CHAPTER 15
THE SENSES

CHAPTER OVERVIEW: This chapter discusses sensation, perception, and the structures and processes associated with sensation. Rather than being treated in isolation, the special senses are included as examples of particular types of sensory receptors with highly modified associated structures. The neuronal pathways and cortical destinations of particular types of sensory information are also discussed.

OUTLINE (two or three fifty-min. lectures):
Seeley, A&P, 5/e

Chapt. Object.	Topic Outline, Chapter 15	Figures & Tables	Transparency Acetates
1	I. Classification of the Senses, p. 462	Table 15.1, p. 462	
	A. Types of Senses		
	1. General Senses		
	a. Somatic		
	b. Visceral		
	2. Special Senses		
	3. Sense Modalities		
2	B. Types of Sensory Receptors	Table 15.1, p.462	
	1. Mechanoreceptors		
	2. Chemoreceptors		
	3. Photoreceptors		
	4. Thermoreceptors		
	5. Nociceptors		
1	II. Sensation, p. 462		
	A. Perception as Conscious Awareness		
	B. Result of Multi-Step Cause and Effect Chain		
	1. Stimulus Present		
	2. Receptor Capable of Detecting Stimulus		
	3. Conduction of Action Potentials to CNS		
	4. Translation of Action Potentials into Sensory Information within CNS		
	5. CNS Processing of Sensory Information to Achieve Conscious Awareness of Stimulus	Clinical Note, p.463	
	C. Phenomenon of Projection	Predict Quest. 1	
	D. Accommodation		
	1. Tonic Receptors Accommodate Slowly		
	2. Phasic Receptors Accommodate Rapidly		
2	III. Types of Afferent Nerve Endings, p. 463	Table 15.2, p. 464 Fig. 15.1, p.464	TA-300
	A. Viscероreceptors Mostly Free Nerve Endings		
	1. Pain		
	2. Temperature		
	a. Cold Receptors		

	b. Warm Receptors		
	c. Pain Receptors	Predict Quest. 2	
	3. Itch and Movement		
	B. Exteroreceptors (Cutaneous Receptors)	Fig. 15.1, p.464	
	1. Free Nerve Endings		
	2. Merkel's Disks		
	3. Hair Follicle Receptors		
	4. Pacinian Corpuscles		
	5. Meissner's Corpuscles		
	6. Ruffini's End Organs		
	C. Proprioceptors	Fig. 15.2, p.465	
	1. Golgi Tendon Organs	Fig. 15.2a, p.465	TA-301
	2. Muscle Spindles	Fig. 15.2b, p.465	TA-301
	IV. Olfaction, p. 466		
3	1. Olfactory Recess	Fig. 15.3, p.466	TA-302
	A. Olfactory Epithelium and Bulb		
	1. Olfactory Neurons	Fig. 15.4, p.467 Predict Quest. 3	TA-303
	a. Bipolar Neurons in Olfactory Epithelium		
	b. Axons Project Through Cribriform Plate to Olfactory Bulb		
	c. Dendrites Enlarged into Olfactory Vesicles		
	d. Olfactory Hairs (Cilia) Extend into Mucus Interface with Inspired Air		
	2. Chemoreceptors are Membrane Receptor Molecules		
	3. Detectable Primary Odors ($7 < N < 50$)		
	4. Threshold for Detection	Clinical Note, p.466	
	5. Regeneration Through Proliferation of Basal Cells	Clinical Note, p.467	
	B. Neuronal Pathways for Olfaction	Fig. 15.4, p.467 Predict Quest. 4	TA-303
3	1. Structure of Olfactory Bulb		
	a. Mitral (Tufted) Cells		
	b. Association Neurons		
	2. Olfactory Tract Directly to Cortex		
4,5	3. Olfactory Cortex		
	a. Lateral Olfactory Area - Conscious Perception		
	b. Medial Olfactory Area - Visceral & Emotional Reactions to Smell		
	c. Intermediate Olfactory Area - Modulation of Sensory Info. in Olfactory Bulb		
	V. Taste (Gustation), p.468	Fig. 15.5, p.469	TA-304
	1. Sensory Structures are Taste Buds		

2. Location in Papillae
    a. Circumvallate
    b. Fungiform
    c. Foliate
    d. Filiform

6 A. Histology of Taste Buds
    a. Taste Pore
    b. Gustatory Cells and Hairs
    c. Supporting Cells
    d. Nerve Fibers

B. Function of Taste
    1. Four Primary Tastes (Sweet, Salt, Sour, Bitter)
    2. Regions of Tongue Sensitivity — Fig. 15.6, p.470
    3. Interactions with Olfaction
    4. Thresholds for Tastes
        a. Bitter Lowest Threshold
        b. Salt and Sweet Highest Threshold

