SCIENCE OLYMPIAD

Exploring the World of Science

2017 Anatomy & Physiology (B & C)

Karen Lancour
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Event Rules – 2017

DISCLAIMER

This presentation was prepared using draft rules. There may be some changes in the final copy of the rules. The rules which will be in your Coaches Manual and Student Manuals will be the official rules.

Event Rules – 2017

- **BE SURE TO CHECK THE 2017 EVENT RULES FOR EVENT PARAMETERS AND TOPICS FOR EACH COMPETITION LEVEL**

ROTATION SCHEME

Year 1	Skeletal	Muscular	Integumentary	(2016 and 2020)
Year 2	Nervous	Sense Organs	Endocrine	(2017 and 2021)
Year 3	Respiratory	Digestive	Immune	(2018 and 2022)
Year 4	Cardiovascular	Lymphatic	Excretory	(2019 and 2023)

ANATOMY & PHYSIOLOGY

Event Content*: *2017 – YEAR 2 OF 4 YR ROTATION

- **BASIC ANATOMY AND PHYSIOLOGY**
  - **Nervous System**
  - **Sense Organs**
  - **Endocrine System**
  - **Major disorders**
  - **Treatment and prevention of disorders**
- **PROCESS SKILLS - observations, inferences, predictions, calculations, data analysis, and conclusions.**

TRAINING MATERIALS

- **Training Power Point – content overview**
- **Training Handouts – General and 3 Systems**
- **Sample Tournament – sample problems with key**
- **Event Supervisor Guide – prep tips, event needs, and scoring tips**
- **Internet Resource & Training CD's – on the Science Olympiad website at www.soinc.org under Event Information**
- **Biology-Earth Science CD (2017), Anatomy/A&P CD (updated 2016) as well as the Division B and Division C Test Packets are available from SO store at www.soinc.org**

NERVOUS SYSTEM

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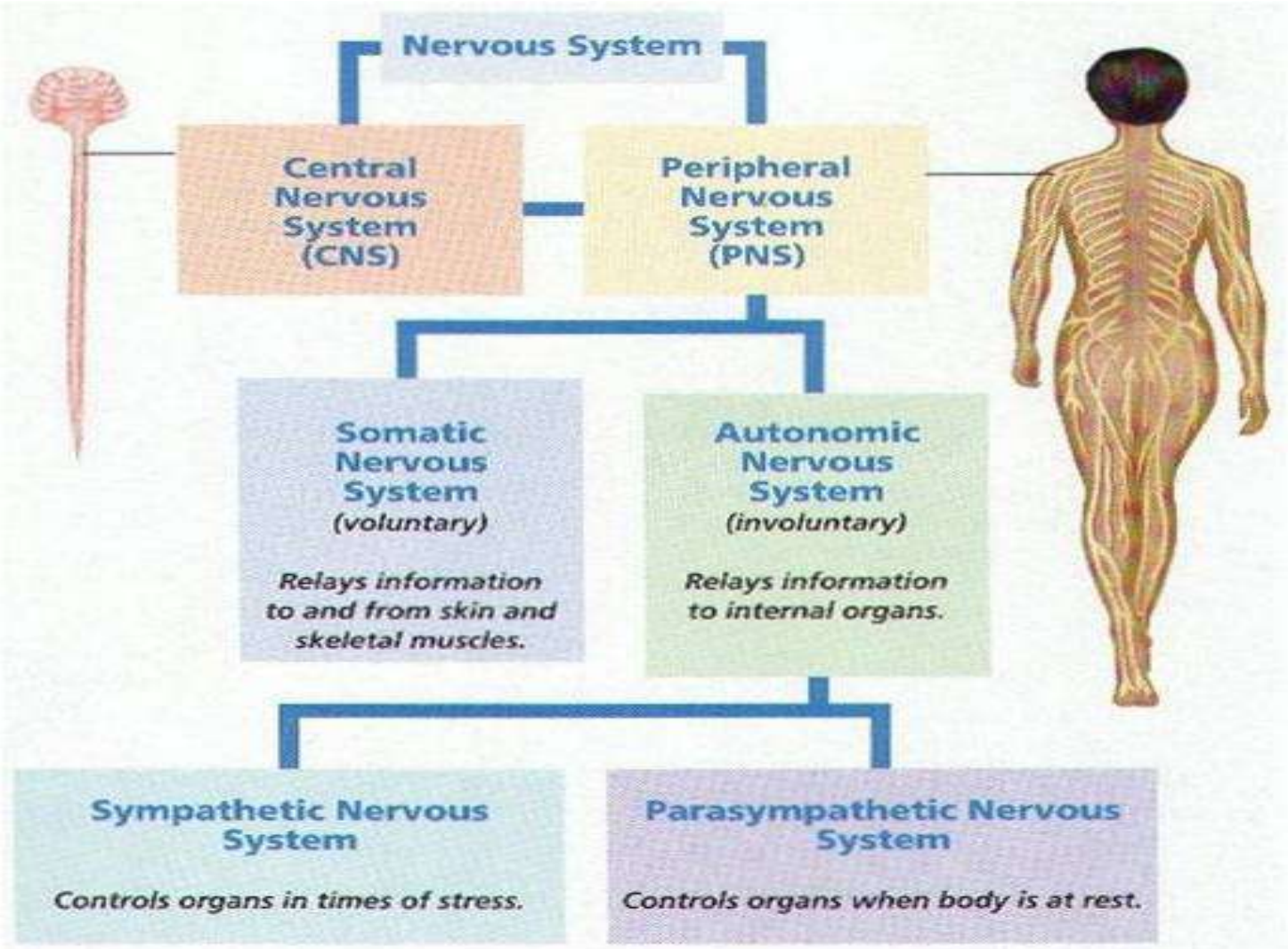
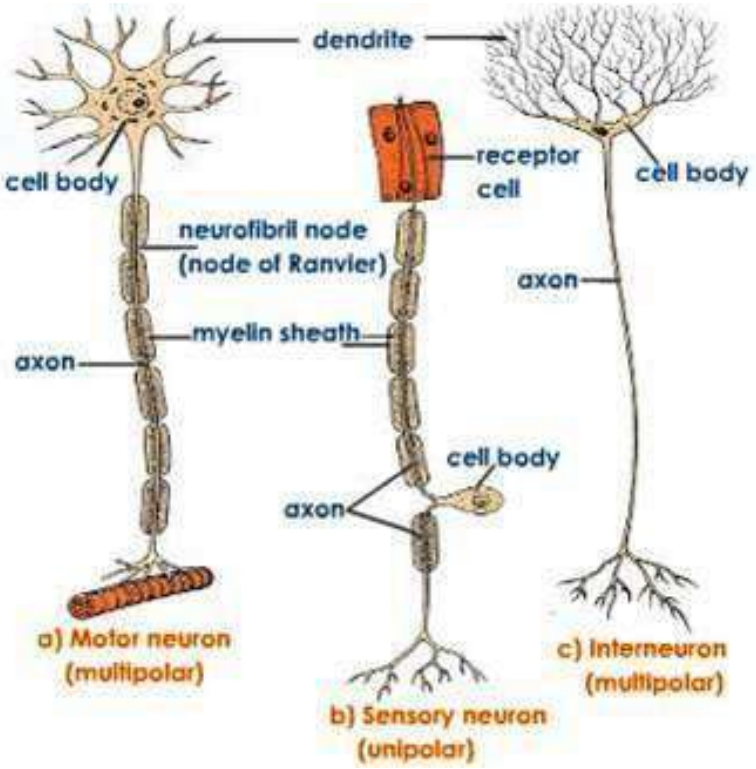
Divisions of the Nervous System

Brain & Spine



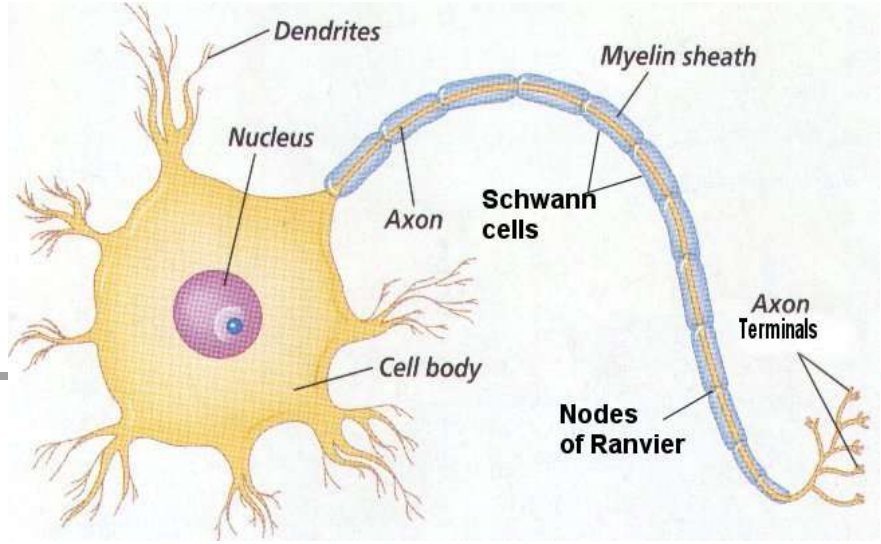
Rest of Body

Neuron



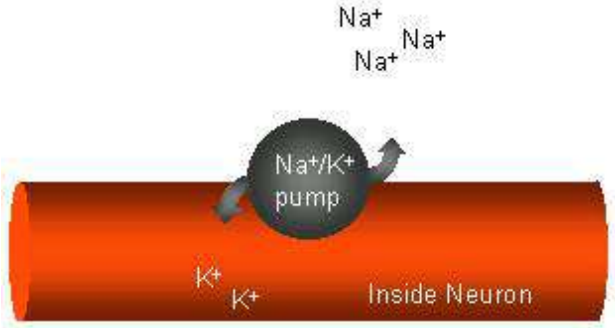
- Basic functional cell of nervous system
- Transmits impulses
- Three types
  - Sensory neurons – bring messages to CNS
  - Motor neurons - carry messages from CNS
  - Interneurons – between sensory & motor neurons in the CNS

Neuron

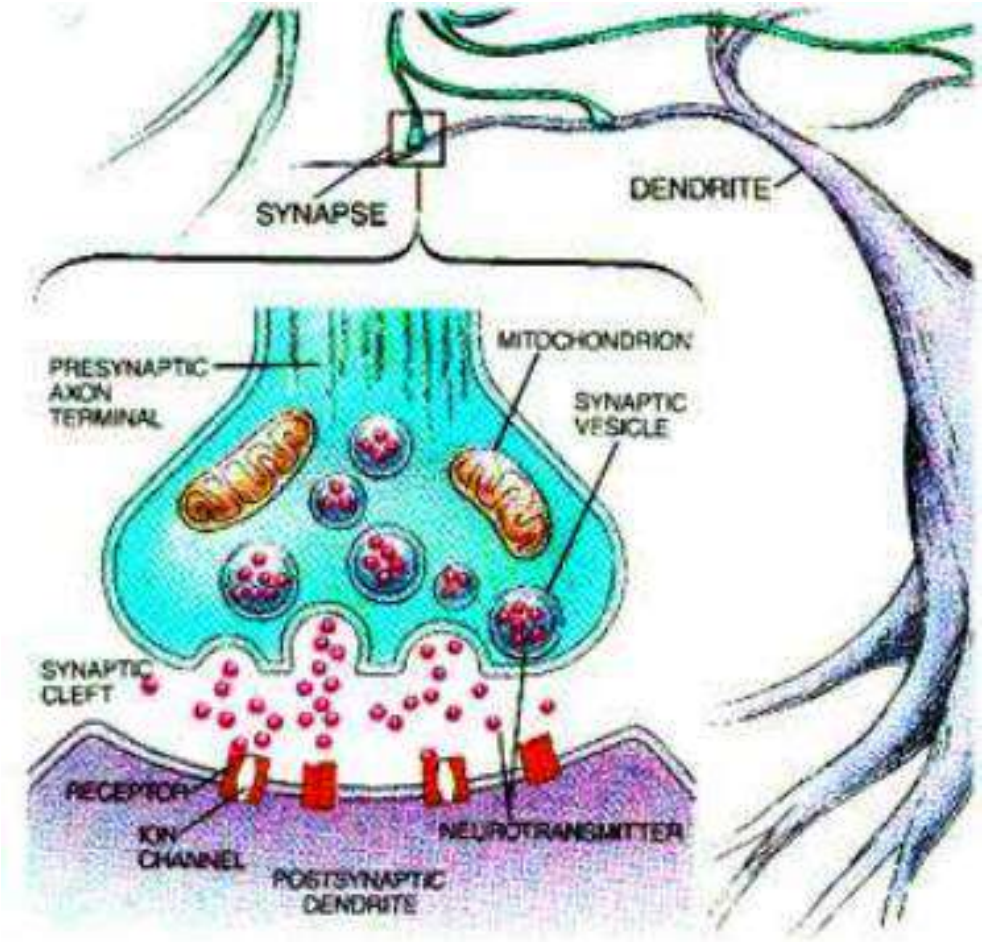


- **Dendrite** – receives stimulus and carries its impulses toward the cell body
- **Cell Body with nucleus** – nucleus & most of cytoplasm
- **Axon** – fiber which carries impulses away from cell body
- **Schwann Cells-** cells which produce myelin or fat layer
- **Myelin sheath** – lipid layer around the axon
- **Node of Ranvier** – gaps or nodes in the myelin sheath
- **Impulses travel from** dendrite to cell body to axon

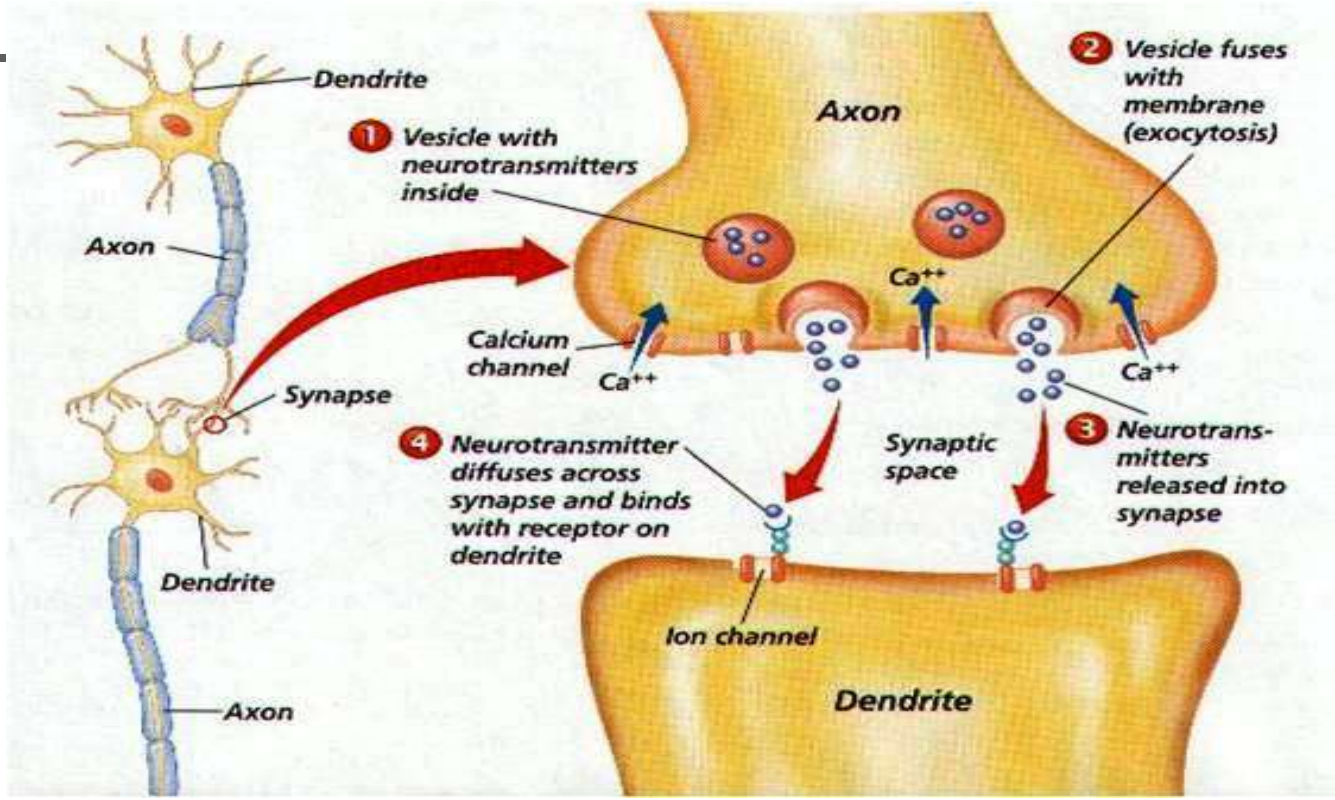
Impulses



- **Impulse**
  - Self propagating
  - All-or-none
  - Mechanism – Na^+ K^+ pump
- **Synapse**
  - Junction between neurons
  - Neurotransmitters



