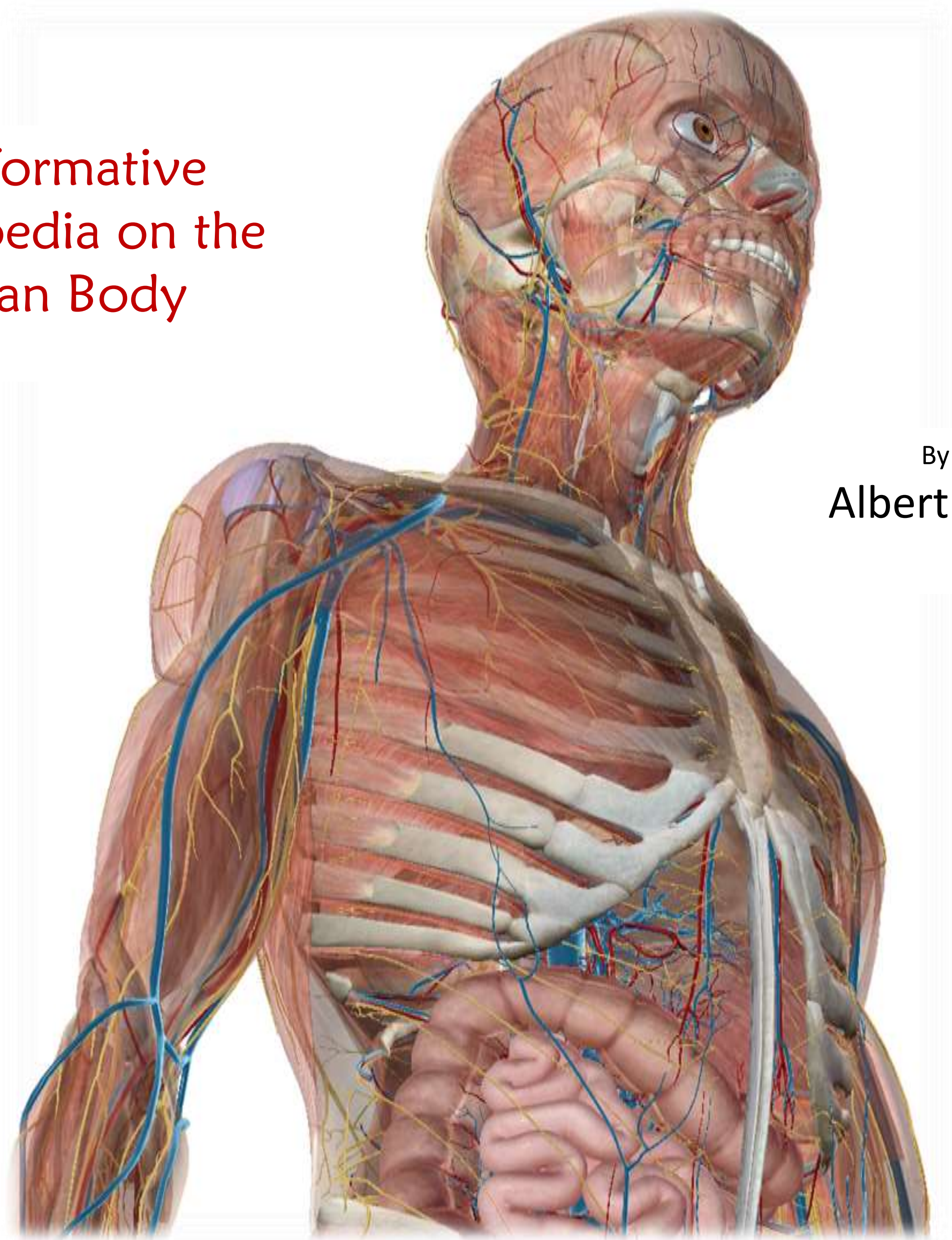
HUMAN BODY ENCYCLOPEDIA

An informative encyclopedia on the Human Body



By
Albert Nitu

Author's preface
Dear reader,

My name is Albert Nitu, and I'm a twelve year old boy.

The book you are holding in your hands right now is written because of my interest and passion for anatomy, and is dedicated to all people who also have a curiosity for knowing what's inside *us* and how *we* work.

My passion of anatomy and the Human Body came at the age of 9, when I attended a dissection course at a program called *A.B.C.* (Association for Bright Children) and I found it incredibly interesting and fascinating, which in turn started by "anatomy" career.

To follow up with my passion, I dedicated myself to writing a book on the Human Body, detailing about all my understandings and knowledge about this vast, but infinitely intriguing subject, while still being disciplined enough to keep up with other more *pressing* activities.

So for 3 long years, I wrote and wrote my book, never thinking *when I was going to finish*, but thinking *what I was going to achieve*. And after three tiresome years, the answer has finally come to me, and I realize now that I've achieved everything I wanted, from finishing this book, to learning all about the Human Body, which is why I now invite you to "dive into" this book and do the same.

However, not only have I achieved my dreams and wishes, but I've also learned that no matter how crazy and far-fetched an idea can be, it can eventually be achieved by hard work, dedication, and perseverance as well as when you are truly determined to achieve your goal.

In conclusion, throughout this wonderful once-in-a-childhood opportunity, I have not only learned innumerable things about the way we work, how we function and what were made out of, but I've also been taken through this wonderful journey that illustrates and animates all my interests, passions, and achievements, and I hope that this book will succeed in taking you down that path too…

Tell me and I forget,
Teach me and I remember,
Involve me and I learn.

- ***Benjamin Franklin***

Preface to Albert Nitu's Human Body Encyclopedia
by Colette Brooks

Albert Nitu is a one-of-a-kind author. In 2015, as I write this preface to Albert's "Human Body Encyclopaedia", Albert is twelve years old and has just completed grade six. I am proud to say that I am (or was, as the school year has ended) Albert's grade six teacher, in the Gifted Early French Immersion programme at Hilson Avenue Public School, in Ottawa, Ontario, Canada. That is not to say, however, that I taught Albert everything he knows; no, far from it! In fact, I may actually have learned more scientific information from Albert than he did from me!

Albert's interest in anatomy began at the young age of nine, after attending a dissection course at the Association for Bright Children (ABC Ottawa). He continued his research, taking notes from texts and drawings. Albert's wonderfully supportive parents, Corneliu and Loredana Nitu, suggested that Albert organize his discoveries in a "book". Over the next three years, Albert's interest in human anatomy steadily increased, as did the information contained in his "book". Albert's perseverance and sustained interest in natural sciences has resulted in the "Human Body Encyclopaedia" that you are now reading!

Albert is an undeniably gifted and talented person in many realms, with an unquenchable thirst for learning. Albert is a talented musician, mathematician, historian, and he fluently speaks several languages - English, French and Romanian. Did I mention that he is twelve years old! I would most humbly like to think that I at least helped, throughout the school year, to inspire Albert in his pursuit of knowledge and that I hopefully helped to encourage him to continue his mighty quest for scientific discovery.

In this publication, you will enjoy reading Albert's in-depth research, and viewing the detailed illustrations about every physiological aspect of the human body, including it's history! It is an interesting, well-organized and informative read, a go-to text for learners of all ages!

Albert is already a very accomplished young man. His unlimited passion and enthusiasm for life and learning will, one day I am sure, help change the world for the better. He is a born leader who will teach and inspire others - whether that be through his dreams of becoming a surgeon, a professor or a business professional, Albert Nitu will be a recognizable name among the best minds and leaders of the future!

Congratulations, Albert, on this magnificent "Human Body Encyclopaedia", and my very best wishes for continued success in all your future endeavours! I am very proud of you and feel most fortunate and honoured to have been your grade six teacher!

Madame Brooks

Contents

1 Introduction

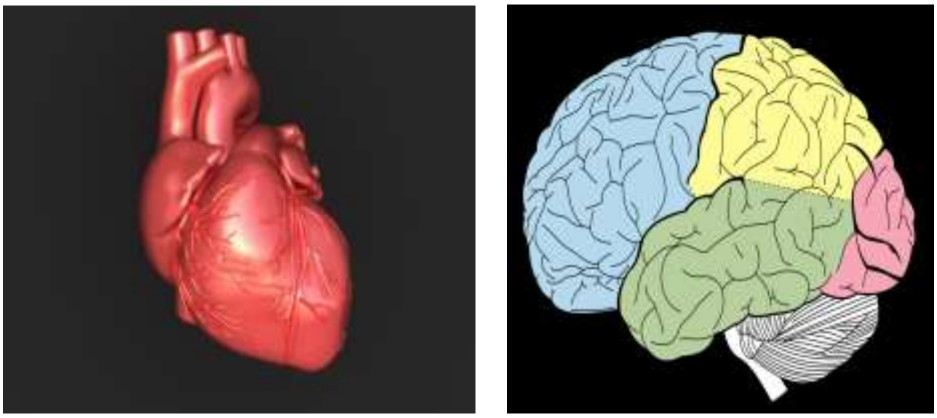
From the longest foot nail of our body, to the longest hair, the human body is the most complex living object in the world today. Our body works 24 hours a day, 7 days a week, 24 hours a day, non-stop to keep us alive.

Even as you read this paragraph, or even this word, the trillions of cells that you are made up of are all collaborating to keep you healthy and alive while all your systems provide you with every decision, movement or thought you have.

We can't see most processes of our body since most of them lay hidden beneath the skin, but some processes such as movement or blinking can be seen externally.

The study of the human body is classified by scientists and doctors in a big category called Biology. Biology is the scientific study of all living things. The human body belongs to a lot of other small categories (often referred to as branches) of the science of Biology such as: Anatomy, Physiology, Psychology and more.

Anatomy concerns of the structure of a living object, Physiology is the branch of Biology that concerns of the functionality of living beings and Psychology studies the brain and behavior or in scientific terms, cognitive processes.



The heart and the brain are some examples of organs that you might know.

This book describes the fundamentals and building blocks of the human body and is split up by describing all of the systems of the body in detail, presenting information, interesting facts, and tips about each system. At the end of each chapter, there is a quiz, exercise, or an activity that can be done to refresh your memory on that particular system.

All in all, at the end of this book, the hope is that you've deepened your understanding of the vast topic of the human body as well as activating your inner curiosity to delve deeper into this wonderful topic.

ENJOY!

2 History of the human body

2.1 The Egyptians

Mummification

The Egyptians were the first civilization to develop a real interest of the human body.

When a Egyptian died he/she went through a process called Mummification.

Firstly, the patient went through a process called Embalmation. The body was brought to a tent like building often known as the Place of Purification, where the Embalmers (workers) rubbed good smelling liquids such as wine on the body and then would rinse it.

Next, another set of the Embalmers would cut a line on the left side of the patient and remove all the organs except the heart. This is one of the most important steps because the organs and blood are the first to decompose. The heart was not removed as the Egyptians thought that it was the center of human intelligence and they will need it in their afterlife.

The removed organs were then dried out using a substance called Natron. The brain was taken afterwards with a long hook out the Nasal cavity. (Nose)

The next thing to do is that the whole body will be stuffed with Natron, preserving all the bodily fluids.

After about 40 days, the body is washed with water. Oil is also rubbed on the skin to keep it elastic after burial.

In the early Egyptian civilization, the dehydrated organs would have been put in jars called Canopic jars. Each jar corresponded for a specific organ.

Later on in the Egyptian civilization, the organs that were dehydrated were put back into the body and the body would be stuffed with dry substances. However, the Canopic jars still existed and now symbolically protected the organs.

Good smelling oil will again be secreted onto the body.

Now, after the body was dried and cleaned, it is wrapped in Linen. First, the neck, head and limbs are wrapped and then the fingers and toes.

The Embalmers now place Amulets and religious figures around the body, which are believed to help the patient in his afterlife.

A spell is read out loud by a priest which will help the patient make the journey to the afterlife but as well as ward off evil spirits. While this is done, the body, now a mummy, is wrapped. Resin, a substance, helps glue the linen together.

The arms and legs, which were wrapped in linen separately, are now tied to the body along with scrolls containing spells.

More linen is wrapped around the body and Resin is applied again to glue the layers of Linen together.

The last step is to place the mummy into numerous layers of coffins. Depending on their wealth status people would be processed with more or less care. The pharaohs, the rulers of Egypt, would be buried with gold and other luxurious amenities.

A Pharaoh's coffin

Cures

Egyptians also were fascinated in cures for numerous diseases. An example of an Egyptian cure is eye polish, that Egyptian men and women might have worn to prevent having eye infections. Although Egyptians had some cures, most of them were mostly riddles and praying to the numerous gods.

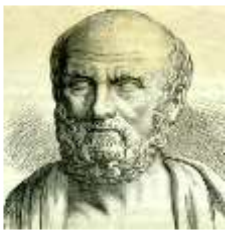
Caring of the sick in Egypt.

2.2 The Greeks

Greek anatomy was a mix of spiritual and actual knowledge and was practiced even in 1000 BC. In fact, the Greeks themselves were inspired by the Egyptians!

The best-known Greek doctor, Hippocrates, also known as the father of modern medicine, was the first person to describe numerous illnesses and diseases.

Hippocrates was born in 460 BC coming from a family in which medical practice was passed on from father to son. This family was called the Asclepiad family and was believed to be priests or represent the Greek god of medicine, *Asclepius*.



Sketch of Hippocrates

The goal of Hippocrates was to better understand medicine and to allow everyone to have medical treatment.

He was also the person who created the expressions *acute* and *chronic*, which are still in use today.

2.3 The Romans

The Romans were also fascinated in the human body.

Claudius Galen was a famous Greek born, Roman gladiator surgeon. Later on, (in 160 AD) he traveled to Rome and became a doctor, with a thought in mind of earning fame.

He would thoroughly examine his patient and would note his observations.

In his free time, Galen improved his knowledge by dissecting animals such as apes, pigs, and noting the location of their organs and the structure of their systems. But since he based his research on animals, most of his observations were wrong. Here are some of his discoveries:

- Urine is formed in the kidneys as oppose to the ancient belief that it was formed in the bladder.
- Arteries **contain** blood and that blood passes from right to left in the body.
- Blood is passed right to left in the body by small pores located on heart. (This is not actually true)
- The Liver produced all the blood. (Not true either)
- Blood is carried around the body only by the veins and the arteries carry a spirit referred to as Pneuma as well as blood.

Later on, while still living in Rome, he was hired as the personal physician of the Rome's emperor Marcus Aurelius.

Galen's focus on the human body was circulation of blood, and the physiology of the nervous system.

Sketch of Galen

2.4 The Renaissance times and higher

In the late 15th century, Leonardo Da Vinci, an Italian artist, discovered numerous facts about the human body. However, his books were never published until 1543 when a Flemish doctor by the name Andreas Vesalius published Leonardo's book called *On the structure of the Human body*, for the use of medical students.

Wooden models were also made as reference tools/guides for medical students.

Then, in the 1750's until the 1800's snatching dead bodies from graveyards for medical students to dissect was popular in some countries although it was illegal.

Wax models were also made in some countries as a reference tool/guide for medical students around the 1800's.

This is a wax model displaying the muscles and arteries of the face.
It was made in 1780 for the use of medical students.

3 Looking inside

It is difficult to tell a lot about ourselves by looking at the exterior of our body. To observe the interior of the human body, we use different methods.

3.1 X Rays

X-rays were invented in 1895 by a scientist named William Roentgen.

He unintentionally discovered X rays while experimenting with electrical currents. He mistook particles of Cesium that he was using for unknown rays, therefore calling it X rays. X was referring to unknown.

His first clear image of X rays is a picture of his wife's hand. Since then, X rays were used all around the world for numerous reasons.

An image of the first clear X-rays photo.

3.2 CT Scans

In a CT scan (Computed Tomography), beams of X rays are directed through the body then picked up by a computer. Next the computer analyses the beams and create a picture.

CT scans create slices of images and can be very useful to locate strokes, tumors and cancer.

A CT scan image.

3.3 Ultrasound

In an ultrasound operation, high pitched beams of sound are sent into the body. These bounce back and are picked up by a computer then turned into an image.

Ultrasound is an ideal way to look at a developing baby because it is very safe, not affecting the baby's development.

An ultrasound image of a faetus

There are more ways to look inside our bodies. Other methods can be MRI scans (Magnetic Resonance Imaging), endoscopes and many more.

4 Cells

4.1 Classification

The body is created of trillions of cells. Cells are microscopic, and therefore can't be seen without a microscope. Blood cells are only visible at 400x magnification while the largest kind of cell (egg cells) can hardly be seen without a microscope.

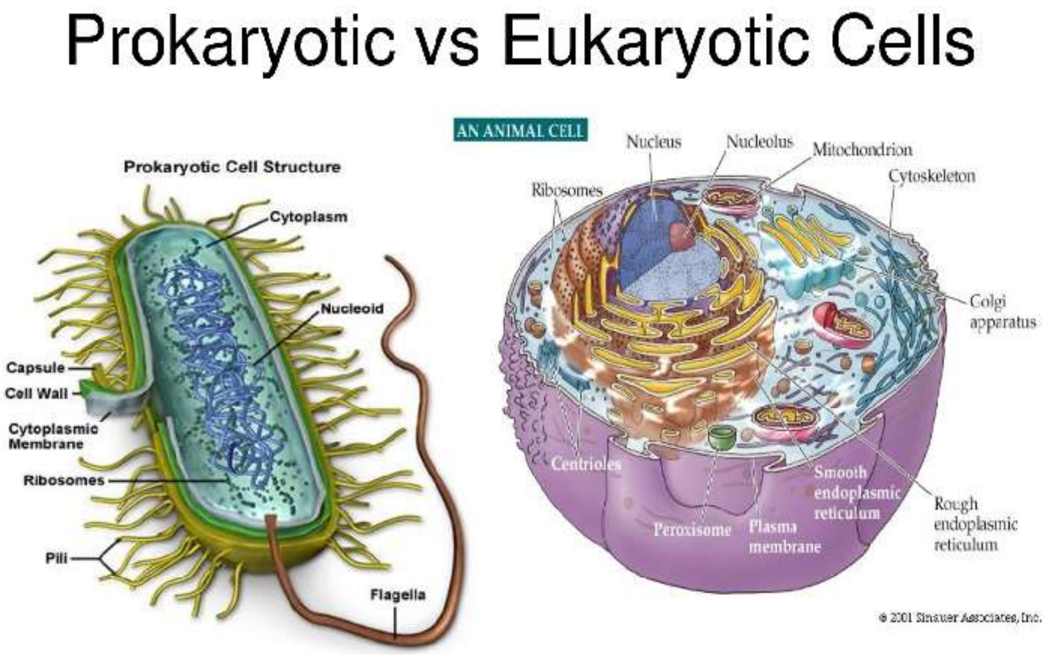
The cells were discovered by Antoine Van Leuwenhoek in 1670 when he discovered sperm and red blood cells.

A magnified human stem cell

There are 2 kinds of cells, Prokaryotes and Eukaryotes.

Prokaryotes are the simplest type of cell and the oldest. They are smaller than Eukaryotes and only contain the Cellular membrane, the Cytoplasm, Pili, Ribosome's and the Nucleoid. Prokaryotes are the cells that form bacteria.

Eukaryotes are cells that form animal tissue, and were first created approximately 1.6-2.1 billion years ago by evolving from Prokaryotes. They have additional organelles (Pg. 12) such as the Golgi complex, Mitochondria, Endoplasmic reticulum, Centrioles, and the Nucleus.



A comparison of a Eukaryote and a Prokaryote

Stem cells

Stem cells are unique as they can transform into any kind of cell and reproduce and create other stem cells.

In medical practices, stem cells proved to be useful to regenerate tissue or to provide the body with blood cells for a long period of time.

There are two main kinds of stem cells, embryonic stem cells, and adult stem cells, but despite their name, adult stem cells are found in children as well.

Adult stem cells

Adult stem cells are mostly found in bone marrow and are used to treat patients with spinal cord injuries or heart disorders.

Adult stem cells found in bone marrow, are believed to be able to transform into liver, skin and lung tissue.

Embryonic stem cells

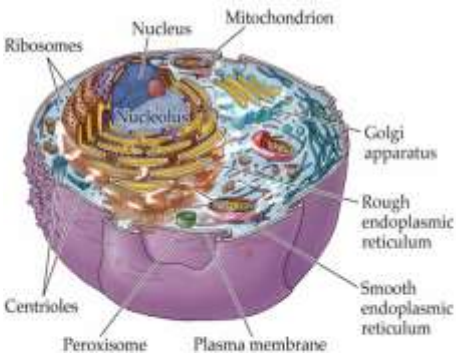
Embryonic stem cells are created in the very early stage of an embryo. These stem cells can transform into any of the 200 kinds of cells when necessary.

4.2 Cell structure

An animal/Eukaryote cell consists of numerous objects called organelles.

Organelles are located in the interior of the cell's nearly spherical-like structure and provide the cell with energy, get rid of dead organelles, create and store proteins or DNA and much more.

Several organelles that are found in the interior of a Eukaryote are: the Nucleus, Mitochondria, the Golgi complex, Ribosome's, the Endoplasmic reticulum, Lysosomes, and Centrioles.



An image of an animal cell

The **Nucleus** is like the capital of the cell. It contains most of the cell's DNA and is wrapped by a membrane known as the nuclear membrane/envelope. The nuclear membrane separates the nucleus' interior from the liquid cytoplasm.

The cytoplasm is a liquid located in the interior of the cell. It has 2 main functions:

- The cytoplasm supports the cells structure by keeping the cells form
- It also helps at holding the organelles of the cells.

The cytoplasm is created of 80% water and contains various salts.

Mitochondria (Plural: Mitochondrion) provide the cell with energy, particularly when the cells reproduces.

Mitochondria also contains DNA, but it is only the mitochondria's instructions. Although Mitochondria contain the same amount of DNA, the amount of Mitochondrial DNA in a cell might vary, due to the number of mitochondria found in the cell.

The **Golgi complex** is named after the Italian man who discovered it, Camillo Golgi. The Golgi complex organizes, identifies, modifies and sends macromolecules (Proteins, fat), which it receives from the endoplasmic reticulum to its needed destination. It is also involved in producing Lysosomes.

Lysosomes are organelles that digest dead or worn out organelles, extra fats, proteins, and as well as bacteria that unintentionally entered the cell.

The word "Lysosomes" comes from Greek word "Lysis" meaning destruction and "Soma" meaning body.

The **Endoplasmic Reticulum** creates proteins and fat and then sends them to the Golgi complex where they are processed.

In the cell, there are two kinds of endoplasmic reticulum's. The rough endoplasmic reticulum creates proteins, while the smooth endoplasmic reticulum creates fats.

Ribosomes are the organelles in the cell that create numerous proteins that each has a different purpose in the cell.

Ribosomes can be found floating freely around the cytoplasm of the cell or on the rough endoplasmic reticulum.

Centrioles: Centrioles are organelles that contribute in cell division by producing microtubules that aid in Metaphase. (See 5.5 for more information)

4.3 DNA

DNAs are microscopic strands containing every instruction of the body and determine how you look. In fact, all humans contain 99.9% of the same DNA.

4.3.1 DNA structure

DNA is composed of numerous parts.

The first part is called the **sugar phosphate backbone**. It is constructed of 2 basic molecules: a sugar molecule and a phosphate molecule. The sugar phosphate backbone helps keep the DNA's shape and also supports the nitrogenous bases.

The **nitrogenous bases** are essentially the body's programs, because they are like the actual "letters" of the DNA program.

There are 4 types of nitrogenous bases: Adenine, Thymine, Cytosine and Guanine.

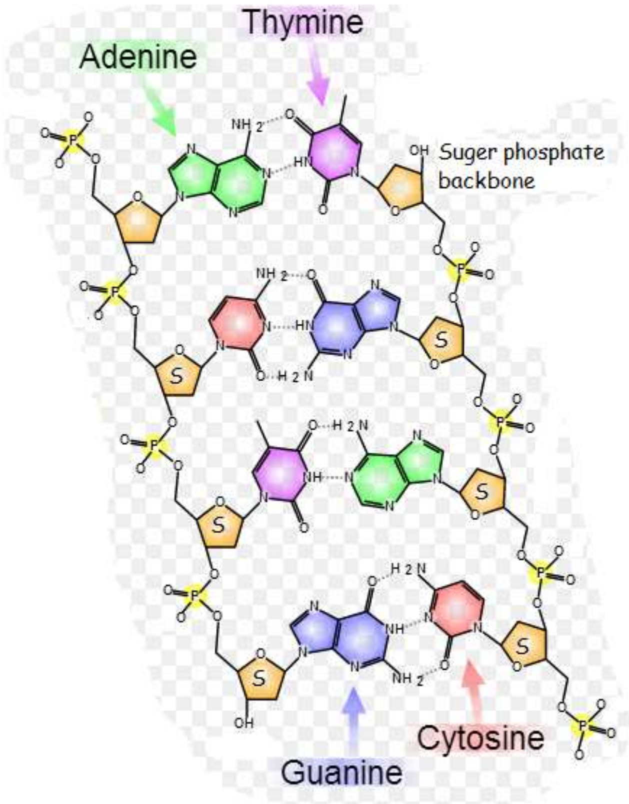
Each base has a permanent partner; Adenine (A) and Thymine (T) go together and are referred to as the A-T pair. Cytosine (C) and Guanine (G) also pair and are referred to as the C-G pair.

Note: A can only go with T and C pairs only with G.

Holding the nitrogenous base pairs together are Hydrogen bonds.

Hydrogen bonds are formed when a Hydrogen atom located on any base is attracted by a oxygen or nitrogen molecule located on its base pair.

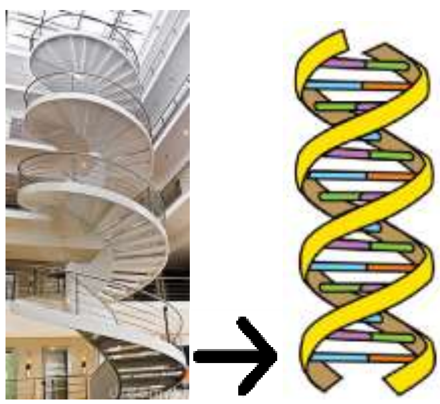
Note: The A-T base pair contains only 2 hydrogen bonds while the C-G pair contains 3.



The image of the components of DNA

DNA's form is a double helix- this allows there to be more DNA stored in the Nucleus than if DNA where to be uncoiled.

Double helix shape is more or less a spiral shape or also in the form of a twisted staircase.

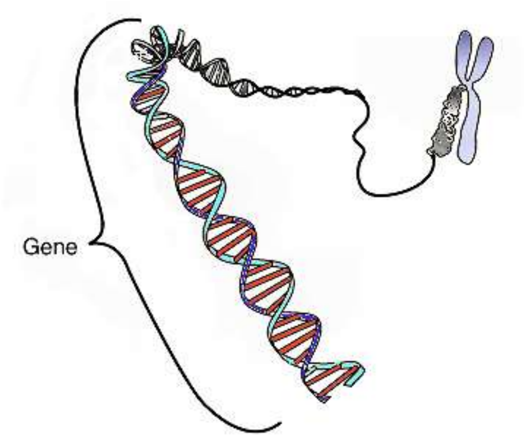


Comparison between a helical staircase and DNA

4.3.2 Genes

DNA is divided in multiple parts called genes. Genes are the instructions for a specific trait such as eye or hair color.

Some genes are more complicated than others, therefore, the length of a gene can differ throughout a strand of DNA.



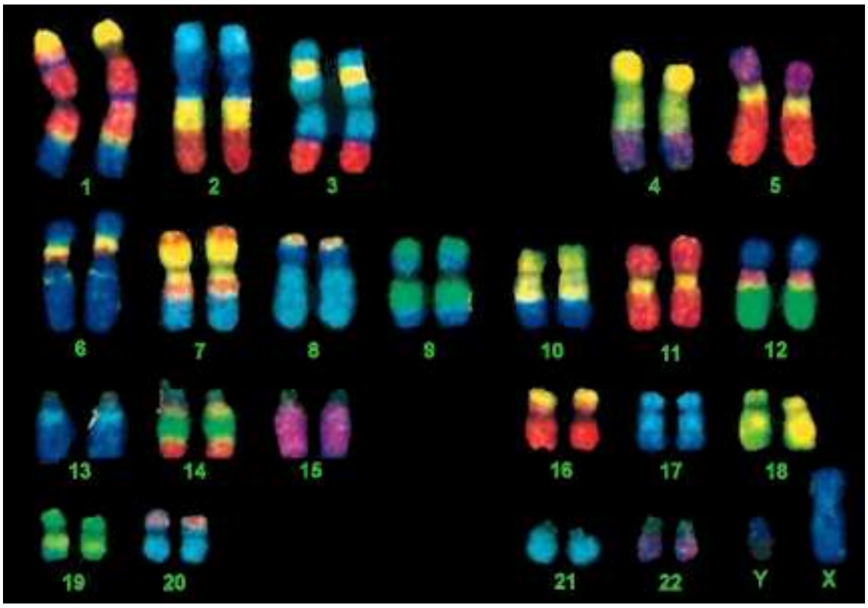
The image of a gene

Genes fall in the science of genetics, which is known as the most complicated of all science groups.

4.4 Chromosomes

Chromosomes are the much better known format of DNA, although they only form during Mitosis.

Humans have 23 pairs of Chromosomes - 23 Chromosomes received from each parent. Each Chromosome has 2 strands, one from the mom, and one from the dad.



An image of the 23 pairs of Chromosomes

Note: In reality, the 2 strands displayed for every Chromosome are joined together.

There are 2 different types of Chromosomes, autonomes and sex Chromosomes.

Autonomes are “normal” Chromosomes, determining everything except for gender. In the body, there are 22 pairs of Autonomes.

Sex Chromosomes determine which gender you have. There are 2 sex Chromosomes, X and Y, although females only have X Chromosomes and males have X and Y.

Note: You only have 1 strand for Chromosome X and Y.

4.5 Mitosis

Cells don‘t live forever, so in order for the body to have cells, cells need to reproduce.

Cellular reproduction is called mitosis. Mitosis has 4 basic steps, each one of them contributing equally in the process of creating a new cell.

- Prophase
- Metaphase
- Anaphase
- Telophase

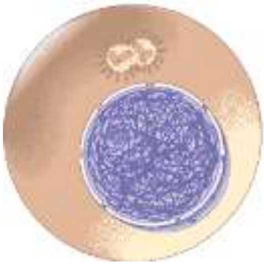
Although there are four steps in mitosis, there are two more steps that also help create a new cell:

- Interphase (Before mitosis)
- Cytokinesis (After mitosis)

Interphase

During Interphase, organelles called centrioles (See picture, pg. 14) split in 2, creating centrioles.

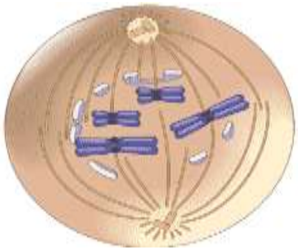
The centrioles slowly move to the opposite sides of the cell and along the way, they create strands of protein called microtubules. The microtubules will help to align the chromosomes in metaphase.



An image of the cell during Interphase

Prophase

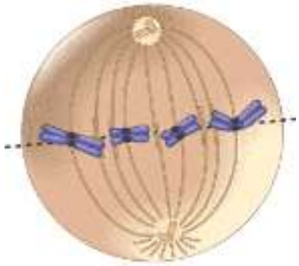
During Prophase, Chromatin transforms into Chromosomes and the Nuclear envelope dissolves, leaving the DNA free in the cell.



An image of the cell during Prophase

Metaphase

In Metaphase, the 23 pairs Chromosomes align in the center of the cell and the microtubules attach to both sides of the center of each Chromosome (Kinetochore).



An image of cell during Metaphase.

Note: In the image, there are only 4 Chromosomes displayed instead of 46.

Anaphase

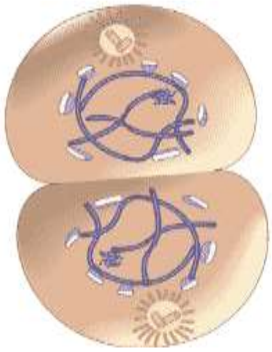
After the microtubules connect to the kinetochores of each Chromosome, they shorten by contracting and split the Chromosomes in two parts. The 2 parts of the Chromosome are now called sister Chromosomes.

An image of the cell during Anaphase

Telophase

Telophase is the last step of Mitosis and is when the Nuclear envelope starts to regenerate around the Chromosomes which start uncoil and transform back into Chromatin. The microtubules also disappear.

Cytokinesis (Next paragraph) also happens in Telophase.



The cell during Telophase

Cytokinesis

Cytokinesis is not considered a step of Mitosis, however, it is essential to cellular reproduction.

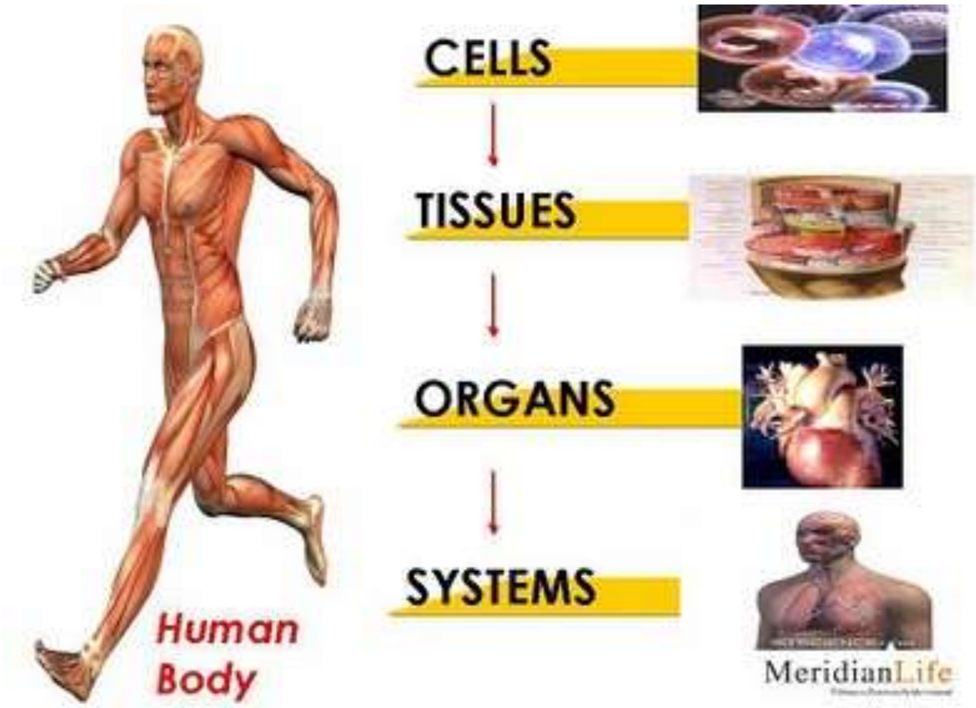
During Cytokinesis (starting in Telophase), a protein referred to as Septin creates a ring of Actin filaments called a contractile ring around the middle of the cell.

Next, the contractile ring contracts, pulling the membrane of the cell inwards. After the cell is done splitting, the 2 new cells are now called daughter cells.

5 The study of systems

5.1 Classification

The body is composed of 10 unique systems that work all together to form the human body. Systems are formed by organs, which in turn are formed by tissues, and the list goes on.



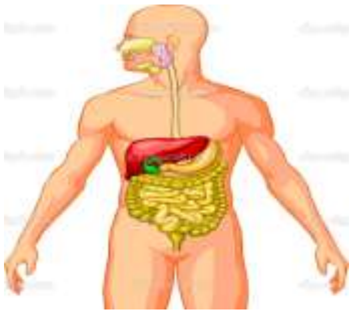
An image of cells creating tissues that make up organs, which form a system.

Although each system does a different job in the body, they all collaborate to form the human body.

