THE NERVOUS SYSTEM

• The Nervous System:

TWO DIVISIONS OF THE NERVOUS SYSTEM

• Central Nervous System (CNS)
  – Composed of:
  – Controls:
  – Integrates:
  – Dependent upon:

• Peripheral Nervous System (PNS)
  – Link between:
  – Consists of:
  – Composed of sensory and motor divisions
    • Sensory:
    
    
    
    • Motor:
    
    
    

DIVISIONS OF THE PNS

• Somatic (Voluntary) Nervous System
  – Conducts impulses from:

• Autonomic (Involuntary) Nervous System
  – Innervates:
  – Maintains:

DIVISIONS OF THE AUTONOMIC N.S.

• Sympathetic N.S.
  
  
  

Lecture Notes

Anatomy 2B

Inhibits:

Dilates:

Accelerates:

• Parasympathetic N.S.

Constricts:

Promotes:

Returns:

NERVOUS SYSTEM CELL TYPES

• Neurons (nerve cells)

• Neuroglia

• NEUROGLIA (Glial Cells)

6 types

• _____ in PNS

• _____ in CNS

SUPPORTING CELLS OF THE CNS

• 1. Astrocytes

In CNS only

Anchor:

Pick up:

Recapture:
Lecture Notes

- **Guide:**

  - 3. Ependymal Cells
    - In CNS only
    - Line:
    - Circulate:

  - 4. Microglia
    - In CNS only
    - Monitor:
    - Devour:

**SUPPORTING CELLS OF THE PNS**

- 1. Schwann Cells
  - In PNS only
  - Wrap around:
  - Form:
  - Needed for:

- 2. Satellite Cells
  - In PNS only
  - Surround:
  - Help control:

**NEURON STRUCTURE**

- Cell Body (soma or perikaryon)
  - Contains:
    - Abundant clusters of rER called:

- Nerve Processes (neurites)
  - Dendrites
    -
Axon (nerve fiber)

- Axon (Nerve Fiber)
  - Axon hillock
  - Axoplasm
  - Axolemma

- Axon terminal = synaptic knobs or terminal boutons
  - Telodendria (terminal branches)
  - Axon collaterals

CLASSIFICATION OF NEURONS

- Neurons can be classified by structure:
  - Multipolar
    - Most common in:
  - Bipolar
  - Unipolar
• Neurons can be classified by function:
  – Afferent (sensory)
    • Carry info.
  – Efferent (motor)
    • Carry info.
  – Association or Interneurons
    • Link

OTHER NERVOUS SYSTEM STRUCTURES
• Ganglion
  – Clusters of
• Nuclei
  – Clusters of
• Tract
  – Bundles of
• Nerve
  – Bundles of

TYPES OF SYNAPSES
• Electrical Synapses
  –
  –
  –
  –
  –
• Chemical Synapses
  –
  –
  –
NEUROTRANSMITTERS

- Released at:
- Chemicals produced:
- Stored in:
- Nerve impulse causes:
- When bound to receptors on postsynaptic neuron, the neurotransmitter:

THE RESTING MEMBRANE POTENTIAL

- Inside of cell membrane is more negative than outside
- Difference between charge inside and outside cell = RMPs :

EXCITATORY NEUROTRANSMITTERS

- When bound to receptors on the postsynaptic neuron membrane:
  - Causes the opening of:
  - RMP becomes:
  - Depolarization of postsynaptic membrane:

DEPOLARIZATION

- A positive change in the RMP
  - Caused by:
  - Causes the inside of the cell membrane to become:
  - Depolarization:

INHIBATORY NEUROTRANSMITTERS

- When bound to receptors on the postsynaptic membrane:
  - Makes the membrane:
  - As the negative ions rush into the neuron, the RMP becomes:
  - Hyperpolarization:
HYPERPOLARIZATION

GRADED POTENTIALS

Can be:

• Alone:

• Together:

POSTSYNAPTIC POTENTIALS

EPSP (Excitatory Postsynaptic Potential)

  Binding of a neurotransmitter on the postsynaptic membrane:

  The neuron:

IPSP (Inhibitory Postsynaptic Potential)

  Binding of a neurotransmitter on the postsynaptic membrane:

  Inhibits:

TYPES OF NEUROTRANSMITTERS

40 to 50 known neurotransmitters

  Acetylcholine (Ach):

  Norepinephrine (NE)

    • Released by:

    • GABA-

    • Dopamine-

    • Serotonin-

    • Glutamate-
ACTION POTENTIALS (AP)

• Action Potential = Nerve Impulse

• Consists of:
  –
  –
  –

• If depolarization reaches threshold (usually a positive change of 15 to 20 mV or more),:
  – The positive RMP change causes:
  – Sudden large influx of sodium ions causes:
  – Begins at:

TYPES OF ION CHANNELS

• Chemically Gated (on dendrite or soma) –

• Voltage Gated (on axon hillock and axon) -

PROPAGATION

• Movement of:

• Caused by:

REPOLARIZATION

• Restoration of:

• A repolarization wave:

• 3 Factors contribute to restoring the negative membrane potential
  – Sodium (Na+) inactivation gates:
  – Potassium (K+) gates open:
  – Sodium/potassium pump kicks in (3Na+ out, 2K+ in)
THE SODIUM/POTASSIUM PUMP

- An active process:
  - Actively pumps:
    - Potassium leaks back out

ABSOLUTE REFRACTORY PERIOD

- Time from:
  - The neuron:
    - Relative refractory period follows: requires increased stimulation in order to fire
      - Most Na⁺ channels:
      - Some K⁺ channels:
      - Repolarization:

SUMMATION BY POSTSYNAPTIC NEURON

- A single EPSP:
  - EPSP’s:
    - Spatial Summation
    - Temporal Summation

ALL-OR-NONE RESPONSE

- An action potential:
  - When threshold is reached:
  - If threshold is not reached:

SALTATORY CONDUCTION

- Occurs:
  - Depolarization wave:
  - Results in:
SUMMARY OF EVENTS

• A nerve impulse in the presynaptic neuron causes:

• Neurotransmitter binding to receptors on postsynaptic neuron dendrite or soma cause:

• If Na+ channels open:
  – (depolarization)
  – (EPSP)
    – If RMP changes in a positive direction by 20mV (or reaches the threshold),:
      – Sodium:
      – As the positive ions get pushed down the axon, :
      – The process of restoring the negative RMP:

NERVE FIBER TYPES

• The larger the axon diameter:

• Myelinated axons :

• Type A fibers

  – Impulses travel at:

• Type B fibers

  – Impulses travel at:

• Type C fibers

  – Slow impulse conduction at:

NEURONAL CIRCUITS

• Diverging Circuits

  –

• Converging Circuits

  –
REFLEX ARCS

- Neural pathways with 5 components
  - Receptor
  - Sensory neuron
  - CNS integration center
  - Motor neuron
  - Effector
- A rapid, automatic response to a stimulus

CENTRAL NERVOUS SYSTEM

- CNS consists of brain and spinal cord

DIVISIONS OF THE BRAIN

- Brainstem
  - Medulla oblongata (1)
  - Pons (2)
  - Midbrain (3)
- Diencephalon (4)
  - Thalamus
  - Hypothalamus
  - Epithalamus
- Cerebellum (5)
- Cerebrum (6)

PROTECTION OF THE CNS

- Structures that help to protect the brain and spinal cord:
  - Cerebrospinal fluid (CSF)
• Three connective tissue membranes surrounding the brain and spinal cord

CEREBROSPINAL FLUID (CSF)

• Total volume of 150ml:
  • 500 ml:
  • Formed by:

THREE LAYERS OF MENINGES

• Dura mater
  – The outer periosteal layer:
    – In some areas the layers:
      – Extends inward in some areas forming:

DURAL SEPTA

• Dural septa
  – Falx cerebri
  – Falx cerebelli
  – Tentorium cerebelli

DURAL SPACES

• Subdural space
  – Space below:

• Epidural space
  – Space between:
THREE LAYERS OF MENINGES

• Arachnoid (Mater) Layer
  –
  –
  – Subarachnoid space
    • Space below:
    • Filled:
    •
• Arachnoid villi (granulations)
  –
• Pia Mater
  –
  –
  –
  – Small extension of pia called:

BLOOD-BRAIN BARRIER

• Barrier formed by:

• Prevents:

DISORDERS OF THE MENINGES

• Hydrocephalus
  – Build up of:
  –
  –
• Meningitis
  – Inflammation of:
  –
  –
BRAIN VENTRICLES

- Filled with:
  - Four ventricles
    - 1st and 2nd (Lateral) ventricles
      - Separated anteriorly by:
        - 3rd ventricle
      - Connected to:
    - 4th ventricle
      - Opens into central canal of spinal cord and subarachnoid space via:

SPINAL CORD

- Function
  - Controls:
  - Transmits:

- Structure

SPINAL CORD STRUCTURE

- Filum terminale
- Conus medullaris
  
- Cauda Equina
  
- Denticulate ligaments
  
- Gray Matter
  
  - Forms:
    - Ventral horns
      
      - Contain:
      
      - Exit through:

- SPINAL CORD: GRAY MATTER

- Dorsal horns
  

- Lateral horns
  
  - Contain:
    
    - Also exit through:

- SPINAL CORD STRUCTURE

- Gray commissure
  
  - Connects:

- External fissures
• White matter
  
  
  
• SPINAL CORD TRACTS
• Ascending Tracts
  – Spinothalamic
    
    
    • Info. regarding:
    
    • In:
  
  – Spinocerebellar
    
    
    • Carries info. regarding:
    
    • In:

• Ascending Tracts
  
  – Fasciculus cuneatus & Fasciculus gracilis
    
    
    • Carries info.:

• Descending Tracts
  
  – Corticospinal
    
    
    • Carries info. from:
    
    • All other descending tracts:

SPINAL CORD INJURIES/DISORDERS
• Trauma to spinal cord can cause:
  
