Visual System (cont)

Center-surround receptive fields revisited

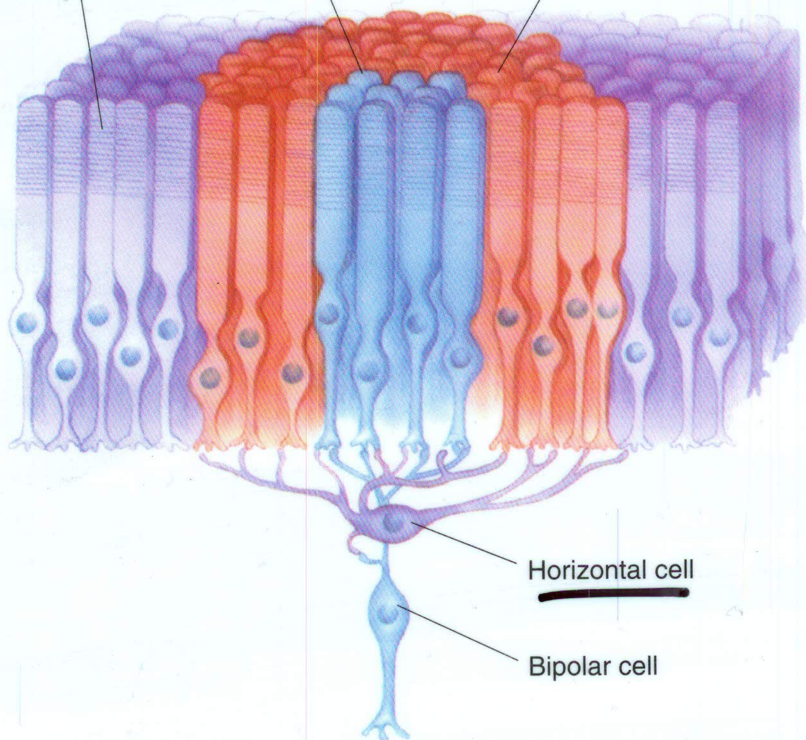
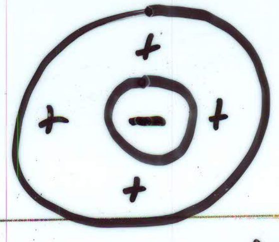


Figure 9.22
Direct and indirect pathways from photoreceptor to bipolar cell. Bipolar cells receive direct synaptic input from a cluster of photoreceptors, constituting the receptive field center. In addition, they receive indirect input from surrounding photoreceptors via horizontal cells.

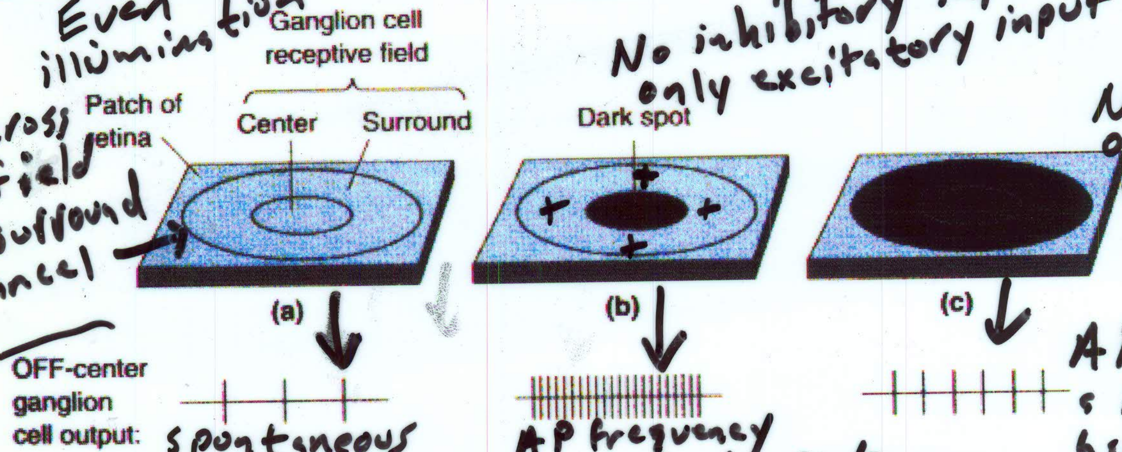


Even illumination across field

center + surround inputs cancel

No inhibitory input only excitatory input

No inhibitory or excitatory input

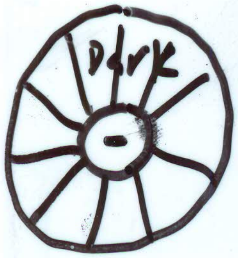


spontaneous AP frequency

AP frequency ↑ relative to spontaneous

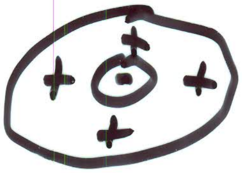
AP freq. a little higher than spontaneous

Figure 9.23
A center-surround ganglion cell receptive field. (a, b) An OFF-center ganglion cell responds with a barrage of action potentials when a dark spot is imaged on its receptive field center. **(c)** If the spot is enlarged to include the receptive field surround, the response is greatly reduced.



inhibition from center
no excitation from surround

AP freq. lower than spontaneous



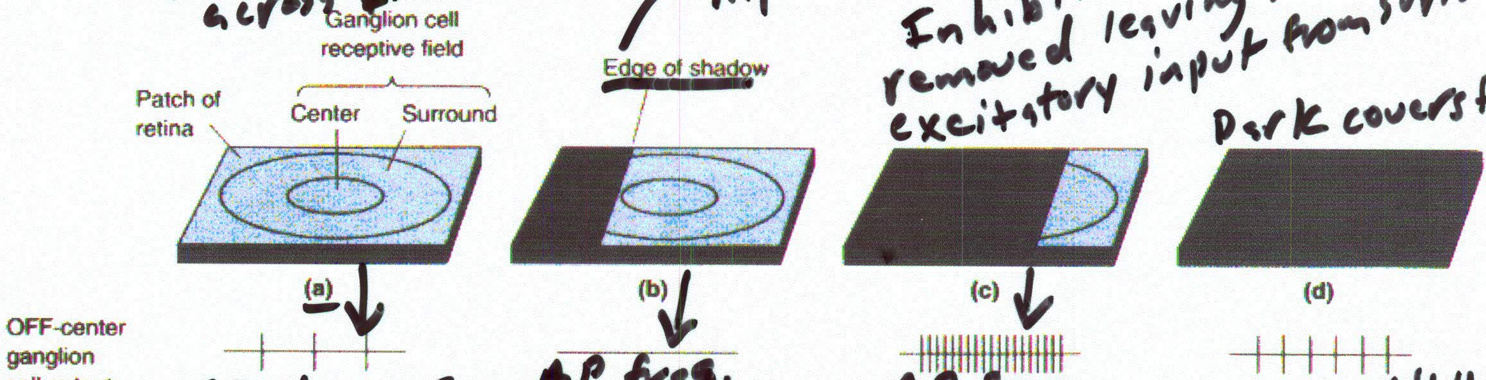
Off-center on-surround ganglion cell's response to an edge moving across its receptive field

Even illumination across field

Removes part of excitatory input to ganglion cell

Inhibition from center removed leaving some excitatory input from surround

Dark covers field



Spontaneous AP freq.

