Human Physiology
Section One: Chapter 1: Introduction to Human Physiology

Figure 1.1 The image above shows an artistic rendering of the left and right hemispheres of the cerebrum of the human brain. It provides insight into the contrasts between the two sides, specifically regarding the functional difference between the logic, reason and order of the left hemisphere, compared to the creative, intuitive and empathetic functions of the right hemisphere. These two sides of the brain do not oppose one another, neither do they work separately, rather they are synergistic and complement one another. They both contain vital elements of human function and when fully integrated they operate in an elegantly balanced and precise manner.

Introduction and General Information about Terms for the Human Body

Words, names and terms are very important in any discipline because often they carry very precise meanings within them. Knowing and understanding the meanings of these words will be of tremendous help to us in remembering, comprehending, and relating one aspect of information to other aspects, providing a deeper understanding. When information stays with you long after the course is over, you will recognize important elements in other disciplines when you connect to the deeper meanings.

Physiology

The **etymology** (word origin) of the term **Physiology** comes from 1560's French, which comes directly from the Latin physiologia, meaning "The study and description of natural objects, natural philosophy". This is derived from '**physios'** meaning "nature, natural, physical"; and '**logia'** meaning "study". Giving the fuller meaning of Physiology as the "Science of the normal function of living things".

When studying physiology (function), it is imperative to also understand the basic anatomy (structure) involved, as structure and function go hand in hand.

Anatomy

The etymology (word origin) of the term **Anatomy** comes from the Late 1300's terms in both Latin, anatomia and Greek, anatome. These words are derived from **ana** which means "up"; and **tomos** (or temnein) which means "to cut". Together this gives "a cutting up", which is clearly involved in dissection. In general, anatomy is considered the "Study or knowledge of the structure (form) and function of the human body". Courses and textbooks for anatomy and physiology are different because they examine the human body from different aspects, but the two (anatomy and physiology) are inextricably connected to each other, thus it is often important to identify and incorporate the way these two are related.

Etymology for the Language of Physiology

Another useful concept related to the importance of words in physiology (and anatomy) is knowing the **etymology** of a word, which means the origin of the word. Etymology is a scientific breakdown and analysis of words. Since many of the words we will encounter are derived from Latin and Greek, it is incredibly helpful to know the origins and 'translations' of these terms. Becoming aware of the origins of words will greatly help students to: **1)** understand what the term means; and **2)** assist you in predicting what a brand-new term means when you first encounter it, as it may contain a portion of a term you have already seen before, and the meanings (from the word origin) usually do not change.

- **Here are some common examples:**

  A solution is **hypertonic**. What is the etymology and meaning of **hypertonic**?
  Hyper means above normal and **tonic** means strength. The solution is too strong or concentrated.

  The person has **hypoglycemia**.
  Hypo is the opposite of hyper and means below normal. The **glyc** portions means glucose (a type of sugar), and **emia** means blood. Therefore, this statement means the person has low blood sugar.

  A runner has **hyponatremia**.
  Hypo still means below normal. The **natr** portion means natrium which is the Latin word for sodium (hence why the chemical symbol for sodium is Na), and **emia** still means blood. Therefore, this statement means the person has low sodium levels in their blood.

Along the way in this physiology course we will encounter many of these terms, and once we know the origin and meaning of them it will help us figure out newer terms with ease and familiarity. Anyone who has taken a medical terminology course will know the value of understanding the meaning of roots, prefixes (at the beginning of a word) and suffixes (at the end of a word).

- **Now you do this one:**
  There is a diagnosis of **pancytopenia**. *(Hint: there are 3 terms here: pan, cyto and penia).*

There are many free reference resources available to students to find the etymologies of various words and terms encountered in the text. Importantly, **Appendix A** in this text has an extensive list of word etymologies called the **Etymology of Anatomy and Physiology Terms**. Check it out!

The word above (pancytopenia), or at least the various separate parts of it, are likely to be found in that Etymology of Anatomy and Physiology Terms contained within this physiology text. Take a look.

Compare Function and Process in Human Physiology

As we seek to understand the central themes of physiology, an important concept is how to ask questions about what's occurring in the human body. In general, there are two basic approaches to physiology:

1) We can ask **Functional Questions**; and

2) We can ask **Process Questions**.

What's the difference between these two, which one will we use, and why?