  – Polio-
  
  – Amyotropic Lateral Sclerosis (ALS or Lou Gehrig’s disease)-
  
  – Spina bifida-
BLOOD SUPPLY TO THE BRAIN

• Circle of Willis

THE CEREBRUM: REGIONS

• In anterior and middle cranial fossa

• Six pair of lobes
  – Frontal (1)
  – Parietal (2)
  – Occipital (3)
  – Temporal (4)
  – Insula (5)

• Many functions in various regions

THE CEREBRUM: GRAY MATTER

• Cerebral Cortex
  – Gray matter (no tracts)
  – Gray matter also in basal nuclei (ganglia)

THE CEREBRUM: BASAL NUCLEI

• Influence:
• Project to:
• Receive:
• Monitor:
• Regulate:
• Important in:
THE CEREBRUM: GYRI AND SULCI

- Gyri (gyrus)
  - 
- Sulci (sulcus)
  - 
- Fissures
  -

THE CEREBRUM: GYRI

- Gyri
  - Precentral gyrus (1)
  - Postcentral gyrus (2)
  - Superior temporal gyrus (3)
  - Cingulate gyrus (4)

THE CEREBRUM: SULCI

- Sulci
  - Central sulcus (1)
  - Lateral (Sylvia) sulcus or fissure (2)
  - Parieto-occipital sulcus (3)
  - Calcarine sulcus (4)
    - Structures 3 and 4 are seen only at a medial view

THE CEREBRUM: FISSURES

- Fissures
  - Longitudinal fissure (1)
    -
  - Transverse fissure (2)
    -

THE CEREBRUM: WHITE MATTER

- White matter =
• Three types of fibers in cerebral white matter
  – Association fibers
  – Commisural fibers
  – Projection fibers

THE CEREBRUM: WHITE MATTER
• Commissures
  – Regions with commissural fibers

THE CEREBRUM: FUNCTIONS
• Three Functional Types of Areas Within the Cerebrum
  – Sensory Areas
  – Motor Areas
  – Association Areas
• Frontal Lobe
  – Primary Motor Cortex (1)
  – Premotor Area (2)
    • Controls:
− Frontal Eye Field (3)

− Broca’s Area (4)
  • Directs:

− Parietal Lobe
  − Primary Somatosensory Cortex (6)
    • Receives:

  − Sensory Association Area (7)
    • Integrates:
      • Evaluates:

− Occipital Lobe
  − Primary Visual Cortex (8)
    • Surrounds:
      • Interprets:
        • Allows for:

− Temporal Lobe
  − Primary Auditory Cortex (10)
    • Receives:
• Interprets:
  – Auditory Association Area (11)
  –

Posterior Temporal Lobe
  – Wernicke’s Area (12)
  –
  –
  –

• Insula (13)
  –
  –
  –
  –
  – Gustatory cortex
  –
  –
  –

• Limbic System
  – Cingulate gyrus, parahippocampal gyrus and hypothalamus and part of the thalamus
  –
  –
  –
  – Allows:

THE CEREBRUM
• Aphasias
  –
  –
  –
  –
  –
  – Flat EEG =
DIENCEPHALON

- Consists of the Thalamus, Hypothalamus and Epithalamus
  - Thalamus
  - Hypothalamus
    - Initiates:
    - Regulates:
    - Controls:
  - Structures in the region
    - Infundibulum
    - Mammillary bodies
  - Hypothalamus
    - Supraoptic Nucleus
      - Contains:
    - Paraventricular nucleus
      - Contains:
      - Stimulates uterine contractions in labor and milk ejection for nursing
  - Other structures in the region
    - Optic chiasma
    - Pituitary gland (hypophysis)
Diaphragma sellae

- Epithalamus
  - Pineal gland
  - 
  - 
  -

THE MIDBRAIN

- Cerebral Aqueduct
  - Runs through:

- Cerebral peduncles
  - Contain:

- Superior cerebellar peduncles
  - Contain:

- Cranial Nerves:

- Corpora Quadrigemina
  - Four nuclei on the dorsal midbrain
    - Superior colliculi
      - 
      - 
      - Inferior colliculi

THE PONS

- 

- Cranial nerves:

- Middle cerebellar peduncles contain tracts which connect pons to cerebellum
MEDULLA OBLONGATA

- Pyramids
  - Carry:
    - These fibers decussate in the lower medulla =
    - Plays a role as:
      - Contains several visceral motor nuclei
        - Cardiovascular center
        - Respiratory center
        - Other centers
      - Ascending sensory Tract Nuclei
        - Nucleus cuneatus
        - Nucleus gracilis
      - C.N. :
    - Reticular formation
      - Project to:
        - Govern :
        - Filters :
        - Separated by:
• Vermis

• Folia and fissures

• Arbor vitae

THE CEREBELLUM

• Function
  – Processes info. from:
  – Sends output:
  – Makes movements:
  – Uses input from sensory, proprioceptors regarding:

• 3 Cerebellar Peduncles
  – Connect:
    – Superior Cerebellar Peduncle (1)
      •
    – Middle Cerebellar Peduncle (2)
      •
    – Inferior Cerebellar Peduncle (3)
      •

