BIO 220 Human Anatomy & Physiology
The Brain: Brainstem and Diencephalon

Review LAB 10: The Brain and Cranial nerves. You are responsible for knowing the parts of the brain listed in the lab handout and you must be able to describe the function of each. You will find that Table 14.2 of your text and the study outline/review questions at the end of the chapter will be very helpful!!!! This is a long handout—most of it can be completed on your own by using/studying your text book and information from lab. Diagrams are a very important learning tool.

I. Major divisions of the brain—Overview. List and describe the major divisions and subdivisions of the brain. See Figure 14.1 and Table 14.2.

1. **Brain stem** (medulla oblongata, pons, midbrain, and reticular formation)

2. **Diencephalon** (thalamus, hypothalamus, pineal and subthalamic nuclei)

3. **Cerebellum** (this will be covered on a separate handout)

4. **Cerebrum** (this will be covered on a separate handout/s)

II. Major divisions of the brain—Detail See Figure 14.1 and Table 14.2

A. **Brainstem**: What are the major divisions of the brain stem? See above and they are discussed in detail below.

1. **Brainstem: Medulla oblongata**
   a. Location
   b. *Associated structures of the medulla oblongata*
      1) Ascending and descending tracts
      2) Pyramids (Fig. 14.6)
         - On anterior side of medulla
         - Large motor tracts
         - Decussation of pyramids
         - Lateral corticospinal tracts are the main motor fibers that undergo decussation. What is the significance to motor function? See p.562, Fig. 16.8 for right anterior and left lateral corticospinal tract. Note: this is just to give you a visual—don’t stress over this diagram.

   Relate this to **spastic and flaccid paralysis** (see page 560) and **ALS** (page 562). 
   *Do this on your own—you’ll need more paper for this.*

   **Think about this:** What would happen to motor function if the spinal cord were cut on one side (lateral hemisection) compared to damage to one side of the medulla in the area of the lateral corticospinal tracts/nuclei? Compare hemisection to complete transection. What would be the sensory loss in either condition? See text pages 467-468 and spinal cord notes (pathways) from lab and lecture.

Revised Fall 2005——some important changes were made to this handout.
3) **Nuclei in the medulla oblongata:** group of cell bodies in CNS
   a) Nucleus vs. ganglion?
   b) Function of nuclei of medulla oblongata
   c) **Nuclei on posterior side of medulla oblongata** (sensory or motor?)
      - Nucleus gracilis (from fasciculus gracilis of spinal cord) and nucleus cuneatus (from fasciculus cuneatus of spinal cord)
        --Stereognosis
        --Touch, proprioception, vibration, weight discrimination
      - Does sensory information cross? What is the significance to sensory function? (Think)
      - Where does this sensory go from here—to what part of the brain first (____________) then (perhaps) on to the ________ ____________ of the cerebrum (if it is allowed through).

   d) **Nuclei for cranial nerves in medulla oblongata** (practice naming these and review their specific functions). Refer to LAB 10.
      - VIII (Cochlear and Vestibular branches)=
      - IX=
      - X=
      - XI=
      - XII=

   e) **Vital reflex centers in medulla oblongata** (describe each)
      - Cardiovascular center—heart rate and force of contraction
      - Medullary rhythmicity area—basic rhythm of breathing

   f) **Nonvital centers of medulla oblongata**—regulate reflexes for swallowing, vomiting, coughing, hiccups, sneezing
The Brain: Brainstem and Diencephalon

g) Injury to the medulla oblongata:

- Examples: Whiplash (describe) or blow to base of the skull or upper neck.

- Fatal injuries due to damage to vital reflex centers, especially when damage occurs to the __________________ center.

- Nonfatal injuries
  1) Cranial nerve malfunction on (same, opposite?) side
  2) Paralysis on (same, opposite?) side
  3) Loss of sensation on (same, opposite?) side
  4) Respiratory regulation

2. Brainstem: Pons Varolii

a. Location of pons varolii

b. Functions of pons varolii: (“Bridge” connects what?)

   - Peduncles
   - Transverse axons
   - Longitudinal axons

c. Associated structures of pons varolii

   1) White matter vs. gray matter (and how does it compare with medulla?)

   2) Nuclei for cranial nerves in pons varolii: Review names & functions from Lab 10.