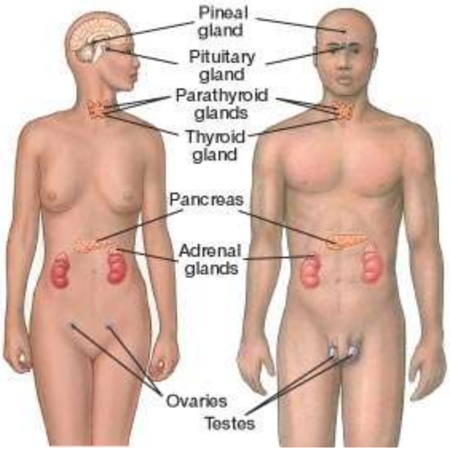
In total, there are 10 systems:

Skeletal, Muscular, Circulatory and Nervous system


Respiratory system

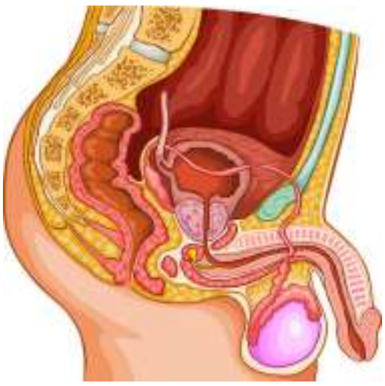

Digestive system


Lymph system

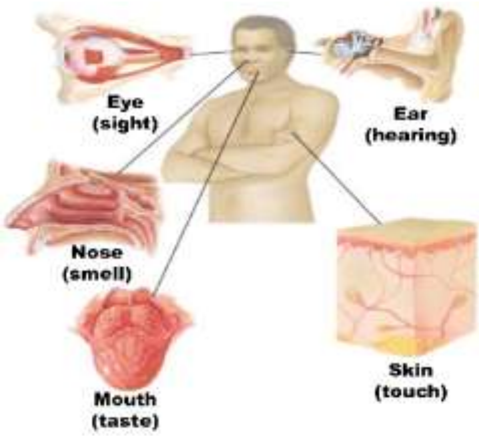


Endocrine system


Urinary system


Men reproductive system


Female reproductive system

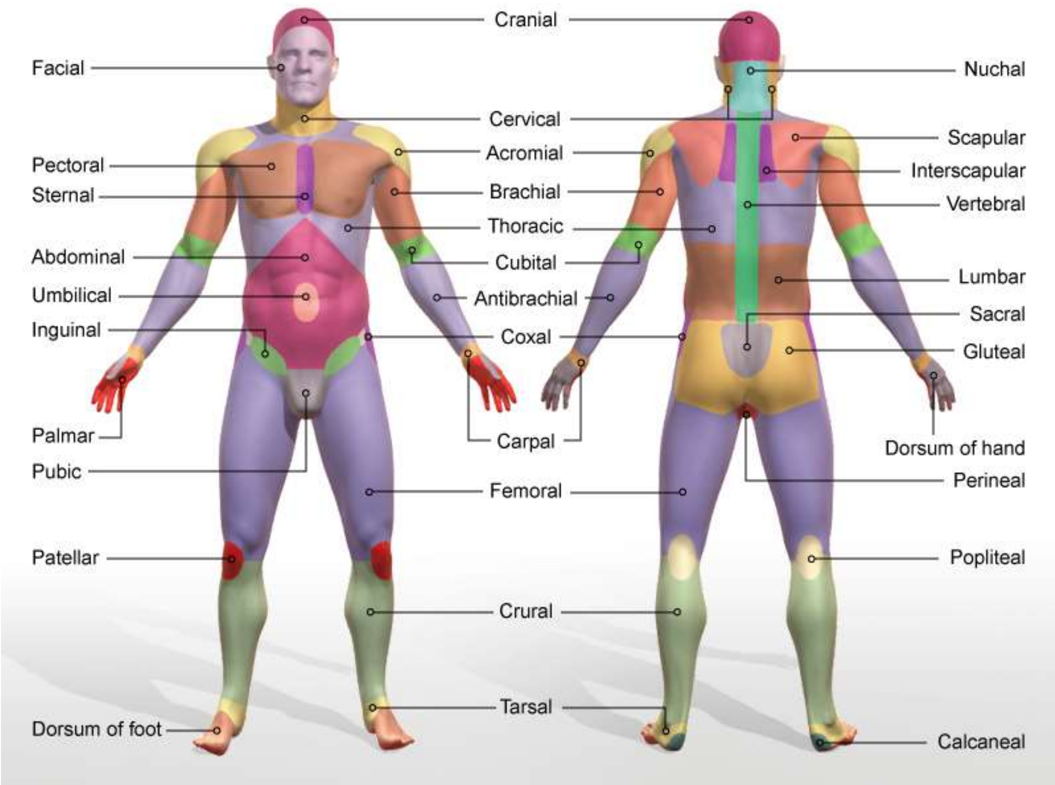


Sensory system

5.2 Anatomical language

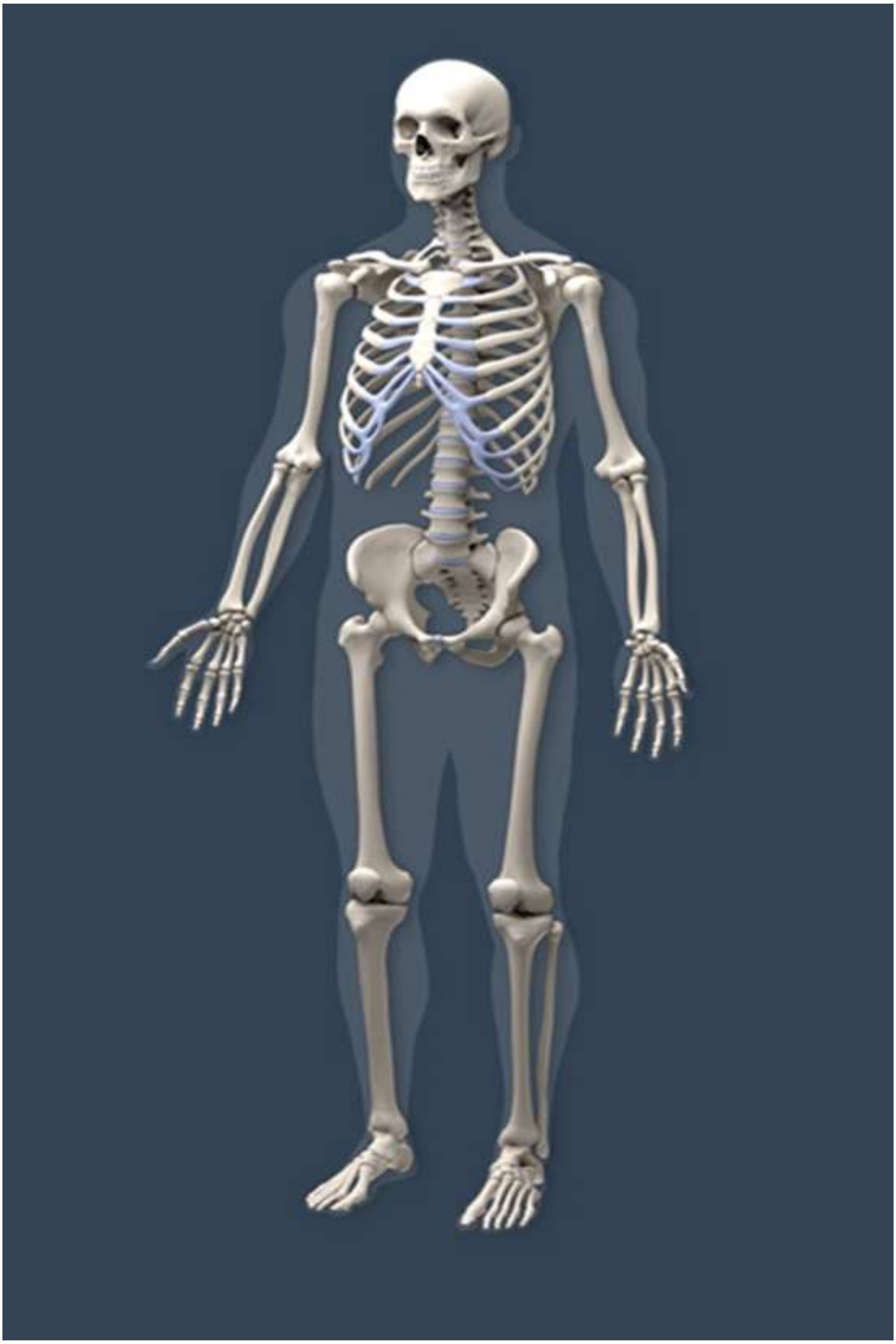
To avoid confusing doctors while describing a report of the patient by using normal English, doctors classify different parts of the body as different names. This is called anatomical language.

For example instead of reporting that a patient feels pain at the back of the knee, a doctor would say that the patient is feeling pain in the Popliteal region.



The main external regions of the body

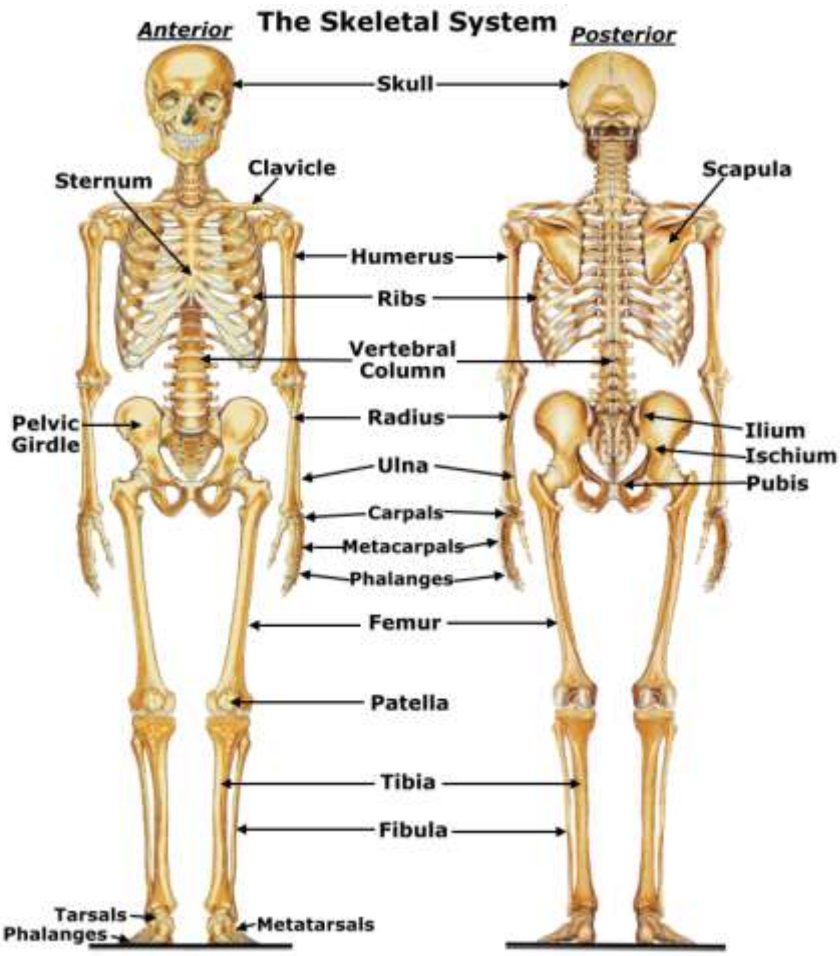
6 The skeletal system



6.1 The Skeletal system as a whole

Together, all the bones in the body form the Skeletal system and when they interact with other systems, they allow the body to move.

But firstly, to better understand the Skeletal system itself, we need to see how every bone interacts with the others.

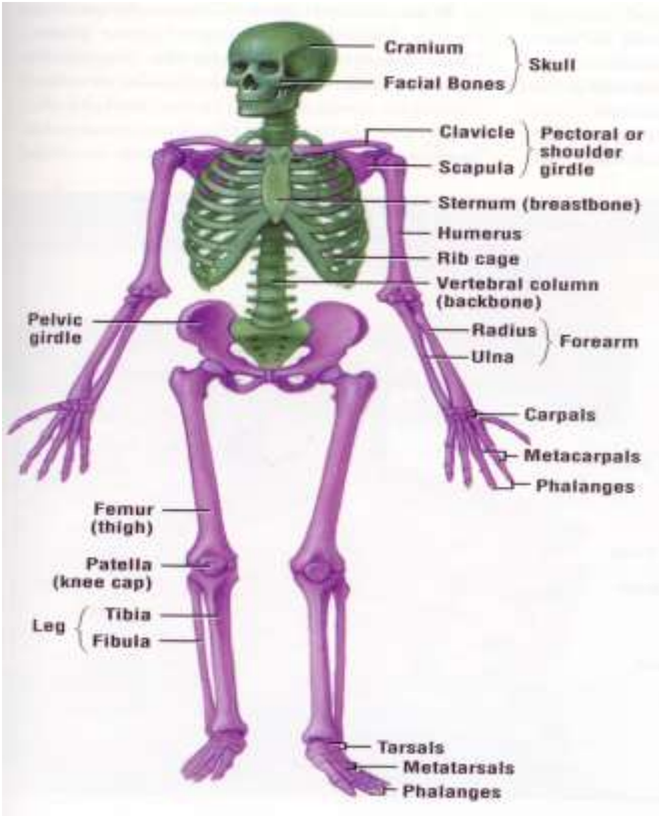


An image of all the bones in the body.

The skeletal system is composed of more than 200 bones and 900 ligaments that support the human body and prevent it from collapsing.

As your body is young your bones are very weak and are easy to break. But over time, your bones grow bigger and stronger, and harden.

In the human body, there are 2 types of bones: Appendicular and Axial bones.



An image of all the main bones in our body.

Axial= Spine chest and the head.

Appendicular bones= Limbs and hips. (Pelvic girdle)

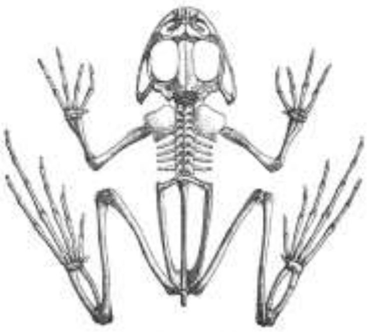
6.2 The Animal Skeletal system

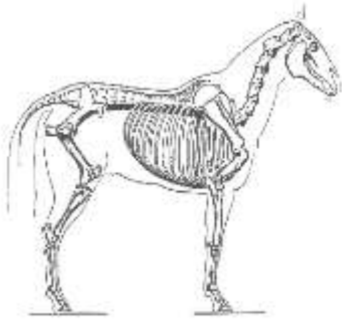
Animals or living objects that have a spine are called vertebrates. The ones who don't have a spine are called invertebrates.

Almost all of the common animals we see day by day are vertebrates. Naturally, that means that they also have a skeletal system. Here are the Skeletal system arrangements of several common animals:

Dog

Cat


Frog


Horse

In some animals such as numerous bugs, the skeletal system is found on the outside. This means that it has an *exoskeleton*. Several bugs with these characteristics are grasshoppers, ladybugs or beetles.


The visible exoskeleton of bugs.

6.3 Joints

Joints are the location where two bones join together. In the body, there are different joints enabling the body to do different actions. There are 6 main joint types in the body.

Pivot joint: As the name suggests, the pivot joint allows you to pivot/turn. One of these joints is located at the top of the spine.

Ball-and-socket joint: This joint is found at the top of the arm and is the most “flexible”, as it allows the arm to move in any direction except backwards.

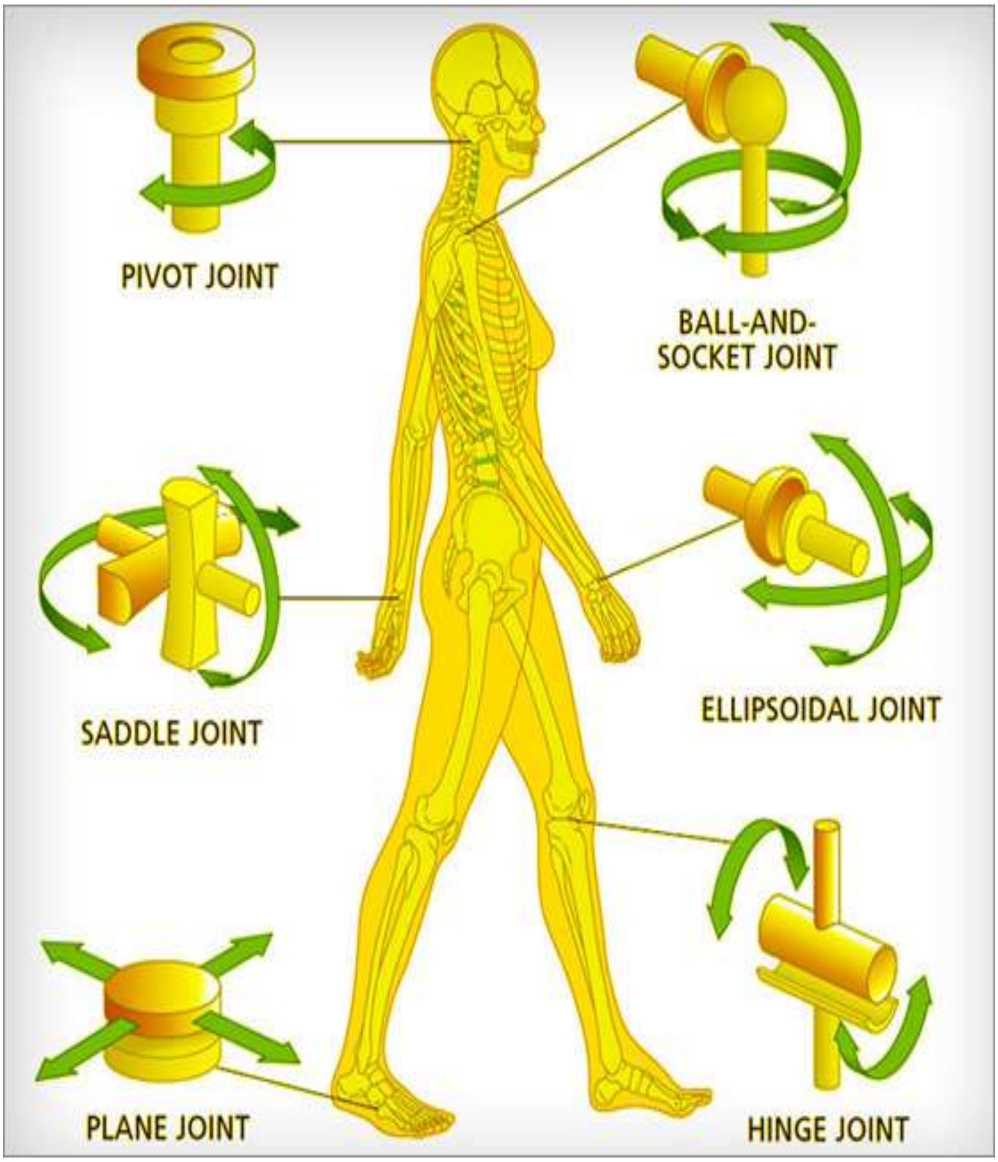
Saddle joint and **Ellipsoidal joint**: These 2 joints are located at the wrist and allow your wrist to move almost as much as the ball-and-socket joint.

The saddle joint allows your wrist to move up and down, and side to side easily.

The Ellipsoidal joint is similar to the ball-and-socket joint since it has a socket and half a ball that fits into the socket. The half ball instead of a full ball comes to a disadvantage since it allows half the movement that the ball-and-socket joint can do.

Plane joint: The plane joint allows 2 areas/planes in a specific area to glide over each other. Both surfaces, to allow them to glide have to be nearly or completely flat.

Hinge joint: A hinge joint can only allow movement from front to back and is located at the knee. To test if this is true, you can conduct an experiment.

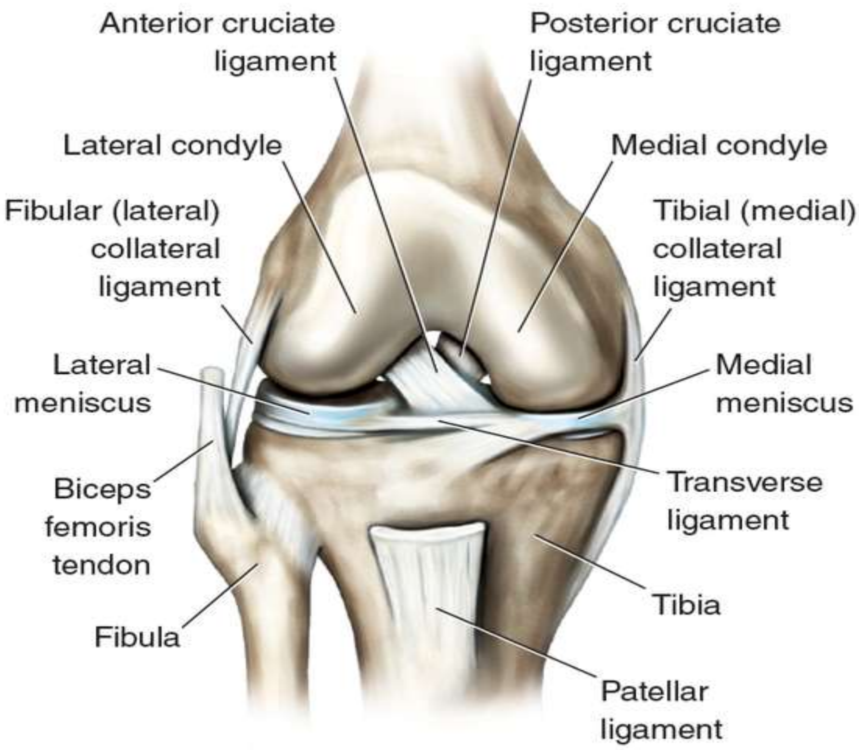


An image of the location of numerous joints in the body.

6.4 Ligaments

Although joints allow the bones to move in whichever direction they are meant to, ligaments are meant to keep the bones together.

Ligaments are tissues that connects 2 bones, or perhaps a bone and some cartilage, so they are able to move.

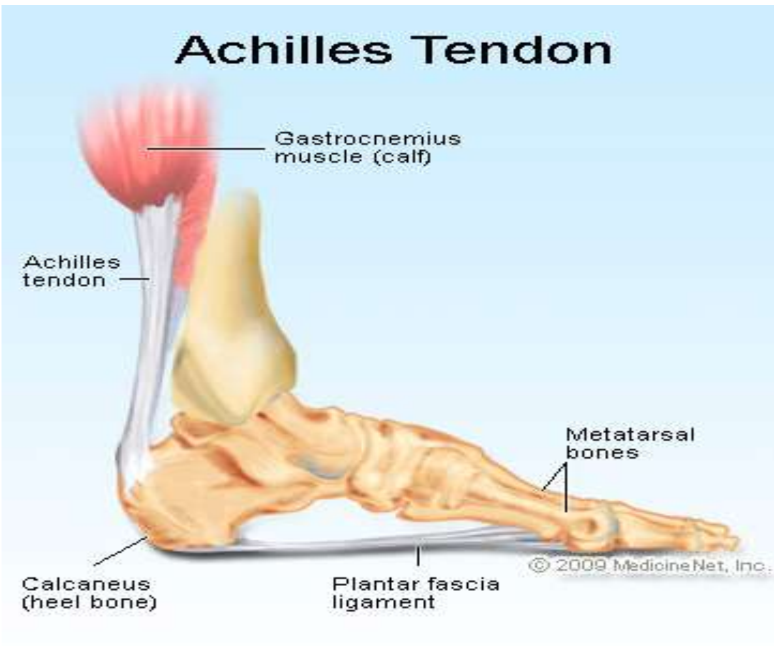


The ligaments of the knee.

6.5 Tendons

Like ligaments, tendons enable two things to attach in the body. But unlike ligaments, a tendon attaches a bone or cartilage to a muscle.

For example, the Achilles (A-kee-lies) tendon is the longest tendon in the body and is attached to the heel bone (Calcaneus bone) and the Gastrocnemius (calf) muscle.



An image of the Achilles tendon attached to the Calcaneus bone and the calf (Gastrocnemius) muscle.

Accordingly, without tendons, muscles would not be able to attach and to move bones.

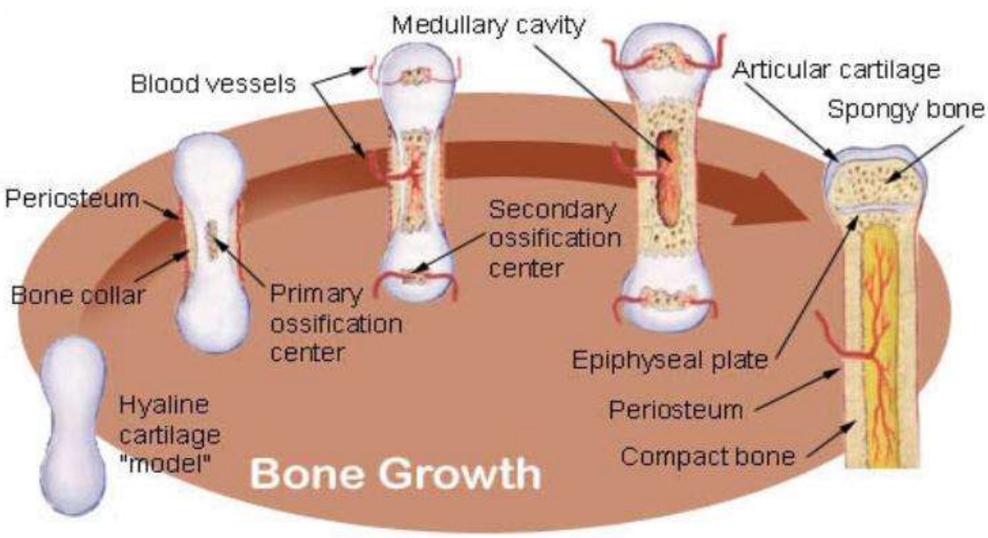
6.6 The lifecycle of bones

Quite surprisingly, bones do have a life cycle. During a bone's life cycle, it endures growth spurts and major changes over the course of your life.

Here it will explain the main changes that happen to bones from when you were in your mother's womb and during all the rest of your life.

Growing bones

As mentioned before, bones start growing when you're still in your mother's womb, about when you're a 4-6 week embryo. Bones stop growing during your middle 20's. After that they become weaker and weaker very slowly. Can see the effect on weakened bones when someone is around his middle 80's. You can see it because the bones are so weak they can't support you anymore and you begin to bend down.



The stages of bone growth

So, how do bones actually grow?

When you are a baby, your bones are made out of cartilage, a material similar to the composition of real bone but much more flexible and weak. It is the same composition that makes up your ear or nose. Adding to this, babies have much more bones that adults.

At the late stage of an Embryo, stem cells located in the area of the head start to specialize into creating cartilage for bones. At the time when you are born, there are more than 300 bones in the body- really small and fragile ones that are still not connected.

Over time, these bones grow stronger and combine to create fewer bones.

For bones to grow, cartilage is added at the starting of the tip of the bone, where the growth palate is located (Not at the very end of the bone or else the joints wouldn't be able to slide properly) making the bones longer. This cartilage soon turns into the solid composition of bone.

Inside the bone.

When you are adolescent, your bones grow presumably faster than when you are a child, in response to hormones that are sent through the body. (Visit endocrine system for more details)

Bones will stop growing, for males at the age of 25, and for females, at the age of 22.

Despite the fact that bones don't continue to grow after a certain age, this doesn't mean they are not constantly changing. Your bones are changing all the time, becoming stronger, or healing or many other possibilities.

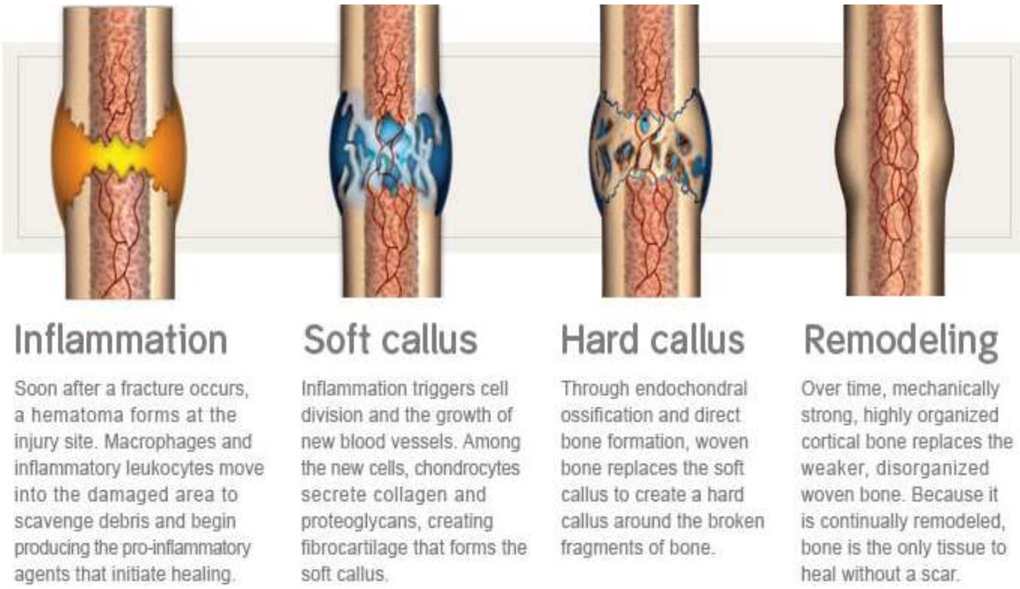
Healing bones

It is possible that you may have already fractured a bone in your lifetime.

Fortunately we are lucky because our bones can heal after their fractures and, in fact, become stronger. This is caused by adding more cartilage to the bone.

Here are some words that you might not know in the picture below:

- Hematoma: A location that is swollen up because of too much blood.
- Macrophages and Leukocytes: Type of white blood cells. (Pg.)
- Chondrocytes: Cells that create cartilage.
- Endochondral Ossification: The process where cartilage bones are created during the Fetus stage of development. (Pg.)
- Proteoglycans: A protein attached to much more complex type of sugar molecule (Glycosaminoglycan) and helps create pressure and hydrates the injury site. This allows the area to withstand pressure.
- Pro-inflammatory agents: This sentence refers to objects (Cells) in the body that cause the injury site to swell up.



A picture and an explanation of how a bone heals.

6.7 Inside bones

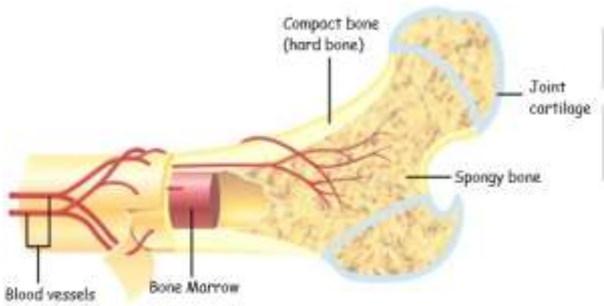
It’s quite intriguing to think that bones are actually not lifeless, because from the outside they appear plain. But if you take a look at the inside, you’ll see that they’re full of life! Bones are amazingly strong because of their internal structure, but also light enough to prevent you from collapsing under their weight.

6.7.1 Bone basics

Although bones differ in shapes and sizes, they still have the same basic structure: A hard bony tough outer layer, surrounding a maze of lighter mass of spongy bone where there is a full network of blood vessels that deliver essential supplies to keep your bones alive.

In addition to that, bones contain a reddish or yellow liquid found in the center of the bone called marrow. Bone marrow cells are able to transform into any kind of cell found in the blood.

Believe it or not, bone marrow creates 500 billion blood cells per day!



The parts of the bone.

At every moment, your bones are being broken down and being to ensure the bone can be as stable and strong as possible.

Two cells are responsible for this, Osteoblasts and Osteoclasts. Osteoblasts make more bone while Osteoclasts destroy bone.

6.7.2 Build for strength

Your bones, surprisingly, are much more resistible than steel. If your skeleton were to be made out of steel, it would weigh 5 times more than our skeleton and make it impossible to move around.

Luckily, our skeleton contains a complex "honeycomb" structure, which supports the walls of the bones, making it hard and light. Because the structure of our bones is so efficient, humans have also applied it numerous structures such as the Eiffel tower in France.

Can you notice the similarities between the bone structure and the Eiffel tower?

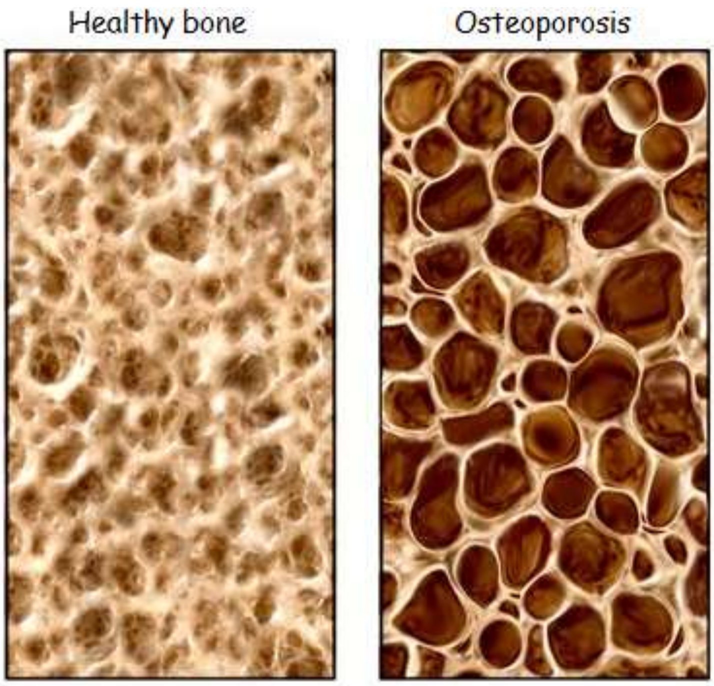

The complex, but highly useful structure of the bone was copied by people to make a stable building such as the Eiffel tower.

6.7.3 Bone components

Bone is composed of Calcium phosphate that, like the name suggests, contains lots of calcium, creating strong bones.

An image of powdered Carbon-Phosphate.(CA-P)

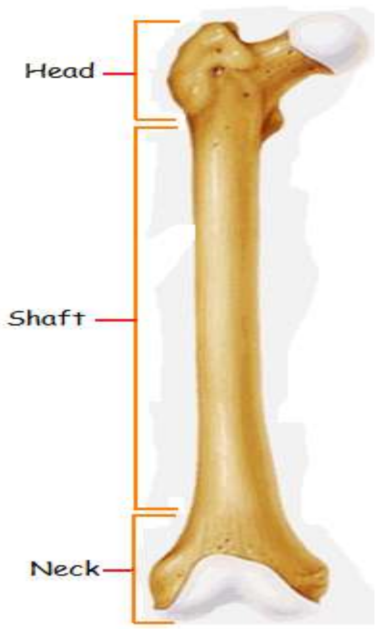
Calcium is a vital ingredient for your bones and the rest of your body. Without it, you may have weak bones and nails, loose hair, or suffer from Osteoporosis (a disease that makes the holes in your bones bigger, thus weakening the bone immensely).



Osteoporosis creates bigger holes in the bone.

6.7.4 The anatomy of the bones

The bone is separated into various parts and has numerous components. The bone has 3 main exterior components, the head, the shaft, and the neck.



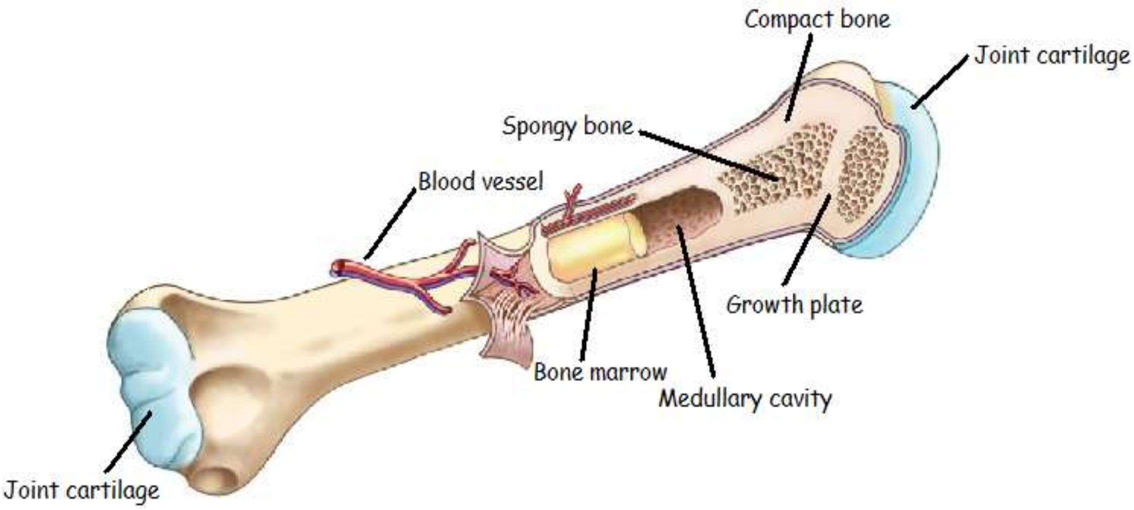
An image of the main 3 exterior components of the bone.

However, the interior, the bone is much more complicated. There are 2 types of bone, compact bone and spongy bone.

Spongy bone is full of holes and is where red bone marrow is created. Red bone marrow contains specialized stem cells that produce red blood cells, white blood cells and platelets. See Circulatory system for more on platelets.

Compact bone is the outer layer of bone and is really strong and dense. But if magnified, the eye will see that compact bone is similar to spongy bone. This is because it also has holes, serving as passageways for blood vessels, nerves and lymphatic vessels. Compact bone also contains yellow bone marrow. Yellow bone marrow is transformed into red bone marrow if there is a loss of blood.

In addition, the center of the bone contains a cavity (space) called the Medullary cavity where the bone marrow is stored.

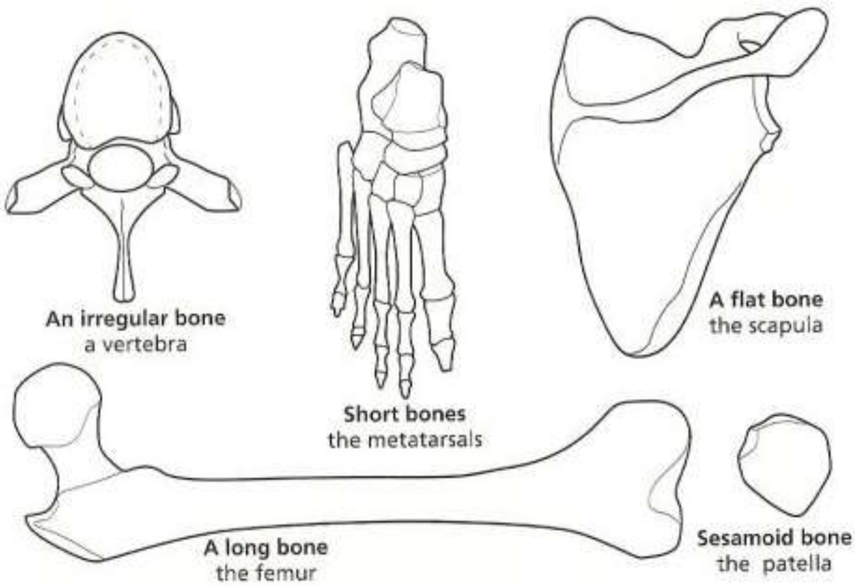


An image of the interior of the bone.

6.8 The classification of the bone

There are several types of bone in the body.

There is the long bone (such as the Femur), the Seamoid (Knee cap/Patella), the flat (the Skull or the Scapula), the short bone (fingers or toes) and the irregular bone (Vertebrae -- bones that protects the spinal cord).

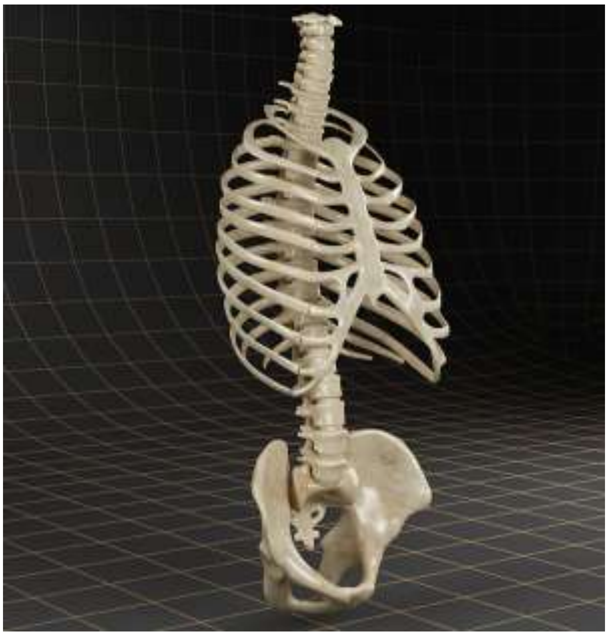


An image of all the main types of bones in the body.

6.9 The 3D imagery of the skeletal system

The skeletal system -- on the contrary of many beliefs -- is not only a complicated self-supporting system that protects our organs from damage, which may become very boring to study at one point, but it is also a very fascinating model that helped humans in the strangest ways possible ever since they discovered it.

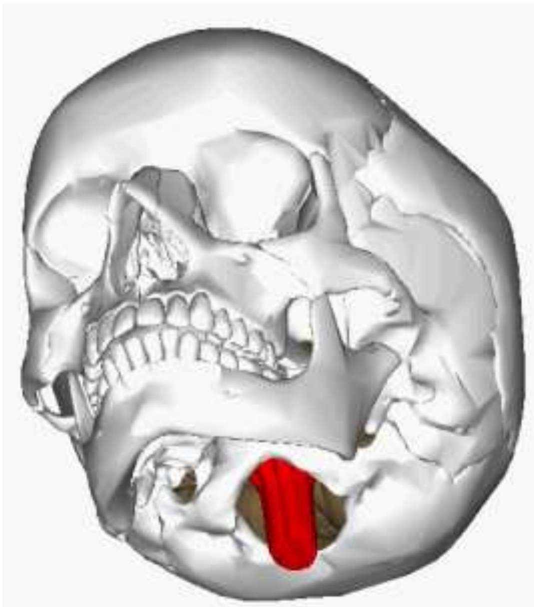
Now, these pages will be about the 3D human skeleton and will bring to life this extraordinary but hidden system.



A 3D model of the axial bones of the body.

6.10 The hard head

The head contains one of the most vital organs: the Brain. Therefore, the Brain is protected by the skull, a bone that protects the Brain from every side.