> **1) Functional Questions** are related to **Why** something occurs. For example, why do we breathe? What is the purpose of it? These can often be answered without much detail.
>
> **2) Process Questions** are related to **How** something occurs. For example, how does breathing actually happen? Often these are answered in a detailed, step-by-step manner.

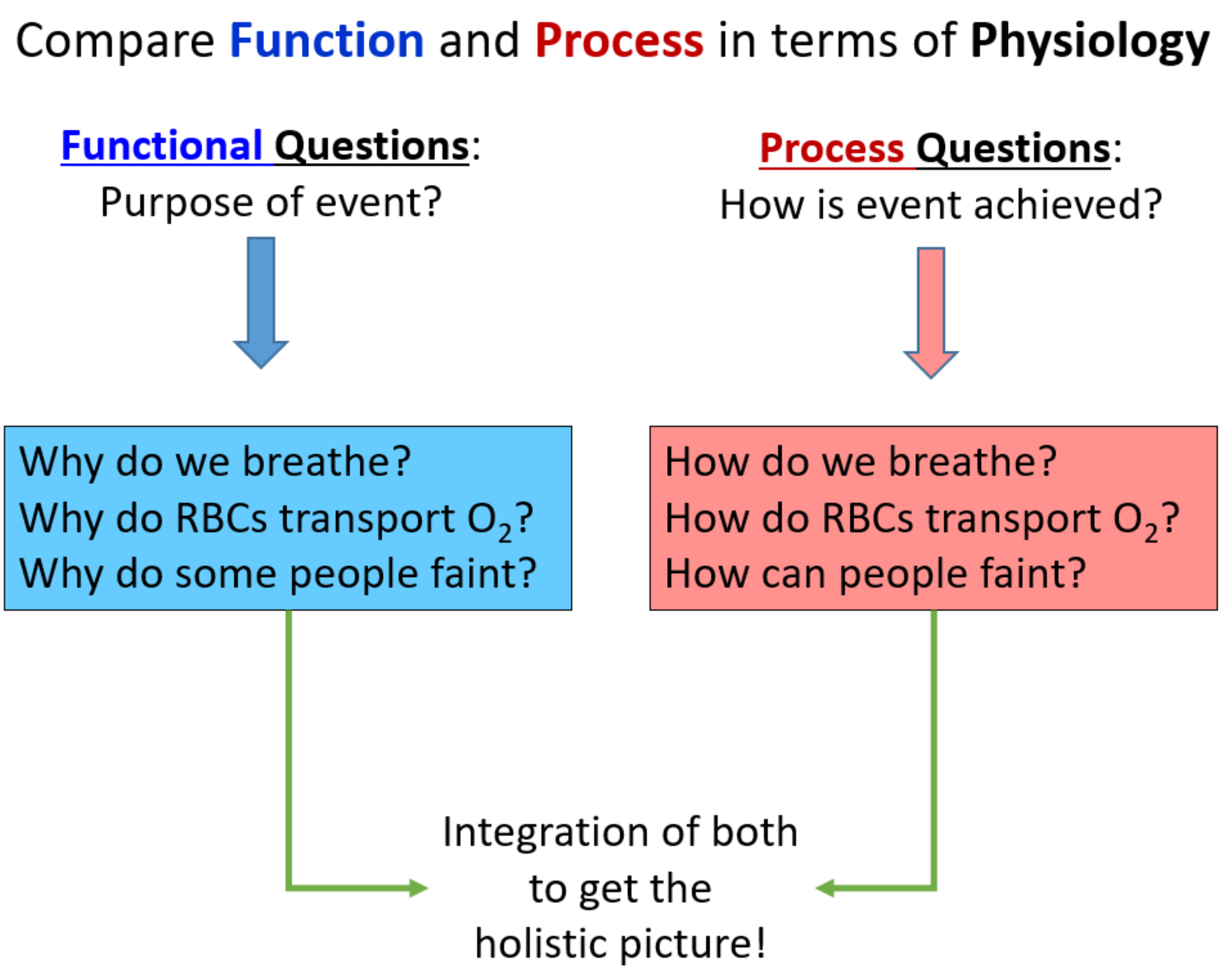


Figure 1.2 Shown here is a comparison of functional and process approaches in terms of asking and answering questions about physiology. Different approaches are used in order to answer the **Why** (functional) and the **How** (process) questions of human physiology.

Questions for Functional and Process Approach

As a quick exercise, let's provide brief answers for the two approaches shown in **Figure 1.2** (above) and then combine them to see the big picture.