      V=
      --3 branches—end in pons
      * ophthalmic branch of trigeminal nerve
      * maxillary branch of trigeminal nerve
      * mandibular branch of trigeminal nerve
      --motor functions (part of mandibular branch):
      --sensory functions:
      --trigeminal neuralgia (tic douloureux)

      VI=

      VII=
      --motor branches and functions
      --sensory function
      --Bell’s Palsy

      VIII (nucleus for cochlear branch only)=

Revised Fall 2005—some important changes were made to this handout.
3) Respiratory centers (nuclei) in *pons varolii*
   - Pneumotaxic center
   - Apneustic center

3. **Brainstem: Midbrain** (Fig. 14.7)
   a. Location of *midbrain*
   b. Functions of *midbrain*
   c. Associated structures of *midbrain:*
      1) Cerebral aqueduct (Aqueduct of Sylvius)
         - What would be found here?
         - Function
      2) Cerebral peduncles
         - Carry motor impulses from/to
         - Send sensory impulses from/to
      3) Corpora quadrigemina
         - Superior colliculi
         - Inferior colliculi
      4) Nuclei
         - Substantia nigra (more with basal ganglia) controls subconscious muscle movement (make connection with Parkinson’s later)
         - Red nucleus—maintains posture
      5) Nuclei for Cranial Nerves (review names and functions)
         - III
         - IV
      6) Medial lemniscus (posterior column medial lemniscus pathway (see Fig 16.5 on page 557)
         - part of medulla, pons, and midbrain
         - band of *white fiber projection tracts* that relay impulses for fine touch, pressure, vibration, and proprioception from medulla to thalamus
         - relationship between posterior column and medial lemniscus pathway to the cortex?
         - Is it motor or sensory? Does it go through the thalamus? Why?
         - Relate this to the antereolateral (spinothalamic) pathway.

Revised Fall 2005—*some important changes were made to this handout.*
4. **Brainstem: Reticular Formation and Reticular Activating System (RAS)**
   a. Describe the *reticular formation*: It is made up of areas of gray matter and white matter. It helps maintain consciousness, causes awakening from sleep, and helps regulate muscle tone.
   b. What is the **RAS** *(reticular activating system)*? Refer to Fig. 16.10 p. 566 and read associated material on pages 564-567.
      1) What does it connect to?
      2) Sensory and motor functions?
   c. Relationship of RAS to cerebral cortex and wakefulness (consciousness) and sleep (see pages 564-567).
      • Arousal: activation of RAS via nocioceptors, touch, pressure, light, sound, vs. smell)
      • Why is smell different and what implication does this have for your safety (hint: why MUST you insist that you have smoke detectors in your house? Ask for one or give them for Christmas presents!)
      • Level of cortical activity
      • Wakefulness: increased cortical activity
      • Sleep: decreased cortical activity
      • Coma?

B. **Diencephalon**

1. **Diencephalon: Thalamus**
   a. Location and description of the *thalamus*
      1) Intermediate mass
      2) Forms lateral walls of the
   b. Why are there so many nuclei labeled on the diagram of the *thalamus*?
      See Fig. 14.9.
   c. Functions of the *thalamus*
      1) *Sensory—relay station* for all sensory impulses except for sensations for __________ cranial nerve ________________
         a) Hearing
         b) Vision
         c) General sensations and taste (touch, pressure, vibration, heat, cold, and pain)
      2) *Sensory—interpretation center* (crude awareness—)
         a) Pain
         b) Touch (not 2 point discrimination—where does discrimination between 2 points occur?)
         c) Temperature
         d) Pressure

Revised Fall 2005—some important changes were made to this handout.
2. **Diencephalon—Hypothalamus** *(Read pages 490-491—important)*
   a. Location and description of the hypothalamus (Fig. 14.10)

   b. The hypothalamus contains at least 12 nuclei—see Fig. 14.10—You do NOT need to know the 4 major regions or the names of the nuclei. They give you a visual impression (impact!) You do need to know that it is a MAJOR control center and a major regulator of homeostasis!!!

   c. Functions of hypothalamus (in detail)
   1) Regulation of homeostasis
      a) Temperature
      b) Osmotic pressure (ADH, Renin-Angiotensin Pathway)

   2) Intermediary between nervous system and endocrine (pituitary)
      a) What connects it (____________________) and what protects it (______)?
      b) Neurosecretory cells produce what 2 hormones then store them in the posterior pituitary?
      c) Produces regulating hormones (RH)—they regulate hormones produced by the anterior pituitary.