Synapse



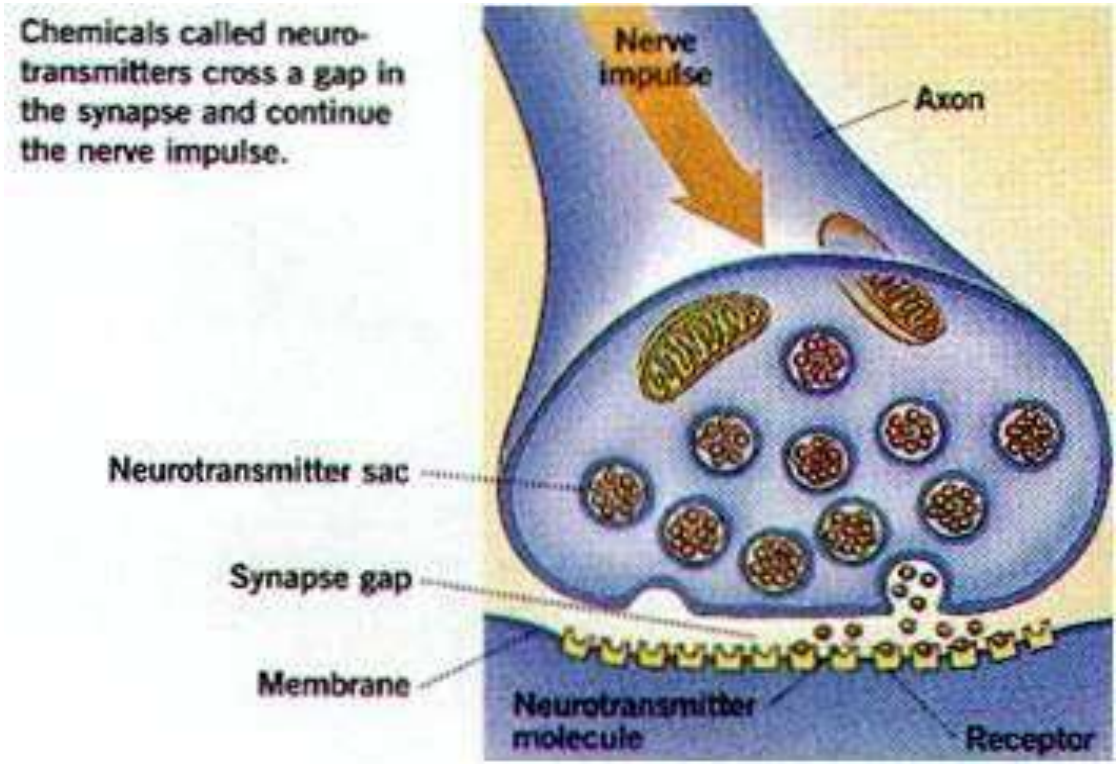
Junction between neurons

The neurons do not actually touch at the synapse

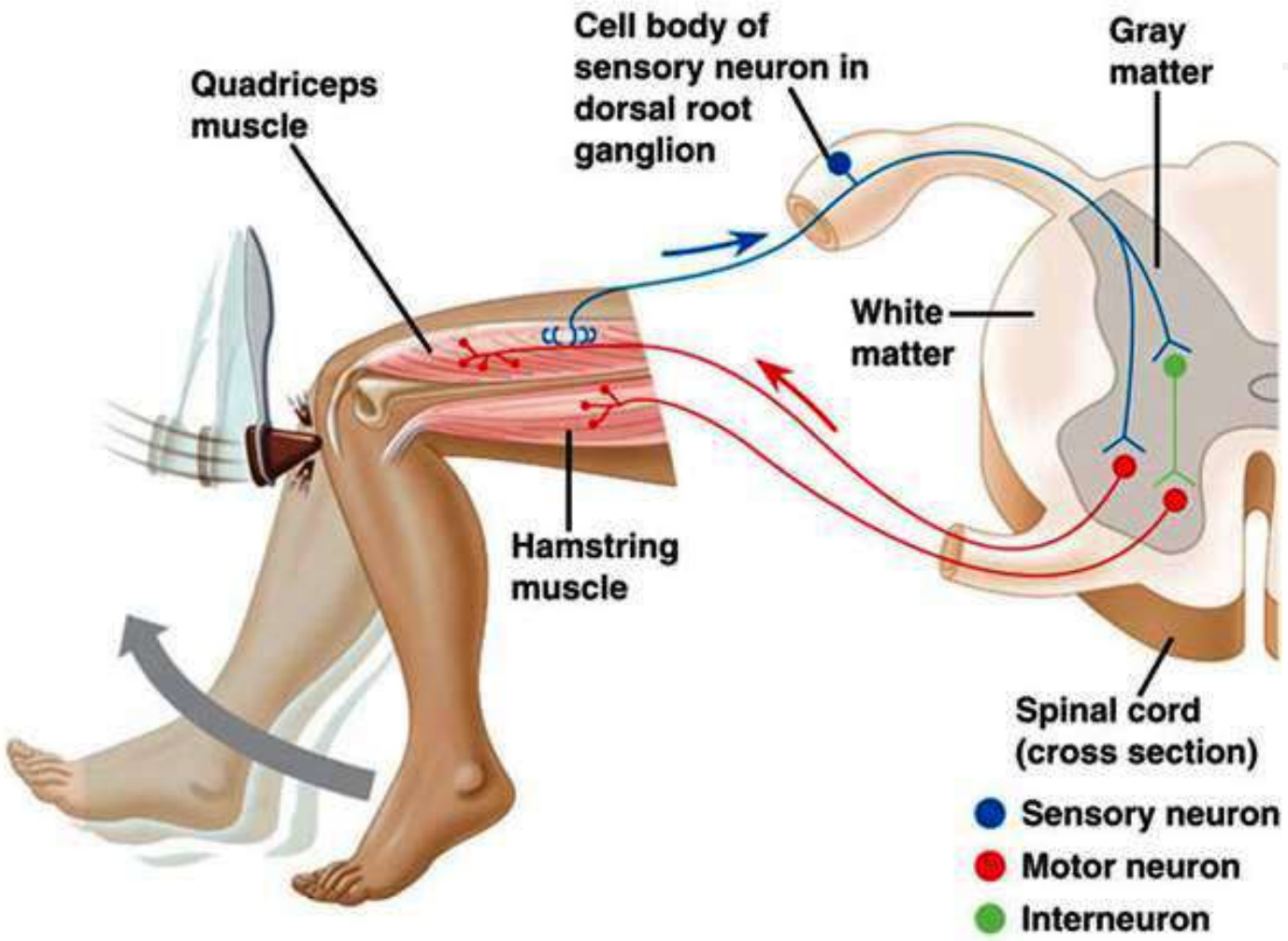
Neurotransmitters are used to restart impulses in dendrite of 2nd neuron

Neurotransmitters

- **Chemicals in the junction which allow impulses to be started in the second neuron**

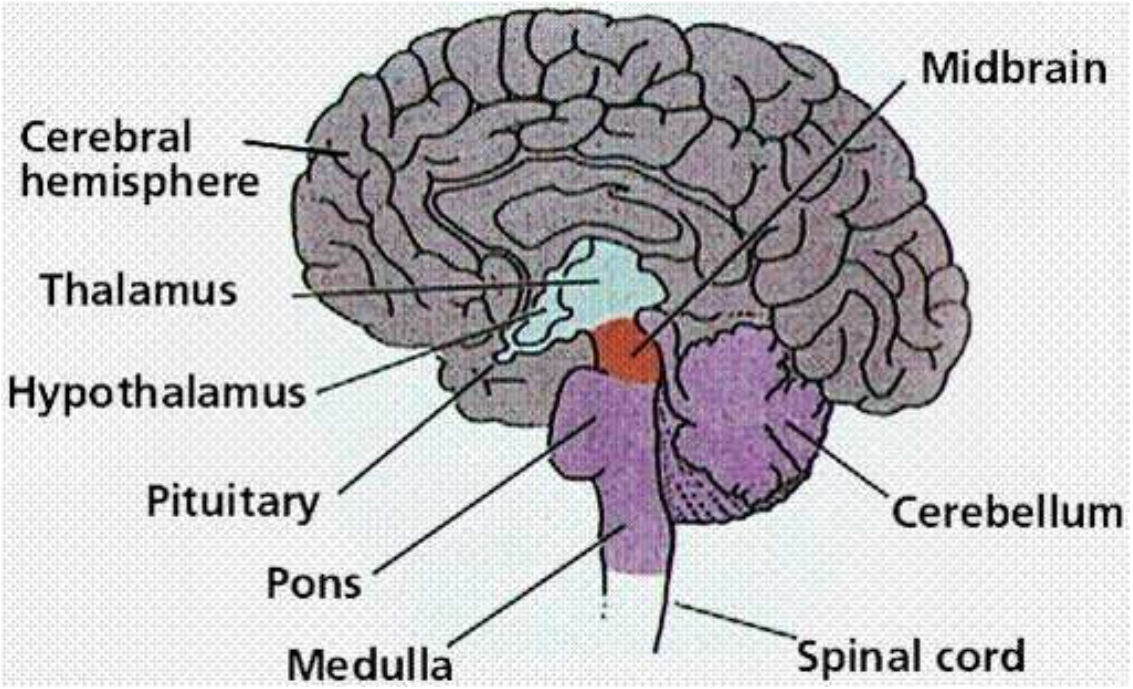


Reflex Arc


Quadriceps muscle
Cell body of sensory neuron in dorsal root ganglion
Gray matter
White matter
Hamstring muscle
Spinal cord (cross section)
Sensory neuron
Motor neuron
Interneuron

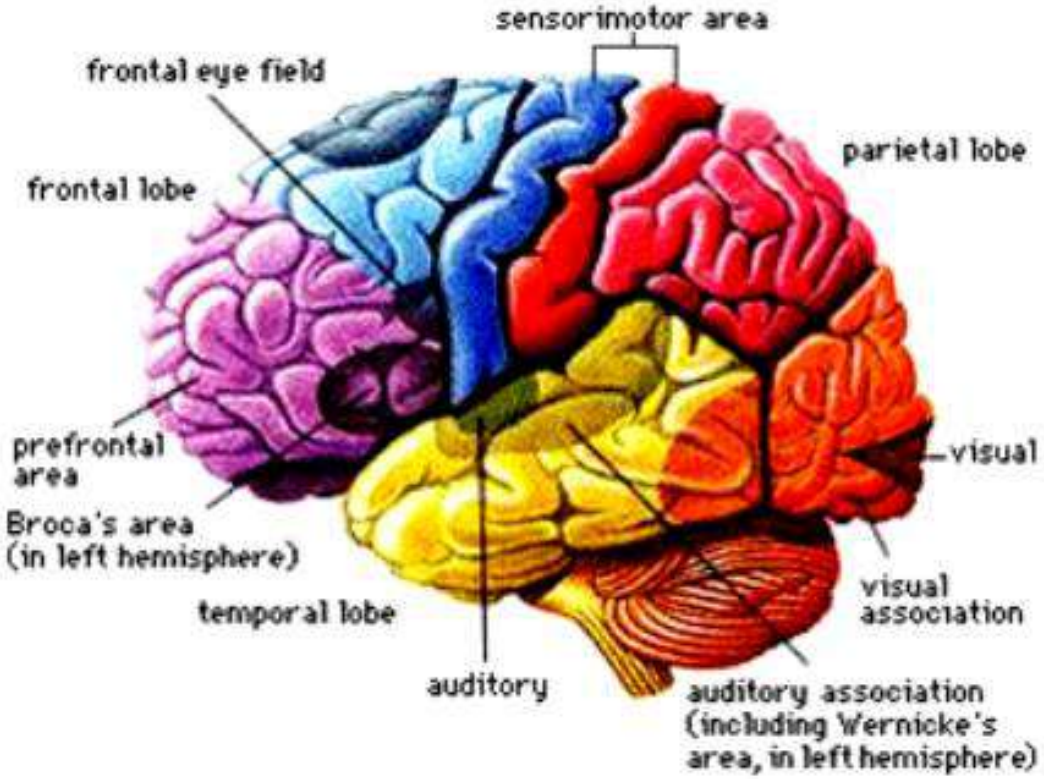
Central Nervous System

- Brain
  - **Brain stem** **medulla, pons, midbrain**
  - **Diencephalon** **thalamus & hypothalamus**
  - **Cerebellem**
  - **Cerebrum**
- Spine
  - **Spinal Cord**



Cerebrum Regions

- Lobes of the Cerebrum
  - Frontal
  - Parietal
  - Temporal
  - Occipital
- Special regions
  - Broca's area
  - Wernicke's area
  - Limbic System



Four Categories of Brain Wave Patterns

Beta (14-30 Hz)

Concentration, arousal, alertness, cognition

Higher levels associated with anxiety, disease, feelings of sparation, fight or flight

Alpha (8-13.9 Hz)

Relaxation, superlearning, relaxed focus, light trance, increased serontonin production

Pre-sleep, pre-waking drowsiness, mediation, beginning of access to unconscious mind

Theta (4-7.9 Hz)

Dreaming sleep (REM sleep)
Increased production of catecholamines (vital for learning and memory), increased creativity

Integrative, emotional experiences, potential change in behavior, increased retention of learned material

Hypnagogic imagery, trance, deep mediation, access to unconscious mind

Delta (.1-3.9 Hz)