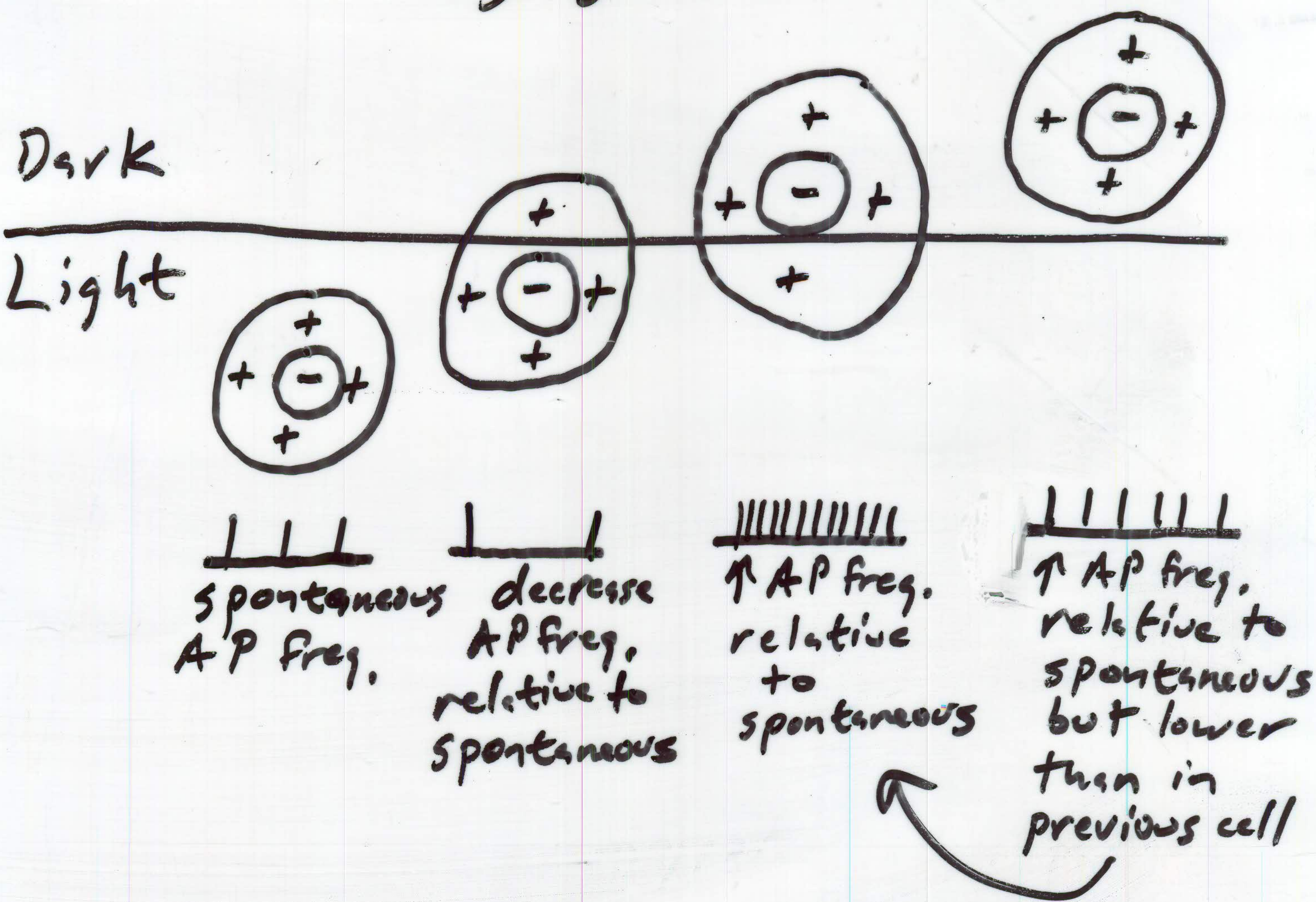
AP freq. ↓ spontaneous

AP freq ↑ spontaneous

No inhibitory or excitatory input to ganglion cell results in low level of AP freq, but higher than spontaneous

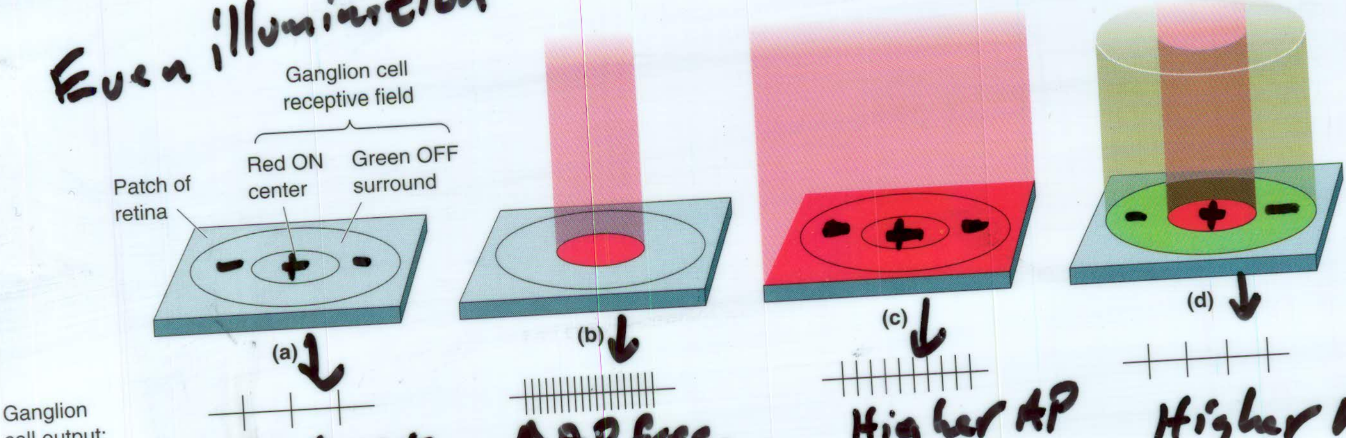
Figure 9.24
Ganglion cell output in response to a light-dark border falling within its receptive field.

Off-center On-surround ganglion cells



Red on-center Green OFF-surround ganglion cell

Even illumination



spontaneous AP freq.

↑ AP freq. relative to spontaneous

Higher AP freq. than spont. but low than red on center alon

Higher AP freq. than spont. but lower than

Figure 9.28
A color-opponent center-surround receptive field of a P-type ganglion cell.

Figure 9.27

Emphasis on contrast provided by the center-surround field arrangement in the retina allows the visual system to distinguish borders and edges between objects based on differences in illumination.

Visual Pathways in Brain

Optic tract has 4 neural targets in the brain:

1. Hypothalamus – uses light/dark cycle to set circadian rhythms (sleep-wake cycles, etc).

2. Pretectum – set of nuclei that are located just anterior to the superior colliculus use intensity of light entering

the eye to initiate the pupillary light reflex - adjusts the contraction - relaxation of the smooth muscle of pupil to increase or decrease pupil diameter.