Functional Questions (Purpose of event)**:**

Q: Why do we breathe?
A: To transport air into and out of our body. This involves taking in oxygen (O_2) during inspiration of atmosphere air, and the release of carbon dioxide (CO_2) when exhaling air out of the body.
Q: Why do RBCs transport O_2?
A: To deliver O_2 to the body tissue that need it.
Q: Why do people sometimes faint?
A: If blood flow to the brain in restricted, a common response is losing consciousness or fainting.

Process Questions (How is event achieved):

Q: How do we breathe?
A: Changes are made in the volume of the thoracic cavity by the contraction and relaxation of the skeletal muscles of respiration. This causes inverse (opposite) changes in the pressure of the thoracic cavity. Low thoracic pressure causes air from the atmosphere to go down its pressure gradient into the lungs, which is inhaling. High thoracic pressure causes air in the lungs to go down its pressure gradient out of the lungs into the atmosphere, which is exhaling.
Q: How do RBCs transport O_2?
A: Inside the red blood cells (RBCs) the heme portion of the molecule hemoglobin has a high affinity for O_2 when the partial pressure of the surroundings for O_2 is high (hence holds onto it tightly), and a low affinity for O_2 (hence releasing it) when the surrounding partial pressure for O_2 is low.
Q: How can people faint?
A: When there is a decrease in the delivery of oxygen (O_2) rich blood to brain tissue, the metabolically active neurons cannot continue their normal functions and shut down from lack of O_2 resulting in the loss of consciousness (fainting) until adequate blood flow is resumed.

Things to notice about Function and Process Approaches

Notice that the **How** part (process) requires more details and also involves a sort of 'pathway' approach. It is more like story telling compared to the less detailed functional aspects. It is the *Functional* part that gives us the overview – the why the lungs do what they do. And it is the *Process* part that gives us the details of how a series of events in a step wise fashion describe the lungs' activities.

The more arduous component of physiology is understanding the detailed processes. This is the reason we need to take our time and fully understand the fundamentals, the groundwork, before we delve into higher levels. Having a solid foundation of the details will enable us to come full circle and see the big picture with greater clarity because we understanding the details that create it.

What most students recognize about physiology is that it is more conceptual than anatomy, because there is a step-by-step manner of details driving a process. There are usually two directions, or sides to any function discussed in physiology, this is because at the center of the human body is **balance**, which provides the equilibrium necessary to function properly. For example, when we explain the mechanism of how we breathe in, we must also explain how we breathe out. Often once one side of the story is mastered, the other side falls into place more easily.

Basic Functions of a Complex Organism

Holistically, we will examine Human Physiology as it relates to the foundational basics of how a multi-system organism functions as *a single coordinated entity*. The basic functions are listed below:

- Differentiation (Development)
- Responsiveness
- Metabolism
- Growth and Repair
- Movement
- Excretion
- Reproduction

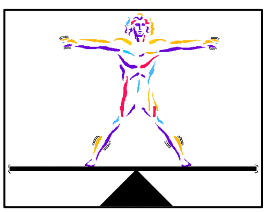
What we will find is that all of the systems studied in this course will contain many if not all of the listed functions embedded within them as we move through the body's various systems in sequence.

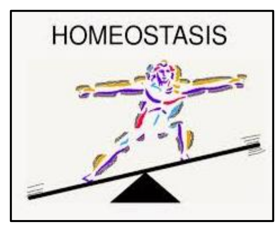
Body (Organ) Systems

A **body system** (also called an **organ system**) is an integrated collection of organs in the body that work together to perform a specific vital function. For example, the digestive system is comprised of several organs, like the stomach, liver and intestines. In actuality, all systems are intimately connected, but it is useful to study them separately, even though they are not separate at all. The 11 major organ systems of the body are shown in the table at the end of this section (**Table 1.2**), and below is the way this course will approach and explore the body systems based on the vital functions and processes defined earlier. With all the body systems operating constantly, it is necessary to have a method in place to maintain stability and equilibrium across all of integrated systems. This unifying element in physiology is called **homeostasis**.

Homeostasis

In physiology, **homeostasis** is defined as **the maintenance of a stable internal environment**. It is about maintaining equilibrium in the body. Many physiologist translate this into a convenient saying "constantly changing to stay the same", that is how **balance** in any realm is accomplished, and this is the essence of homeostasis in the human body. For example, if we decide to stand on a balance beam (left), then suddenly change position, multiple factors immediately engage to adjust to this change (right) in order to recalibrate and create a new balance and stability for the body in this new position. This usually occurs rapidly and seamlessly.





