Introduction
History of the Physiology of Behavior
- Investigation of the physiology of behavior has a long history.
- With roots in:
  - Philosophy
  - Biology
  - Psychology

History of the Physiology of Behavior continued
- The philosophical roots of physiological psychology can be traced to the French philosopher and mathematician René Descartes (1596-1650).

René Descartes

History of the Physiology of Behavior continued
- Before Descartes, the common belief was that human behavior was entirely determined by conscious intent and free will.
- People's actions were not thought to be controlled by external stimuli or mechanistic natural laws.
- What someone did was presumed to be the result of his or her deliberate intention.
- Descartes took exception to this view of human nature.
- He recognized that many things people do are in fact automatic reactions to external stimuli.
- However, he was not prepared to abandon altogether the idea of free will and conscious control of one's own action.

History of the Physiology of Behavior continued
- He therefore formulated a dualistic view of human behavior known as Cartesian dualism.
- According to this view, there are two aspects of human behavior:
  - One set of actions are involuntary and occur in response to external stimuli.
  - These actions are called reflexes.
  - Another aspect of human behavior involves voluntary actions which do not have to be triggered by external stimuli.
  - Voluntary actions may occur because of the person's conscious choice to act in a certain way.
- The details of Descartes dualistic view of human behavior can be diagramed.
**Cartesian Dualistic Model**

- Source of Involuntary Action
  - Sense organs
  - Brain
  - Pinal gland
  - Mind
  - Muscle

**Mechanisms of Involuntary Behavior**

- Stimuli in the environment are detected by the person's sense organs.
- The sensory information is then relayed to the brain through nerves.
- From the brain, impetus for action is sent through nerves to the muscles that create the involuntary response.

**Aspects of this system**

- Stimuli in the external environment are seen as the cause of all involuntary behavior.
- These stimuli produce involuntary responses by way of a neural circuit that included the brain.
- Descartes assumed that involuntary mechanism of behavior was the only one available to animals.
- According to this view, all of animal behavior occurs as reflex response to external stimuli.

**Free Will**

- Descartes did not believe that animals had free will or were capable of voluntary, conscious action.
- Free will and voluntary behavior were considered to be uniquely human attribute.
- This superiority of humans over animals existed because only human beings were thought to have a mind, or a soul.

**The Mind**

- The mind was assumed to be a nonphysical entity.
- However, if the mind, or soul, is not physical, how can it generate the physical movement involved in voluntary behavior?
- Descartes believed that the mind was connected to the physical body by way of the pineal gland in the brain.
- Because of its connection to the brain, the mind could be aware of and keep track of involuntary behavior.

**The Mind continued**

- Through this mechanism the mind could also initiate voluntary actions.
- Because voluntary behavior was initiated in the mind it occurrence could be independent of external stimulation.
- The mind/body dualism introduced by Descartes was followed by two intellectual traditions.
  - One of these involved discussions about what is in the mind and how the mind works.
  - This approach used the method of introspection to study the mind.
  - These thinkers were philosophers rather than experimental scientists.
  - The second intellectual tradition has been concerned with the mechanism of reflexive behavior.
The Mind continued

- Because reflexes are produced entirely by external stimuli acting on body organs.
- The study of reflexes has been conducted using the methods of direct observation and experimentation.

The Study of the Mind

- One set of issues that concerned philosophers involved questions about what is in the mind and how the mind works.
- Descartes had some things to say about both these questions.
  - Because Descartes thought the mind was connected to the brain by way of the pineal gland, he believed that some of what is in the mind came from sense experience.
  - However, he also believed that some of the contents of the mind were innate.
  - And existed in all human beings independent of worldly experience.

The Study of the Mind continued

- He believed that all human beings were born with certain ideas.
- The concept of God
- The concept of self
- And certain fundamental axioms of geometry
  - For example, the shortest distance between two points is a straight line.
- The philosophical approach that assumes we are born with innate ideas about certain things is called nativism.

The British Philosophers

- Some philosopher after Descartes took issue with the nativist position.

The British Philosophers continued

- The British philosopher John Locke (1632-1704), for example, believed that all the ideas people had were acquired directly or indirectly through experience after birth.
- He believed that human beings were born totally innocent of any preconceptions about the world.
- The mind was considered to start out as a tabula rasa (a clean slate).
- To be filled with ideas and information as the person had various sense experiences.
- This philosophical approach that assumes we acquires ideas through sensory experiences after birth is called empiricism.
How the Mind Works

- The nativist and empiricist philosophies differed not only on what the mind was assumed to contain but also on how the mind was assumed to operate.
- Descartes believed that the mind did not function in a predictable and orderly manner according to discoverable rules or laws.
- One of the first to propose an alternative to this view was another British philosopher Thomas Hobbes (1588-1679).