DISEASES AND DISORDERS

• Transient Ischemic Attacks (TIA’s)
  –
  –
  –

• Alzheimer’s Disease
  –
  –
• Parkinson’s Disease
  – Degeneration of:
  –
  – Causes:
  – Ldopa w/ drugs that inhibit dopamine breakdown may delay

• Ataxia
  –
  –

• Cerebrovascular Accidents (Strokes)
  –
  –
  –

• Huntington’s Disease
  –
  –
  –
  –
  – Death w/in 15 yrs.; protein build-up in brain cells causing them to die

PERIPHERAL N.S.: COMPONENTS

• Sensory Division
  – Sensory fibers: (somatic afferents)
  – Sensory fibers: (visceral afferents)

• Motor Division

• Efferent motor fibers: (muscles glands and viscera)
  –
  –
PNS: THE MOTOR DIVISION

• Consists of Two Subdivisions
  – Somatic Nervous System
    • Conduct impulses to:
    • Allows conscious control of:
  – Autonomic Nervous System
    • Regulates:
      • Regulates:
      • Divided into two subdivisions:
        –
        –

Autonomic Nervous System

– Sympathetic System
  •
– Parasympathetic System
  •

Sensory Receptors of the PNS

• Classified by location or type of stimuli detected

• Location
  – Exteroceptors
  – Interoceptors
  – Proprioceptors

• Stimuli Detected
  – Mechanoreceptors
  – Chemoreceptors
Anatomy 2B

- Photoreceptors
- Thermoreceptors
- Nociceptors

Location: Exteroceptors

- Detect:
- Pick up:

Location: Interoceptors (Visceroreceptors)

- Detect:
- Detect:

Location: Proprioceptors

- Respond to:
- In:
- Monitor:

Stimuli Detected: Mechanoreceptors

- 
- 

Stimuli Detected: Chemoreceptors & Photoreceptors

- Chemoreceptors
  - Detect:
  - Examples:
    - 
    - 

- Photoreceptors
  - Detect:
  - Examples:
    - 

Stimuli Detected: Thermoreceptors & Nociceptors

- Thermoreceptors
  - Detect changes in temperature
  - Examples:

- Nociceptors
  - Stimulated by potentially damaging stimuli
  - Examples:
    - Free nerve endings
    - All receptor types function as nociceptors when overstimulated

Receptors

- Examples:
  - Free nerve endings
    - Detect:
  - Merkel’s Discs
    - Detect:
    - Examples:
      - Meissner’s Corpuscles
        - Detect:
        - Examples:
          - Pacinian Corpuscles
            - Detect:
Ruffini’s Corpuscles
  - Detect:

Examples:
  - Muscle spindles
    - Detect:
  - Golgi Tendon Organ
    - Detect:
    - Response:

Pain
  - Pain Receptors
    - Pain receptors (free nerve endings):

Classification
  - Somatic Pain
  - Visceral Pain
    - Results from:
      - Because visceral pain and somatic pain follow the same neural pathway:

Homeostatic Imbalance
  - Phantom limb pain –
    - Now use epidural anesthesia to block pain to spinal cord
Nerve Structure

- Epineurium—
- Perineurium—
- Endoneurium—

Cranial Nerves

(from rostral to caudal)

- C.N. (I) and (II):

- C.N. (III) through (XII):

  - Almost all of the cranial nerves:

  - C.N. (X), Vagus, :

  - Cranial nerves:

  - C.N (III), (VIII), (IX) and (X) contain:

C.N. I: Olfactory Nerves

- Originate in:

- Pass through:

C.N. II: Optic Nerves

- Originate from:

C.N. III: Oculomotor Nerves

- Motor to:

- Parasympathetic fibers to:

- Proprioceptive afferents from:
C.N. IV: Trochlear Nerves

•
  • Motor to:
  • Proprioceptive afferents from:

C.N. V: Trigeminal Nerves

•
  • Three branches
    – Ophthalmic Branch (V₁)
    – Sensory from:

C.N. V: Trigeminal Nerves

• Maxillary Branch (V₂)
  – Sensory from:

C.N. V: Trigeminal Nerves

• Mandibular Branch (V₃)
  – Motor to:
  – Sensory from:

C.N. VI: Abducens Nerves

•
  • Motor to:
  • Proprioceptive afferents from:

C.N. VII: Facial Nerves

•
  • Motor to:
  • Taste from:
  • Parasympathetic innervation of:
C.N. VIII: Vestibulocochlear Nerves

- Two branches
  - Cochlear Branch
    - 
  - Vestibular Branch
    - 

C.N. IX: Glossopharyngeal Nerves

- Motor to:
- Taste from:
- General sensory from:
- Sensory from:
- Parasympathetic innervation to:

C.N. X: Vagus Nerves

- Motor to:
- Sensory from:
- Parasympathetic innervation of:

C.N. XI: Spinal Accessory Nerves

- Motor to:
- Proprioceptive afferents from:
C.N. XII: Hypoglossal Nerves

- Motor to:
  - Proprioceptive afferents back from:

Spinal Nerves

- Transmit: (afferents)
  - Transmit motor info. from: (afferents)
  - Numbered according to:
  - C₁ exits the spinal cord:
  - C₂ through C₇ exit through: (C₈ is above T₁)
  - All of the rest:
  - There is only one small pair of coccygeal nerves (C₀)

Spinal Nerves: Composition

- Each spinal nerve:
  - The Ventral root contains:
  - The Dorsal root contains:
    - Dorsal root ganglion contains:

Spinal Nerve Divisions

- Meningeal branch –
- Rami communicantes (autonomic pathways):
Spinal Nerves: Plexuses

- Plexus
  - Allows:

The Cervical Plexus

- Formed by:
- Most branches form:
  - Innervate:
- Phrenic nerve
  - (receives fibers from C₃–C₅)

The Brachial Plexus

- Formed by:
- Major branches of this plexus:
  - Roots—
  - Trunks—
  - Divisions—
  - Cords—

Brachial Plexus Nerves

- Musculocutaneous
  - (BBC)
- Axillary
  - (Deltoid, teres minor)
- Radial
  - (BEST)
- Median
  - (lateral flexors of wrist & fingers 31/2)
• **Ulnar**
  
  (medial flexors)

• **Pectoral N.**
  
  – Lateral:
  
  – Medial:

• **Thoracodorsal-**
  
  – From:
  
  – Innervates:

• Long thoracic
  
  – From:
  
  – Innerv.: 

• **Subscapular**
  
  – From:
  
  – Innerv.:

• Suprascapular
  
  – From:
  
  – Innerv.:

**The Sacral Plexus**

• Arises from:

• Has about one dozen branches serving the gluteal region, pelvic structures, perineum and lower limbs

**Lumbosacral Nerves**

• **Femoral nerve (from Lumbar plexus)**
  
  – Innerv.:

• **Obturator nerve (from Lumbar plexus)**
  
  – Innerv.:

• Sciatic nerve
  
  –
  
  – Innerv.:
Composed of:
- Pudendal

Nerve Damage
- Sciatica

- Usually the result of:

Brachial Plexus Injuries
- Brachial Plexus Injuries
  - Cause:
    - Median nerve damage
      - Loss of:
    - Ulnar nerve damage
      - Results in:
    - Radial nerve damage
      - Results in:

Reflex Actions

Reflex Arcs

- Neural pathways with 5 components:
  - 1. Receptor
  - 2. Sensory neuron
  - 3. Integration center
  - 4. Motor neuron
Types of Reflexes

• Monosynaptic Reflexes
  – Chain of only 2 neurons involved
    • Example: Patellar reflex (stretch reflex)
      – Quadriceps tendon stretched, muscle spindles send impulse (muscle stretching), spinal cord, motor neuron, quadriceps muscle contracts

• Polysynaptic Reflexes
  – Requires:
  – Example: Withdrawal reflex (crossed extensor reflex)

THE ENDOCRINE SYSTEM

Endocrine System

• Function
  – Regulates:
  – Maintains:
  – Integrates:

Hormones

–

– Some produced by:
  – Some produced by:

• Types of Hormones
  – Amino acid derivatives
    • Simple amines, thyroxin, peptides, and proteins
  – Examples:
• Thyroid hormones, epinephrine and NE, insulin, glucagon

• Steroid hormones
  • Includes:
    • Examples:
      •

• Eicosanoids
  •
    • Are paracrine hormones:
      • Examples:
        •

Hormone Actions

•
  •
  •
  •

Receptors

•
  • Determine:
    • Binding may cause:
      •
      •
      •
      •
      •
Hormone Mechanisms

- Two mechanisms enable hormone/receptor binding to influence cell activity:
  -
  -

- Second messengers
  -
  -
  - Used By:
    - Example:
      -

- Cyclic AMP (cAMP)
  - Formed from:
  - Hormone/receptor binding
    -
    -
    -
    -
  - Effect depends on:

- PIP Mechanism (also for a.a. based hormones)
  -
  - Both act as:
  - IP3 triggers:
    - Ca$^{2+}$ activates:
    - DAG activates:

Direct Activation of Genes

- Steroid hormones and thyroid hormone:
- Bind to:
- Hormone/receptor binding stimulates:
Hormone Regulation

- **Nervous System**
  - Ultimate control of hormone mechanisms belongs to the nervous system

- **Stimulation or inhibition of endocrine glands comes from THREE sources:**
  - Humoral stimuli
  - Other hormones (Hormonal stimuli)
  - Neural stimuli

- **Regulation by Humoral Stimuli**
  - Example:

- **Regulation by Other Hormones**
  - Hormones may stimulate or inhibit the release of other hormones
    - Hypothalamus
      - Pituitary hormones-

- **Regulation by Neural Stimuli**
  - Example:
Feedback Mechanisms

- Negative Feedback System
  -
- Positive feedback system
  -

Hypo or Hypersecretion

- May result in a disorder

Examples:
- Diabetes
- Graves disease
- Addison’s Disease
- Cushing’s disease

Major Endocrine Glands

- Pituitary gland (hypophysis)