The **etymology** of the word homeostasis, from its Greek and Latin origins, is as follows: **Homeo** means 'similar to', or 'the same'. **Stasis** means to 'stand still, stop or stay'. Therefore, the origins of this word are inferring that 'things are staying the same'. In physiology, this translates to the ability of the human body to quickly adapt to any changes and re-establish stability to maintain its equilibrium.

Homeostasis is maintained by Feedback Loops

It is often said that <u>the fundamental unifying concept in physiology is homeostasis</u>. This means that the body strives for balance, and within all of its functioning, it is centered on creating and maintaining a stable internal environment, regardless of the external or internal changes. As mentioned, a valuable way of thinking about it is <u>constantly changing to stay the same</u>! The primary way the human body maintains homeostasis is with the use of **feedback loops**.

A feedback loop is a mechanism that allows for continual assessment of the body's physiology and a way to correct various elements if they should go out of balance. There are two types of feedback loops:

1) Negative feedback loops
2) Positive feedback loops

We will go through specific examples for each of these feedback loops with all of the relevant physiological details. Before we do that, keep in mind the following succinct yet valuably accurate definitions for both of these feedback loops below, in preparation for going through the detailed physiological examples.

A Negative Feedback Loop - is when the response opposes (or negates) the original stimulus.

A Positive Feedback Loop - is when the response augments (or intensifies) the original stimulus. The cycle repeats until it is broken and ends.

The negative feedback loop is by far the **most common** in the human body. Although the positive feedback loop is very rare, its importance in the body cannot be overstated. For any feedback loop there is a **parameter** that is being monitored and it has a **set point**. All this means is that a parameter (some factor in the body) has a 'normal range' that exists (and can be measured) for when everything is in balance. The stimulus that starts the feedback loop into action is a ***change*** in that parameter that pushes it above or below its normal set point range. In **Table 1.1** below are shown some commonly known parameters in the body and their normal values. As the course moves forward, we will see many of these parameters.

Table 1.1 Shown in table below are various parameters in the human body, and then the specific examples of their normal (set point) ranges that are usually found in blood.

Various Parameters (factor that changes)	Normal Blood Levels (set point range)
Osmolarity of Blood	295-310 mOsM
pH of Blood	7.35-7.45
Arterial blood gas P_{CO2}	40-46 mmHg
Arterial blood gas P_{O2}	80-100 mmHg
Hematocrit (HCT)	42-52% Male 37-48% Female
Blood Sugar Regulation	
Glucose (fasting)	70-100 mg/dL
Glucose (2 hours post prandial)	140 mg/dL
Insulin (fasting)	5-25 mU/mL
Glucagon	50-100 pg/mL
Ions/Minerals	
Sodium (Na^+)	135-145 mM
Potassium (K^+)	3-5 mM
Calcium (Ca^{2+})	1.8 mM
Chloride (Cl^-)	106 mM
Phosphorus (*i*) (PO_4^{3-})	3-4 mM

There are many examples of how feedback loops operate in the body that may already be familiar to you. Here is a quick one to get the general idea.

Example of what happens in between meals

A person's blood glucose (**parameter**) has a normal range (**set point**) of between 70 to 100 mg/dL (see table 1.1 above). If a person has not eaten in a while, **their blood glucose decreases**. If it goes below 70 mg/dL, then it falls out of the normal range - this is the **stimulus** for the start of a feedback loop. The person will now have **hypoglycemia**, or low blood sugar (etymology examined earlier). This decrease in blood glucose is detected by receptors in the pancreas, and in response to this decrease, the pancreas releases a hormone called **glucagon** into the bloodstream. This elevated glucagon goes to the liver and stimulates hepatocytes (liver cells) to hydrolyze (breakdown) its glycogen stores to liberate glucose molecules into the blood stream, thereby **increasing blood glucose**. The loop was stimulated by a decrease in blood glucose and the response was to increase blood glucose. This nicely exemplifies the very definition of a negative feedback loop. Also note, once the glucose has been restored back to within its normal range, the signal for more of the hormone glucagon will dissipate and its levels will be reduced back to normal. This is an important element of the negative feedback loop, and functions like an 'off' switch for the loop once balance has been restored.