↑ light intensity $\xrightarrow[\text{reflex}]{\text{pup. light}}$ constricts pupil → decreases light entering eye

↓ light intensity $\xrightarrow[\text{reflex}]{\text{pup. light}}$ dilates pupil → increase light entering eye

(3) Superior colliculus - use visual inputs to initiate eye + neck muscle reflexes allowing your eyes + head to follow the movement of an object across your visual field.

(4) Lateral Geniculate Nucleus (LGN) of the thalamus

receive visual inputs from ganglion cells + relay them to primary visual cortex.

Responsible for concious visual perception

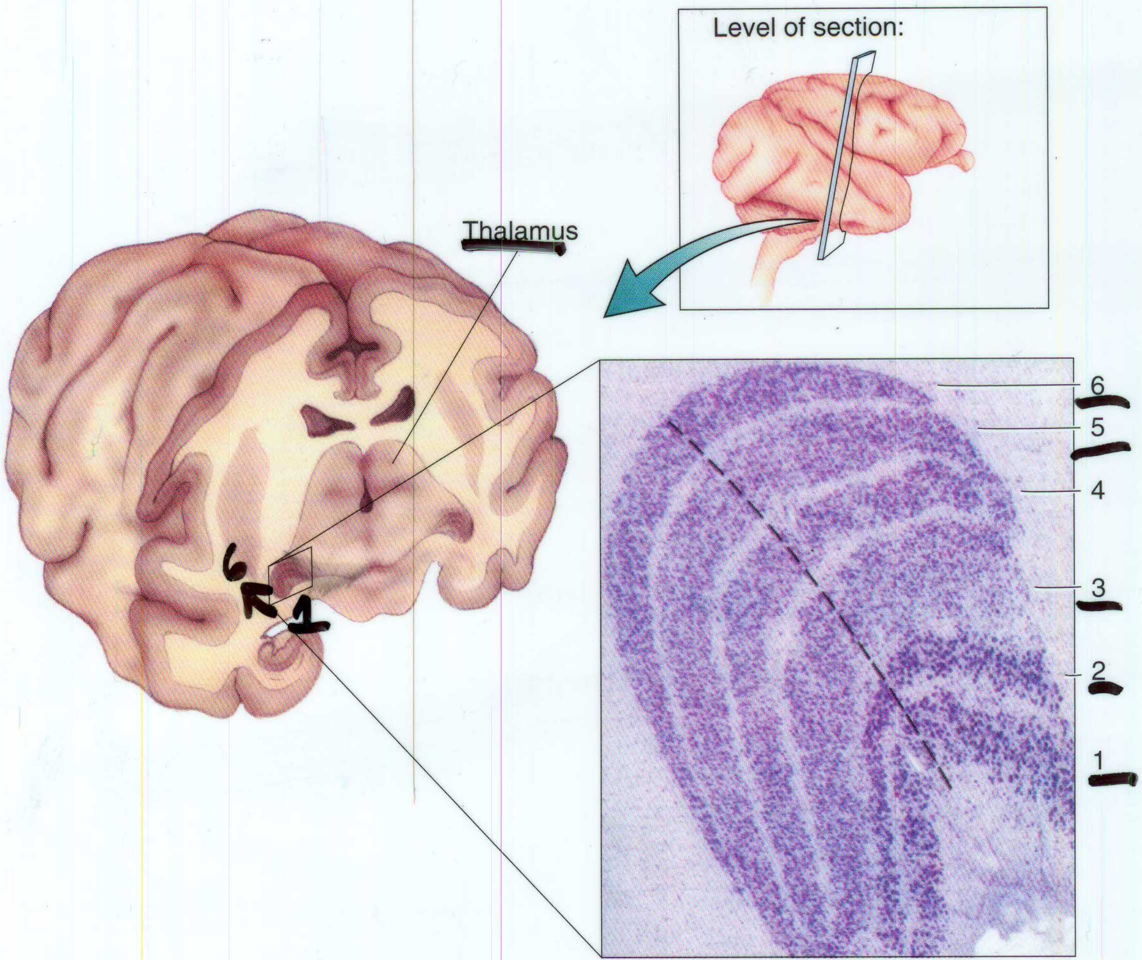
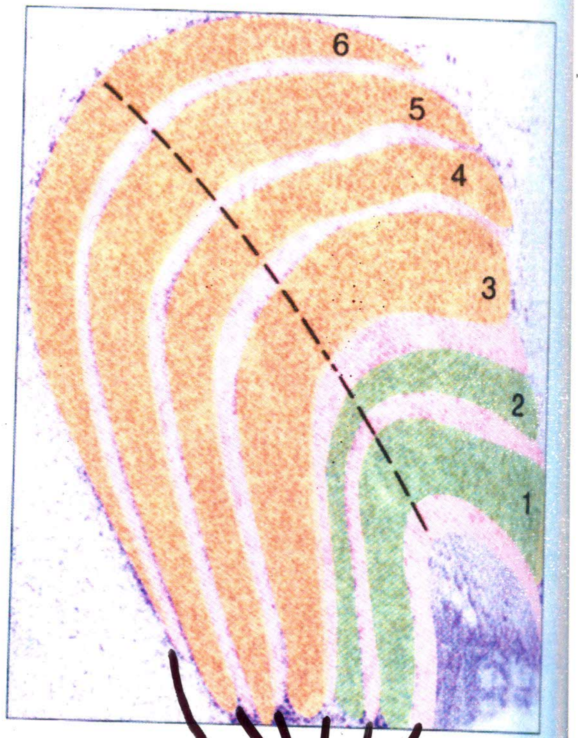


Figure [redacted]
The LGN of the macaque monkey. The tissue has been stained to show cell bodies, which appear as dots. Notice particularly the six layers and the larger size of the cells in the two ventral layers (layers 1 and 2). (Source: Adapted from Hubel, 1988; p. 65.)

Retinal output: Eye	Retinal output: Ganglion cell type	LGN: Layer	LGN: LGN cell type
Contralateral	P-type	6	Parvocellular
Ipsilateral		5	
Contralateral		4	
Ipsilateral		3	
Temporal retina: Ipsilateral	M-type	2	Magnocellular
Nasal retina: Contralateral		1	
Same as overlying principal layer	nonM-nonP	Ventral to each principal layer	Koniocellular

(a)

