

Eye and Brain

We are so familiar with seeing, that it takes a **leap of imagination** to realize that there are **problems to be solved**. But consider it. We are given tiny distorted upside-down images in the eyes and we see separate solid objects in surrounding space. From the patterns of stimulation on the retina we perceive the worlds of objects and this is nothing short of a miracle.

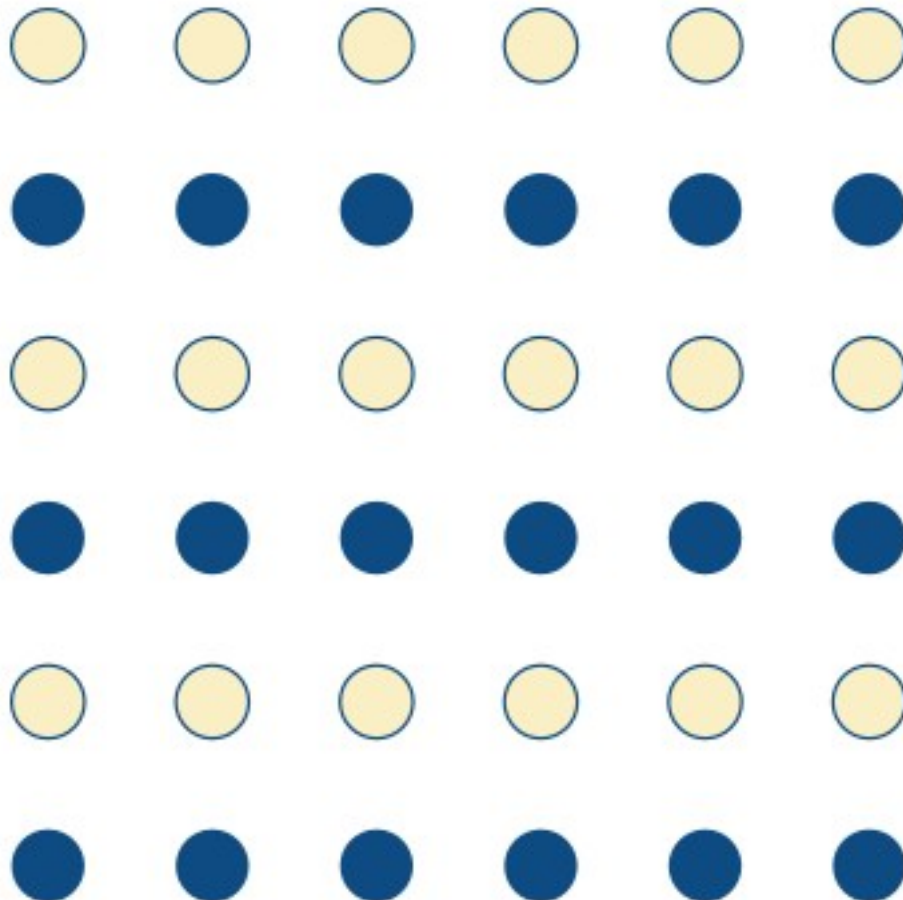
Richard L. Gregory, Eye and Brain, 1966

Problems to be Solved



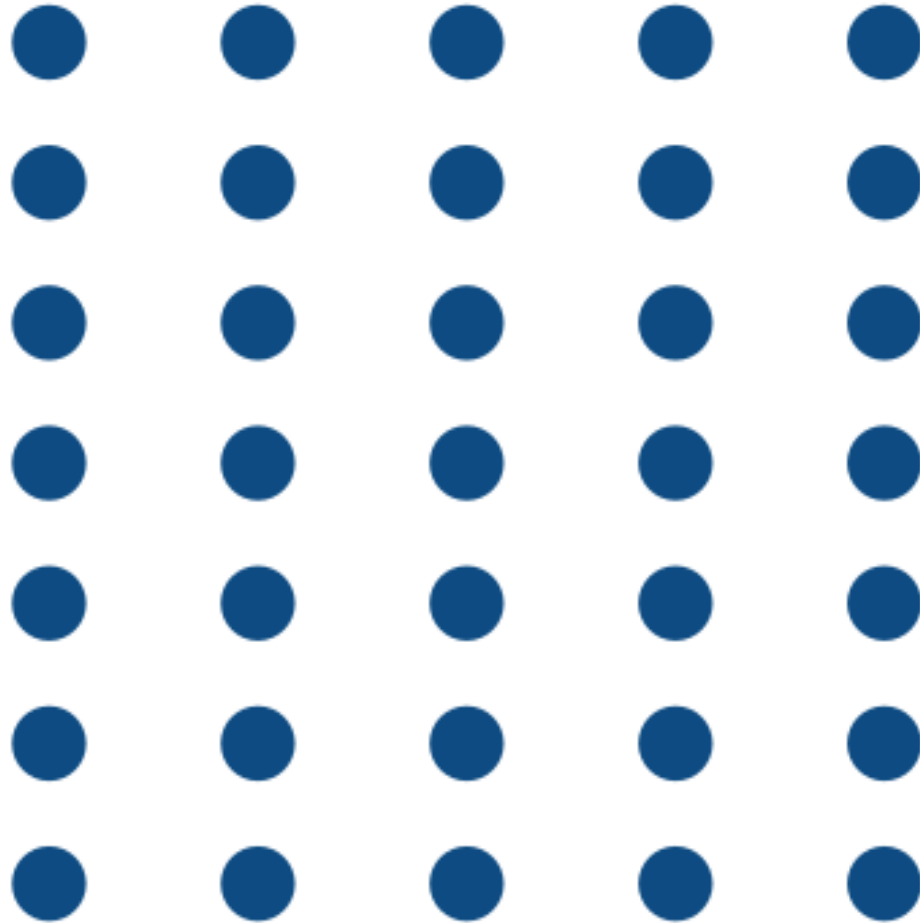
Organizational Rules of Visual Perception^[2]