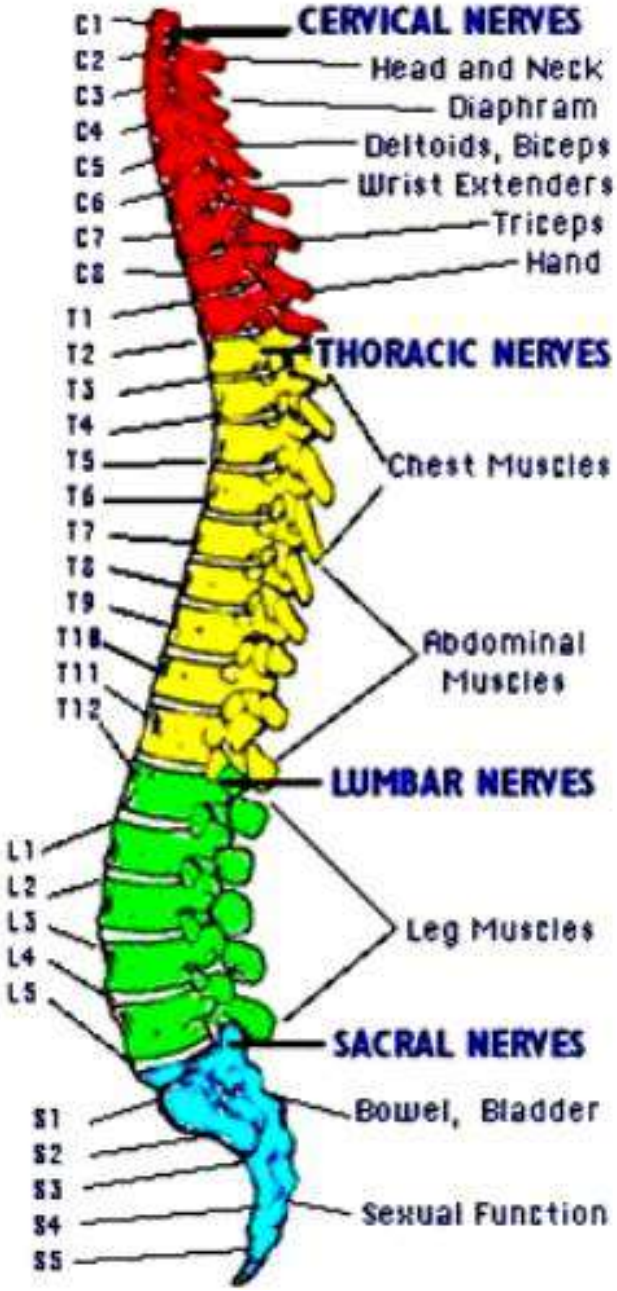
Dreamless sleep
Human growth hormone released

Deep, trance-like, non-physical state, loss of body awareness

Access to unconscious and "collective unconscious" mind, greatest "push" to brain when induced with Holosync®

Peripheral Nervous System

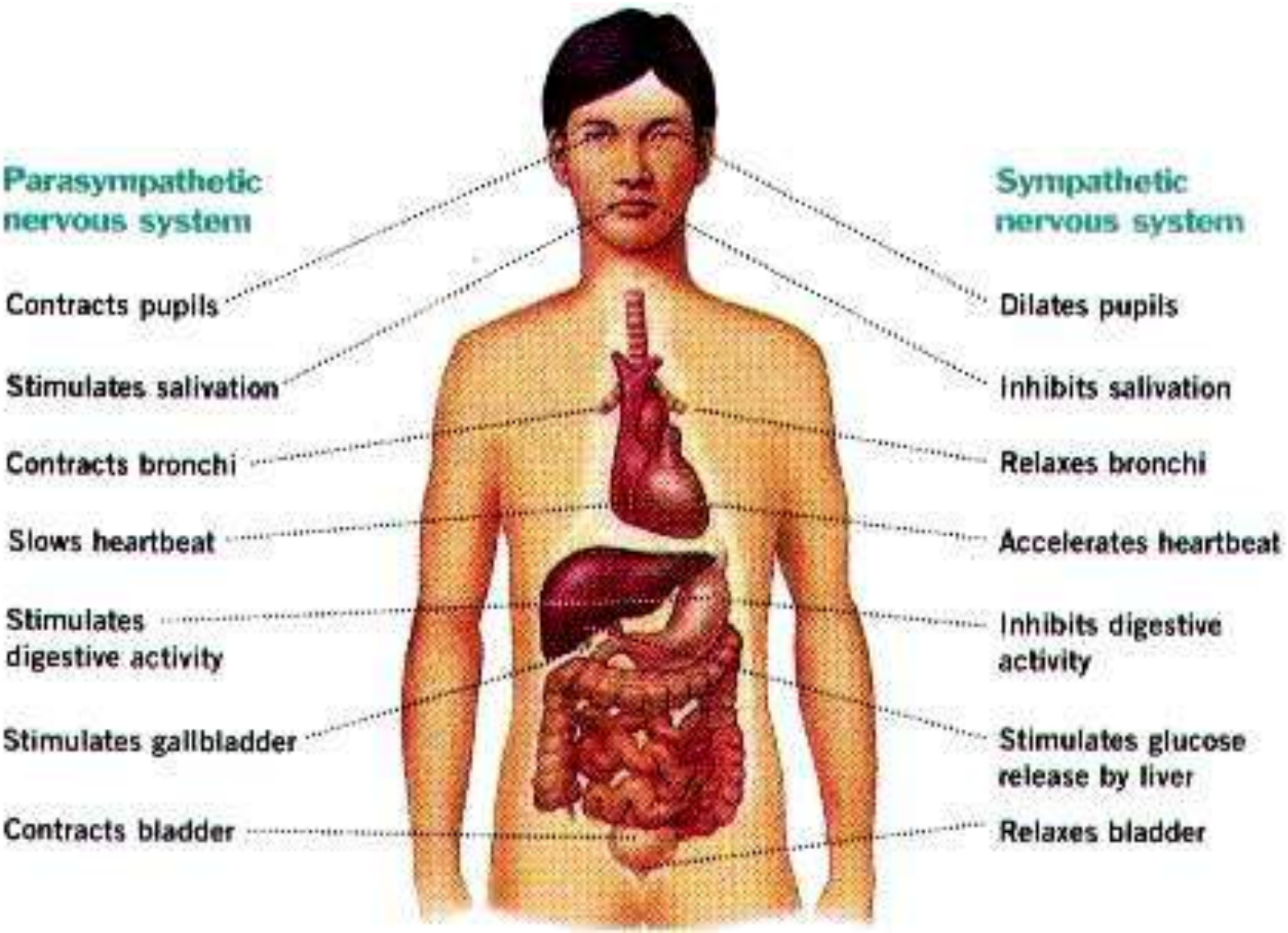
- Cranial nerves
  - 12 pairs
  - Originate from the undersurface of brain
- Spinal nerves
  - 31 pairs
  - Attached to spinal cord



Autonomic Nervous System

- Regulates body's involuntary responses
- Two divisions
  - Sympathetic nervous system
    - Emergency response
    - Fight or flight
  - Parasympathetic nervous system
    - Normal everyday conditions
    - Rest and digest

Autonomic Nervous System



SENSE ORGANS

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Sense Receptors

- receive input and transduce stimuli
- generate receptor potentials with enough summation
- generate action potentials in the neurons they are part of or synapse with

5 Types of Sensory Receptors

Based on the type of stimuli they detect:

- **Mechanoreceptors** - pressure receptors, stretch receptors, and specialized mechanoreceptors involved in movement and balance.
- **Thermoreceptors** - skin and viscera, respond to both external and internal temperature
- **Pain receptors** - stimulated by lack of O_2, chemicals released from damaged cells and inflammatory cells
- **Chemoreceptors** - detect changes in levels of O_2, CO_2, and H^+ ions (pH) as well as chemicals that stimulate taste and smell receptors
- **Photoreceptors** - stimulated by light

Distribution of Receptors in the body

Special Senses

- mediated by relatively complex sense organs of the head, innervated by cranial nerves
- eg. vision, hearing, equilibrium, taste and smell

General (somesthetic, somatosensory)

- receptors widely distributed in skin, muscles, tendons, joints, and viscera
- they detect touch, pressure, stretch, heat, cold and pain, blood pressure and chemistry

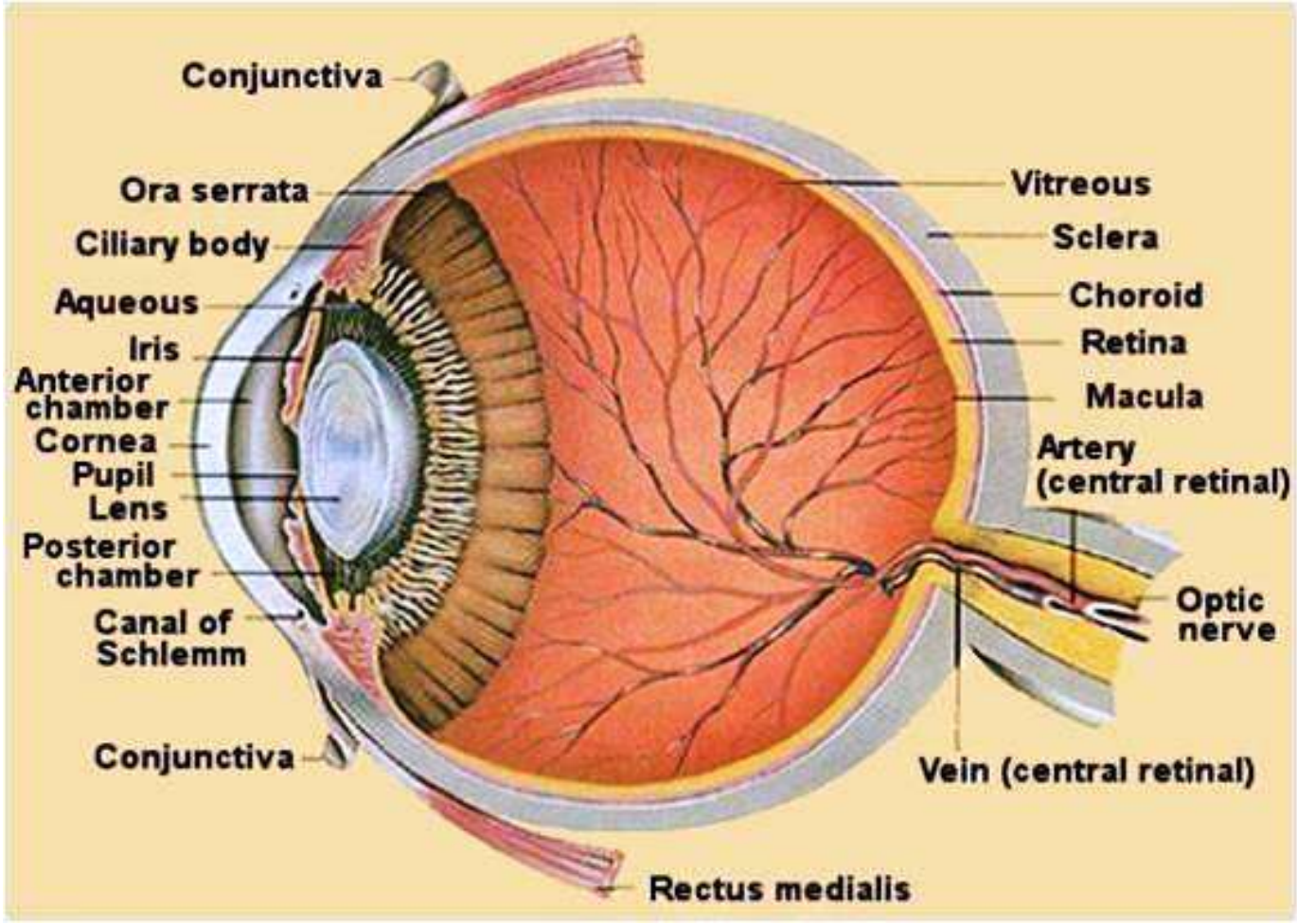
The Senses

- Special senses
  - Smell- chemoreceptors (chemicals)
  - Taste- chemoreceptors
  - Sight- photoreceptors (light)
  - Hearing- mechanoreceptors
  - Equilibrium- (balance) mechanoreceptors
- General senses
  - touch (tactile)
  - Temperature- thermoreceptors (heat)
  - Pressure- mechanoreceptors (movement)
  - Pain- mechanoreceptors

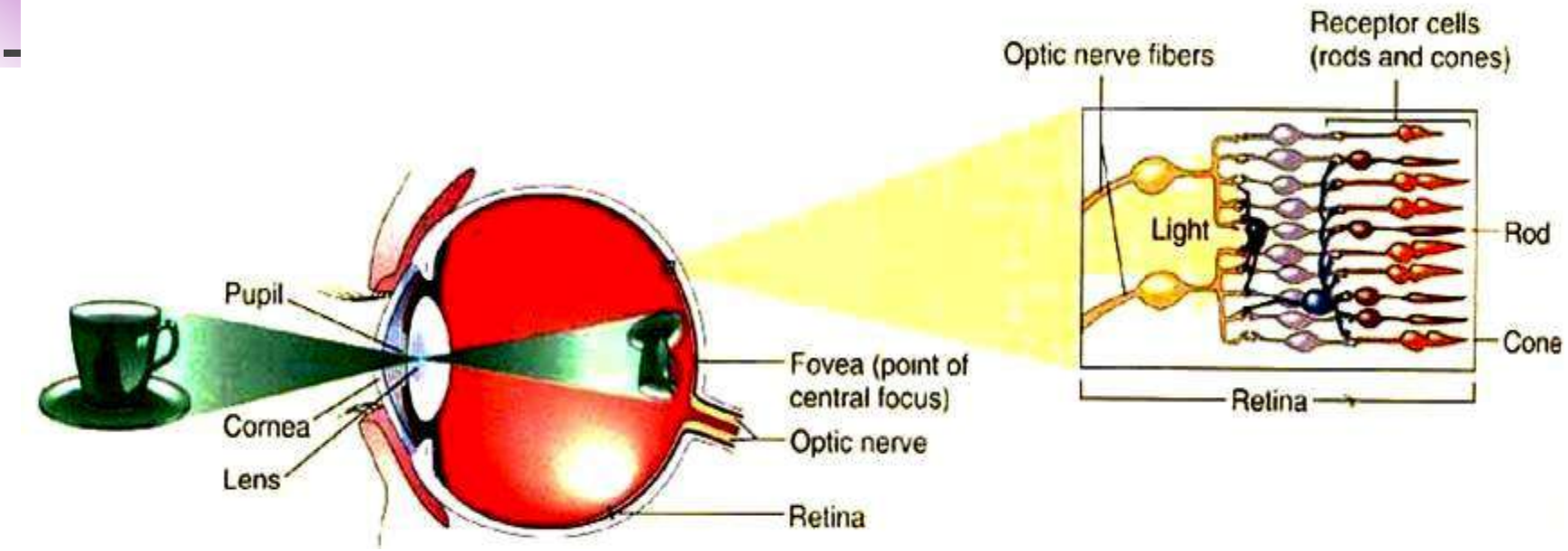
Major Sense Organs

- **Vision** – Eye
- **Hearing** – Ear
- **Taste** – Taste receptors (new)
- **Smell** – Olfactory system
- **Skin** – Hot, cold, pressure, pain

Eye


Conjunctiva
Ora serrata
Ciliary body
Aqueous
Iris
Anterior chamber
Cornea
Pupil
Lens
Posterior chamber
Canal of Schlemm
Conjunctiva
Rectus medialis
Vitreous
Sclera
Choroid
Retina
Macula
Artery (central retinal)
Optic nerve
Vein (central retinal)