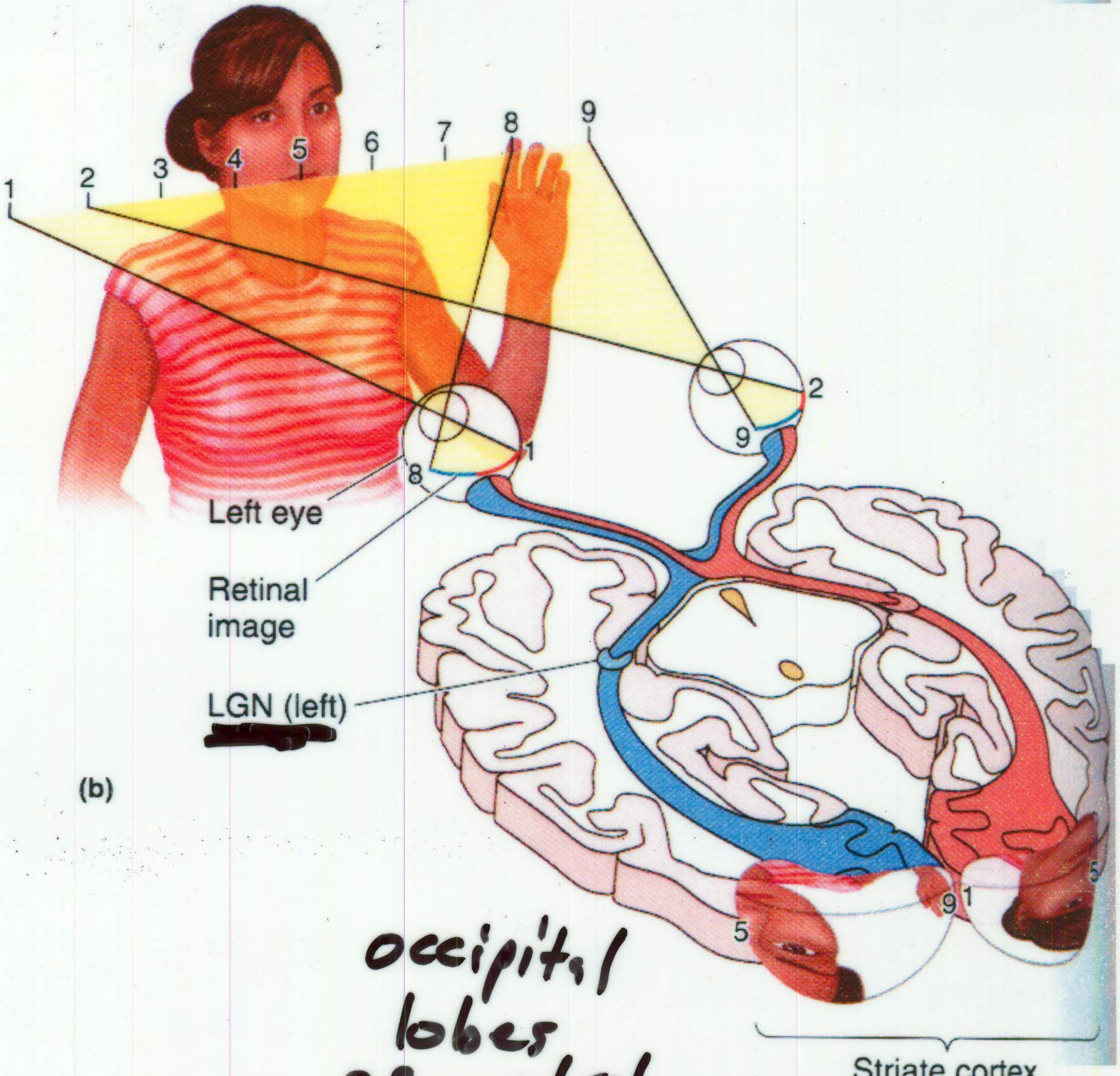


(b)

Koniocellular layers → ("dustlike" cell layers)

inputs arise from non-M non-P type ganglion cells

FIGURE 10.9



(b)

FIGURE 10.11

occipital lobes of cerebral hemispheres

a.k.a. primary visual cortex or Brodmann area 17

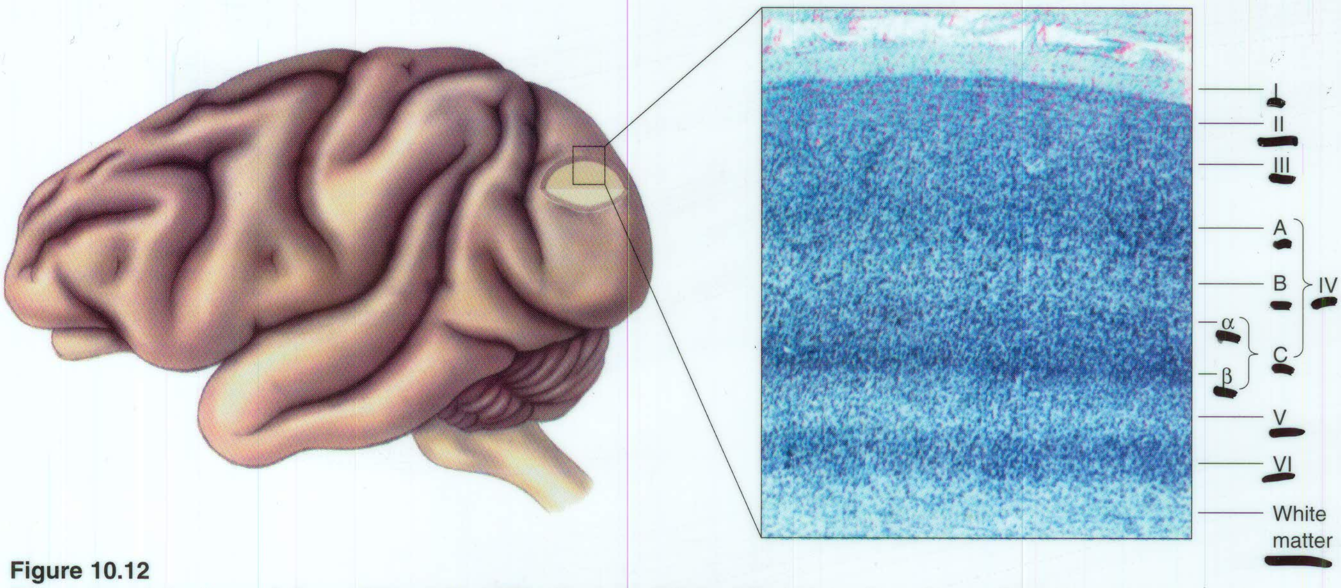
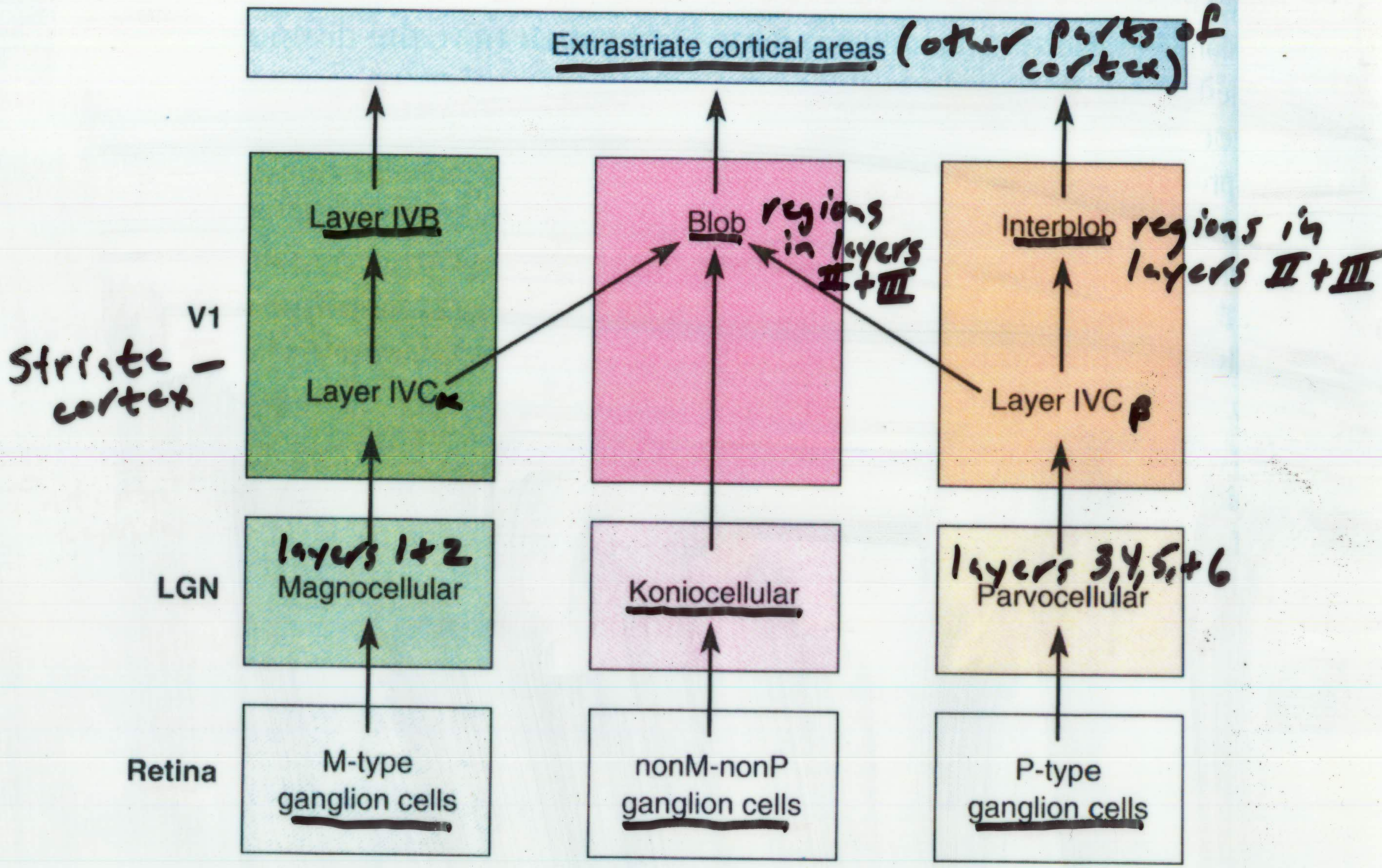


