

CmpE 489/COGS 500:

Cognitive Science

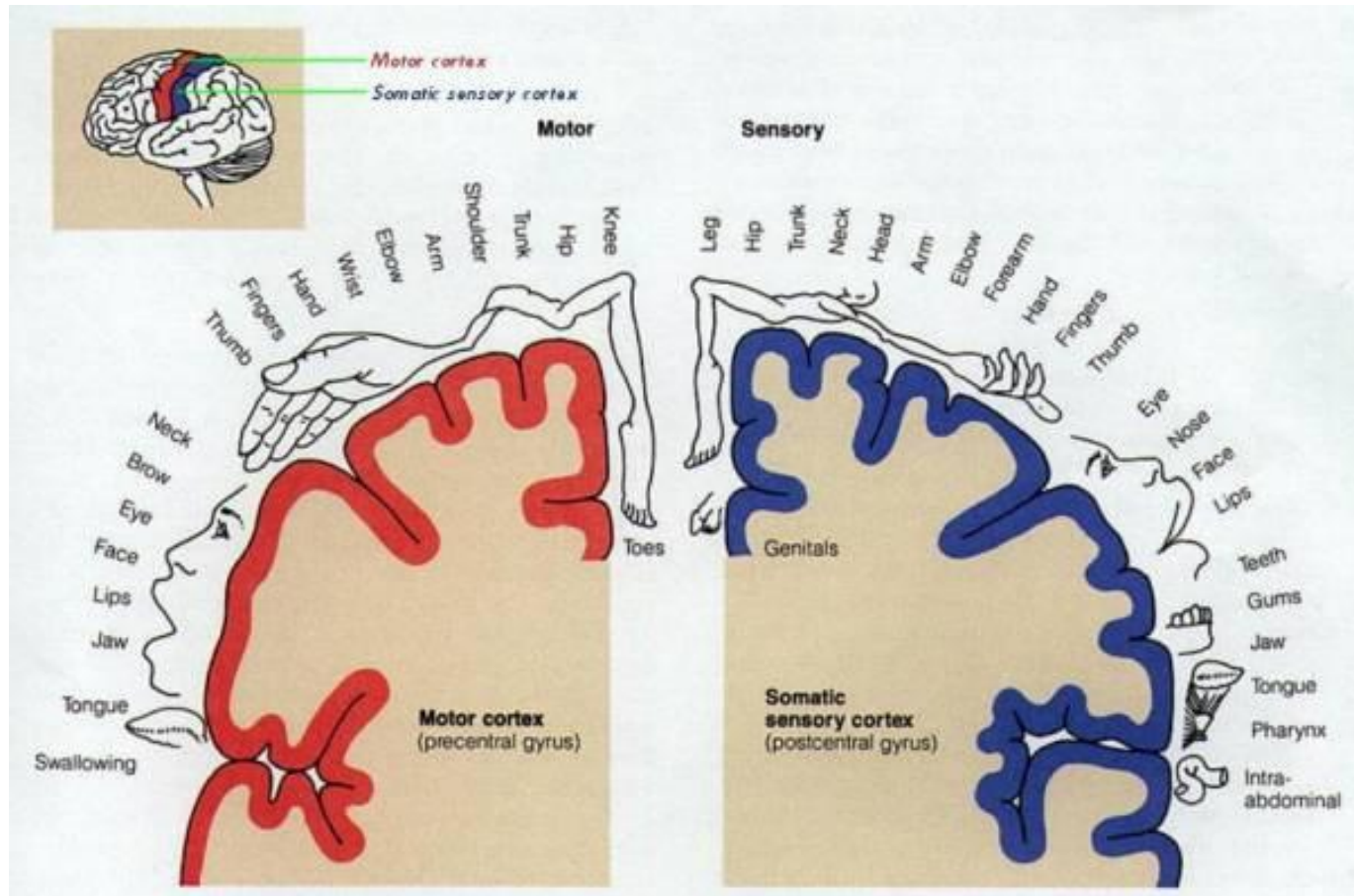
Week 4

Representation of Sensory Information
Multisensory integration in cortex

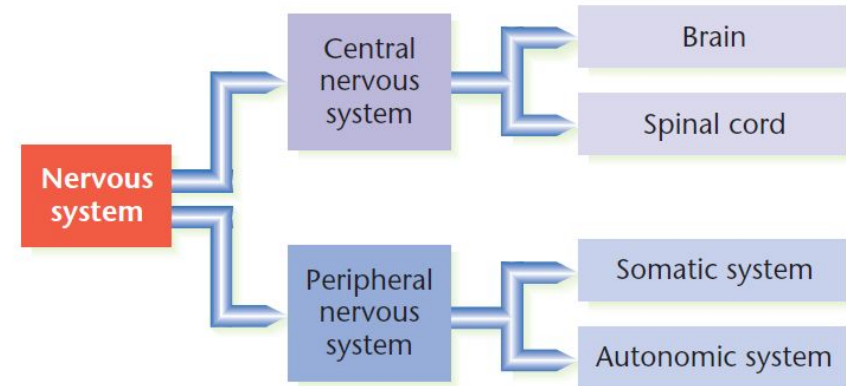
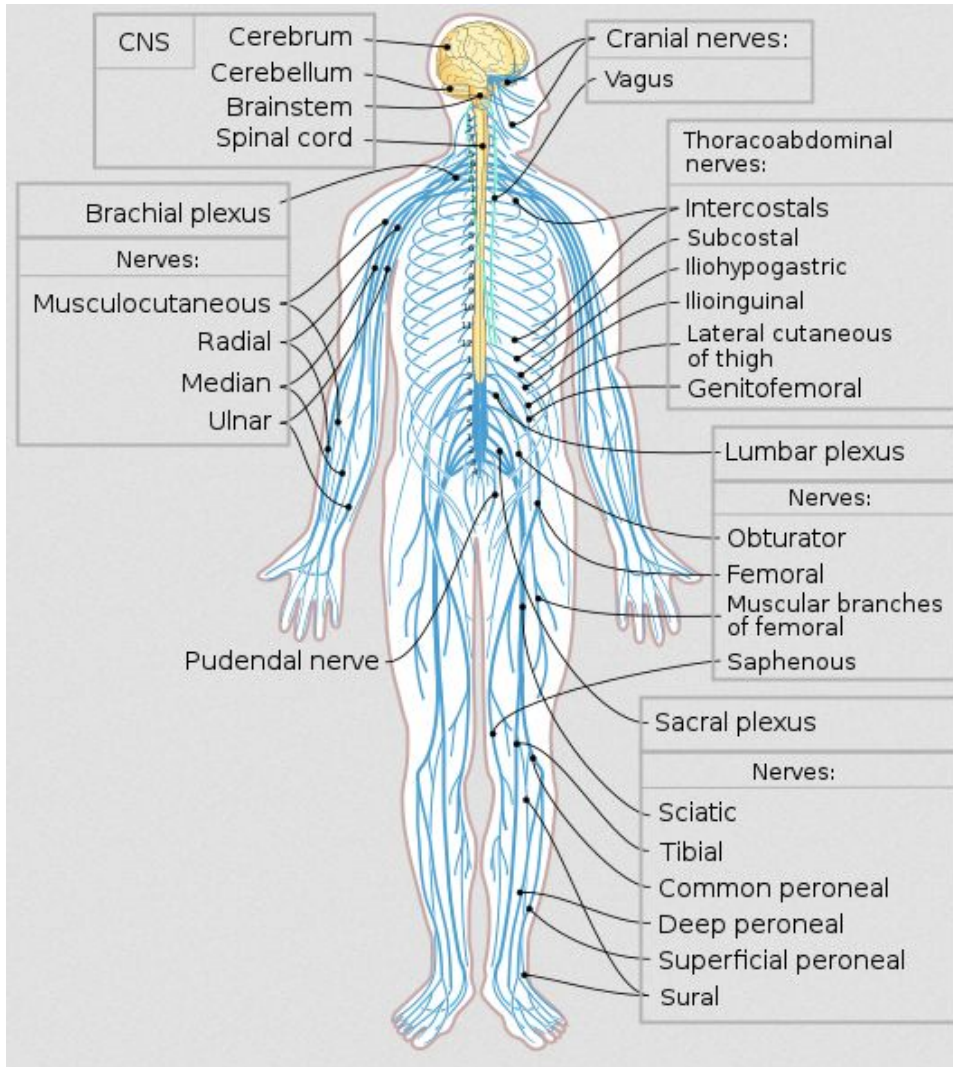
Overview

- Processing of sensory information in the brain:
 - Motor and sensory areas
 - Visual pathways
- Overview of senses

Organization of sensory and motor cortices



Nervous system

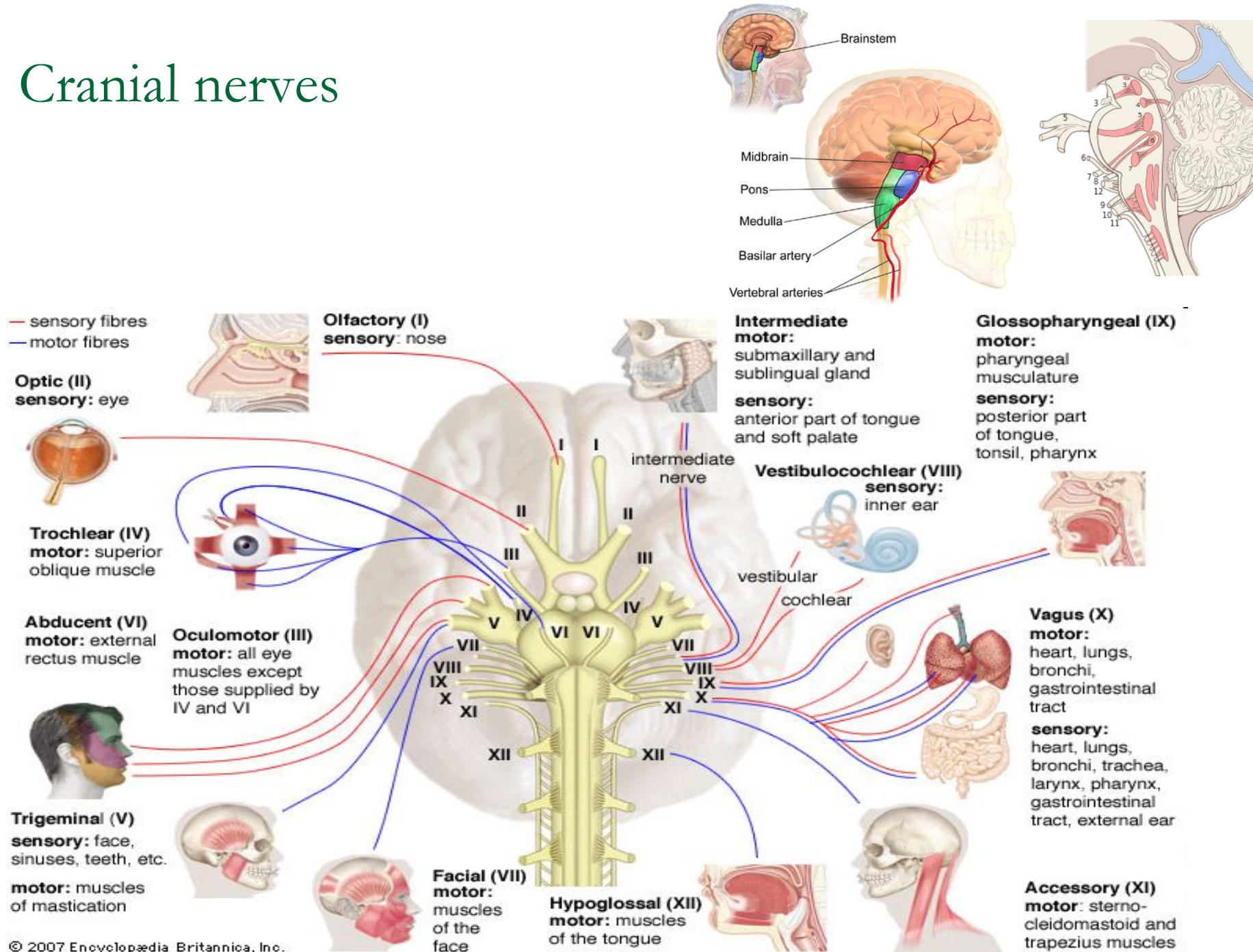


Somatic system: to/from the sense receptors, muscles, and surface of body – voluntary motor functions

- **Sensory nerves:** transmit information about external stimulation from skin/muscles/joints, e.g. pain, pressure, temperature
- **Motor nerves:** from CNS to muscles