The Nitty Gritty of the Feedback Loop

What we want to do now is describe feedback loops using consistent terms. To do that we can identify the seven (7) components that create this loop (see below). These components are somewhat arbitrary but allow us to create and use a framework to describe feedback loops. Listed below are the general names of the terms used to describe a feedback loop in detail, whether negative or positive. In the next part, we will examine a specific example and give specific names for each of these general terms.

Here are the General components of the Feedback Loop:

1. **Stimulus** – the change in a parameter (above or below the set point) that starts the loop.
2. **Receptor** – the element or structure that detects this change.
3. **Afferent Pathway** – the incoming pathway used to convey information about this change.
4. **Integration Center** – the site where an evaluation is made about what to do to restore balance.
5. **Efferent Pathway** - the outgoing pathway used to signal a tissue how to respond to this change.
6. **Effector Tissue** - the structures acted upon by the efferent pathway to respond to the stimulus.
7. **Response** - the change that is created by the effector tissue in response to the original stimulus.

The Negative Feedback Loop

Body temperature (T_b) is highly regulated. If you get either too hot or too cold, sensors in the periphery and brain tell the temperature regulation center of your brain - a region called the hypothalamus - that your temperature has strayed from its set point and needs to be brought back within the range.

Specific detailed example of a Negative Feedback Loop

Increased Body Temperature (T_b): Let's examine changes in body temperature using an example of the **body becoming too hot** (see **Figure 1.3** below). A person has been digging in the garden on a hot day, and their body temperature has risen above its set point of about 98.6°F, that is the stimulus which starts the loop that will work to bring it back down into the set point range. The **thermoreceptors** in the skin detect this change and since sensory receptors are specialized endings of sensory neurons, this causes the **sensory pathway** to send this afferent (incoming) information into the **hypothalamus** which is the integration center for thermoregulation. The body's thermostat is located in the **preoptic nucleus** of the hypothalamus, and it sends out information through the efferent **motor pathway** to the effector tissue of the **sweat glands** and **blood vessels** that can help cool the body. The response is **diaphoresis**, or to **increase sweat** (as water vaporizes more heat energy leaves the body) and **cutaneous vasodilation** (increase blood supply to superficial skin, allowing more heat energy to leave the body). The result is a decrease in body temperature. From the description of how the body cools down after being the overheated (above), here is what the negative feedback loop looks when it is filled in as a loop.