- Hobbes accepted the distinction between voluntary and involuntary behavior stated by Descartes.
- He also accepted the notion that voluntary behavior was controlled by the mind.
- However, unlike Descartes, he believed that the mind operated just as predictably and lawfully as reflex mechanisms.
- More specifically, he proposed that voluntary behavior was governed:
  - by the pursuit of pleasure
  - and the avoidance of pain
- Thus the function of the mind were not determined by reason but by the principle of hedonism.

How the Mind Works continued

- According to the British empiricists, another important aspect of how the mind works involved the concept of association.
- The British empiricists accepted two sets of rules for the establishment of associations.

How the Mind Works continued

- One primary
  - contiguity
  - similarity
  - And contrast
- The other secondary
  - intensity of sensation
  - frequency
  - And recency
- The British empiricists discussed rules of associations as a part of their philosophical discourse.
- They did not perform experiments to determine which rules were correct and which ones were incorrect.
- or the circumstances in which one rule was more important than another.

How the Mind Works continued

- Empirical investigation of the mechanisms of associations did not begin until the pioneering work of the 19th century German psychologists Hermann Ebbinghaus.
The Study of Reflexes

* The concept of reflex action, introduced by Descartes, greatly advanced our understanding of behavior.
* Descartes model of reflexes
  * He believed that sensory messages going to the brain and motor messages going to the muscles traveled along the same nerves.
  * The nerves were considered to be hollow tubes.
  * The pineal gland was thought to release a substance called “animal spirits,” which flowed down the tubes and enter the muscles, causing them to swell and create a movement.
  * Descartes believed that there was a direct relationship between the intensity of the stimulus and the intensity of the response.

The Study of Reflexes continued

* Finally, Descartes considered all reflexive movement to be
  * innate
  * and to be fixed to the anatomy of the organism.
  * It was not until the 19th century that we had a better understanding of the physiological processes responsible for reflexive behavior.
  * Experimental observations after Descartes showed that he was wrong about the anatomy of the reflex arc and the mechanism of neural conduction.
  * Later research also indicated that not all reflex responses are innate.

Sir Charles Bell & François Magendie

Charles Bell & François Magendie

* The anatomy of the reflex arc was established in experiments performed by Charles Bell (1774-1842) in England and François Magendie (1783-1855) in France.
  * They discovered that separate nerves are used to transmit sensory information from the sense organs to the central nervous system.
  * And motor information from the central nervous system.
  * If a sensory nerve is cut, the animal remains capable of muscle movement.
  * If a motor nerve is cut, the animal remains capable of registering sensory information.

Charles Bell & François Magendie continued

* Dorsal Root of the spinal nerves carry somatosensory information into the CNS.
* Ventral Root of the spinal nerves carry motor information from the CNS to the muscles or gland cells.
* The Bell-Magendie Law states that there are two pathways: a sensory pathway carrying information into the CNS and a motor pathway carrying information away from the CNS.

Hermann Ludwig von Helmholtz

* Helmholtz at about the time he first measured the speed of the nerve impulses.
Hermann Ludwig von Helmholtz continued

- Hermann Ludwig von Helmholtz estimated the speed of neural conduction.
- Johannes Müller argued that neural conduction operated at the speed of light.
- Other had estimated the speed of neural conduction was 57,600 ft/sec.
  - This is 80 times faster than the speed of light.
- Helmholtz estimated the speed of neural conduction to be 90 ft/sec.\textsuperscript{[5]}

Swammerdam & Glisson

- In 1669 Swammerdam (1637-1680) showed that mechanical irritation of a nerve is sufficient to produce a muscle contraction.
- The infusion of animal spirits from the pineal gland was not necessary.
- Francis Glisson (1597-1677) demonstrated that muscle contractions are not produced by a swelling of the muscle by the infusion of some fluid, as Descartes thought.
- Glisson had people submerge one arm in water and observed that the water level did not change when they were asked to make a muscle contraction.
- Such experiments indicated that neural conduction did not occur by the mechanisms Descartes proposed.\textsuperscript{[6,7]}

Reflex Mechanism

- Better understanding in the 19th century of the physiological processes responsible for reflexive behavior was accompanied by a liberalization of the restricted role of reflexes in the explanation of behavior.
- Descartes and most philosophers after him assumed that reflexes were responsible for simple reactions to stimuli.
- The energy in a stimulus was thought to be translated directly into the energy of the elicited response by the neural connections.
- The more intense the stimulus, the more vigorous the resulting response.\textsuperscript{[8]}