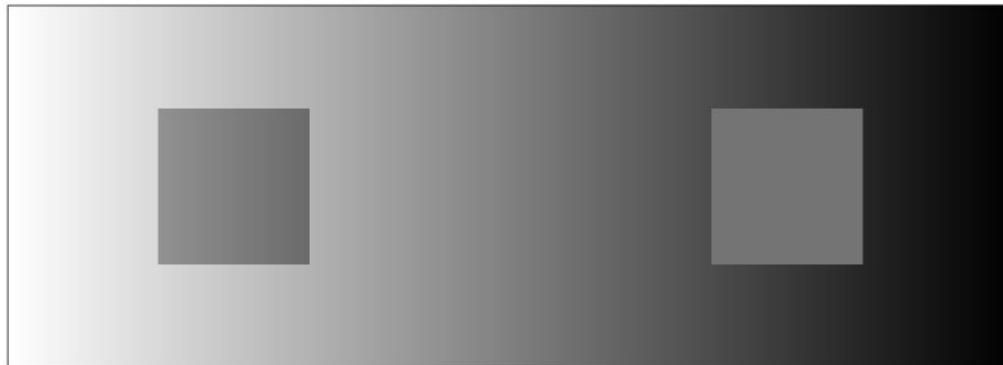
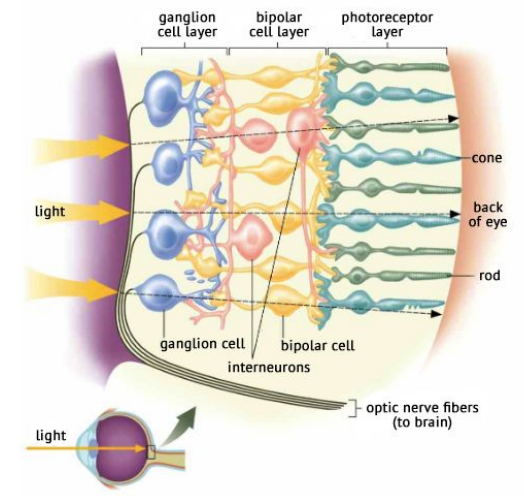
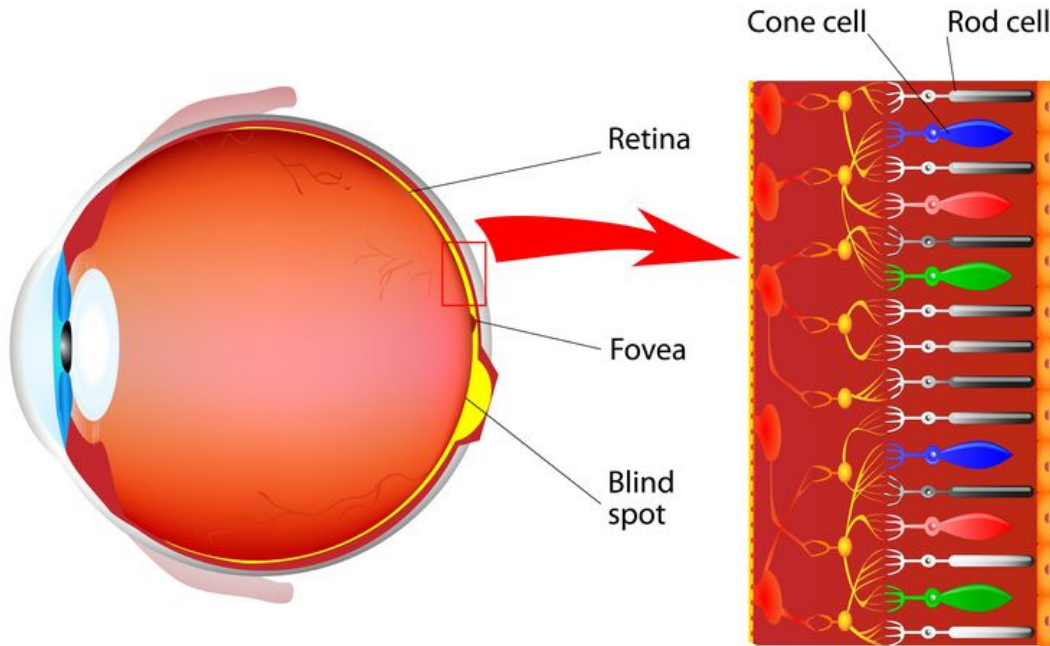
Autonomic: involuntary control system. internal organs and glands for automatic and involuntary actions such as beating of the heart. Respiration, heart rate, digestion

Cranial nerves

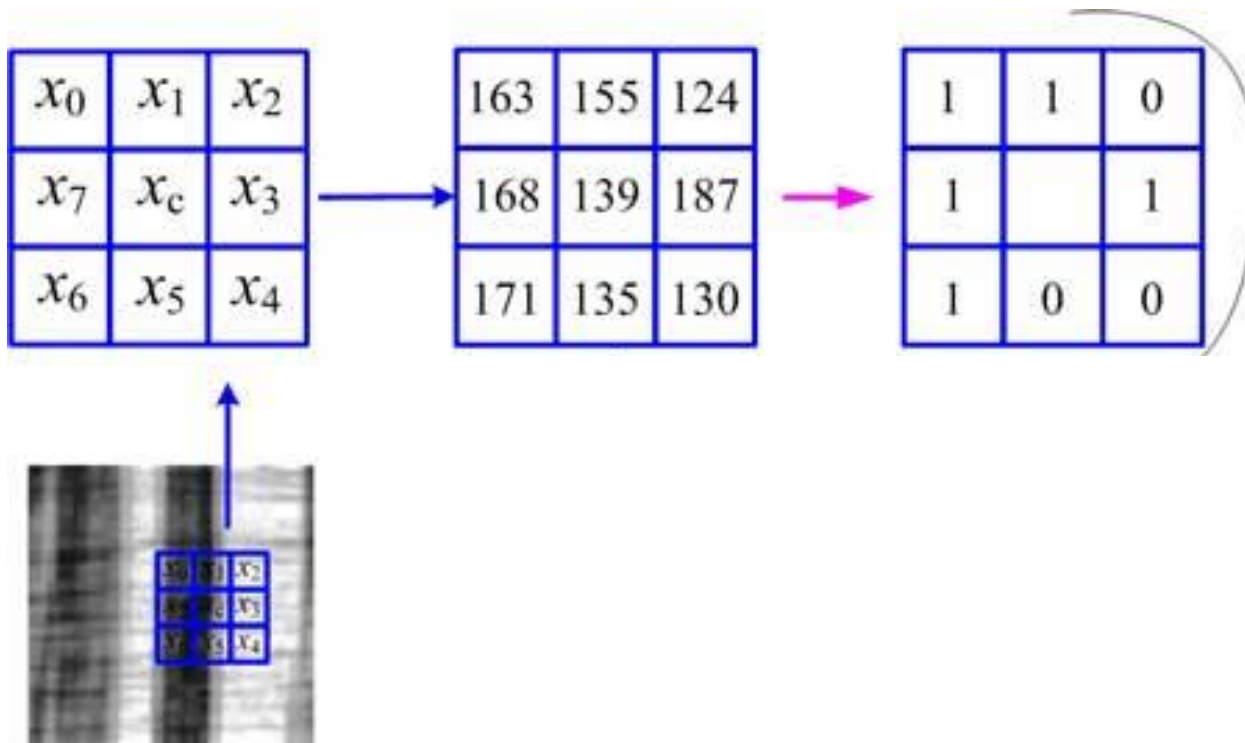


Eye and retina

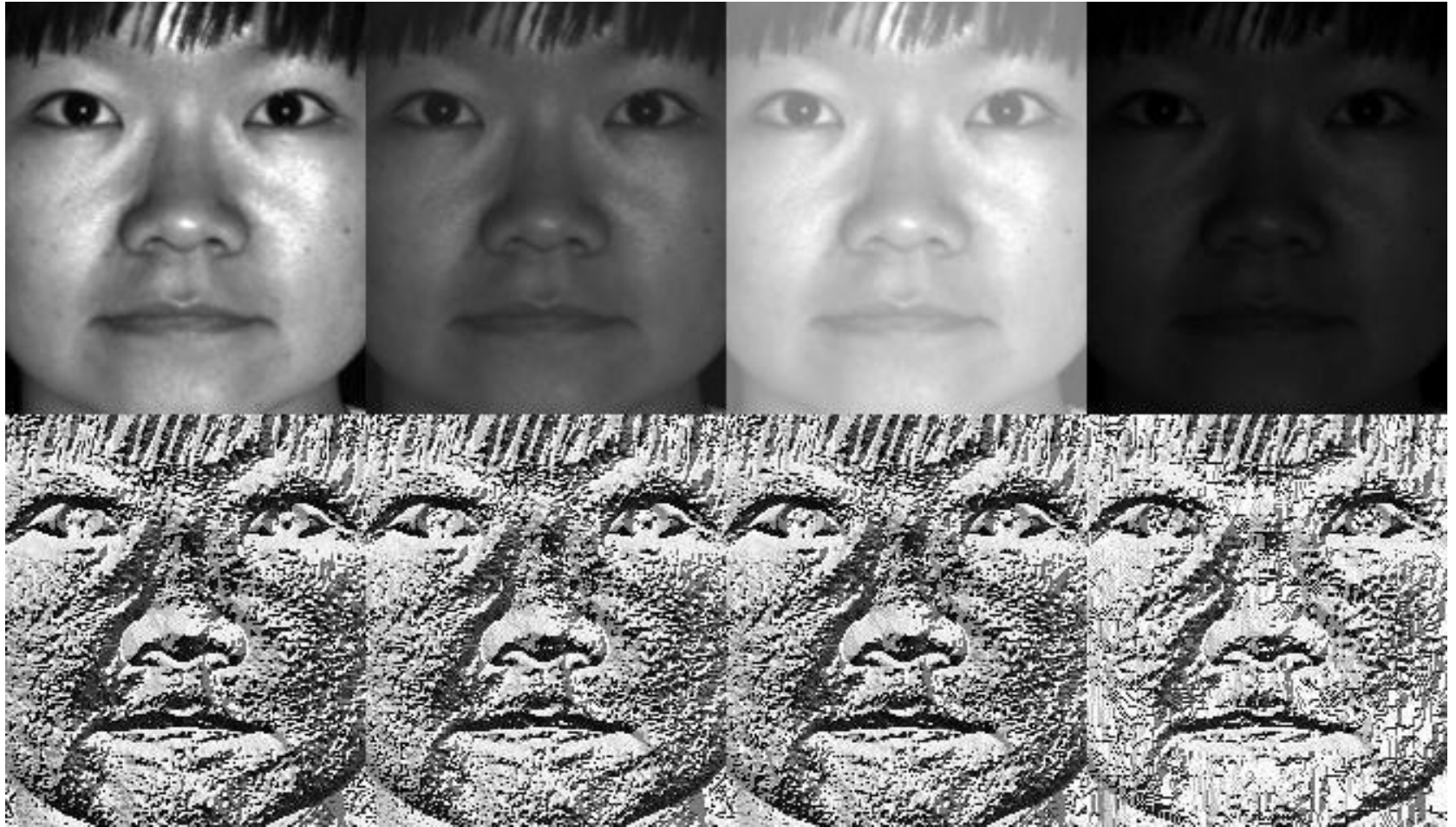
Photoreceptor cell



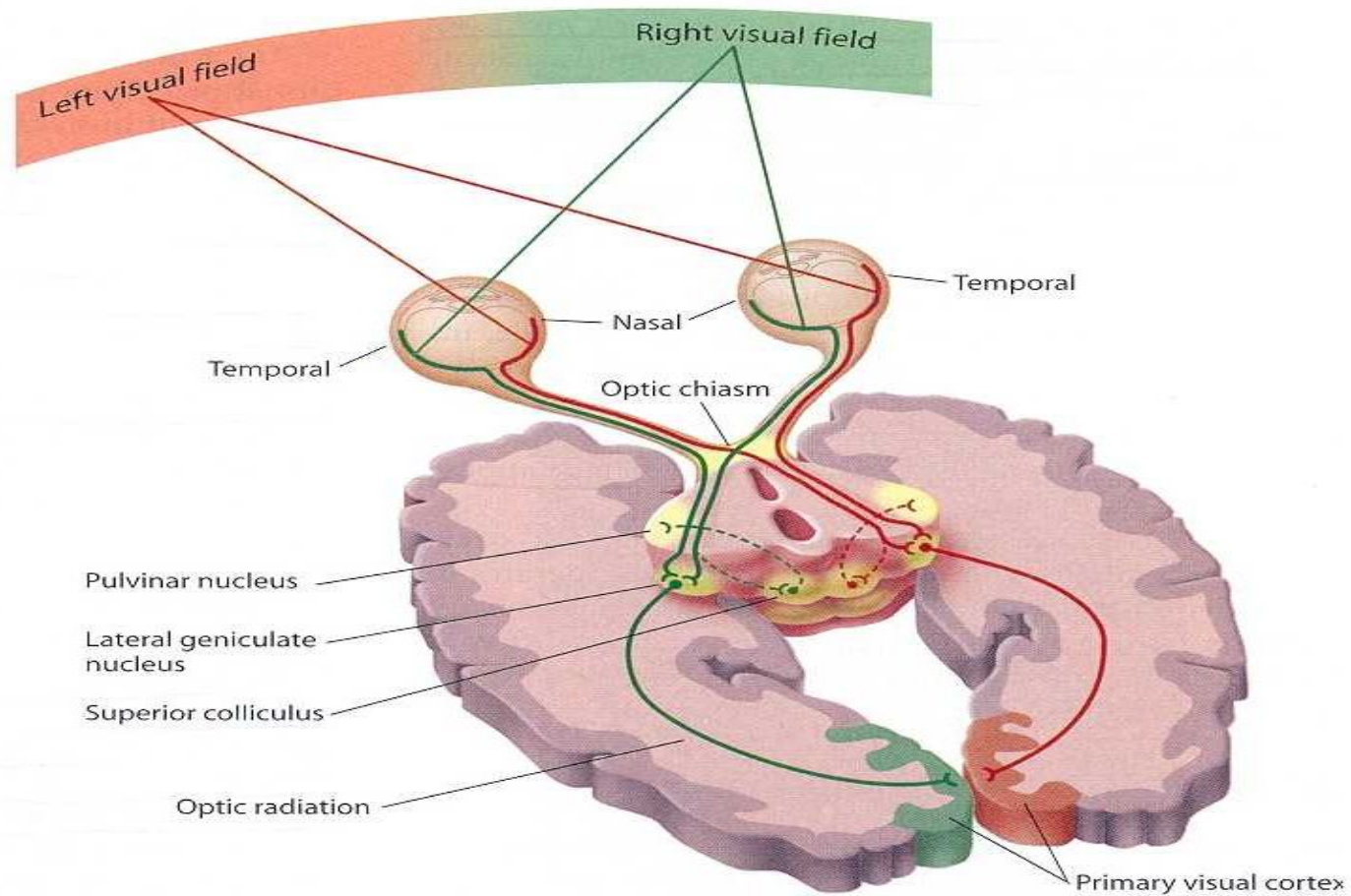
Local binary patterns



Illumination invariance



Visual pathways



Senses vs Perception

■ How many senses do we have?

