

## CHAPTER 12: SOMATIC & SPECIAL SENSES

### OBJECTIVES:

1. Define the terms *sensation* and *perception* and differentiate between the two.
2. Name the site where most conscious sensation occurs.
3. Define the term *sensory receptor* and classify them according to stimulus type.
4. Explain what is meant by the term *sensory adaptation*, and name the only type of sensory receptor that does not undergo sensory adaptation.
5. Name the three groups of somatic senses.
6. Discuss the three types of receptors responsible for the senses of touch and pressure.
7. Distinguish between the two types of thermoreceptors.
8. Name the ultimate function of pain receptors.
9. Explain the phenomenon of *referred pain*.
10. Compare and contrast acute and chronic pain.
11. Explain how a rhizotomy could relieve chronic pain.
12. Compare the two types of stretch receptors.
13. Name the five special senses.
14. Define the term *olfaction*, name the type of sensory receptors involved in olfaction, name the location of those receptors, and identify the responsive portion of those receptors.
15. Once an olfactory chemoreceptor is stimulated, track the nerve impulse to its site of interpretation in the brain.
16. Define *gustation*, name the type of sensory receptors involved in gustation, name the location of those receptors, and identify the responsive portion of those receptors.
17. Sketch a tongue and locate the four different types of taste buds.

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### Objectives (continued)

18. Once a gustatory chemoreceptor is stimulated, track the nerve impulse to its site of interpretation in the brain.
19. Name the three parts of the ear, list the specific components within each, and give a general function for the structures.
20. Describe the tympanic reflex, and explain its significance.
21. Name the opening between the middle and inner ear (i.e. the entrance to the inner ear).
22. Name the tube that connects the middle ear to the nasopharynx and explain its significance.
23. Describe the structure of the inner ear labyrinth in detail, and give a function for each of the three major portions.
24. Name the fluid that fills each compartment in the inner ear.
25. In the cochlea, give the specific names for the bony and membranous labyrinths, name the fluid that fills each, and name the membranes that separate the three chambers.
26. Describe the structure, location and function of the Organ of Corti.
27. Trace the pathway of sound from where sound waves reach the auricle to where to its interpretation site in the brain.
28. In the vestibule, give the specific names for the bony and membranous labyrinths, and name the fluid that fills each of them.
29. Describe the structure and function of the macula in the vestibule.
30. Name the enlarged portion at the end of each semi-circular canal, and describe the significance of what each canal contains.
31. Once the mechanoreceptors in the macula or crista ampullaris are stimulated, trace the nerve impulse to its site of interpretation.
32. Discuss the accessory organs of the eye in terms of their names, location, and functions.
33. Explain the function of the enzyme lysozyme.

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### Objectives (continued)

34. Name the three tunics of the eye, give a general function for each, and name the specific components of each tunic.
36. Describe the structure and function of the cornea & sclera.
37. Name the fibers that connect the components of the ciliary body, and describe what happens to them when focusing on a close versus a distant object (i.e describe accommodation).
38. Explain how the eye is divided into cavities and chambers, and name the fluid that fills each.
39. Name the instrument used to observe the retina of the eye.
40. Compare and contrast the two types of photoreceptors present in the retina of the eye.
41. Explain why we possess a blind spot.
42. Trace a photon of light from where it penetrates the cornea of the eye to where it's interpreted in the brain.

## CHAPTER 12: SOMATIC & SPECIAL SENSES

### I. INTRODUCTION

All senses work in basically the same fashion. Special sensory receptors collect information from the environment and stimulate neurons to send a message to the brain. There the cerebral cortex forms a perception, a person's particular view of the stimulus.

### II. SENSATION

#### A. Definitions:

1. **Sensation** = the conscious or unconscious awareness of external or internal stimuli.
2. **Perception** = the conscious awareness and interpretation of sensations.

#### B. See Table 12.1, page 433 to distinguish between sensation & perception.

#### C. **Sensory Receptors** = specialized structures at the end of peripheral nerves that respond to stimuli; can be classified according to their location in the body, stimulus type and structure.