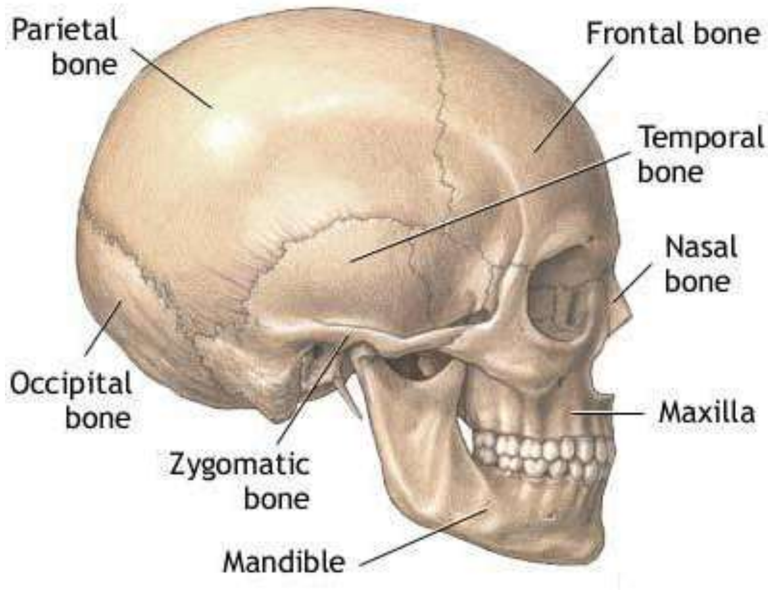


This is a 3D image of the skull.

In the image above, you see the front and bottom of the skull with the spinal cord (in red) coming out by the Foramen Magnum (the hole where the spinal cord comes out of the skull).

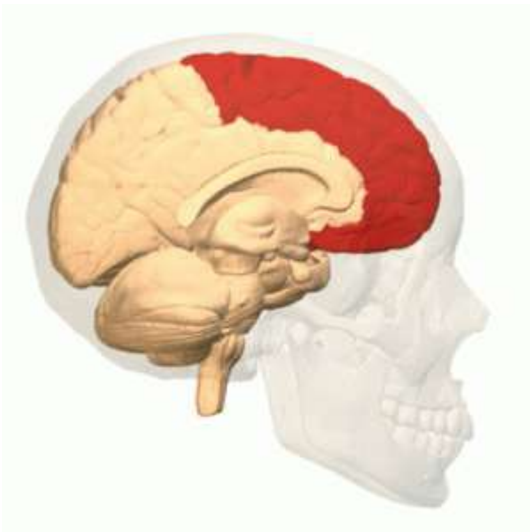
An image showing the side of the head.

The "cracks" that you see on the skull are not cracks at all, but are in fact different pieces of bone that cover different parts of the brain.



An image of the parts of the skull.

The layers protecting the brain



A cross section of the Brain.

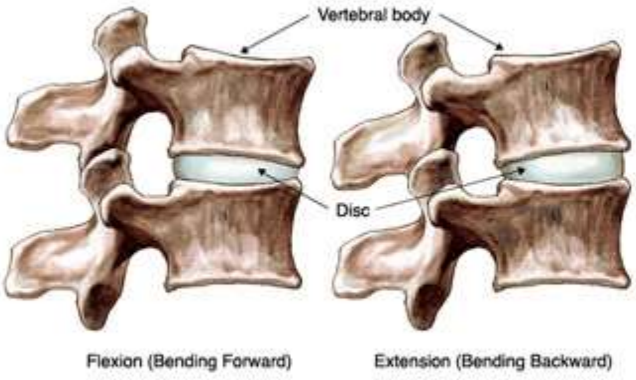
An image of all the parts of the Brain.

6.11 The spine

The Spine is a part of the skeletal system and protects the spinal cord.

It is composed of numerous bone segments called Vertebrae. In the inside, they are hollow, to allow the spinal cord to pass through. This hole is called the spinal canal. The vertebrae protect the spinal cord from any potential damage.

Separating each Vertebra is something called an intervertebral disc. These “discs” are in between two Vertebrae and prevent the vertebrae from rubbing against each other and also help absorb shock.



The role of the intervertebral disc

The spinal cord is split into numerous parts: The Cervical, Thoracic, Lumbar, Sacrum, and Coccyx.

- The 7 highest Vertebrae are called the Cervical Vertebrae which move the head side to side and up and down.
- The next 12 Vertebrae are called the Thoracic Vertebrae and are where the ribs sprout from.
- The next 5 Vertebrae are the Lumbar Vertebrae and are located right behind your intestines.
- Below the Lumbar Vertebrae, are the 5 sacral Vertebrae, which support the bladder.
- Finally, the 4 smallest vertebrae are called the Coccygeal Vertebrae which used to support our ancestor’s tail!

An image of the sections of the spine.

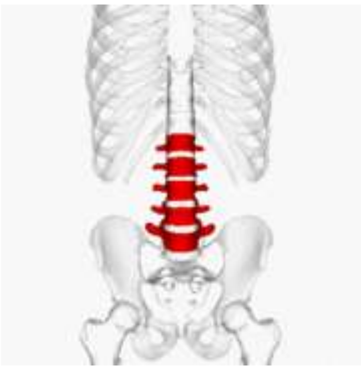
To indicate a specific Vertebrate, doctors would say the first letters of the section the Vertebrate is in and then indicate which vertebrate it is.
For example, C04, would mean the 4th Vertebrate in the Cervical region. TH12 would symbolise the 12th Vertebrate in the Thoracic region. L03 would mean the 3rd

Vertebrate in the Lumbar region. There would be no such thing as L6 or TH13, because the Thoracic region has 12 Vertebrae and the Lumbar region has only 5.

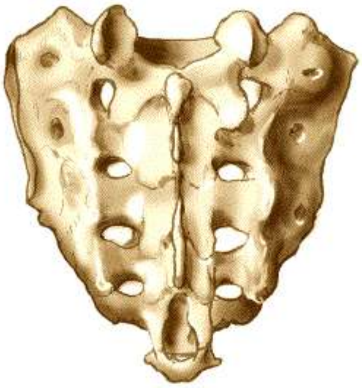
An image of the spinal cord.

An image of the Cervical Vertebrae.

A picture of the Thoracic Vertebrae



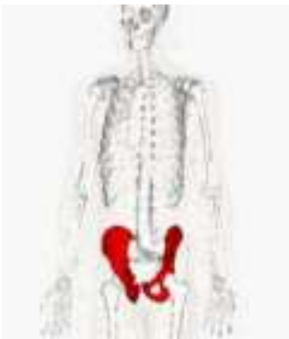
A picture of the Lumbar Vertebrae.



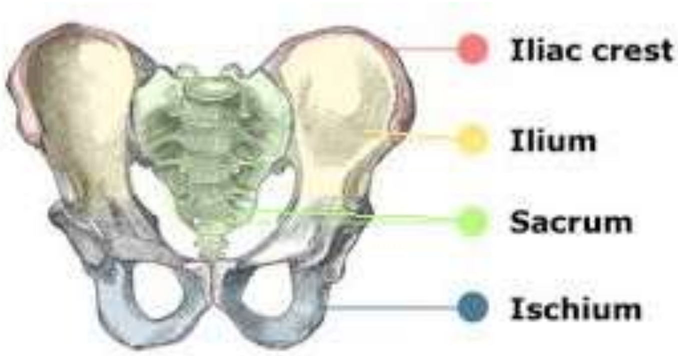
An image of the Sacrum posterior view. All the Vertebrae in the Sacrum are fused together.

6.12 The pelvis

The pelvis is very useful as it holds the reproductive system, the bladder, supports the legs, and more.
The pelvis is also composed of numerous parts.



A picture of the Pelvis bone, otherwise known as the Pelvis bowl.

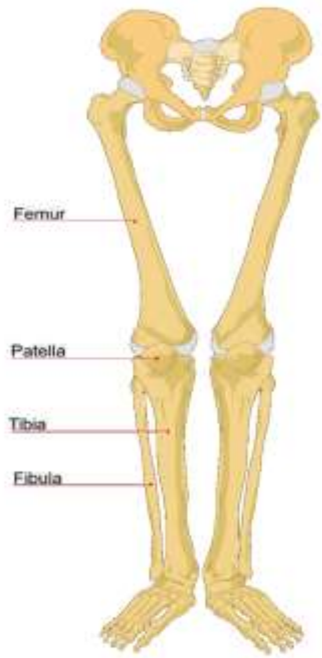


An image of the main bones in the pelvis bowl.

6.13 The supporters, the legs.

The legs support the body and must be very strong to hold all our weight. The legs are made of 4 bones:

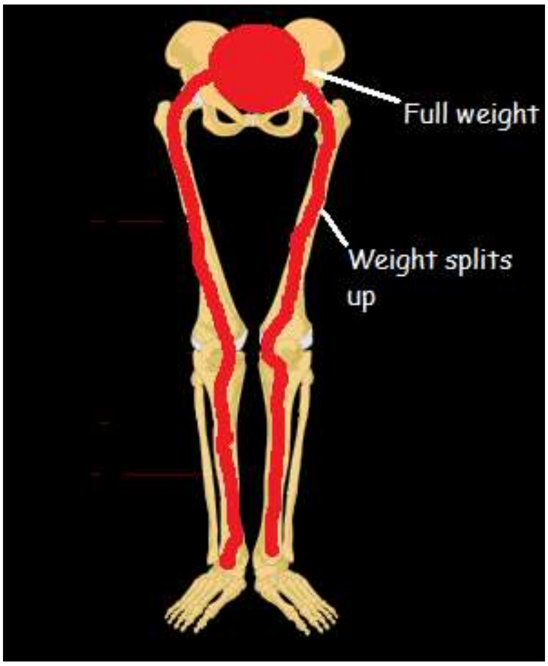
- The highest one is called the Femur, otherwise known as the Thigh.
- Underneath the Femur is a small, round bone called the Patella, or the knee cap. This is the bone that “forms” the knee.
- The Tibia is located under the Patella and is the bone that hurts when someone kicks your shin. This is because the bone is superficial (It is a shallow bone) and there are no muscles covering it.
- A thinner bone is located beside the Tibia and is called the Fibula.



An image of the bones that make up the legs.

A picture of a Skeleton walking.

The purpose of the legs is mainly to support the body. But simultaneously, the legs also divide the weight of the body equally on each leg. The weight is further divided by the arches in the legs.

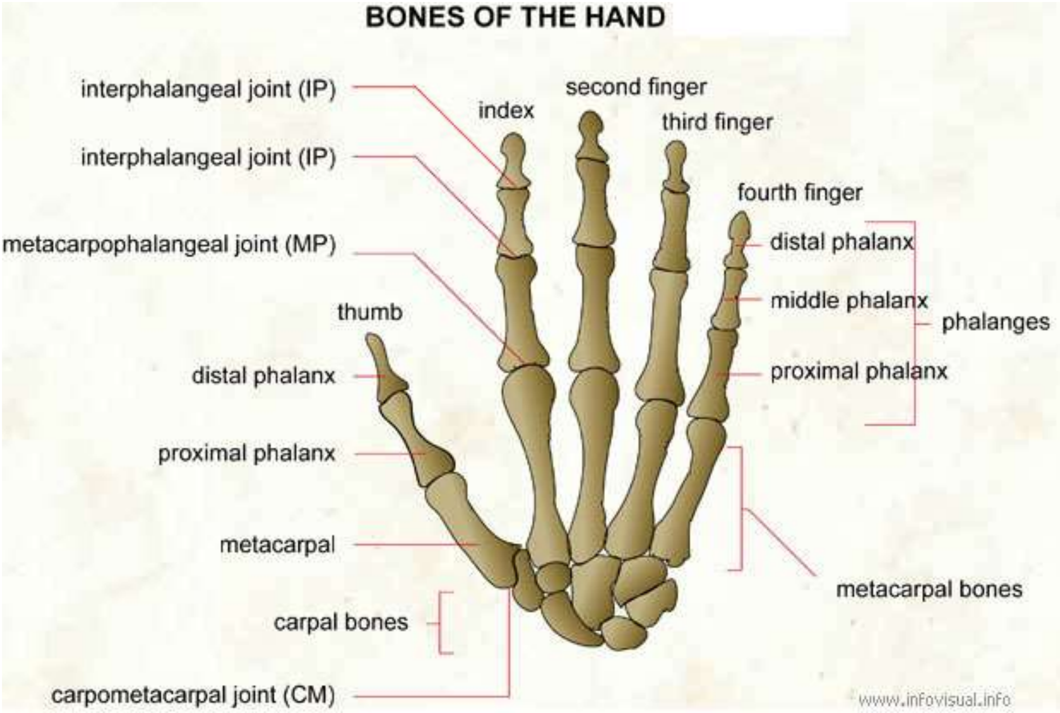


An image of how the weight of the body is split in between the 2 legs.

6.14 Joints of the hand

The arms and hands are undoubtedly essential for humans—not only for practical purposes such as grabbing but also for protecting.

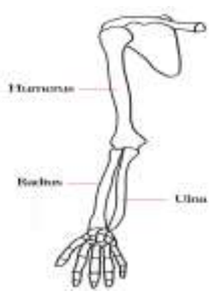
However, the hand is very fragile in comparison to other body parts. This is because the hand is composed of almost 30 bones (27 to be precise!).



An image that displays all the bones in the hand.

6.15 Arms and the joints

The arms have always helped people and are essentially mankind's greatest tool. But despite the fact that the arms are useful, they are also intriguingly complex when studied further.


An image showing the bones of the arm.

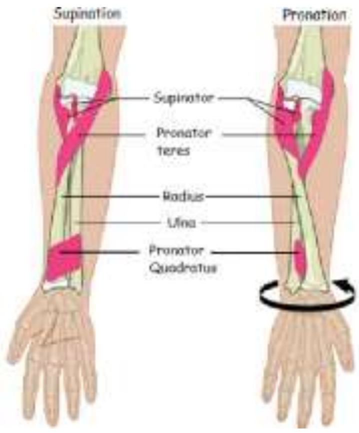
The arms are composed of three bones: The Humerus, the Ulna and the Radius.

The Humerus is the highest of bones in the arm and is attached to the body.

The lower bones of the hand are the Ulna and the Radius.

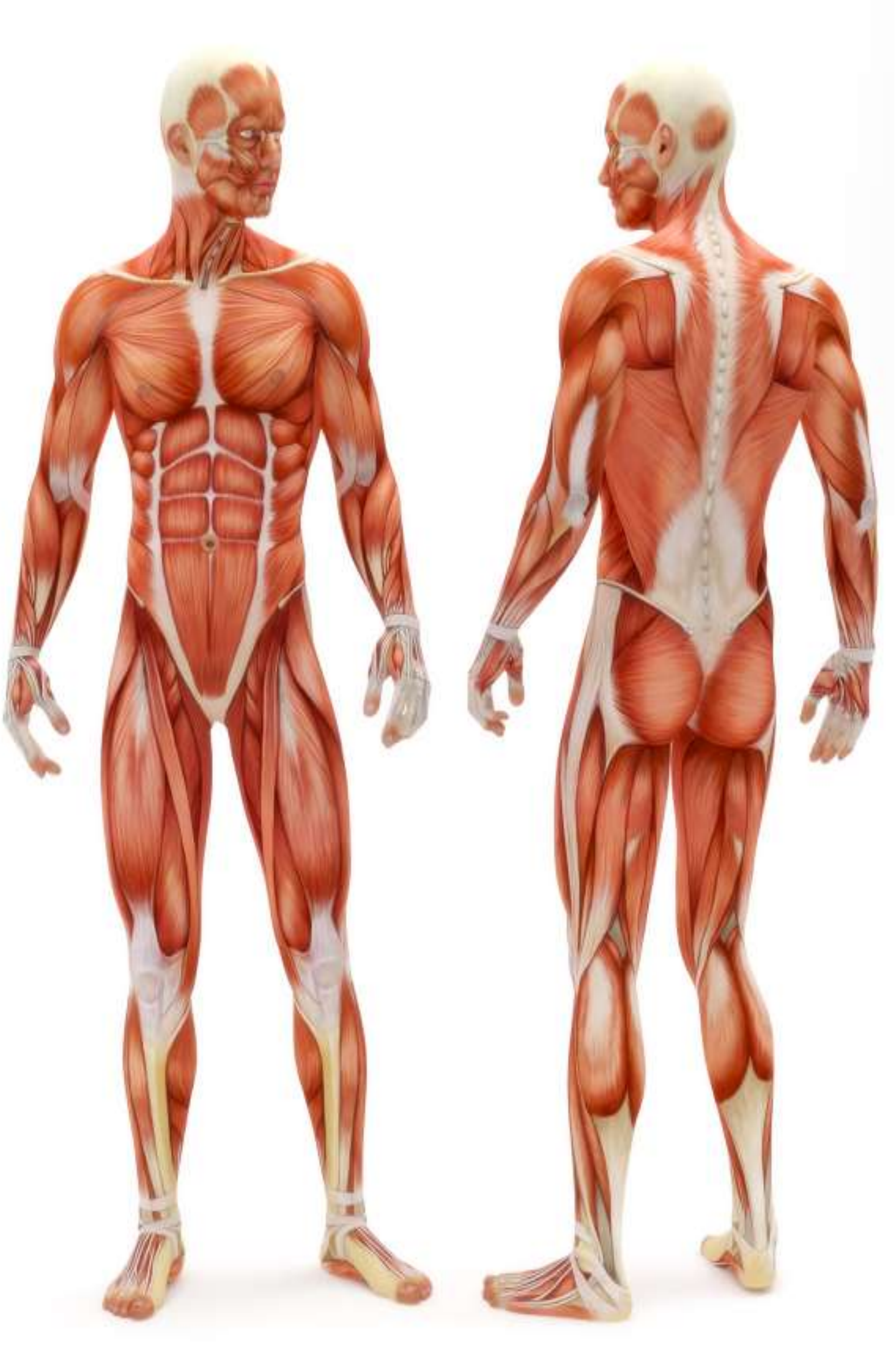
When you twist your arm, the Radius and the Ulna pivot around each other. The twisting of the arm can be further divided into 2 actions: Supination and Pronation.

When you twist your arm clockwise, you supinate your arm, while when you twist your arm counterclockwise, you pronate you arm.



The supination and pronation movement.

7 The muscular system



7.1 Our own motor

The muscular system helps us move. (Put simply)

But without bones, muscles would not have anything to anchor on, therefore making them useless.

In the Muscular system, there are several key ideas to recognize.

1. The first rule is that muscles do not push.

For example, if you bend your arm towards you, it is a specific muscle doing the corresponding action.

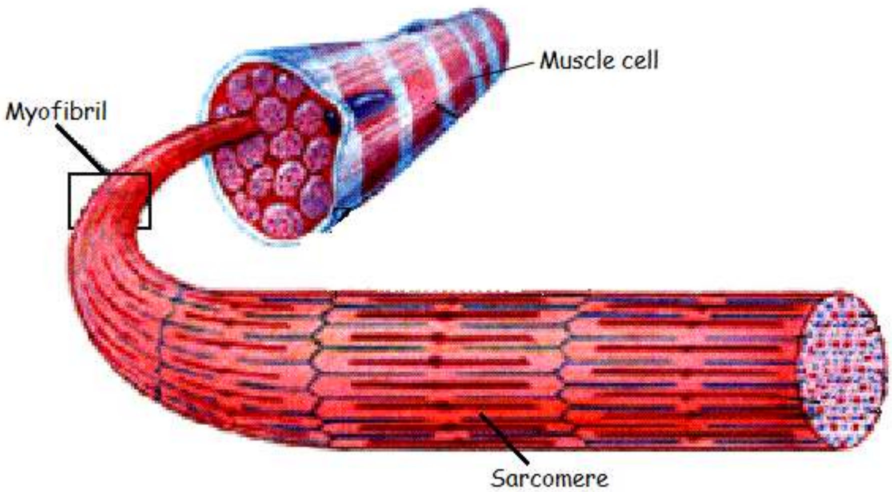
But when you move your arm in the opposite direction, the muscle that pulled your arm inwards does not push your arm back. A muscle located opposite to the muscle that pulled your arm inwards would now pull your arm back.

An image of the action explained above.

2. The second rule is that muscles aren't directly attached to a bone (As you can see in the previous picture). You see there that there is a white object that connects the bone to the muscle. It is called a tendon.
But naturally, the body isn't perfect, therefore, the tendons might fracture causing tendon pain such as the famed Achilles pain.

7.2 Parts of the muscle

There are different components of the muscle. This section presents the main parts.



An image of the main muscle components.

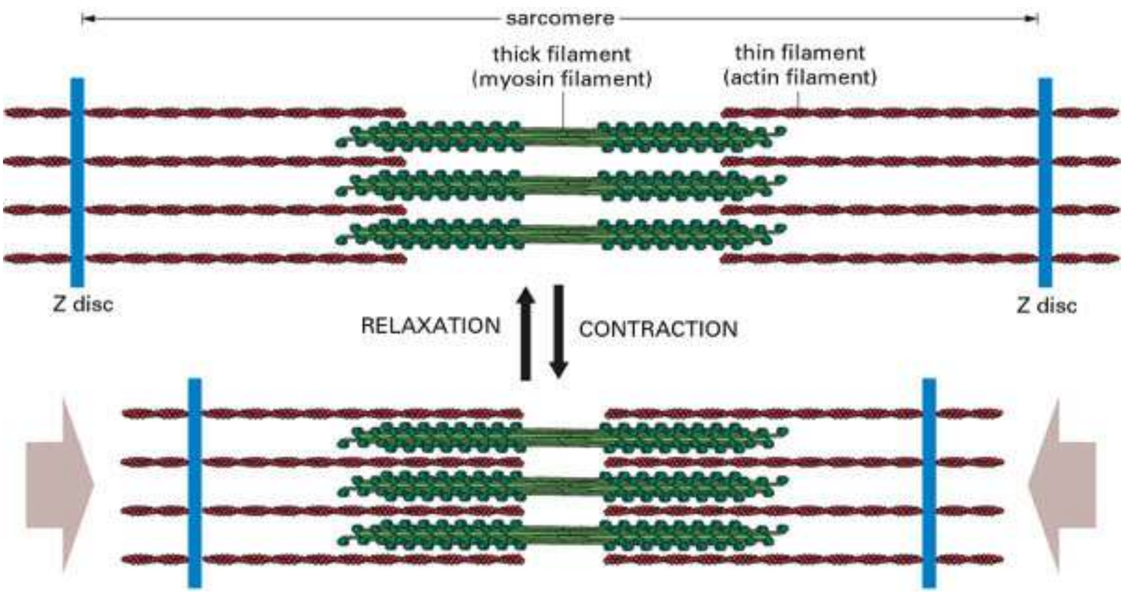
Firstly, muscles are composed of muscle cells. Each muscle cell is composed on numerous Myofibrils. Each Myofibril is composed of a lot of Sacromeres.

There are 3 main types of muscle cells: Smooth, Cardiac, and Skeletal muscle cells.

- Smooth muscles are involuntary muscles and are found in the stomach, intestines, Esophagus, and much more. To function, they are enveloped in Autonomic neurons. (Involuntary neurons)
- Cardiac muscles are found only on the heart and never get tired. This means that they can contract without getting tired. They are also involuntary.
- Skeletal muscles are voluntary muscles and are attached to bones by tendons and help move the bones so you can move.

7.3 How muscles contract

Scientists have yet to prove the real way that muscles contract. However, there are still many theories. Here is one of the most common:



An image of components inside a Sacromere.

The components of a muscle that help make the muscle contract are located inside a Sacromere.

The green object is a thick filament, otherwise known as a Myosin filament. The red object is a thin filament or also known as an Actin filament.

For the muscle to contract, the Myosin Filament will have to grab the Actin filament and pull inwards.

(Imagine the Myosin filament as a caterpillar pulling itself on the Actin filament which is the ground)

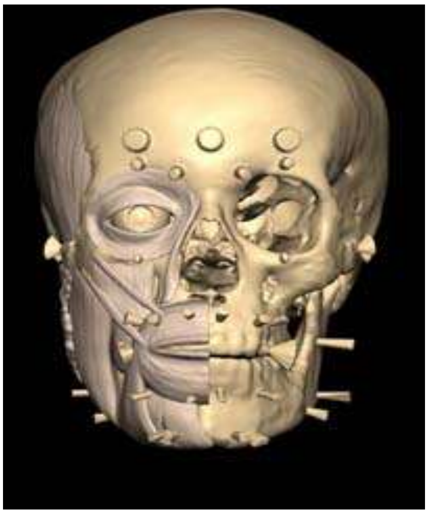
The myosin pulls itself inwards by some “cross bridges” that have heads that attach to the Actin filaments.

7.4 Facial expressions

Happy, sad, angry, scared, surprised, disgusted... These are all emotions of how we feel.

Most of these emotions are also imitated by the face. Emotions on the face are all created by muscles.

There are also specialists, which use their combined knowledge of arts and anatomy to create a visual understanding of how a person looked like by just using the patient’s skull. This also helps scientists see how people looked a long time ago.



An example of the work of a Forensic artist.

7.5 Identifying muscle names

Muscle names can be hard to understand because of the fact that they might be long and are in a different language. Fortunately, there are ways to figure out where they are in the body.

Because the Renaissance of anatomy started in Italy with Leonardo Da Vinci and other great Renaissance figures, muscles where named by Italy’s main language, Latin. Therefore, muscle names are in Latin.

For example where is the muscle *Latissimus Dorsi*? Well firstly, what does Latissimus mean? Latissimus comes from the word lateral (Up-down) and then Dorsi means on the dorsal side (Back) so a lateral muscle on the back. ;-)

Or *Levator Labii Superiosis*. So first let’s find out what Levator means. Well it’s close to “Lève” (Lift) in French so it probably means lift. Labii is similar to “Labios” which means lips in Spanish and Superiosis means that it is superior meaning if you take the skin off you will see it.

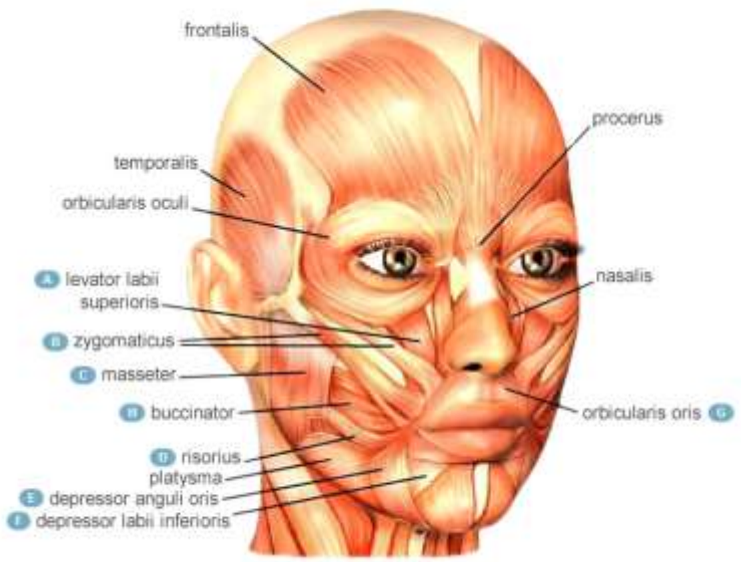
Note: To figure out other Latin words, you can make inferences in languages close to Latin such as French, Spanish, Portuguese, Romanian, Italian, etc.

Muscle clues. Here are some words that will help you understand muscle names:

- *Flexor*= Flexing muscle,
- *Extensor*= Straitening muscle,
- *Digitorum*= Finger,
- *Profoundus*= Deep,
- *Carpi*= Wrist,
- *Radialis*= Radial side,
- *Ulnaris*= Ulnar side,
- *Hallux*= Toe,
- *Pollicis*= Thumb,
- *Quadratus*= Four sided muscle,
- *Brevis*= Short,
- *Longus*=Long,
- *Minimi*= Little,
- *Abductor*= “Separate“,
- *Adductor*= Pulling inwards,
- *Anguli*= Angle.

7.6 The face

In the face there are around 43 facial muscles.



Several muscles that make you smile or frown.

The *Orbicularis Oris* is mostly for kissing and acts when you push your lips forwards. It is a circular muscle similar to the *Orbicularis Oculi* (The muscle around the eye).

When you blow in a trumpet the *Buccinators* take action, and you use the *Masseter* and the *Temporalis* to chew and *Procerus* + *Frontalis* to frown.

The *Temporalis* is also for moving the ears but not many people can do it indicating that the Temporalis is not well developed in most people.

The *Depressor Labii Inferioris* and *Depressor Anguli Oris* are for making a sad face, the *Risorius* is meant for chewing.

In the tongue there is a wide array of 14 muscles which help flex the tongue and help push food to the back of the throat.

In fact, the whole Digestive system from the tongue and lower is actually more or less all muscular.

First, the Esophagus needs muscle to push the food down to the stomach which is also composed mostly of involuntary muscle tissue to push the food through the Duodenum.

The following muscles will be the muscles for chewing:

- The *Lateral Pterygoid*: Helps close in the jaw after chewing. (In anatomical words: draws the mandibuar condyle, and articular disk forward)

- *Platisma*: Lowers inferior (Lower) jaw.

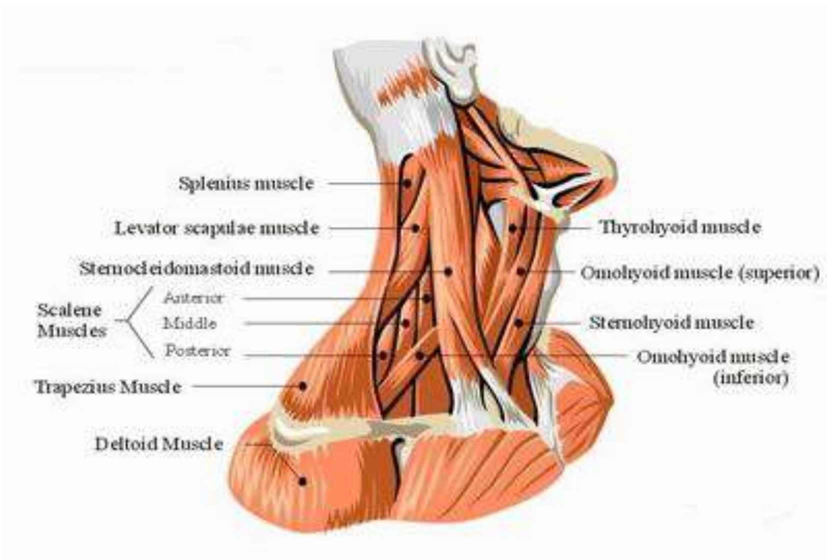
- *Levator Labii Superiosis Alaeque Nasi*: Raises upper lip (English definition: A superior muscle attached to the nose which raises the)

- *Zygomatus*: Pulls jaw back on a angle.

- *Mylohyoid*: Raises the mandible.

7.7 The neck

The neck contains a lot of muscles which help rotate the head in numerous directions.



An image of the muscles located at the neck.

For example, the *SternoCleidoMastoid* is useful for pulling the head on an angle and helps lifting the chest. The *Trapezius* helps lift the shoulder and pushes the *Scapula*. (shoulder)

The *Omohyoid* lowers the Hyoid bone, the *Mylohyoid* is a muscle found right under the Mandible and raises the mandible, as well as the Hyoid.

The *Stylohyoid* pulls back the Hyoid bone and also lifts the tongue.

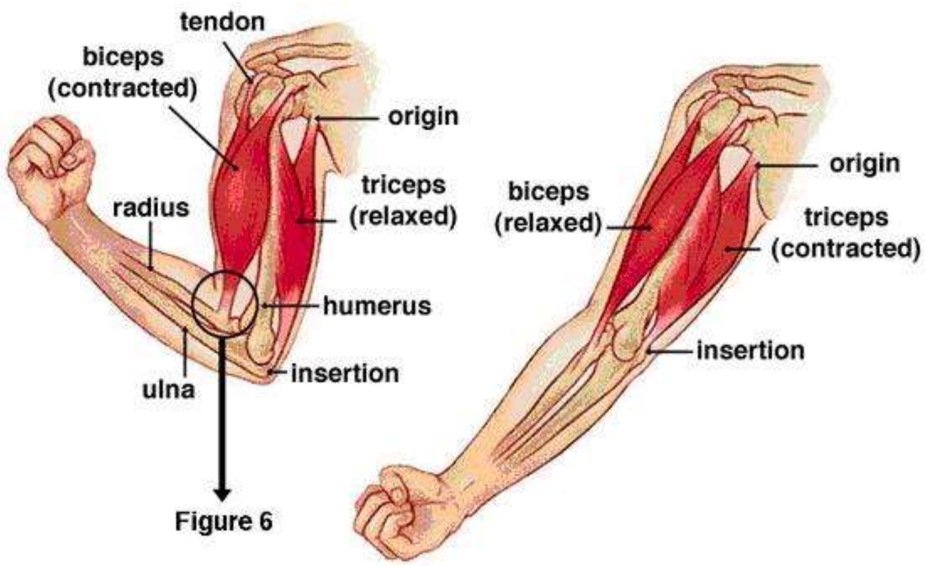
The *Scalene* group of muscles (*Anterior, Middle,* and *Posterior*) help raise the first and second rib (The first and second "True rib") and also help in tilting the head to one side.

7.8 The arms

The arms are separated into 2 "parts", the forearm and lower arm.

In the forearm there are only three muscles:

- The *Biceps*: This muscle pulls and Supinates (pg. 54) the forearm.
- The *Triceps*: This particular muscle pulls the forearm back and Pronates (pg. 54) the forearm also.
- The *Brachialis*: It flexes the forearm.
-



A picture of the forearm muscles along with their actions when the arm is either contracted or relaxed.

However, the lower arm has a lot more muscles than the upper arm:

There is the *Pronator Teres* which pronates (Pronation) the lower arm by attaching from the Humerus until the radius and then contracts and pulls the radius in a result of turning the arm.

The muscle right beside it is the *Flexor Carpi Radialis* meaning that it is a muscle that passes by the radial side which flexes the wrist.

The muscle underneath is a muscle called the *Flexor Digitorum superficialis*. This means that it flexes the fingers (And the wrist) and is partly superficial.

The muscle *Flexor Digitorum superficialis* (superficial muscle that flexes the fingers) is covering two inside muscles which are right beside the Radius and Ulna.

The muscle on the Radial side is called the *Flexor Pollicis Longus*. This muscle flexes the thumb inwards.

The other muscles on the Ulnar side is called the *Flexor Digitorum Profoundus* which flexes the fingers inwards. This muscle is also a profound (Profoundus) muscle.

Stretching across the whole length of the hand is the *Palmaris Longus* which flexes the whole hand inwards.

Right beside the *Pronator Teres* and the *Flexor Carpi Radialis* (See image) there are three muscles.

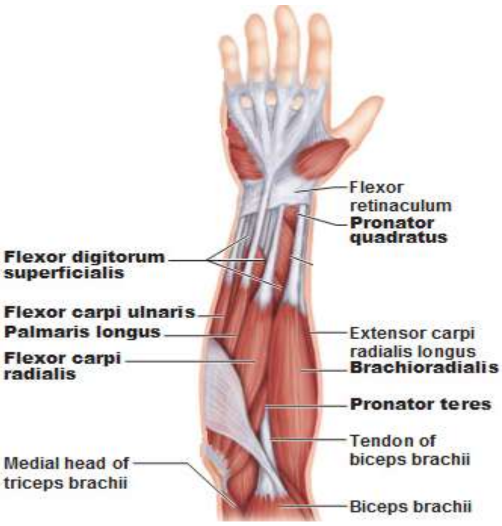
The first is referred to as *Brachioradialis* which helps flex the forearm.

The second muscle is the *Extensor Carpi Radialis Longus* which extends and abducts the wrist.

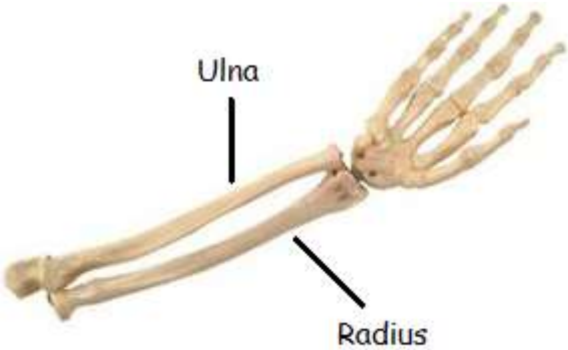
The third muscle is known as the *Extensor Carpi Radialis Brevis* which is a short muscle which pulls the palm of the hand outwards.

Covered by the group of three muscles and barely visible from the side is the *Supinator*. The *Supinator* supinates the arm (Pg. 54) if the *Pronator Teres* were to pronate the arm.

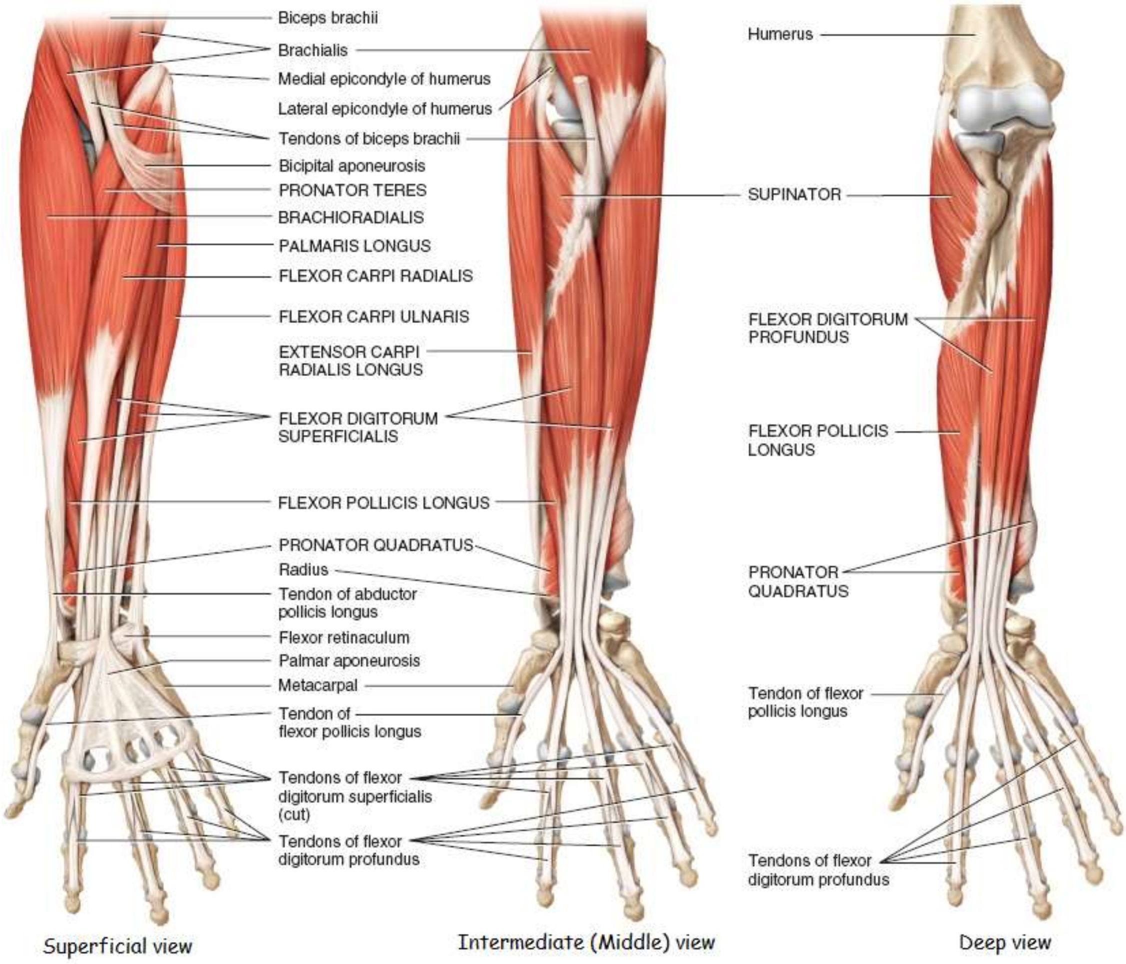
There are two muscles which neighbour the *Flexor Carpi Radialis*:
The *Palmaris Longus* which flexes the wrist. The other muscle present beside the *Flexor Carpi Radialis* is called the *Extensor Pollicis Brevis*. It helps move both ways the thumb. (Pollex)



Main muscles of the forearm.