- Five traditional senses: sight, touch, audition, taste, and smell
- Proprioceptive senses: ?
- Sub-senses: ?

- “Sensation is the body's detection of external or internal stimulation. Perception utilizes the brain to make sense of the stimulation.” wikipedia
- Sensation < Perception
- Perception is the organization, identification, and interpretation of sensory information in order to represent and understand the presented information, or the environment.
- not only the passive receipt of these signals, but it's also shaped by the recipient's learning, memory, expectation, and attention.

Mooney faces

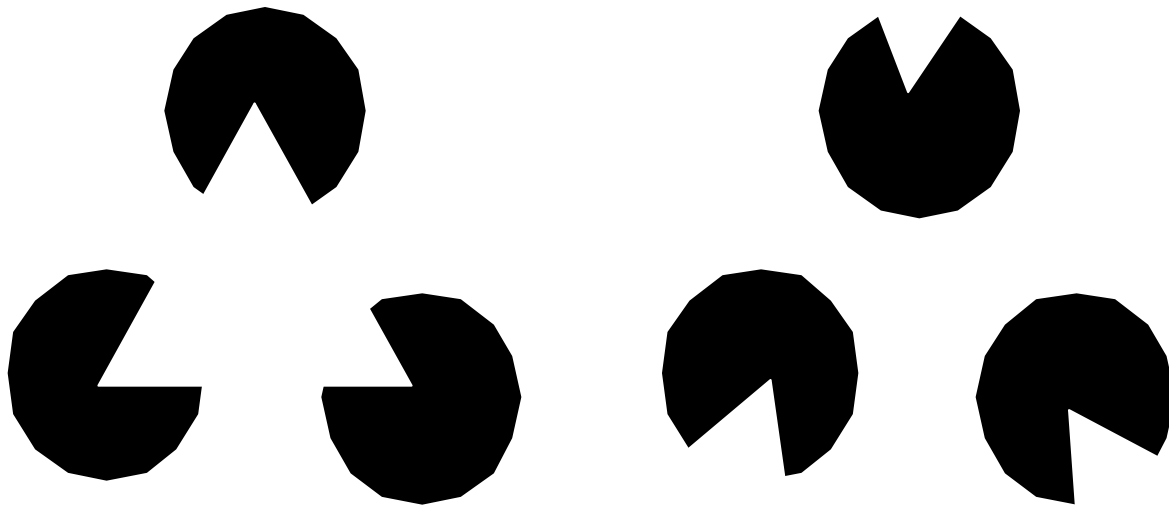




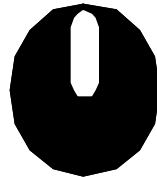
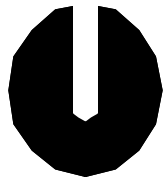
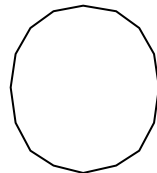
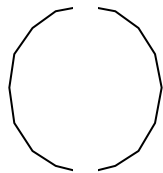
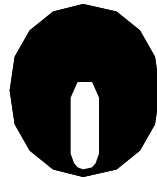
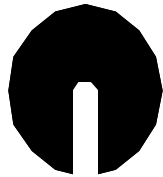




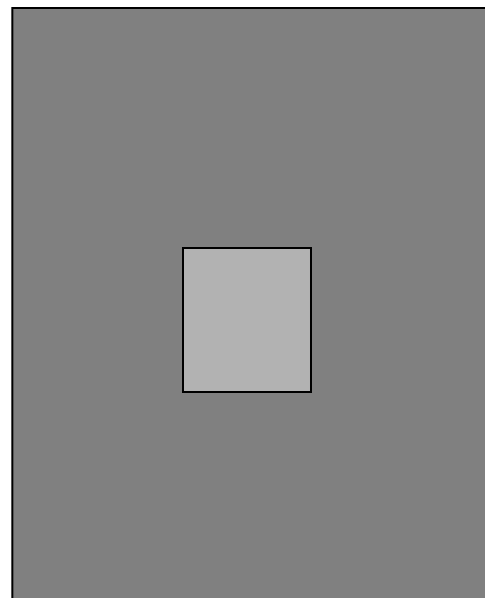
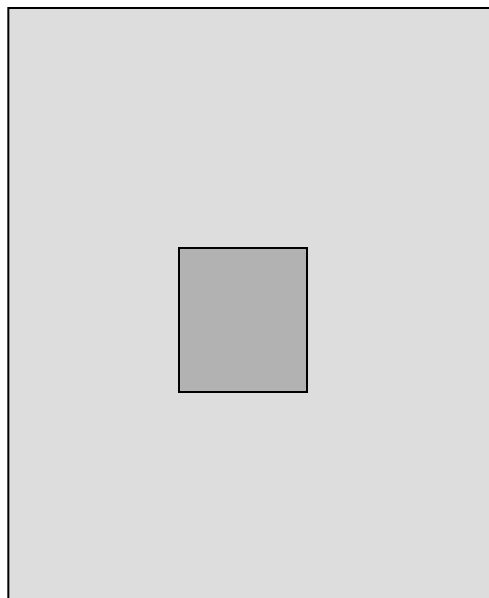
See the triangle?

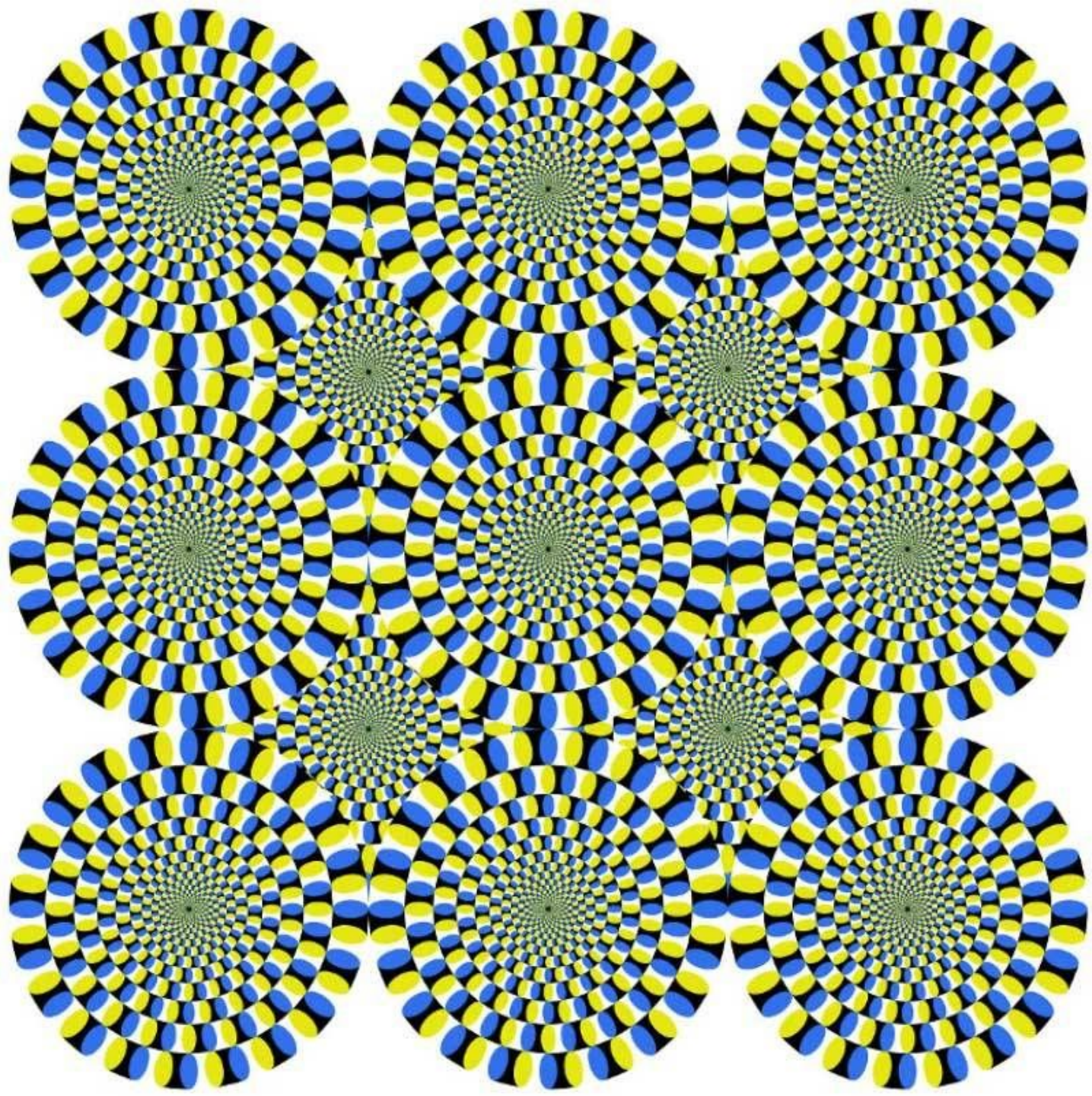


See the white bar?



Which small square is darker?