Figure 10.12
The cytoarchitecture of the striate cortex. The tissue has been Nissl stained to show cell bodies, which appear as dots. (Source: Adapted from Hubel, 1988; p. 97.)

Most inputs from LGN synapse on neurons in IVCα + β



Magnocellular pathway (motion)
specialized for analysis of movement + guidance of motor actions

Blob pathway (color)
specialized for analysis of object color

Parvo-interblob pathway (shape)
specialized for analysis of object shape

FIGURE 10.25

Analysis of visual motion

"Dorsal stream"

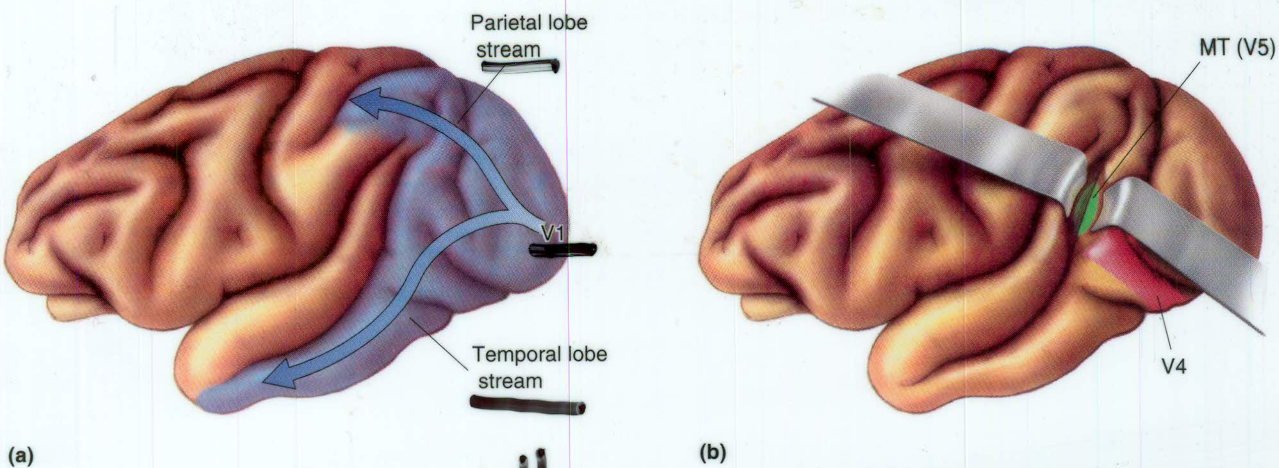


Figure 10.27. Location of (a) parietal and temporal lobe visual processing streams and (b) areas MT and V4 in the macaque brain.

Ventral stream

object recognition

Some neurons in this stream respond to specific faces or facial expressions.

Audition - Sense of Hearing

Conversion of variations in air pressure into neural signals.

Variations in air pressure are created by objects vibrating in the environment

Air pressure waves (soundwave) features:

- Frequency (Pitch)
  defined as the # of waves that pass a given point per unit time

the greater the # of waves that pass the point per unit time the higher the frequency of the sound wave.

frequency is expressed in units of Hertz (Hz)

1 Hz = 1 wave passing a point/sec = 1 oscillation cycle of an air molecule

Human ear is responsive to sound frequencys in range of 20 Hz to 20,000 Hz (20 kHz).

Dogs – 67 – 45 kHz

Cats – 45 Hz – 64 KHz

(2) Loudness of the sound (Intensity of the sound wave)

related to sound wave amplitude

the higher the amplitude the louder the sound loudness is expressed in units called decibels (dB)

logarithmic scale

10 dB is 10x louder than 1 dB
20 dB is 100x louder than 1 dB

conversational speech 60-65 dB

Jet engine 140 dB

Hearing receptors of the human ear can sense sounds up to 120 dB without damage. Above this loudness the sensory receptors are damaged and cannot be replaced resulting in hearing loss.

(3) Sound waves have location
they originate from a sound
source located in space
somewhere around a person's
head.

Your auditory system uses the
frequency and loudness of a
sound to localize the source of
the sound.