Bones of the forearm.



An image of numerous layers of the forearm.

On the backside of the forearm (Opposite of the palm side) there are numerous other superficial muscles:

On the very left, you will find the *Flexor Carpi Ulnaris*, a muscle that assists in flexing the wrist and is located on the Ulnar side.
(Flexor= Flexing muscle, Carpi= Wrist, Ulnaris=Ulnar side. Therefore, the result is: “Muscle flexing the wrist found on the Ulnar side“.)

Beside it, you would spot the *Extensor Carpi Ulnaris*. This muscle aids at extending and pulling the wrist outwards. (This action is also referred to as adduction.)

The *Extensor Digiti Minimi* is located to the right of *Extensor Carpi Ulnaris* and, as it’s name suggests, extends the 5th finger.

The last superficial muscle located on the back of the arm is called *Extensor Digitorum*. This muscle plays a significant role in finger movement, as it extends the second, third, fourth and fifth finger outwards.
(*For reference, see image on next page.*)

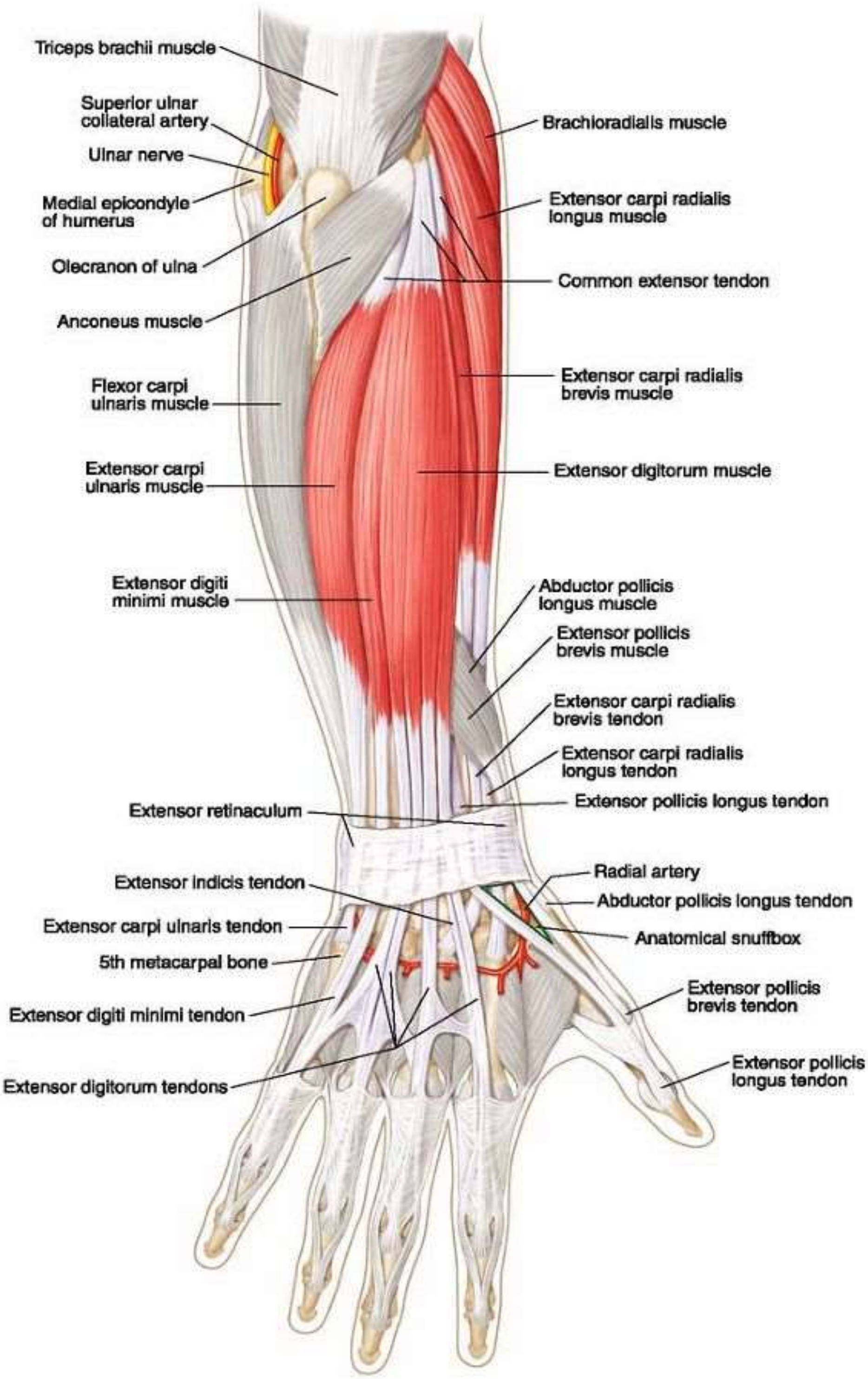
But if we were to remove these superficial muscles, we would find 3 other muscles hidden beneath.

First, and to the very top, attached to both the Humerus and Ulna (Located opposite to the elbow) is a medium sized muscle called *Anconeus*. This muscle helps in extending the forearm.

Crossing both the Ulna and Radius at their mid-point is the *Abductor Pollicis Longus*. Its function is to abduct the thumb and wrist.

Below the *Abductor Pollicis Longus*, there is the muscle *Extensor Pollicis Longus*, which helps extend the thumb.

Located right under the *Extensor Pollicis Longus*, (Ulnar side) there is the *Extensor Indicis* which extends the second finger.



Superficial muscles of the back of the forearm:

Deep muscles of back of forearm

In addition to that, there are numerous other muscles located on the anterior (Palm) of the hand. (*As there aren't many muscles on the back on the hand.*)

Adducting the thumb are 2 main muscles: *Adductor Pollicis* and *Abductor Pollicis Brevis*.

Adductor Pollicis adducts the thumb while *Abductor Pollicis Brevis* allows us to abduct our thumb.

Flexor Pollicis Brevis, as the name suggests, flexes the upper part of the thumb.

Hidden under *Abductor Pollicis Brevis* is the muscle *Opponens Pollicis* opposes (For the "*tip of the thumb to touch the tips of other fingers"* - Wikipedia, Opponens Pollicis muscle.)

Near each finger, there a muscle called *Lumbrical*.

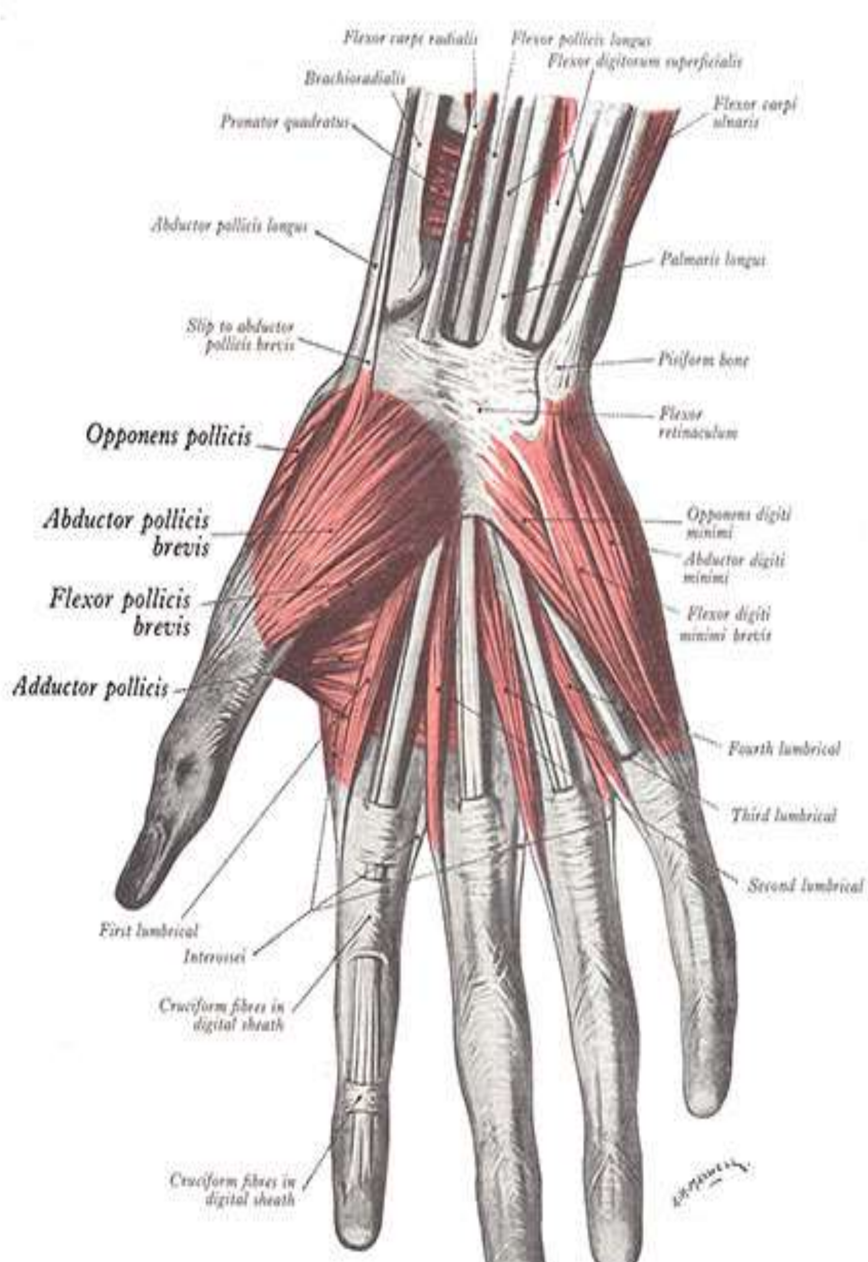
The 1st *Lumbrical* corresponds to the index, the 2nd *Lumbrical* corresponds to the

middle finger, the 3rd *Lumbrical* corresponds to the ring finger and so on…
Each *Lumbrical* allows you to move different sections of the corresponding finger.

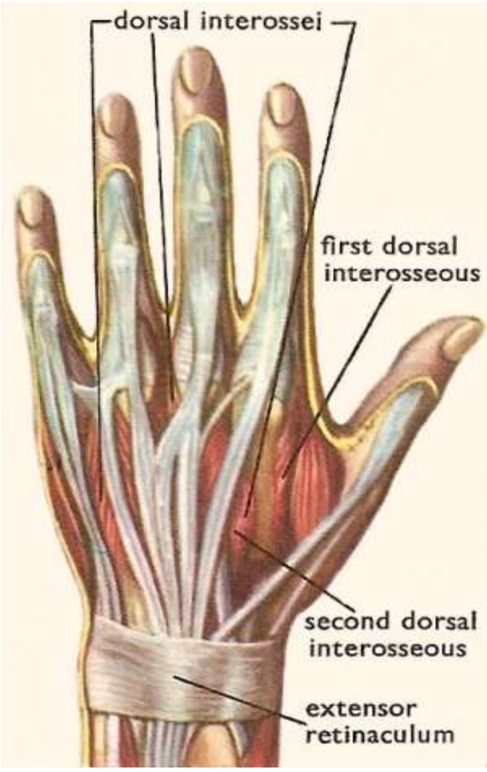
Beside the 4th *Lumbrical* (To the right), there is the *Flexor Digiti Minimi Brevis* which flexes the 5th finger of the hand.

Located beside the muscle *Flexor Digiti Minimi Brevis* in the *Abductor Digiti Minimi* which, as the Latin name indicates, abducts the “small digit” (Latin translation of *Digiti Minimi*)

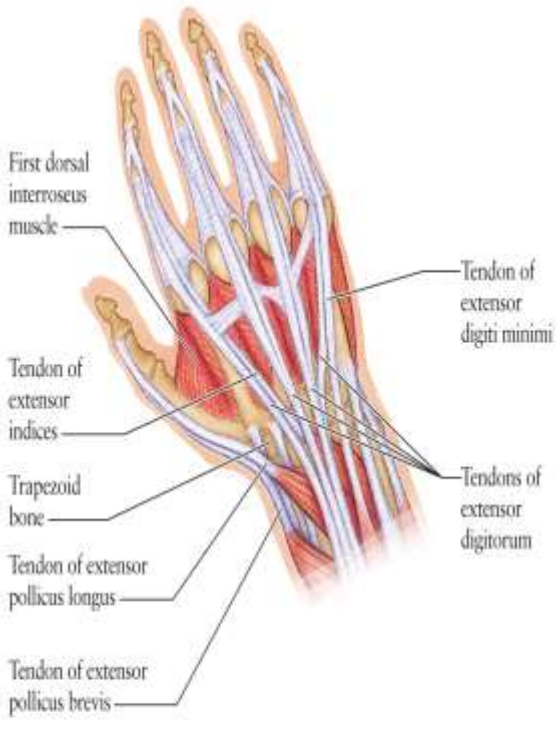
As the *Flexor Digiti Minimi Brevis* and *Abductor Digiti Minimi* are removed, we will see yet another muscle which opposes (See top of page) the “small digit” (5th finger). This muscle is called *Opponens Digiti Minimi*.
(*See image on next page for reference*)



Muscles of the palm of the hand



Muscles of the back of the hand.



Tendons of the back of the hand.

7.9 The shoulder

As we know, the upper arm holds the lower arm and the lower arm holds the hand. However, the main question now is *what holds the upper arm to the body*?

If we were to look at an image of the skeletal system, we would notice immediately that the shoulder is the connection between the upper arm and the rest of the body.

But attaching the upper arm to the shoulder are mostly ligaments.

But adding to this, there are also several muscles helping to move the upper arm.

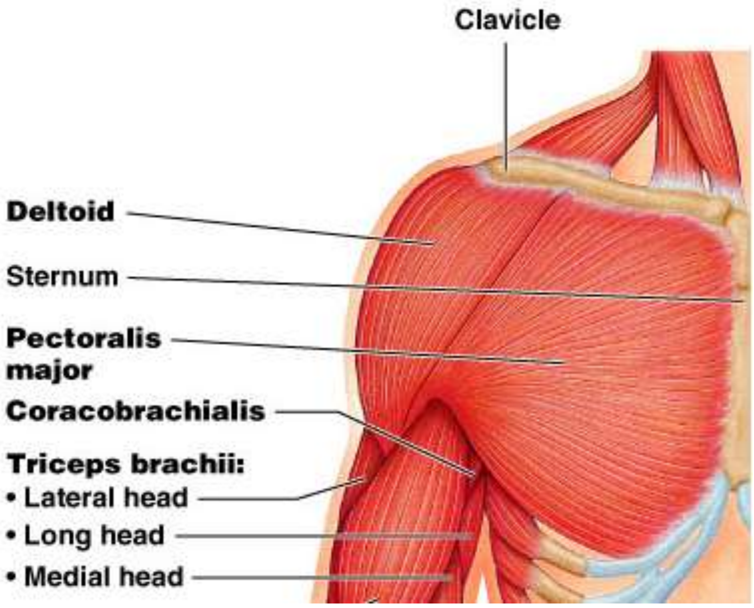
Looking from the front, the most visible muscle is the *Deltoid*. The Deltoid has three parts, the *Anterior head*, the *Middle head* and the *Posterior head:*
- *Anterior head:* Flexes and rotates (Thumb side) Humerus.
- *Middle head:* Abducts Humerus.
-*Posterior head:* Rotates (5th finger side) Humerus.

Found superficially on the chest, the *Pectoralis Major* helps flex, rotate (Towards the chest) and pull inwards (Towards body) the Humerus.

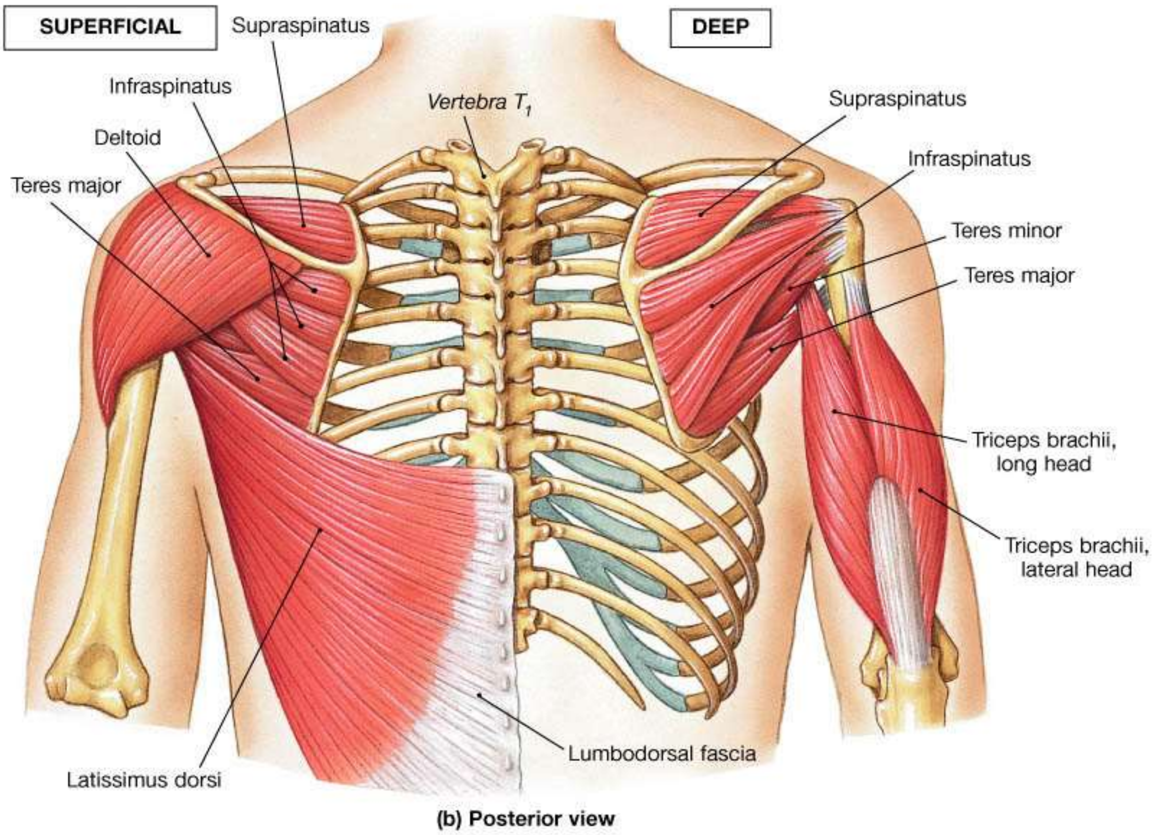
In the region of the "Armpit", there is the muscle *Coracobrachialis*. This muscle flexes and also pulls the Humerus inwards (Adduction).

Other muscles that help move the Humerus are:
- *Latissimus Dorsi:* Adducts Humerus.
- *Supraspinatus:* Abducts arm.
- *Infraspinatus:* Rotates Humerus. ("Laterally")
- *Teres Major:* Extends, adducts, rotates (Outside) Humerus.
- *Teres minor:* Rotates (Thumb side/inside) Humerus.

- *Subscapularis:* Rotates the Humerus. (Thumb side)



Anterior view of muscles that move the Humerus:



Posterior view of muscles that move the Humerus

7.10 The body

7.10.1 The Abdomen.

In the region of the abdomen (belly), there are mainly 3 layers of muscle.

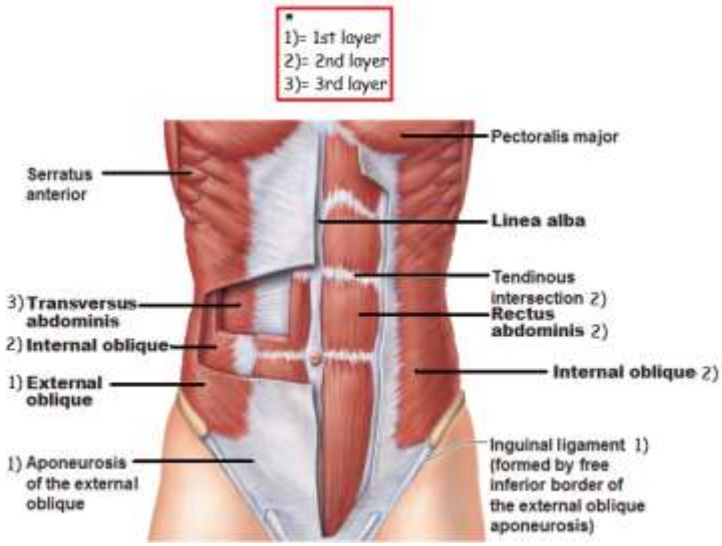
The first layer is simply covered by the right (R) and left (L) *External oblique.* This muscle is capable of flexing the spine and constricts the abdomen. It also aids in rotating the hips. (Depending on which side the muscle is on.)

If we were to now remove the first layer of the Abdomen, we would be found with the second layer which unlike the first layer, contains numerous muscles.
In fact, we would see 2 muscles:

- *Rectus Abdominis: "*Protects" abdomen by tensing, flexes spine. It is located in the center of abdomen.
- *Internal oblique:* Rotates (Corresponding side) and flexes spine. It is located on the side of abdomen.

We are now found with the third layer (after removing all the second layer muscles) which, similar to the first layer, contains only one muscle.

- *Transversus Abdominis:* Tenses and constricts Abdomen. (And Abdominal organs)
-



Abdominal muscles

7.10.2 The Chest.

In the chest, there are roughly 7 main muscles. As their position suggests, they mostly help with either breathing or moving the Humerus:

If we were to remove the skin and look at the chest, we would easily spot one of the most prominent muscles there, the *Pectoralis Major*.

Beside the sternum, there are the Sternalis muscles.
Surprisingly, the exact function of the Sternalis is unknown although several speculations are that it may help raise the Sternum during inhalation or, more abstractly, help the movement of the shoulder. (It is often considered part of the *Pectoralis Major,* as shown in image)

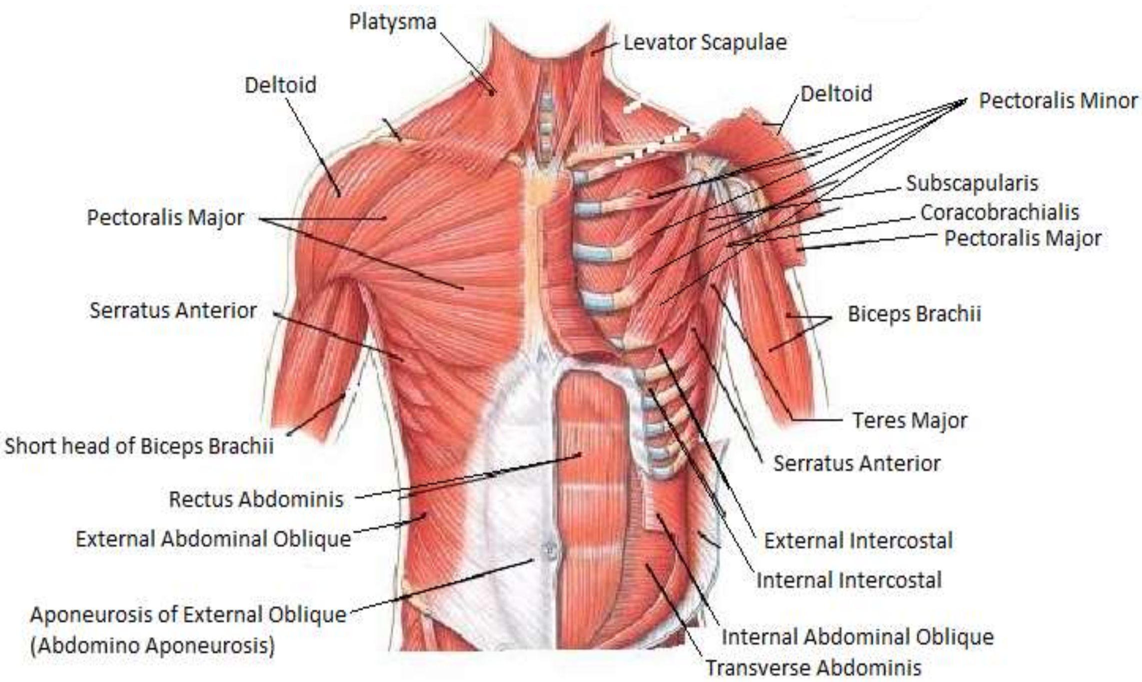
Located under the *Pectoralis Major*, is the *Pectoralis Minor* which assists in lifting the ribs during inhalation and drawing the Scapula downwards.

If we were to now look at the very extremities of the ribs, we would find a group of muscles called the *Serratus Anterior* muscles. These muscles rotate the Scapula as well as keep it in place, but also raise the ribs.

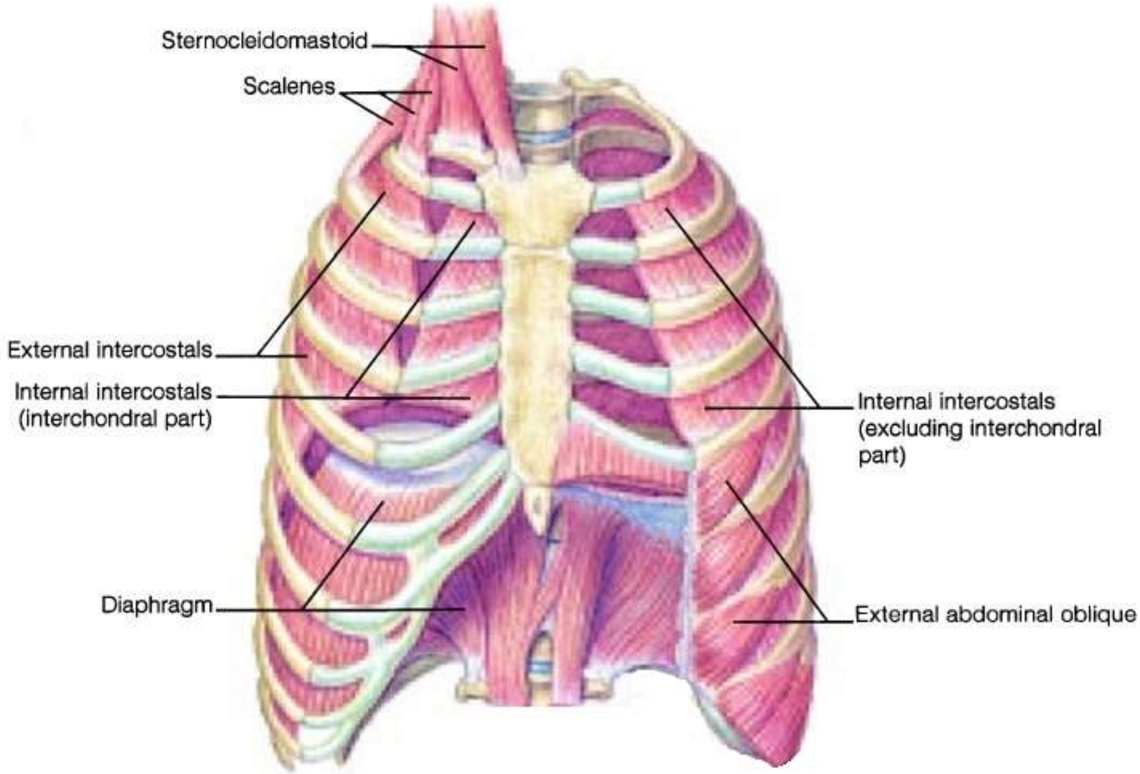
After removing all these muscles, we are found with 3 other muscles that all aid in respiration.

- *External Intercostal:* Raises ribs.
- *Internal Intercostal:* Pulls down the ribs.
- *Subcostal:* Pulls down (Depresses) ribs.

Together, all these muscles help either your breathing, the movement of the Humerus or any other action the body has in store for it.
*Note: The three muscles that mainly help respiration (*External Intercostal, Internal Intercostal and Subcostal).* They may not always be considered as muscles deriving from the chest.



A picture of the muscles of the chest.



Muscles of the “chest”/ribs.

7.10.3 The back

The back contains 3-4 main layers and over 30 muscles! Therefore, I’ll only explain the main muscles.

The 1st layer

- *Trapezius:* Located at the top of the back and extends to the shoulders and the neck. It helps rotate, pull down and lift the scapula, as well as extend the neck. (Pull it outwards.)

- *Latissimus Dorsi:* Found in the lower back section (Opposite to the abdomen) and helps us twist, bend and extend our body. It also aids in respiration.

- *Rhomboideus Major and Rhomboideus Minor:* Help lift/elevate and rotate the Scapula.

The 2nd layer

- *Serratus Posterior Inferior:* Pulls back the ribs (The lower ribs). It also aids in pulling the lower ribs downwards.

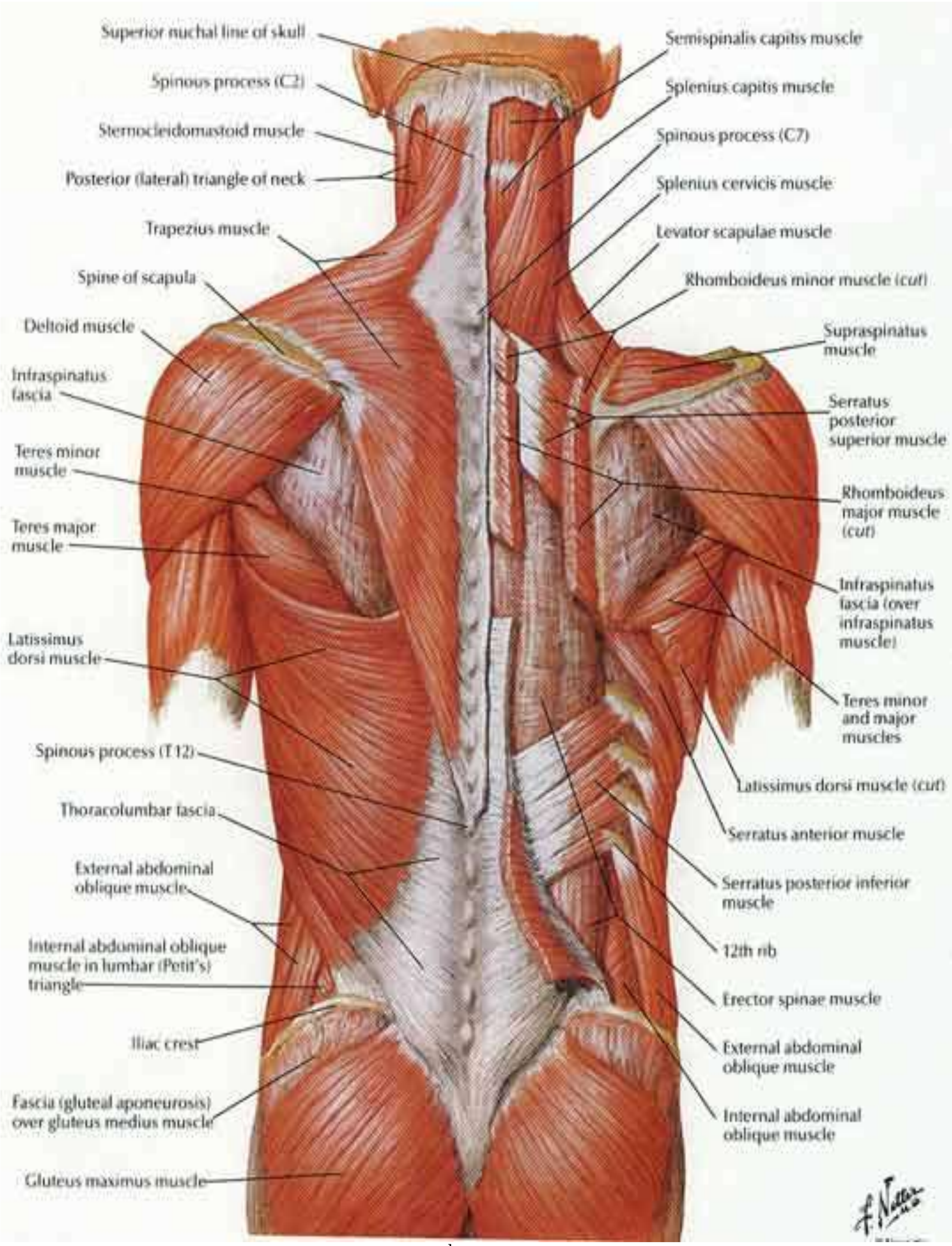
- *Serratus Posterior Superior:* Lifts the upper ribs up.

The 3rd layer

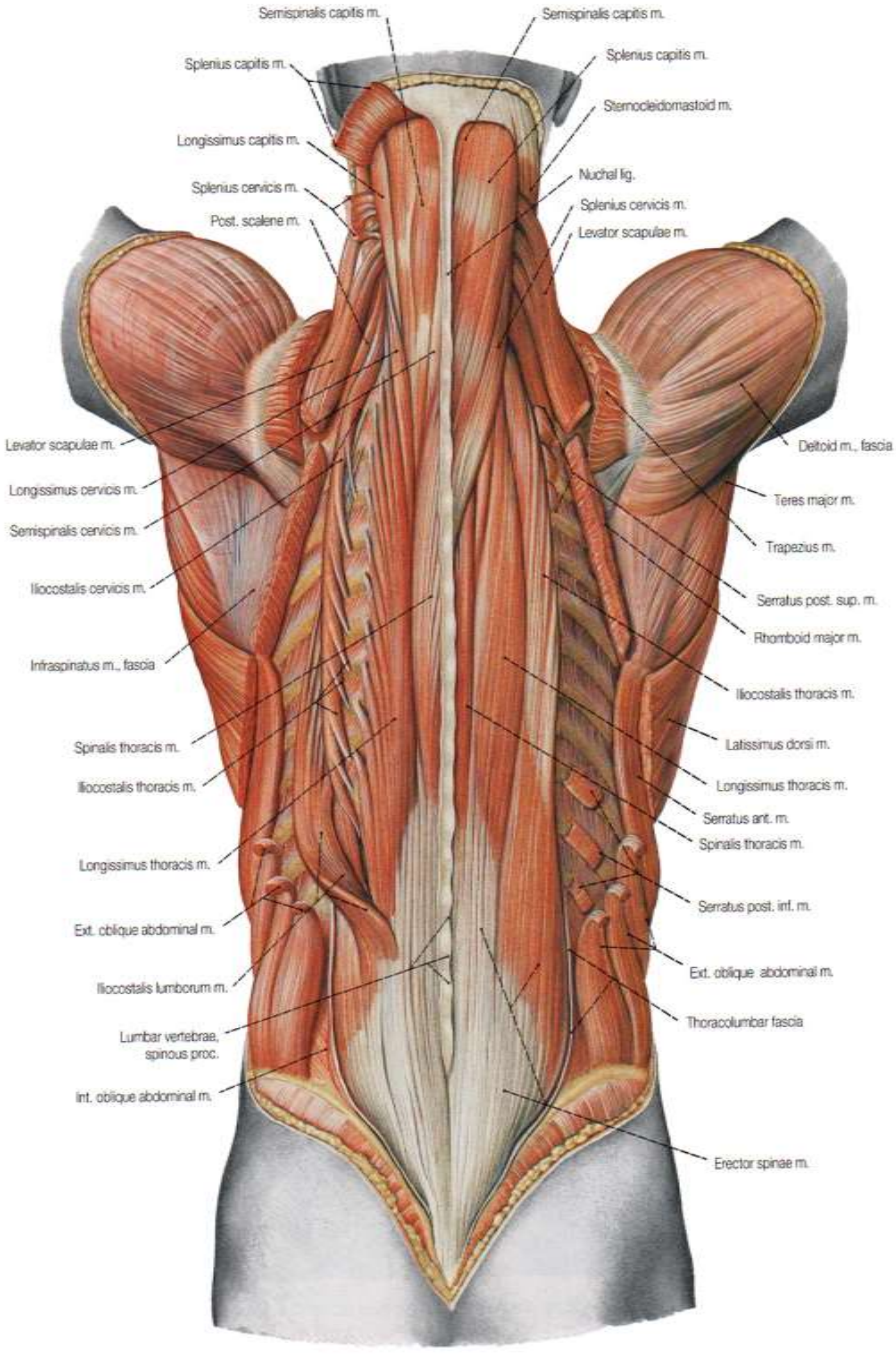
- *Spinalis:* Extends torso and bends the neck from side to side.

- *Splenius Capitis/Splenius Cervicis:* Pull, rotate and support the head. (Pull head backwards)

- *Semispinalis:* Erects spinal column, pulls head backwards along with turning it to corresponding side. (The side that it's located)



The 1st and 2nd layers of the back.



3rd layer of muscles on the back.

7.11 The Pelvis

Along with the joints of the pelvis, the role of supporting and moving the feet is one of the most important roles of the pelvis muscles.

The muscles which are conjoined to the vertebral column consist of the *Psoas Major*, *Psoas Minor* and the *Quadratus Lumborum*. The *Quadratus Lumborum* is located behind the *Psoas* muscles and raises the pelvis and brings the lower ribs down as well.

The *Psoas Minor* and *Psoas Major* help us to sit up.

Making the buttock (bottom) are three muscles. The superficial muscle is the strongest and most powerful muscle in the body: the *Gluteus Maximus*. Along with the *Gluteus Medius*, *Gluteus Minimus*, this pair of muscles helps in moving the thigh away from the body as well as "stabilizing" the hip. Other muscles in the buttock region include muscles such as the *Piriformis* which holds the pelvis joint as well as abducts and extends it.

Located inferior (lower) to the *Piriformis* are approximately 5 other muscles. The lowest of them all is the *Quadratus Femoris* (Femoris = Femur) and helps in rotating our hips.

Under the *Quadratus Femoris* is the *Obturator externus*. This muscle has its origin and insertion (where the muscle starts and ends) to the pelvis and the thigh bone. Naturally, that means that it rotates the thigh.

Above the *Quadratus Femoris* and *Obturator Externus* is the muscle *Inferior Gemellus*. This muscle helps primarily in moving the hip joint. Above the *Inferior Gemellus* is the *Obturator Internus* which assists in rotating or abducting the thigh—depending in what position the thigh is in.

Lastly, there is the *Superior Gemellus* which rotates and extends the hip as well as abducts the thigh when in certain position.

But despite the names and functions of these 5 muscles, the key thing about this group is that they make up a region called the *Lateral rotators* which, as the name suggests, rotates the hip laterally.

Located on the Ilium bone in the pelvis is the *IIiacus* muscle which aids in flexing the thigh.