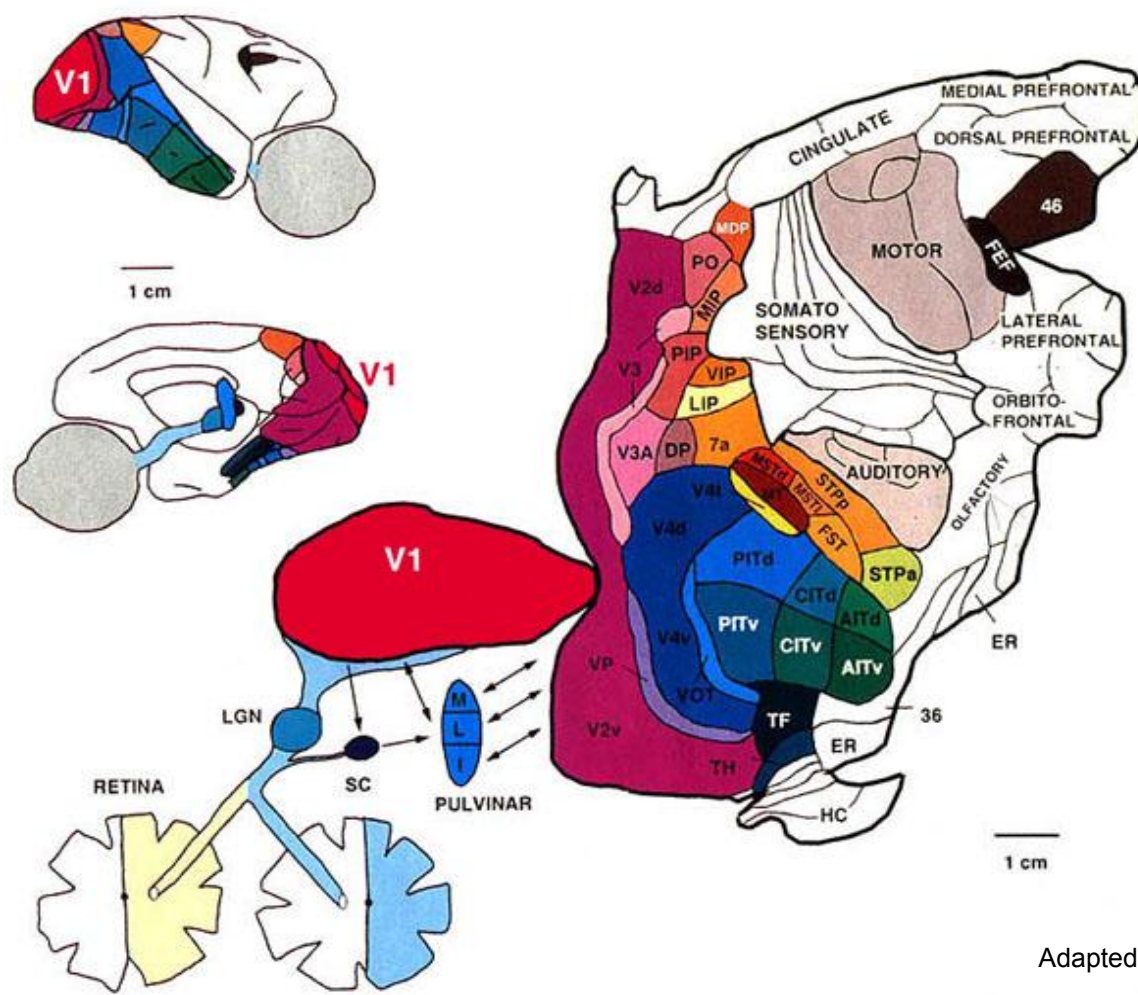




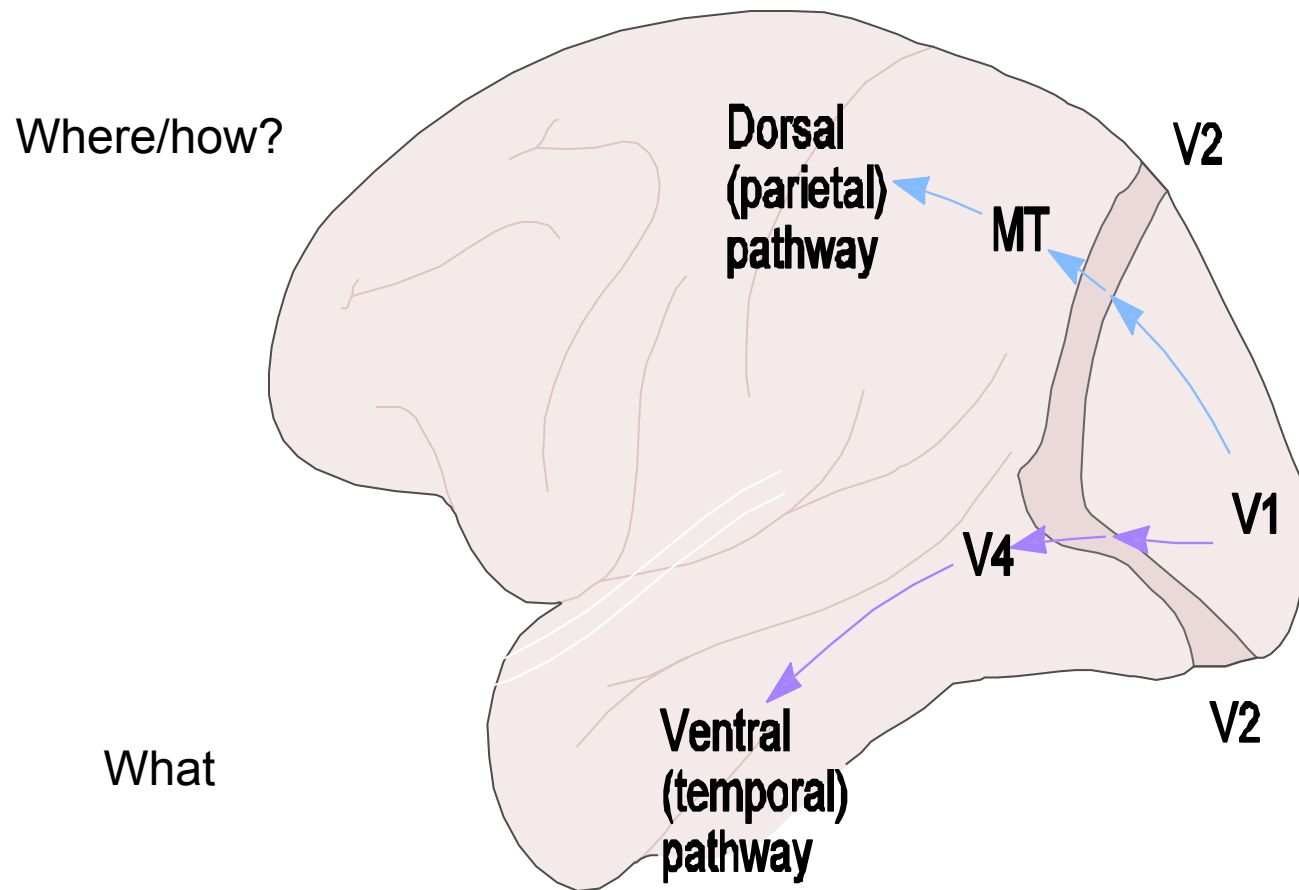
So

- Your visual system does not measure and report the exact physical nature of the visual world.
- It collects some data, and makes guesses.
- Optical illusions take advantage of the guessing strategies.

Roughly 40% of cerebral cortex is involved in vision

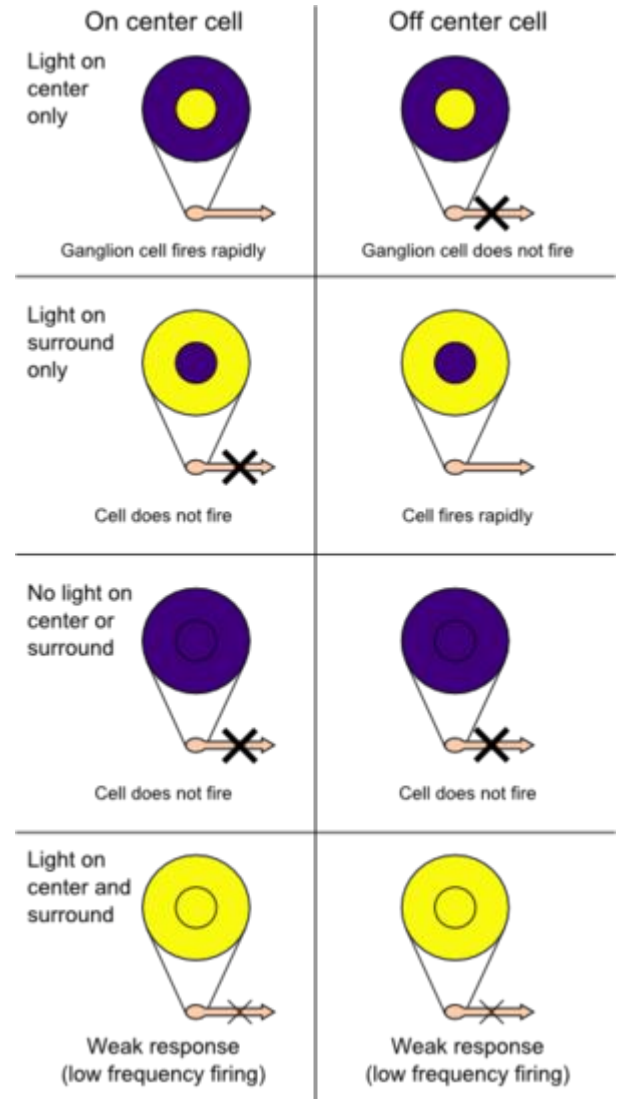


Two cortical visual streams subserve two different visual functions.



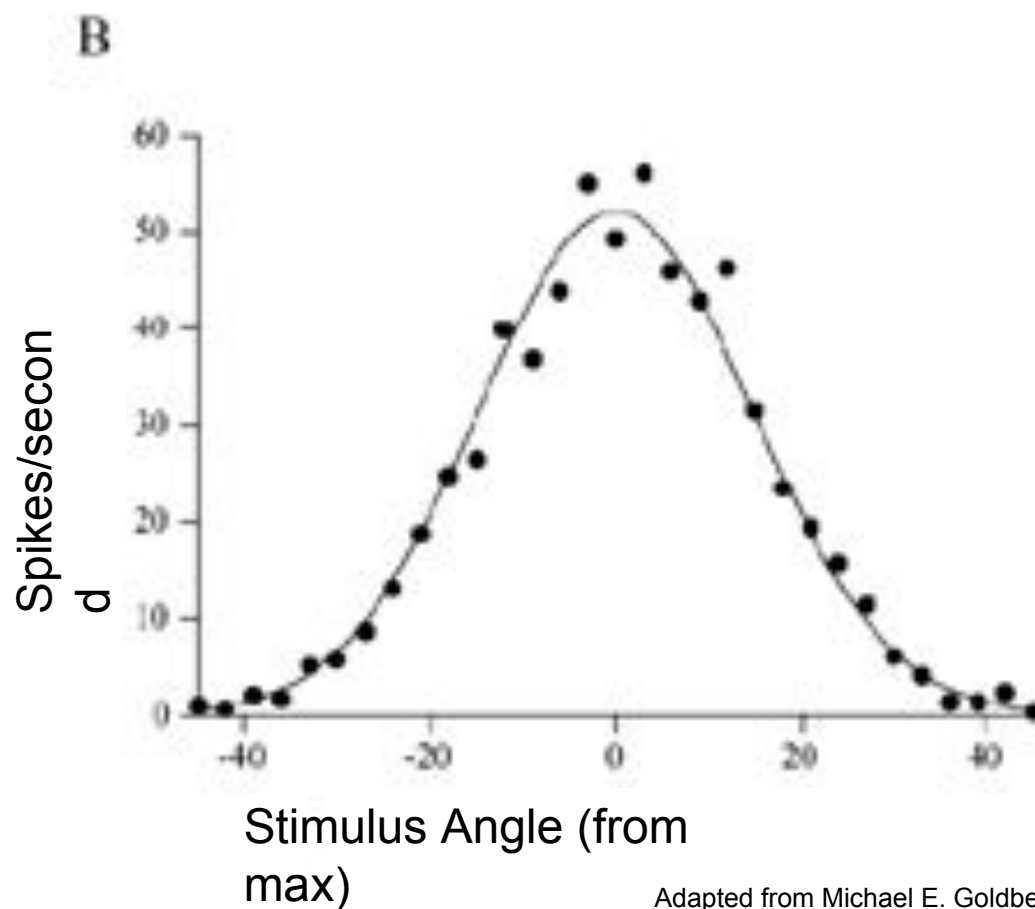
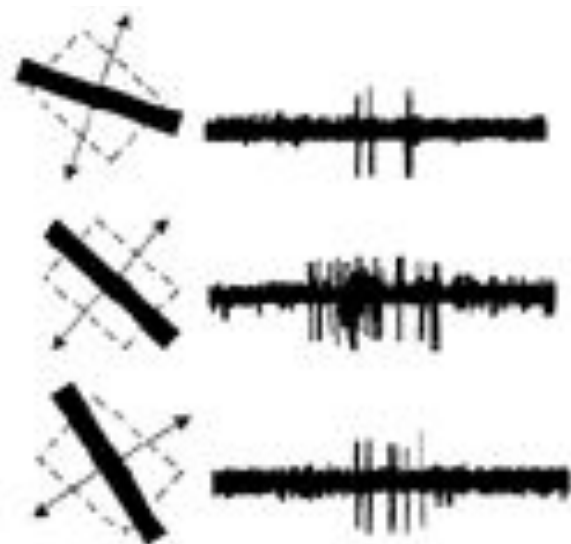
Receptive fields