##### 1. Classification is **by Stimulus Type**:

- a. **Mechanoreceptors** respond to a change in pressure; (i.e. touch, pressure, vibrations, stretch);
- b. **Thermoreceptors** are sensitive to temperature change;
- c. **Photoreceptors** (in retina of eye) respond to light energy;
- d. **Chemoreceptors** respond to changes in chemical concentrations;
- e. **Nocioreceptors** respond to extreme (harmful) stimuli by producing the sensation of pain (i.e. all types under extreme stimuli).

##### 2. **Sensory Adaptation**

- a. The process by which a sensory receptor becomes less stimulated following continuous stimuli.
- b. All sensory receptors, except nocioreceptors, adapt to continuous stimuli (i.e. undergo sensory adaptation).

## CHAPTER 12: SOMATIC & SPECIAL SENSES

### III. SOMATIC SENSES

#### A. Introduction

Receptors associated with skin, muscles, joints, and viscera provide somatic senses.

#### B. Three groups:

##### 1. **Exteroceptive Senses:**

- a. detect changes at the body's surface:
  - m touch
  - m pressure
  - m temperature

##### 2. **Proprioceptive Senses:**

- a. detect changes in muscles, tendons, and body position:

##### 3. **Visceroceptive Senses:**

- a. detect changes in viscera:
  - m only pain will be discussed here.

#### C. **Touch and Pressure Senses: See Fig 12.1, page 434.**

##### 1. Employ three types of receptors:

- a. free (naked) nerve (dendritic) endings;
  - m in epithelium, CT;
- b. **Meissner's Corpuscles** are encapsulated dendritic endings;
  - m surrounded by CT wrapping;
  - m mechanoreceptors;
  - m detect light touch;
  - m abundant in the hairless portions of skin (i.e. lips, fingertips, palms, soles, nipples, external genitalia).
- c. **Pacinian Corpuscles** are also encapsulated dendritic endings:
  - m surrounded by CT wrapping;
  - m mechanoreceptors;
  - m detect heavy pressure;
  - m abundant in deep subcutaneous tissues of hands, feet, penis, clitoris, urethra, breasts.

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### III. SOMATIC SENSES

#### D. Temperature Senses

1. Two types that respond to temperature change;
  - a. **Heat receptors**
    - m sensitive to temps above 25°C (77°F);
    - m unresponsive at temps above 45°C (113°F).
    - \* Pain receptors are also triggered as this temp approaches producing a burning sensation.
  - b. **Cold receptors**
    - m sensitive to temps between 10°C (50°F) and 20°C (68°F);
    - m below 10°C, pain receptors are triggered producing a freezing sensation.
2. Both undergo rapid sensory adaptation!

#### E. PAIN

1. Introduction

Free nerve endings are the receptors that detect pain. They are widely distributed throughout the skin and internal tissues, with the exception of the nervous tissue of the brain.
2. **Pain Receptors (Nocioreceptors)**
  - a. function is protection against further tissue damage;
  - b. many stimuli may trigger them (i.e. temperature, pressure, chemoreceptors);
  - c. generally do **not adapt to continual stimuli.**
3. **Visceral Pain: See Fig 12.3, page 436.**
  - a. only visceral receptors that produce sensations;
  - b. stretch receptors are stimulated by pressure and/or a decrease in oxygen levels;
  - c. may feel as if its coming from another area of the body = **referred pain.**
    - m may derive from common nerve pathways.  
See Fig 12.4, page 437.

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### III. SOMATIC SENSES

#### E. PAIN (continued)

##### 4. Pain Nerve Pathways:

###### a. Acute pain

- m occurs rapidly (0.1 sec);
- m is not felt in deep tissues;
- m sharp, fast, pricking pain;
- m conducted on **myelinated fibers**;
- m ceases when stimulus is removed.

###### b. Chronic pain

- m begins slowly and increases in intensity over a period of several seconds or minutes;
- m dull, aching, burning, throbbing pain;
- m can occur anywhere;
- m conducted on **unmyelinated fibers**;
- m may continue after stimulus is removed.

