Vision Anatomy

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About 1/3 of the brain is devoted to vision or visual processing

- **Vision**
  - Light turning into image perception

- **Visual Processing**
  - What is the image
  - Understanding the image within the context of spatial world

- **Eye Movement**
  - Coordinating conjugate movements
  - Generating FAST movements (saccades)
  - Generating TRACKING movements (smooth pursuits)

- **Pupils**
View of Retina through an Ophthalmoscope

Macula: "spot or stain"

Fovea: "pit"

Retinal vasculature

Optic nerve head: optic disk ("blind spot")

temporal retina

nasal retina
Vision: Pathways of Light
Retina

(A) Diagram of the eye showing the retina, fovea, and macula.

(B) Diagram of the retinal layers:
- Inner plexiform layer
- Outer plexiform layer
- Photoreceptors in outer nuclear layer
- Vitreous humor
- Fovea
- Cones
- Rods
- Pigment epithelium
- Ganglion cell layer
- Bipolar cell layer
- Horizontal cell

Axons traveling to optic nerve
Amacrine cell
- Light flow from inner toward outer layers
- Light passes through multiple layers before reaching photoreceptors
Photons to Perceptions

• Rods
  • Retinal plus opsin = rhodopsin
  • Low light situations
  • Poor spatial resolution
  • Poor temporal resolution
  • 20:1 ratio with cones
  • Synapse with parasol cells (Pα or A cells) which then go to the magnocellular layer in the LGN

• Cones
  • Retinal plus opsin like protein = photopsin
  • Three types for short, medium, and long wavelengths
  • Excellent spatial and temporal resolution
  • Taken by midget cells (Pβ or B cells) to the parvocellular layer of the LGN
Distribution of Rods & Cones Across Retina

Photopic vision - fovea
Scotopic vision - peripheral > 10°
Photons to Perceptions

- Rods and Cones are always releasing glutamate.
- They synapse on Bipolar cells which then synapse on retinal ganglion cells.
- Each of these synapses cause neurotransmitter gradients not action potentials.
- The inhibitory and excitatory regulation of these junctions is provided by amacrine cells and horizontal cells.
Getting from Three Discrete Types of Cells to the Whole Visible Spectrum

Cone cell

Rod cell

[Graph showing absorbance across different wavelengths for different types of cones and rods]
What visual disability results from genetically lacking one type of cone cell?

A. Macular Degeneration
B. Quadrantanopsia
C. Color Blindness
D. Achromatopsia
Vision: Optic Nerve

• Images remain inverted!
• Optic chiasm – visual fields are sorted onto contralateral side
• Temporal Lobe - superior visual field information
• Parietal Lobe - inferior visual field information
Retinal detachment in the upper temporal aspect of retina results in what visual field defect?

A. Inferior nasal quadrant defect
B. Central Vision Loss
C. Superior Nasal quadrantanopsia
D. Superior Temporal quadrantanopsia
First Synapse of Vision Pathway after Globe
Primary Visual Cortex
What visual field loss will this pathology cause?

A. Right eye blindness
B. Right hemianopia
C. Left eye blindness
D. Cortical blindness
How do you test Vision?

• Most “Vision” Testing is for the Fovea
Peripheral Vision Testing

• Finger Count or Finger Wiggle
Visual Processing

• The WHERE
  • Catching a moving object
  • Seeing a whole room at the same time (not just what you are focusing on at that moment)

• The WHAT
  • Identification of objects
  • Knowing what an object is for
Pupillary Function

- Pupillary constrictor muscle
- Ciliary ganglion (parasympathetic)
- CN II
- Optic chiasm
- CN III
- Optic tract
- Edinger–Westphal nucleus
- Brachium of superior colliculus
- Lateral geniculate nucleus
- Optic radiation
- Pretectal nucleus
- Posterior commissure
- Visual cortex
- Light
Afferent Pupillary Defect (APD)

- **CN II** carries light
- To the **Edinger Westphal Nucleus**
- Synapse onto parasympathetics
- Carried on **CN III**
What visual field loss will this optic glioma cause?

- Right hemianopia
- Diplopia
- Anisocoria (unequal pupils)
- Monocular visual loss
Relative Afferent Pupil Defect

Highly sensitive and specific for optic nerve disease
Sympathetic problem - Horner’s Syndrome

The eye will not dilate completely
Which Cranial Nerve is NOT involved in eye movement?