- Similarity



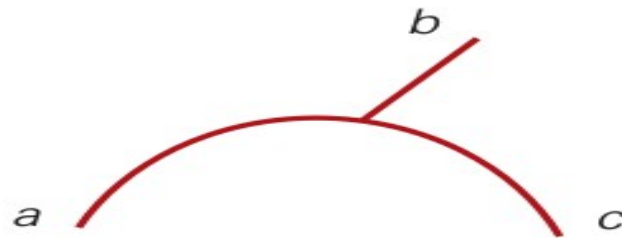
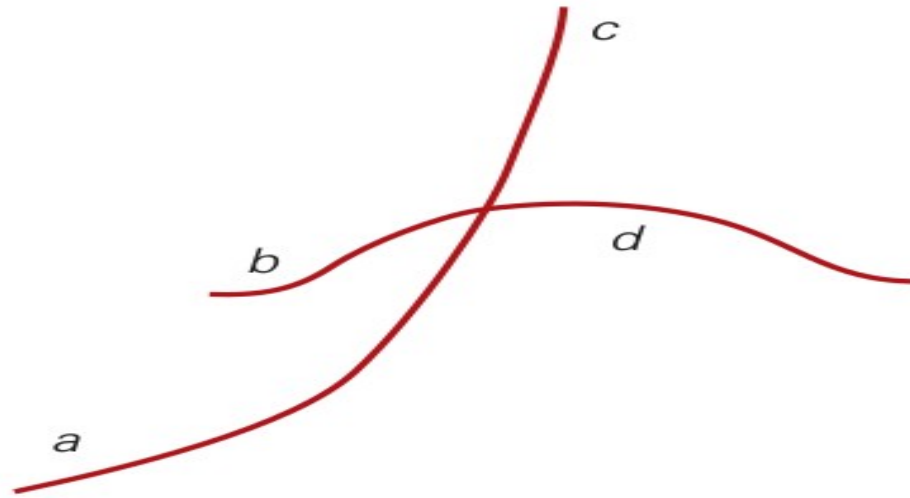
Organizational Rules of Visual Perception^[2]

- Proximity



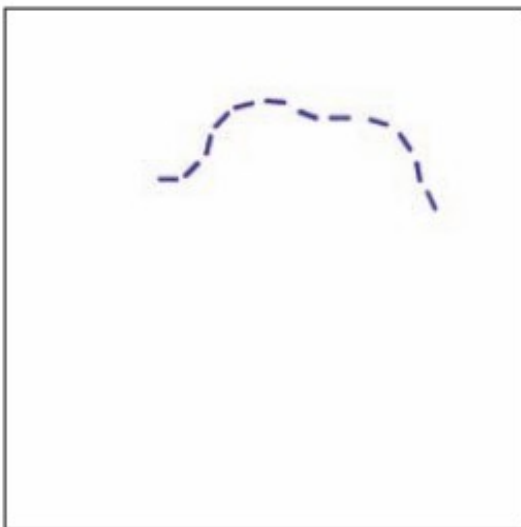
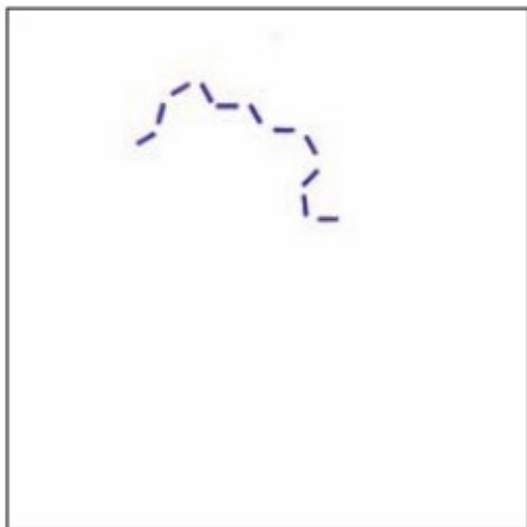
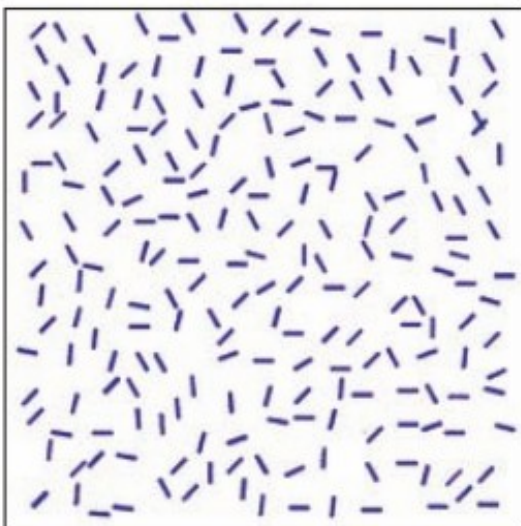
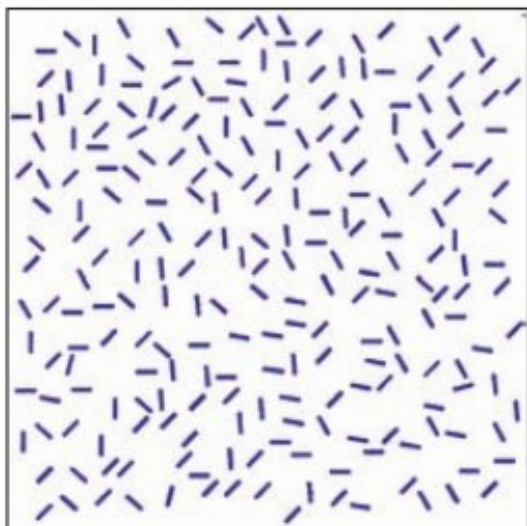
Organizational Rules of Visual Perception^[2]

- Continuation



Organizational Rules of Visual Perception^[2]

- Contour Saliency



Object Recognition depends on the separation of foreground and background in a scene^[2]



Optical Illusion

Three level Processing of a Visual Scene^[2]