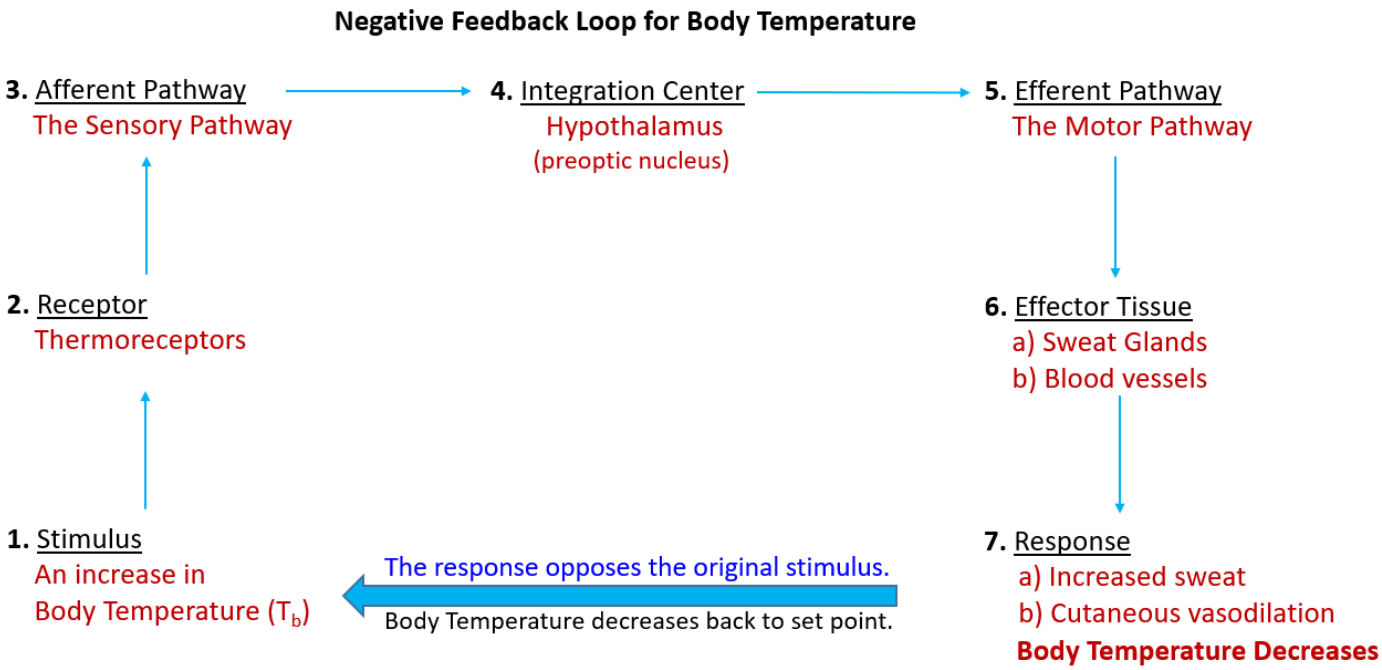


Figure 1.3 This loop or arc, starting from number 1, shows the main components of the negative feedback loop for body temperature regulation when it becomes too hot and needs to cool down. The loop moves from number 1 all around the loop to number 7. Note that the response opposes the original stimulus.

The Positive Feedback Loop

The positive feedback loop is not very common in the body, but that does not mean it is not vitally important to human physiology. Although it can seem to be going 'out of control', ultimately it does maintain homeostasis! Very important examples of positive feedback loops in the body are: **a)** blood clotting from platelet cell aggregation; **b)** sexual orgasm; **c)** opening of voltage-gated Na^+ channels; and **d)** childbirth (shown in the detailed example described below).

Specific detailed example of a Positive Feedback Loop

Childbirth: When the baby in the womb (uterus) is just about ready to be born, the baby's head pushes down upon the cervix of the uterus (see **Figure 1.4** below), **increasing pressure on the cervix**. This stretch is detected by **mechanoreceptors** in the cervix, and this causes the **sensory pathway** to send afferent (incoming) information into the **hypothalamus** and then to the **posterior pituitary** gland which acts as the integration center. The posterior pituitary releases the hormone **oxytocin** into the **bloodstream**, which is the **efferent pathway** that sends out this information to the effector tissue of the smooth muscle of the walls of the **body of the uterus**. The response is **contraction of the uterine wall**, which pushes the baby's head down upon the cervix, **applying more pressure to the cervix**. This intensifies the original stimulus and triggers another round of the feedback loop. In addition, oxytocin increases the release of prostaglandins, which increase the uterine contractions further. This cycle repeats until the baby is born, at which time the signal for the loop is no longer present the cycle is broken and subsequently ends.

A Pictorial Diagram of the Positive Feedback Loop for Childbirth

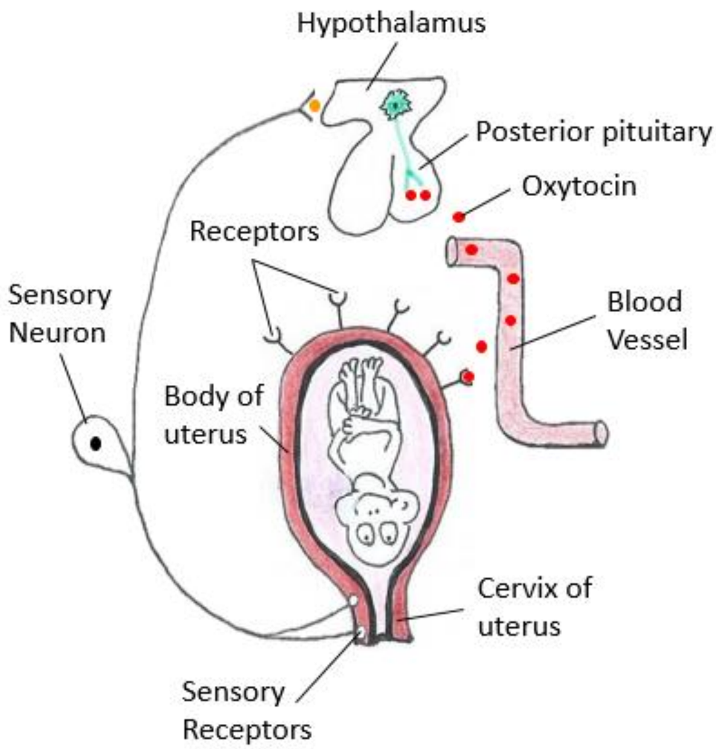


Figure 1.4 This is a diagram of the positive feedback loop involved in childbirth. The loop is started by the increase of pressure applied by the baby's head on the cervix of the uterus, which is the entrance to the birth canal – the way out! The hormone oxytocin is released by the posterior pituitary in response to this increased pressure, it binds to receptors on the smooth muscle of the uterus, triggering contractions of the body of the uterus, which pushes the baby against the cervix, increasing the pressure applied there, stimulating the loop to continue until child birth.