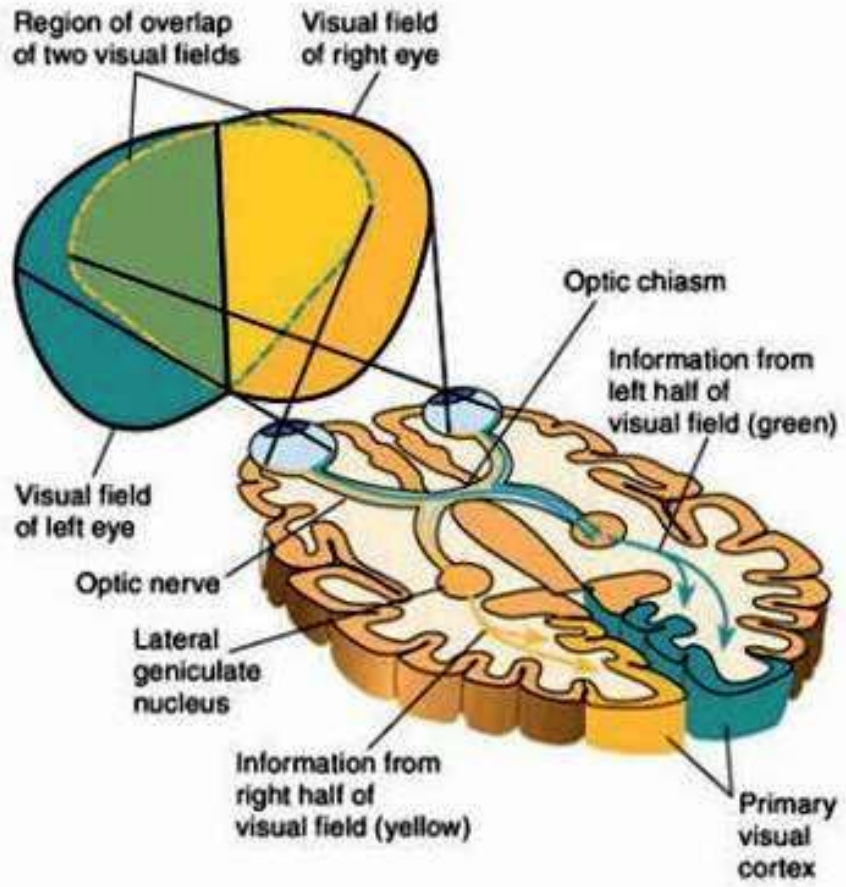
Images



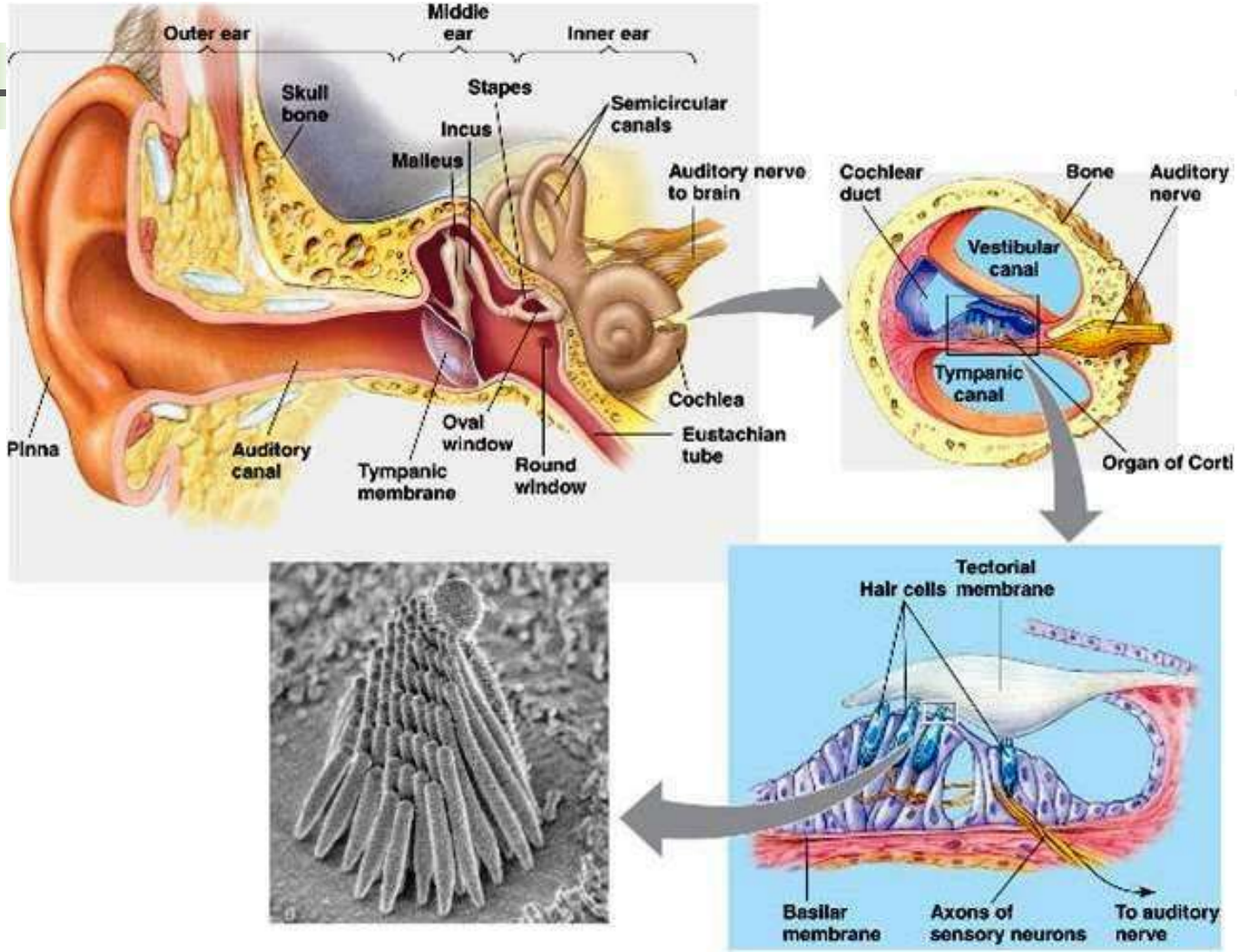
Cornea and the lens help to produce the image
Images are upside down and backwards when they reach the retina

Visual Pathway

► The Primary Visual Pathway

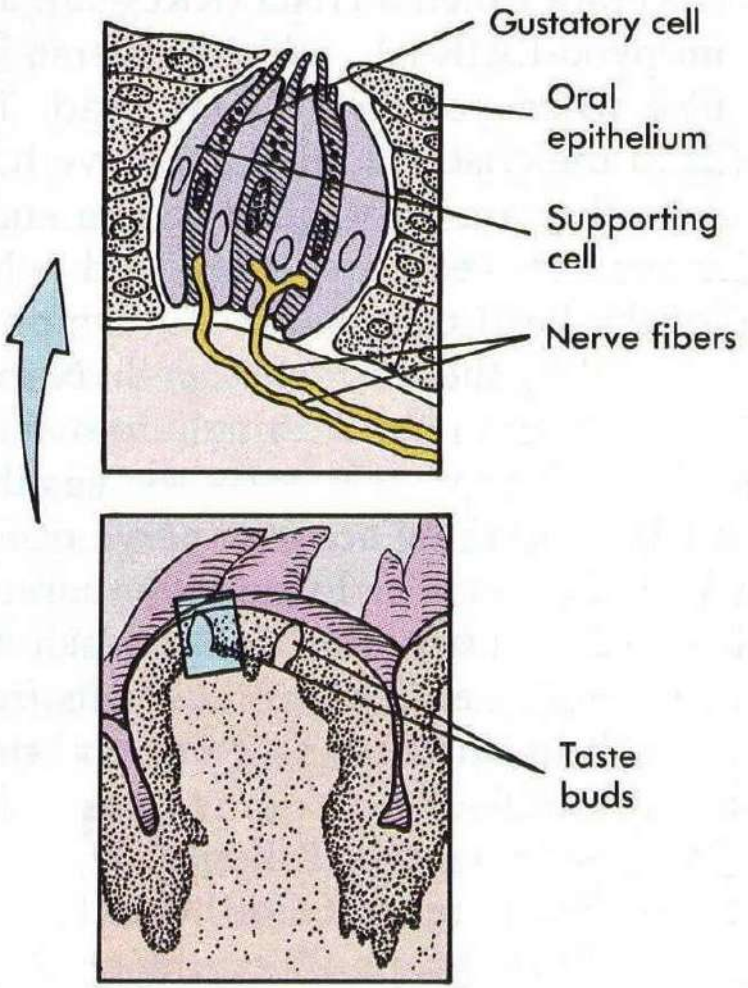


Ear

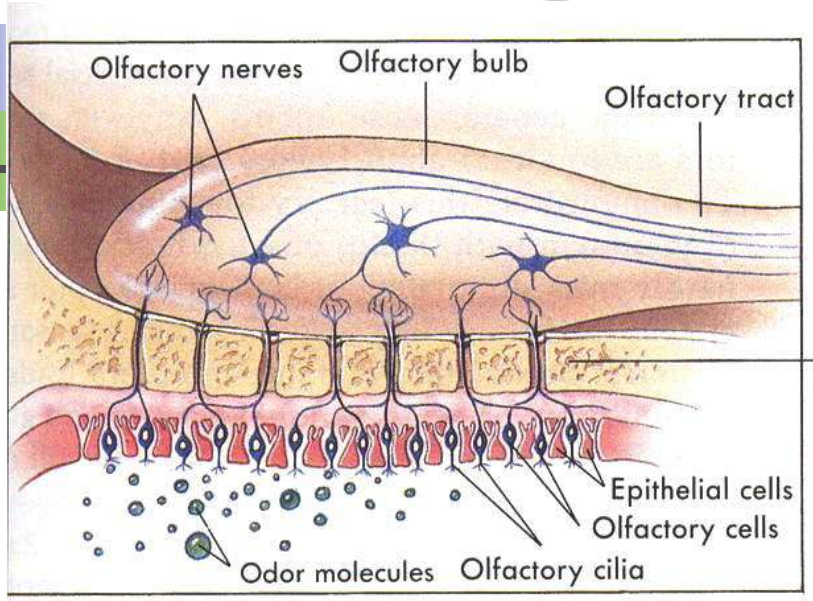

Outer ear
Middle ear
Inner ear
Skull bone
Stapes
Incus
Malleus
Semicircular canals
Auditory nerve to brain
Pinna
Auditory canal
Tympanic membrane
Oval window
Round window
Cochlea
Eustachian tube
Cochlear duct
Bone
Auditory nerve
Vestibular canal
Tympanic canal
Organ of Corti
Tectorial membrane
Hair cells
Basilar membrane
Axons of sensory neurons
To auditory nerve

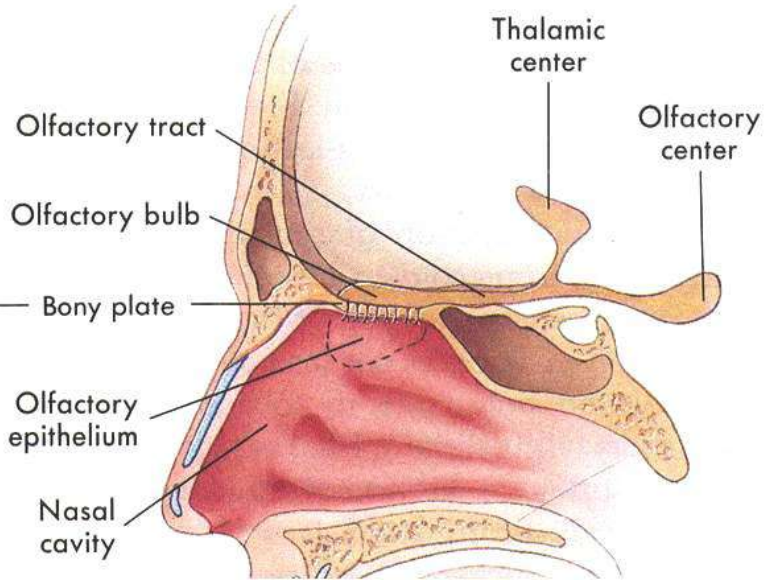
Taste Buds

- Chemical Receptors
  - Sweet
  - Sour
  - Bitter
  - Salty
  - Umami



Olfactory Receptors





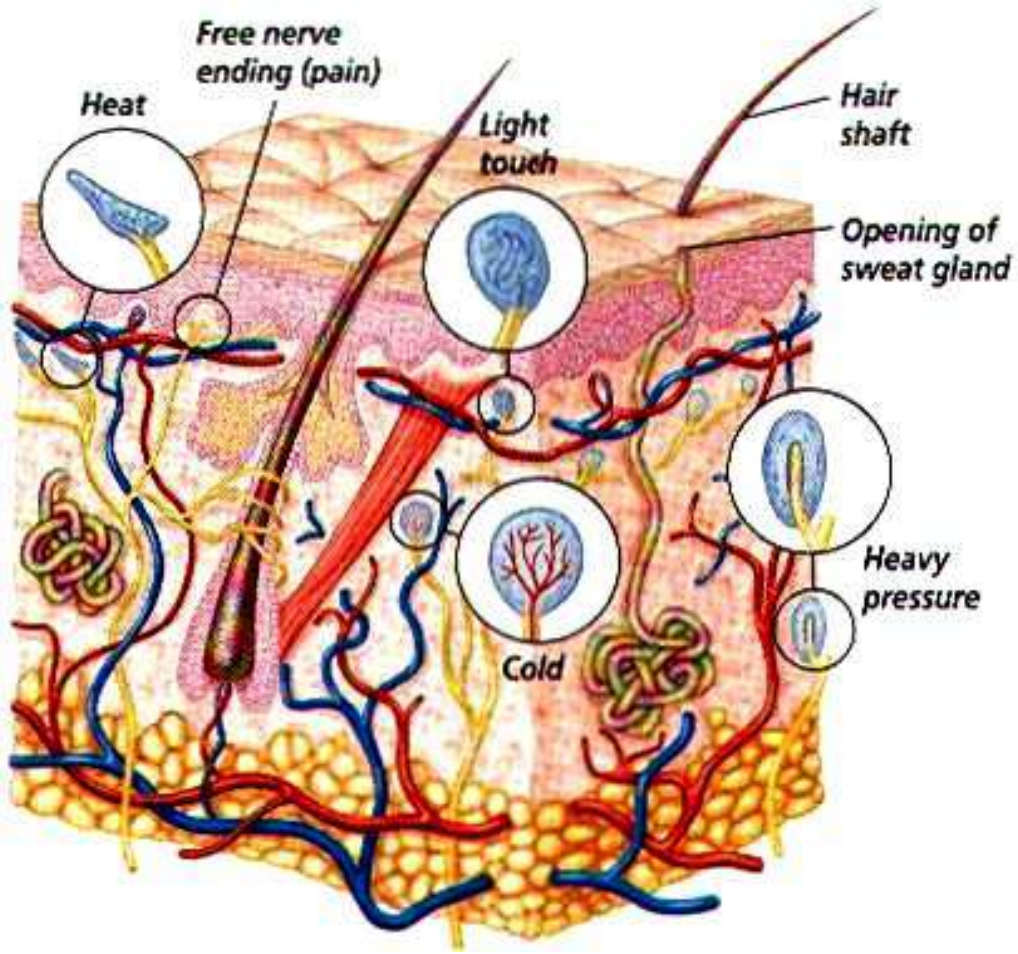
- Chemical Receptors
- Top of nasal cavity
- Extremely sensitive
- Easily fatigued
- Much of "taste" involves smell

General Senses

- **Skin receptors – touch, pressure, heat, cold, pain**
- **Proprioceptors – Stretch receptors in joints, ligaments, and tendons**
- **Pain receptors – skin, skeletal muscle and visceral**

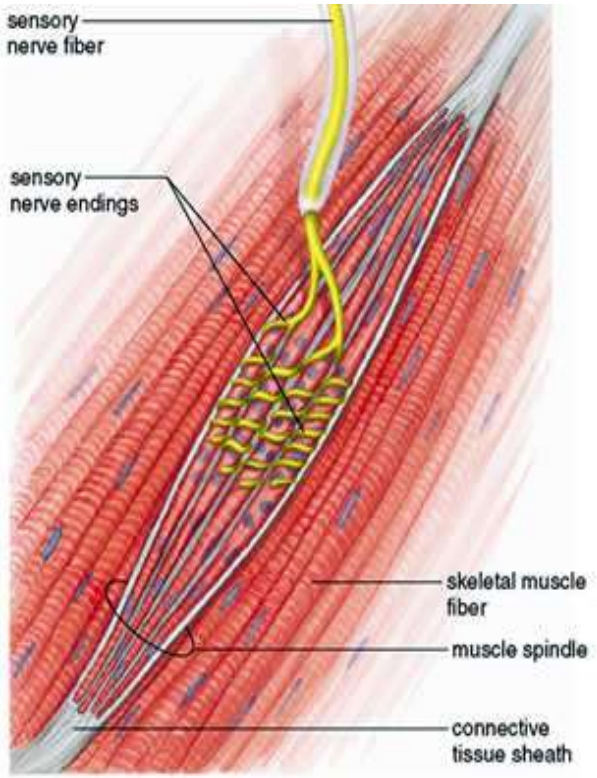
Senses in Skin

- Heat
- Cold
- Light pressure
- Heavy Pressure
- Pain



Proprioceptors

- Maintain some degree of continuous contraction (partial sustained contraction) or **muscle tone**
- **Muscle spindles** – modified muscle fibers with sensory nerve endings wrapped around the middle (and also found at the ends)
- Detect stretch and stimulate a reflex contraction



Pain Receptors

- **Somatic nociceptors -** from skin and skeletal muscle
- **Visceral nociceptors -** receptors that help maintain internal homeostasis
  - Respond to stretch, lack of O_2, chemicals released from damaged cells and inflammatory cells.
  - ***Referred pain*** – visceral pain afferents travel along the same pathways as somatic pain afferents, so sometimes the brain interprets the visceral pain as the more common somatic pain. Example – Often pain from the heart felt during a heart attack is perceived as a pain that originates in the left arm.