Receptive fields of Ganglion cells

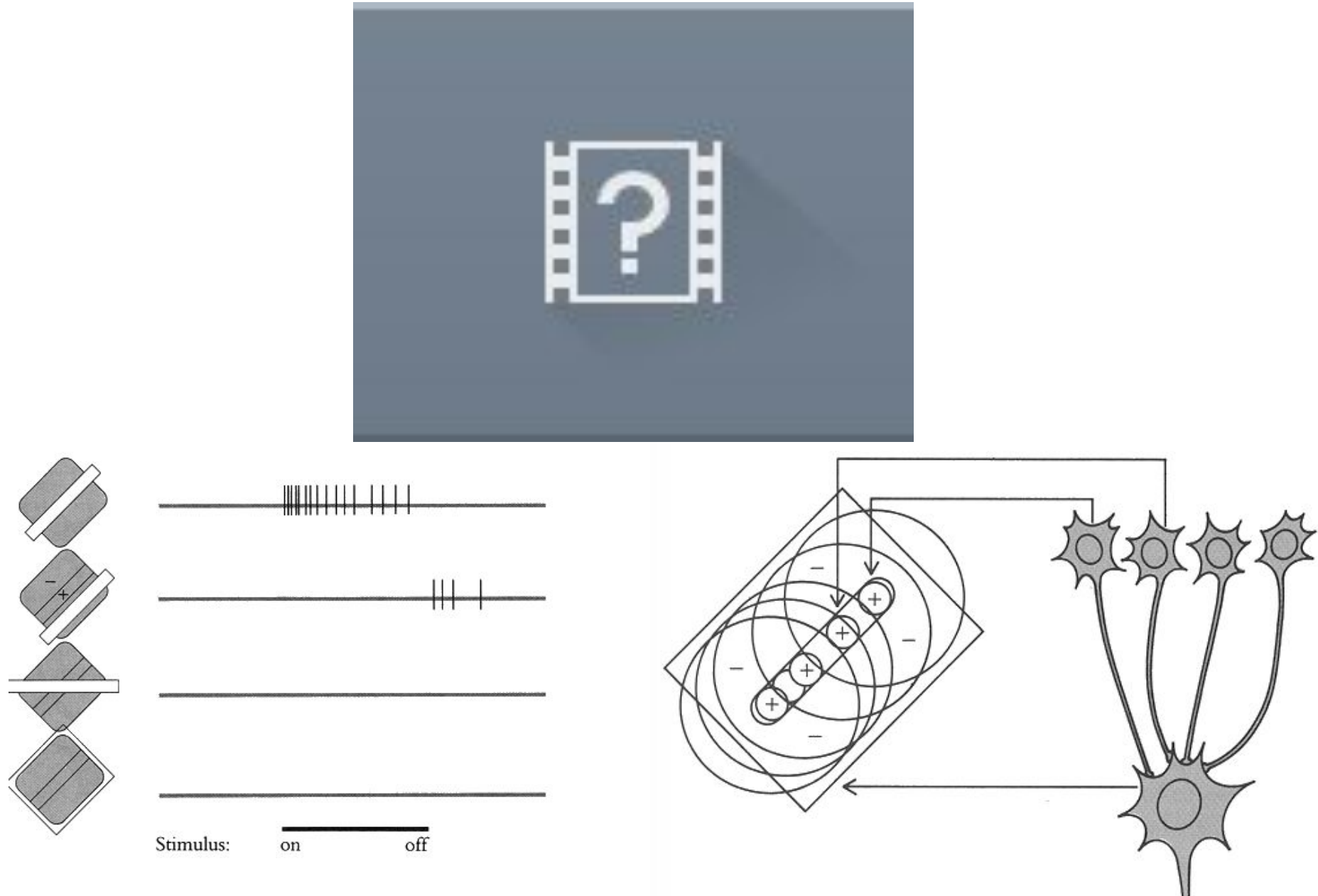


Receptive fields of Mirror Neurons

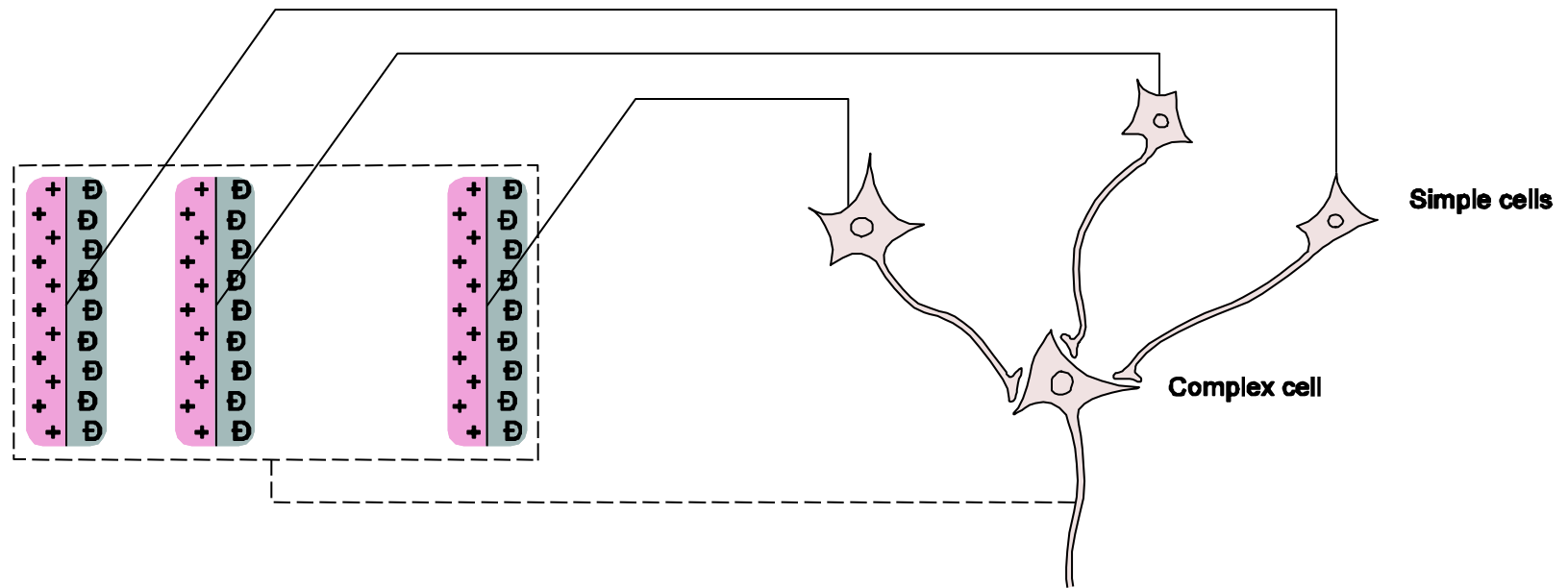
Orientation tuning in a V1 simple cell



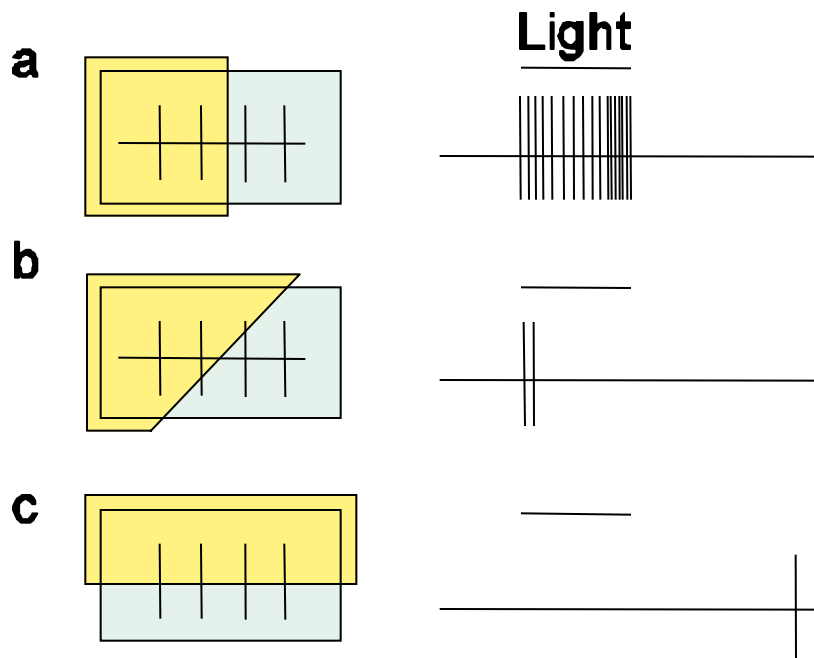
Orientation tuning in a V1 simple cell



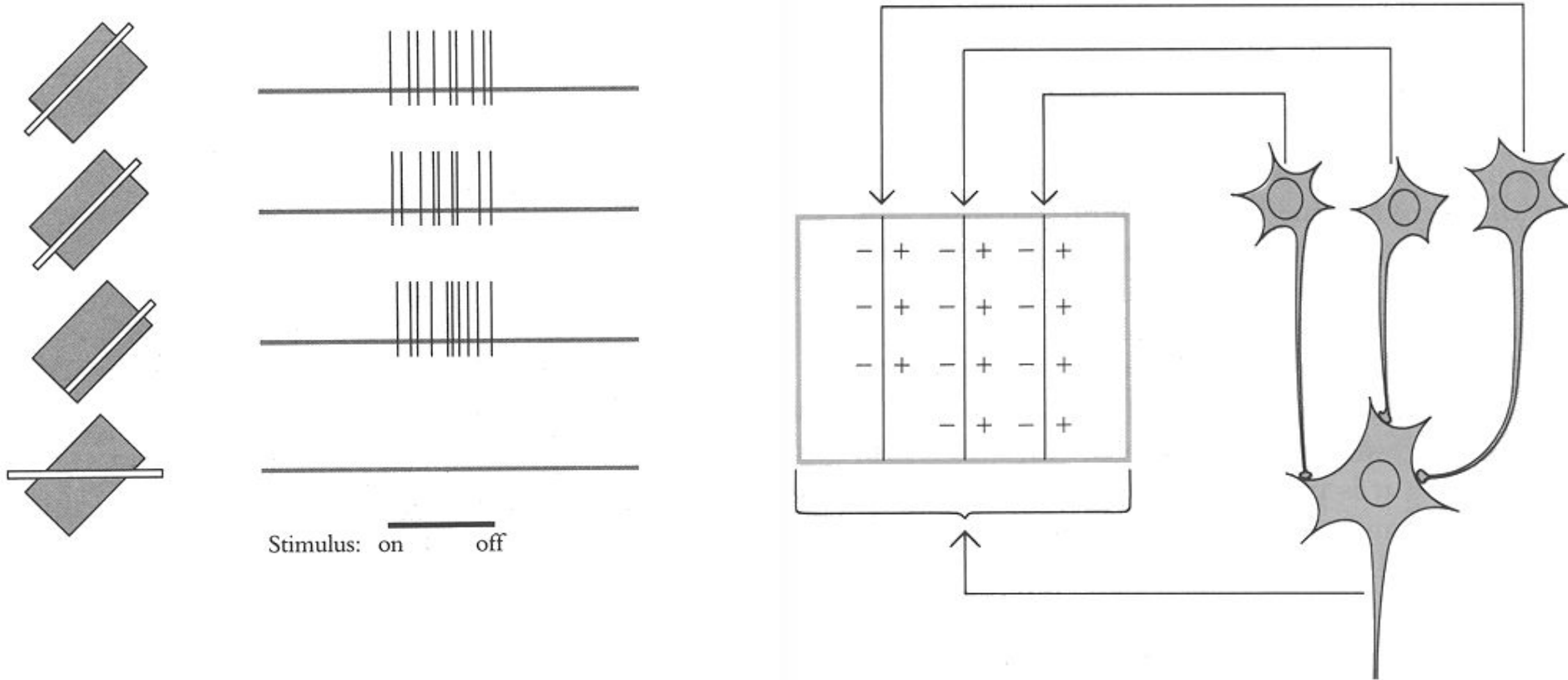
Complex cells can be constructed from an array of similarly oriented simple cells