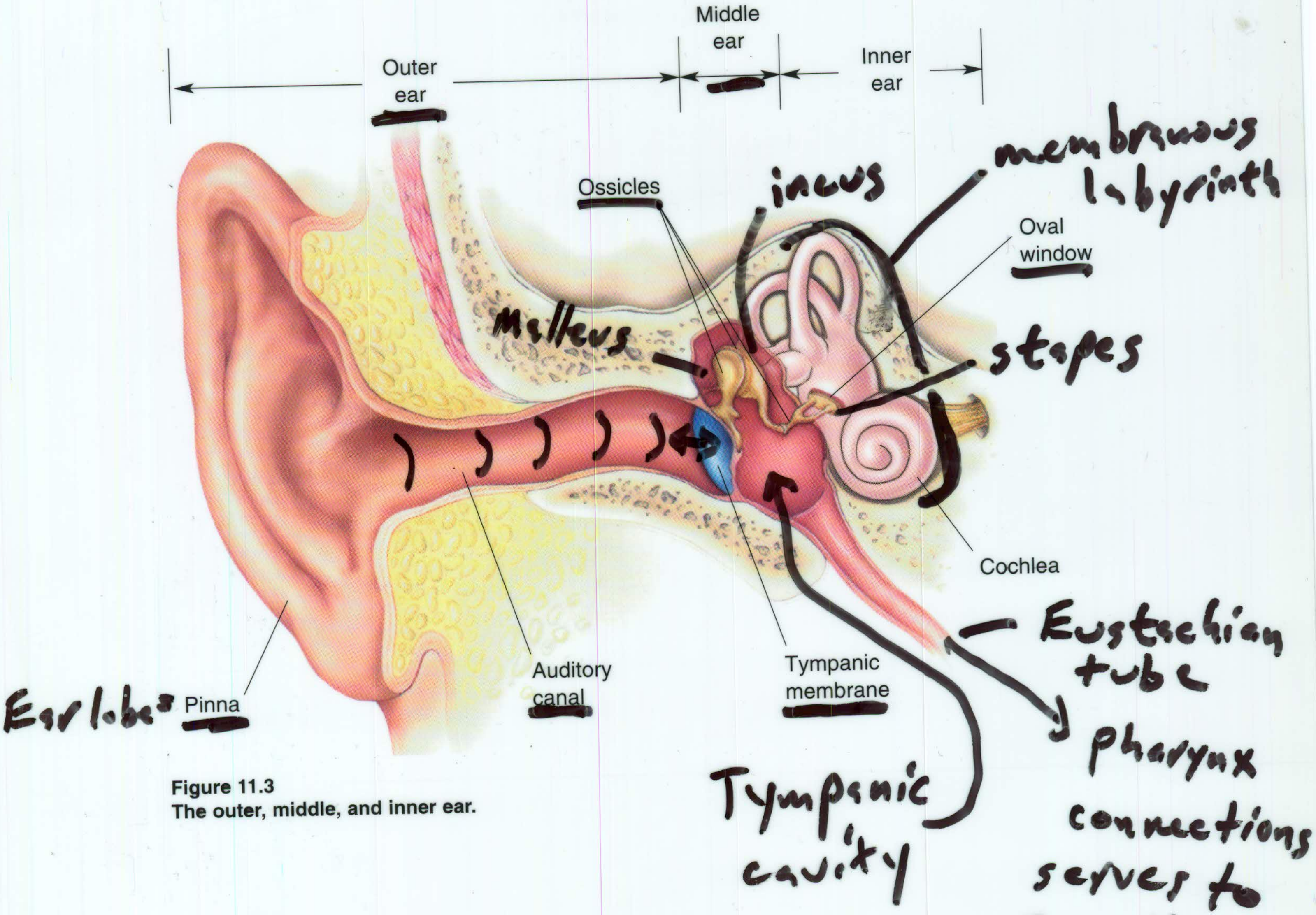
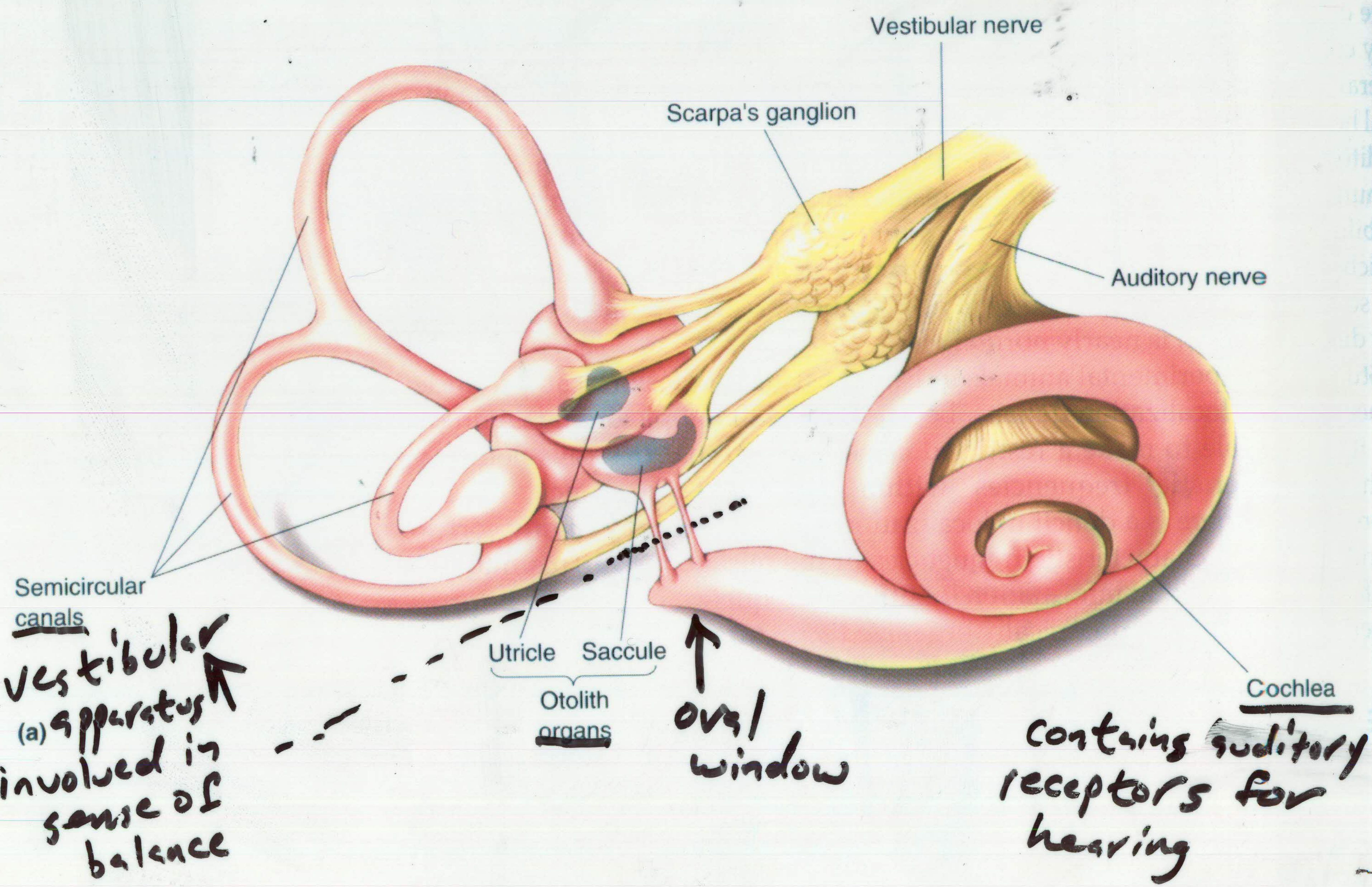