- Two major lobes:
  - Anterior lobe (adenohypophysis)
    -
  - Posterior lobe (neurohypophysis)
    -

Posterior Pituitary Gland

- Posterior Lobe
  - Posterior lobe + infundibulum =
  - Neuron axons to pituitary =

- Two hormones released here
- Both produced in nuclei of hypothalamus
- Both secreted into capillaries posterior pituitary for distribution to body
• Supraoptic Nucleus
  – ADH (Vasopressin/Antidiuretic hormone)
    •
    •
    •

• Paraventricular Nucleus
  – Oxytocin
    •
    •

Anterior Pituitary Gland
• Anterior Lobe=
  –
  –
  – Release of hormones is controlled by:

• Hypophyseal Portal System

Nontropic Hormones
• Hormones Secreted
  – Growth Hormone (GH) or Somatotropin
    • Produced in response to:
    • Also secreted in response to:
    • Inhibited by:
    • Stimulates:
    • Hyposcretion results in:
    • Hypersecretion results in:
- Prolactin (PRL)
  - Release stimulated by:
  - Inhibited by:
  - Both are influenced by:
  - Stimulates:

Anterior Pituitary Gland

- The following four anterior pituitary hormones are tropic hormones
  - TSH-
  - FSH, LH-
  - ACTH-

Tropic Hormones

- Hormones Secreted
  - Thyroid Stimulating Hormone (TSH)
    - Stimulates:
    - Release stimulated by:
    - Inhibited by:
  - Adrenocorticotropic Hormone (Corticotropin)
    - Stimulates:
    - Release stimulated by:
    - Inhibited by:
  - Follicle Stimulating Hormone (FSH)
    - Promotes:
  - Luteinizing Hormone (LH)
The Thyroid Gland

- Cuboidal follicle cells produce thyroglobulin
  -
  -

Thyroid Hormone

- Secreted in response to:
- Inhibited by:
- Effects
  - Increases:
  - Increases:
  - Promotes:
  - Promotes:
  - Promotes:
  - Speeds up:
- Hyposecretion
  -
  -
- Hypersecretion
  -

Calcitonin

- Secreted by:
- Released in response to:
The Parathyroid Glands

- Stimulates:
  
  - Secrete parathyroid hormone (PTH)
    - Secreted in:
    - Stimulates:
      
      - Increases:

Parathyroid Hormone

- Hypersecretion
  - Depletes:
    - Depresses:
      
      - Hyposcretion
        
        -

Adrenal (Suprarenal) Glands

- Two glands-
  
  - Cortex produces:
    
    -

Adrenal Cortex

- Three Regions:
  - Zona Glomerulosa
    
    - Production of:
• Regulation of:

Aldosterone

•

• Increases:

• Stimulated:

• Renin secreted by:

• Stimulates:

• Inhibited by:

• Secreted by:

  Zona Fasciculata

  •

  • Secretes:

  • Cortisol

    • Released in response to:

    • Inhibited by:

    • Promotes:

    • Causes a rise in:

Cortisol

  Hypersecretion

  •

  •

  •

  •

  •

  Hyposcretion

  •
Adrenal Cortex

- Zona Reticularis
  - Produces:

Adrenal Medulla

- Chromaffin Cells
  - Secretes:
    - Release stimulated by:

The Pancreas

- Acinar cells
  - Secrete:
    - Islets of Langerhans
      - Contain alpha cells
      - Contain beta cells

Insulin

- Stimulated by:
- Inhibited by:
- Enhances:
- Stimulates:
- Promotes:
• Stimulates:

Glucagon

- Released in response to:

- Promotes:
  - Promotes:
    - Gluconeogenesis:
    - Glycogenolysis:

Diabetes
• Diabetes Insipidus (non insulin related)
  - Caused by:

Diabetes Mellitus
  - Results from:

Diabetes
• Diabetes Mellitus
  - Two types:
    - Type 1 (Juvenile Onset)

    - Type 2 (Adult Onset)
Influenced by:

Diabetes

- Lack of:
  -
  -
  -
  -
  -
  -
  -
  -

- Symptoms
  - Polyuria
    -
  - Polydipsia
    -
  - Polyphagia
    -

The Pineal Gland

- Secretes:
  -
  -

The Thymus Gland

- Shrinks:
  - Produces:
  - Aids in:

The Gonads

- Produce gametes and reproductive hormones
  -
Estrogens and progesterone in females

- Estrogens cause:
- With progesterone, promote:

**THE CIRCULATORY SYSTEM**

- Blood: Function
- Transport
- Protection
- Regulation
Physical Characteristics

- Color
- pH
- Average Volume
- Viscosity

Blood: Components

- Blood
  - Plasma
  - Erythrocytes
  - Leukocytes
  - Platelets
- Hematocrit

Composition of Plasma

- 92% water
- Proteins (8%
- Clotting proteins:
• Nutrients
  -

• Wastes
  - Urea -
  - uric acid
  - Creatinine-

• Electrolytes
  -

• Gases
  -

• Hormones

• SERUM =

Plasma Proteins

• Albumins
  -

• Globulins
  - Alpha and beta (produced by liver)
    -
  - Gamma
    -
  - Fibrinogen (produced by liver)
    -
Formed Elements: Erythrocytes