See CA 12.1, p 438 concerning cancer pain & chronic pain.

##### 5. Relief from pain

- a. Inappropriate pain = when pain sensations are **not** warning about impending tissue damage;
- b. **Analgesics** are used to reduce inappropriate pain.
  - m block formation of prostaglandins which stimulate nociceptors:
  - m common types:
    1. aspirin (acetylsalicylic acid)
    2. Tylenol (acetaminophen);
    3. Motrin (ibuprofen)
- c. Surgery may be necessary:
  - m **Cordotomy** = severing the sensory nerve;
  - m **Rhizotomy** = cutting of spinal posterior (sensory) nerve roots.

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### III. SOMATIC SENSES

#### F. Stretch Receptors

##### 1. Introduction

Stretch receptors are proprioceptors that send information to the spinal cord and brain concerning the length and tension of muscles.

##### 2. Two types:

###### a. **Muscle Spindles:** See Fig 12.5a, page 439.

- m located in skeletal muscles near their junction with tendons;
- m This sensory receptor is stimulated when the skeletal muscle relaxes and therefore the spindle is stretched;
- m Action produced is called the "stretch reflex";
- m helps maintain the desired position of a limb despite other forces tending to move it.

###### b. **Golgi tendon organs:** See Fig 12.5b, page 439.

- m found in tendons close to their muscle attachment;
- m each is connected to a set of skeletal muscle fibers and is innervated by a sensory neuron;
- m These receptors have a high threshold and are stimulated by increased tension;
- m stimulate a reflex with an opposite effect as above;
- m helps maintain posture, prevents tearing of tendons.

\* See Table 12.5, page 439 to summarize the different types of somatic receptors.

## CHAPTER 12: SPECIAL SENSES

### I. Introduction

- A. SPECIAL SENSES are senses whose sensory receptors are located in large, complex organs in the head.
- B. There are five special senses that include
  - 1. vision,
  - 2. hearing,
  - 3. equilibrium,
  - 4. taste, and
  - 5. smell.

### II. OLFACTION = sense of smell.

See Fig 12.6 and Fig 12.7, page 441.

- A. Organ = olfactory epithelium in upper nasal cavity of nose (on the superior nasal concha)
- B. Receptors:
  - 1. **chemoreceptors** that are located in the upper nasal cavity;
    - a. sensitive portion is "hair cell";
    - b. chemicals must be dissolved in water to be detected;
    - c. undergo rapid sensory adaptation.
- C. Olfactory Pathway to Brain for Interpretation:
  - 1. Primary Neuron = Olfactory receptor cell;
    - a. Axons pass through cribriform plate of ethmoid; b.synapse in Olfactory bulb;
  - 2. Secondary Neuron in olfactory bulb (CN I)
    - a. Axons reach to cerebral cortex;
    - b. **do not pass through thalamus.**

\* See green box on page 442 concerning our keen sense of olfaction.

## CHAPTER 12: SPECIAL SENSES

### III. SENSE OF TASTE (Gustation)

A. Organ = taste buds on tongue.

See Fig 12.8, and Fig 12.9, page 443.

B. Receptors =

1. **chemoreceptors** that are located in taste buds;

a. Sensitive portion is a "**taste hair**" which protrudes out of a "**taste pore**", which is an opening in a "**taste cell**", which make up the "**taste bud**";

b. Chemicals must be dissolved in saliva to be detected;

c. undergo rapid sensory adaption;

d. detect four taste sensations based on location on tongue:  
(See Fig 12.10, page 444)

m sweet = tip of tongue,

m sour = lateral tongue,

m salt = perimeter of tongue,

m bitter = posterior tongue.

C. **Gustatory Pathway** to Brain for Interpretation:

1. Two pathways:

a. CN VII ---> anterior 2/3 of tongue;

b. CN IX ----> posterior 1/3 of tongue;

2. Once chemoreceptors in these areas are stimulated, a gustatory impulse passes to the

a. medulla,

b. thalamus,

c. gustatory cortex within parietal lobe.