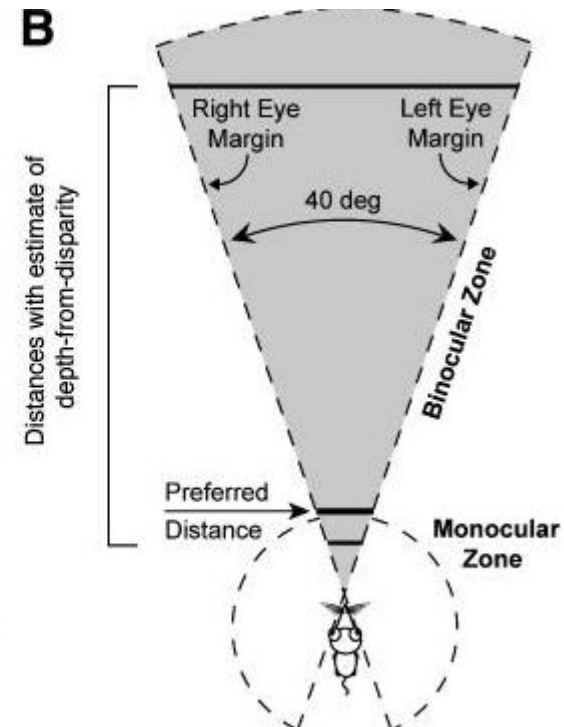
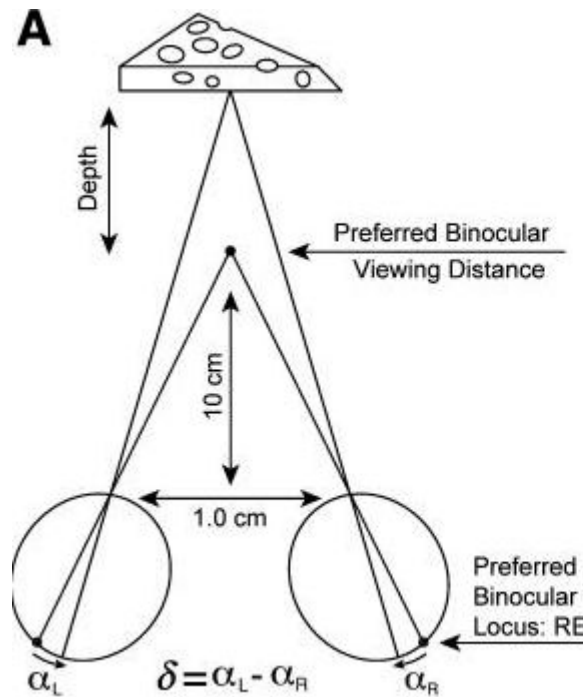
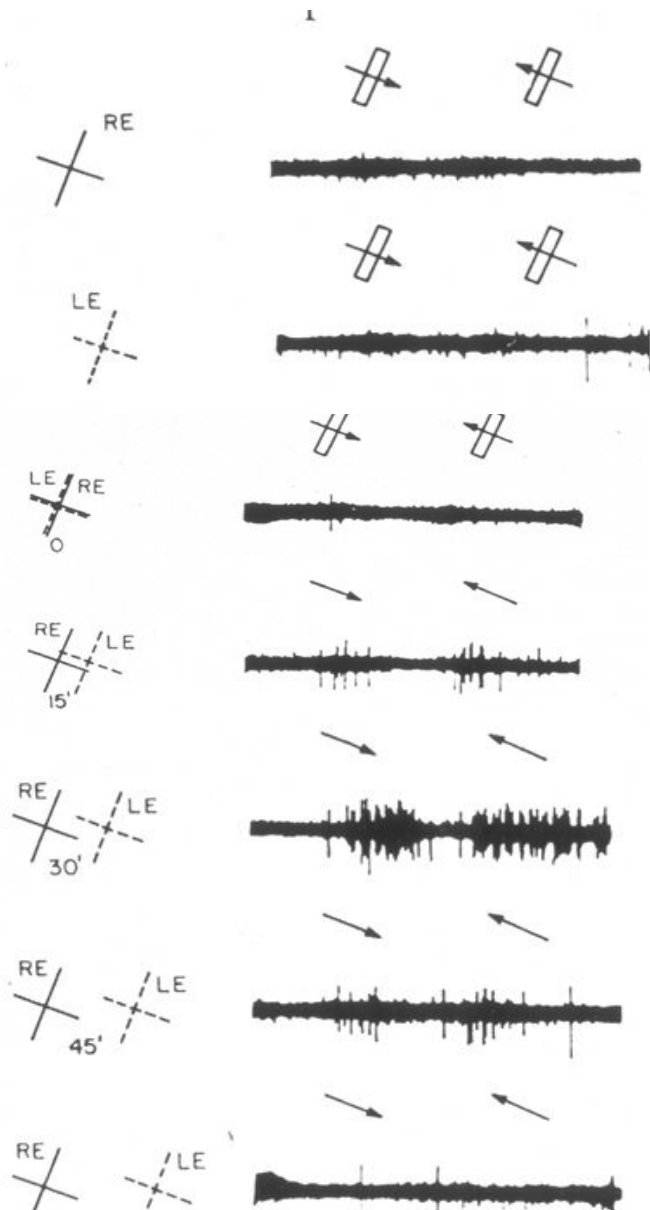
V1 complex cells are sensitive to orientation of stimuli



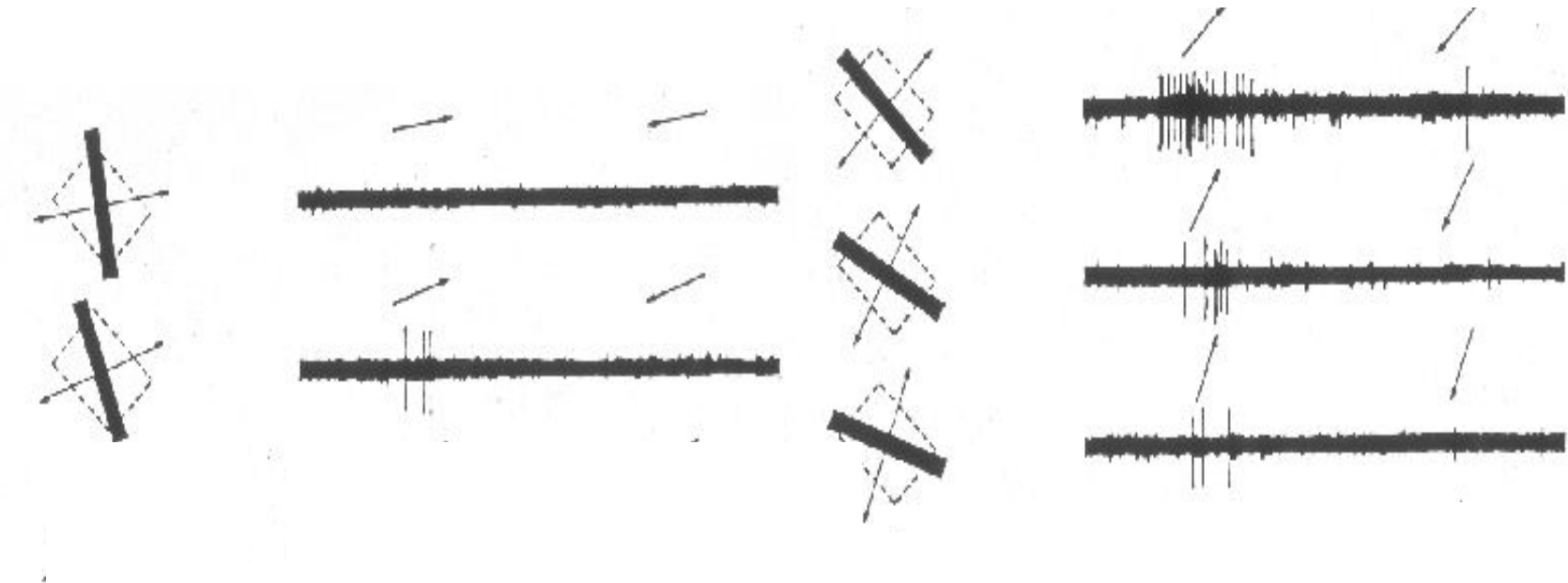
V1 complex cells are sensitive to orientation of stimuli



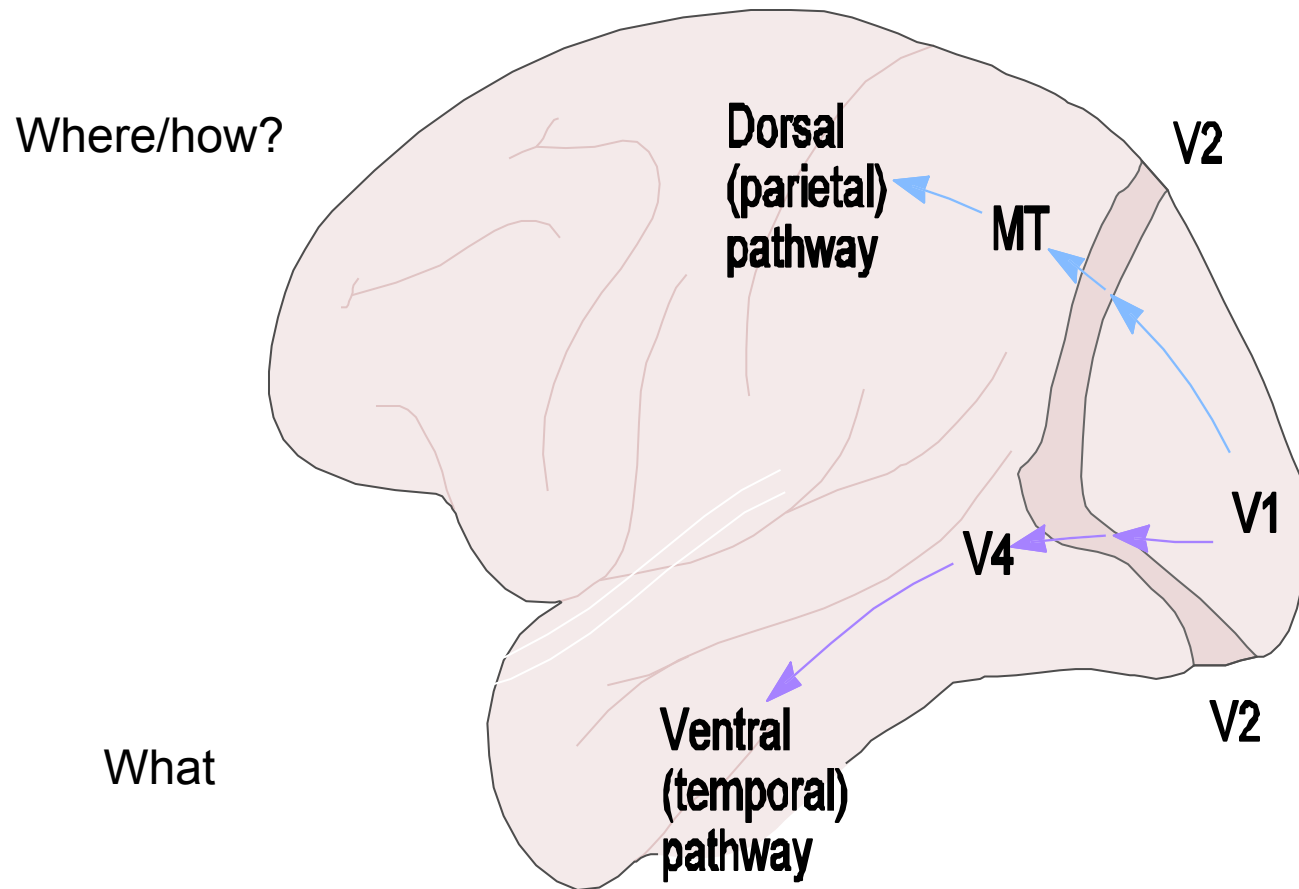
Disparity selectivity in a V1 neuron



Motion selectivity in a V1 neuron



Two cortical visual streams subserve two different visual functions.

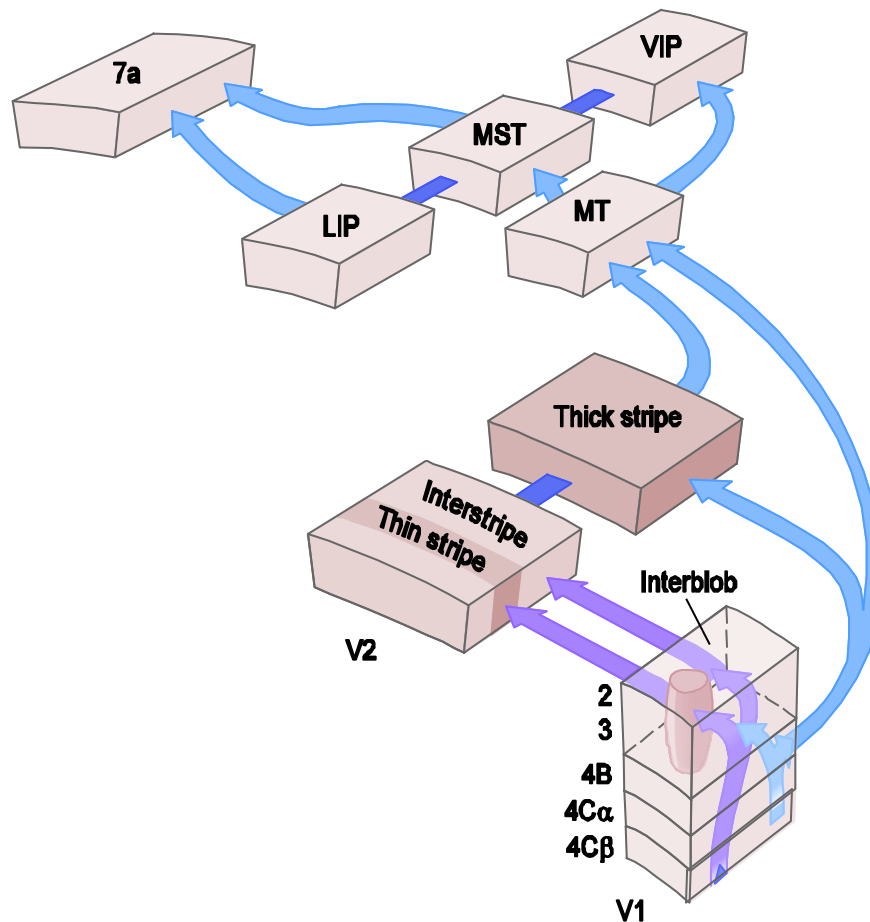


Patients demonstrate this functional segregation

- Patients with V1 lesions generally have total visual field deficits in the affected field.
- Patients with dorsal stream lesions have deficits in sensory location (and attention), motion perception, color perception, and the performance of visually-guided movements.
- Patients with ventral stream lesions have visual agnosia, the inability to associate a visual stimulus with a name or function.