7 C. Neuronal Pathways for Taste — Fig. 15.7, p.471 — TA-305
    1. Cranial Nerves to Medulla
        a. Chorda Tympani Branch of Facial Nerve (VII) - Anterior 2/3 of Tongue
        b. Glossopharyngeal Nerve (IX) - Posterior 1/3 of Tongue & Upper Pharynx
        c. Vagus Nerve (X) - Epiglottis
    2. Nucleus of Tractus Solitarius of Medulla Oblongata to Thalamus — Fig. 15.7, p.471
    3. Thalamus to Taste Area of Cortex - Extreme Inferior end of Postcentral Gyrus

VI. Visual System, p. 470

8 A. Accessory Structures — Fig. 15.8, p.471 — Fig. 15.9, p.472 — TA-306
    1. Eyebrows
    2. Eyelids (Palpebrae) & Eyelashes
        a. Palpebral Fissure
        b. Canthi
        c. Caruncle
        d. Five Tissue Layers
            1). Thin Integument
            2). Areolar Connective Tissue
            3). Skeletal Muscle
                a). Orbicularis Oculi
                b). Levator Palpebrae Superioris
            4). Tarsal Plate - Dense Connective Tissue
            5). Palpebral Conjunctiva
        e. Ciliary Glands and Stys
        f. Meibomian Glands and Chalazions

	or Meibomian Cysts		
	3. Conjunctiva	Fig. 15.9, p.472 Clinical Note, p.471	TA-306
	a. Mucous Membrane		
	b. Regions		
	1). Palpebral - Inner Eyelid		
	2). Bulbar - Anterior Eye		
	3). Fornices - Points of Connection		
	4. Lacrimal Apparatus	Fig. 15.10, p.473	TA-307
	a. Lacrimal Gland	Clinical Note, p.472	
	1). Parasympathetic Innervation, Facial Nerve (VII)		
	2). Superolateral Corner of Orbit		
	b. Nasolacrimal Duct System	Predict Quest. 5	
	1). Inferomedial Corner of Orbit		
	2). Parts		
	a). Lacrimal Canaliculi		
	b). Punctum		
	c). Lacrimal Papilla		
	d). Lacrimal Sac		
	e). Nasolacrimal Duct		
	5. Extrinsic Muscles of the Eye	Fig. 15.11, p.473 Fig. 15.12, p.474	
	a. Rectus Muscles		
	1. Superior (Oculomotor III)		
	2. Inferior (Abducens VI)		
	3. Medial (Oculomotor III)		
	4. Lateral (Oculomotor III)		
	b. Oblique Muscles		
	1. Superior (Trochlear IV)		
	2. Inferior (Oculomotor III)		
	c. "H" Test		
9	B. Anatomy of the Eye	Fig. 15.13, p.474	TA-308
	1. Fibrous Tunic		
	a. Sclera		
	b. Cornea	Predict Quest. 6 & Clinical Note, p.474	
	1). Transparent		
	2). Avascular		
	2. Vascular Tunic	Fig. 15.14, p.475	TA-309
	a. Blood Supply = Branches off Ophthalmic Artery		
	b. Posterior Portion is Choroid Containing Dark Pigment		
	c. Anterior Portion		

10	1). Ciliary Body a). Ciliary Ring b). Ciliary Processes & Aqueous Humor c). Suspensory Ligaments to Lens d). Ciliary Muscles - Outer/ Radial & Inner/ Circular Smooth Muscle		
10	2). Iris a). Pupil	Clinical Note, p.476	
	b). Circular Sphincter Pupillae Smooth Muscle c). Radial Dilator Pupillae Smooth Muscle		
	3. Retina	Fig. 15.13, p.474	TA-308
	a. Histology 1). Pigmented Retina - Cuboidal Epithelium 2). Sensory Retina		
10	b. Ophthalmoscopic View	Fig. 15.15, p.476 Clinical Note, p.476	
	1). Macula Lutea 2). Fovea Centralis 3). Optic Disc is Blind Spot		
11	4. Compartments of the Eye	Fig. 15.14, p.475	TA-309
	a. Anterior Compartment 1). Anterior Chamber 2). Posterior Chamber 3). Aqueous Humor a). Produced by Ciliary Processes b). Returned at Canal of Schlemm c). Build-up and Glaucoma		
	5. Lens a. Specialized Cells = Lens Fibers b. Crystallines Collect Intracellularly c. Held in Place by Suspensory Ligaments from Ciliary Body		
	C. Functions of the Complete Eye	Clinical Focus, pp.487-489	
12	1. Light a. Visible Light (Wavelengths of 400 to 700 nm)	Fig. 15.16, p.477	