   3) Controls Autonomic Nervous System (ANS)—give some examples (review what you know about ANS)
      a) Parasympathetic = “Rest Repose”
      b) Sympathetic = “Flight or Flight” (stress)

   4) Regulates eating and drinking
      a) Satiety and hunger centers
      b) Thirst centers (refer back to osmoreceptors and osmotic pressure)

   5) Regulates emotions and behavior patterns
      a) Pleasure center and anger center—part of limbic system (see below)
      b) Sexual arousal

   6) Relay station for smell
      a) Mammillary bodies—relay station for smell via CNI Olfactory
      b) Cranial Nerve I-Olfactory
      c) Has close connection with limbic system (see below)

   7) Regulates circadian rhythms (daily sleep-wake patterns) and states of consciousness in conjunction with photoreceptors of retina, and the pineal gland of the epithalamus (melatonin), and the RAS.
8) **Limbic System:** (p. 495-496 and Fig. 14.14.) *You do NOT have to learn all these structures—just get an idea that these areas are in a number of different parts of the brain and are made up of neurons and lots of nuclei.*

1) Consists mainly of gray matter arranged in a specific pattern and is interconnected through several areas of the brain (not just the hypothalamus—though this is a very important part of the limbic system)

2) “Emotional brain”—has connections with the hypothalamus, thalamus, and cerebral cortex (common integrative areas and somatosensory association areas—more on this later)

3) Integrates pleasure, pain, affection, anger, and rage responses—governs the emotional aspects of behavior. Has very important relationship to sexual behavior, memory, and learning.

4) *Hippocampus*—one area of the limbic system in the temporal lobe plays a very important role in memory storage—putting something into long term memory. If damaged can’t put anything into long term memory and can’t remember recent past.

5) What is the relationship to memory? *You might find it interesting to read Learning and Memory on pages 567-568 NOW.* It will help you remember this information. Note and define/describe these terms: *(more space needed)*

- Learning
- Memory
- Immediate memory
- Short-term memory
- Long-term memory
- Memory consolidation
- Amnesia (anterograde and retrograde)
- Long term potentiation
- List anatomical changes that occur in neurons when they are stimulated and when learning and, hopefully, memory are taking place.

*I know you’ll be interested in hearing more about this later with the cerebral cortex in lecture. In the meantime, don’t forget to turn the page.*
3. **Diencephalon—Pineal Gland (Epithalamus)** We will mainly consider the Pineal Gland here (see pages 650-651) and its role in our circadian rhythms and mood.
   a. Location of pineal gland

   b. General functions of the pineal gland: Produces melatonin and regulates the day/night circadian rhythm (and you’ll see many more connections)

   c. What is meant by “circadian rhythm” and “biological clock”?

   d. There are 3 components to this “biological clock”:
      1) the genetic mechanism of the clock regulates specific gene expression (yes, you have a specific genetic makeup that at least partially controls your day/night cycle—but YOU can alter your genetic expression).

      2) the timekeeping machinery of the clock includes the pineal gland, related hormones *(melatonin, serotonin, S-Adenosylmethionine [SAMe]), amino acids (tryptophan, methionine, tyrosine)* and nervous system input (ANS, sympathetic fibers, and norepinephrine [NE] and epinephrine).

      3) receptors collect input from the outside world to set the clock: your eyes and other sensory systems receive information about environmental (e.g. day-length), physical (e.g. artificial light, clocks), psychological factors (e.g. stressors, depression, mental state, social adjustment) and social factors (e.g. travel and jetlag, work schedule, and other social factors).

   e. **Sleep** is very important for many body functions. It allows a person to achieve peak performance; it improves attention and learning, and it is vital for restoring body functions. It influences mood and is especially important for healing and maintaining a healthy immune system.

   f. **Neurotransmitters and hormones**: Their sources, actions and associated mimicking, helping and inhibiting medications (not all are directly associated with the pineal gland and sleep, but notice the close interrelationship between mental status, mood, sleep and these neurotransmitters and related medications):

      1) Biogenic amines *(norepinephrine [NE], epinephrine, dopamine [DA], serotonin, and SAMe)* are produced from amino acids (see p. 409 and previous notes).
2) *NE*, **epinephrine**, and **DA** are catecholamines and catecholamines are synthesized from the amino acid tyrosine. Remember tyrosine and synthesis of **melatonin** and also its role in PKU? It’s an important amino acid.

3) **NE** and **epinephrine** are associated with wakefulness and ability to focus attention. Medications that increase **NE** improve ability to focus on a task. **Strattera**, a new medication for ADHD (attention deficit hyperactivity disorder), inhibits **NE** reuptake.

4) **DA** stimulates pleasure emotions via the hypothalamus and limbic system and **DA** is also important for regulating skeletal muscle tone (Read about Parkinson’s Disease-PD on p. 521 in DETAIL). **DA** reuptake inhibitors (**Wellbutrin** and **Zyban**) are used to reduce addictive behaviors such as smoking.