Disorders of the Nervous System

- Epilepsy
- Seizures
- Alzheimer's Disease
- Multiple Sclerosis
- Parkinson's Disease
- Shingles (herpes zoster)
- Cerebral palsy
- Glaucoma
- Pink eye (conjunctivitis)
- Symptoms of all disorders
- Treatments and prevention

Effects of Drugs

Effects of drugs on the nervous system

- **Alcohol**
- **Caffeine**
- **Nicotine**
- **Marijuana**

ENDOCRINE SYSTEM

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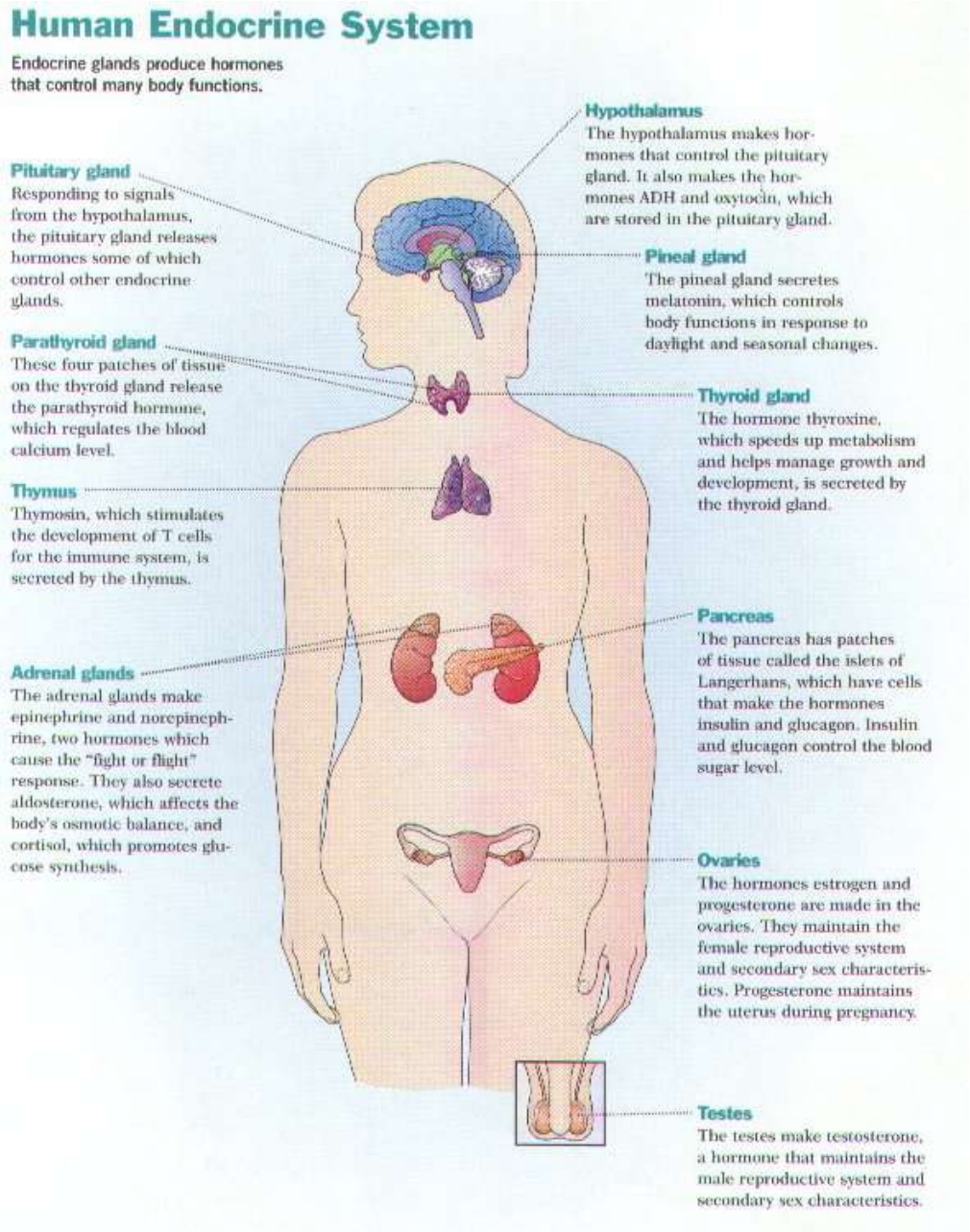
Nervous System vs. Endocrine System

	Nervous System	Endocrine System
Chemical Messenger	neurotransmitters	hormones
Location of message	synapses	target cells
Effects	rapid & short-lasting	slower & longer lasting
Controls	muscles & glands	activities of cells

Endocrine System

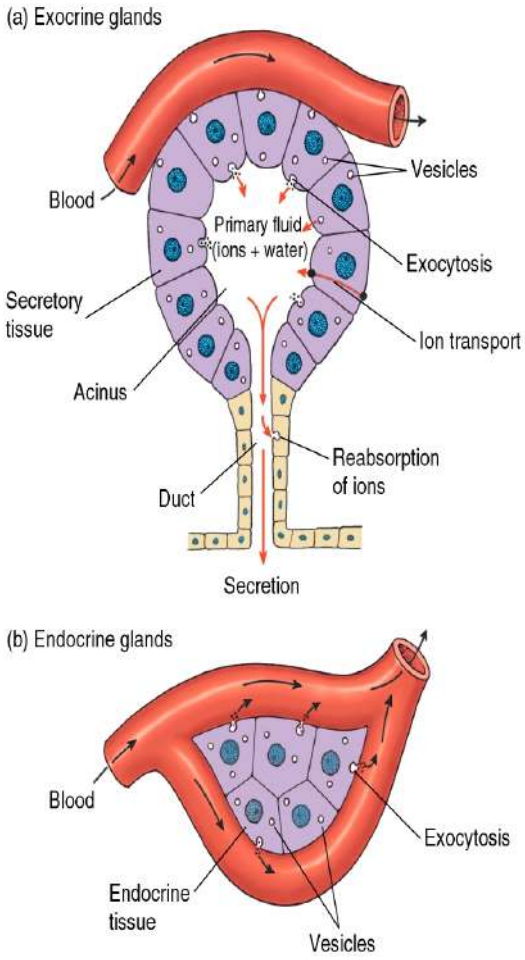
- **Major Endocrine Organs**
  - **Hypothalamus**
  - **Pituitary gland**
  - **Pineal gland**
  - **Thyroid gland**
  - **Parathyroid gland**
  - **Thymus**
  - **Adrenal gland**
  - **Pancreas**
  - **Ovaries**
  - **Testes**



GLAND TYPES

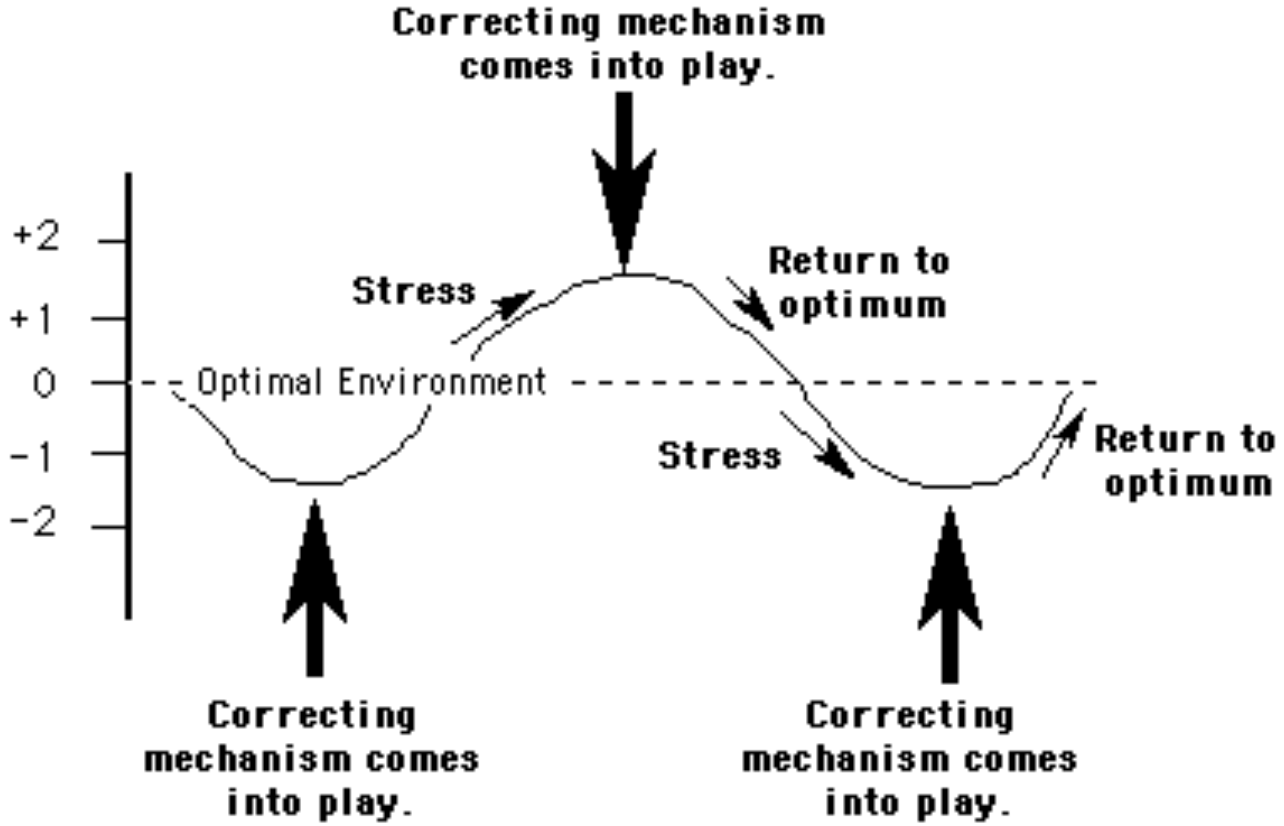
A. **Exocrine gland**
   - Ducts
   - Lumen and surfaces

B. **Endocrine gland**
   - Chemical messengers
   - Blood stream



ENDOCRINE SYSTEM AND HOMEOSTASIS

- Homeostasis



Feedback Mechanisms

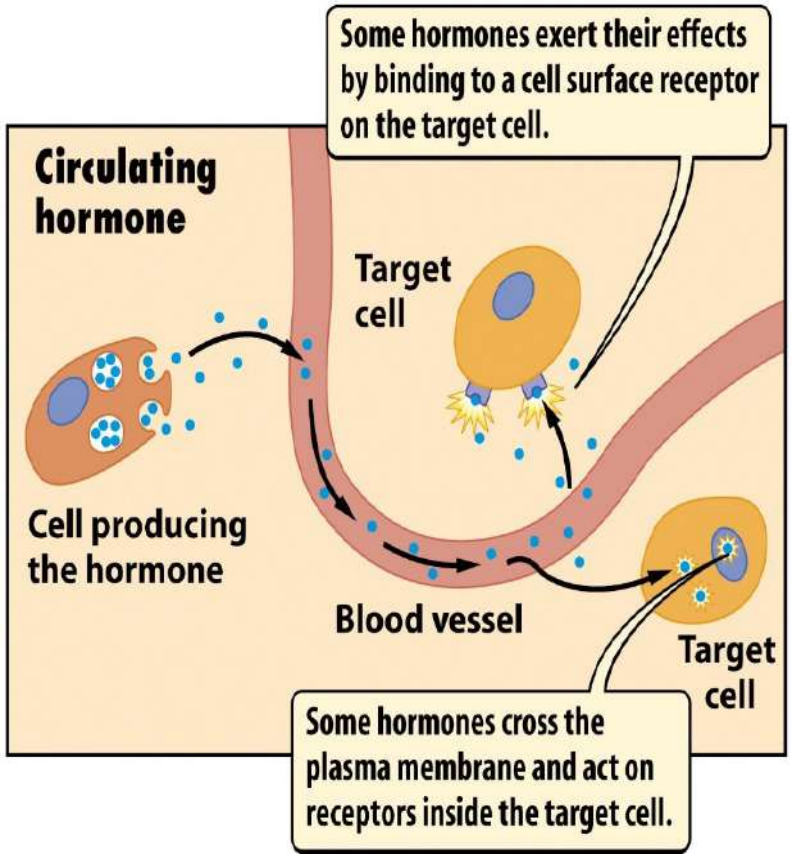
- Stimulus
  - change in homeostatic environment
  - signal sent to CNS
- Response
  - signal sent from CNS
  - produces effect
  - body returns to homeostasis

Hormones

- specific chemical compounds
- produced by a specific tissue of the body
- released into the body fluids
- carried to a distant target tissue
- affects a pre-existing mechanism
- effective in small amounts.

Hormones

- **Chemical messenger**
  - Secreted by endocrine glands
  - Specific to target
  - Activate cellular changes
  - Of 4 different chemical types



Hormone types

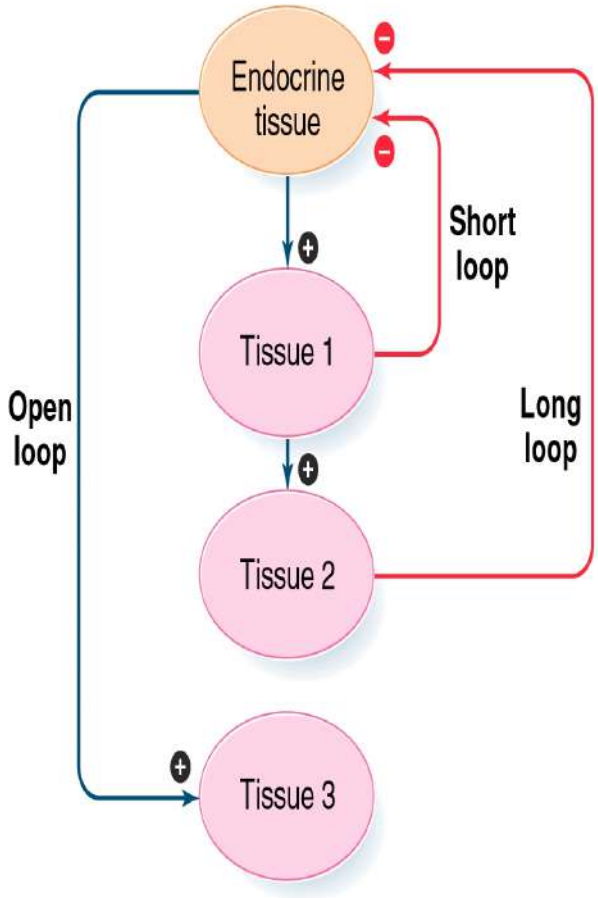
- Steroid hormones – made from cholesterol.
- Eicosanoids: lipid hormones – made from fats.
- Amino acid derived
- Peptides, polypeptides and proteins – small peptide hormones include TRH and vasopressin.