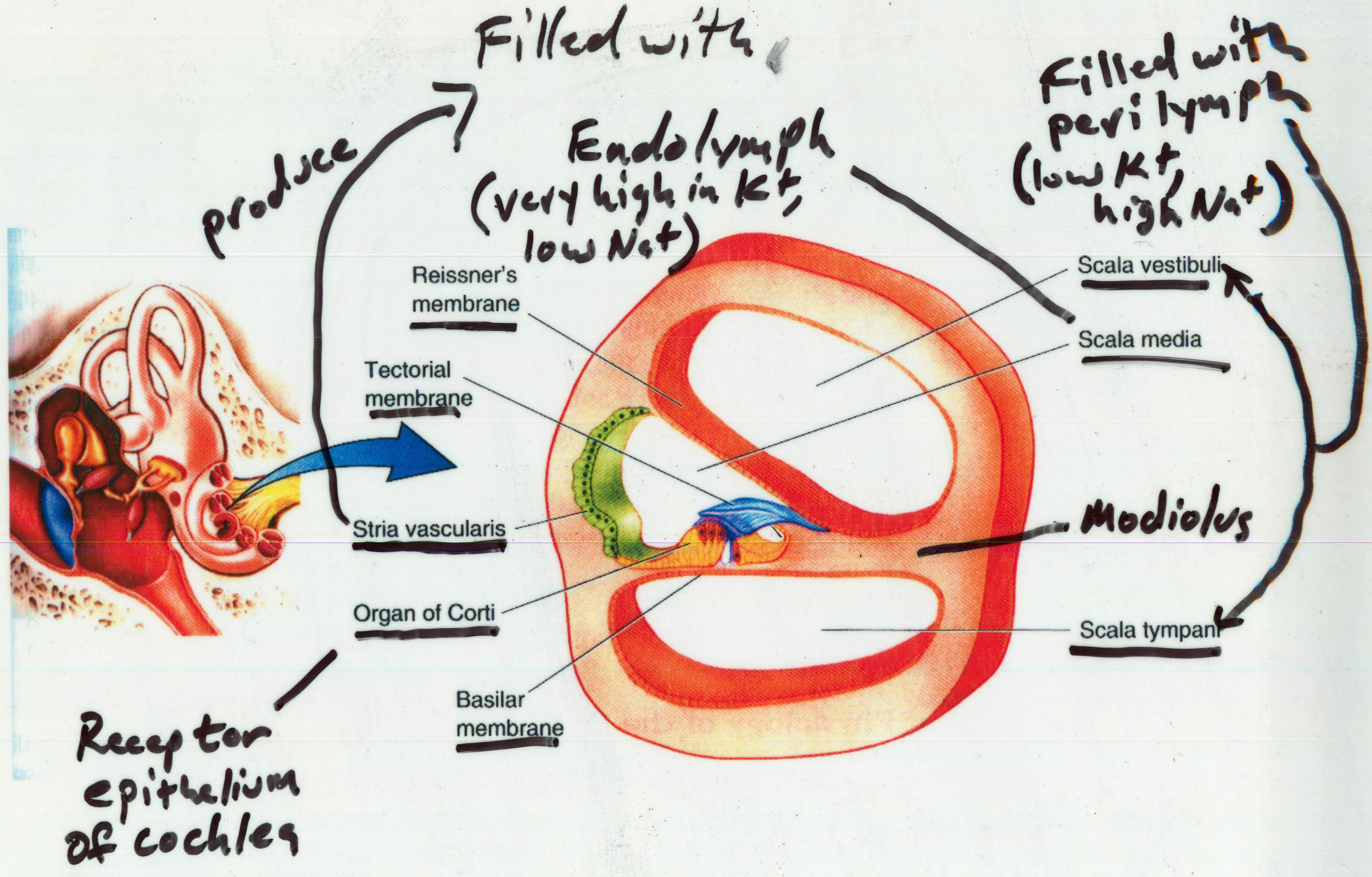
Figure 11.3
The outer, middle, and inner ear.

Figure 11.3



Vestibular nerve
Scarpa's ganglion
Auditory nerve
Semicircular canals
Utricle
Saccule
Otolith organs
Cochlea
vestibular apparatus involved in sense of balance
oval window
contains auditory receptors for hearing

(a)



Filled with
produce
Endolymph
(very high in K^+, low Na^+)
Filled with perilymph
(low K^+, high Na^+)
Reissner's membrane
Tectorial membrane
Stria vascularis
Organ of Corti
Basilar membrane
Scala vestibuli
Scala media
Modiolus
Scala tympani
Receptor epithelium of cochlea