Reflex Mechanism continued

- This view of reflexes is consistent with many casual observations.
- If you touch a stove, the hotter the stove is, the more quickly you withdraw your finger.
- However, reflexes can also be more complicated.
- Two Russian physiologists, Sechenov (1829-1905) and Pavlov (1849-1936), were primarily responsible for extending the concept of reflexes to explain more complex behavior.\textsuperscript{[8]}

Hermann Ludwig von Helmholtz continued

- This finding is very important:
  - One, it demonstrated that our perceptions are of past events, because it takes time for neural conduction
  - Two, it brought the soul under physical constraints of time
  - and the mind in the domain of natural science.
- Establishing the mechanisms of neural conduction involved much more extensive experimentation.
- The idea that animal spirits were involved in neural transmission was disproved soon after the death of Descartes.\textsuperscript{[8]}
Ivan Sechenov

- Sechenov proposed that in some cases the effect of a stimulus is not to elicit a reflex response directly.
- Rather a stimulus may release a response from inhibition.
- Sexual responses, for example, are suppressed in most situations.
- These responses may be released between lovers by the stimuli of their private bedroom.
- With this type of mechanism the intensity of a stimulus does not necessarily become translated into the intensity of the elicited response.
- Other factors may be responsible for the intensity of the response such as, the length of time since last having sex.

Ivan Sechenov continued

- Sechenov suggested that it is possible for a very faint stimulus to produce a large response.
- He suggested that complex forms of behavior (e.g. actions or thoughts) that occur in the absence of an obvious eliciting stimulus are in fact reflexive responses.
- It is simply that in these cases the eliciting stimuli are so faint that we do not notice them.
- Thus, according to Sechenov, voluntary behavior and thought are actually elicited by inconspicuous, faint stimuli.

Ivan Pavlov

- From Descartes through Sechenov, reflex responses were considered to be innate and to be fixed by the anatomy of the organism’s nervous system.
- They were thought to depend on a prewired neural connection between sense organs and the relevant muscles.
- According to this view, a given stimulus is expected to elicit the same response throughout the organism’s life.
- Although this is true in some cases, there are also many examples in which the response to a stimulus changes.

Ivan Pavlov continued

- Examples
  - The rooting reflex
  - And the Moro reflex
  - Explanation of such cases by reflex processes had to wait the experimental and theoretical work of Ivan Pavlov.

Ivan and Sara Pavlov at about the time of their Marriage
Ivan Pavlov continued

- Pavlov showed experimentally that not all reflexes are innate. New reflexes can be established to stimuli through the mechanism of association.
- Primarily by the principle of contiguity.
- Which states that when two events appear close in time they become associated.
- Pavlov's role in the history of the study of reflexes is comparable to the role of Ebbinghaus in the study of the mind.
- Both were concerned with establishing the laws of associations through empirical research.

Charles Darwin

- A very important historical antecedent of the study of the physiology of behavior was the work of the 19th century British biologist Charles Darwin (1809-1882).
- Darwin's contribution is the concept of evolution.

The Concept of Evolution continued

- Darwin was concerned with figuring out why different species and subspecies have different characteristics.
- On the basis of extensive observation of various types of animals, he formulated his theory of evolution.
- He recognized that each member of species is slightly different from other members. These individual variations, he thought, occurred randomly through unspecified processes.

The Concept of Evolution continued

- Darwin believed that those individuals whose skills best match the challenges to survival posed by the environment will be most likely to survive and pass on these characteristics to their offspring.
- This process is repeated over and over again across generations,
- with the result that more and more members of a group of animals will have the particular traits that promote survival in their environment.
- This process is called evolution through natural selection.

The Concept of Evolution continued

- There are four factors essential for the theory of evolution:
  - variability within members of the same species
  - traits and characteristics are inherited.
  - survival to the stage of reproduction (and may be longer?) (Survival of the Fittest)
  - sexual selection

- Through the process of evolution, one set of organisms can have descendants after many generations that bear little resemblance to their ancestors.
- For example, the avian species evolved from reptiles.
- Cetacean species (porpoise & whales) evolved from land mammals.