- **Function**
  
- **Structure**
  
  - 250-280 million hemoglobin molecules/RBC X 4 O2 binding sites =

**Hemoglobin**

- **Composed of**
  
- **Binds:**
- May also bind to:
  
- **Forms:**
  - Releases O2 in tissues
  - CO2 may bind to globin
Erythrocyte Production: Erythropoiesis

- Stimulated by:
- Formed elements:
  - Hemocytoblast = stem cell
  - Reticulocytes enter circulation
  - Reticulocyte counts:
  - Over 2 million RBC’s produced/sec.
- Iron and B vitamins necessary;
- Kidney cell hypoxia =
- Accelerated RBC production triggered by:
  - Testosterone:

Erythrocytes Destruction

- RBC Life span:
- Old RBCs:
  - Hemoglobin
  - Globin
The iron of the heme group

Remainder becomes:

Bilirubin:

Erythrocyte Disorders

- Anemias
  - Accompanied by:
  - Causes:
  - 1. Reduced number of RC’s
    - Blood loss, RC destruction, bone marrow failure
    - Three types:
      - Hemorrhagic anemia-
      - Hemolytic anemia-
      - Aplastic anemia-(abnormalities in marrow)-
  - Anemias
    - Causes of anemia (continued):
    - 2. decreased hemoglobin
      - Athletes anemia-
      - Pernicious anemia (B₁₂ deficiency)
        - Intrinsic factor-
  - Anemias
    - Causes of anemia (continued):
    - 3. Abnormal hemoglobin
      - Thalassemias
      - Genetic-
• **Sickle cell anemia**
  
  – Genetic-

  – RBC’s collapse/sickle-shaped -

• **Polycythemia**
  
  – Dizziness, high RBC count (hematocrit may be 80%), viscous blood, impaired circulation

  •

  •

  • Treated by-

**Leukocytes**

•

•

• Protect body from:

• Use:

•

**Granulocytes**

• **Neutrophils (50-70% of WBC’s)**
  
  –

  –

  –

  –

• **Eosinophils (2-4% of WBC’s)**
  
  –

  – granules filled with:

  –

  –
Lecture Notes

- Basophils (0.5-1% of WBC’s)
  
  -

- Agranulocytes
  
  • Lymphocytes (25% of WBC’s)
    -
    - Increase during viral infection
      
      
    •

  • Monocytes (3-8% of WBC’s)
    -
    - Phagocytosis of:

Leukocyte disorders

• Leukocytosis
  
  -

• Leukopenia
  
  -
  
  -

• Leukemias – all fatal if untreated
  - Cancer:
    - Rapidly dividing WBC’s, unspecialized, nonfunctional
      
      -

• Mononucleosis
  
  -
  
  -
Symptoms include:

Differential White Blood Cell Count:

Platelets

- Fragments of:
  -
  -
- Life span:
- Normal =

Hemostasis

- =

Stages of Hemostasis

1. Vascular spasm – reduces blood loss
   -
   -

2. Platelet plug formation
   -
   -
   - Platelets release chemicals (serotonin, ADP, thromboxane) to:

3. Coagulation (blood clotting)
   - Begins:
   -
   -

Steps of coagulation

- Damaged tissue activation of many procoagulants factor X activated forms a complex with PF3 factor V and calcium ions becomes prothrombin activator
- Prothrombin converted to enzyme thrombin fibrinogen forms fibrin mesh platelets stick to mesh and plasma becomes gel-like
Clotting and Bleeding Disorders

- Hemophilia
  - ↑
  - →

- Thrombocytopenia
  - ↓

- Thrombus
  - Clot develops in unbroken vessel

- Embolus
  - Traveling thrombus

ABO Blood Groups

- Protein antigens on RBC plasma membrane:
  -
  - (agglutinogens)

- Antibodies:

- Results in:
Lecture Notes

• Universal Donor

• Universal Recipient

Rh Blood Groups

• Anti-Rh antibodies not spontaneously formed in Rh− individuals

• Second exposure to Rh+ blood:

Erythroblastosis fetalis

• Rh+ fetus/Rh- mother

• Second pregnancy

THE CIRCULATORY SYSTEM: BLOOD VESSELS

Blood Vessels: Arteries

• Arteries

• Three groups:
  • Elastic Arteries
Aorta, pulmonary trunk, common iliac arteries

- Muscular Arteries
  
- Active in:
  
- Examples:

  Femoral, brachial, axillary arteries

- Arterioles

Blood Vessels: Veins

Other Vessels

- Capillaries

- Sinusoids
Anatomy 2B

• Anastomoses

Structure of Blood Vessels

• Capillaries

• Arteries and Veins
  – Three tunics
    •
    •
    •
  – Vasa vasorum
    •

Blood Pressure

• mm Hg pressure in:
  • Measured with a sphygmomanometer

  – Systolic pressure:
  – Diastolic pressure:
  – Pulse pressure = systolic –

Influences on B.P.