Positive Feedback Loop for Childbirth

1. Stimulus
An increase in
Pressure on the Cervix

2. Receptor
Mechanoreceptors
(Stretch receptors)

3. Afferent Pathway
The Sensory Pathway

4. Integration Center
Posterior
Pituitary Gland

5. Efferent Pathway
Oxytocin in the Blood Stream

6. Effector Tissue
Smooth muscle on
body of uterus wall

7. Response
Contraction of wall of uterus
Pressure on Cervix Increases

The response augments the original stimulus.
More pressure on cervix, cycle then repeats until broken by birth of the baby.

Figure 1.5 This arc, starting from number 1, shows the main components of the positive feedback loop for childbirth with all of the components filled in. The loop moves from number 1 all around the loop to number 7. Note that the response augments or intensifies the original stimulus.

Overview of Physiology Course Introduction

All complex multicellular organisms need the vital functions discussed above to be operating properly in order to survive and thrive. In the next chapter of this text, we will examine the **Levels of Organization** in detail. We will define each of the levels from the simplest building blocks of atoms, all the way to the most complex level of human physiology, which is us, the whole human.

Summary of the Course Introduction

This text for our Human Physiology course focuses on the themes of balance and purpose. As we will see, this starts at the foundational level of simple building blocks, on into the increasingly complex organs and organ systems. We will recognize the power of balance, of maintaining balance, and in this the incredible ability of the highly integrated inner workings of the human body will be revealed.

- With each new section and chapter, we will be able to appreciate the key relationship between **structure** (anatomy) and **function** (physiology) of the body, and the inextricable connection between the two.

- We will recognize the importance of the **language of physiology** (and anatomy), and how knowing the **etymology** (origins) and meanings of the words and terms that are frequently used will be critical to creating and maintaining a deeper understanding of this discipline – it also adds to the enjoyment of understanding this material.

- The fundamental unifying concept of **Homeostasis** ('always changing to stay the same') is how the human organism maintains its stable internal environment despite constant changes, both internally and externally, both large and small. In the study of the systems, discussions of the **Why** (functional) and the **How** (process) will complement each other to give a fuller understanding and appreciation of the complexity and resiliency of the human body.

- In the first part of section one, we will look at the **levels of organization** in more detail as well as the basics of atoms, ions, bonds and molecules. This introduction to the fundamentals is important because it places us on the ground floor as we build up.

- The next critical aspect of section one, before entering into organ systems, is the **plasma membrane of cells**. It is very important for us to try to understand the nature of the boundary of structures, the forces at play that regulate permeability and the transport mechanisms which allow for substances to cross into and out of cells and regions.

Our progress in class will be somewhat int the same order as listed in **Table 1.2** below. It will become more and more clear how the fundamentals we learn in section one are vital to understanding any of the organ systems we encounter later.

There are useful "Class Activities" on the website that act as companions for our study along the way and will allow students to gauge their level of understanding of the specific issues discussed in lecture and presented in this textbook. The specific order and the examples used in each system will be determined by your instructor, but the information discussed in lectures, labs and class activities are contained in this text and integrated into class and lab activities that are designed to support and highlight the details provided here in order to give us an ever-developing view of the big picture.

The Systems Studied in Human Physiology

Table 1.2 The Body Region/Systems we will cover in sequence.

