BIOLOGICAL BASES OF BEHAVIOR: NEURAL PROCESSING AND THE ENDOCRINE SYSTEM
Our understanding of how the brain gives birth to the mind has come a long way. For example, Plato correctly located the mind in the spherical head. Aristotle believed the mind was in the heart, which pumps warmth and vitality to the body. The heart remains our symbol for love, but we know now you fall in love with your brain, not your heart.

Earliest form of Brain study was phrenology. Phrenologist used to travel around North America giving skull readings. Although completely untrue, Phrenology did correctly focus the idea that various brain regions have particular functions.

We know now:
- Nerve cells conduction electricity and ‘talk’ through the use of neurotransmitters
- Specific brain systems serve specific functions
- Information is integrated in these specific brain sections and help us to function
• Biopsychology ➔ a branch of psychology concerned with the links between biology and behavior.

• Some biological psychologists call themselves
  • behavioral neuroscientists,
  • neuropsychologists,
  • behavior geneticists,
  • physiological psychologists, or
  • biopsychologists.

• Can be used to understand sleep patterns, dreams, depression, schizophrenia, hunger, sex, stress and disease, etc.
WHAT’S THE CONNECTION?

• Larger body systems are made up of smaller and smaller sub systems. As these systems condense, they create specific organs, such as heart and lungs. These are then involved in larger systems, such as your circulatory system. These systems then become part of the an even larger system, the individual itself. This individual is then part of a family, population, culture, etc.

• We will start very small, with neurons and move our way up to eventually understand how biological systems influence psychology overall.
NEURAL COMMUNICATION

• Nerve tissue looks the same in many animals, such as a human and a monkey.
• We can use this information to understand how neurons work in simple animals, with no set brains, such as a squid or insect.
• Also, if we can study mammal brains, we can learn more about our own.
• Think of a car, they all have the same parts, so we can understand how they operate. Same of brains in mammals.
NEURAL COMMUNICATION

- **Neuron** → a nerve cell; the basic building block of the nervous system.
- **Building blocks**
  - **Sensory Neuron** → neurons that carry incoming information from the sensory receptors to the brain and spinal cord for processing.
  - **Motor Neuron** → neurons that carry outgoing information from the brain and spinal cord to the muscles and glands.
  - **Interneuron** → neurons within the brain and spinal cord that communicate internally and intervene between the sensory inputs and motor outputs.

- **Middle neuron**
- Most complexity seen here.

- A few million sensory neurons, a few million motor neurons and billions and billons of interneurons.
- All have basically the same structure, with a few slight differences.
NEURON STRUCTURE

1) Dendrite → the bushy, branching extensions of a neuron that receive messages and conduct impulses toward the cell body.

2) Axon → the extension of a neuron, ending in branching terminal fibers, through which messages pass to other neurons or to muscles or glands.
   - Much longer than dendrites. Can be up to several feet in length!

3) Myelin Sheath → a layer of fatty tissue segmentally encasing the fibers of many neurons; enables vastly greater transmission speed of neural impulses as the impulse hops from one node to the next.
   - Laid down up to age 25 – causes neural efficiency, judgment and self control.
   - Neurological disorders such as multiple sclerosis – break down of muscle control due to break down of myelin sheath.
4) Terminal Branches - branched end of a neuron
5) Cell Body – control of the neuron cell, contains nucleus.

- Neuron signals can travel from 2 miles and hour up to 200 miles per hour.
  - Measured in milliseconds
    - (thousandths of a second)
- This is still 3 million times slower than electricity through a wire... this is why we still get electrocuted.
- Therefore reactions can take up to ¼ second or more.
Neurons
Neurons

Dendrites (receive messages from other cells)
Neurons

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- **Axon** (passes messages away from the cell body to other neurons, muscles, or glands)
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- **Dendrites**: (receive messages from other cells)
- **Axon**: (passes messages away from the cell body to other neurons, muscles, or glands)
- **Terminal branches of axon**: (form junctions with other cells)
- **Cell body**: (the cell’s life-support center)
- **Neural impulse**: (action potential; electrical signal traveling down the axon)
- **Myelin sheath**: (covers the axon of some neurons and helps speed neural impulses)
YOUR TURN TO DRAW

• You will have 3 minutes to look at the neuron picture. After 3 minutes, books will be closed, and you will be asked to label and draw 1 neuron cell. GO!
The Neuron: Basic Units of Communication

Length: 10:15

Introductory Psychology Videos
HOW NEURONS TRANSMIT IMPULSES

• **Action Potential** ➔ a neural impulse; a brief electrical charge that travels down an axon.
• This is done by our senses or when triggered by chemical signals from a neighboring neuron.
• Ion (charged atoms) exchange is the reason for the signal transfer.
HOW TO FIRE A NEURON: 101

1) The fluid inside of a resting neuron has an excess of negatively charged ions.
2) The fluid outside of the neuron has an excess of positively charged ions.
   • This is called resting potential.