The Concept of Evolution continued

- Darwin proposed that evolution was responsible for the appearance of new species
- and saw no reason that unique human characteristics could not have developed from other types of organisms in the same way.
- He believed in the continuity of species that included human beings.
- One species may simply have taken a different course of evolution than another.
- The evidence for continuity of species provides a strong rational for the study of animals as a way to give insight into human beings.
The Concept of Evolution continued

- Some developmental psychologists have argued that during prenatal development we go through the evolutionary stages of our ancestors.
- This prenatal developmental process has been called **Ontogeny Recapitulates Phylogeny**.
- Examples cited for this theory are, gill slits and tails in human fetus.
- This theory more recently has fallen out of favor.
- All of Darwin's scientific observations were concerned with the physical traits of animals.
- **On the Origin of Species by Means of Natural Selection** (1859)
- However, he did not restrict his theory of evolution to explaining physical characteristics.

The Concept of Evolution continued

- He also believed that:
  - behavioral characteristics,
  - emotional expression,
    - *The Expressions of the Emotions in Man and Animals* (1872)
  - and intelligence
    - *The Descent of Man and Selection in Relation to Sex* (1871)
  - can evolve in the same way that physical traits evolve.
- For example:
  - language
  - culture
- Darwin other contribution is functionalism.
- The concept that all structures or traits serve or had served in the past a function.

Contribution of Modern Psychology

- The field of physiological psychology grew out of psychology.
- Indeed, the first textbook of psychology, written by Wilhelm Wundt in the late 19th century was titled:** Principles of Physiological Psychology**
- The modern history of investigating the physiology of behavior has been written by psychologists
- who have combined the methods of:
  - experimental psychology
  - with the methods of experimental physiology
- and have applied them to the issues that concern psychologist.

Contribution of Modern Psychology continued

- Thus, we have studied:
  - perceptual processes
  - control of movement
  - sleep and waking
  - reproductive behavior
  - aggressive behavior
  - ingestive behavior
  - learning
  - and communication
- In recent years we have begun to study
  - the physiology of pathological conditions, such as mental disorders.

The Goal of Research

- The goal of all scientists is to explain the phenomena they study.
- But what do we mean by "explain?"
- Scientific explanation takes two forms:
  - generalization
  - reduction
- Most psychologist deal with generalization.
- They explain particular instances of behavior as examples of general laws,
- which they deduce from their experiments.

The Goal of Research continued

- For example:
  - Most psychologist would explain pathologically strong fears of dogs as an example of classical conditioning.
  - John B. Watson - Little Albert study
  - Most psychologist deal with reduction.
  - They explain phenomena in terms of simpler phenomena.
  - For example:
    - they may explain the movement of a muscle in terms of the changes in the membrane of muscle cells
    - the entry of particular chemicals
    - and the interaction among protein molecules within the cells.
The Goal of Research continued

- The task of the physiological psychologist is to explain behavior in physiological terms.
- But physiological psychologists cannot simply be reductionists.
- It is not enough to observe behaviors and correlate them with physiological events that occur at the same time.
- Identical behaviors may occur for different reasons and thus may be initiated by different physiological mechanisms.
- Therefore, we must understand "psychologically" why a particular behavior occurs before we can understand what physiological events made it occur.\(\text{\textsuperscript{199}}\)

- For example:
  - Mice, like many other mammals, often build nests.
  - Behavioral observations show that mice will build nests under two conditions:
    - when the air temperature is low
    - and when the animal is pregnant
  - a nonpregnant mouse will not build a nest if the weather is warm,
  - whereas a pregnant mouse will build one regardless of the temperature.
  - The same behavior occurs for different reasons.
    - It should not be surprising that these behaviors are initiated by different physiological mechanisms
    - one involving changes in the level of various hormones in the animal's blood
    - the other involving nerve cells that detect temperature changes.\(\text{\textsuperscript{199}}\)

The Goal of Research continued

- Sometimes, physiological mechanisms can tell us something about psychological processes.
- This relationship is particularly true of complex phenomena such as:
  - language
  - memory
  - and mood
- which are poorly understood psychologically.
- For example:
  - Phineas Gage (mid 1800's) had an iron rod pass through his forebrain after that he was unable to carry out plans (impulsive)
  - H. M. bilateral removal of the hippocampus was unable to learn anything new.\(\text{\textsuperscript{199}}\)

The Goal of Research continued

- In practice, the research efforts of physiological psychologists involve both form of explanation:
  - generalization
  - and reduction.
- Ideas for experiments are stimulated by the investigator's knowledge both of psychological generalizations about behavior and of physiological mechanisms.
- A good physiological psychologist must be both a good psychologist and a good physiologists.\(\text{\textsuperscript{199}}\)