	b. Different Colors Correspond to Different Wavelengths		
	2. Light Refraction and Reflection		
	c. Light Can be Bent or Refracted		
	1). Concave Surfaces Cause Divergence of Light Rays		
	2). Convex Surfaces Cause Convergence of Light Rays; Focal Point	Fig. 15.17, p.478	TA-310
	d. Light Reflects off of Non-Transparent Objects		
	3. Focusing of Images on the Retina		
	a. Cornea has Fixed Effect		
	b. Crystalline Lens has Variable Effect		
	1). Lens Shape Changed by Contraction and Relaxation of Ciliary Muscles		
	a). Relaxed Muscles = Flat Lens		
	b). Contracted Muscles = Rounded Lens		
	2). Distance to Retina is Fixed		
	c. Image Formed on Retina is Inverted	Fig. 15.17, p.478 Clinical Note, p.478	
	d. Emmetropia		
	1). Normal Resting Condition		
	2). Distant Objects (20+ Ft.) in Focus on Retina		
	3). Lens Flattened		
	e. Adjustments for Focussing on Near Objects	Predict Quest. 7	
	1). Lens Accommodation		
	2). Pupil Constriction	Clinical Note, p.479	
	3). Convergence		
13 D. Structure and Function of the Retina		Fig. 15.18, p.480	TA-311
	1. Rods	Table 15.3, p.481	
		Fig. 15.19a, p.481	TA-312
	a. Bipolar Receptor Cells - Cylindrical Photosensitive Area		
	b. Vision in Reduced Light		
	c. Contain Rhodopsin	Fig. 15.19d, p.481	TA-312
14	2. Function of Rhodopsin		
	a. Cycle of Activity in Response to Light	Fig. 15.20, p.482	TA-313
	b. Bleaching		
	c. Light and Dark Adaptation	Predict Quest. 8	

	3. Cones	Table 15.3, p.481 Fig. 15.19b, p.481	TA-302
	a. Bipolar Receptor Cells - Conical Photosensitive Area		
	b. Color Vision and Visual Acuity	Fig. 15.21, p.483 Clinical Note, p.484	
	c. Contain Iodopsin - Different Opsins Sensitive to Different Wavelengths of Light		
	4. Distribution of Rods and Cones in the Retina	Predict Quest. 9	
	5. Inner Layers of the Retina	Fig. 15.18, p.480	TA-311
	a. Photoreceptors		
	b. Bipolar Cells		
	c. Ganglion Cells - Axons Form Optic Nerve	Clinical Note, p.484	
	d. Association Neurons		
	1). Horizontal Cells		
	2). Amacrine Cells		
	3). Interplexiform Cells		
15	D. Neuronal Pathways for Vision	Fig. 15.22, p.485	TA-314
	1. Optic Nerves (II)		
	2. Optic Chiasma	Clinical Note, p.486	
	a. Crossing Over of Some Ganglion Cell Axons		
	b. Cells from Nasal (Medial) Retina Cross		
	c. Cells from Temporal (Lateral) Retina Do Not Cross		
	3. Optic Tracts	Fig. 15.22, p.485	TA-314
	a. Most Axons Terminate at Lateral Geniculate Nucleus of Thalamus		
	b. Remaining Axons Terminate in the Superior Colliculi		
	4. Optic Radiations from Lateral Geniculate Bodies to Visual Cortex of Occipital Lobes		
15	5. Binocular Visi	Predict Quest. 10	
	on and Depth Perception Functions of Overlapping of Visual Fields from Each Eye		
	VII. Hearing and Balance, p. 486		
	A. Auditory Structures and Their Functions	Fig. 15.23, p.490 Clinical Note, p.490	TA-315
16	1. External Ear (Sound Collection and Defense Against Injury)		
	a. Auricle	Fig. 15.24, p.490	

	b. External Auditory Meatus 1). Hairs 2). Ceruminous Glands (Cerumen = Earwax)		
	c. Tympanic Membrane - Separation between External & Middle Ear	Clinical Note, p.491	
16	2. Middle Ear (Amplification of Sound Waves)	Fig. 15.23, p.490	TA-315
	a. Air Passages for Pressure Equilibration 1). To Mastoid Air Cells 2). Auditory (Eustachian) Tube to Pharynx		
	b. Auditory Ossicles 1). Malleus 2). Incus 3). Stapes		
	c. Membrane-Covered Openings to Inner Ear 1). Oval Window - Under Annular Ligament and Foot-Plate of Stapes 2). Round Window		
	3. Inner Ear (Location of Sensory Receptors)	Fig. 15.25, p.491	
	a. Bony Labyrinth and Perilymph		
	b. Membranous Labyrinth and Endolymph		
	c. Semicircular Canals		
	d. Vestibule		
17	e. Cochlea 1). Membranes and Compartments a). Oval Window		
	b). Scala Vestibuli	Fig. 15.26a, p.492	TA-316
	c). Helicotrema d). Scala Tympani e). Round Window f). Vestibular Membrane		
	g). Basilar Membrane 1). Spiral Lamina 2). Spiral Ligament	Fig. 15.26b,c, p.492	TA-316
	h). Scala Media (Cochlear Duct)		
	c). Organ of Corti (Spiral Organ)	Fig. 15.26d, p.492 Fig. 15.27, p.493	TA-316