3) When a neuron fires, the first part of the axon opens its ‘gates’ (think manhole covers).
4) Positively charged sodium flows in.
5) This causes ‘depolarization’ – The inside and the outside of that part of the neuron are no longer charged differently.
6) This depolarization causes the next gates to open, following a pattern like dominoes until it hits the end of the axon.
7) Once a gate has been opened and depolarization has taken place, the positively charged sodium ions are pumped back out of the axon. This is called the refraction period.
8) Then it can fire again, up to 1000x a second!
Action Potential
Action Potential

Direction of neural impulse: toward axon terminals
Action Potential

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3. As the action potential continues speedily down the axon, the first section has now completely recharged.
TYPES OF RESPONSES AND SIGNALS

• Each neuron will receive any signals at a time and will need to decide what type of signal it is.

• Excitatory Signal – Think of it like pushing a neuron’s accelerator. These signals are quick moving and need to invoke a quicker response.

• Inhibitory – Think of it like pushing a neuron’s brake. These signals slow down processes.

• Threshold → a level of stimulation required to trigger a neural impulse.

• Excitatory signals minus inhibitory signals exceed a minimum intensity (threshold), the combined signals trigger an action potential – or a signal to move down the neuron.

• This action potential will fire down the axon on the neuron, which will branch to thousands of other neurons and the body’s muscles and glands.
• You might think that increasing the level of stimulation above threshold will get a faster response or increase in the intensity. BUT, neurons are all or nothing – either they fire or they don’t.

• How do we then determine the difference between a pat on the back versus a slap in the face?

• A strong stimulus signals MORE neurons to fire and to fire more often.

• However, the action potential's strength or speed does not change.

• Think of a gun... it fires or it doesn't. If you squeeze the trigger harder, the bullet does not go faster in the air.
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How Neurons Communicate

• Neurons interweave very close together. We used to think there was no space between each neuron until we noticed a slight time delay.

• From this we saw that there must be an interruption in the pathway, or a meeting point between 2 neurons called a synapse.

• Synapse → the junction between the axon tip of the sending neuron and the dendrite or cell body of the receiving neuron. The tiny gap at this junction is called the synaptic gap or synaptic cleft. Will be less than 1 millionth of an inch wide.

• Think of how fancy ladies kiss.
• Much like the air kiss, neurons need to communicate with each other without touching. For this they use Neurotransmitters.

• Neurotransmitters → chemical messengers that cross the synaptic gaps between neurons. When released by the sending neuron, neurotransmitters travel across the synapse and bind to receptor sites on the receiving neuron, thereby influencing whether that neuron will generate a neural impulse.
• Neurotransmitters cross the synaptic gap and bind to receptor sites on the next neuron.

• This is precise, like a key in a lock, must match up!

• Once they have matched up, for an instant, they will unlock tiny channels at the receiving site. This causes the electrically charged atoms (ions) to flow in, either causing an excitatory or inhibitory signal to occur.

• If there are any extra neurotransmitters that were not initially bonded at the start of the process, they are reabsorbed by the first neuron. This is called reuptake.

• **Reuptake** → a neurotransmitter’s reabsorption by the sending neuron.

• Reuptake plays a huge roll in how psychological drugs work.
How Neurons Communicate
1. Electrical impulses (action potentials) travel down a neuron's axon until reaching a tiny junction known as a synapse.
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3. The sending neuron normally reabsorbs excess neurotransmitter molecules, a process called reuptake.
HOW DO NEUROTRANSMITTERS INFLUENCE US?

• How do neurotransmitters affect our moods, memories and mental abilities?
• Can they be changed with drugs or diet?
• They are found to be used in analyzing depression, euphoria, hunger, thinking, addictions and therapy.
A particular pathway in the brain may only use one or two neurotransmitters, and particular neurotransmitters then have particular effect on behaviour and emotions.