Control of Endocrine Function

A. **Positive**

B. **or Negative Feedback mechanisms**

- **Self-regulating system**



STIMULUS

↓

Hypothalamus

Releasing Hormone (Release-Inhibiting Hormone)

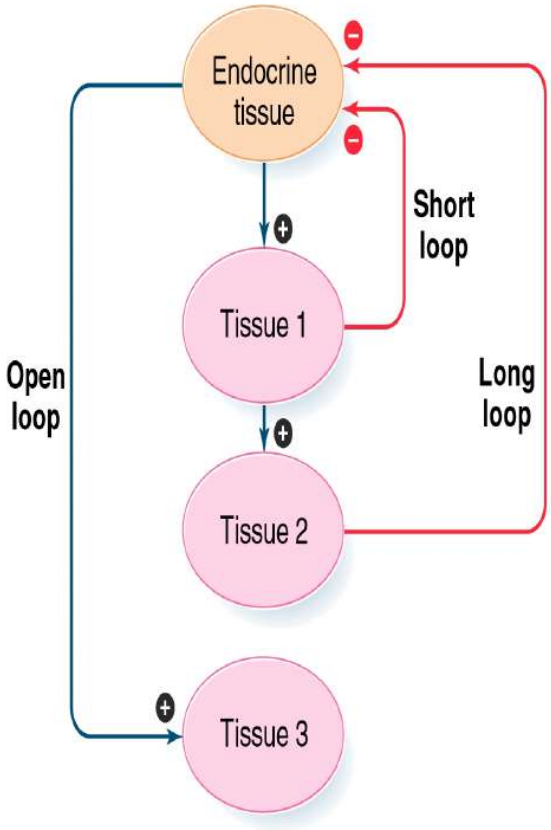
↓

Pituitary

Stimulating Hormone

↓

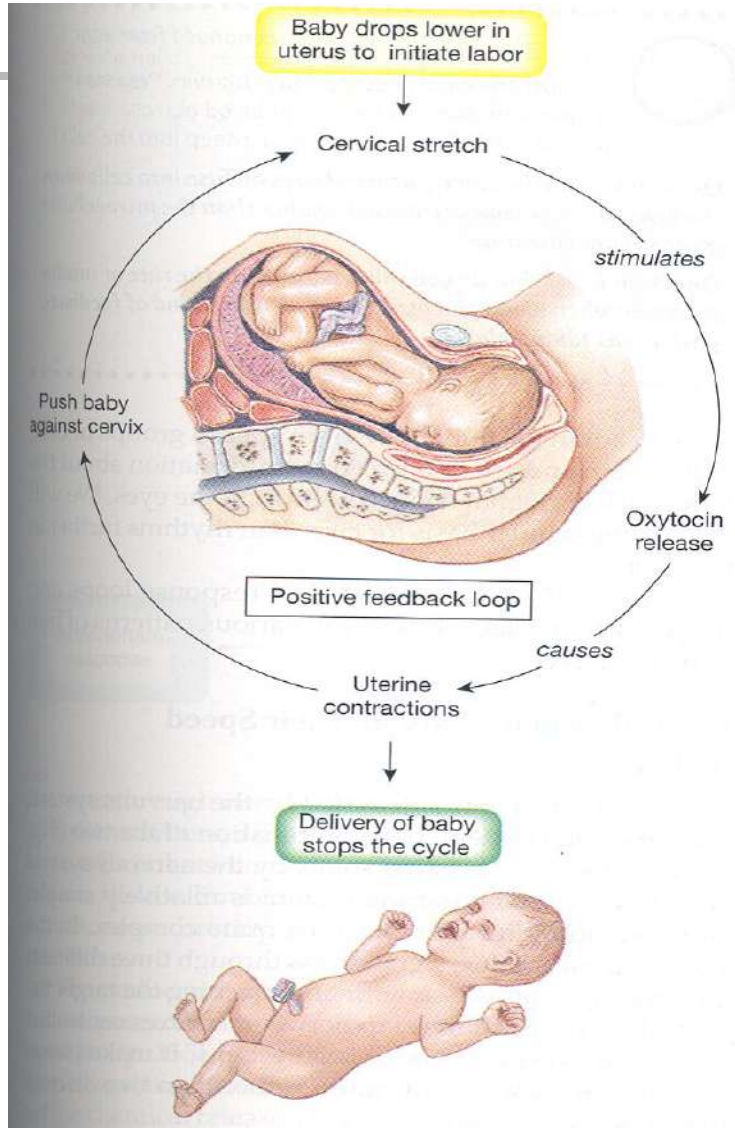
Gland Hormone → **Target**



Positive Feedback

- **Not common**
- **Classic example:**

  Action of OXYTOCIN on uterine muscle during birth.

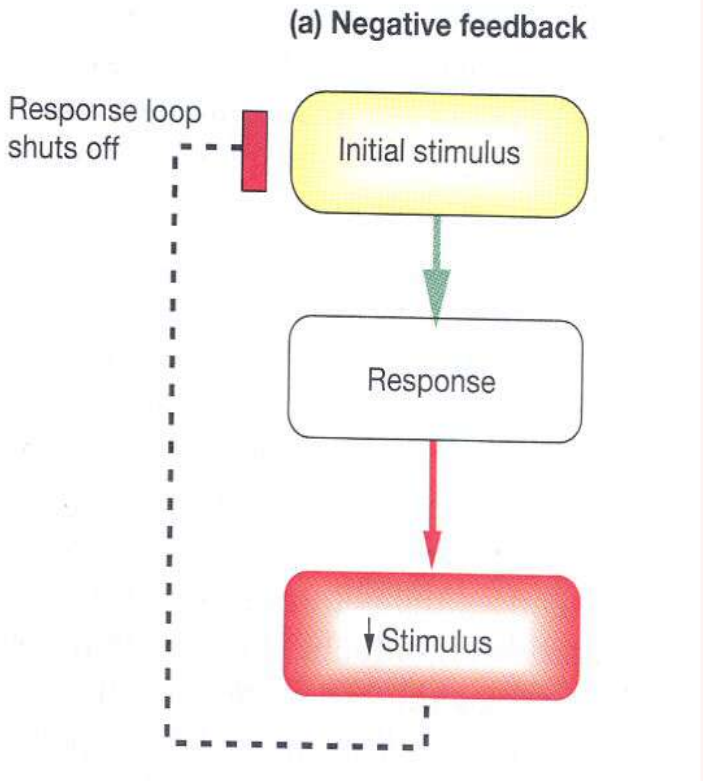


Positive Feedback

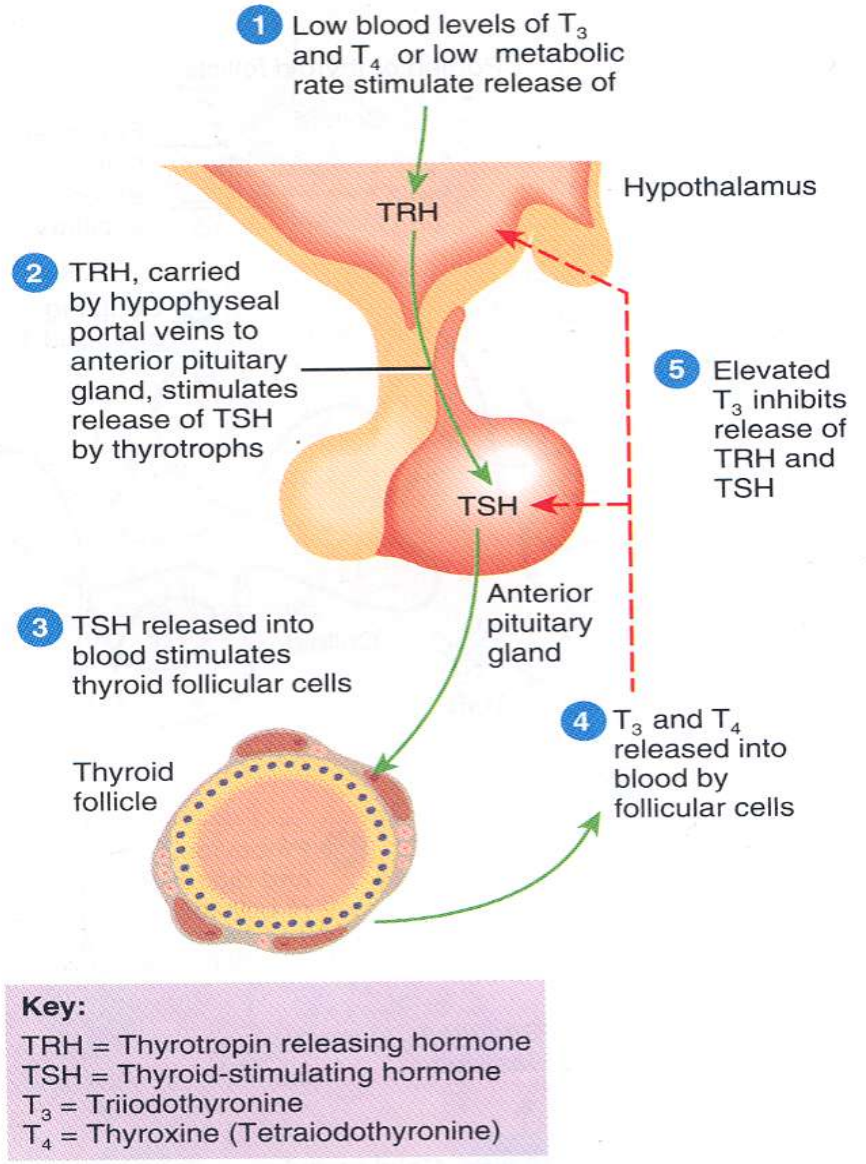
- Baby pushes on cervix
- Nervous signal to Hypothalamus
- Hypothal. manufactures OXY
- OXY transported to POSTERIOR PITUITARY & released
- OXY stimulates uterine contraction
- Feedback loop stops when baby leaves birth canal

Negative Feedback

- Most common control mechanism
- Level of hormone in blood or body's return to homeostasis shuts off loop at hypothalamus and pituitary



Negative Feedback: Thyroid



Basic Structure of a Feedback Loop

- Environmental Stimulus
- Stimulates Control Center (Brain-hypothalamus)
- Hypothalamic hormones stimulate Pituitary
- Pituitary hormone stimulate Target area
- Target area produces changes
- Change acts negatively or positively on the cycle.

Endocrine System

- **Major Endocrine Organs**
  - **Pituitary gland**
  - **Hypothalamus**
  - **Pineal gland**
  - **Thyroid gland**
  - **Parathyroid gland**
  - **Thymus**
  - **Adrenal gland**
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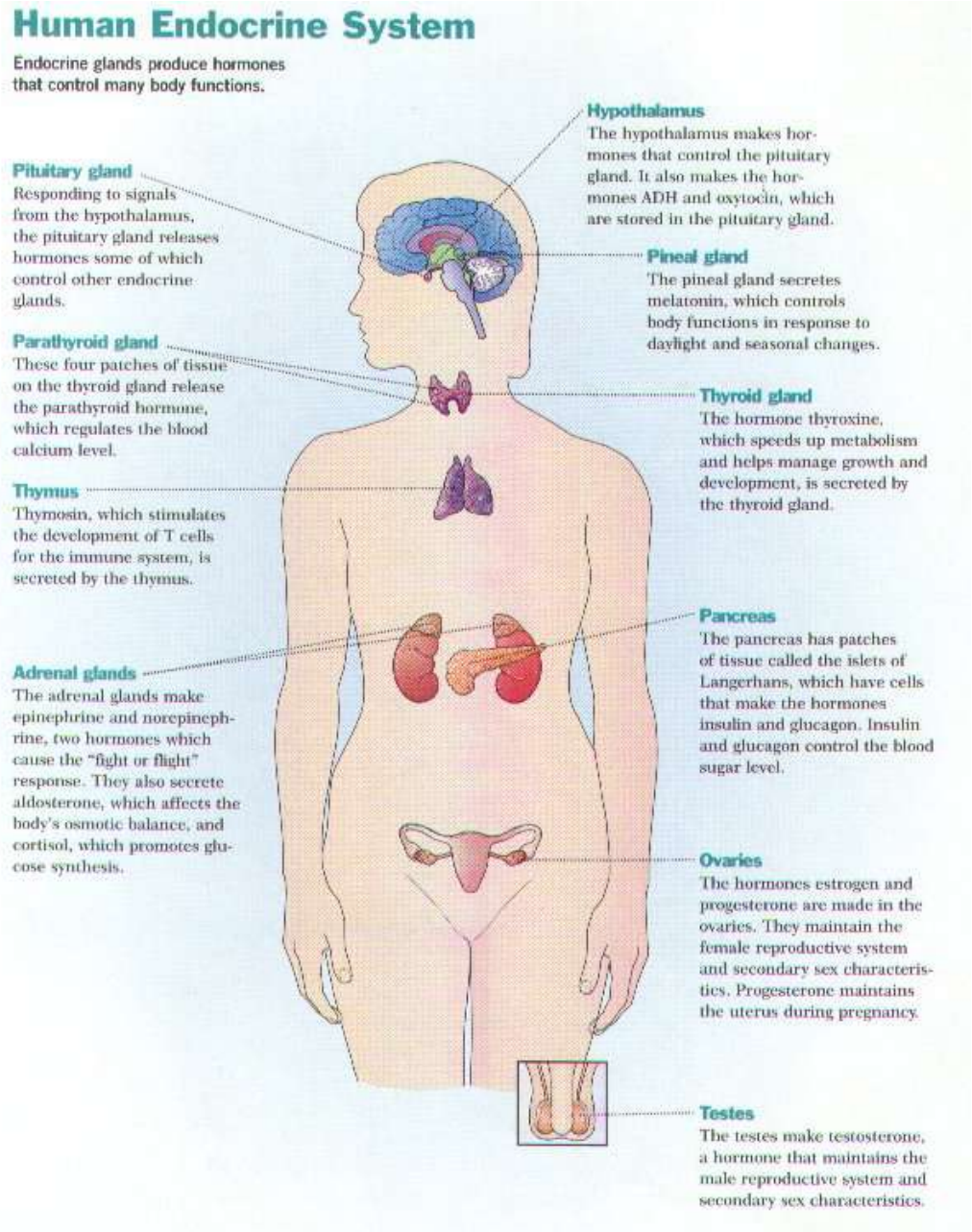
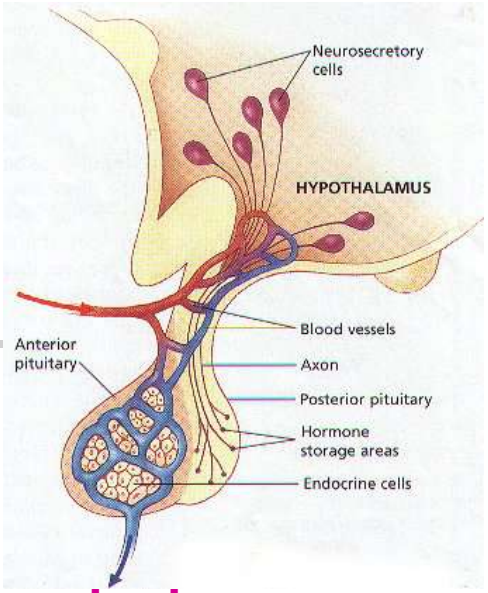
  - **Testes**