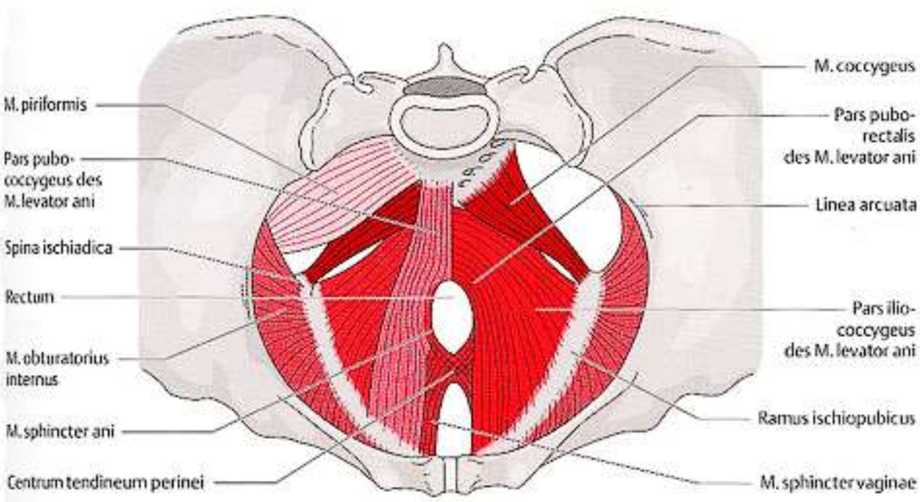
Near the center of the pelvis are the muscles crucial during childbirth, to excrete waste, and support other organs such as the bladder.

For simplicity purposes, only the important muscles are to be listed:

- *Coccygeus:* Holds the coccyx in place and draws it forwards during childbirth.
- *Levator Ani:* The *Levator Ani* crosses the whole arch of the pelvis and helps hold all the pelvic organs (such as the bladder and reproductive organs) in place.
- *lliococcygeus:* Helps the Levator Ani with its job.

Note: The *lliococcygeus* may be treated as a distinct muscle, but in fact it is part of the *Levator Ani*. (Other muscles such as *Puborectalis* are also part of *Levator Ani*)

- *Anal Sphincter:* Pushes waste "down and out" along with the Anus.
- *Deep Transverse Perineal:* Stabilizes ligaments in the pelvis along with it's "partner", *Superficial Transverse Perineal.*



The muscles of the Pelvis

7.12 The legs

As the legs support practically the whole body, they naturally have to be one of the strongest supporting parts in the body. The reason why is because all of the body weight is separated into two groups: both of the legs. If you stand up, you will feel next to no pressure at all.

For that, thank your legs!

And to make stuff worse, you will see that the legs have a lot of muscles! Why? Because the legs need to be very strong for walking—let alone bearing all that weight!

In addition, there are "regions of function" in the legs. For example, the side muscles stabilize the hip joint, the posterior muscles usually bend the knee backwards, the outwards-upper leg muscles help with the hip joint and tilt the lower leg outwards, and so on.

But yes, one can never express how important the legs are, so if someone asks you why the legs are important… respond: "SEPARATING WEIGHT!".

The front

Looking from the front, there are three main muscles and one muscle that travels across. The muscle crossing is the *Sartorius* and is the longest muscle in the body. It helps rotate the upper leg (thigh) outwards and pulls the thigh up.

Going chronologically from right to left, (left to right from the anterior view) the first muscle that streaks laterally down the thigh is the *Vastus Lateralis* and is found on the outwards side of the upper leg. Next to the *Vastus Lateralis* is the *Rectus Femoris*. The third muscle (found to the inside of the leg) is called the *Vastus Medialis*. This is one of the many "muscle regions" that do approximately the same function—extending the lower knee. In addition of extending the lower knee, the *Rectus Femoris* helps in flexing the hip.

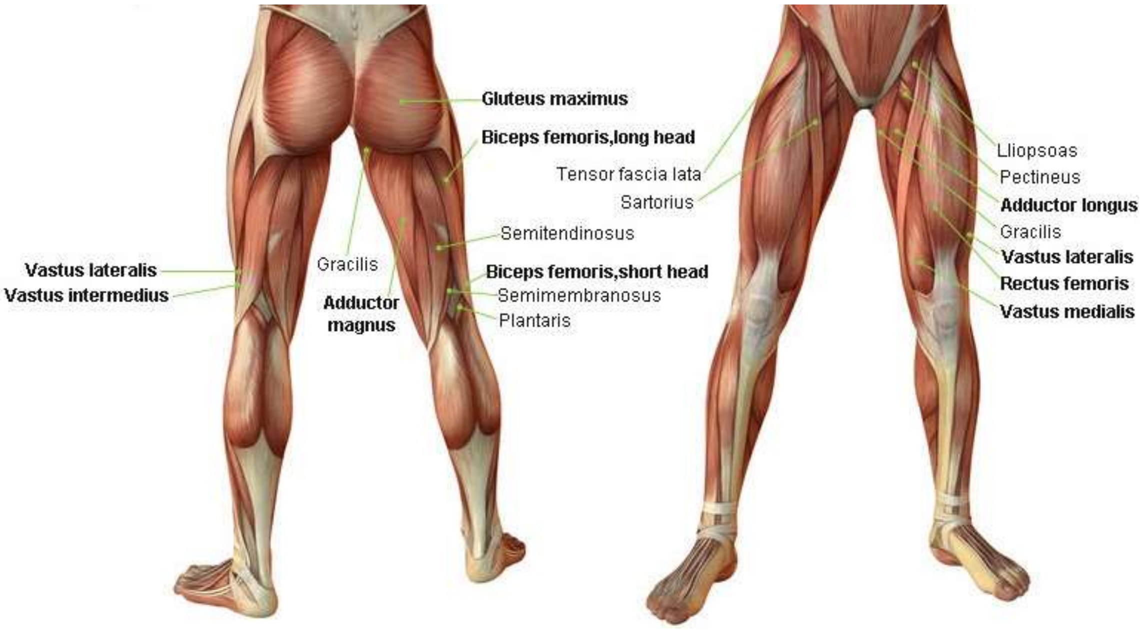
Found under the *Rectus Femoris* is the muscle *Vastus Intermedius*. As it's "origin" (or root) is located at the patella (or kneecap), it does the same function as the previous group of muscles. (This makes sense as the origins of the other three muscles are also located on the patella) This group of muscles is *Quadriceps* "group".

Surprisingly, there is another tiny muscle right underneath the *Vastus Intermedius* called *Articularis Genu*. It may be small, but it is vital to knee extension.

If this muscle weren't there, every time you would extend your knee, the tendon holding your patella would fracture. Essentially, this muscle helps ensure the "patellar ligament" doesn‘t rip.

On the posterior side of the leg, there are several groups of muscles:

- *Adductors*: Adduct (pull) the femur up to the pelvis. **(*Adductor Longus, Adductor Brevis, Adductor Magnus*)**
- Posterior "compartment": Adduction of lower leg. (Think of the action your lower leg does while running) **(*Biceps Femoris, Semimembranosus, Semitendinosus*)**
- Medial "compartment": Adducts the thigh. **(*Adductors group, Pectineus, Gracilis*)**
- Anterior "compartment": Extends the knee. **(*Quadriceps group, Tensor Fascia Lata*)**



Picture of the muscles of the upper leg.

The lower leg

The anterior (from the front) view of the lower leg is scarce with muscles. Kick a hard surface (not recommended) with the front of your shin and you will tumble down in pain!
This is because there is no muscle or fat protecting the front of your shin. When you hit your shin on a hard surface, tiny "pain receptors" (found on every bone) receive this signal and send it to your brain.

The shin

Only the major muscles which be covered.

To the right (left from anterior view) from the shin is the *Tibialis Anterior* which signifies "*An anterior muscle on the Tibia*". This muscle helps in flexing the foot.

Next, there is the muscle group that moves the toes of the feet:

(f=front of lower leg, b=back of lower leg)

- *Extensor Digitorum Longus:* Extends toes 2 through 5. **(f)**
- *Flexor Digitorum Longus:* Flexes toes 2 through 5. **(f)**

- *Extensor Hallucis Longus:* Extends the “big toe”. (“Hallux”) **(f)**
- *Flexor Hallucis Longus:* Flexes the “big toe”. **(b)**

Other main muscles located in the anterior view of the shin are:

- *Tibialis Posterior:* Rotates (Supination) and adducts the foot.
- *Peroneus Brevis* + *Peroneus Longus:* Pronate the foot. In addition, the *Peroneus Longus* helps in supporting the arch of the foot.

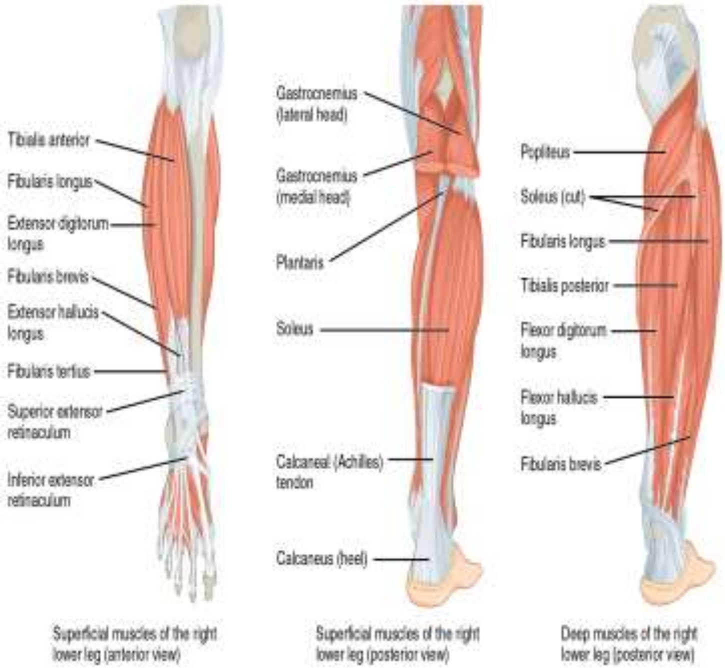
The back of the leg

The back of the leg has 2 distinct muscles and one tendon: *Gastrocnemius*, Soleus and *Achilles tendon*:

-*Gastrocnemius:* Flexes lower leg.

-*Soleus:* Attaches to Achilles tendon and pulls the sole of the foot up. (Directs the toes downwards)

-*Achilles tendon:* Pulls sole of foot up. (Plantar flexion of the foot)



Picture of the muscles of the lower leg.

7.13 The foot

The muscles located on our foot help us primarily with bending and extending our toes:

Top of foot:

- *Extensor Digitorum Brevis:* As the name suggests, this muscle extends the toes from 2 to 4. (The tips)
- *Extensor Hallucis Brevis*: Extends the big toe. (Located on top of foot beside *Extensor Digitorum Brevis*)
- *Dorsal Interossei:* Extends the toes from 2 to 4. (The middle of the toes—not the tips)

Found on the sole of foot:

- *Flexor Digitorum Brevis:* Flexes toes from 2 to 5.
- *Abductor Digiti Minimi:* Flexes the 5th toe.
- *Abductor Hallucis:* Abducts (pulls outwards) big toe.
- *Lumbrical(s):* Flex the toes from 2 to 5. (The middle of the toes—not the tips)

- *Adductor Hallucis:* Adducts (pulls inwards) the big toe.
- *Flexor Hallucis Brevis:* Flexes the big toe.
- *Plantar Interossei:* Adducts toes from 3 to 5. (The middle of the toes—not the tips)
- *Flexor Digiti Minimi Brevis:* Flexes the 5 toe along with the muscles *Opponens Digiti Minimi*.
- *Quadratus Plantae:* Flexes toes 2 to 5.

The muscles on top of the foot.

7.14 Research project!

Oh no! Not the much feared "research" word! Yes, it might be frightening but read on to see why it's here…

Firstly, it's not a surprise to say that the muscular system is more than complicated! Nevertheless, it is a truly amazing system in which it is more than possible to sharpen your knowledge on.

But to do this, we will need to become friends with our enemy word (research) and use our fellow internet!

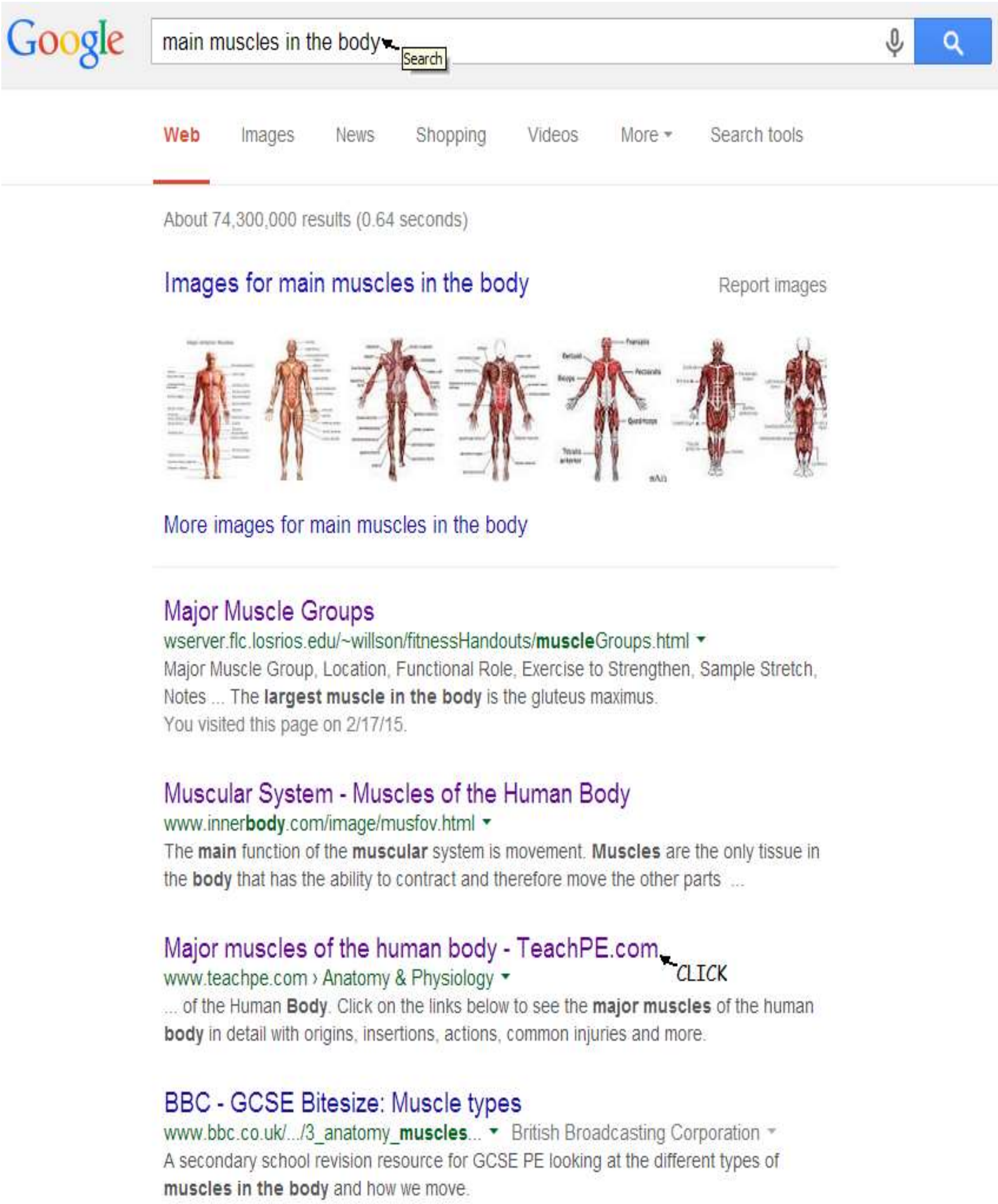
On the internet, type in (any browser and search engine will do although we use Google in this example), "main muscles in the body".

Click the link that says: "Major muscles of the human body - TeachPE.com". You will now see a list of muscles.

Research as much as you'd like about these muscles.

After you've researched these muscles (and it doesn't necessarily have to be overnight!) you will find that you know much more about these muscles. But not only that! You will also find that it is much easier to recognize other muscles that are found beside these muscles as well. Why? Well because it is likely that those muscles have a similar name to other muscles that are nearby as they do similar functions.

For example, *Extensor hallucis longus, Extensor hallucis brevis, Abductor hallucis longus,* and *Abductor hallucis brevis* all have similar prefixes or suffixes—therefore, we can infer that they all reside and act upon a particular area! And using our knowledge of Latin, we figure out that they all act on the big toe! TADA, just like that!


Google
main muscles in the body
Search
Web
Images
News
Shopping
Videos
More
Search tools
About 74,300,000 results (0.64 seconds)
Images for main muscles in the body
Report images
More images for main muscles in the body
Major Muscle Groups
wserver.flc.losrios.edu/~willson/fitnessHandouts/muscleGroups.html
Major Muscle Group, Location, Functional Role, Exercise to Strengthen, Sample Stretch, Notes ... The largest muscle in the body is the gluteus maximus.
You visited this page on 2/17/15.
Muscular System - Muscles of the Human Body
www.innerbody.com/image/musfov.html
The main function of the muscular system is movement. Muscles are the only tissue in the body that has the ability to contract and therefore move the other parts ...
Major muscles of the human body - TeachPE.com
CLICK
www.teachpe.com › Anatomy & Physiology
... of the Human Body. Click on the links below to see the major muscles of the human body in detail with origins, insertions, actions, common injuries and more.
BBC - GCSE Bitesize: Muscle types
www.bbc.co.uk/.../3_anatomy_muscles... British Broadcasting Corporation
A secondary school revision resource for GCSE PE looking at the different types of muscles in the body and how we move.

The Major Muscles of the Human Body should be listed on the page:

Home > Anatomy & Physiology > Muscles

Major Muscles of the Human Body

Click on the links below to see the major muscles of the human body in detail with origins, insertions, actions, common injuries and more.

Shoulder Girdle

- Trapezius / Levator Scapulae / Rhomboids / Pectoralis Minor / Serratus Anterior / Sternocleidomastoid

Shoulder joint including Chest Muscles

- Pectoralis Major / Latissimus Dorsi / Deltoid / Supraspinatus / Infraspinatus / Teres Minor / Subscapularis / Teres Major

Elbow joint muscles / Arm Muscles

- Biceps Brachii / Brachialis / Brachioradialis / Triceps Brachii / Anconeus / Supinator / Pronator Teres / Pronator Quadratus

Wrist and hand

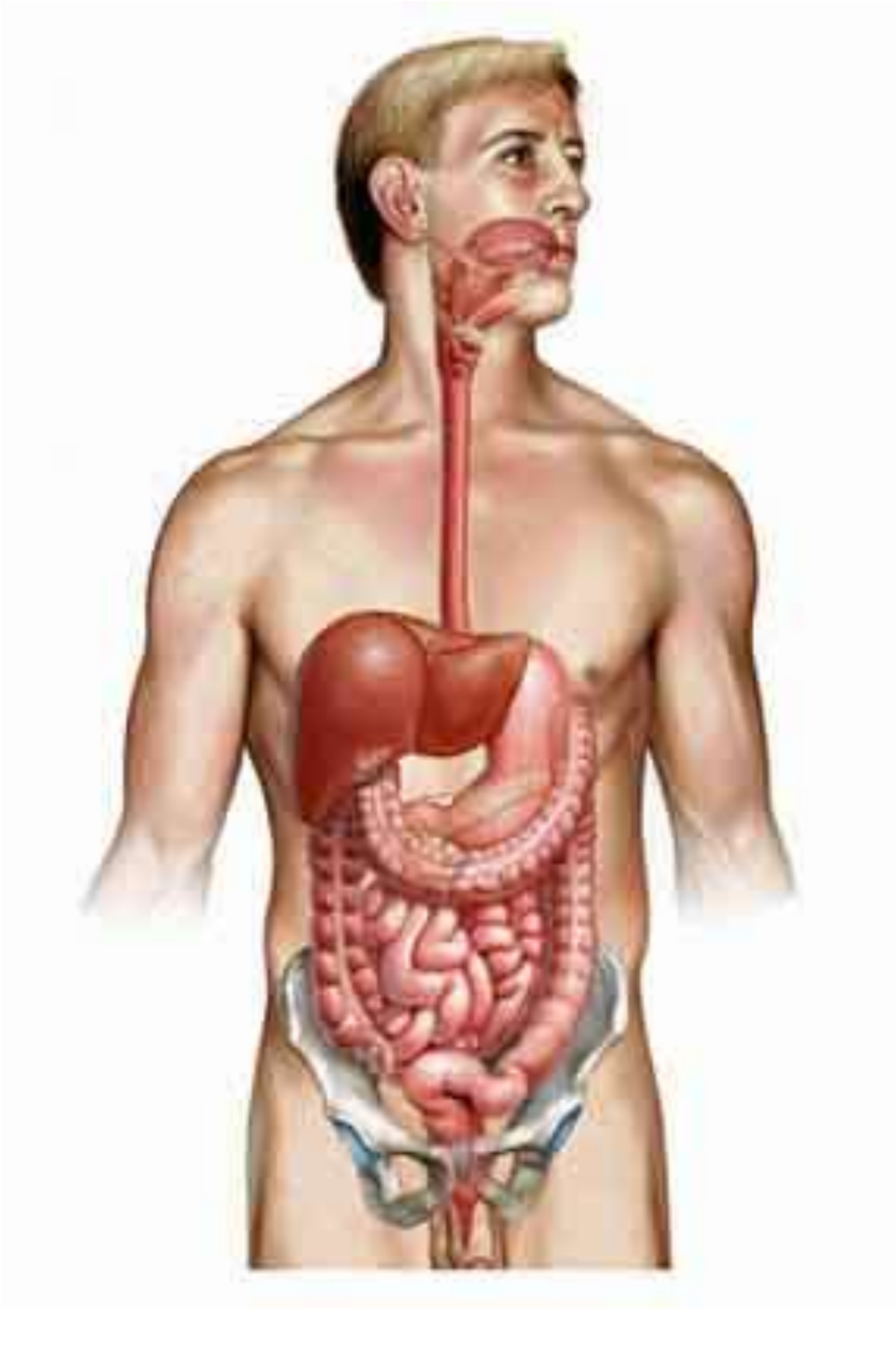
- Flexor Carpi Radialis / Flexor Carpi Ulnaris / Extensor Carpi Radialis Brevis / Extensor Carpi Radialis Longus / Extensor Carpi Ulnaris / Extensor Digitorum Communis / Flexor Digitorum Superficialis / Extensor Pollicis Longus / Flexor Pollicis Longus

Knee joint

- Vastus Lateralis / Vastus Intermedius / Vastus Medialis / Popliteus

Next, do some research on each muscle by clicking on the muscle name or searching it up independently.

8 The digestive system



The fuel-house of our body

The digestive system provides all the essential nutrients to all the systems. It is also mostly composed of muscles.

For example, food that's transferred from the stomach to the intestines is done so by *muscles*! Or if the food gets stuck in the narrower part of the intestines, it's the *muscles* that come to the rescue and push the food along!

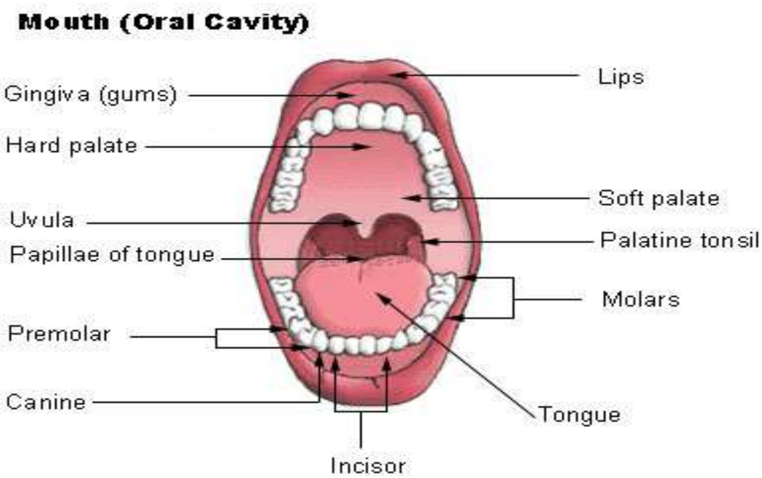
In fact, we can go on for days and days listing muscles and their roles in the digestive system.

8.1 The main parts

The digestive system contains numerous parts—all of which will be covered in this "chapter": The oral cavity, the throat, the Esophagus, the stomach and the small and large intestines. Other parts that will be covered are: the Salivary glands, Liver, the Gallbladder and the Pancreas.

8.1.1 The mouth

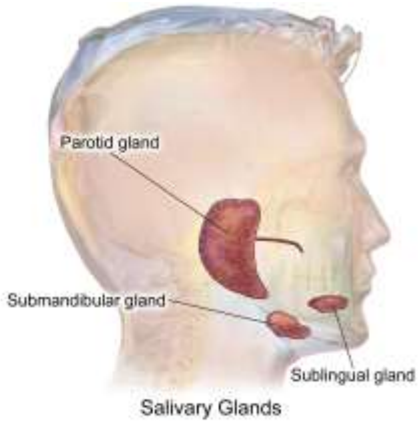
The mouth contains several major and important components such as the tongue, Tonsils, Salivary glands (there are three pairs of salivary glands) that are essential for the digestive system to function.



The parts of the mouth.

The Salivary glands

The Salivary glands help digest the food when it's in the oral cavity so that the stomach can break the food down further.



The 3 main salivary glands of the mouth.

As you can see, there are 3 main salivary glands in the mouth. A common misconception among people is that there are only 3 salivary glands that are present in the mouth. However, there are as many as 900-1000 tiny salivary glands found in the oral cavity.

The salivary glands in the body are activated when the brain recognizes the food and the salivary glands start to produce saliva to digest the food.

<<*Ohhh, that's why my mouth starts watering when I see those creamy chocolate caramel treats topped with strawberry cream!*>> you're thinking…

Processes in the mouth

It should be to no surprise to you that even in the mouth, the food passes through several stages. Firstly, it gets chewed up and split up by the teeth and then it gets "softened" and digested by the saliva produced by the Salivary glands.

Now that's food cruelty!

The Uvula

Once we are comfortable with the size of the chewed up food, the tongue helps push down the food down the Larynpharynx—one of the 2 "segments" of the throat.

(The throat is split up into the Larynpharynx and the Oropharynx. The Larynpharynx is where the food goes by while the Oropharynx is the passage for air)

The Larynpharynx leads into the 24cm [~9.45"/~0.79ft.] tube that we refer to as the Esophagus.

However, **before** it passes through the Esophagus, the food reaches what's called the Uvula. The Uvula helps ensure that nothing touches *the back of the top the mouth* which may make us choke.

If the Uvula senses "a disturbance" (not to be related to "the force" in *Star Wars*!), the body will try to get rid of it by gagging.

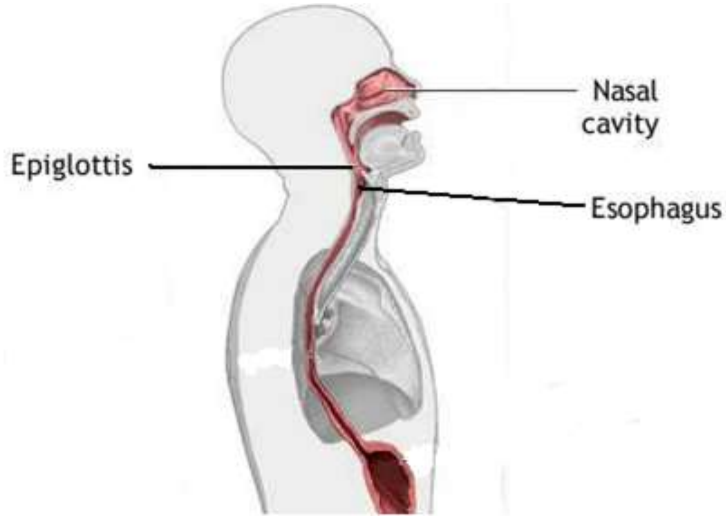
Gagging, you could say, is like vomiting but without the "*vomit*" part. (Although they serve the same purpose, getting something unwanted out of the body)

But if the food does not disturb *the back of the top the mouth*, the Uvula raises. Once the Uvula raises, the food is ready to continue it's journey. But not only that! Apart from preventing the food to touch *the back of the top the* mouth, the Uvula also closes a skin flap called the Epiglottis. The Epiglottis, when closed, covers the Oropharynx so that the food does not continue through the wind pipe and into the lungs.

If the food somehow manages to get into the wind pipe (also called the

Trachea), the brain triggers the natural response to cough and choke to get the food out.

The food proceeds down the Esophagus.



An image of part of the digestive system. The Nasal cavity, Epiglottis, Esophagus are referenced here.

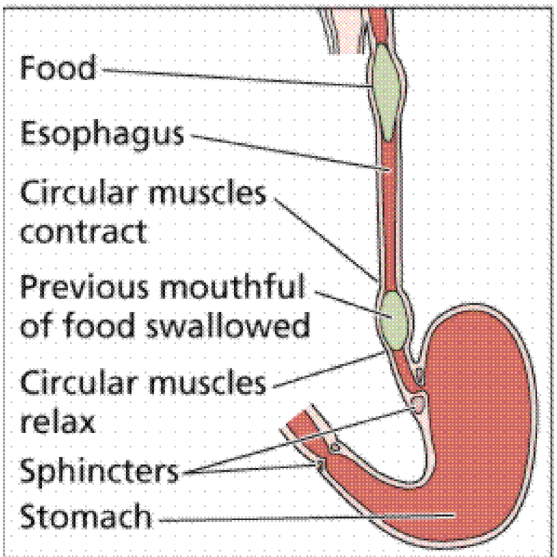
8.1.2 The Esophagus

The Esophagus connects the oral cavity with the stomach. After the food has passed through the Larynpharynx, it will proceed down to the stomach.

But there is surprisingly a lot of action during the 6 seconds that the food goes down the Esophagus.

The Esophagus is formed from circular muscles which contract, pushing the food from the top to the bottom of the Esophagus, and into the stomach.

A common misconception among people is that the Esophagus relies fully or partially on gravity. Of course, gravity does help indeed, but the amazing part is that the food is able to go to the stomach by the Esophagus even if you are upside down. (Although it’s not recommended to try)



The circular muscles in action!

Sphincters

Presently, the food has reached the end of the Esophagus and is entering the stomach… through the Lower Esophageal sphincter (also known as the Cardiac Sphincter).

But what is a sphincter?

Well, a sphincter is like a gate that is located on either sides of the stomach and prevents the food in the stomach to escape further down the digestive system or into the Esophagus. Essentially, a sphincter is a muscle that regulates what goes in and out of the stomach.

To open, the sphincter contracts. To close, it relaxes. The Cardiac Sphincter relaxes after the stomach is half full.

8.1.3 The stomach

Chemical reactions

Once the food is in the stomach, it undergoes digestion. The role of the stomach, is essentially just to digest the food.

But despite what you may be thinking (*pff*… the processes in the stomach are simple!), digestion in the stomach is amazingly complex and intriguing.

So it has been my mission to make you understand this subject that is understood by few people today as well as you can. Bear with me…

***Note:** The digestive process in the stomach is called the Gastric Phase…

Firstly, stomach cells that are found on the stomach walls (Parietal, Neck, Chief cells) release a mixture of digestive enzymes (that form gastric acid) out to the stomach walls and the stomach fluid.

Luckily, the stomach itself does not get digested by these enzymes with a pH (acidity level) of 3.0 to 3.5! This is because the walls of the stomach are layered with a wall of thick mucus, which prevents the body to be digested from "inside out".

Now let us continue with the digestive enzymes… The different cells of the stomach walls secrete numerous components that altogether form Gastric acid which helps in turning the food into something that can be digested.

While the components of the Gastric acid (such as Pepsinogen, Hydrochloric acid, sodium, potassium, and more) continue to digest the food, the release of amino acids (make up proteins) from the food excites the Parietal cells to produce more Gastric acid.

However, several components in Gastric acid such as Pepsinogen need to be broken down into pepsin to help digest the food. This action is done by the highly acidic Hydrochloric acid.

After the food is digested, it is sent further into the digestive system and is now called *Chyme*.

Got it?

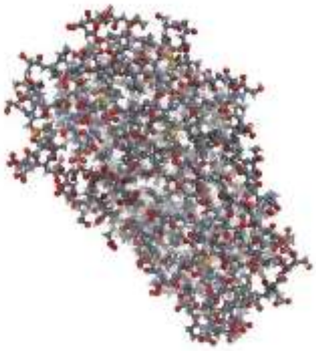
If not, here's another explanation: (You can skip ahead to the next page if you understand…)

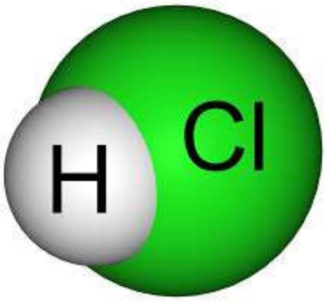
Once food that we have eaten enters the stomach, glands that are found in the stomach walls secrete/send out numerous acids, enzymes, and other components to digest the food.

Component	Function	Secretion	*Other info.*
-Pepsin	Breaks down proteins. *(Into peptides)*	Chief cells. (Although it is secreted as Pepsinogen)	It is secreted by the chief cells as Pepsinogen. (Not pepsin)
-Hydrochloric acid	Kills bacteria in food as well as turns Pepsinogen into Pepsin.	Parietal cells.	The pH level of Hydrochloric acid is ~3.1/mm. (3.1 per millimetre)
-Intrinsic factor	Helps absorb vitamin B_{12} in small intestine.	Parietal cells.	Although secreted in stomach, this component helps in small intestine.
-Water	Forms most of the liquid Chyme.	Mucous cells.	The chemical composition of water is H_2O.
-Mucus	Protects stomach wall from the Hydrochloric acid.	Mucous cells.	Mucus is found not only in the stomach but virtually everywhere in the body.
-Gastric Lipase:	Absorbs fat in small intestine.	Chief cells.	Lipases are essential for processing lipids and fats.

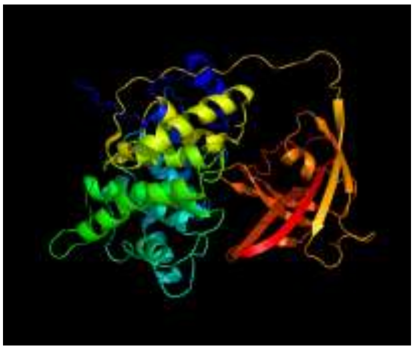
Different components are sent out by different types of cells that make up the glands found in the stomach walls. Such components are:
Hydrochloric acid (a very acidic acid), Pepsinogen (enzyme), sodium, potassium, proteins, calcium, etc.
(For Pepsinogen to be able to digest the food, it must be broken into Pepsin by Hydrochloric acid)

Together, all these components create Gastric acid which, as you might suspect, break-up/digest the food into a sort of mush referred to as *Chyme*. The Chyme is then proceeded further down the digestive system.
Hopefully that helped, but if you still don't get it, just know:
In the stomach, Gastric juice is released by cells to digest the food and turns it into a mush called *Chyme*.
Here are the main components of Gastric acid, their function and from where they are secreted from:

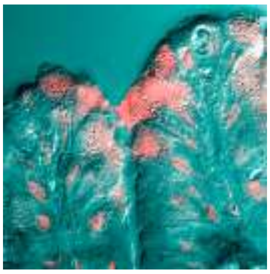




Structure of Pepsin Structure of Hydrochloric acid



Structure of Intrinsic factor



|Water | | Mucus cells | | Gastric Lipase |

Enzymes

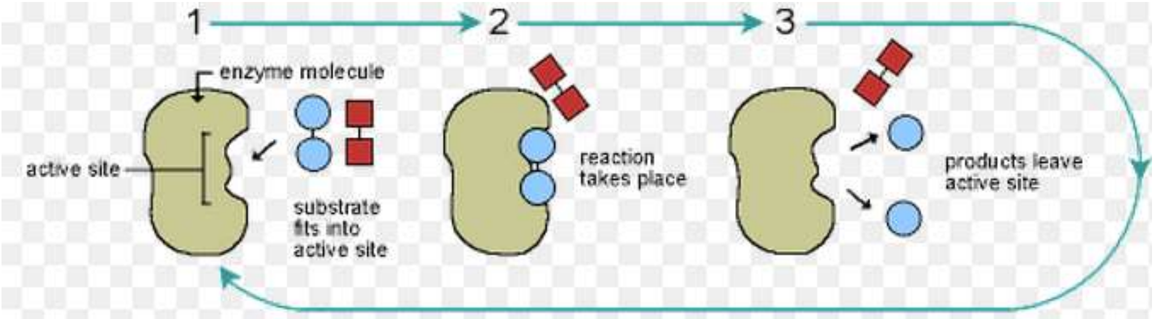
Enzymes are incredibly vital and complex "machines". But firstly, what is an enzyme? Well, an enzyme is a *catalyst* (something that speeds up a reaction) that helps speed up digestion. Now on to how they work…

An enzyme works by attaching to a food molecule. The food molecule that has now attached to the enzyme is called a *substrate*.

Enzymes have a unique shape where the substrate is to "land". Different enzymes are meant for different food molecules.

The area where the food molecule is to "land" on the enzyme is called the active site and is where the reaction takes place. Think of the activation site like some sort of dock for the food.

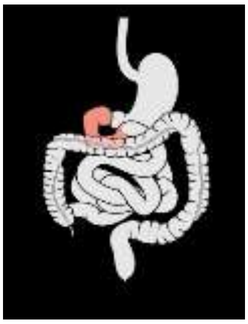
After the food molecule is broken up, it is released from the enzyme.



An image illustrating how an enzyme processes a substrate.

8.1.4 The Duodenum

After the food is excreted out of the stomach by the Pyloric sphincter, it enters the Duodenum—the connection between the stomach and the small intestine. In the duodenum, the food is further digested by enzymes secreted by the liver and pancreas. (More information in the following sections)

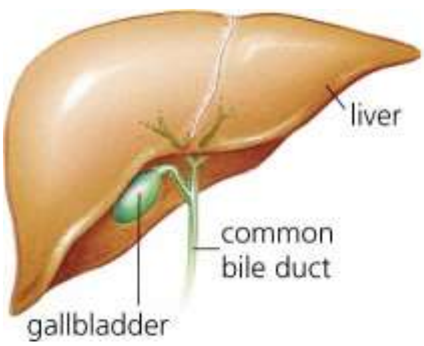

An image of the stomach, small and large intestine along with the duodenum, which is highlighted.

8.1.5 The Liver and Gallbladder

The Liver is a large organ (separated into 4 pieces/lobes) that helps produce digestive juices (such as Bile), removes toxins from the blood/body, and creates proteins.

However, its main function in the Digestive system is to create Bile, a digestive juice that helps digest the Chyme in the Duodenum.

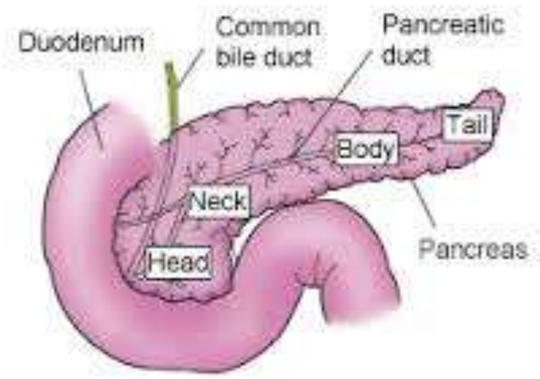
After the Bile has been secreted, it is stored in a small "pouch" behind the Liver called the Gallbladder. Bile is transported to the Duodenum from the Gallbladder via the Common Bile duct.



An image of the liver and the gallbladder.