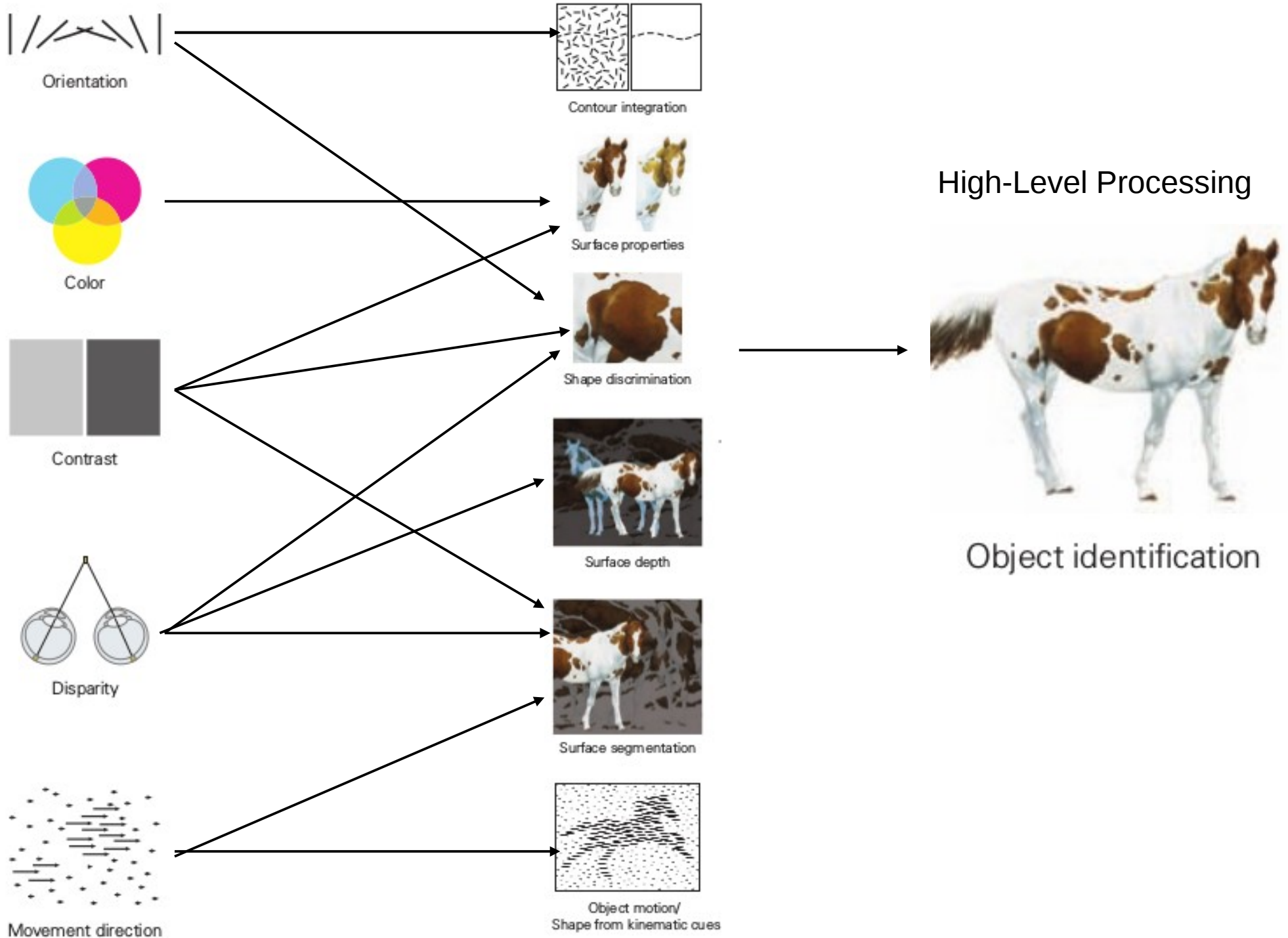


Three level Processing of a Visual Scene^[2]

Low-Level Processing

Intermediate Level Processing

High-Level Processing



How this Vision Process or Interpretation of the world in front of us happens?

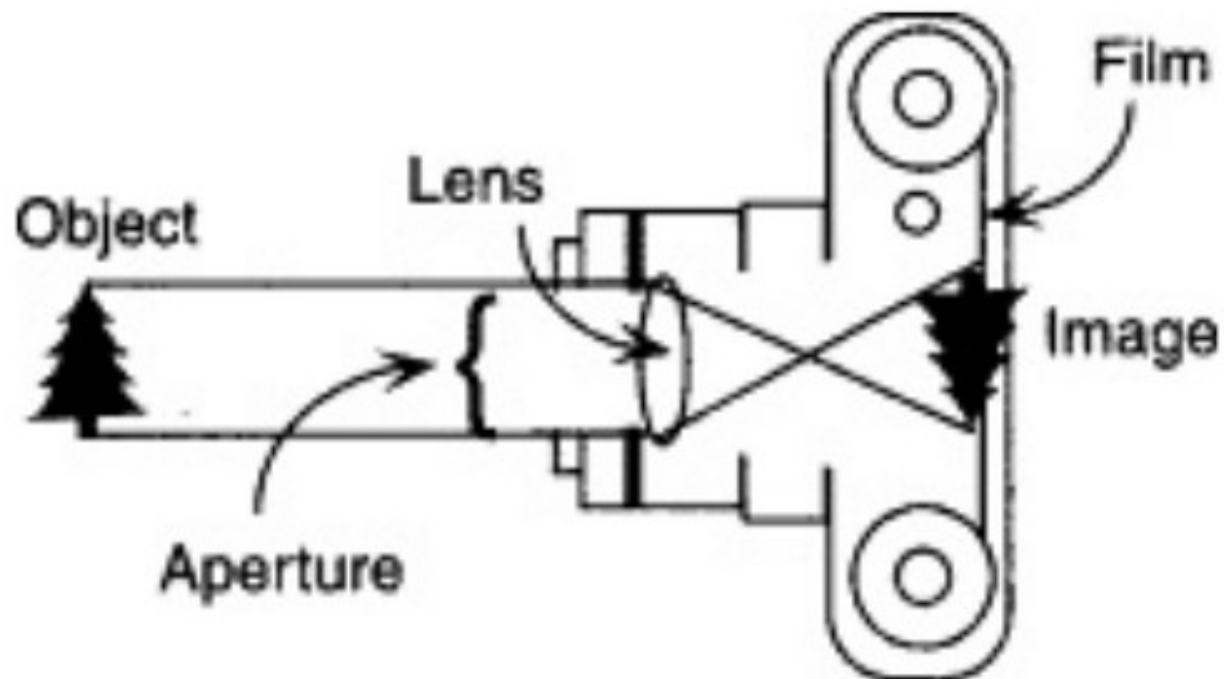
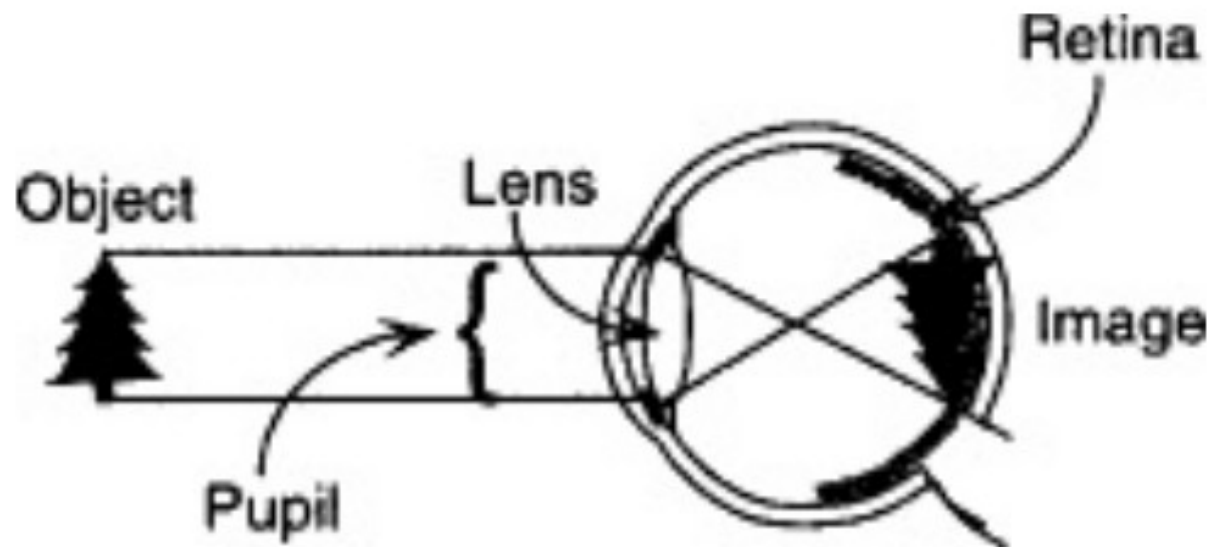
Vision Processing