\* See green boxes on pages 442 and 444 concerning the inheritance of taste and smell.

\* See CA 12.3 and Table 12.3, page 445 concerning taste and smell disorders.

## CHAPTER 12: SPECIAL SENSES

### IV. SENSE OF HEARING

Intro: The organ of hearing is the **Organ of Corti** which is present in the cochlea of inner ear. The sensory receptors are called **mechanoreceptors**. Once these mechanoreceptors are stimulated, the impulse travels on the cochlear branch of the **vestibulocochlear (CN VIII) nerve** which leads to the primary auditory cortex (temporal cortex) of the cerebrum.

A. **EAR STRUCTURE:** See 12.11, page 446.

1. **External Ear:**

- a. **Auricle** = outer ear (cartilage);  
Function = collection of sound waves.
- b. **External auditory meatus** = ear canal;  
Function = starts vibrations of sound waves and directs them toward tympanic membrane.

2. **Middle Ear:**

Function = to amplify and concentrate sound waves

- a. **Tympanic membrane** = eardrum.
  - \* **Tympanic Reflex** = protective mechanism for hearing mechanoreceptors; Loud noises cause 2 muscles associated with the tympanic membrane to contract; This decreases amplification effect of ossicles (see below).
  - \* See green box on page 448.
- b. **Tympanic cavity** = air-filled space behind eardrum; separates outer from inner ear.
- c. **Auditory ossicles** = 3 tiny bones in middle ear:  
See Fig 12.12a & b, page 447.
  - m **Malleus** (hammer) is connected to tympanic membrane;
  - m **Incus** (anvil) connects malleus to stapes;
  - m **Stapes** (stirrup) connects incus to the
    - \* **Oval window** = the entrance to inner ear.
- d. **Auditory (Eustachian) tube** = passageway which connects middle ear to nasopharynx (throat).
  - m **Function** = to equalize pressure on both sides of the tympanic membrane, which is necessary for proper hearing.
  - \* See green box on page 448 concerning otitis media.

## CHAPTER 12: SPECIAL SENSES

### V. A. Ear Structure (continued)

#### 3. **Inner Ear:** See Fig 12.13, page 449.

a. The inner ear consists of a complex system of intercommunicating chambers and tubes called a **labyrinth**. Actually, two labyrinths compose the inner ear:

- m **Osseous labyrinth** = bony canal in temporal bone;
- m **Membranous labyrinth** = membrane within osseous labyrinth.

b. Two types of **fluid** fill the spaces in the labyrinths:

- m **Perilymph** fills the space between the osseous and membranous labyrinth;
- m **Endolymph** fills the membranous labyrinth.

c. The inner ear labyrinth can further be divided into **three regions** (cochlea, vestibule & semi-circular canals), each with a specific function:

- m **Cochlea** = snail shaped portion;  
Function = **sense of hearing**.
- m **Semi-circular canals** = 3 rings;  
Function = **dynamic equilibrium**.
- m **Vestibule** = area between cochlea and semi-circular canals;  
Function = **static equilibrium**.

d. The osseous labyrinth of the cochlea can be divided into **2 compartments**:

See Fig 12.13 & 12.14, page 449 and 450.

- m **Scala vestibuli** = upper compartment which extends from oval window to apex;
- m **Scala tympani** = lower compartment which extends from apex to round window.
  - \* Both compartments are filled with **perilymph**.

e. Between the two bony compartments, we find the **membranous labyrinth = cochlear duct**.

- m The cochlear duct is filled with **endolymph**.

## CHAPTER 12: SPECIAL SENSES

### V. Hearing

#### A. Ear Structure (continued)

3. **Inner Ear:** See Fig 12.15, page 451.

f. There are **membranes** that separate the cochlear duct from the bony compartments:

m **Vestibular membrane** separates the cochlear duct from the scala vestibuli;

m **Basilar membrane** separates the cochlear duct from the scala tympani;

g. The **mechanoreceptors** responsible for the sense of hearing are contained in the **Organ of Corti** = 16000 hearing receptor cells located on the **basilar membrane**.