5) **Serotonin** is produced from the amino acid, tryptophan. Is tryptophan an essential or nonessential amino acid? Remember what this means? **Serotonin** is important for **melatonin** synthesis and sleep, for regulating mood, and for sensory perception and temperature regulation. What’s the possible **milk connection**? It is at its highest levels in the daytime.

6) **Effexor** is an antidepressant that inhibits **NE**, **serotonin**, and **dopamine** reuptake.

7) Indications for **SSRIs** (selective serotonin reuptake inhibitors such as **Paxil**, **Celexa**, **Prozac**, and **Zoloft**) may be depression, social anxiety disorder, obsessive compulsive disorder (OCD), panic disorder, bulimia nervosa, premenstrual dysphoric disorder (PMDD commonly known as PMS), or post-traumatic stress disorder (PTSD).

8) **SAMe** is produced from methionine (an essential amino acid) and adenosine. It is **melatonin**’s daytime counterpart—it is produced in the **daytime** and peaks in the daytime. It acts as a cofactor with serotonin to make melatonin.

9) **Melatonin** is produced from the combination of **SAMe** and **serotonin**. It regulates our sleep cycle during **the night**. There will be 10 times more melatonin in the brain at night than in the day. When exposed to bright light, there will be a sharp drop in melatonin levels.
4. **Diencephalon:** Describe the day/night cycle and its relationship to the pineal gland, melatonin, norepinephrine, serotonin, and SAMe. How are these related to Seasonal Affective Disorder (SAD) and depression? Note: this is one explanation. References will vary the details in their explanations so just understand the basic ideas presented here and how your diet, stress level, brain chemicals and sleep patterns may affect your mood and general feeling of wellbeing.

![Diagram showing the interaction between tryptophan, serotonin, and melatonin](image)

Light enters the eye and photoreceptor cells are activated (some believe there are other receptors throughout the body sensitive to specific wavelengths of light). Impulses travel to the hypothalamus and on to various parts of the body, including the pineal. The pineal indirectly detects the level of light and responds accordingly.

**Darkness/Night:**
- Less light enters
- *NE* binds to β receptors in the pineal gland.
- *Melatonin* levels rise and serotonin and *SAMe* levels decrease as the pineal gland uses the daytime stores of *SAMe* and serotonin to make melatonin.
- The person becomes sleepy. High melatonin levels are associated with sleepiness.
- When *SAMe* levels taper off and no more melatonin can be made, then *SAMe* and serotonin levels start to rebuild.

**Light/Day:**
- Serotonin and *SAMe* levels are made from specific amino acids and are in highest concentrations during the middle of the day.
- Melatonin is in very small quantities or not present at all.
- Low melatonin levels and high levels of serotonin and *SAMe* are associated with higher levels of alertness.
- An “early morning” person’s circadian rhythm shifts to the left so that melatonin levels and sleep induction begin earlier in the evening while serotonin and *SAMe* levels and alertness begin rising earlier in the morning.
- A “late night” person’s (many college students’) circadian rhythm shifts to the right so that serotonin and *SAMe* and wakefulness lasts longer into the evening and melatonin levels and sleepiness are pushed to later in the night and into the morning or even into the daytime. Refer to graphs on next page.

Don’t let these graphs stress you…they’re just interesting and may be helpful.
The two graphs above show the cycles of the main molecular factors that regulate the mammalian sleep circadian rhythm. Level of alertness, depicted on the left with a thick green dashed line, and sleepiness is depicted on the right with a thin blue dashed line. Melatonin, serotonin, and SAMe lines are the same in both graphs. Melatonin is speckled orange, serotonin is thick black, and SAMe is thick purple.

From: http://dubinserver.colorado.edu/prj/jph/braincircadian.htm. This link and the links given above are no longer functional.

5. **Seasonal Affective Disorder (SAD):** Answer the following questions based on the information given above and in lecture.

1. What causes SAD?

2. What is the connection between serotonin and melatonin here?

3. Decreased levels of serotonin are associated with ________________

4. Why do depressed people frequently have sleep disorders (or why are people with sleep disorders frequently depressed?). What role does stress play? Why are people with PD frequently depressed?

5. Explain why bright-light therapy or SSRI type antidepressants might be beneficial.

6. What’s the relationship between jetlag and melatonin? What about shift workers?
6. Heart patients, beta blockers and depression:

And here’s a question to ponder: Heart patients are often given beta blockers (this means they block β receptors). Why do many heart patients on beta blockers suffer from depression? You might be interested in one study that showed that people who suffered a heart attack and were treated with the conventional therapy (including a beta blocker) and an antidepressant lived longer than people who were treated with conventional therapy (and a beta blocker) and no antidepressant.

Think about this. Just how important is the mind and our “attitude” to our well-being (our health)?