- Constructive Nature
- Low-level Visual Processing
- Intermediate-level Visual Processing
- High-level Visual Processing

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- Constructive Nature
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Eye-Camera Analogy ^[1]



Expectation and Perceptual task play a critical role in
what is seen^[2]

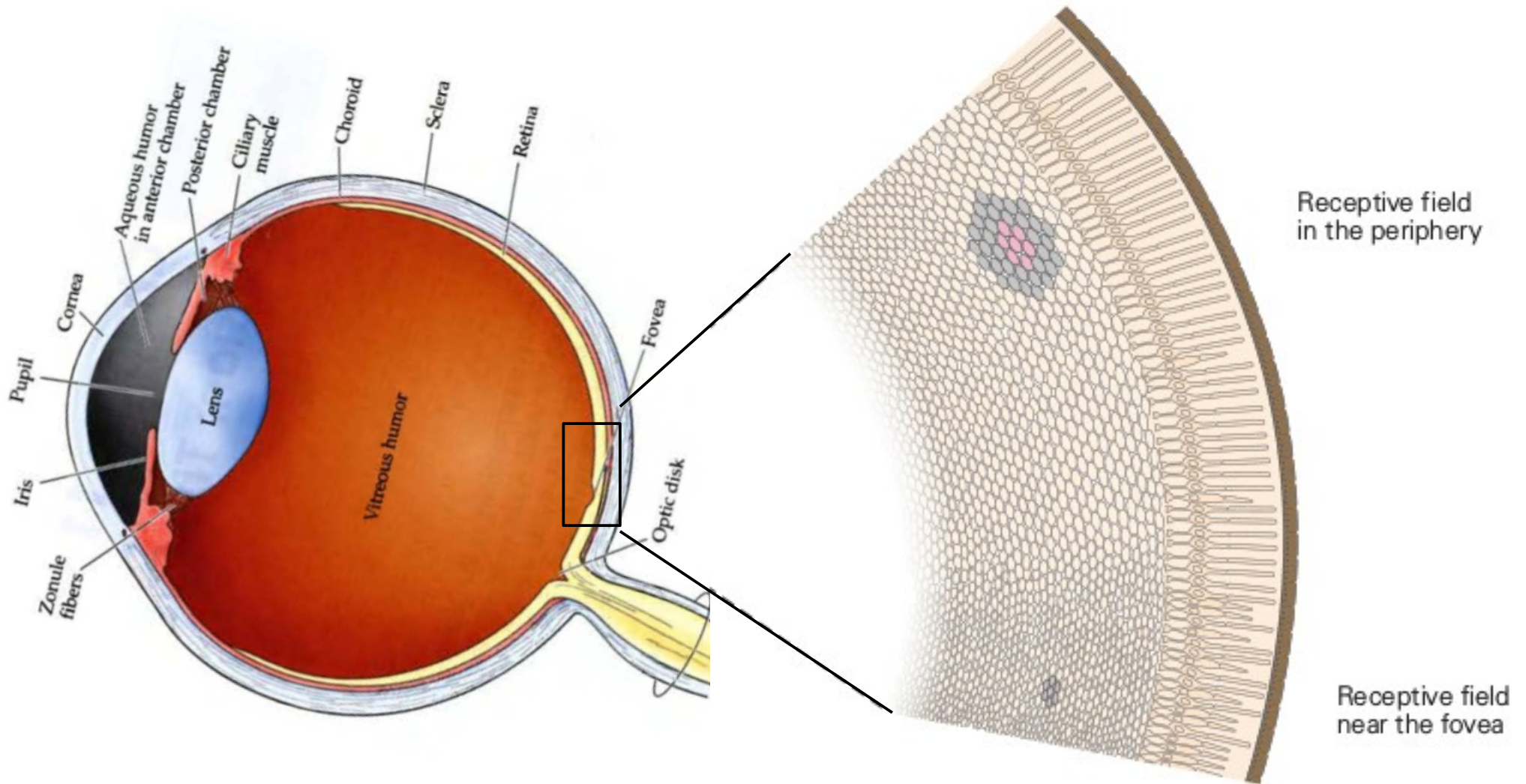


Expectation and Perceptual task play a critical role in
what is seen^[2]



How this constructive process took place?