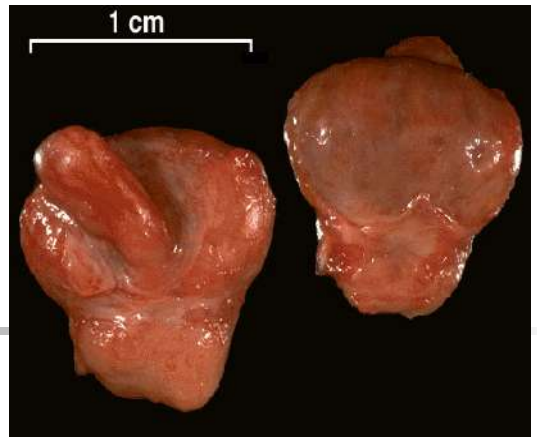


Hypothalamus



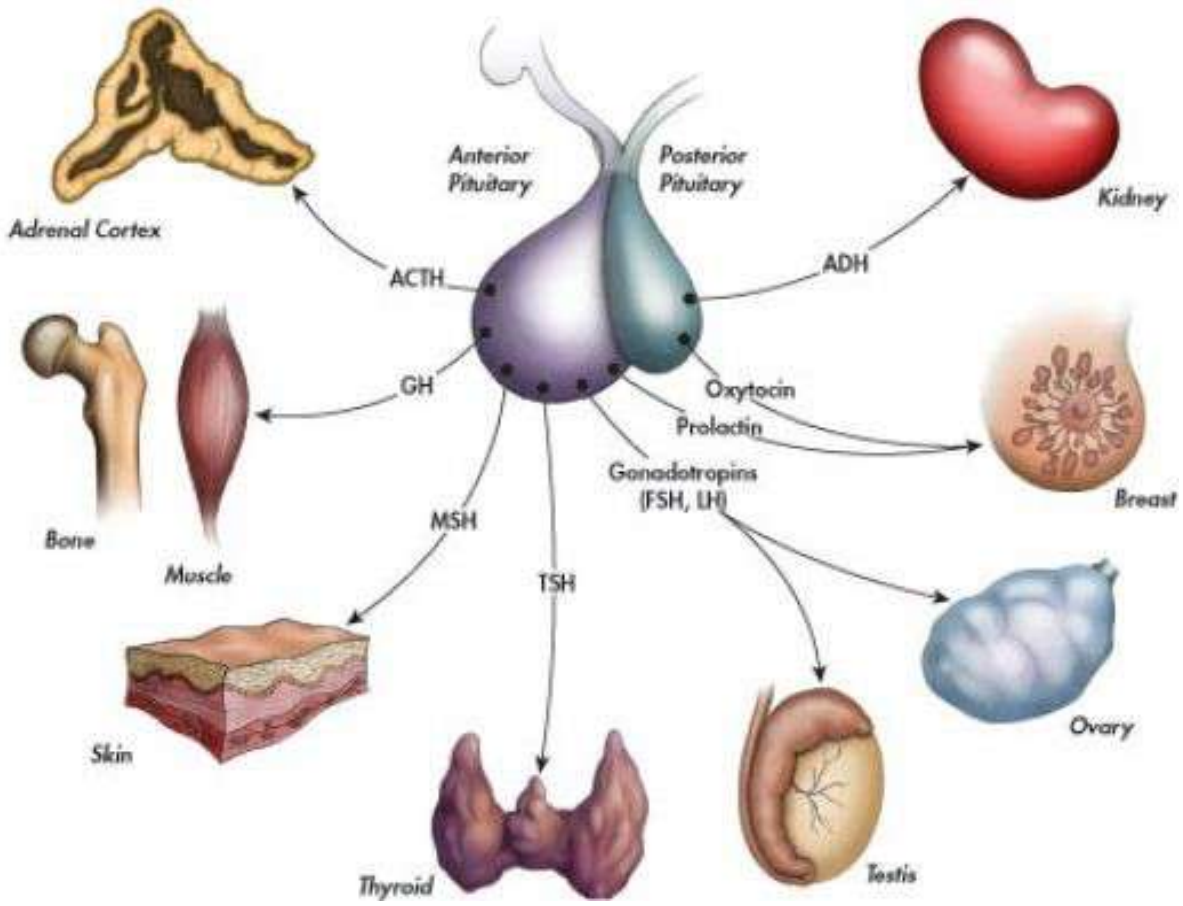
- **Connection to pituitary**
- **Also part of the brain, attached to the posterior pituitary gland**
- **Its function is to synchronize the information from the brain and the secretions of hormones**
- **Neurosecretory cells – specialized neurons that synthesize & secrete hormones**
- **The hypothalamus controls the secretions of the pituitary gland through nervous stimulation (posterior pituitary) and releasing hormones secreted to the anterior pituitary**
- **Neuronal to POSTERIOR PITUITARY**
- **Endocrine to ANTERIOR PITUITARY**
  - **RH = Pituitary releasing hormones**
  - **RIH = Pituitary release inhibiting hormones**

Pituitary gland



- Located at the base of the brain and is no larger than the size of a pea.
- Considered the most important part of the endocrine system and is often called the "***master gland***".
- Controls many other endocrine system glands. The pituitary gland helps control body and tissue growth.
- Also secretes endorphins, chemicals that reduce sensitivity to pain.
- Divided into anterior and posterior sections

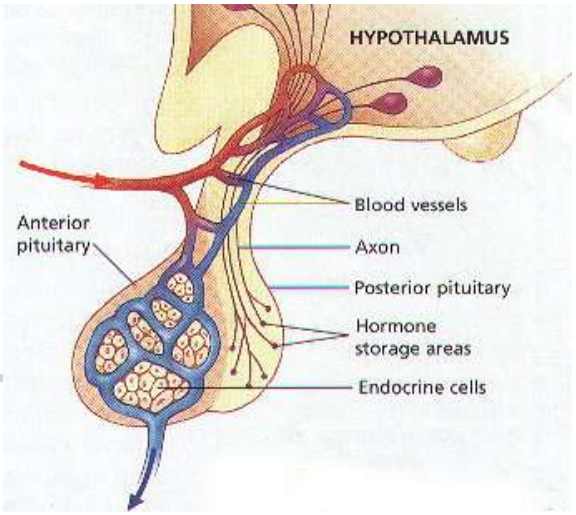
Anterior & Posterior Pituitary



Anterior Pituitary Hormones

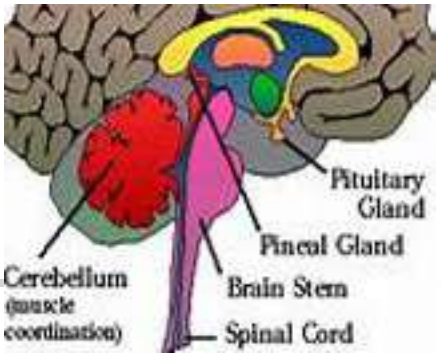
HORMONE	TARGET	FUNCTION
Thyroid (TSH) Stimulating	Thyroid gland	TH synthesis & release
Growth (GH)	Many tissues	growth
Adrenocortico-Tropin (ACTH)	Adrenal cortex	Cortisol release (androgens)
Prolactin (Prl)	Breast	Milk production
Follicle (FSH)	Gonads	Egg/sperm prod.
Luteinizing (LH)	Gonads	Sex hormones

Posterior Pituitary Hormones



- Manufactured in Hypothalamus, & released from Posterior Pituitary
- Oxytocin
  - Target = smooth muscle. Uterus and Breast (& brain)
  - Function = labor and delivery, milk ejection, (pair bonding)
- ADH (Vasopressin, AVP)
  - Target = kidneys
  - Function = water reabsorption

Pineal Gland



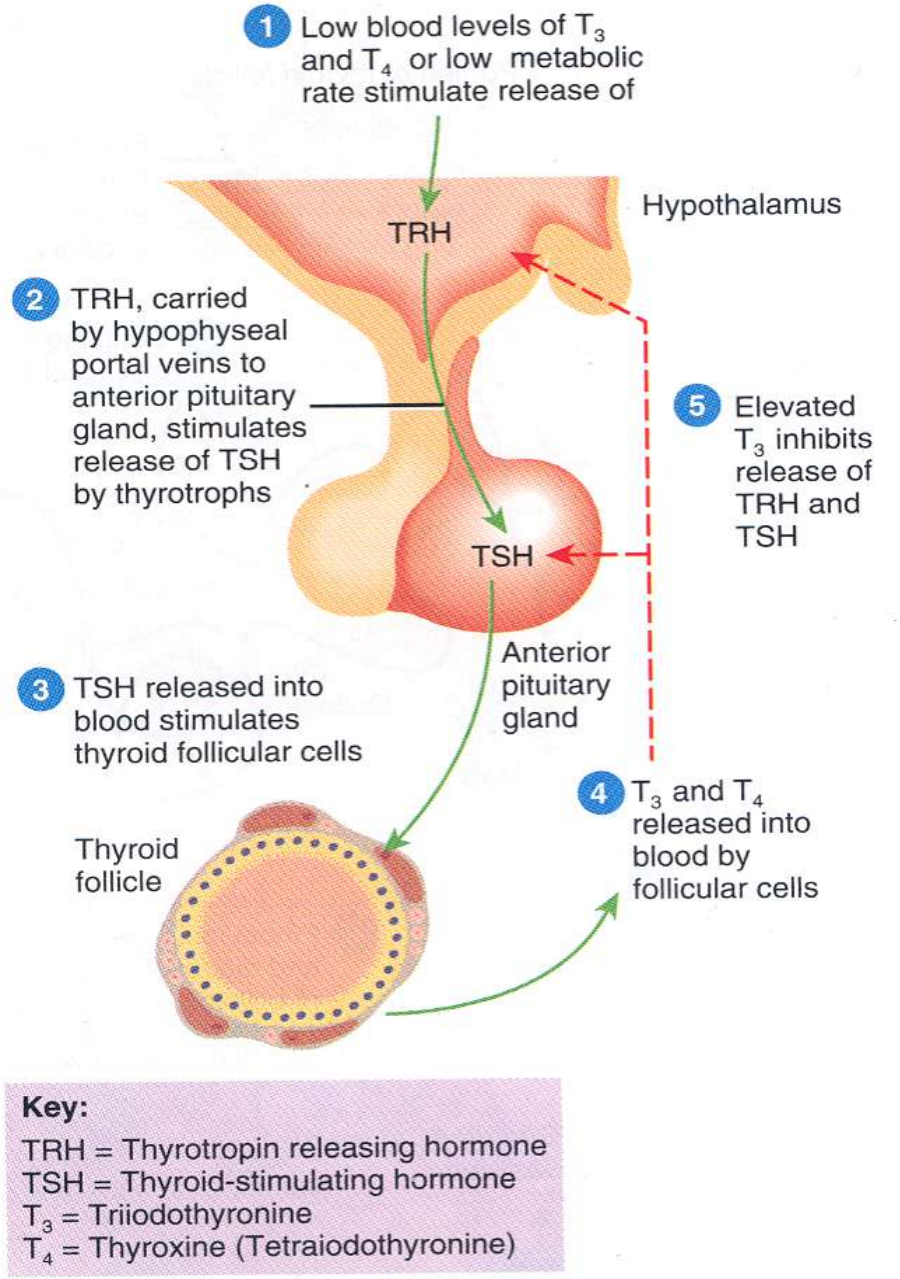
- The pineal gland is located in the brain
- It secretes **melatonin**, which regulates our internal clocks and any rhythmic activities
- It plays a large role in our sleep and wake cycles

Thyroid

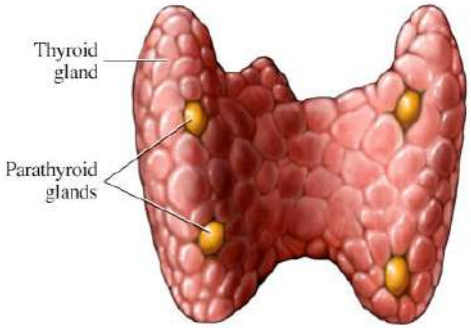
- It wraps around the trachea at the base of the neck
- Secretes a hormone called **thyroxine**
- Thyroxine regulates the metabolic rates of almost all the cells in the body
- As the thyroxine levels in the blood increase so does the rate of cellular respiration
- The thyroid gland needs iodine to create thyroxine, that is why salt is iodized now

Thyroid Hormone

- ↓ T3 & T4 stim. Or environmental stim. Hypothalamus
- TRH stim. Anterior Pituitary
- TSH stim. Thyroid
- ↑ T3 & T4 shuts off TRH and TSH production



Parathyroid

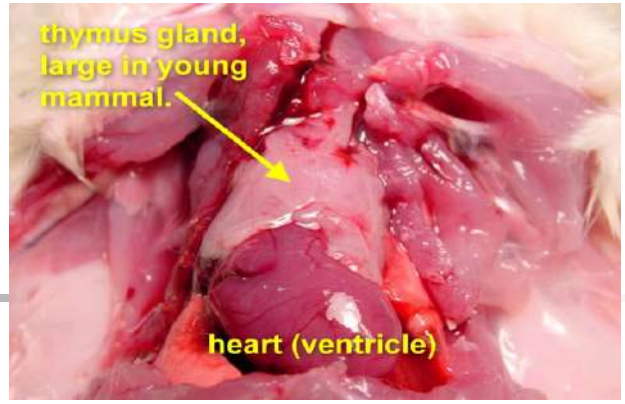


These four little glands are embedded in the thyroid gland
They secrete **parathyroid hormone (PTH** which regulates the amount of calcium in the blood and its absorption by bones
The action of PTH is opposed by another hormone, **calcitonin**, secreted by the thyroid gland.

Hypothalamic Hormones

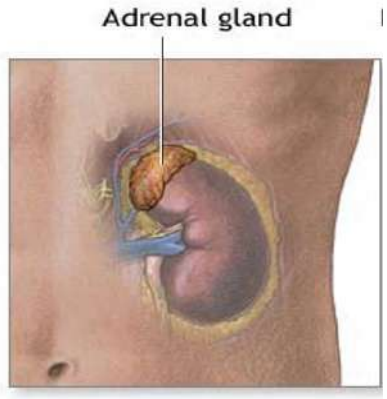
- Release Inhibiting Hormones
  - Somatostatin
  - Prolactin release inhibiting hormone-PIH
- Releasing Hormones
  - Thyrotropin releasing hormone-TRH
  - Growth hormone releasing hormone-GHRH

Thymus



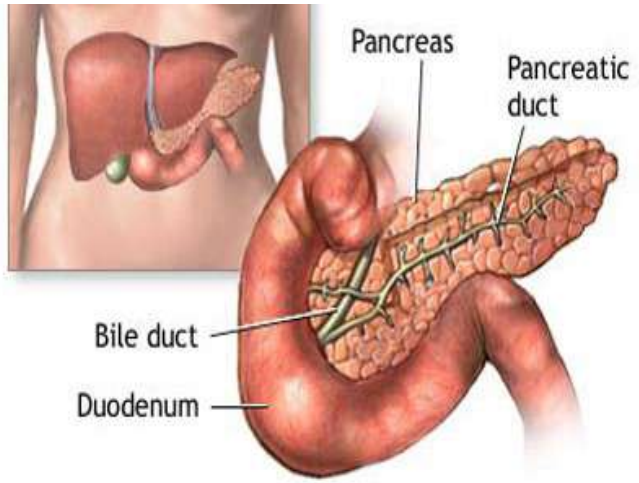
- Located below the thyroid between the right and left lung
- Secretes **thymosin** which stimulates T-cell (that is a type of white blood cell) production in children.
- This gland shrinks with age as we are exposed to more germs and build up our stores of antibodies

Adrenal



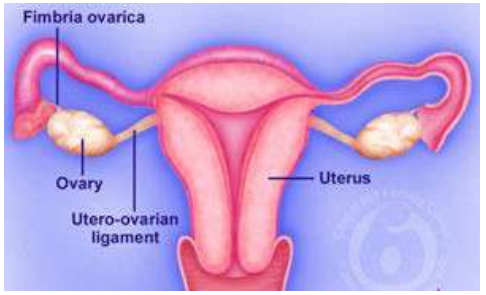
- There are two located on top of the kidneys
- The adrenal medulla secretes epinephrine (adrenaline) and norepinephrine which regulate our fight or flight response in times of extreme stress
- Cortex secretes aldesterone which regulates reabsorption of minerals from the kidney
- It also secretes cortisol which controls the rate of metabolism of carbohydrates, fats, and proteins

Pancreas



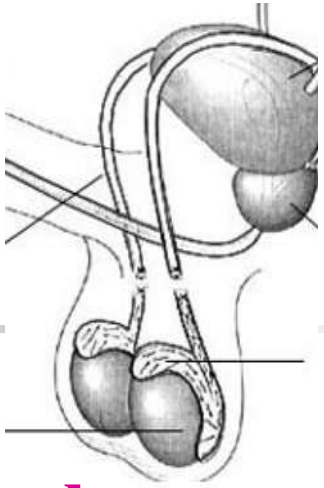
- Located behind the right side of the stomach
- Secretes **insulin** which tells the liver and muscles to remove sugar from the blood and store it as fat
- Also secretes **glucagon** which tells the liver to break down fat stores and release sugar back into the blood

Ovaries (females)



- Secrete estrogen and progesterone which regulate the female menstrual cycle
- Endometrium in the uterus also secretes a estrogen when a fertilized egg binds to it, to stop the menstrual cycle from progressing to menstruation

Testicles (Males)



Secretes male steroid hormones such as testosterone.