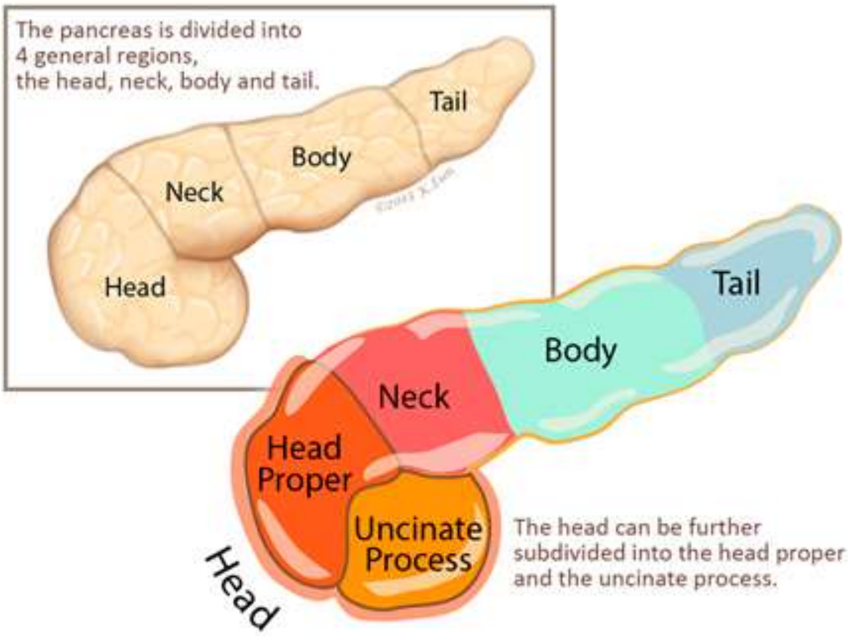
8.1.6 The Pancreas

The Pancreas is an organ found behind the Stomach and secretes Insulin and Glucagon into the Duodenum. (Next section) These hormones are inserted by the Pancreatic duct.



The parts of the pancreas

The Pancreas is split into 4 parts, the tail (being the most to left right in your perspective), body, neck, and head (The head can be divided into the Head Proper and Ucinate Process).



An image of the different sections of the pancreas.

Glucagon and Insulin

In the Duodenum, 2 hormones are added to help digestion:

-Glucagon and Insulin.

These enzymes ensure that there is the right amount of Glucose (sugar) in the blood. Both of these hormones are secreted by the cells of the Pancreas.

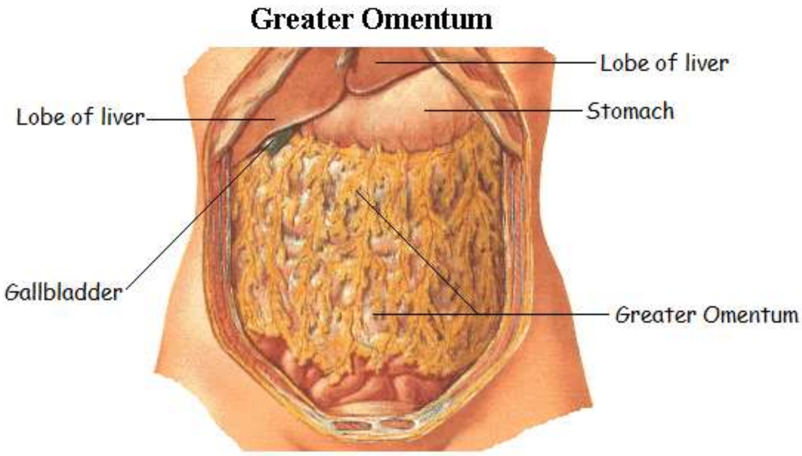
As foods rich in carbohydrates are turned into Glucose, the sugar/Glucose level in the blood rises.

Insulin helps reduce the amount of sugar in the bloodstream (Glucose). Insulin "tells" the cells in your body to take glucose from the bloodstream to use as energy. Extra glucose is turned into Glycogen and is stored in Liver cells.

On the contrary, Glucagon helps increase the amount of glucose in the blood to keep it constant after the level of glucose has diminished several hours after you have eaten. This is performed by Glucose "ordering" the Liver cells to release the Glycogen that it had stored into the bloodstream. (After transforming the Glycogen into Glucose again)

Fat

The digestive process is different in fat. The needed fat is directly absorbed and is stored on arteries and the belly. On the belly, fat is stored on a connective tissue referred to as the Greater Omentum.



The Greater Omentum along with other organs of the digestive system.

Diabetes

Diabetes is a mostly a genetic disorder and is when the body has a high concentration of glucose in the blood. This is caused by the body's incapability to create or respond to insulin. (Remember, insulin is the hormone for suppressing glucose in the blood)

Diabetes may be life threatening if not treated properly.

Effects of Diabetes include:

- Blindness
- Nerve damage
- Kidney failure **(Life threatening if no precautions are taken)**
- Thirst (Polydipsia)
- High urination (Polyuria)
- Increased hunger (Polyphagia)
- Stroke **(Life threatening)**
- Blood vessel damage **(May be life threatening)**
- Nausea
- Heartburn
- Intoxication **(Life threatening)**

There are 2 types of Diabetes, type 1 and type 2.

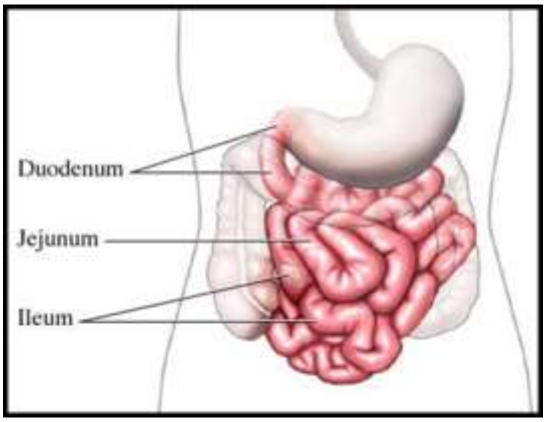
- Type 1 Diabetes is when the body is not capable of creating insulin.
- Type 2 Diabetes is when the body cannot respond to insulin.

As the sugar is absorbed by the digestive lining, the insulin must open a sort of "gate" for the sugar to be able to be absorbed. When the body doesn't react or can't produce insulin, the sugar is not absorbed. Thus, the blood has too much sugar.

8.1.7 Small intestine

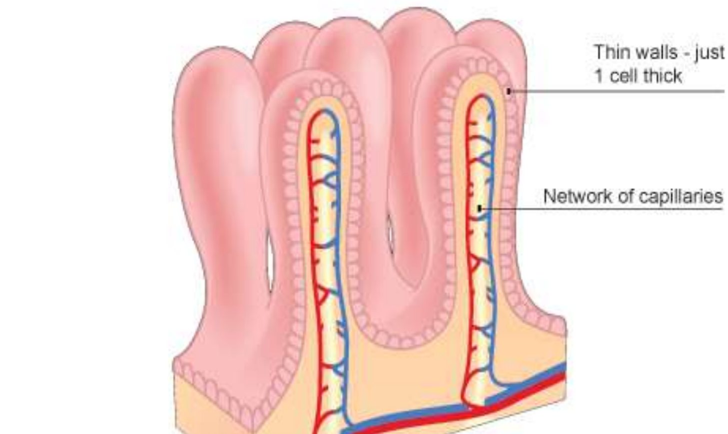
After passing through the Duodenum, the food is found in the small intestine.

The small intestine is split into two parts, the Jejunum and the Ileum. The food passes firstly through the Jejunum and then proceeds to the Ileum.



An image of the duodenum and the two parts of the intestine. (The Jejunum and the Illeum)

To absorb the nutrients of the food, there are the Villi. These round objects stick out from the intestinal lining to increase the surface area of the intestine and absorb any nutrients that are needed. These nutrients are then transported through the blood stream to the organs of the body.



Villi found on the walls of the intestinal tract.

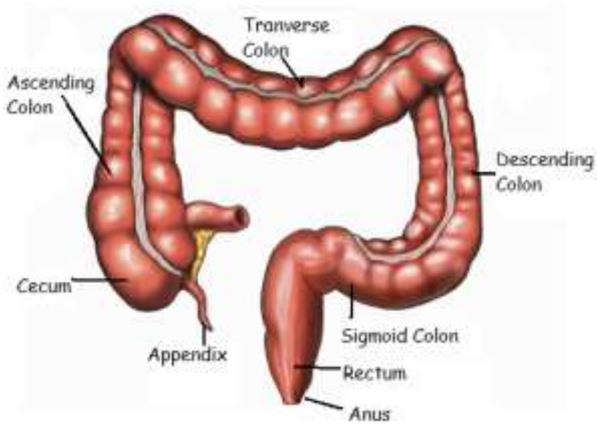
Besides the Villi, the surface area of the intestinal track is increased by fold the intestine in the abdomen so as to increase the length of the intestine.

8.1.8 Large intestine

The food proceeds into the large intestine after travelling through the small intestine.

The large intestine is usually known to be split in 3 main parts. However, in total, there are 8 parts:

- **Appendix**: Helps fight disease. Used to be part of Cecum.
- **Cecum:** "Useless". Beginning of large intestine. Connected to Ascending Colon.
- **Ascending Colon:** Part of the colon that ascends. (Goes up)
- **Transverse Colon:** Transversal (Sideways) part of the colon.
- **Descending Colon:** Section of the colon that descends.
- **Sigmoid Colon:** Attached to the Descending colon and Rectum. Shaped like an elongated "U".
- **Rectum:** Stores waste.
- **Anus**: Derives from "Ano" (Ring) in Proto-Indo European. Expels waste from digestive tract.



Parts of the large intestine.

The function of the large intestine is to absorb any remaining nutrients as well as water.

8.2 Do it yourself!

Making a real digestive system is basically impossible. However, it is possible to make a *mock* digestive system which acts *more or less* like one.

CAUTION: Requires permission of a parent. May result in mess…

Firstly, take a pot and fill it ¾ with water. (Any amount of water with any pot will do) This pot acts as the oral cavity. Next, add acid (e.g. lemon juice) to act as the saliva. For the food, put a fatty food in the solution of water and acid. The reason why it is better to put a food that has fat in the solution is because it is easily broken down by the "enzymes". Leave the chocolate to be broken down a little before doing the next step.

Step three of this experiment! (After putting water and acid into a bowl)

The next step is to either pour the water with the chocolate into another bowl (which acts like the stomach) or leave it in the original bowl.

Add an acid to act as the Gastric juice and another one for the Duodenum (acts like Bile).

Have patience as the chocolate is broken down further. (This may take several hours) If the chocolate doesn't dissolve, break it up with a fork or spoon.

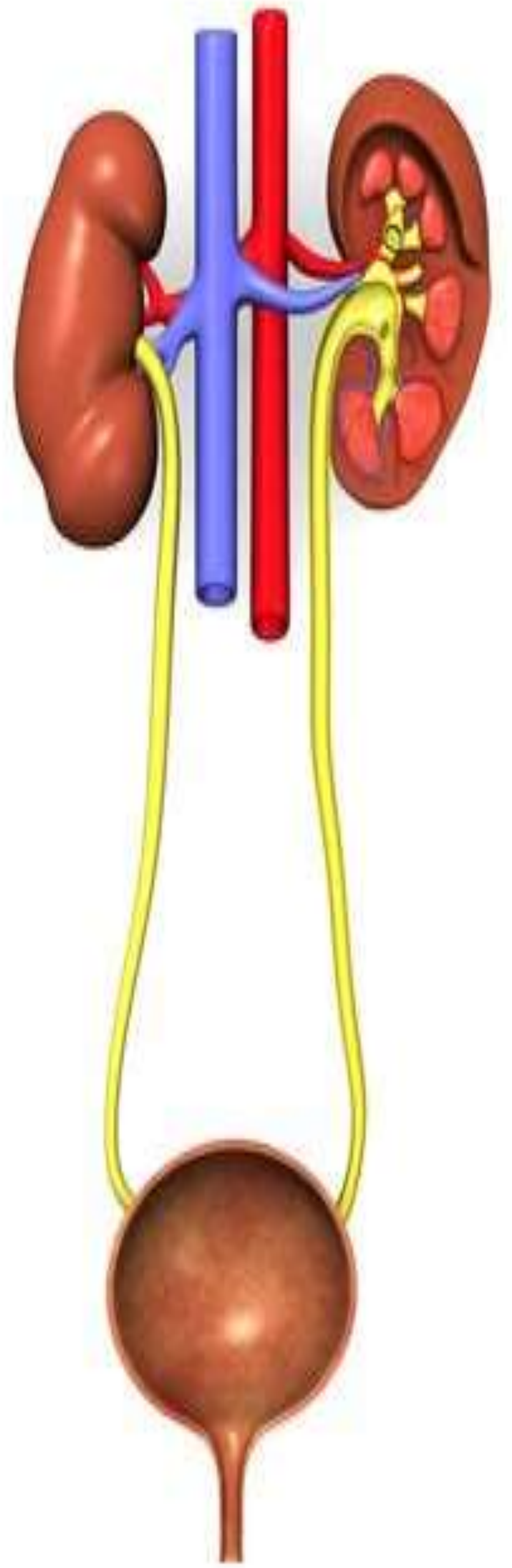
Now in another bowl, (or if you prefer to be tidier, the same bowl) take out all the small pieces of chocolate that have chipped off. These are the pieces of the food (nutrients) that have already been absorbed.

Finally, pour out the water from your bowl—leaving the big chunks of chocolate left. This imitates the large intestine, which absorbs any remaining water. Everything else that still remains (chocolate) is the waste.

This "digested" chocolate!

Hope you had fun!

9 The Urinary system



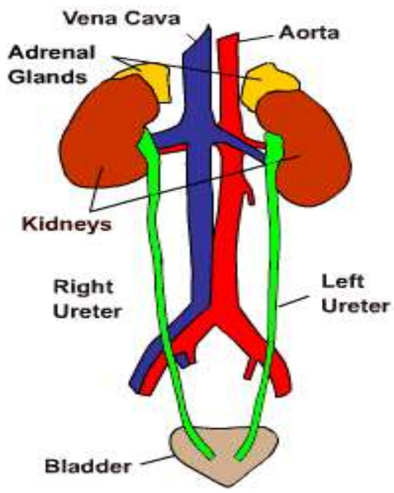
The dump… Just for us

The Urinary system is the only system which filters out the toxins from the body's fluids.

After filtering out the toxins from the body's fluids, the toxins (urine) are transported to the bladder via the 2 Ureters.

The bladder is an organ that stores urine until it is excreted by the urethra. The urethra is basically a tube where the urine is excreted.

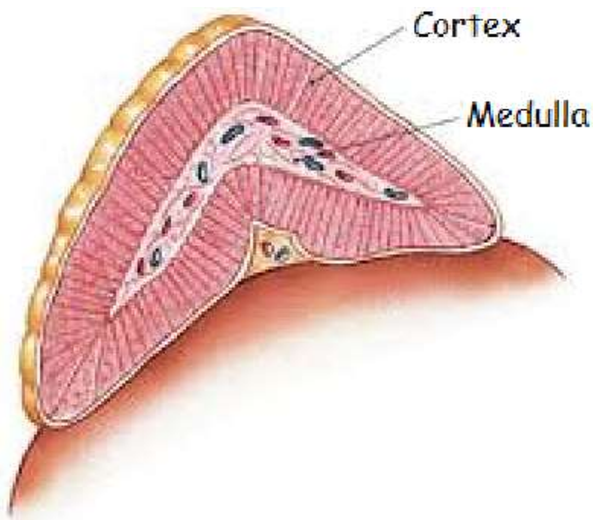
The adrenal glands (explained in the following section) produce adrenaline (which is covered in more detail in the nervous system section), and different hormones that aid numerous systems: some of which include the immune system, the cardiovascular system, the urinary system and more.



Parts of the Urinary system.

9.1 The Adrenal glands

The adrenal glands are separated into 2 main parts: the Medulla, and the Cortex.



Parts of the adrenal gland.

The Medulla, (as explained previously) helps in creating adrenaline, the hormone that is activated when we are scared/surprised. (Fight or flight response)

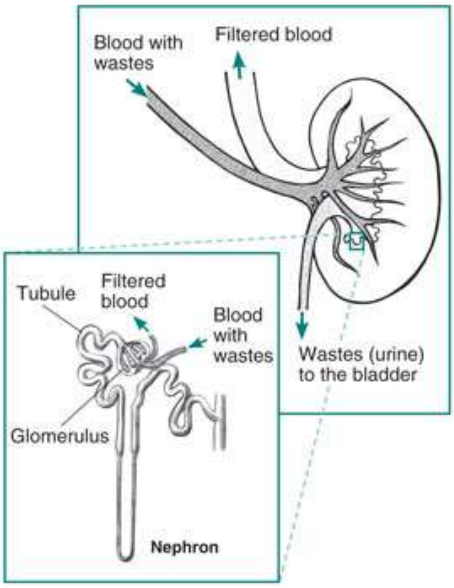
The cortex however, creates all sorts of hormones for mostly all the systems of the body. Some of them include:

- **Aldosterone**: The hormone that regulates the blood pressure.
- **Cortisol**: Creates glucose and helps in regulating the body's *metabolism*. (Our metabolism is the reactions that keep us alive)
- **Hormones** for the reproductive system such as testosterone in males and females.

9.2 The Kidneys

To filter water in the blood and remove all toxins, the blood is "fed" to the kidneys by the Renal artery, which originates from the Aorta. (Explained in the Cardiovascular system)

To filter the blood, the kidneys contain millions of filtering organisms namely called Nephrons.



A depiction of a Nephron.

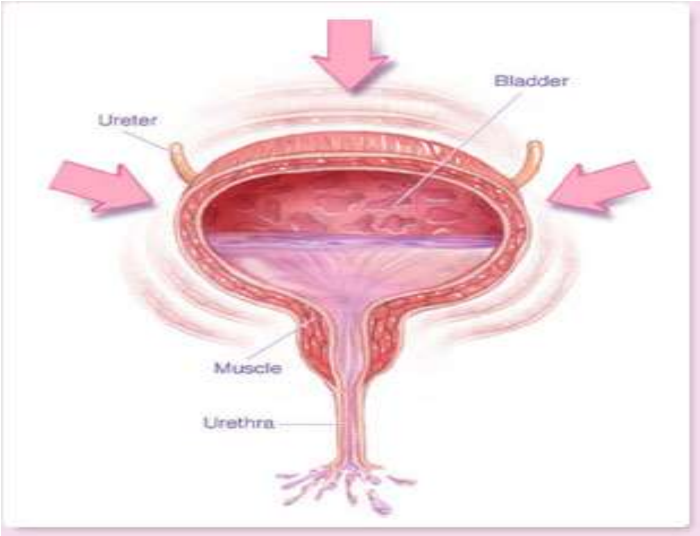
To start, the Glomerulus (also called Bowman's capsule) acts as a filter, trapping blood cells and proteins. Now, only the blood fluid and waste is present in the kidney.

To finish it off, the tubules collect the waste in the fluid and transport needed minerals and other objects back to the bloodstream.

9.3 The bladder

After the blood is filtered, the toxins (now called urine) are transported by the Ureters to the bladder, where it is stored.

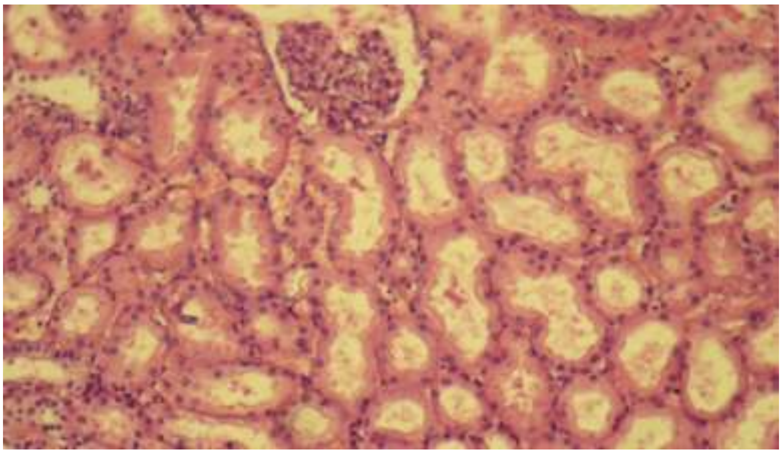
Once enough urine has accumulated in the bladder, electrical pulses are sent from nerves located at the bladder to the brain. The brain then orders the urethra muscles to relax and the urine rushes out by the urethra.

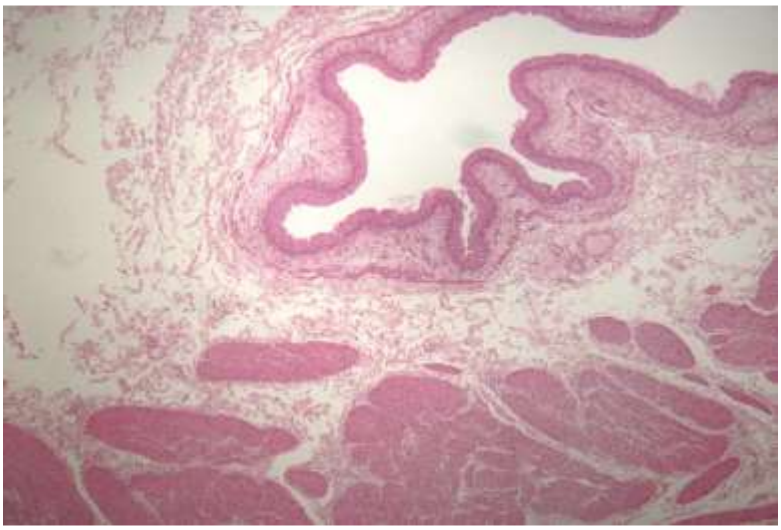


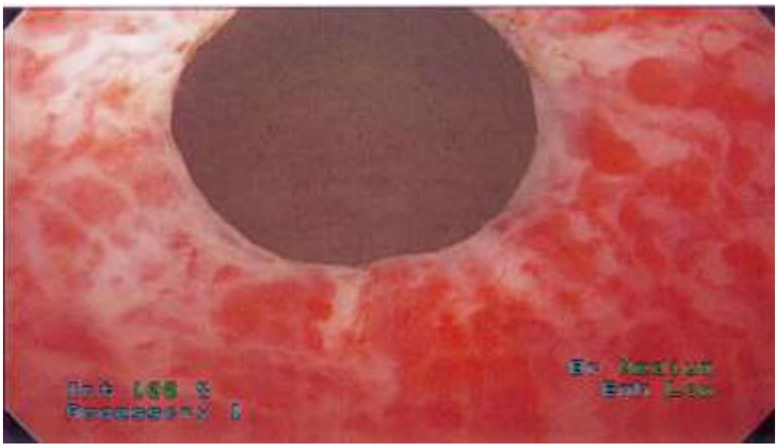
A picture of the bladder and urethra.

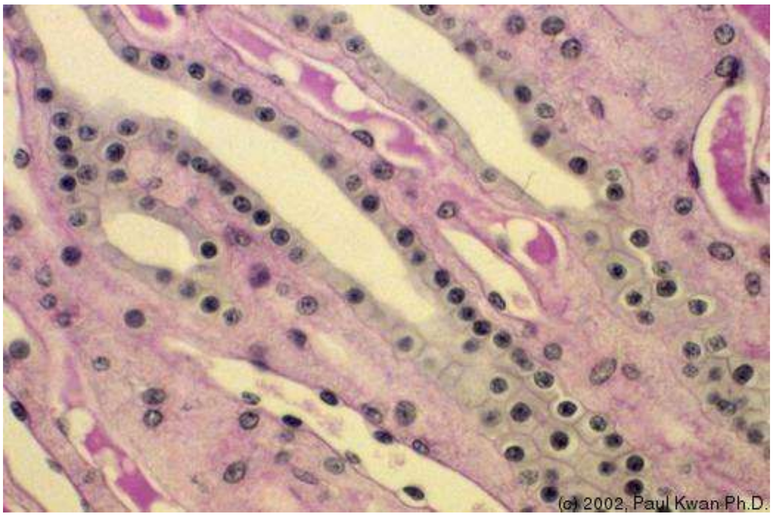
9.4 The Close up Guessing!

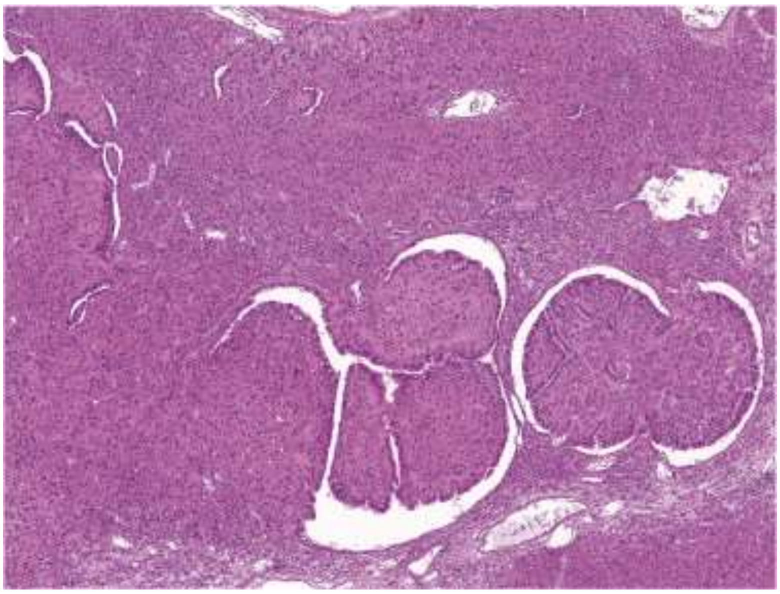
Here we will magnify a certain part of the urinary system a number of times. You have to guess where it is.
The answers are below.

a) 

b) 

c) 

d) 

e) 

Answers:
a): Renal Cortex (Kidney)

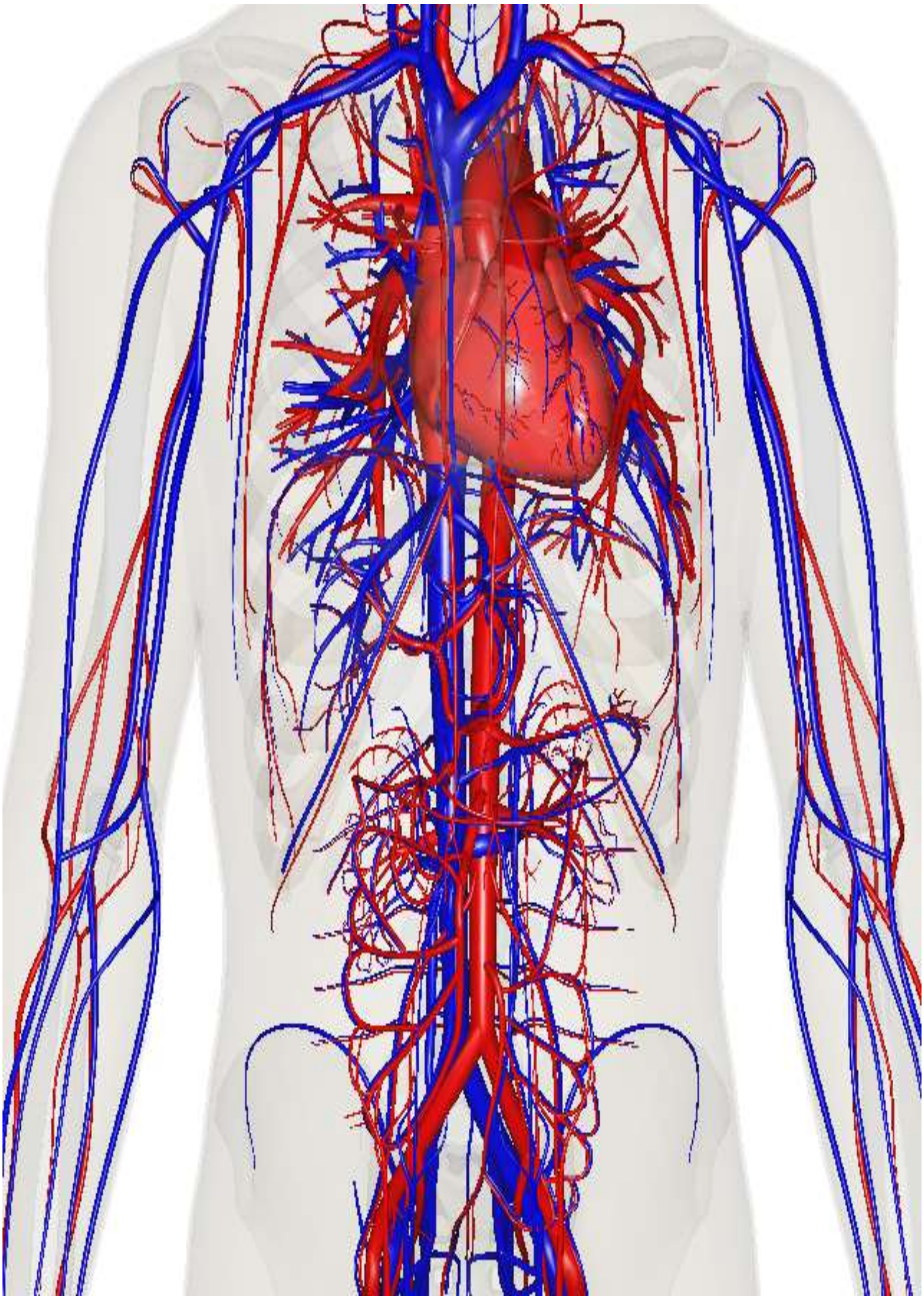
b): Medullar Cortex (Kidney)

c): The Urethra

d): Cortex (Kidney)

e): Medulla (Kidney)

10 The Cardiovascular system



The body's transportation service

Following the event in digestion where nutrients are absorbed in the small intestine, the nutrients are passed on into the blood stream.

As you may know, the blood stream is part of the vital system called the Cardiovascular system. Also known as the Circulatory system, the Cardiovascular system derives from the words *Cardio* meaning heart, and *vascular* from circulation.

The Cardiovascular system has several functions, some of which include bringing nutrients and oxygen to the body by blood, absorbing nutrients from the digestive system and to bring waste to the kidneys.

There are several main components in the circulatory system, including: the heart, arteries and veins, blood, and much more!

10.1 Blood

Blood "stores" oxygen in some of its cells and then "feeds" it to the cells, muscles, organs of the body. Another function of blood is to deliver nutrients to cells. These nutrients are taken from the absorbed nutrients in the small intestine.

After the oxygen is fed to the organs, the blood is carried back to the heart. After the blood is oxygenated again, it is sent once again to the organs for another fresh supply of oxygen and nutrients. This cycle repeats…

Contents of the blood

The blood is composed of different components:

- Plasma
- Red blood cells
- White blood cells
- Platelets

10.1.1 Plasma

Plasma is the "liquid of the blood" and forms the fluid of the blood. It forms ~55% of the blood.

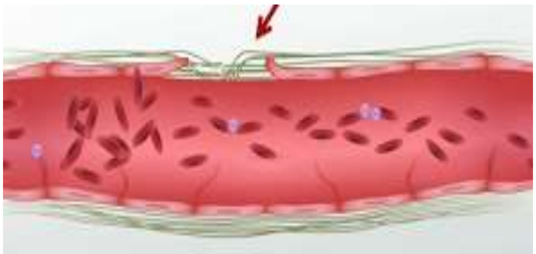
10.1.2 Red Blood Cells

Red blood cells (also known as Erythrocytes) are the cells that carry oxygen in the blood. In fact, the specific substance that carries the oxygen is called Hemoglobin, and is found on the red blood cell's surface.

A picture of how a red blood appears

10.1.3 Platelets

Platelets are tiny cells that help make cuts stop bleeding (clotting it). It does this by sticking to fibers (called Collagen fibers) that have been placed like a spider web over the wound and blocking any blood from going out of the vessel.



This is an image of the platelets in the blood along with a cut.

As you can see, the collagen fibers are already covering the wound so that platelets can stick on to it.

10.1.4 White Blood Cells

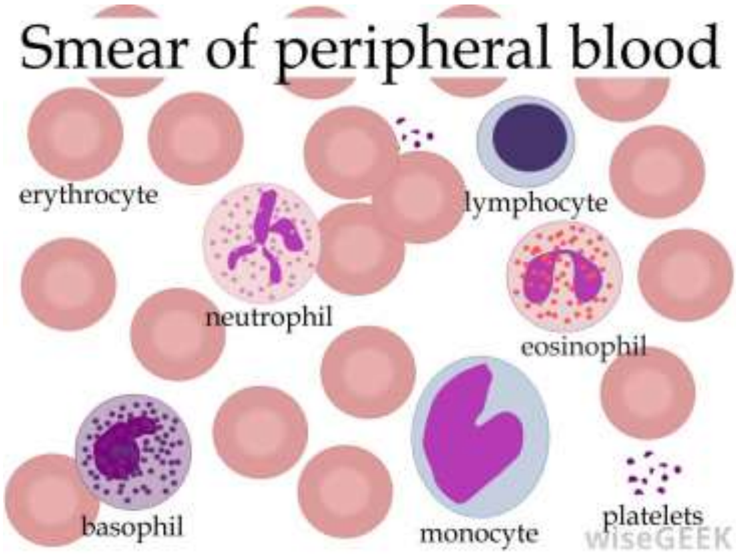
Finally, there are the white blood cells (also called leukocytes). These cells eliminate any unwanted bacterium or object in the blood and (most of the time!) prevent diseases.
We can go even further by classifying different white blood cells and their function! Here they are:

Lymphocyte:
There are 3 kinds of lymphocytes,

- T cells: These cells are responsible for remembering different foreign and unwanted substances and recognising them when they are found in the body.
- B cells: Using the information of the T cells, B cells recognise the unwanted substance and then create a antibody (See Immune system for more detail) to counteract the "intruder" substance.
- -Natural Killer cells: The cells create small holes in the unwanted substance and then inserts a digestive substance to digest the opponent substance from inside out.

Other white blood cell types include:

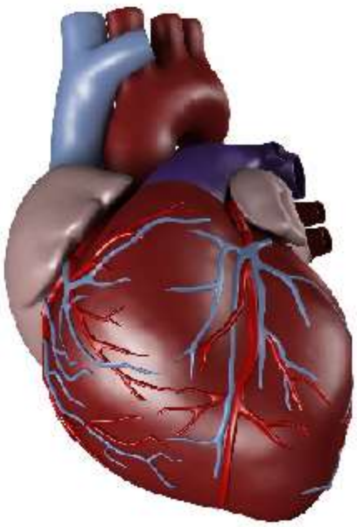
- Neutrophil: These white blood cells inject toxic substances into the bacteria.
- Eosinophil: Like the Neutrophils, these leukocytes inject poison into the unwanted bacteria. (These cells deal with parasites)
- Basophil: Instead of killing bacteria, Basophil cells excrete inflammatory substances that inflame the affected area.
- Monocyte: These cells also digest the foreign and unwanted particles.



Different kinds of white blood cells found in the blood stream.

10.2 The heart

When most of us hear the words Circulatory system or the word blood, it is most likely that the first word to come to mind is *heart*.



One of our most precious organs—the heart!

In general, we may think of the heart as just a mildly important organ that pumps blood, but it's certainly <u>much</u> more than that!
However, before we get started into the structure of the heart, let us explore the heart's functions.

10.2.1 The heart's functions

The heart is awesome! Seriously, if it weren't for the heart, we wouldn't be LIVING! So to worship its level of "greatness", we have listed two functions of the all mighty heart.

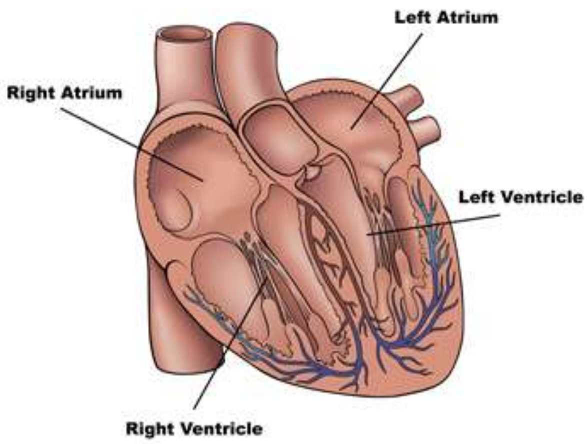
- **Pumping of blood:** It's the heart pumps blood around the body and makes sure that every cell receives it's share of blood no matter where it is!
- **Circulation of the blood:** The heart also circulates the blood in the body, so that cells around the body receive a new supply of blood constantly.

Keep hold of this information, as we'll come back to it later…

10.2.2 The heart's structure

To keep things simple, the heart is split into 4 compartments:

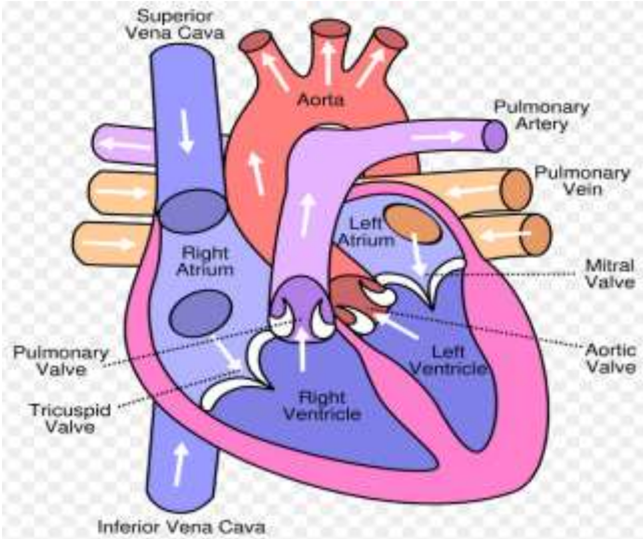
- The Right Atrium,
- The Right Ventricle,
- The Left Atrium,
- The Left Ventricle.



The four compartments of the heart.

In addition, there are arteries and veins that join the heart and feed it with the blood it needs to pump around the body. (Of course, the heart <u>itself</u> also needs blood!)

There are also *valves*. Valves make sure that the blood can only go one way, and not flow back to where it came from.



A depiction of the blood flow inside the heart.

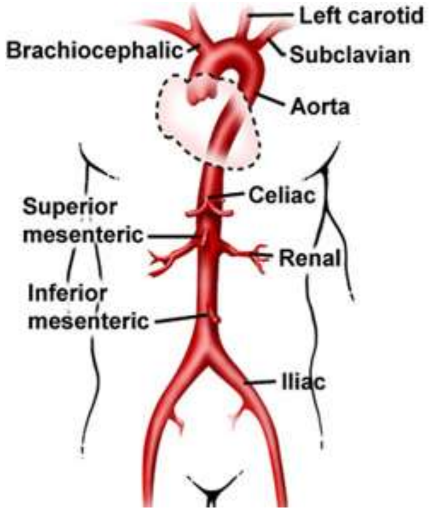
To start, let's explain the compartments of the heart.
***Note: You can see in the picture above that the right atrium and ventricle are on the left side. This is because if you were to be a patient on an operating table, your right atrium would be on the doctor's left side. This picture is shown from the patient's perspective.**

The right Atrium is found at the middle left of the image above and is where all the de-oxygenated blood comes. It is stored there until it can be given to the right ventricle. The de-oxygenated blood is fed to the right Atrium by the Superior and Inferior Vena Cava.

Once the de-oxygenated blood is let into the right ventricle by the Tricuspid valve, it is pumped (by the right Ventricle) through the pulmonary artery to the lungs. At the lungs, the blood is oxygenated (with the air we breathe) and returns to the heart by the pulmonary vein.

The pulmonary veins lead the now oxygenated blood to the left atrium where it is stored until the Mitral valve lets the blood into the left ventricle.