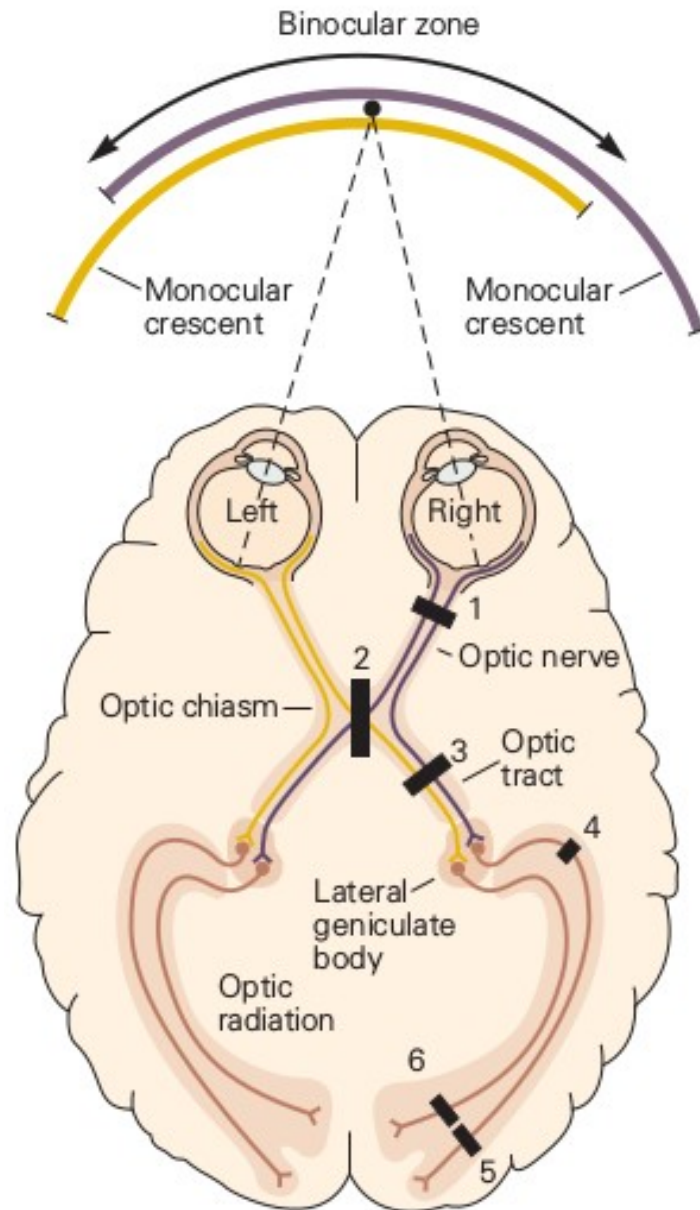
Structure of the Human Eye^[2,3]



Visual Pathway

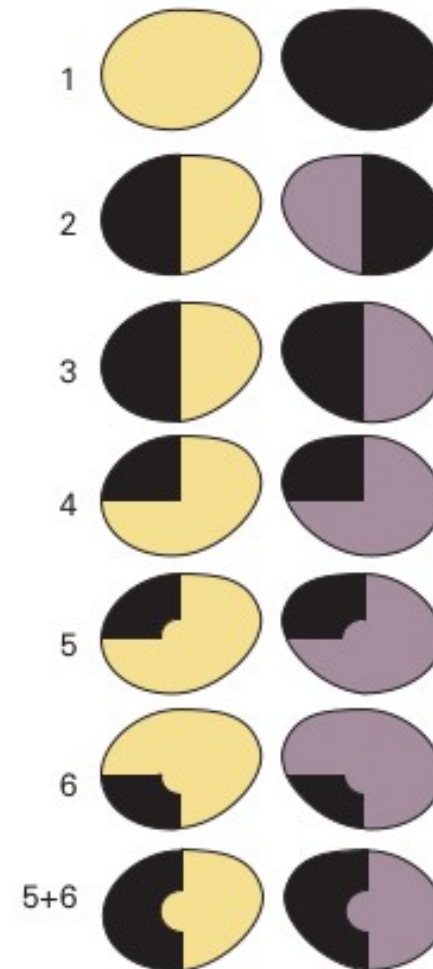
Visual Field along the Visual Pathway^[2]