See Fig 12.16, page 452.

m The receptor cells are called "**hair cells**";

m The hair cells are covered by the **tectorial membrane** which lies over them like a roof.

#### B. **Pathway of sound waves** from outside to the Organ of Corti:

See fig 12.17, page 452.

1. auricle
2. external auditory meatus
3. tympanic membrane
4. malleus
5. incus
6. stapes
7. oval window
8. perilymph of scala vestibuli
9. endolymph of cochlear duct
10. hair cells in Organ of Corti.

Once these mechanoreceptors are stimulated, a sensory impulse is triggered and then travels on the

11. **cochlear branch** of **vestibulocochlear nerve** (CN VIII) to the

12. **thalamus** for direction to the

13. **primary auditory cortex** (temporal lobes) of cerebrum for interpretation.

\* See Table 12.4, page 453 for a summary of the above events.

\* See CA 12.4, page 454 concerning Hearing Loss.

## CHAPTER 12: SPECIAL SENSES

### V. SENSE OF EQUILIBRIUM

A. **Static Equilibrium** functions to sense the position of the head and help us maintain posture while motionless.

1. The **vestibule** of the inner ear contains the two membranous chambers responsible for static equilibrium.

Fig 12.19,  
page 455.

- a. The **utricle** communicates with the semi-circular canals;
- b. The **saccul**e communicates with the cochlear duct.
- c. Each of these chambers contains a **macula** = organ of static equilibrium.

Fig 12.20,

m The macula is composed of "**hair cells**" that are in contact with a jelly-like fluid containing calcium carbonate crystals (=otolith).

m When the head is moved, the gelatin sags due to gravity and the **hair cells bend**.

m This triggers a sensory impulse which travels on the **vestibular branch of the VC nerve** to the pons which directs the impulse to the cerebellum for interpretation.

B. **Dynamic Equilibrium** functions to prevent loss of balance during rapid head or body movement.

1. The three **semi-circular canals** contain the organ responsible for dynamic equilibrium.

Fig 12.19,  
page 455.  
Fig 12.22,

- a. Each semi-circular canal ends in an enlargement called the **ampulla**.
- b. Each ampulla houses a sensory organ for dynamic equilibrium called the **crista ampullaris**, which contains a patch of "**hair cells**" in a mass of gelatin.

Fig 12.23,  
page 458.

- c. When the head is moved, the gelatin stays put due to inertia, causing the **hair cells to bend**. This triggers a sensory impulse which travels on the **vestibular branch of the VC nerve** to the pons which directs the impulse to the **cerebellum** for interpretation.

\* **See green box on page 456 concerning motion sickness.**

## CHAPTER 12: SPECIAL SENSES

### VI. SENSE OF SIGHT: Vision

Introduction: The organ of vision is the **retina** of eye. The sensory receptors are called **photoreceptors**. When photoreceptors are stimulated, impulses travel within the **optic nerve** (CN II) to the visual (occipital) cortex for interpretation

#### A. Accessory organs of the eye:

See Fig 12.25, pg 459 and Fig 12.26, page 460.

1. **Eyelids** = protective shield for the eyeball.
  - a. **Conjunctiva**= inner lining of eyelid; = red portion around eye.  
\* See green box on page 458 concerning pink eye.
2. **Lacrimal apparatus** = tear secretion & distribution.
  - a. **Lacrimal gland** = tear secretion; located on upper lateral surface
    - m Tears contain an enzyme called **lysozyme** which functions as an anti-bacterial agent.
  - b. **Nasolacrimal duct** = duct which carries tears into nasal cavity (drainage)
3. **Extrinsic muscles** hold eyeball in orbital cavity and allow for eye movement.
  - a. superior rectus muscle
  - b. inferior rectus muscle
  - c. lateral rectus muscle
  - d. medial rectus muscle
  - e. inferior oblique muscle
  - f. superior oblique muscle  

\* See Table 12.5, page 461 for a summary of the muscles associated with the eyelids and eye.