- Oculomotor (III)
- Abducens (VI)
- Trigeminal (V)
- Trochlear (IV)
Eye Movements

• Symptoms of eye movement problems
  • Double vision
  • (Sometimes blurry vision if the two images are close to each other)

• Rudimentary Eye Movement Coordination
  • Midbrain (CN III and IV)
  • Pons (CN VI)
Damage to the nerve causes:
• Blown pupil
• Down and Out eye
CN III

(A) Superior rectus

(B) Intorsion

(C) Elevation

(D) Adducted eye—depression

Superior oblique muscles
A 70-year-old woman with a new severe headache and complete left ptosis and new left 3rd nerve palsy (A). Computed tomography angiography shows a posteriorly projecting left posterior communicating artery aneurysm (red arrow) and signs of a subarachnoid hemorrhage (yellow arrows demonstrating blood in the subarachnoid space). Digital subtraction angiography pre-(C) and post-(D) endovascular coiling demonstrating the untreated (blue arrow) and treated (orange arrow) aneurysm.
Trochlear nerve palsy

Straight-ahead gaze

Largest divergence

Head tilt to unaffected side

Paresis of superior oblique m.

Left eye
Right eye
No diplopia
CN VI
CN VI

• Which side has the problem?

Left gaze: no deviation  Primary position: right esotropia  Right gaze: left esotropia
Internuclear Ophthalmoplegia (INO)
Cavernous Sinus

Diaphragma sella
Chiasm
Optic nerve
Cavernous sinus
Dura mater
Oculomotor nerve (CN III)
Trochlear nerve (CN IV)
Internal carotid artery
Abducens nerve (CN VI)
Ophthalmic division (CN V₁)
Maxillary division (CN V₂)
A 69 year old man presented to the hospital 1 hour after suffering sudden onset blindness and difficulty opening his eyes. On exam, he is sleepy and his pupils are fairly large and don’t react very briskly.

A. Bilateral Optic Neuritis  
B. Basilar Artery Thromboembolus  
C. Diabetic Third Nerve Palsy  
D. Cavernous Sinus Thrombosis
Top of the basilar syndrome
Case 2

A young woman reports a headache behind her right eye that started about a week ago and has been getting worse. Her right eye does not seem to move very much in any direction.

A. PCA aneurysm
B. Cavernous Sinus Thrombosis
C. Midbrain Stroke
D. Cerebellar Tumor
Venous Sinus Thrombosis
Case 3

As he went along, he saw a man blind from birth. His disciples asked him, “Rabbi, who sinned, this man or his parents, that he was born blind?”

“Neither this man nor his parents sinned,” said Jesus, “but this happened so that the works of God might be displayed in him. As long as it is day, we must do the works of him who sent me. Night is coming, when no one can work. While I am in the world, I am the light of the world.” After saying this, he spit on the ground, made some mud with the saliva, and put it on the man’s eyes. “Go,” he told him, “wash in the Pool of Siloam” (this word means “Sent”). So the man went and washed, and came home seeing. His neighbors and those who had formerly seen him begging asked, “Isn’t this the same man who used to sit and beg?” Some claimed that he was. Others said, “No, he only looks like him.”

But he himself insisted, “I am the man.”

“How then were your eyes opened?” they asked.

He replied, “The man they call Jesus made some mud and put it on my eyes. He told me to go to Siloam and wash. So I went and washed, and then I could see.” “Where is this man?” they asked him.

“I don’t know,” he said.
Case 3

They brought to the Pharisees the man who had been blind. Now the day on which Jesus had made the mud and opened the man’s eyes was a Sabbath. Therefore the Pharisees also asked him how he had received his sight. “He put mud on my eyes,” the man replied, “and I washed, and now I see.” Some of the Pharisees said, “This man is not from God, for he does not keep the Sabbath.” But others asked, “How can a sinner perform such signs?” So they were divided. Then they turned again to the blind man, “What have you to say about him? It was your eyes he opened.”

The man replied, “He is a prophet.” They still did not believe that he had been blind and had received his sight until they sent for the man’s parents. “Is this your son?” they asked. “Is this the one you say was born blind? How is it that now he can see?” “We know he is our son,” the parents answered, “and we know he was born blind. But how he can see now, or who opened his eyes, we don’t know. Ask him. He is of age; he will speak for himself.” His parents said this because they were afraid of the Jewish leaders, who already had decided that anyone who acknowledged that Jesus was the Messiah would be put out of the synagogue. That was why his parents said, “He is of age; ask him.” A second time they summoned the man who had been blind. “Give glory to God by telling the truth,” they said. “We know this man is a sinner.” He replied, “Whether he is a sinner or not, I don’t know. One thing I do know. I was blind but now I see!”