• Blood Pressure varies directly with the following:
  – Cardiac Output
    •
    •
  – Peripheral Resistance
    • Opposition to blood flow
• Blood Pressure varies directly with the following:
  – Blood Volume
    • Mainly regulated by kidneys
      • ↑
      • ↓

Short Term Regulation of B.P.

• By:
• Nervous System Regulation:
  – Sympathetic nerve fibers
    • Vasomotor center in medulla
      –

  »
  – Controls:
    – Controls:
  – Baroreceptors
    •
    •
    • Stretching ➔
    • Vasomotor center inhibited ➔
  – Chemoreceptors
    • Monitor:
    •
    •
    • Vasoconstriction ➔
Chemical Regulation of B.P.

- **Epinephrine and Norepinephrine**
  -
  - ↑

- **ANF (Atrial Natriuretic Peptide or hormone)**
  -
  - ↓

- **ADH (Antidiuretic Hormone)**
  - Stimulates:
    -
    - ↑

- **Renin**
  - Released from:
  - Stimulates:
  - Kidneys reabsorb:

- **Renin/Angiotensin/Aldosterone System**

Renal Regulation of B.P.

- **Kidneys may alter B.P. directly**
  -
  - ↓

- **Kidneys may alter B.P. indirectly**
  - Renin angiotensin system activated with:
  - Vasoconstriction, water reabsorption due to:
    - ↑
Disorders

• Hypotension
  —
  — Aging, poor nutrition, anemia, hypothyroidism, Addison’s disease, low blood protein levels or circulatory shock w/ acute hypotension

• Hypertension
  —
  —
  — Higher risk with
    •
    •
    •
    •
    •
    •
  • Circulatory shock
    — Not enough blood to fill the vessels and circulate normally
      • Hypovolemic shock
      —
      » Diarrhea, vomiting, hemorrhage, burns
      —

Heart Location & Anatomy

• Location:
  —

• Base
  —
Apex

- Deep two-layered serous pericardium
  - Parietal layer lines:
  - Visceral layer (epicardium) on:
    - Two layers separated by:

- Superficial fibrous pericardium

The Heart Wall

- Three Layers
  - Endocardium-
  - Myocardium-
  - Epicardium-

Heart Chambers: Atria

- Two superior atria separated by:
  - Each atrium:

Heart Chambers: Ventricles

- Two inferior chambers separated by:

Pulmonary and Systemic Circulation

- Right side receives oxygen-poor blood from tissues

- Left side receives oxygenated blood from lungs
Coronary Circulation

- Arteries arise from:
  - Left coronary artery branches → Supplies:
  - Right coronary artery branches → Supplies:
- Cardiac veins:
- Coronary sinus empties into:
- Great cardiac vein of:
- Middle cardiac vein in:
- Small cardiac vein from:
- Several anterior cardiac veins empty directly into:

Cardiac Histology

- Cardiac muscle cells

Cardiac Conduction System

- Nodal System
• **Sinoatrial (SA) Node**
  
  • Near:
    • **Depolarizes:**

• **Atrioventricular (AV) Node**
  
  • Above:
    • **Depolarizes:**
    • Passes impulse on to:

• **Bundle of His (AV Bundle)**
  
  • Conducts impulse to:

• **Bundle Branches**
  
  • Branch into:
    • **Depolarizes:**

• **Purkinje Fibers**
  
  • Cardiac Conduction System Summary
Extrinsic Innervation of the Heart

- Autonomic Nervous System
  - Stimulation by sympathetic neurons (cardioacceleratory center in medulla)
  - Inhibition by parasympathetic neurons (cardioinhibitory center in medulla)
    - Via:

Cardiac Cycle

- Interval from:

- Consists of Two Phases:
  - Systole phase-
  - Diastole phase-

- Systole Phase
  - Atrial Systole (0.1sec.)
  - Ventricular Systole (0.3sec.)
• Diastole Phase
  – Ventricular Diastole
  – ECG Readings
    – Heart block
    – Arrhythmias - irregular heart rhythms
    – Fibrillation

Heart Sounds
• Two sounds (lub-dub)
  –
  –
• Pause
  –
  –
• 0.8 sec. total=
Cardiac Output (CO)

- Sympathetic stimulation needed if:
  - Starlings Law

Heart Rate Regulation: Nervous System

- Cardiac Inhibitory Center

- Cardiac Acceleratory Center

Other Regulators

- Hormonal Regulation
  - Accelerators
    -
  - Body Temperature
    - Increase temp. =
    - Decrease temp. =
  - Baroreceptors
    - Carotid Sinus and Aortic Arch
      - Stretch→
Bainbridge (Atrial) Baroreceptors

• Measure intraatrial pressure

Disorders

• Tachycardia
• Bradycardia
• Myocardial Infarction
• Arrhythmia
• Fibrillation
• Angina Pectoris
• Pericarditis
• Congestive heart failure
• Atherosclerosis
• Ischemic Heart Disease

• Heart Murmur