Chapter Two

The Anatomy and Evolution of the Nervous System
Anatomical Directions

• Rostral or anterior
  – Head end of four legged animal

• Caudal or posterior
  – Tail end of four legged animal

• Inferior or ventral
  – Towards the belly

• Superior or dorsal
  – Towards the back
Figure 2.1 Anatomical Directions
Planes of Section

- Coronal (front to back view)
- Sagittal (side view)
- Horizontal (top to bottom view)
Figure 2.2 Planes of Section
Protecting and Supplying the Nervous System

• **Meninges**
  – Three layers of meninges provide protection
  – Dura Mater – connected to the skull itself
  – Arachnoid (and sub) layer – tweener for circulation
  – Pia Mater – connected to the brain itself

• **Cerebrospinal Fluid**
  – Secreted in hollow spaces in the brain known as ventricles
  – Circulates through ventricles, subarachnoid space, and central canal of the spinal cord. Cushions & floats the brain

• **Blood Supply**
  – Brain receives nutrients through the carotid arteries and vertebral arteries
Figure 2.3 The Skull and Three Layers of Membrane Protect the Brain
Figure 2.5 Cerebrospinal Fluid Circulates Through the Ventricles, Spinal Cord and Subarachnoid Space
Figure 2.7 The Brain Has a Generous Supply of Blood
Figure 2.8 The Organization of the Nervous System
The Central Nervous System

• The Spinal Cord
  – Extends from medulla to the first lumbar vertebra
  – From top down: cervical, thoracic, lumbar, sacral, coccygeal

• The Hindbrain
  – The myelencephalon (Medulla) handles heart rate and respiration
  – The metencephalon (Pons and Cerebellum)

• The Reticular formation – runs through both hind and mid brain areas – helps with sleep & arousal

• The Midbrain
  – The Periaqueductal Gray allows us to experience pain
Figure 2.9 The Anatomy of the Spinal Cord
Figure 2.10 Structures of the Brain Stem
Table 2.1 Some Important Structures of the Brainstem

<table>
<thead>
<tr>
<th>Brainstem Location</th>
<th>Important Structures</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medulla</td>
<td>Reticular formation&lt;br&gt;Cranial nerve nuclei</td>
<td>Arousal&lt;br&gt;Various</td>
</tr>
<tr>
<td>Pons</td>
<td>Reticular formation (continuing)&lt;br&gt;Cranial nerve nuclei&lt;br&gt;Cochlear nucleus&lt;br&gt;Vestibular nucleus&lt;br&gt;Raphe nucleus&lt;br&gt;Locus coeruleus</td>
<td>Arousal&lt;br&gt;Various&lt;br&gt;Audition&lt;br&gt;Balance, position&lt;br&gt;Sleep and arousal&lt;br&gt;Sleep and arousal</td>
</tr>
<tr>
<td>Cerebellum</td>
<td></td>
<td>Balance, motor coordination, cognition</td>
</tr>
<tr>
<td>Midbrain</td>
<td>Reticular formation (continuing)&lt;br&gt;Cranial nerve nuclei&lt;br&gt;Periaqueductal gray&lt;br&gt;Red nucleus&lt;br&gt;Substantia nigra&lt;br&gt;Superior colliculi&lt;br&gt;Inferior colliculi</td>
<td>Arousal&lt;br&gt;Various&lt;br&gt;Pain&lt;br&gt;Motor&lt;br&gt;Motor&lt;br&gt;Vision&lt;br&gt;Audition</td>
</tr>
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Figure 2.11 The Internal Structure of the Midbrain
The Central Nervous System

• The Forebrain

• The Thalamus — filters sensory info + consciousness

• The Hypothalamus — manages temperature control, hunger, thirst, and sex

• The Basal Ganglia — helps manage our motor systems

• The Limbic System

• The Amygdala — participates in processing emotions, particularly fear and aggressive impulses

• The Hippocampus — a key player in memory & learning

• The Cingulate Cortex

  • Anterior — manages decisions, anticipation of rewards, social pain
  • Posterior — influences eye movements, spatial orientation & memory
Figure 2.12 The Thalamus and Hypothalamus of the Diencephalon
Figure 2.13 The Basal Ganglia Are Located Deep Within the Cerebral Hemispheres
Figure 2.14 The Limbic System Participates in Learning and Emotion
# Table 2.2 Structures of The Limbic System