	1). Hair Cells - Sensory Receptors 2). Nerve Endings 3). Cochlear Ganglion		
	B. Auditory Function	Table 15.4, p.495 Clinical Note, p.491	
	1. Properties of Sound Waves	Fig. 15.28, p.494	TA-317
	a. Amplitude and Volume b. Frequency and Pitch		
	c. Resonance and Timbre	Fig. 15.29, p.496	TA-318
	2. External Ear (Collection and Direction) 3. Middle Ear (Conduction, Modulation & Amplification)		
18	a. Sound Attenuation Reflex b. Tensor Tympani and Stapedius Muscles	Fig. 15.30, p.496 Predict Quest. 11	
	4. Inner Ear (Sensory Reception)	Fig. 15.29, p.496 Clinical Note, p.497	TA-318
	a. Movements of Perilymph and Endolymph b. Vibration of Basilar Membrane	Fig. 15.31, p.497	
	c. Stimulation of Hair Cells and Endocochlear Potential	Predict Quest. 12-13	
18	C. Neuronal Pathways for Hearing		
	1. From Neurons Synapsing on Hair cells of Cochlea to Cochlear Ganglion 2. From Cochlear Ganglion Through Cochlear Portion of Vestibulocochlear Nerve (VIII) to Cochlear Nucleus in Superior Medulla Oblongata 3. From Cochlear Nucleus to Superior Olivary Nucleus	Fig. 15.32, p.498	TA-319
	4. From Superior Olivary Nucleus	Clinical Focus, p.499	
	a. to Pathways Returning to Cochlea and Middle Ear 1). Modulation of Pitch Perception 2). Sound Attenuation Reflex		
	b. to Ascending Pathways in Lateral Meniscus which synapse in Inferior Colliculi		
	5. From Inferior Colliculi		
	a. to Superior Colliculus - Leading to Reflexive Head and Eye Movements		
	b. to Medial Geniculate Nucleus of		

	Thalamus for Cerebral Processing of Sound		
	6. From Thalamus to Auditory Cortex		
	a. Dorsal Temporal Lobe		
	b. Superolateral Surface of Temporal Lobe		
	D. Balance		
19	1. Static Labyrinth - Position of Head Relative to Gravity	Fig. 15.33, p.500	TA-320
	a. Saccule		
	b. Utricle		
	c. Macular Sensory Apparatus	Fig. 15.33, p.500	TA-320
	1). Hair Cells		
	a). Kinocilium		
	b). Stereocilia		
	2). Otoliths	Fig. 15.34, p.501	TA-321
	3). Otolithic Membrane		
19	2. Kinetic Labyrinth - Acceleration		
	a. Three Semicircular Canals, Each Oriented in a Different Plane	Fig. 15.35, p.502	TA-322
	b. Parts		
	1). Ampulla		
	2). Crista Ampularis		
	3). Cupula	Fig. 15.36, p.506	TA-323
	4). Hair Cells		
	c. Monitors Relative Movement of Endolymph	Clinical Note, p.501	
20	E. Neuronal Pathways for Balance	Fig. 15.37, p.503	TA-324
	1. From Neurons Synapsing on Sensory Hair Cells of Macula and Cristae Ampulares to Vestibular Ganglion		
	2. From Vestibular Ganglion Through Vestibular Portion of Vestibulocochlear Nerve (VIII) to Vestibular Nucleus in Medulla Oblongata		
	a. Joined by Fibers Carrying Ascending Proprioceptive Information		
	b. Vestibulospinal Tract		
	3. From Vestibular Nucleus to a Variety of Locations in CNS		
	a. Posterior Ventral Nucleus and then to Vestibular Area of the Cortex		
	b. Nuclei of Cranial Nerves, Oculomotor (III), Trochlear (IV) and Abducens (VI)		
	1). Control Eye Movements		
	2). Responsible for Nystagmus		
	c. Descending Pathway -	Clinical Focus,	

IMPORTANT CONSIDERATIONS: If this material is to be covered in two lectures one logical split is between the generalized senses and the special senses. There is enough to discuss about the special senses that this section can easily fill two lecture periods.
Another way to organize the material would be to talk about all the examples of two or three of the classes of receptors in each session, so balance and hearing could be discussed with other mechanoreceptors such as Pacinian Corpuscles and Golgi Tendon Organs. This second arrangement has more power to help students focus on the principles of sensory reception rather than getting stuck in the details of the accessory structures of the ear and eye.

SEE INSTRUCTOR'S MANUAL AND COURSE SOLUTIONS MANUAL FOR ADDITIONAL RESOURCES.