For example, Acetylcholine (ACh), one of the best understood neurotransmitters, plays a role in learning and memory, as well as, being the messenger at every junction between a motor neuron and a skeletal muscle (muscles for movement, attached to your bones).

- ACh released = muscle contracts
- Ach transmission blocked = muscle is paralyzed (used in anesthesia)
HOW NEUROTRANSMITTERS INFLUENCE US

- Acetylcholine (AcH)
- Dopamine
- Serotonin
- Norepinephrine
- GABA
- Glutamate

**Endorphins** → “morphine within” – natural, opiate like neurotransmitters linked to pain control and pleasure. Ex – runners high, acupuncture, pain tolerance/shock.
<table>
<thead>
<tr>
<th>Neurotransmitter</th>
<th>Function</th>
<th>Examples of Malfunctions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetylcholine (ACh)</td>
<td>Enables muscle action, learning, and memory.</td>
<td>With Alzheimer’s disease, ACh-producing neurons deteriorate.</td>
</tr>
<tr>
<td>Dopamine</td>
<td>Influences movement, learning, attention, and emotion.</td>
<td>Excess dopamine receptor activity is linked to schizophrenia. Starved of dopamine, the brain produces the tremors and decreased mobility of Parkinson’s disease.</td>
</tr>
<tr>
<td>Serotonin</td>
<td>Affects mood, hunger, sleep, and arousal.</td>
<td>Undersupply linked to depression. Prozac and some other antidepressant drugs raise seroton levels.</td>
</tr>
<tr>
<td>Norepinephrine</td>
<td>Helps control alertness and arousal.</td>
<td>Undersupply can depress mood.</td>
</tr>
<tr>
<td>GABA (gamma-aminobutyric acid)</td>
<td>A major inhibitory neurotransmitter.</td>
<td>Undersupply linked to seizures, tremors, and insomnia.</td>
</tr>
<tr>
<td>Glutamate</td>
<td>A major excitatory neurotransmitter; involved in memory.</td>
<td>Oversupply can overstimulate brain, producing migraines or seizures (which is why some people avoid MSG, monosodium glutamate, in food).</td>
</tr>
</tbody>
</table>
HOW DRUGS AND OTHER CHEMICALS ALTER NEUROTRANSMISSION

• If endorphins feel so good to us, why don’t we want to be hooked on artificial opiates, such as morphine and heroin?
• When the brain is constantly flooded with artificial opiates, it may stop producing its own natural ones.
• When the drug is withdraw, no natural opiates are formed and the user feels intense discomfort.
• Drugs are divided into 2 categories: agonists and antagonists. They either magnify or block a neurotransmitters activity.
• Agonist molecules – similar enough to a neuro transmitter to bind with it’s receptor and mimic effects.

• Opiates are typically agonists and produce a ‘high’ by amplifying normal sensations of arousal and pleasure. However, black widow venom is also an agonist, mimicking ACh, causing violent muscle convulsions.

• Antagonist molecules – also bind to receptors, but block neurotransmitter function.

• Botulin (Botulism) causes paralysis by blocking ACh release... Botox for wrinkles to cause facial paralysis.

• Some antagonists are similar enough to neurotransmitters, so they block the site, but not enough to cause a response. (ex. Curare – South American dart point, paralysis because it blocks ACh sites.)
Agonists and Antagonists Fig 3A.6

**Agonist**
- A neurotransmitter molecule fits the receptor site on the receiving neuron, much as a key fits a lock.
- This agonist molecule excites. It is similar enough in structure to the neurotransmitter molecule to mimic its effects on the receiving neuron. Morphine, for instance, mimics the action of endorphins.

**Antagonist**
- A neurotransmitter molecule inhibits. It has a structure similar enough to the neurotransmitter to occupy its receptor site and block its action, but not similar enough to stimulate the receptor. Curare poisoning paralyzes its victims by blocking ACh receptors involved in muscle movement.
The Nervous System

Peripheral nervous system

Nervous system

Peripheral

Autonomic (controls self-regulated action of internal organs and glands)

Sympathetic (arousing)

Parasympathetic (calming)

Central nervous system

Central (brain and spinal cord)

Somatic (controls voluntary movements of skeletal muscles)
NERVOUS SYSTEM

• **Nervous System** → the body’s speedy, electrochemical communication network, consisting of all the nerve cells of the peripheral and central nervous systems.

• **Central Nervous System** → (CNS) the brain and spinal cord

• **Peripheral Nervous System** → (PNS) the sensory and motor neurons that connect the central nervous system (CNS) to the rest of the body.