Testosterone controls development of male characteristics such as formation of male sex organs in the womb, sperm development, and secondary sex characteristics at puberty (deep voice, facial hair, chest and armpit hair, etc.)

Endocrine Disorders

Hypersecretion disorders are caused by too much hormone – these are much harder to treat

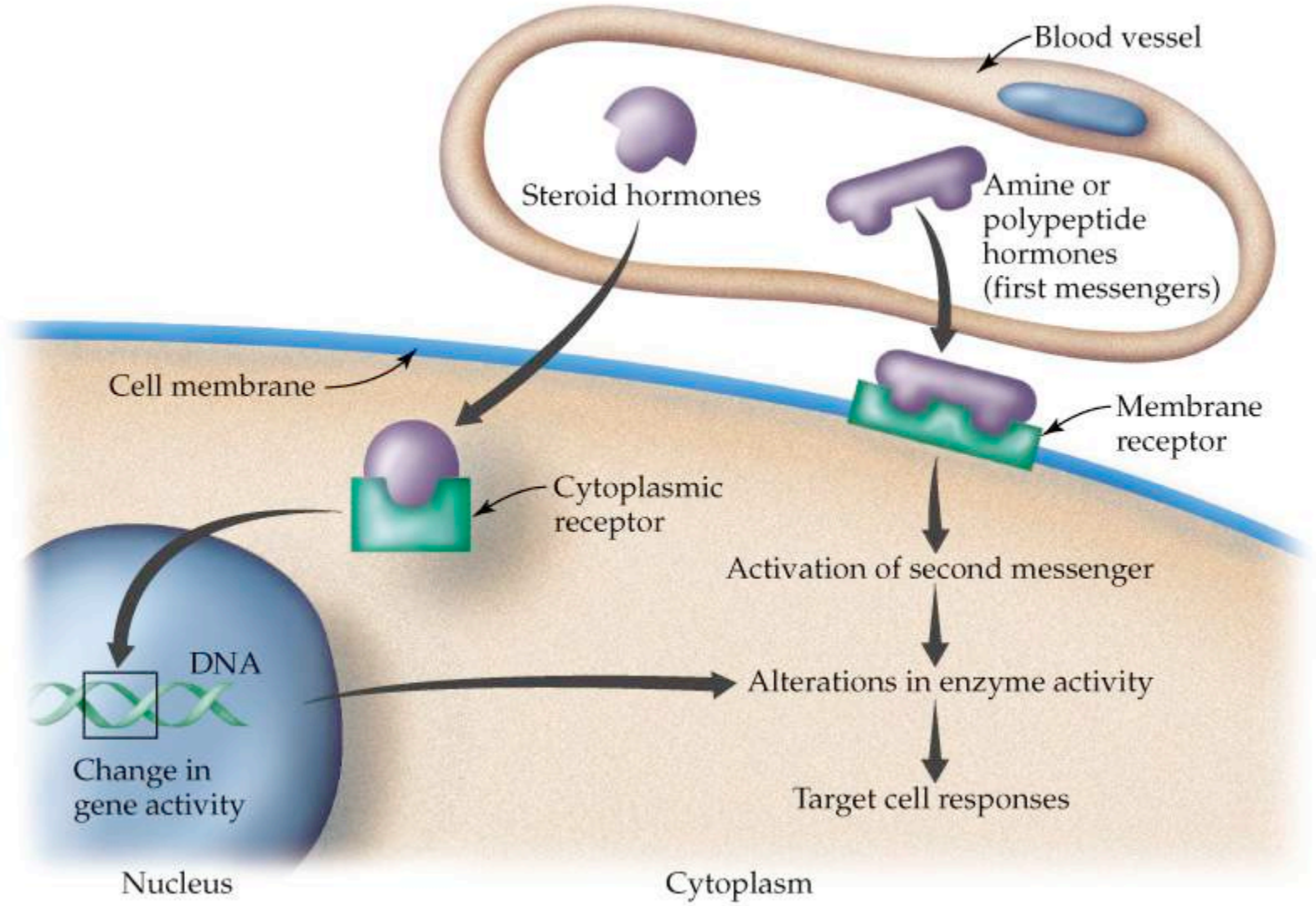
Hyposecretion disorders are caused by too little hormone – they can be treated by addition of the hormone

Target cell insensitivity produces symptoms similar to hyposecretion

Examples of the Endocrine System Disorders

- **Diabetes – increased levels of glucose in blood**
- **Hypoglycemia - low blood sugar**
- **Graves Disease – overactive thyroid**
- **Goiter – enlarged thyroid gland**

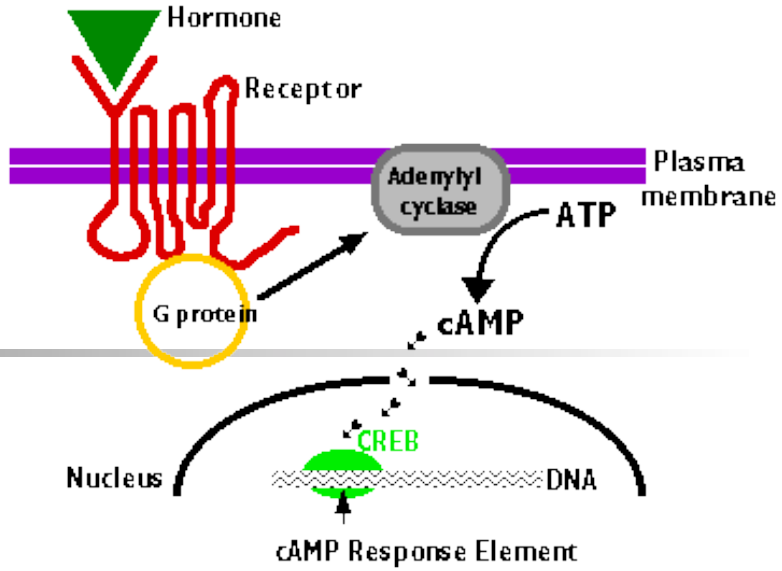
Mechanism of Hormone Action



Protein/Peptide Hormones

- Hydrophilic
- Large
- Can't fit through membrane
- Second messenger mechanism of action
- Most hormones
- Example: Insulin

peptide and amines

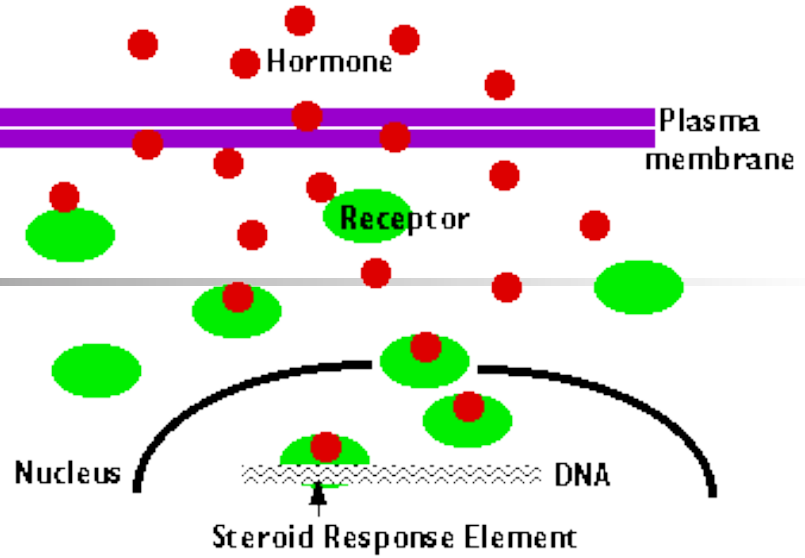


- **Protein hormones (1st messengers) - bind to receptor on target cell triggering 2nd messenger to affect cell's activity**
- **hormone (1st messenger) *does not enter the cell* but binds to receptor on the plasma membrane receptors**
- **hormone-receptor complex activates G protein**
- **generates chemical signal (2nd messenger) – most common is cAMP and IP3**
- **2nd messenger chemical signal activates other intracellular chemicals to produce response in target cell**

Steroid Hormones

- Small
- Hydrophobic/Lipophilic
- Travel in blood w/carrier
- Cytoplasmic or nuclear receptors
- change protein synthesis
- Example: estradiol

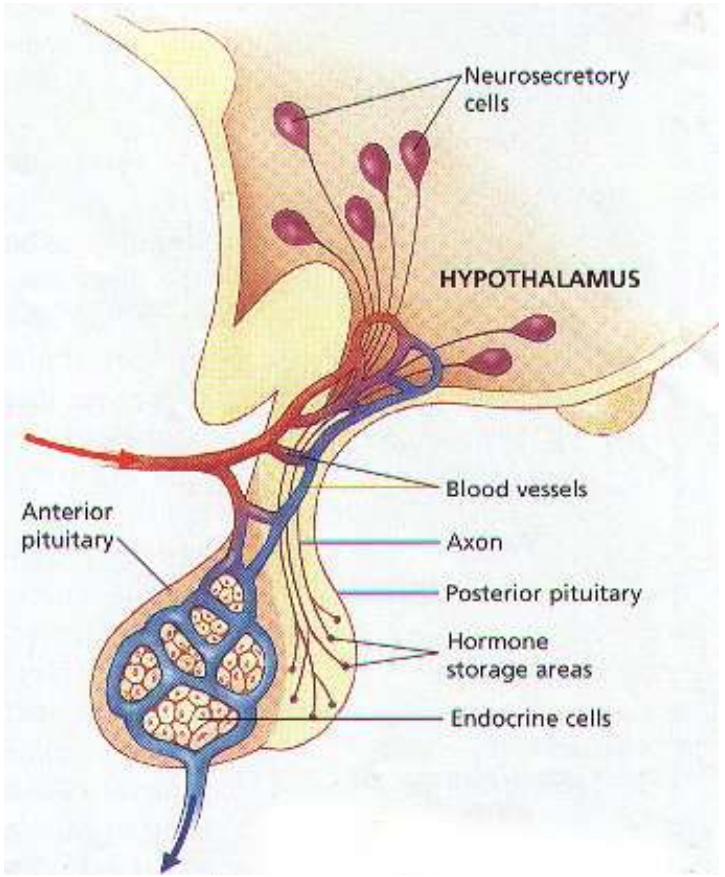
Steroid Hormones



- **Steroid hormones** - bind to receptors within target cell and influence cell activity by acting on specific genes
- **hormone** diffuses freely into cell where cytoplasmic and/ or nuclear proteins serve as receptors
- **hormone** binds to receptor (hormone-receptor complex)
- **complex bonds** to steroid response element (sections of DNA receptive to the hormone-receptor complex
- **hormone-receptor complex** acts as transcription factor to turn target genes "on" or "off"

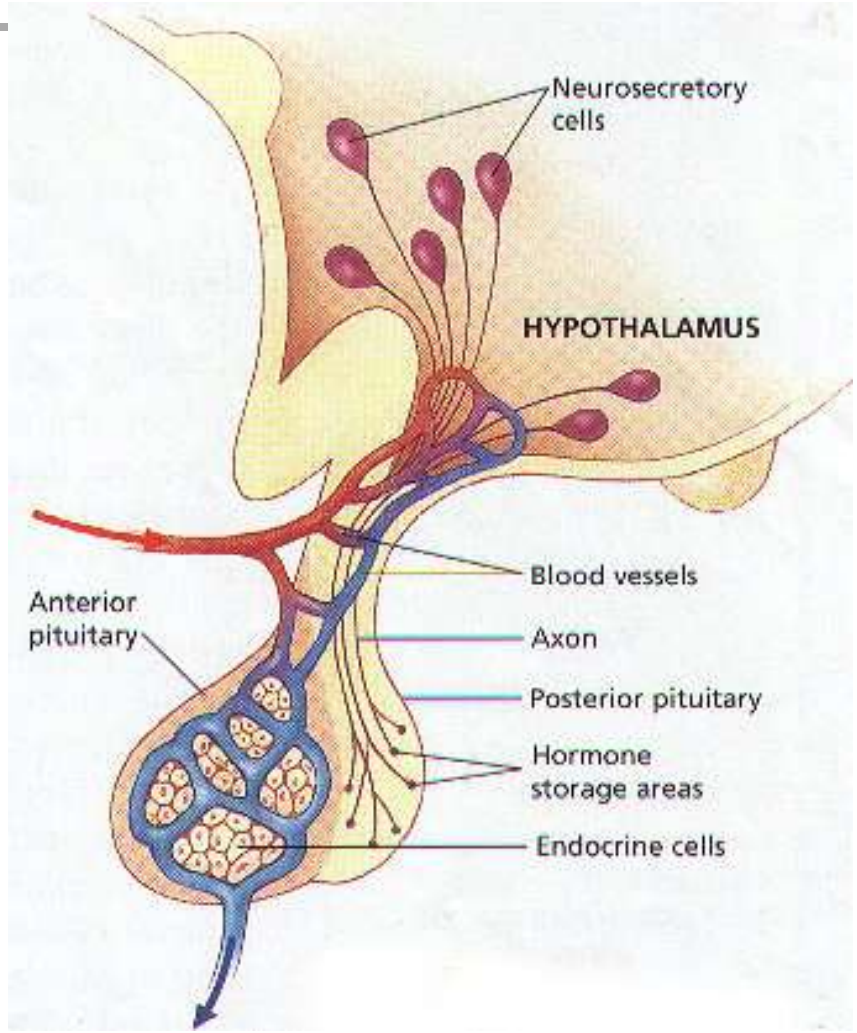
Neurosecretory Cells

1. **Specialized neurons**
   - **Synthesize and secrete hormones**
2. **Extend from HYPOTHALAMUS to POSTERIOR PITUITARY**



Neurosecretory cells in Hypothalamus

- Nuclei synthesize and secrete hormones
- Neuronal connection to POSTERIOR pituitary
- Antidiuretic Hormone (ADH), Oxytocin



Questions?

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