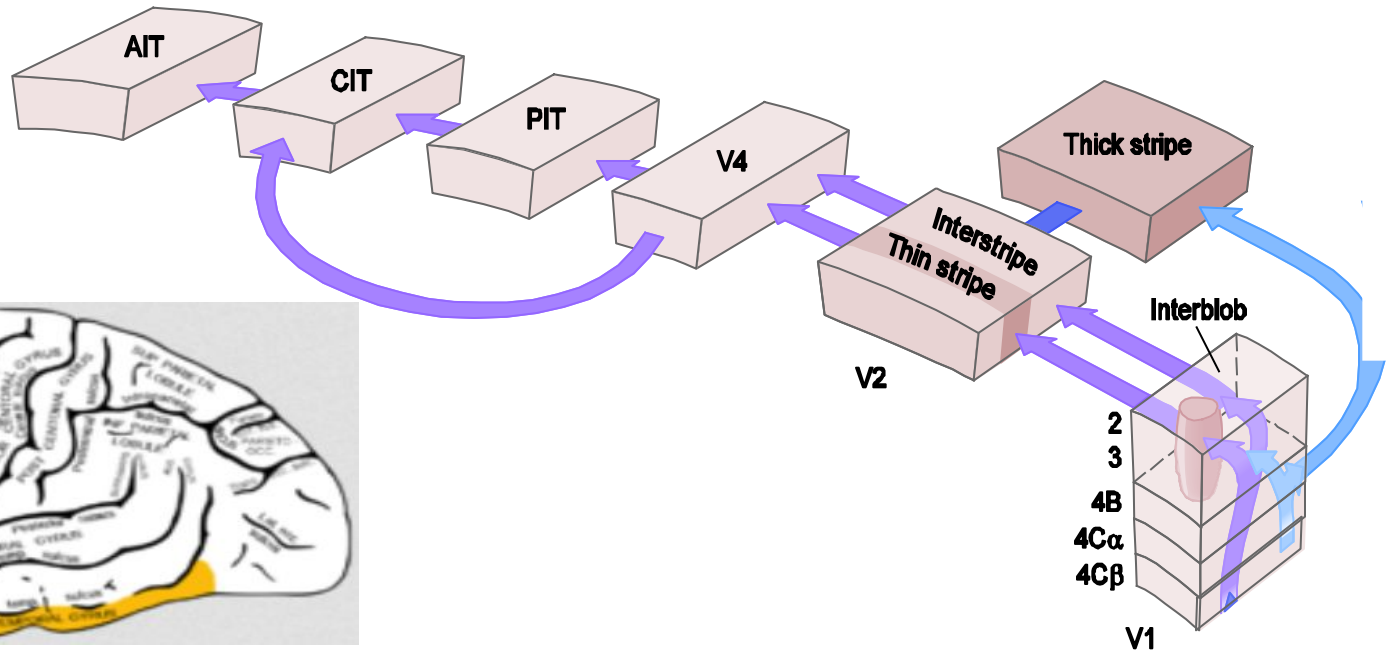
After V2, different functions are performed by anatomically different areas:

The dorsal stream provides vision for action – where and how



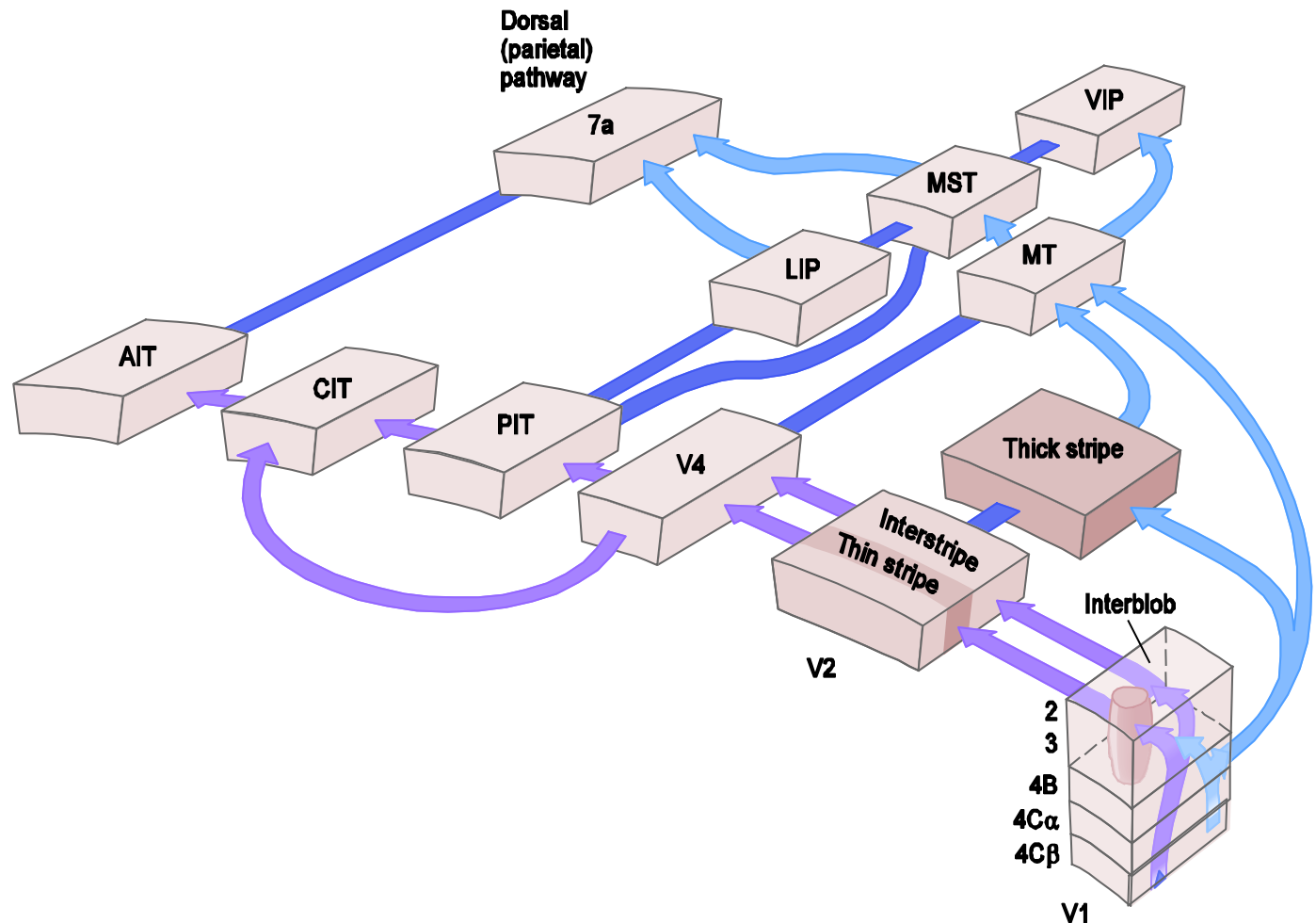
After V2, different functions are performed by anatomically different areas:

The ventral stream provides vision for object identification



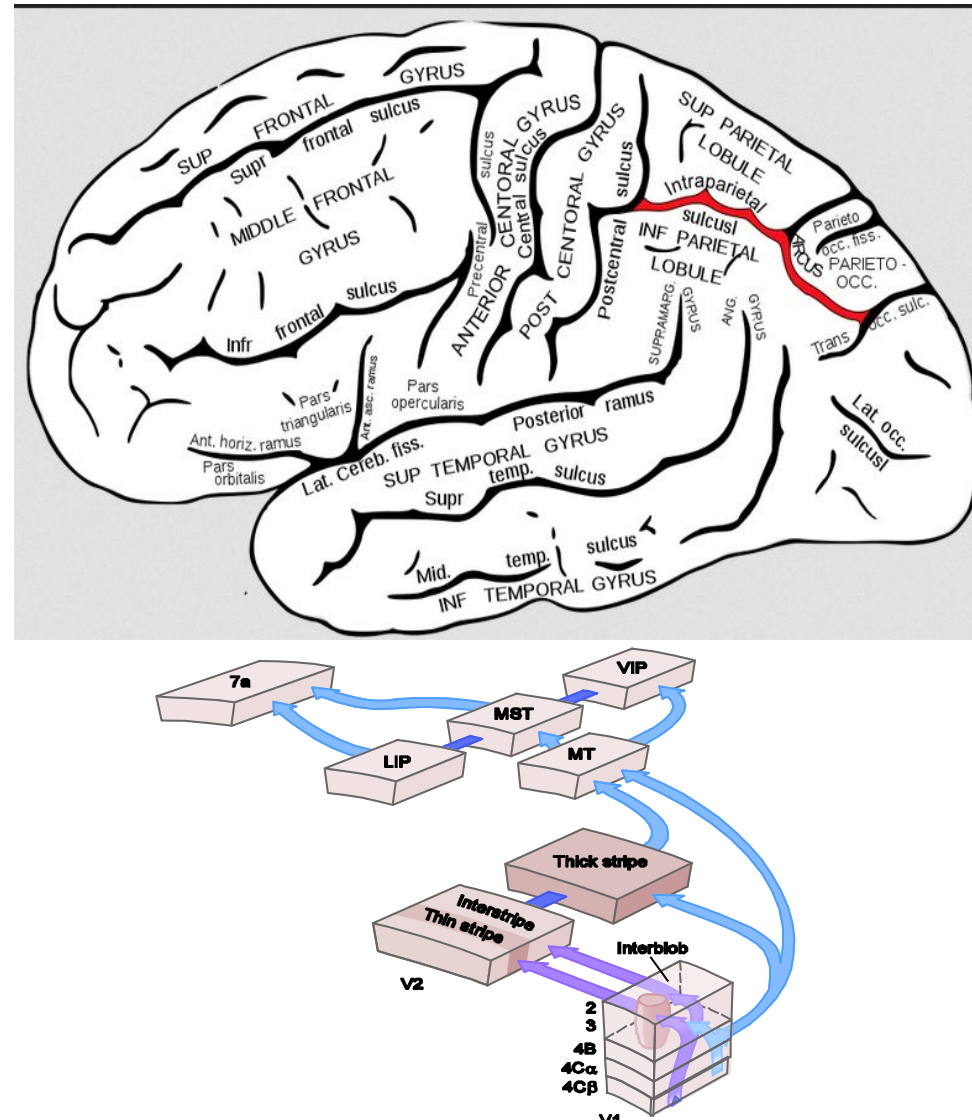
After V2, different functions are performed by anatomically different areas:

But the areas are interconnected



Within the dorsal stream there is further functional segregation –

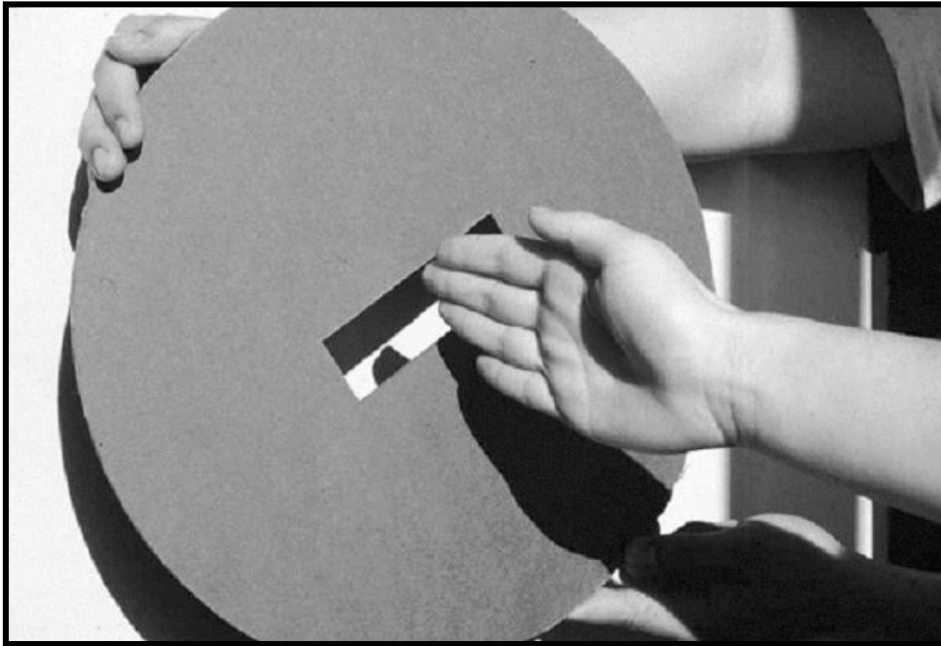
- MT is specialized for depth and motion.
- LIP is specialized for attention in far space.
- MIP is specialized for providing visual. information for reaching.
- AIP is specialized for providing visual. information for grasping.
- VIP is specialized for providing visual. information for mouth and head movements.



An example of a dorsal stream function

- When you reach for something, your grip opens to accommodate the size of your target.
- Patients with dorsal stream lesions can't do this.
- They can, however, describe the size of the object.