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hippocampus</td>
<td>Declarative memory formation</td>
</tr>
<tr>
<td>Amygdala</td>
<td>Fear, aggression, memory</td>
</tr>
<tr>
<td>Hypothalamus</td>
<td>Aggression; regulation of hunger, thirst, sex, temperature, circadian rhythms, hormones</td>
</tr>
<tr>
<td>Anterior cingulate cortex</td>
<td>Decision making, error detection, emotion, anticipation of reward, pain, and empathy</td>
</tr>
<tr>
<td>Posterior cingulate cortex</td>
<td>Eye movements, spatial orientation, and memory</td>
</tr>
<tr>
<td>Septal area</td>
<td>Reward</td>
</tr>
<tr>
<td>Olfactory bulbs</td>
<td>Olfaction (smell)</td>
</tr>
<tr>
<td>Parahippocampal gyrus</td>
<td>Memory</td>
</tr>
<tr>
<td>Mammillary bodies</td>
<td>Part of the hypothalamus; memory</td>
</tr>
<tr>
<td>Fornix</td>
<td>Connects the hippocampus to mammillary bodies and other parts of the brain</td>
</tr>
</tbody>
</table>
Figure 2.16 Comparative Convolutions of the Cortex

- Rat
- Sheep
- Human

- Cerebral cortex
- Sulci
- Gyrus
- Fissure

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The Cortex - from Anterior to Posterior

• The Frontal Lobes – memory, emotions, and more
• The Primary Motor Cortex – self explanatory?
• The Central Sulcus – mind the gap?
• The Somatosensory Cortex – self explanatory?
• The Temporal Lobes – the primary auditory cortex
• The Parietal Lobes – some language & memory
• The Occipital Lobes – the primary visual cortex
• Association areas integrate sensory and motor
• Corpus Callosum & Anterior Commissure connect the two halves (hemispheres)
Figure 2.19 The Lobes of the Cerebral Cortex
Figure 2.20 The Corpus Callosum and the Anterior Commissure
The Peripheral Nervous System

• The Cranial Nerves
  – Enter and exit the brain directly to serve the region of the head and neck

• The Spinal Nerves
  – 31 pairs of spinal nerves exit the spinal cord to provide sensory and motor pathways to the torso, arms, and legs
  – Mixed nerves contain an afferent or sensory nerve, and efferent or motor nerve
  – Some are coated in myelin (for speed), others not so much

• The Autonomic Nervous System
  – Manages the vital functions of the body without conscious effort or awareness
Figure 2.22 The 12 Pairs of Cranial Nerves
Figure 2.23 The Structure of the Spinal Cord
The Autonomic Nervous System

• The Sympathetic Nervous System
  – Fight-or-flight system
  – Increased H.R. and B.P., decreased digestion processes and circulation to the skin’s surface & peripheral parts

• The Parasympathetic Nervous System
  – Provides rest, repair, and energy storage
  – Systems seem opposed, but both used in sex

• Central Control of the Autonomic Nervous System
  – Primarily the Hypothalamus, with a little help from the midbrain tegmentum, and reticular formation
Figure 2.24 The Autonomic Nervous System
Evolution of the Human Brain & Nervous System

• Natural Selection and Evolution
  – Natural selection = survival of the most fit
  – Evolution = decent from a common ancestor

• Evolution of the Nervous System
  – Fairly recent development
  – Vertebrates or chordates = animals with spinal columns and real brains

• Evolution of the Human Brain
  – Modern humans’ brain (to body) size is relatively large
  – Intelligence associated with encephalization quotient
  – Brain development occurred very quickly
  – No real change since Homo Sapiens showed up
Figure 2.25 Timeline for the Evolution of the Brain

- 4,500: The Earth forms
- 3,500: First single-celled organisms
- 700: First simple nervous systems
- 250: First brains
- 65: Extinction of the dinosaurs
- 7: First Hominids
- 1.5: First Homo erectus
- 0.2: First Homo sapiens

Million of Years Ago
Figure 2.26 True Brains Are Found in Chordates

Chordate: Rat

Nonchordate: Aplysia
Figure 2.27 Chordate Brains Continued to Evolve