— Left visual field
— Right visual field



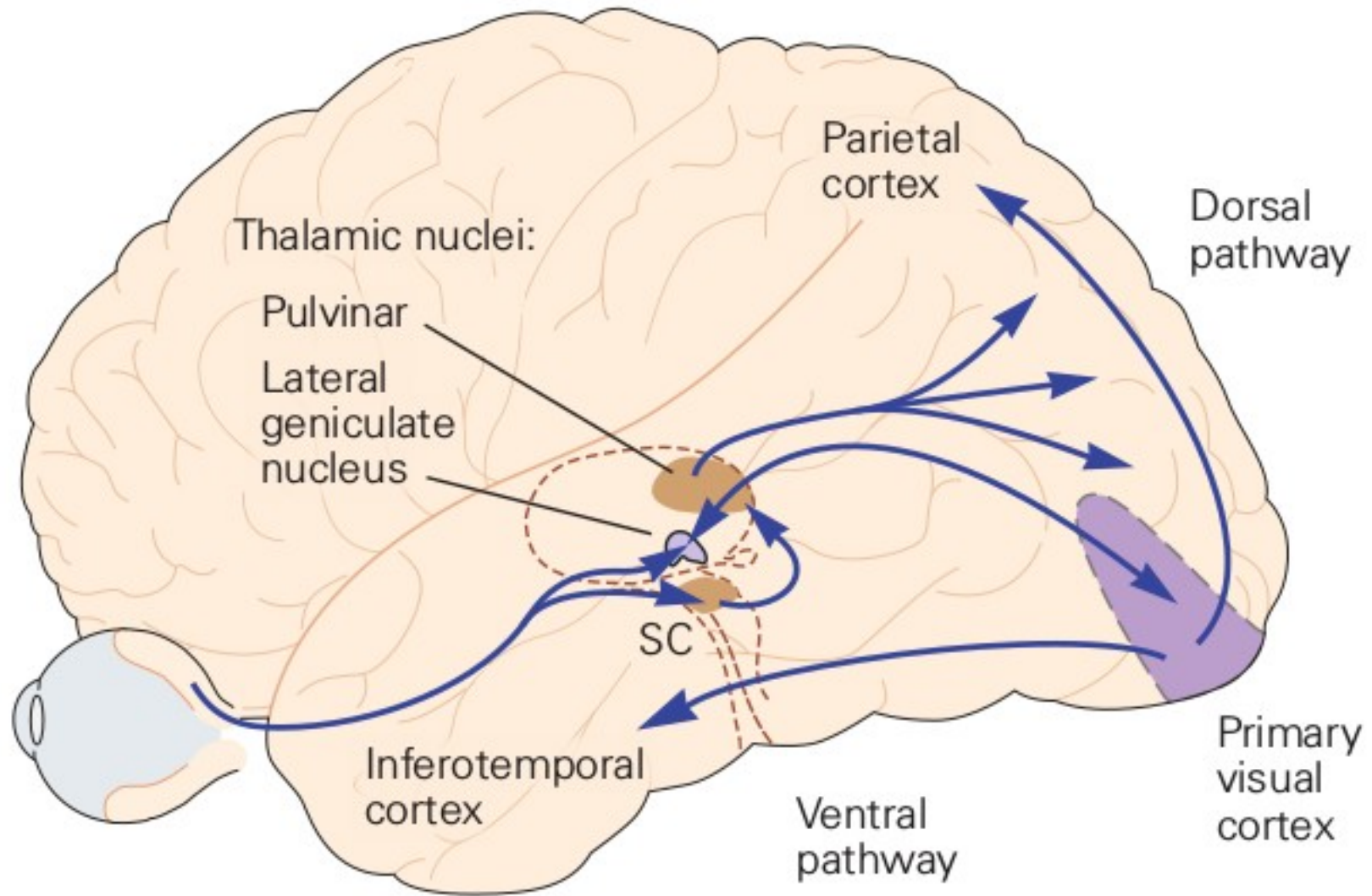
Defects in visual field of

Left eye Right eye



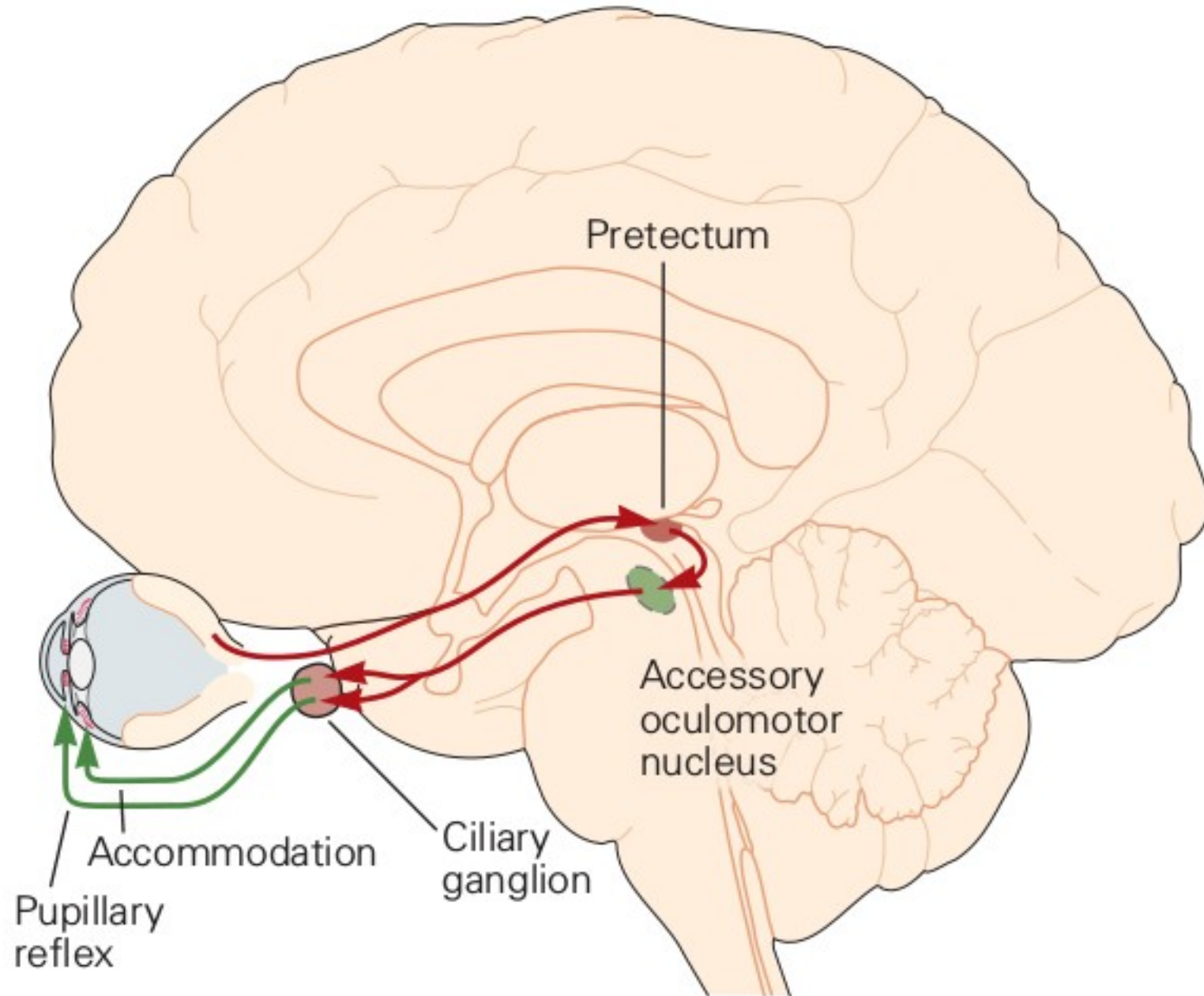
Three Visual Pathway from retina^[2]