Body Region/System	General Function	Primary Components
Body Chemistry	Metabolic and Homeostatic pathways for regulation of body functions.	Atoms, bonds, molecules, enzymes in metabolic pathways.
Cells/Cell Membranes	Emphasis on transport mechanisms across the plasma membrane.	Phospholipid bilayer theory and transporter proteins.
Nervous System	Communication, control and regulation of body functions over long distances.	Neurons, glial cells, central and peripheral nervous systems.
Muscular System Skeletal System	Support, protection and movement. Skeletal, cardiac and smooth muscle.	Bones, cartilage, tendon and contractile muscle.
Special Senses	The senses are specialized organs, the eye for vision, the ears for hearing, etc.	Eyes, ears, olfaction (smell), equilibrium (balance) and taste.
Cardiovascular (Circulatory) System	Blood moving throughout body through the heart via blood vessels for transport of vital nutrients, wastes and gases.	Heart, arteries, arterioles, capillaries, venules, veins.
Lymphatics	Return of excess tissue fluid to the blood. Lymphocytes helps protect the body, repair and remove cellular debris.	Lymph vessels, ducts, nodes, tonsils, spleen and thymus.
Respiratory System	Ventilates and provides surface for gas exchange to deliver oxygen to the blood and remove carbon dioxide from the body.	Nose, nasal cavity, trachea, bronchial tree, alveoli (lungs).
Digestive System (Laboratory)	For ingestion and propulsion of food and liquid through gastrointestinal tract where digestion occur for nutrient absorption and waste excretion.	Mouth, esophagus, stomach, small intestine, large intestine, liver, pancreas, including enzymes and other substances.
Renal System	Kidneys filter blood to balance water, pH and ion levels, remove waste from blood to make urine, stored in bladder until excreted. Also produces hormones.	Kidney, ureters, urinary bladder, and urethra.
Endocrine System	Communication throughout the body controls many functions, including metabolism, growth, and development.	Pituitary, thyroid, adrenal, pineal, parathyroid glands, and pancreas.
Reproductive System	The gonads are ovaries (females) and testes (males). They are responsible for producing gametes, eggs/ova (female) and sperm (males), and making sex hormones to maintain and develop gametes and secondary sexual characteristics.	Ovary, uterine tube, uterus, vagina. Testes, epididymis, ductus deferens, glands, urethra, penis.

Review Questions for Chapter 1: Introduction to Physiology

1. The root meaning or the origins of a word, is called what?
- **a)** homeostasis
- **b)** definitions
- **c)** medical terminology
- **d)** etymology
- **e)** philosophy

2. A good way of thinking about **Homeostasis** in the body is:
- **a)** Constantly staying the same and never changing.
- **b)** Always randomly changing.
- **c)** Constantly changing to stay the same.
- **d)** Maintaining outer imbalance regardless inner of stimuli.

3. The term **hypernatremia** means:
- **a)** Blood glucose that is too low
- **b)** Abnormally high levels of sodium in the blood
- **c)** Exaggerated levels of sodium in body fluids
- **d)** Abnormally low levels of sodium in the blood
- **e)** Abnormally low pH of blood

4. With regard to homeostasis, the term '**set point**' for a parameter (e.g., pH of blood) means:
- **a)** The normal range of a parameter as it exists in the body.
- **b)** The exact value that the parameter must be in the body at all times.
- **c)** The receptors that relay information about that parameter.

5. The afferent pathway in a <u>negative</u> feedback loop
- **a)** carries outgoing information to effector tissue
- **b)** brings incoming information into the integration center
- **c)** processes and integrates sensory data
- **d)** involves the response of the effector tissue
- **e)** is concerned with detecting any changes in the set point by using receptors

6. In the positive feedback loop of childbirth, <u>receptors</u> detecting changes in pressure of the cervix are:
- **a)** the stimulus
- **b)** oxytocin
- **c)** thermoreceptors
- **d)** the pituitary gland
- **e)** mechanoreceptors

7. Which of the following is <u>not</u> considered a part of the digestive system?
- **a)** The mouth and stomach
- **b)** The liver and the pancreas
- **c)** The pituitary gland
- **d)** The large intestine

8. Which of the following act as the <u>integration center</u> in the positive feedback loop of childbirth?

- **a)** hypothalamus
- **b)** stretch receptors
- **c)** thermoreceptors
- **d)** posterior pituitary gland
- **e)** oxytocin

9. For the reproductive system, what are the gonads?

- **a)** The sex hormones.
- **b)** The sex cells the egg and the sperm.
- **c)** The secondary sexual characteristics for men and women.
- **d)** The ovaries and the testes.
- **e)** Both a and d

10. What would be the best statement about the normal pH of the blood in the human body?

- **a)** It is constantly changing to stay the same.
- **b)** It should be a pH of about 7.
- **c)** It exists in a range between 7.35 and 7.45
- **d)** It fluctuates but is always above 7.0
- **e)** It exists in a range between 7.25 and 7.35

Answers in Appendix B