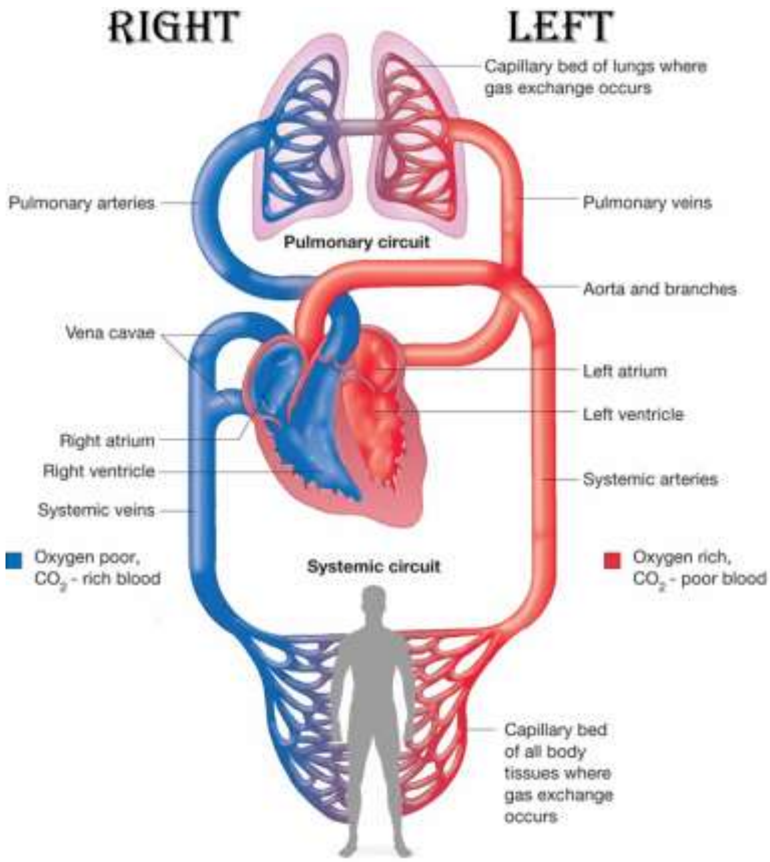
In the left ventricle, the blood is pumped through the Aorta all around the body.



The left ventricle pumps blood into the Aorta (explained further on), which brings oxygenated blood all around the body.

You may have also noticed that (bonus point if you did!) the right side of the heart (left side for you) has less *pink stuff* surrounding it than the left side. (Right side for you)

Well, that *pink stuff* is heart muscle (also called cardiac muscle) and is what makes the ventricles able to pump blood to the desired place. However, the left ventricle needs <u>more</u> heart muscle, as it pumps the blood to the whole body. The right ventricle however, only pumps blood to the lungs, thus resulting in the need of less power.



A wonderful diagram depicting the *idea* of circulation.

10.2.3 The heart's "brain"

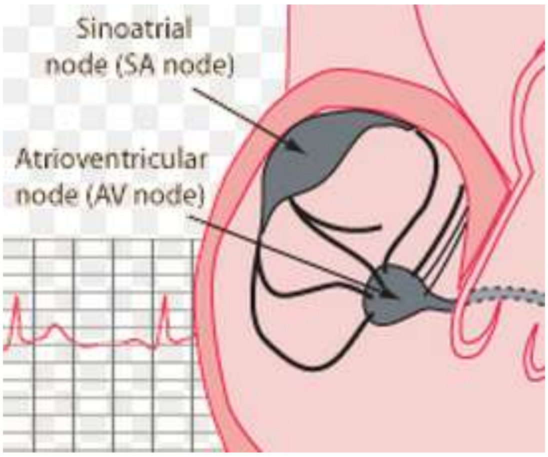
Of course, the heart doesn't *really* have a brain, but it has something similar…

It's called the SA node (Sinoatrial node), and it established the rate that your heart beats! It does this by sending an electrical pulse to the right Atrium, making it beat. This (of course) starts the whole blood flow circulation in the heart.

What's fascinating about the SA node is that the brain does not control it. It's like the heart's own nervous system, it has 'mini nerves' and it continues to work even if the heart is taken out of the body!

The AV node is a group of cells (similar to the SA node) which sends the messages from the SA node to the other Atriums and Ventricles of the heart. This establishes at steady heartbeat.

If the SA or AV node does not function properly, the heart rate either increases (Tachycardia) or decreases. (Bradycardia)



An illustration showing both the SA and the AV node.

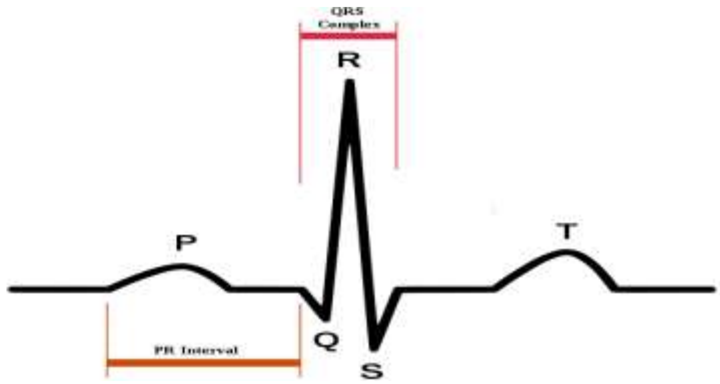
Reading an EKG

An EKG is a device that makes sure the your pulse and heart rate are in good shape. In this chapter, I will teach you how to interpret an EKG reading.

An EKG reading of a healthy heart.

As you can see, there is a part of the reading that repeats itself over and over again. (Kind of like something copied and then pasted on the computer!)

-In this section, there are numerous parts:



The different sections in an EKG for one heart beat.

The first “bump” found on the picture is when the SA node transmits an electrical current to the right Atrium which causes it to push the de-oxygenated blood into the right ventricle.
The red “group” (the PR Interval) is the time it takes for the SA node’s signal to reach the ventricles. (By the AV node)

Next is the QRS Complex group, and is when the ventricles pump the blood to the lungs (the right ventricle) and to the body (the left ventricle). When the ventricles contract, they do what’s called ventricular depolarization. This is the state of the ventricles when they are contracting.

The final (observable) part is the “bump” labelled T. This bump is the action of ventricular repolarization. Ventricular repolarization is basically the opposite of ventricular depolarization and is the state when the ventricle relaxes.

10.3 Did I cut an artery or vein?!?

If you happen to cut yourself, it is possible (although I guarantee that it wouldn’t be the *first* thing on your mind…) to identify if you have cut a vein or an artery without *peeling off your skin*! In addition, this method is extremely simple and an efficient way to dazzle and impress your friends with your knowledge! =-)

If you have cut an artery, the blood will be running out/spurting out quickly and the wound will not clot easily.

However, if you have cut a vein, the blood will “ooze” out and the wound will clot very rapidly. (Since the blood is flowing out slowly)

10.4 Arteries and veins

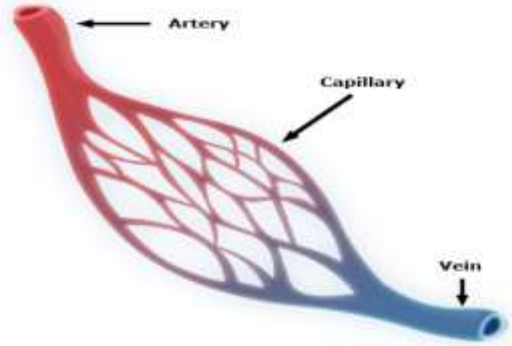
10.4.1 Classification

Arteries and veins are the “tubes” that carry/transport the blood to the organs of the body, but what defines a *vein* and an *artery*?

A **vein** is defined by the “tubes” that bring blood back to the heart.
***Note: It is a misconception to believe that the definition of a vein is that it brings back de-oxygenated blood. Although this is true for most veins, the pulmonary veins bring oxygenated blood back to the heart.**

An **artery** is the opposite of a vein, it transports blood to the rest of the body.

A **capillary** is very thin blood vessel and is where arteries transition into veins. It is at this stage, when the blood reaches the capillaries, that the oxygen exits the vessel and is absorbed by the cells.



An image of an artery transitioning into a vein by the capillary.

While blood cells can fit into an artery/vein easily, blood cells are required to go in "single file" in the capillaries to pass through.

With the distance of all blood vessels combined, the total distance of blood vessels in the body amounts to 160,934.4km, or 100,000mi per healthy adult and 96,560.64km or 60,000mi per child! But in fact, this is not surprising, as every cell needs a supply of oxygen.

Displayed here are all (not including capillaries) the blood vessels of the head.

10.4.2 Arteries

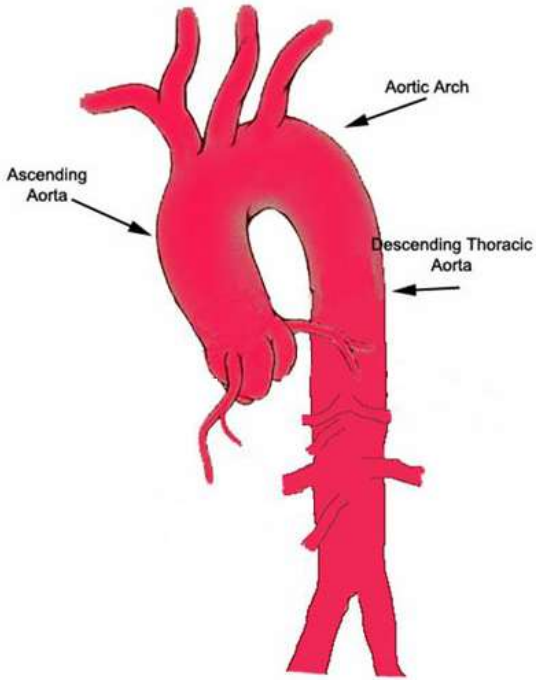
Aorta

Sprouting from the heart is the thickest and the longest vessel in the body: The Aorta.

The Aorta itself (When it is sprouting from the heart) is separated into 3 parts:

- The ascending Aorta,
- The arch of Aorta,

- The descending Aorta. (Or also called the descending Thoracic Aorta)
-



The ascending, arch and Thoracic Aorta

Descending Aorta

As the Descending Aorta continues, arteries sprout from the Aorta, some of which being:

- Renal arteries (feed blood to the kidneys),
- Celiac arteries (liver, duodenum, pancreas, stomach and spleen),

***Note: The Celiac artery splits into the Hepatic and Splenic (also called Lienal) arteries. The Hepatic artery supplies the liver, duodenum, pancreas, and part of the stomach. The Splenic artery (as the name suggests), supplies blood to the spleen.**

- Mesenteric arteries. (Which feed blood to the intestines)

***Note: The Mesenteric arteries are composed of the Superior and Inferior Mesenteric arteries. The Superior Mesenteric artery feeds/supplies blood to the small intestine along with about the 1st half of the large intestine. The Inferior Mesenteric artery supplies the rest of the large intestine.**

Near the pelvic region, the Aorta *finishes its journey* by finally splitting into the Iliac artery. The Iliac arteries continue further down the body to the legs and branch to the pelvis.

The Aorta and its higher branches

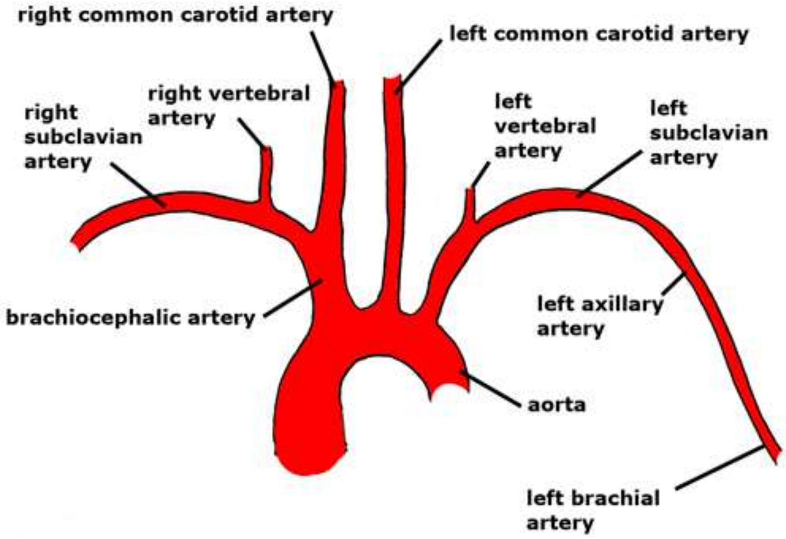
The higher branches of the Aorta originate from the Arch of the Aorta. Sprouting from the Aortic Arch are 3 arteries:

- Brachiocephalic artery
- Left common Carotid artery
- Left Subclavian artery

The Brachiocephalic branches further out into the Right Subclavian artery, Right Common Carotid artery, and the Right vertebral artery.

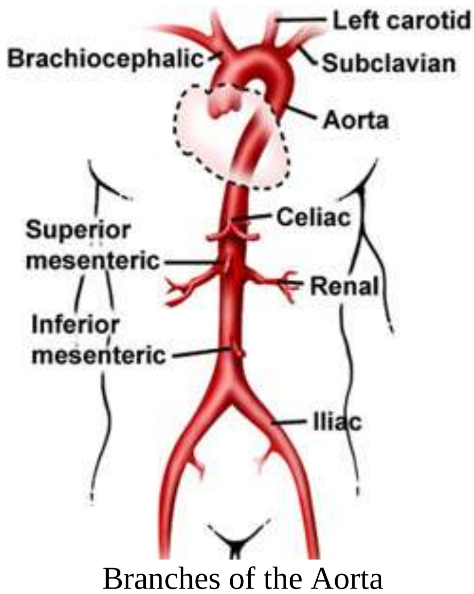
From these arteries, both the Vertebral arteries and Common Carotid arteries supply blood to the brain and head. However, the Subclavian artery passes by the shoulder and continues down the arm. (*Clavian* is similar to clavicle. Therefore, Subclavian literally signifies "*under the Clavicle*"!)

The Left Common Carotid artery does the exact same function as the Right Common Carotid artery except for the left side of your body. This also applies to any vessel in the body—whether vein or artery!



An image of the arteries branching of the transversal Aorta.

I admit myself that the names of the upper Aortic branches may be overwhelming, but they're actually as simple as your ABCs! Seriously, have a look!
A: Aorta,
B: Brachiocephalic,
C: Common Carotid,
s: Subclavian.



Branches of the Aorta

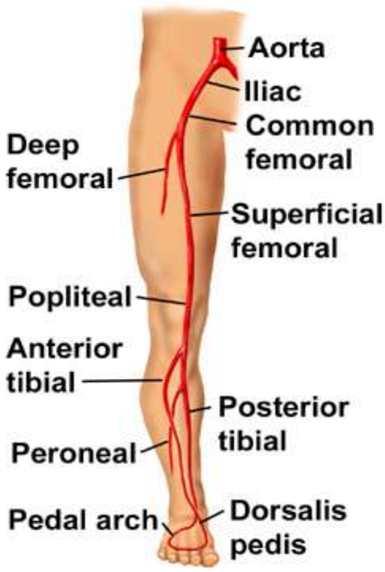
The arteries of the legs

As mentioned, the Aorta continues down the body until it reaches the hip/pelvic region where it splits into the Iliac artery. Each Iliac artery splits into the Internal and External Iliac artery (which supply blood to the bladder, reproductive organs, and pelvic region) and also continues to the legs.

The artery that continues to supply the legs with oxygen is now called the Common Femoral. Once the "end of the pubic area", it separates into the Deep Femoral and the Superficial Femoral. While the Deep femoral stops to feed blood to the upper leg, the Superficial Femoral is extended down until the knee cap (or Popliteal area). It is then renamed the Popliteal artery.

The Popliteal artery continues until the tibia where it is separated into the Anterior Tibial, Posterior Tibial, and Peroneal arteries. These arteries supply the lower leg with all the blood it needs…

Finally, the arteries reach the foot where they are separated into 2 main vessels: the Pedal Arch and Dorsalis Pedis. Both vessels supply blood to the toes and feet.



An image of the arteries of the foot.

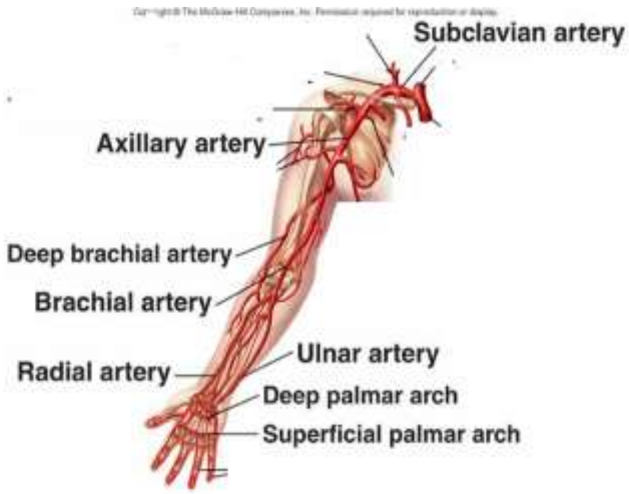
The arteries of the arms

The arteries of the arms start with the Subclavian artery. At the "Axilla" area, (also known as the *Armpit*), the Subclavian artery becomes the Axillary artery.

As the Axillary artery progresses down the arm, it runs alongside the Deep Brachial Artery. However, as the Axillary artery reaches the Antecubital fossa (also known as the area opposite of the elbow), it turns into the Brachial artery. The Brachial artery runs parallel to the Deep Brachial artery (which sprouted from the beginning of the brachial artery).

As the Brachial artery reaches the Ulna and Radius, it splits into the Ulnar and Radial artery. (Which run along the Ulna and radius respectively)

Once the Ulnar and Radial artery reach the wrist, they form the Deep and Superficial Palmar arch. The Deep Palmar arch supplies blood the palm of the hand, while the Superficial Palmar arch feeds blood to the fingers.



An image of the arteries in the arm.

10.4.3 Veins

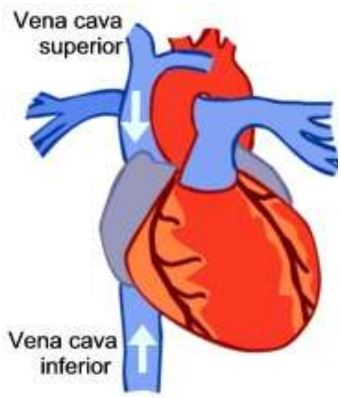
The Superior and Inferior Vena Cava

Since oxygenated blood is transported away from the heart by the arteries, there must be a way of returning the deoxygenized blood back to the heart!

For this, there are the veins! And similar to the Aorta, there are 2 main vessels that bring blood back to the heart called the Superior Vena Cava and the Inferior Vena Cava. All the other veins that supply the body sprout from either the Superior or Inferior Vena Cava.

The Superior Vena cava is a major vein that returns to the heart and brings back deoxygenated blood from the upper part of the body. (As the name suggests)

On the contrary, the Inferior Vena Cava collects deoxygenated blood from the lower part of the body and returns it to the heart.



An image of the superior and inferior Vena Cava

Superior Vena Cava

As mentioned before, the Superior Vena Cava returns blood to the heart from the area of the body found higher than the heart itself. (A slight exception is the Azygos vein which collect deoxygenated blood from the chest—part of which is lower than the heart!)

As the Superior Vena Cava progresses from the heart, it splits into the right and left Brachiocephalic veins. The Brachiocephalic veins then splits into the Subclavian vein (remember the Subclavian artery?) and Internal Jugular vein.
The jugular vein is the major vein that delivers blood to the head and if cut, the victim

will die due to blood loss within minutes. (Unless it is done in controlled circumstances such as in a hospital)

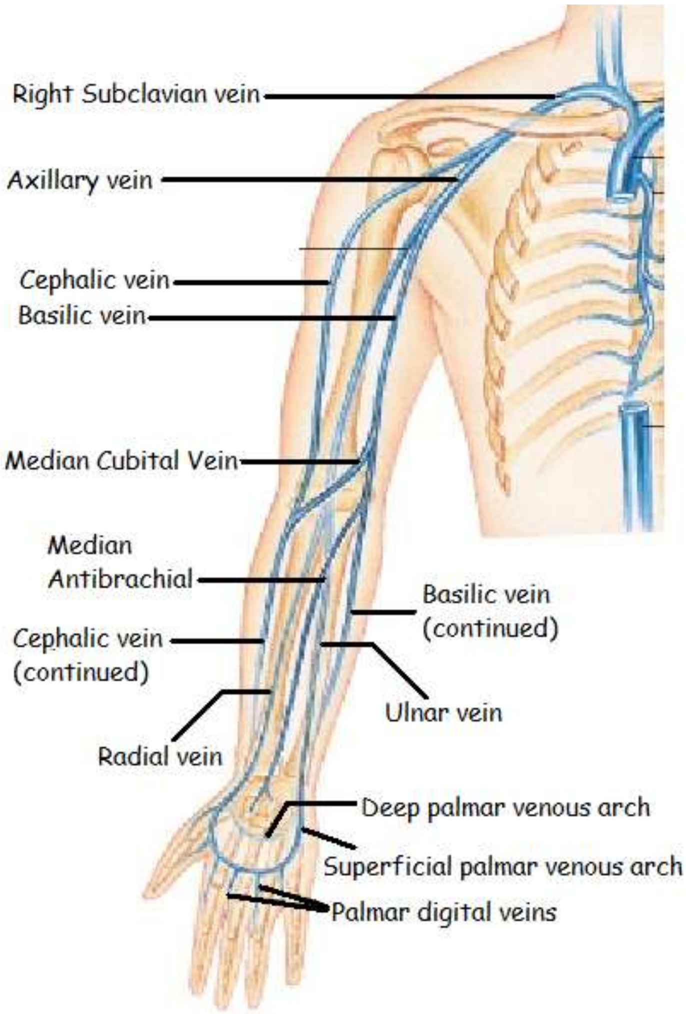
***Note: You will notice that most of the veins have the same name as the artery located in that area.**

The veins of the arm.

The Subclavian vein (same with the Subclavian artery) continues under the Clavicle and to the arm. However, once it reaches the Clavicle, it splits into the Axillary and the Suprascapular vein.

As the name suggests, the Suprascapular vein travels on top of the Scapula bone and collects blood from both the thorax (chest) and the Scapular muscles.

The rest of the veins of the arm are shown below:



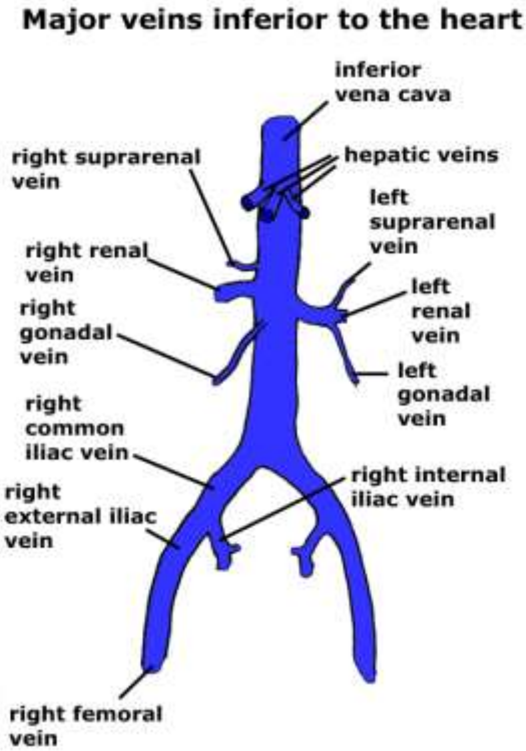
An image of the main veins of the arm.

(Keep in mind that the veins on the right arm are exactly the same on the left arm)

Inferior Vena Cava

Contrary to the Superior Vena Cava, the Inferior Vena Cava collects blood from the area below the heart.

Not too surprisingly, the Inferior Vena cava is very similar to the descending Aorta—both in looks and names.



An image of the Inferior Vena Cava's branches.

The Inferior Vena Cava has numerous branches that collect deoxygenated blood from different parts of the body:

- Hepatic veins: Collect blood from the Liver
- Renal and Suprarenal veins: Collect deoxygenated blood from the kidneys and adrenal glands.
- Gonadal veins: Collects blood from reproductive organs.

The veins of the legs

Once the Inferior Vena Cava has reached the pelvic region, it splits into the Right and Left Common Iliac which in turn splits into the (right and left) Internal and External Iliac veins.

Much like the External Iliac arteries, they "turn into" the Deep Femoral and Superficial Femoral vein once they reach the Femur. (The External Iliac artery turns into the Femoral artery at the Femur)

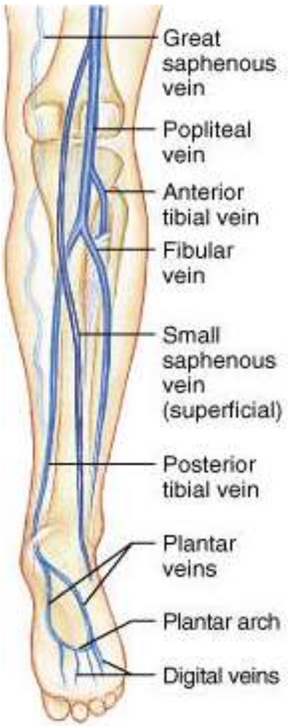
In addition, the Great Saphenous veins also sprouts from the External Iliac vein and helps collect the blood from sole of the foot. (Fun Fact: The Great Saphenous Vein is very great— it's the longest vein in the body!)

Once the Femoral vein reaches the patella (knee), it is turned in the Popliteal vein. (Popliteal is the scientific term for knee) The Popliteal vein continues down the shin where it splits into the Anterior Tibial vein, Posterior Tibial vein and the Small Saphenous vein.

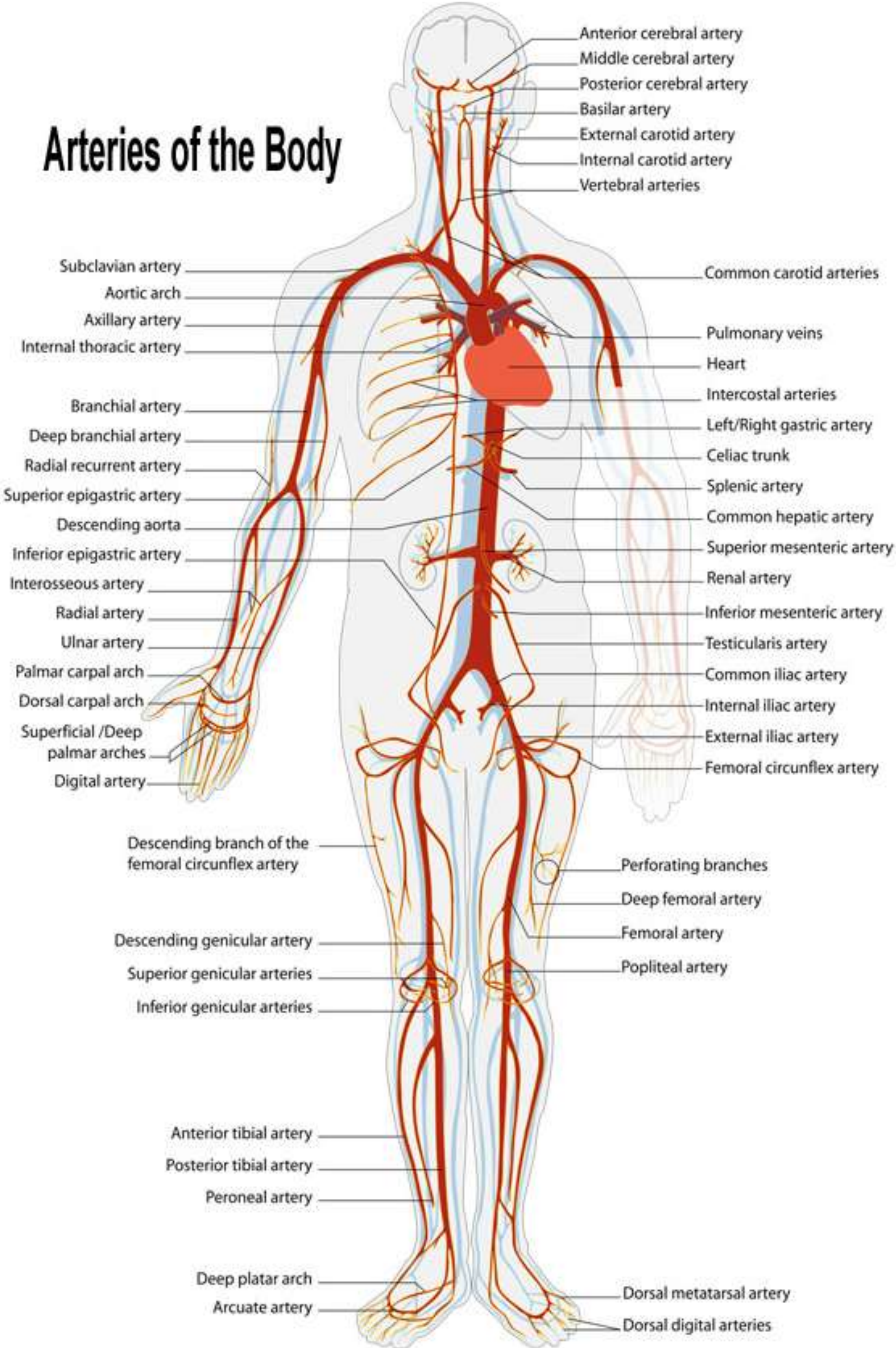
- Anterior Tibial vein: Collects deoxygenated blood from the Popliteal (knee) join as well as muscles located beside the tibia.

- Posterior Tibial vein: Collects deoxygenated blood from the muscles near the tibia and also forms the Plantar arch. (The Plantar arch collects blood from the foot)

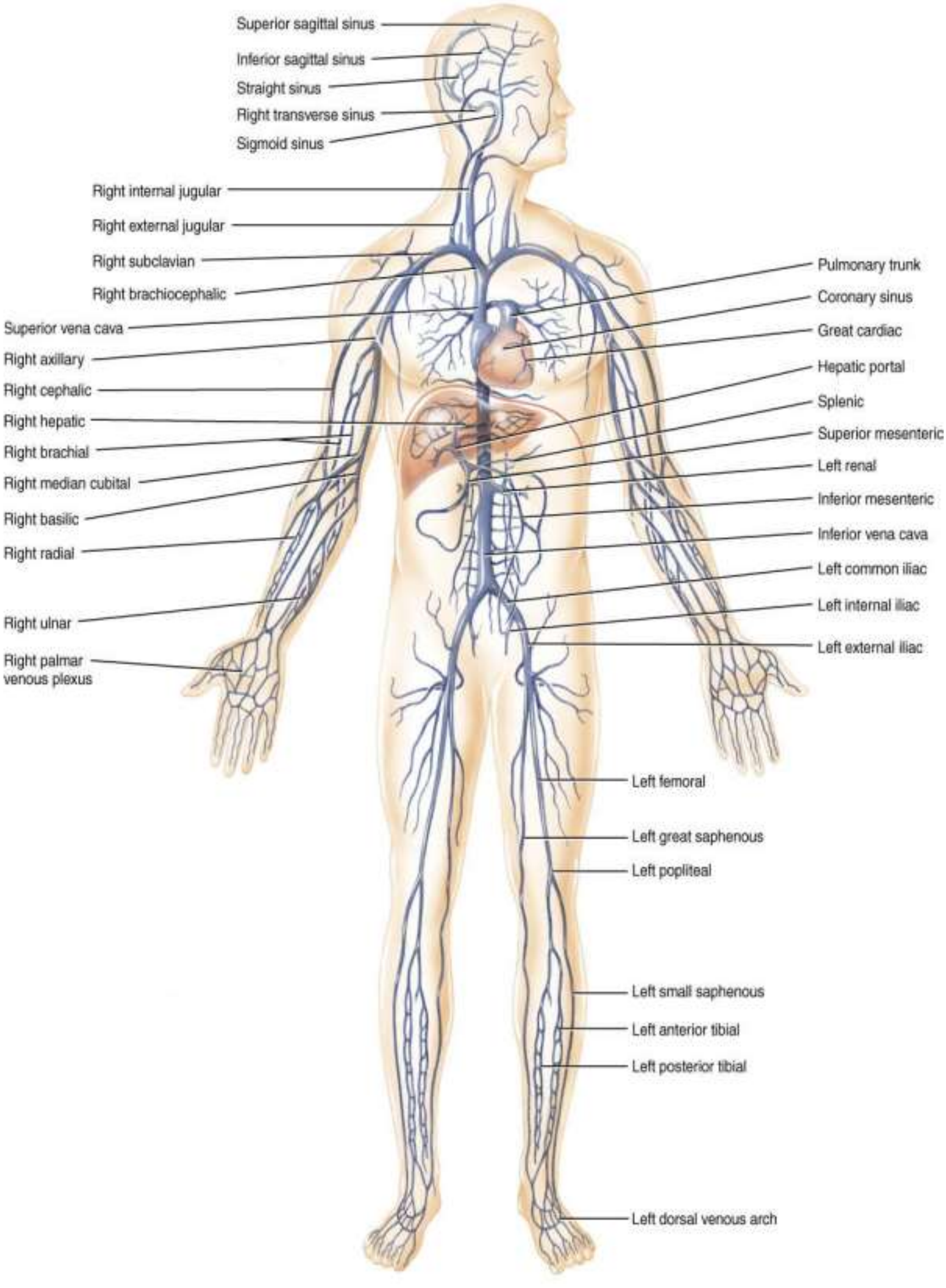
- Small Saphenous vein: Collect deoxygenated blood from the foot.
- Fibular vein: The Fibular vein collects blood from the muscles beside the Fibula.



The veins of the posterior leg.



Main arteries of the body



Overall anterior view of the principal veins

Main veins of the body

10.4.4 Where am I?

This *test* (oh no!) will test you on your knowledge of the body's main blood vessels.

The clues are to be found under this description and the answers are after the list of clues. Each clue is marked with a number. The corresponding answer is also labelled with the same number.

1. I am an artery. I start at the heart by going upwards, transversal, then down. I split at the Pelvic region. **Who am I?**
2. I am a common artery. I split at the start of the Femur into a deep and superficial artery. **Who am I?**
3. I come from the lower extremity of the body and I am the major vein of the lower extremity. I am going to the heart. **Who am I?**
4. I am an artery that arches at the foot. **Who am I?**
5. I am located right in the Axilla region. I am named by the Axilla region. I am an artery. **Who am I?**
6. I carry oxygenised blood from the lungs to the heart. **Who am I?**
7. I am an external vein. If I'm cut, you will bleed to death. **Who am I?**
8. I sprout from the Aorta and start with a B. **Who am I?**
9. I am a vein, and I split from the Inferior Vena Cava at the hip. **Who am I?**
10. I am a vein that comes from the upper part of the body. I start with an S. **Who am I?**

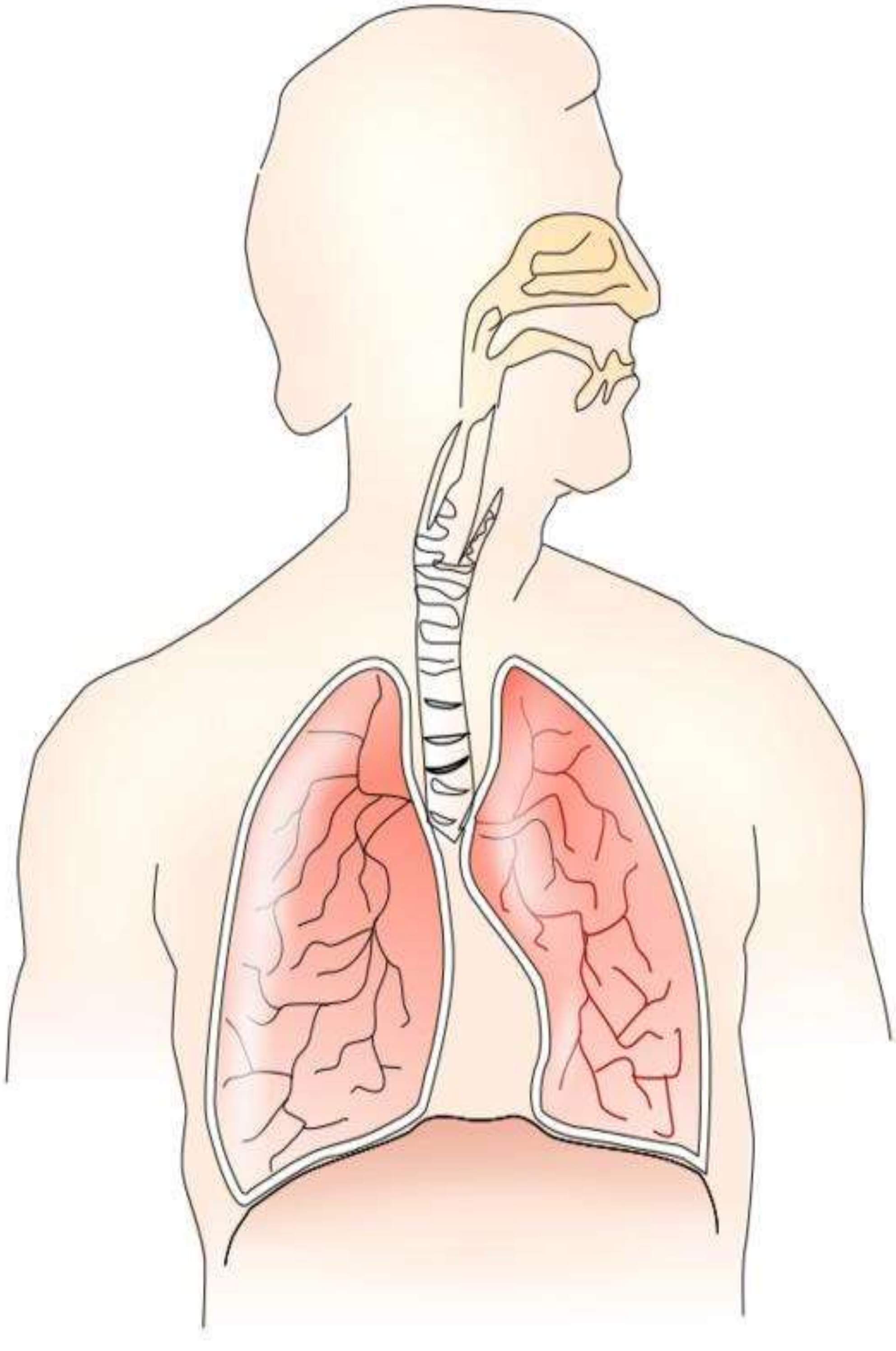
BONUS: I run parallel to the Brachial artery.

Answers below this line.

Answers:

1. Aorta
2. Common Femoral Artery
3. Inferior Vena Cava
4. Pedal arch
5. Axillary artery
6. Pulmonary "Vein"
7. External Jugular Vein
8. Brachiocephalic
9. Iliac Vein
10. Superior Vena Cava
11. **BONUS:** Deep Brachial Vein

11 The Respiratory system



Imagine yourself breathing without this…

The Respiratory system works with three main components: Lungs, blood and air. But the real purpose of the respiratory system is to use gas exchange to supply oxygen to our deoxygenated blood.

11.1 How the Respiratory System works

There are two principal steps in breathing: inhalation and exhalation. When we inhale, we bring new and fresh oxygen into our lungs. This oxygen is absorbed into the blood. In exhalation, Carbon Dioxide (CO_2) is sent out into the air.