- Visual Processing



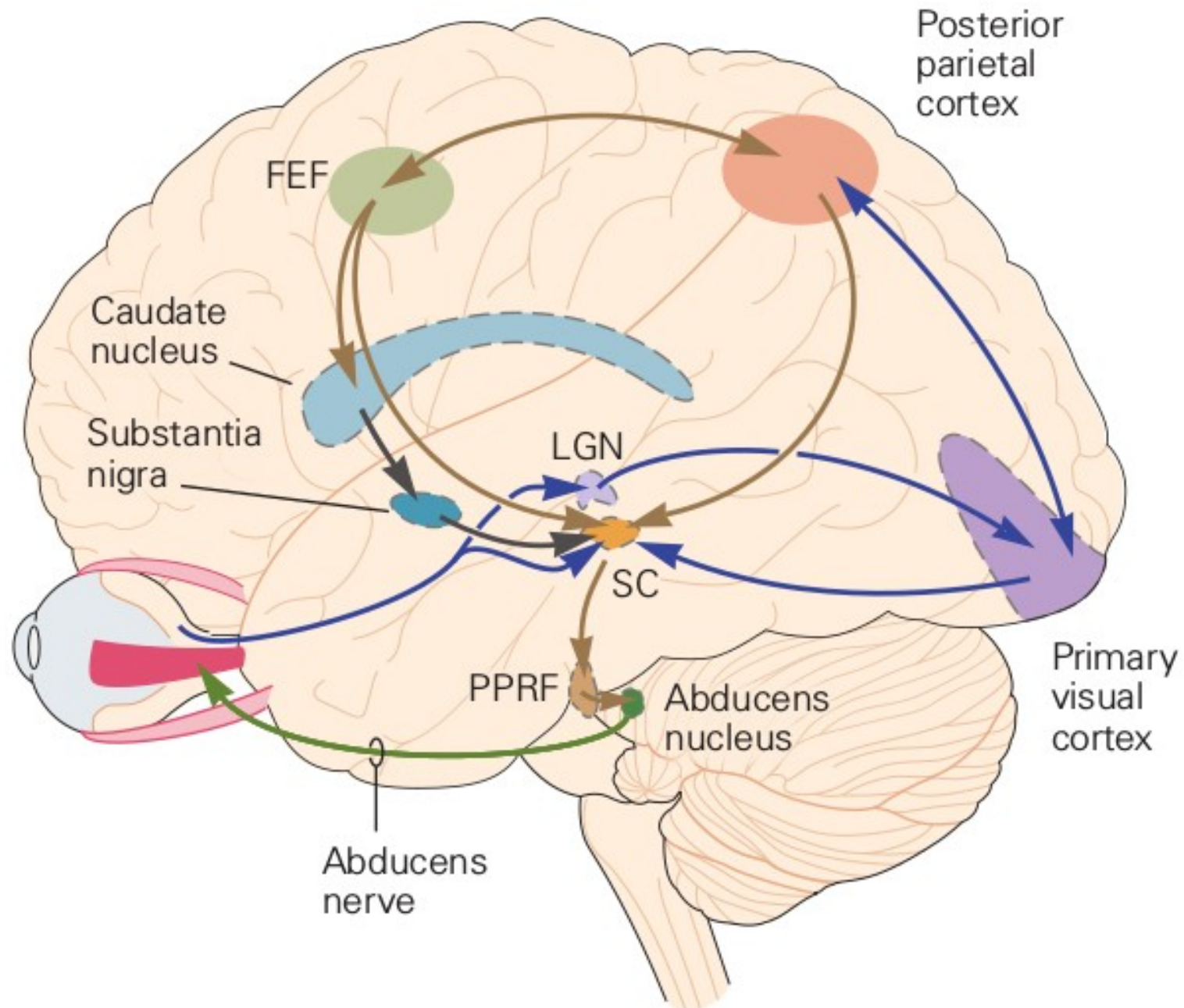
Three Visual Pathway from retina^[2]