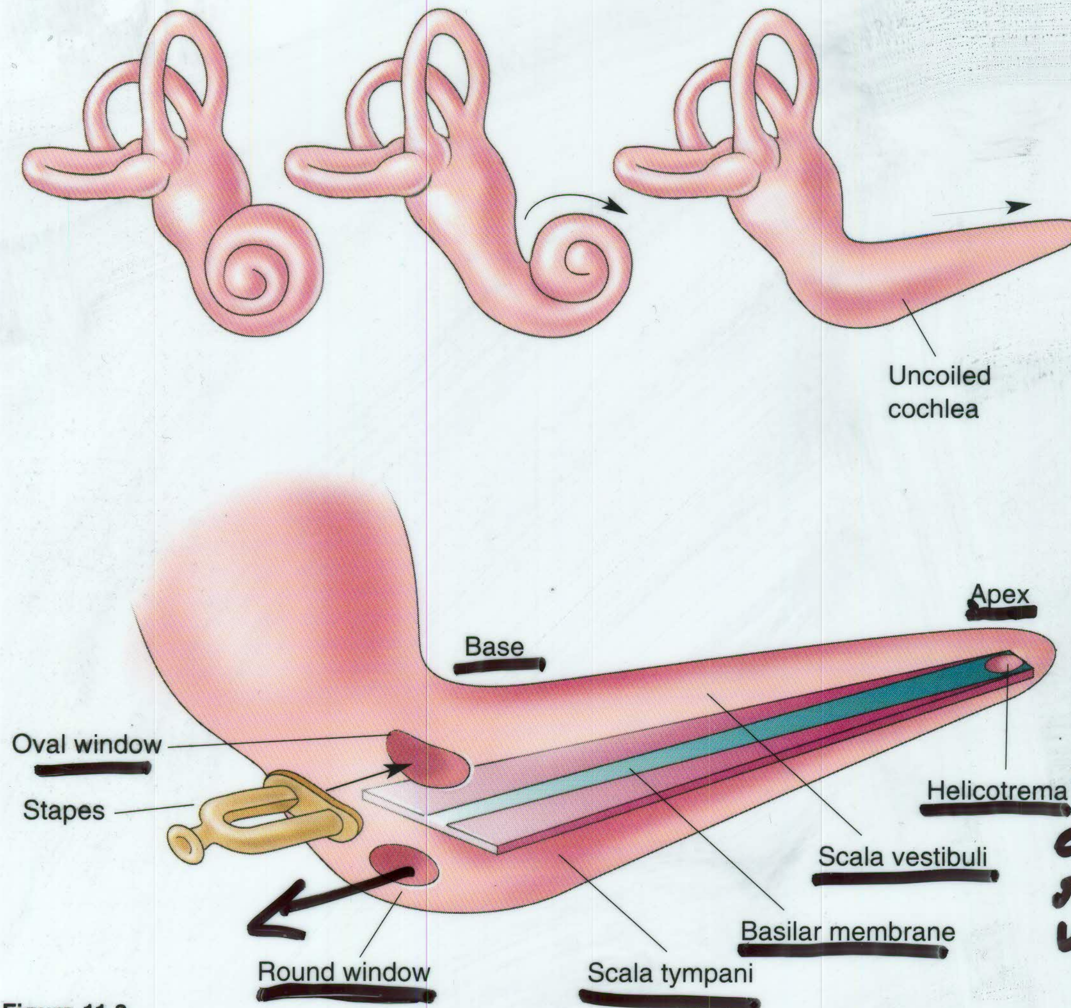
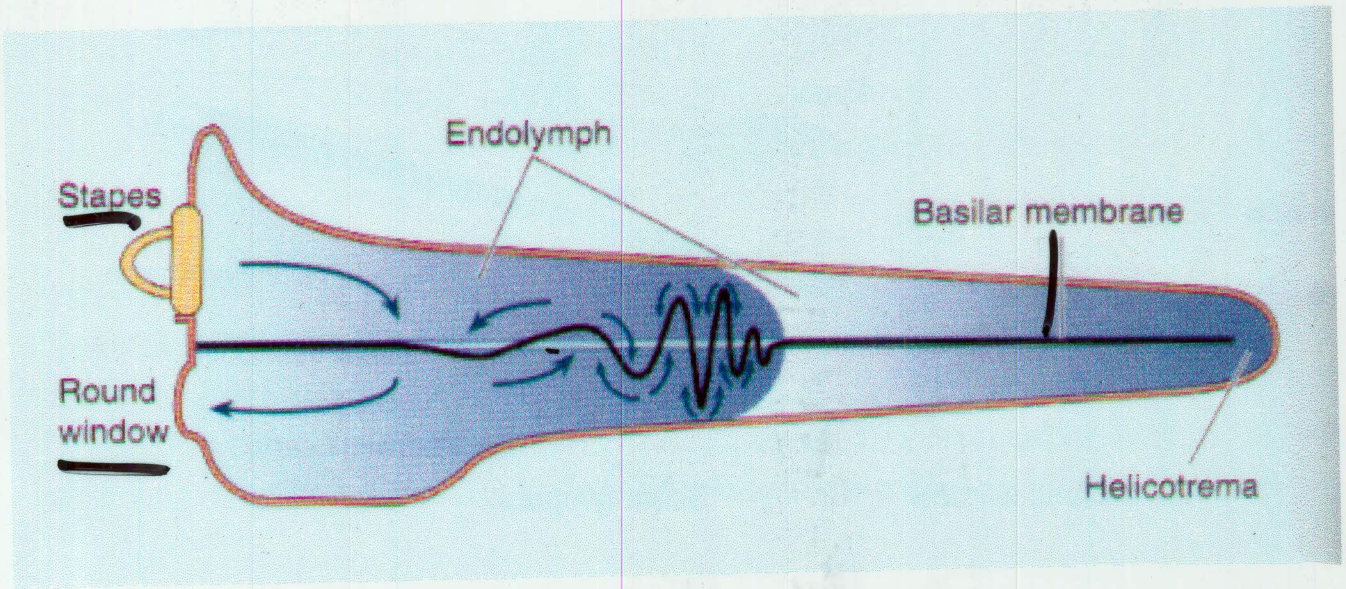


Figure 11.8
The basilar membrane in an uncoiled cochlea. Although the cochlea narrows from base to apex, the basilar membrane widens toward the apex. The helicotrema is a hole at the apex of the basilar membrane, which connects the scala vestibuli and scala tympani.

hole in basilar connects scala vestibuli to scala tympani

Pressure waves in the scala vestibuli are transmitted through Reisnner's membrane + into the scala media causing a deformation wave in the basilar membrane

Figure 11.8

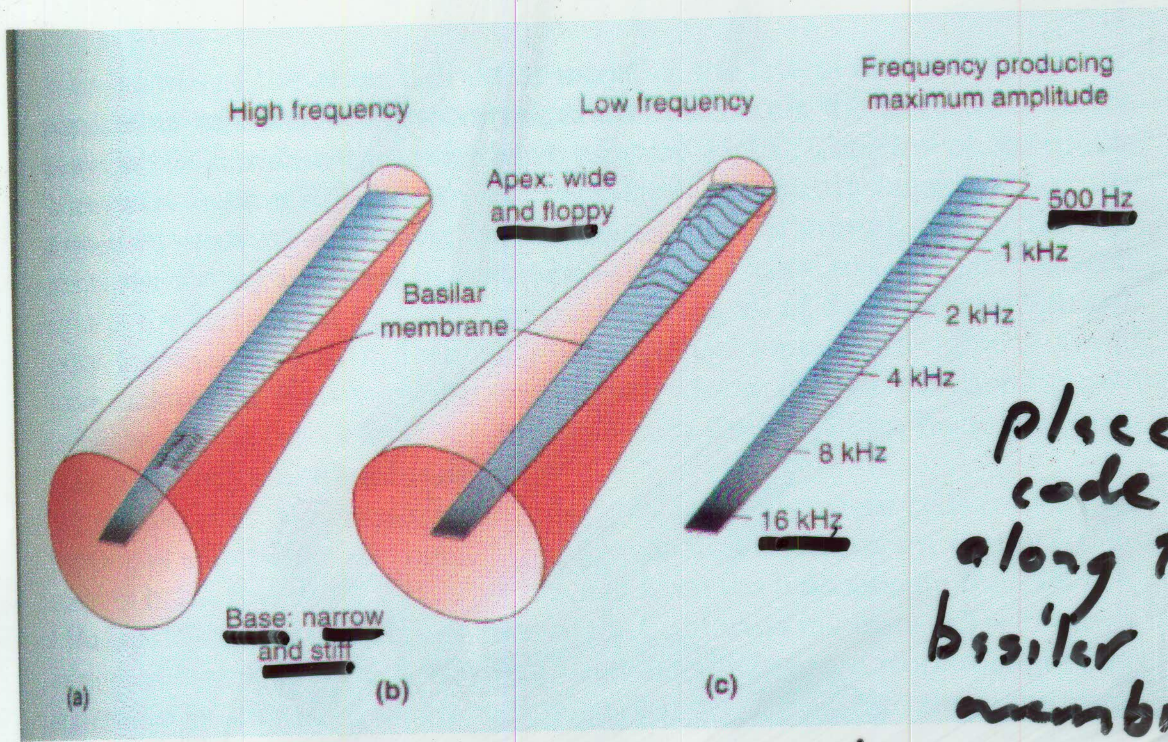

Endolymph
Stapes
Basilar membrane
Round
window
Helicotrema

Properties of basilar membrane:

1. The basilar membrane is wider at its apex than it is at its base

2. The basilar membrane becomes less and less stiff as you go from the base to the apex

As a result of these two properties the distance the deformation wave travels along the basilar membrane and the point of maximum deformation is related to the frequency of the pressure wave.



place code along the basiler membrane in which different locations along the basiler membrane are maximally deformed by sounds of different frequencies.