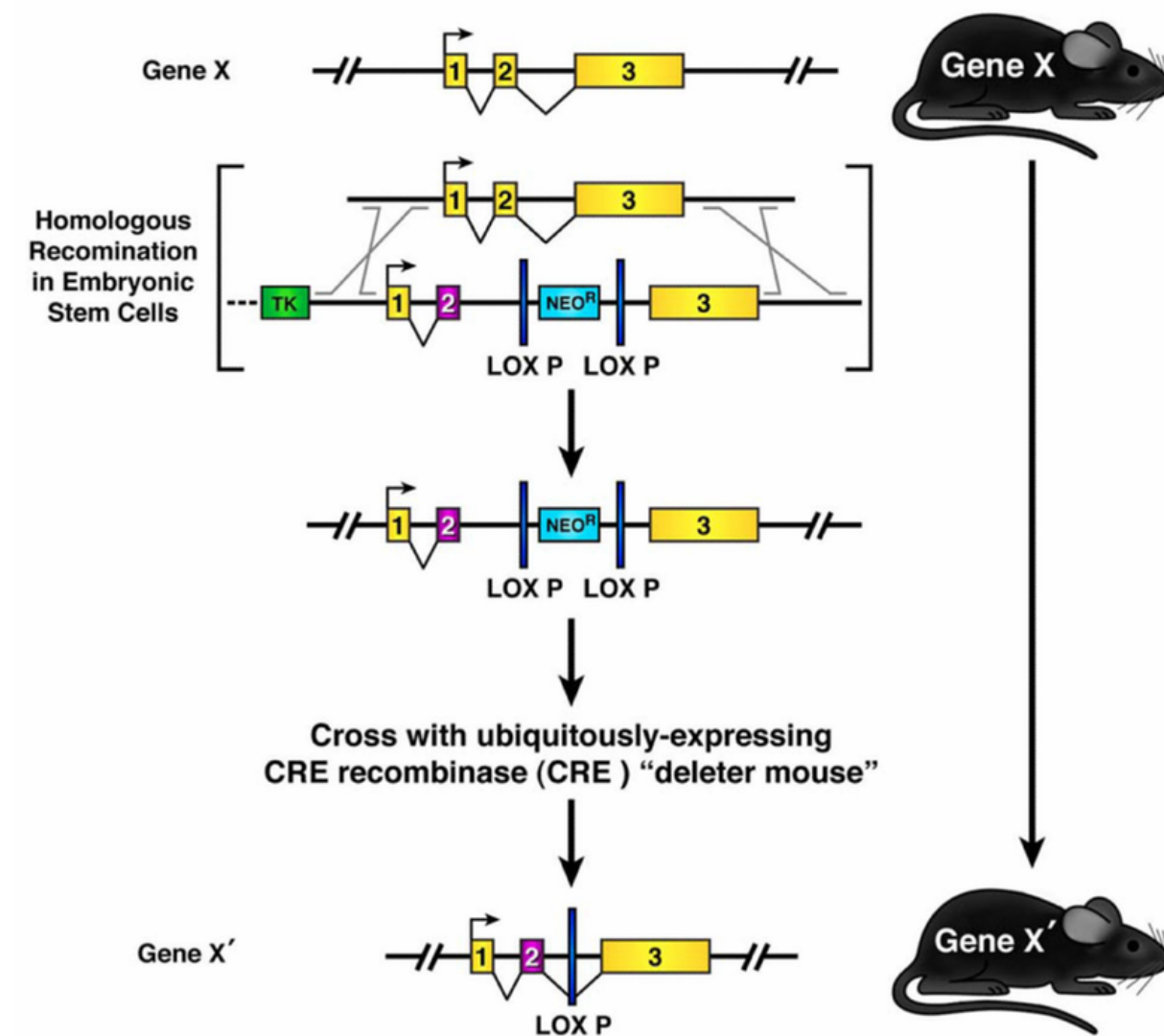
- Inhibit gene expression by hybridizing to the coding (sense) sequences of specific mRNA
- Can inhibit specific harmful genes from being expressed
- Primarily used in the CNS

- Closed system
- Localization
- Efficacy

ASO Mechanism



# Knock-in/Knockout mice



Construction of Transgenic Mouse Models

## MECHANISM

- Usage of the bacterial artificial chromosome (BAC)
- Exogenous genes introduced into mouse genome
  - Disruption of endogenous gene
- Allows for the study of neurological disorder pathology
  - Ethical concerns



# Ethical implications



- Emergence of a new field: Neuroethics
  - Severe potential off-target effects with ASOs
- Benefits need to be weighed with potential harm
- Lack of knowledge of how treatments alter brain function
- Neuroimaging
  - Privacy
  - Connection between subjective experience and electromagnetic signals



# The Hard Questions



- Should genetic engineering be able to be used for the enhancement of human cognitive function?
- What happens if ASOs alter the wrong gene and future generations are impacted?
- Is it acceptable to subject mice to significant harm as models for human diseases?
- Who should have access to these technologies as they continue to advance?