- Pupillary Reflex and Accommodation

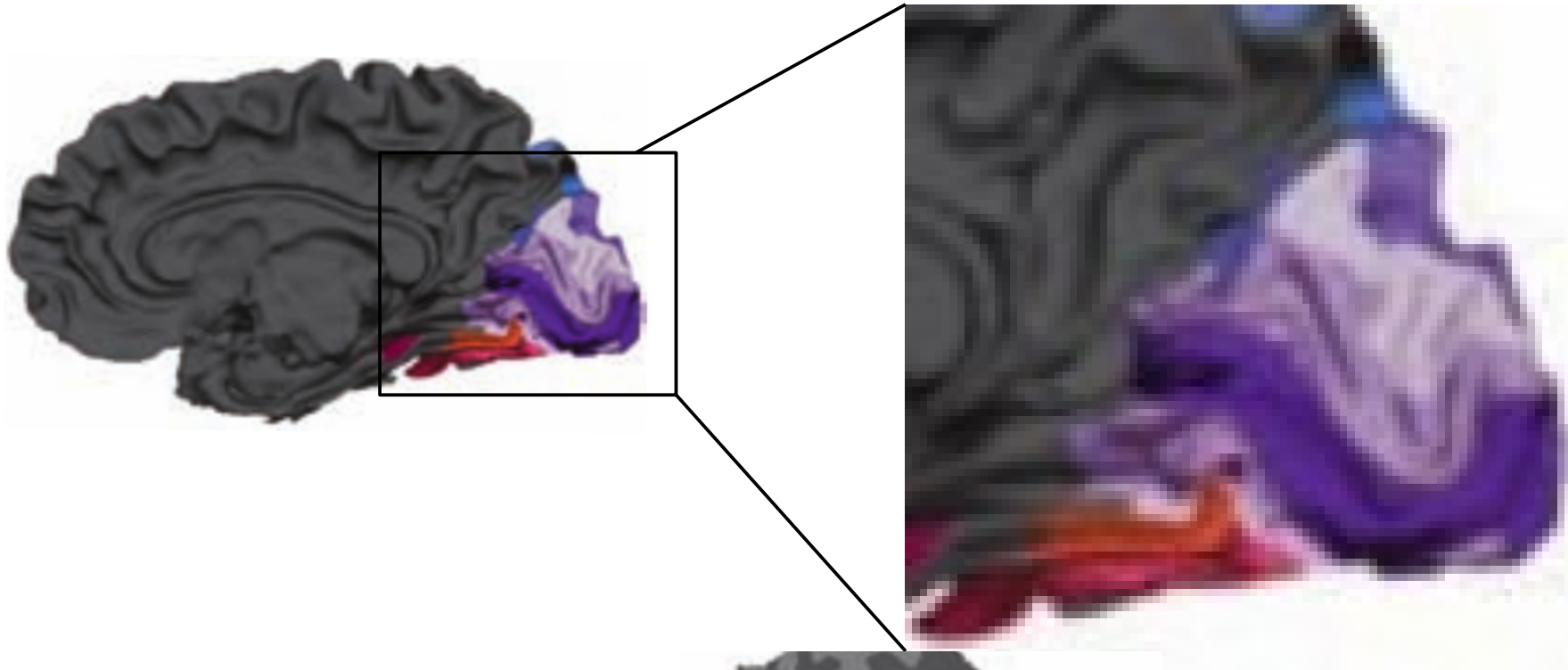


Three Visual Pathway from retina^[2]

- Eye Movement (Horizontal)



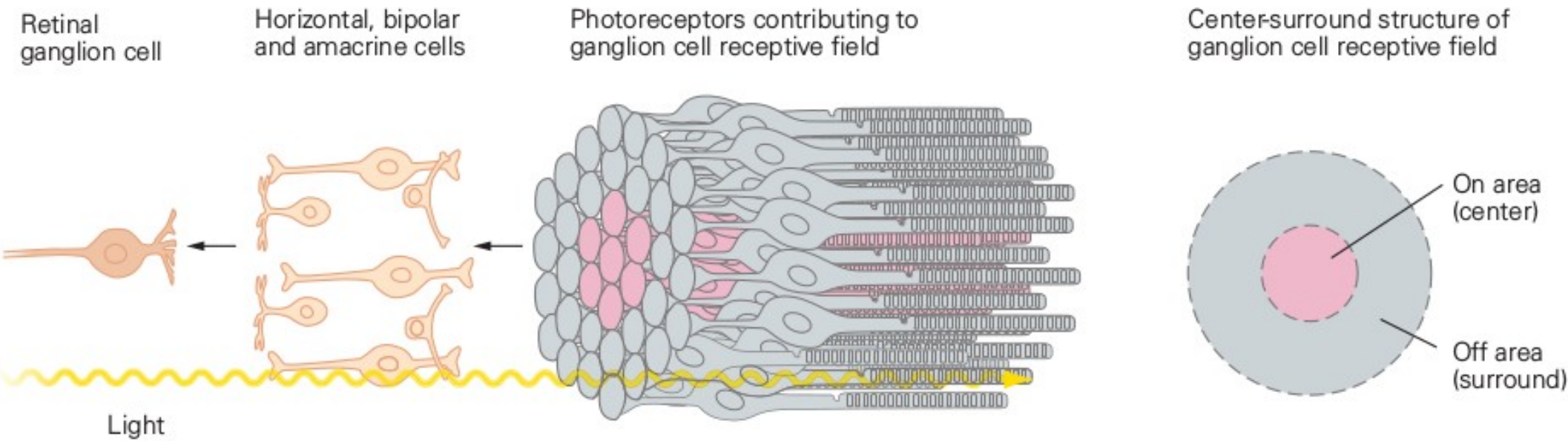
Visual Pathways in the Cerebral Cortex^[2]



- | | | |
|-----|-------|------|
| V1 | V5/MT | LO1 |
| V2 | V6 | LO2 |
| V3 | IPSO | pLOC |
| V3A | IPS1 | FFA |
| V3B | IPS2 | EBA |
| hV4 | VO1 | PPA |

Receptive Fields^[2]

Receptive Field of a Retinal Ganglion Cells



Summary

- Visual perception is a constructive process
- Visual perception is mediated by the Geniculostriate pathway
- Form, Color, Motion, and Depth are processed in Discrete Areas of the Cerebral Cortex
- The receptive fields of neurons at successive relays in an afferent pathway provide clues to how the brain analyzes visual form
- The visual cortex is organized into columns of specialized neurons
- Intrinsic cortical circuits transform neural information
- Visual Information is represented by a variety of neural codes

Important Dates in Vision Science

- 1604- First explanation of the optics of the eye by Kepler's *Ad Vitellionem*.
- 1611- Projection theory of stereoscopic vision by Kepler's *Dioptrice*
- 1619- First accurate diagram of human eye by Scheiner's *Oculus*
- 1625- First direct observation of the retinal image by Scheiner
- 1637- First suggestion of point to point projection of retina onto brain (onto the walls of the ventricles) by Descartes'
- 1681- Discovery of the blind spot; articulation of the trichromacy of human color vision by Mariotte
- 1751- Neurology of pupillary light reflex by Whytt
- 1776- Striate Area of the occipital cortex by Gennari
- 1824- Involvement of cortex in vision by Flourens
- 1833- Stereoscopic Vision by Wheatstone
- 1896- Flechsig describes course of visual radiation from lateral geniculate nucleus to striate area (based on myelogenesis)
- And so on.....

Abbreviations

LGN	Lateral Geneculate Nucleus
SC	Superior Colliculus
PPRF	Paramedian Pontine Reticular Formation
FEF	Frontal Eye Field
AIP	Anterior Intraparietal Area
IT	Inferior Temporal Cortex
LIP	Lateral Intraparietal Area
MIP	Medial Intraparietal Area
MT	Middle Temporal Area
PF	Prefrontal Cortex
PMd	dorsal Premotor Cortex
PMv	ventral Premotor Cortex
V1	Primary Visual cortex (BA: 17)
V2	Secondary Visual area (BA: 18)
VIP	ventral Intraparietal area
IPS1, IPS2	Intraparietal Sulcus (Attention Based retinotopy)
L02,pLOC	Lateral Occipital Cortex
PPA	Parahippocampal place area
EBA	Extrastriate Body area

References

1. Palmer, Stephen E. Vision science: Photons to phenomenology. MIT press, 1999.
2. Siegelbaum, Steven A., and A. J. Hudspeth. Principles of neural science. Eds. Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell. Vol. 4. New York: McGraw-hill, 2000.
3. Purves, D. et al (2008) Neuroscience 4th edition. Sinauer Associates, Sunderland, MA