## CHAPTER 12: SPECIAL SENSES

### IV. Vision (continued)

#### B. **Eye Structure:** See Fig 12.27, page 462.

The eye is composed of **three distinct layers or tunics**:

1. **Outer (fibrous) Tunic** = protection.
  - a. **Cornea** = transparent anterior portion; Function: helps focus (75%) incoming light rays.
    - \* See green box, page 462 on cornea transplant.
  - b. **Sclera** = white posterior portion, which is continuous with eyeball except where the optic nerve and blood vessels pierce through it in the back of eye.
2. **Middle vascular tunic** = nourishment...
  - a. **Choroid coat** = membrane joined loosely to sclera containing many blood vessels to nourish the tissues of the eye.
  - b. **Ciliary body** = anterior extension from choroid coat which is composed of 2 parts:
    - m **Ciliary muscles** which control the shape of the lens (i.e. Accommodation);
    - m **Ciliary processes** which are located on the periphery of the lens.
      1. **Suspensory ligaments** extend from the ciliary processes on the lens to the ciliary muscles (i.e. they connect above structures), and function to hold the lens in place.
        - \* **Accommodation** = the process by which the lens changes shape to focus on close objects.
          1. The lens is responsible (with cornea) for focusing incoming light rays.
          2. If light rays are entering the eye from a distant object, the **lens is flat**.
          3. When we focus on a close object, the ciliary muscles contract, relaxing the suspensory ligaments. Accordingly, the **lens thickens** allowing us to focus.

Fig 12.31, page 464.

## CHAPTER 12: SPECIAL SENSES

### IV. Vision (continued)

B. **Eye Structure:** See Fig 12.28, and Fig 12.30, pg 463.

#### 2. **Middle vascular tunic** (continued)

c. **Iris** = colored ring around pupil; thin diaphragm muscle; lies between cornea and lens;

\* The iris separates the **anterior cavity** of the eye into an **anterior chamber** and **posterior chamber**. See Fig 12.32, page 465.

\* The entire anterior cavity is filled with **aqueous humor**, which helps nourish the anterior portions of the eye, and maintains the shape of the anterior eye.

#### 3. **Inner nervous (sensory) tunic**

a. **Retina** = inner lining of the eyeball; site of photoreceptors.

Fig 12.36, p 467.

A picture of the retina can be taken with a camera attached to an **ophthalmoscope** as seen in

Fig 12.34, p 466.

m There are **two types** of visual receptors (**photoreceptors**) in the retina:

Fig 12.35, p 466.

1. **Cones** = photoreceptors for color vision; produce sharp images.

2. **Rods** = photoreceptors for night vision; produce silhouettes of images.

m The **optic disk** is the location on the retina where nerve fibers leave the eye & join with the optic nerve; the central artery & vein also pass through this disk.

\* No photoreceptors are present in the area of the optic disk = **blind spot**. See Fig 12.36, page 467.

m The **posterior cavity** of the eye is occupied by the lens, ciliary body, and the retina.

\* The posterior cavity is filled with **vitreous humor**, which is a jelly-like fluid which maintains the spherical shape of the eyeball.

## CHAPTER 12: SPECIAL SENSES

### IV. The Sense of Vision (continued)

#### C. The Pathway of Incoming Light:

1. Intro: Incoming light rays are refracted (bent) onto the retina due to the convex surface of both the cornea and the lens.  
See Fig 12.37 and 12,38, page 468.
2. Visual Pathway to Brain for Interpretation:
  - a. cornea
  - b. aqueous humor
  - c. lens
  - d. vitreous humor
  - e. photoreceptors in retina.

Once the rods and/or cones are stimulated, a sensory impulse is carried on the:

- f. **optic nerve** (CN II) which crosses at the
- g. optic chiasma forming optic tracts that carry the impulse to the
- h. **thalamus** for direction to the
- i. **primary visual cortex** (occipital lobe) for interpretation.

- \* See green box on page 464 concerning cataract.
- \* See green box on page 464 concerning glaucoma.
- \* See green box on page 467 concerning "floaters".
- \* See CA 12.5, page 470-471 concerning refraction disorders.