A patient with a dorsal stream lesion cannot orient her hand with respect to a slot

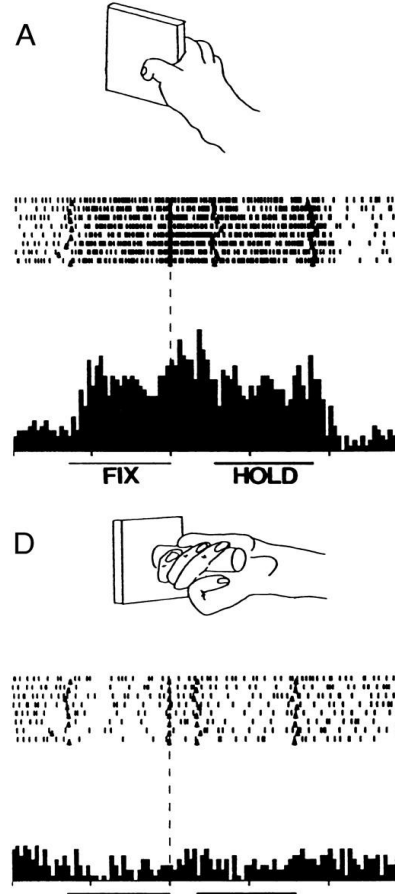
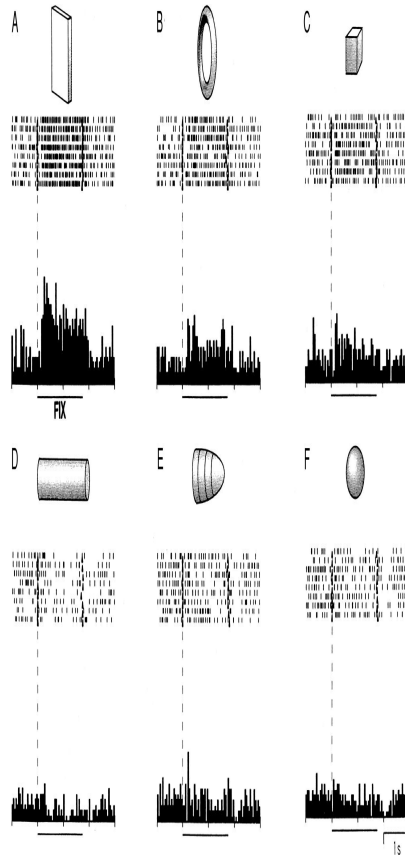


Marie-Thérèse Perenin and Alain Vighetto discovered that patients with 'optic ataxia' not only have problems reaching to point to something accurately, but also tend to direct their hand at the wrong angle when trying to pass it through a slot. The same patients, however, often have no problem describing the orientation of the slot in words.

Quiz:

- Dorsal or Ventral Pathway?
- Mirror neurons?

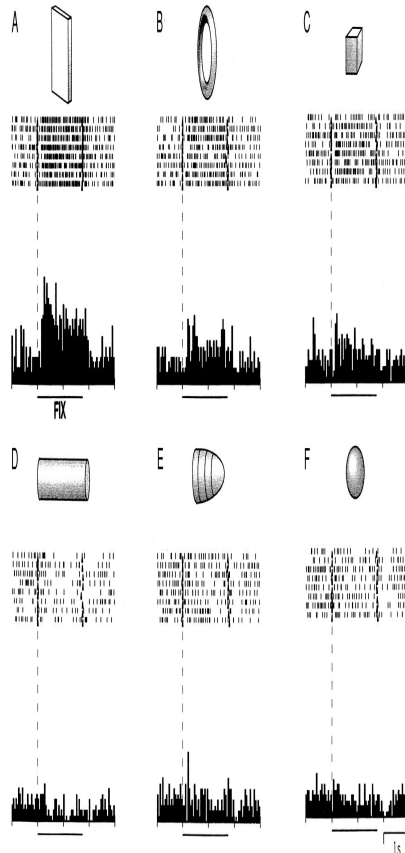
Look at the
object



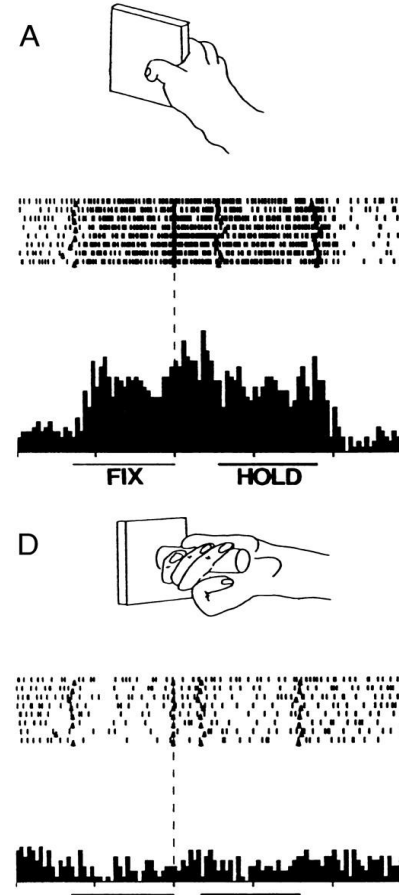
Reach for
the object

Neurons in AIP specialized for grip

Look at the object



Reach for the object



Dorsal visual pathway is concerned with the aspect of form, orientation, and/or size perception that is relevant for the visual control of movements.

A patient with a ventral stream lesion can move her hand to a slot, but can't match the position or can't report the orientation

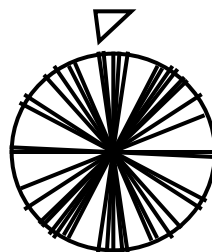
Matching



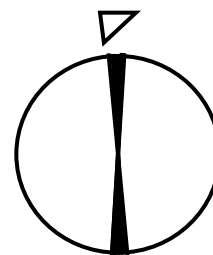
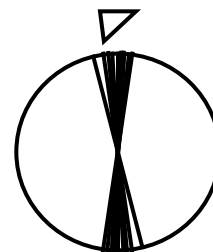
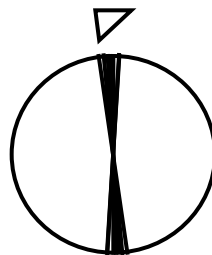
Posting



DF

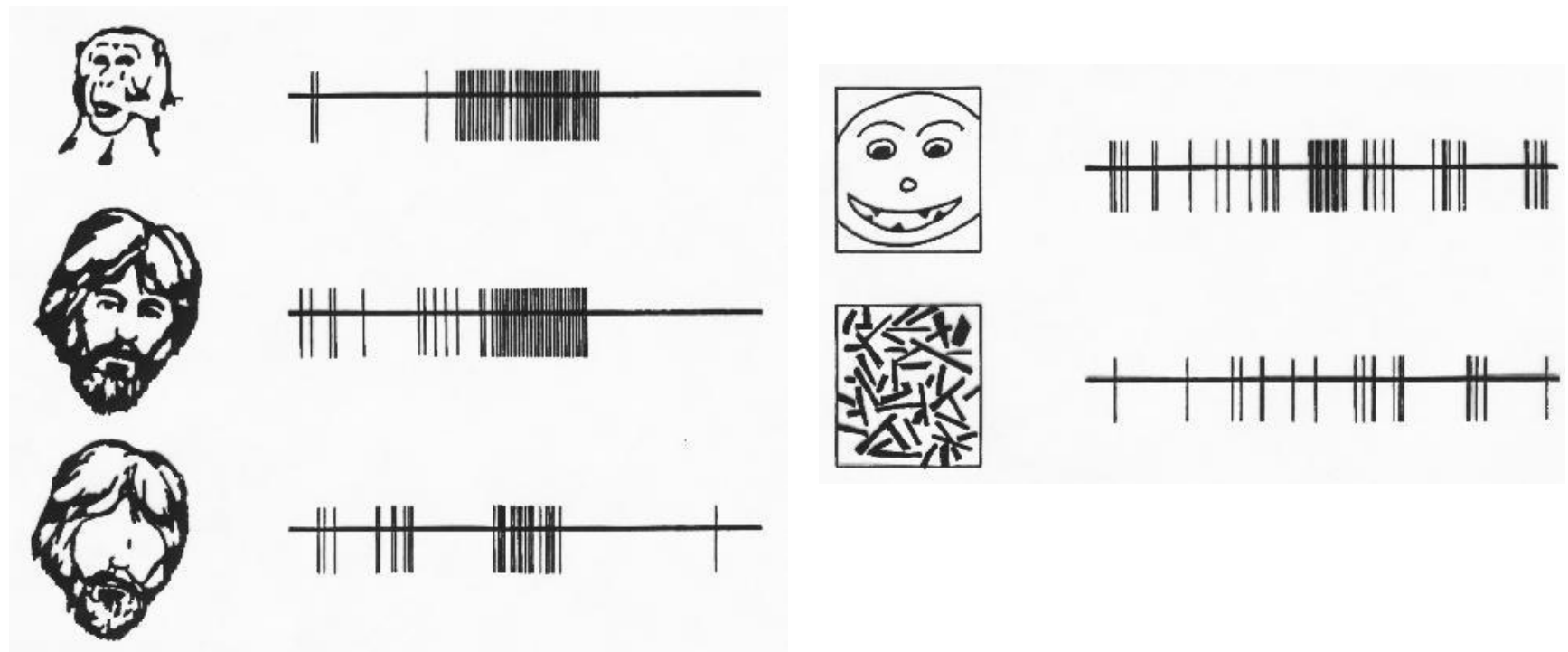


Control



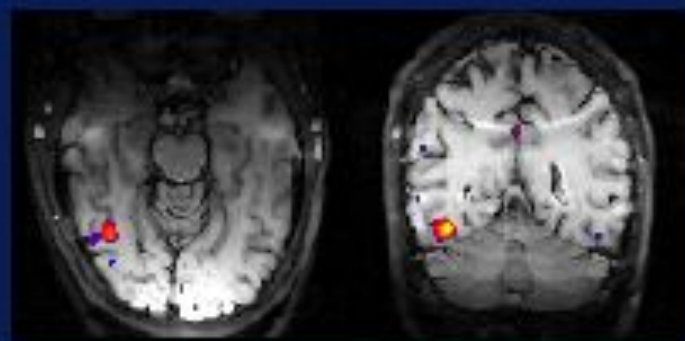
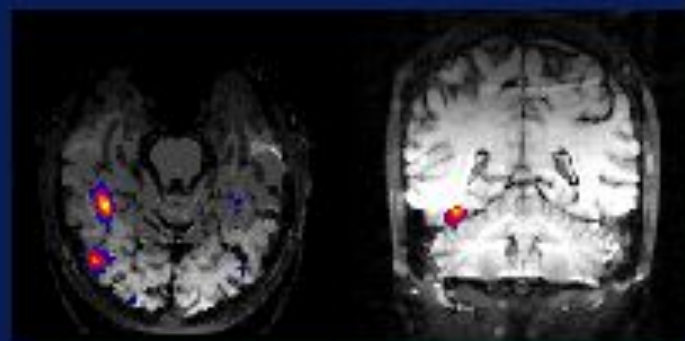
Goodale, et al., (1991)

Neurons in inferior temporal cortex are selective for complex patterns like faces



The Fusiform Face Area (FFA)

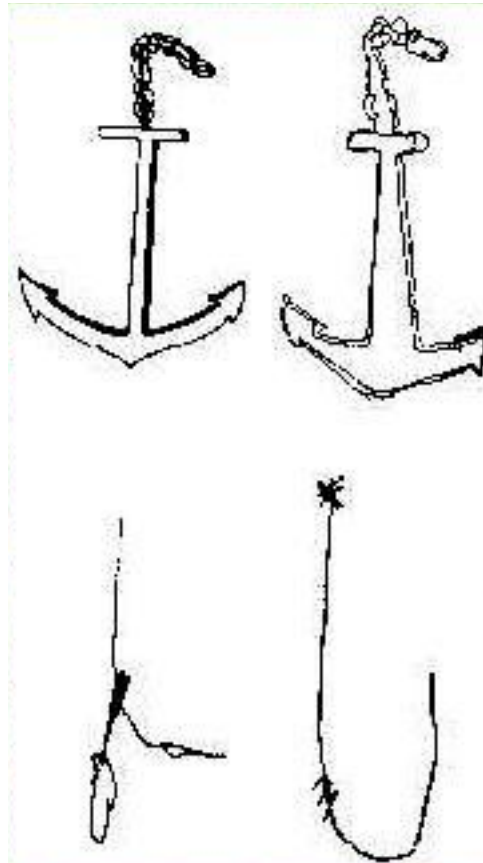
Kanwisher, McDermott, & Chun (1997)



- Responds during passive viewing of faces > objects.
- Cannot be explained in terms of
 - » differences in low-level features
 - » attentional confounds
 - » subordinate - level categorization of any stimulus class
 - » generalized response to anything animate/human
- Is selectively involved in perception of faces.

Patients with inferior temporal lesions have visual agnosia

Copy the drawing
Visuomotor function
Intact – but patient
can't name the object



Draw an anchor.
Patient cannot
conceptualize the
anchor

Ventral stream patients

- Cannot identify objects
- But they can make appropriate visually-guided movements.
- The patient who could not set her grip can still tell you which cylinder is thicker.
- The patient who cannot tell you which cylinder is thicker can set still her grip.

Prosopagnosia “face blindness” is the most dramatic ventral stream deficit

- Term first used by Bodamer, 1947
- Inability to recognize familiar faces
- Visual acuity is normal
- Caused by lesion to right inferior temporal lobe
- May be congenital (“developmental prosopagnosia”)
- Patients compensate by using other recognition cues: clothing, gait, voice, etc.