• **Nerves** → bundled axons that form neural “cables” connecting the central nervous system with muscles, glands, and sense organs.
PERIPHERAL NERVOUS SYSTEM

• 2 parts

• **Somatic Nervous System** ➔ the division of the peripheral nervous system that controls the body’s skeletal muscles.

• Also called the skeletal nervous system

• As the bell rings to signal the end of class, your somatic nervous system reports to your brain the current state of your skeletal muscles and carries instructions back, triggering your body to rise from your seat.

• **Autonomic Nervous System** ➔ the part of the peripheral nervous system that controls the glands and the muscles of the internal organs (such as the heart). Its sympathetic division arouses; its parasympathetic division calms.

• Influences things such as heartbeat and digestion. Unless it is overridden, will run on its own, hence the word autonomously.
2 DIVISIONS OF THE AUTONOMIC NERVOUS SYSTEM

• **Sympathetic Nervous System** → the division of the autonomic nervous system that arouses the body, mobilizing its energy in stressful situations.
  - Arouses and expends energy.
  - If something alarms, enrages or challenges you, this system will accelerate your heartbeat, raise your blood pressure, slow digestion, etc.
  - Once the stress subsides the parasympathetic nervous system takes over to produce opposite effects.

• **Parasympathetic Nervous System** → the division of the autonomic nervous system that calms the body, conserving its energy.
THE CENTRAL NERVOUS SYSTEM

- Brain = humanity.
- Thinking, feeling and acting.
- Roughly 400 trillion synapses in your brain alone.
- Your brain neurons cluster together in working groups called neural networks.
- Much like how a city exists in a province, neurons like to be close together.
• Spinal Cord = Information Highway
• Connects the PNS to the brain.
• Ascending neuron fibres send up sensory information,
• These pathways cause reflexes ➔ a simple, autonomic response to a sensory stimulus such as the knee-jerk response.
• Think of the knee jerk response – one pathway.
• Pain reflexes
• Your fingers touches a flame.
• Neural activity is excited by the heat
• Travels via sensory neurons to interneurons in your spinal cord.
• Stimulates motor neurons in your arm.
• Move hand instantly
• This pain sensor when directly from your fingers to your spinal cord and back out, your hand will actually move from the candle BEFORE your brain will receive and respond to information that causes you pain.
• Paralysis? – Think about it...
A Simple Reflex

1. In this simple hand-withdrawal reflex, information is carried from skin receptors along a sensory neuron to the spinal cord (shown by the red arrow). From here it is passed via interneurons to motor neurons that lead to muscles in the hand and arm (blue arrow).

2. Because this reflex involves only the spinal cord, the hand jerks away from the candle flame even before information about the event has reached the brain, causing the experience of pain.
ENDOCRINE SYSTEM

• Second form of communication system.

• **Endocrine System** ➔ the body’s “slow” chemical communication system; a set of glands that secrete hormones into the bloodstream.

• Uses **hormones** ➔ chemical messengers that are manufactured by the endocrine glands, travel through the bloodstream, and affect other tissues.

• When hormones act on the brain, they influence our response to food, sex and aggression.

• These are similar to neurotransmitters, therefore the nervous system and the endocrine system are interconnected.
• Endocrine messages tend to outlast effects of neural signals. Ex. Taking time to ‘simmer down’.
• For example in a moment of danger, your adrenal glands release epinephrine/adrenaline and norepinephrine/noradrenaline in response to fight or flight.
• Heart rate up, blood pressure up, blood sugar up = energy
• Adrenal Glands ➔ a pair of endocrine glands that sit just above the kidneys and secrete hormones (epinephrine and norepinephrine) that help arouse the body in times of stress.
• Most influential one is your **pituitary gland** → the endocrine system’s most influential gland. Under the influence of the hypothalamus, the pituitary regulates growth and controls other endocrine glands.

• Pea sized structure, right at the core of your brain

• Releases hormones for growth and also influences other glands – think puberty.
Hypothalamus (brain region controlling the pituitary gland)

Pituitary gland (secretes many different hormones, some of which affect other glands)

Parathyroids (help regulate the level of calcium in the blood)

Thyroid gland (affects metabolism, among other things)

Adrenal glands (inner part helps trigger the “fight-or-flight” response)

Pancreas (regulates the level of sugar in the blood)

Testis (secretes male sex hormones)

Ovary (secretes female sex hormones)