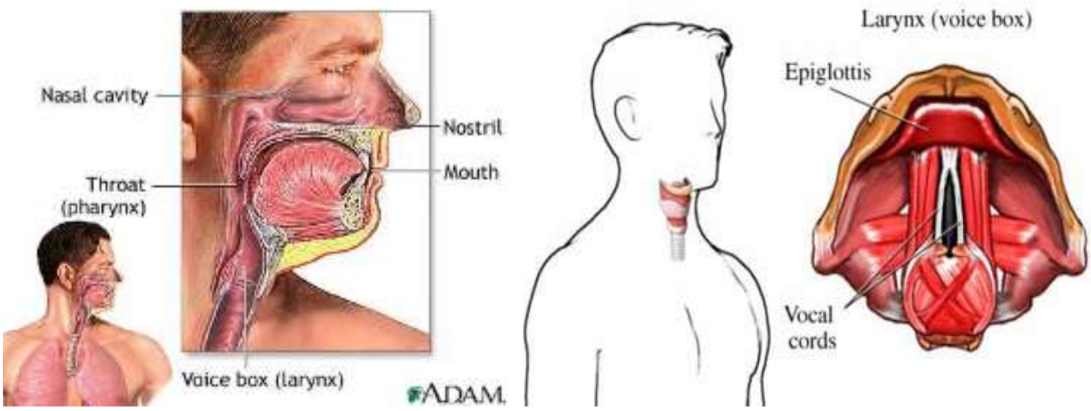
11.1.1 The nose and windpipe

Firstly, air is pulled in through the nose and in the nasal cavity. The word nasal comes from Latin, the nose. The air then passes through the Larynpharynx (the part between the nasal cavity and the mouth). Next, the air goes to the throat where there is the Esophagus and the Windpipe or Trachea.

The windpipe is the tube that leads the air from the nasal cavity to the lungs.

Because the Windpipe is open and there is no food, the air goes by the Windpipe.

Found at the very start of the windpipe is the voice box, which helps us talk by forming different shapes to let air through.



An image of different parts of the mouth as well as an image of the voice box.

11.1.2 Bronchi, Bronchioles

Once the windpipe reaches the lungs, it splits in two, one tube leading to each lung. These tubes are called Bronchi.

As soon as the Bronchi reach the inside of the lungs, they split into 2 smaller tubes: the Bronchioles. The Bronchioles then split into the secondary pair of Bronchioles which in turn split into the third pair of Bronchioles, and so on… The reason behind why there is so much of these tubes is to increase the lung's capacity of storing air.

These sections continue until they end up with little microscopic sacs at the end called Alveoli.

The number of tubes in a particular section is determined by $2^{\text{section number - 1}}$. (An example of a section is the Bronchi or Bronchioles)

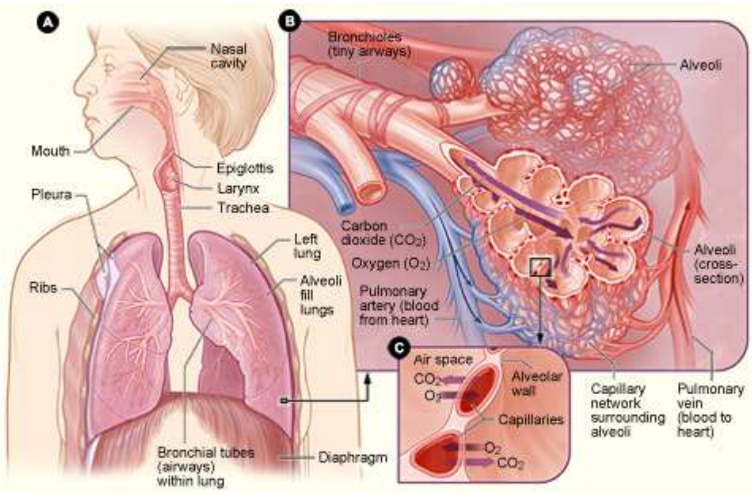
11.1.3 Alveoli

Alveoli are sac-like structures at the end of the last sections. The Alveoli are coated with blood vessels. Once air reaches the Alveoli, it *passes through* the very thin Alveolar membrane and is absorbed by the red blood cells. *(The action of passing through a membrane/surface is called diffusion and appears innumerably throughout science)*

***The membrane of the alveoli is what we call semi-permeable. A semi-permeable membrane let's only certain elements pass. One of these elements is oxygen!**

So, to recapitulate, the oxygen (O_2) in the Alveoli diffuses across it's membrane into the capillaries that bring oxygenated blood to the heart. The oxygen then begins its epic journey around the body.

Carbon Dioxide (given out as toxic waste by the organs) is then brought to the lungs. The Carbon Dioxide diffuses across the Alveolar membrane and is exhaled.

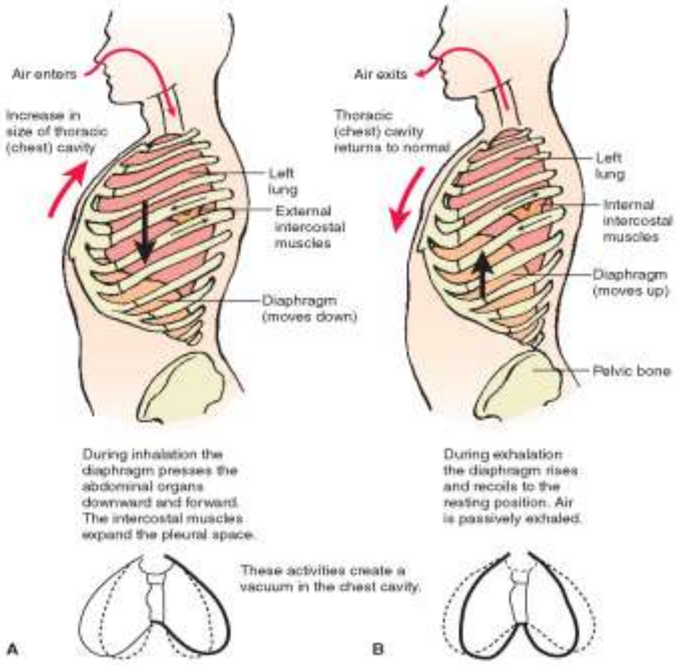


A picture of the respiratory system including a close up of the Alveoli and diffusion.

11.1.4 Diaphragm

Below the lungs rests a flat muscle called the Diaphragm. This muscle makes us inhale and exhale.

It does this by pushing or pulling on the bottom of the lungs. If the diaphragm pulls the lungs outwards, we suck in air and inhale. Exhalation is when the Diaphragm relaxes and the lung walls are pushed in—forcing all the lungs content out of the body.



A brief description of how the diaphragm works.

11.2 Breathing in other organisms

11.2.1 Amphibians

Amphibians, as you might know, breathe through their nose but also through their skin.
Since amphibians live both in water and land, they have developed lungs for breathing on land and have developed a semi-permeable membrane.

- Lungs: The lungs of amphibians is very similar to ours.

- Skin: The porous skin of amphibians is covered with capillaries that absorb the oxygen from the water.
  Since the skin of amphibians is semi-permeable, it allows only the oxygen from the oxygen-rich water to be absorbed.

11.2.2 Reptiles

Reptiles contain only lungs. However, unlike us, they lack a diaphragm and possess complex airways.
To make for the diaphragm, the lungs are inflated by the Intercostal muscle, which contract making the lungs bigger. When these muscles relax, they deflate the lungs thus letting all the air out.

11.2.3 Fish

Since fish live their entire lives in water, they have gills. Gills separate the oxygen from the rest of the water for them to breathe. (They take away the O from H_2O)

11.2.4 Birds

Birds have lungs, although they are used very differently than our lungs. Since birds don't have a diaphragm, they can't inflate or deflate their lungs. Instead, they contain capillaries that take and then carry the air they breathe. Air diffuses from those capillaries (Air capillaries) to capillaries filled with blood.

11.2.5 Plants

Plants have a respiratory system like no other… Plants <u>don't have</u> lungs and <u>neither</u> semi-permeable skin. And in addition, they don't breathe in oxygen, they breathe in Carbon Dioxide!

But instead of having lungs, they use photosynthesis to obtain both food and breathable material.

Despite the fact that photosynthesis seems simple, it's not! So I will try my best to simplify photosynthesis as much as I can.

Photosynthesis requires sunlight, carbon dioxide and water to breathe and to create food. Carbon Dioxide is taken from the air, sunlight is provided by the sun, and water is taken from the ground.

- Breathing: The plants breathe by taking the Carbon Dioxide from the air. They secrete oxygen as their waste.

- Food: Using Carbon Dioxide, water and sunlight, plants can then create a glucose molecule and oxygen.

Glucose, (in case you don't remember) is a sugar which is used by almost every type of cell in different organisms to create the energy for the cell.

The glucose molecule is then stored for later while the plant excretes the oxygen in our atmosphere.

Cellular respiration (which is even more complicated!) is used to unpack the glucose for immediate usage.

The equation for photosynthesis is:

$6CO_2 + 6H_2O + \text{Light energy} \rightarrow C_6H_{12}O_6 + 6O_2$

In more *human* terms, photosynthesis takes in: 6 Carbon Dioxide molecules, 6 water molecules and Light energy and transforms it into a Carbohydrate molecule along with 6 Oxygen molecules.

The oxygen is released into the air as waste. (The same way we release Carbon Dioxide into the air as waste)

***Note: Photosynthesis is used only for most organisms that make food themselves. These organisms are called autotrophs. (Auto=self, troph=eater) Autotrophs produce their own food and don't need to eat other organisms to survive.**

Heterotrophs, on the other hand, are like us: they have to eat other organisms to survive

However, despite that photosynthesis is only for most autotrophs (those that get energy from the sun) cellular respiration is used both in autotrophs and heterotrophs.

11.3 Emergency situation!

Our respiratory system is not perfect—nothing is! So it's no surprise that there can be emergencies. Some of these include heart failure (affects respiratory system profoundly), asthma attack, drowning and much more.

It is fairly easy to see if someone has drowned. They will be in a surrounding with water, be choking, or that they have fallen unconscious.

Before you even help, follow the GOLDEN rule: DON'T PANIC!!! Panicking simply worsens the situation.

The steps to follow are listed below:

11.3.1 First steps

1. *Hazards:* Even before calling 911, you must make sure that there are no hazards that may hurt you as well. If you do find a hazard avoid trying to help if it poses a threat to your safety.
2. *Level of consciousness:* Before proceeding to emergency procedures, check the level of consciousness of the victim. The level of consciousness of a victim is "how conscious they are". The two extremes are being awake/asleep or fully unconscious. This step is needed as you don't want to call 911 because the victim is sleeping!
3. To find this out, rub their sternum with you knuckles or pinch their ear. (Shouting also help wake up the victim if he/she is sleeping)
4. *History:* Find a witness/passer-by and ask them if they saw what happened. This can help both you and the medical professionals deal with the situation more appropriately.
5. If there is no witness, carefully examine your surroundings to see if you can find the cause of why the victim is hurt.
6. *Help! :* Finding assistance of a more qualified person is always helpful. Shout help as loudly as you can.

***Note: Only call for help if you are in a very familiar environment. Calling on strangers is never a good idea.**

11.3.2 911

The next thing to do is to call 911 (in North America). This is done so that medical professionals can arrive at the scene quickly and deal with the patient/victim.

11.3.3 ABCs

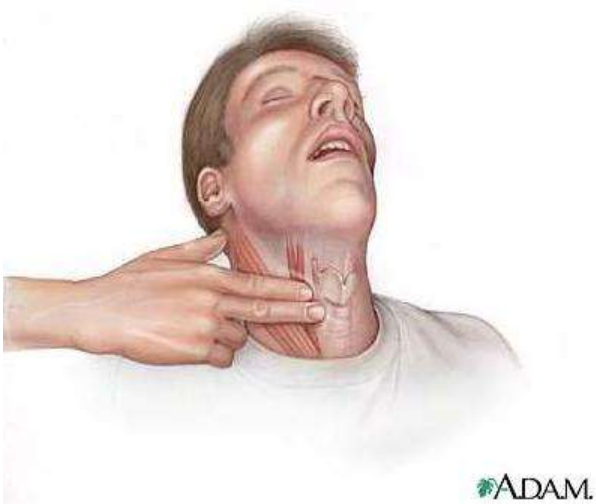
If the person is unconscious or in unstable condition, use your ABCs:

A: Airway… Lift the chin of the patient up so that their neck is fully visible.

B: Breathing… Put your ear near their nose and mouth and look at their chest. If you see that their chest is going up or down or that you feel air rushing out of the mouth or nose, they are breathing.

C: Circulation… With your "strong" hand, put your index (2^{nd} finger) and middle finger (3^{rd} finger) on their carotid artery. (See picture below)
If you feel a pulse—that is, a beating—their circulatory system is functional. If not,

proceed to the next step.



Note the position of where the index and middle finger are.

11.3.4 C.P.R. (Cardio-Pulmonary-Resuscitation)

If either their breathing, or circulatory (or both) system is not functioning properly, perform CPR. Make sure the victim is placed on a solid flat surface facing upwards.

After that you have to see if their circulation or breathing, or even both is malfunctioning.

***Do not perform CPR on a patient whose breathing and circulation is functional.**
If the patient's breathing is also not functional, give 2 breaths and then perform 30 compressions. (CPR is composed of numerous compressions)

In case of CPR, put the strong hand on the victim's chest. Wrap the other hand around the strong hand like so:

An image showing how the hands should be placed while performing CPR.

***This guide is to be performed on adults and children only!**

If breaths are also needed, place your mouth over theirs (if you have a safety kit with you, find the pocket mask and place between your mouth and theirs), pinch their nose so that your breaths don't escape by their nose and then blow into their mouth.

***Avoid as much as possible the contact between your mouth and the victim. If necessary, perform breaths with contact of the victim's mouth but rinse your mouth thoroughly as soon as you can afterwards.**

If paramedics or a person with higher medical qualifications than you arrives, or if you start getting tired from performing rescue breathing (by tired I mean *more or less exhausted*), you may stop performing rescue breathing on the victim.
***Remember, your life is more of a priority than the victim's life, avoid as much as possible risky/life threatening actions.**

An image depicting where on the body CPR should be performed.

11.3.5 Problems

Breathing blocked

In the case where only the breathing is blocked, perform both breaths and CPR.
(2 breaths, 30 compressions)
Continue until medical assistance arrives or if they start moving.

Circulation blocked

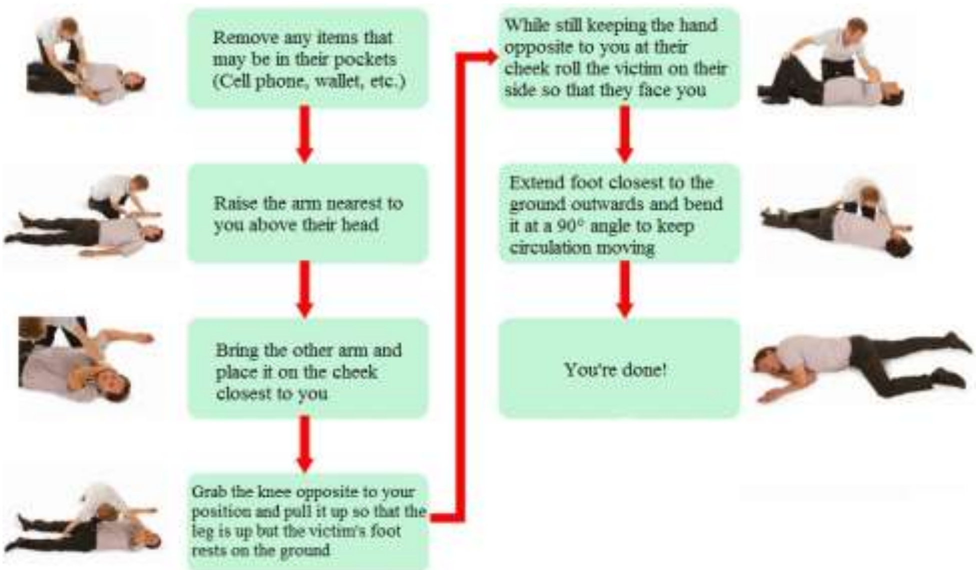
If the victim’s circulation is the only factor, perform only CPR and no breaths. Compress chest 30 times (quickly) until medical help is at the scene.

Both circulation and breathing blocked

If both circulation and breathing is blocked, perform both breaths and chest compressions. As normal, continue this procedure until assistance or medical professionals have arrived.

Vomiting

While performing life saving procedures such as CPR (rescue breathing), the victim may vomit. Since they are facing up, the victim will most likely choke by their own vomit. To prevent this, raise the arm of the victim that is on your side relative to your position and then turn them sideways. (Facing you)



Follow this reference when a victim is vomiting during rescue breathing.

Choking

Chances are that you've choked before… At the time you were choking, it felt like the end of the world! But after that, you realised it wasn't <u>that</u> bad. However, sometimes it can be!

There are 2 types of choking: Temporary chocking and Full blockage choking.

- Temporary choking: This kind of choking was similar (not fully similar though!) to normal *everyday* choking. During temporary choking, an object is blocking air flow temporarily. Encourage the choking person to cough as hard as they can so they can get the object out of their throat. Tell them to not panic and comfort them while still encouraging them to choke.
- Full blockage is when the airway of the "victim" has been fully clogged and they can barely/not breathe. Coughing will not help so it is mandatory to intervene.

Firstly, use your hand to hit his/her back hard so that the object clogging his airway gets out. Always have the other hand on his chest to keep the victim from falling down. Repeat this 5 times.

Next, use your strong arm to create a closed fist. Wrap the fingers of your other hand over the clenched fist and place it on their abdomen.

First you put one arm in front of his chest to keep him from falling down. Use your other hand to hit his back hard. This will get the food out. Do this 5 times.

Next, clench one hand and grab that hand with your other hand. Put it right in front of the person's stomach and pull and go up with your hands.

Perform this action during full blockage choking.

CPR

1. Call 911.

2. Tilt the person's head back and lift their chin until their teeth almost touch. Look and listen for breathing.

3. If the person is not breathing, pinch their nose closed and cover their mouth with yours. Give 2 full breaths.

4. Put your hands in the center of the person's chest, between the nipples. Place one hand on top of the other. Push down with the heel of your hand 30 times. Continue with 2 breaths followed by 30 pushes until medical help arrives or the person starts moving.

12 The Endocrine system

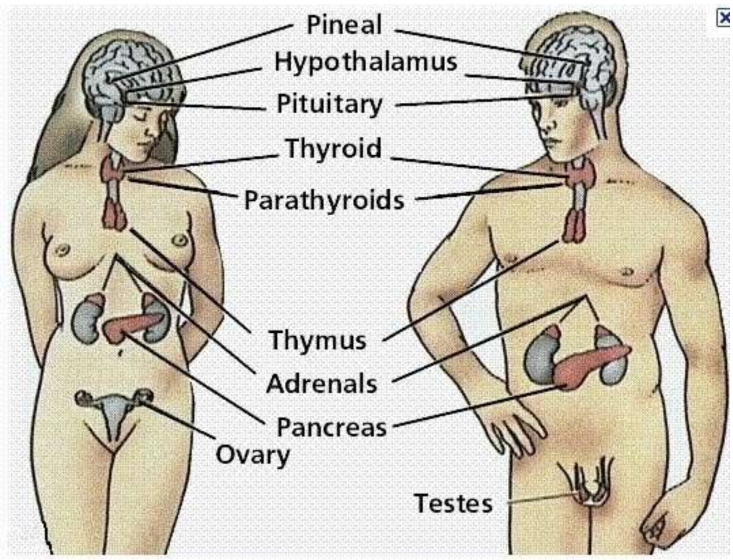
The endocrine system is another version of the nervous system. But instead of sending messages in the form of "electrical" signals, it sends messages in form of chemicals.

The Endocrine system is a very wonderful system, but has not had enough attention. One of its crucial functions includes making changes to our body.

12.1 The Parts of the Endocrine system

The messages that the Endocrine system sends out are called hormones. Hormones are the chemicals that help make the body change in a certain way.

The parts that secrete these hormones include the Hypothalamus, Pituitary gland, Pineal gland, the Thymus, Thyroid and Parathyroid glands, Pancreas and Adrenal glands and Testes (male) and Ovaries (female). Phew! What a long list!
But don't worry, this section is design specially to make the Endocrine system and all its parts less daunting.



An image of the parts of the Endocrine system.

12.1.1 The Brain

The brain plays a considerable role in the Endocrine system. It's the brain's job to order the secretion of these hormones as well as secrete several of them. The other components of the Endocrine system simply secrete the hormone into the bloodstream.

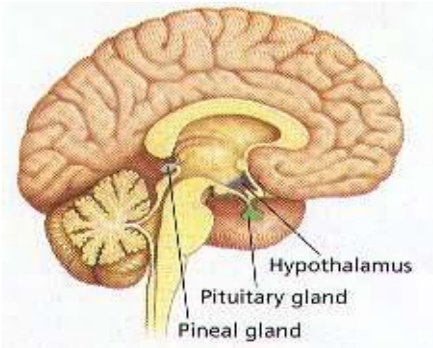
So in a sense, you could say that the whole Endocrine system would malfunction without the help of the brain!

But enough chatter, let's get to the point: there are two main parts of the brain that are part of the endocrine system:

- **Hypothalamus**: This part of the brain activates the pituitary gland by sending numerous hormones. Each hormone "orders" the pituitary gland to send a specific hormone.
- **Pituitary gland**: This gland sends out specific hormones — the most important of which being the Thyroid-stimulating hormone — depending on which hormone is received from the hypothalamus.

- **Pineal gland**: Although this gland is very small and seemingly insignificant, it packs a big punch! The pineal gland secretes Melatonin, a hormone that regulates the level of light that we take in. This helps us evaluate when to wake up and when to sleep.

(For more information about our body's routine, see the next section)



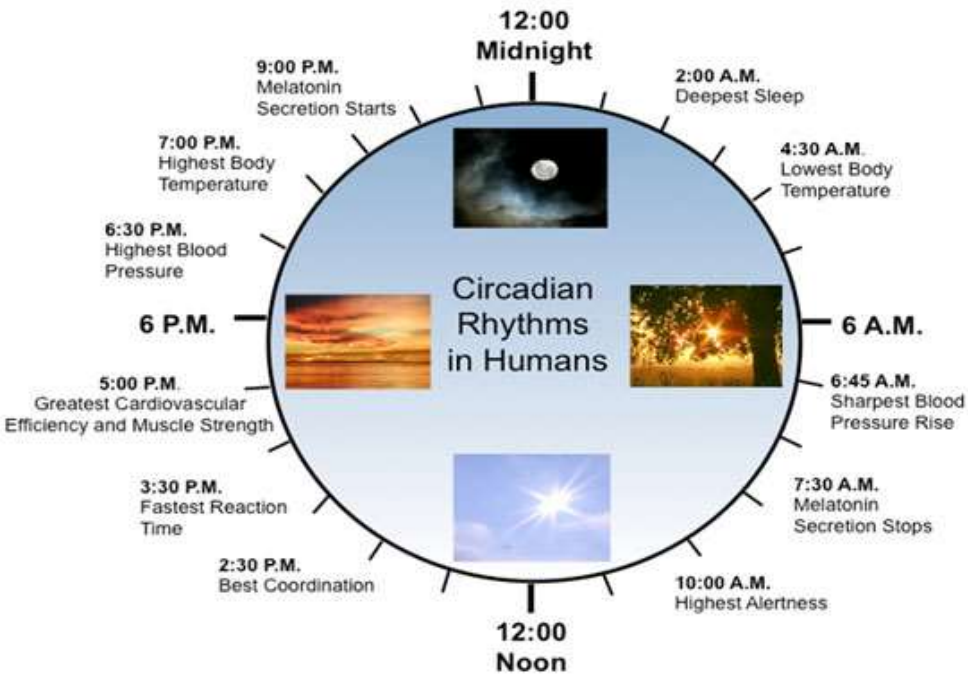
An image of the Hypothalamus, Pituitary gland, and the Pineal gland.

The body clock

The Pineal gland takes care of our *body clock*. The body clock is very important to the body for maintaining regular a consistent schedule.

For example, you may have noticed that you probably wake up around the same time every day. Not *all* people wake up at the same time as you do, so there must be something internal to help you wake up at a consistent period of time. In fact, it's the job of the body's *body clock!*

This is because your body clock contains your schedule of everything you do during the day and executes the proper actions at the proper time of the day.



A typical biological body clock. Of course yours may be slightly different, but it still rests upon this foundation.

12.1.2 The Thyroid gland, TSH, T_3, T_4

As mentioned before, the pituitary gland secretes the Thyroid-stimulating hormone. The hormones is directed to the Thyroid gland and is meant to activate the secretion of 2 very important hormones.

The hormones are sent out by the Thyroid gland, and are called T_3 and T_4. T_3 is Triiodothyronine (Try-o-doth-iron-in) and T_4 is Thyroxine.

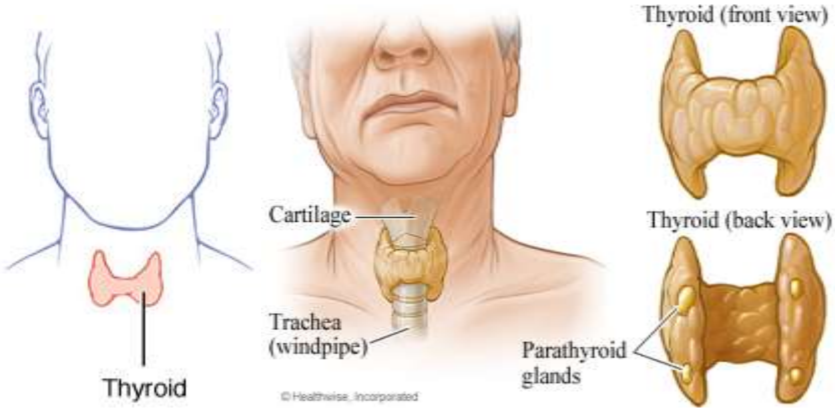
The importance of Thyroxine and Triiodothyronine cannot be overstated, as they control practically every function of the human body: growth, energy production, bone health, development of the organs and so on...

- Thyroxine (T_4): As mentioned before, Thyroxine is secreted from the Thyroid gland. This hormone helps in controlling growth, energy production, development and much more.
  However, to do this, Thyroxine requires a special component: Iodine. Iodine helps control the "level of intensity" of development. It does this by regulating the amount of energy produced by the mitochondria.

- Triiodothyronine (T3): Triiodothyronine is also a hormone made by the Thyroid gland. It is very similar to Thyroxine as it performs the same functions. Differences include the intensity and level of production. (The level of production relies on the strength of T3 and T_4)
  The reason why T3 is so similar to T_4 is because T_4 is created when Iodine molecules are removed from T3.

12.1.3 Parathyroid Glands

The last section talked simply about the Thyroid gland and its role in the secretion of T3 and T_4. However (as you can see in the picture below), little bumps indicate the Parathyroid glands. These small glands located on the back of the Thyroid gland control the amount of calcium within the body and the bones. This helps regulate the density of the bones.

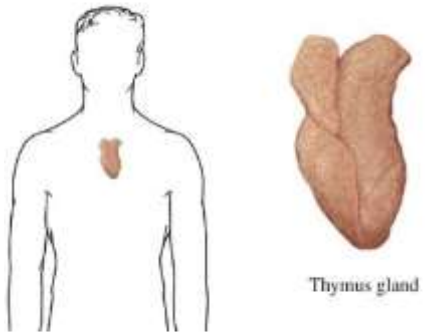


Views of the Thyroid and Parathyroid glands.

12.1.4 The Thymus gland

The Thymus gland, is also part of the Endocrine system. But as oppose to all the rest of the Endocrine organs, instead of secreting hormones, it secretes Lymphocytes and other fighting disease cells in the blood stream to fight off antigens. (Antigens are germs or infectious organisms)
The Thymus gland, (not too surprisingly) is most important in children and young

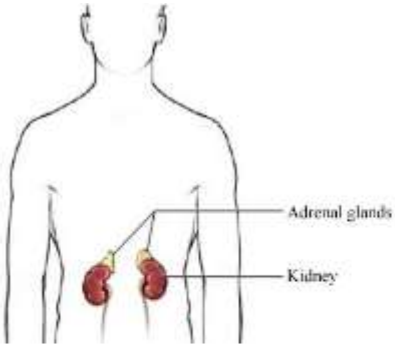
adults.



An image of the Thymus gland and where it is found in the body

12.1.5 The Adrenal glands

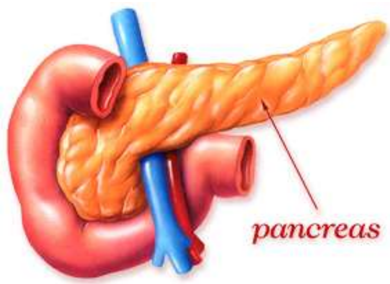
The Adrenals (Adrenal glands) send the Adrenaline hormone to the brain is we get excited, scared or stressed. The hormone Adrenaline (one of the most well-known) helps us get ready and then respond to any danger, excitement, scary, or stressful situations.
The effects of Adrenaline consist of having increased heart rate, having sweaty palms, and arm hair sticking out.
The body’s response to any of these situations is known as the fight or flight response.



An image of the Adrenal glands and the Kidney

12.1.6 The Pancreas

The Pancreas is a part of both the digestive system and the endocrine system! The Pancreas plays a role in the endocrine system by secreting Insulin and Glucagon. This does a key role in digestion. (For more information on the pancreas, Insulin and Glucagon see page 67)
Other digestive organs such as the liver and stomach are also considered part of the endocrine system.



An image of the pancreas and nearby blood vessels.

12.1.7 The reproductive system

In males, the reproductive system secretes Testosterone. In the female reproductive system, the body secretes Estrogen.

- Testosterone: In males, Testosterone is secreted to increase the performance of men as well as develop reproductive organs.
- Estrogen: In females, there is a hormone called Estrogen which is released into the blood stream which stimulates the growth of reproductive organs.

Receiving hormones:

Each system has its own receptor cells — cells that receive hormones from different Endocrine organs and then order other cells to execute a specific function. These cells are known as target cells.

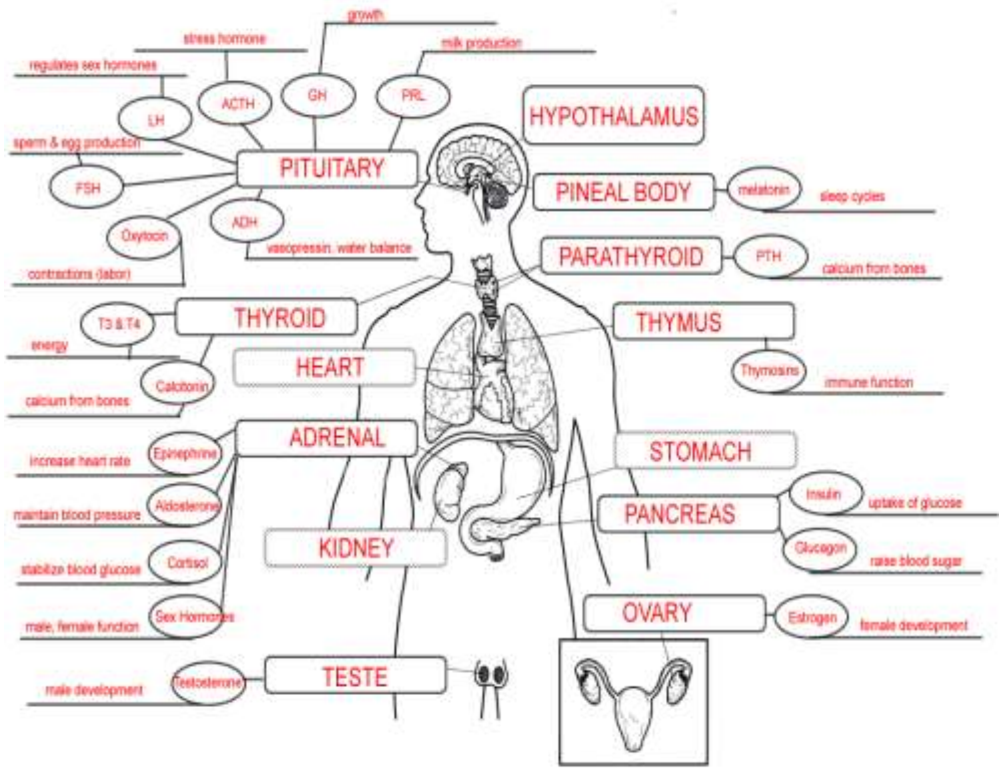
Once the specific hormone as reached its "destination", it exits the bloodstream (hormones are transported to desired areas via the blood stream) and finds the target cell specific for that hormone.

Since target cells have what are called receptors, the hormone molecules simply have to attach to the correct receptors.

As soon as the hormone molecules have bound to the proper receptor, signals are sent to the cell Nucleus to perform the desired function.

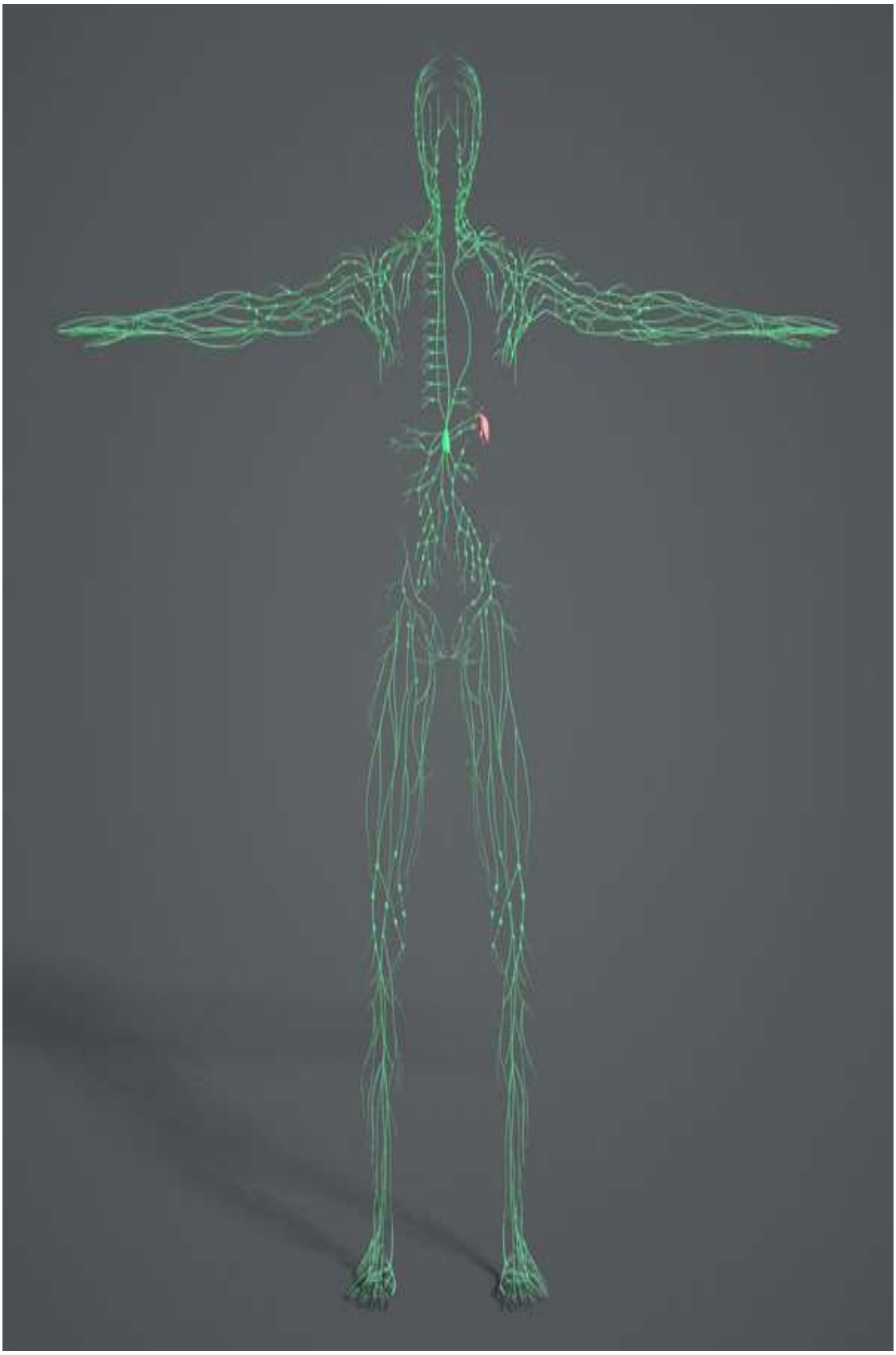
12.2 The Endocrine system and its functions (detailed)

Below, you can see a picture of what the main organs of the Endocrine system are used for:



A depiction of the uses of numerous Endocrine system organs.

13 The Lymphatic system



Our personal bodyguard

If you look at the picture of the Lymphatic system, you may notice that it resembles greatly the circulatory system. This is because instead of sending messages, it carries a clear fluid known as lymph.

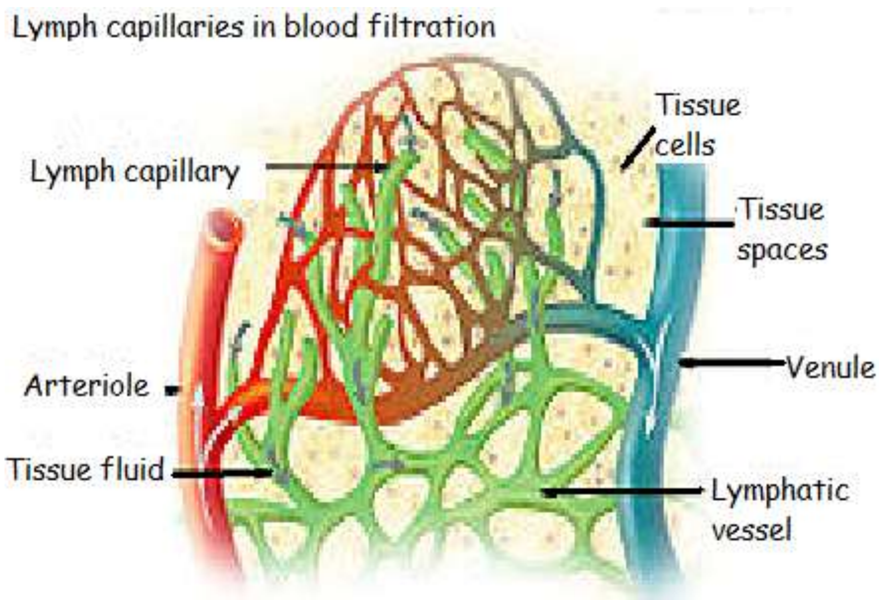
But surprisingly, the lymphatic system is essentially part of the circulatory system as it helps the circulatory system in numerous functions. The lymphatic system also acts as our protector against diseases or bacterial infections. (Which is why it is treated as a system of its own)

The lymphatic system has 2 main functions: Return filtered out plasma back into the circulatory system and fend off or defeat diseases.

Every day, ~20 liters of blood are filtered. The purpose of this filtration is to eliminate plasma from the blood stream. The plasma will then be put back into the blood stream later. However, only 17 out of the 20 liters is reabsorbed, and that's where the lymphatic system comes in!

The lymphatic system then takes these 3 liters (now called lymph) that have not yet been put back in the circulatory system and essentially reintroduces it into the circulatory system. It drains the plasma back into the circulatory system by Lymphatic ducts. (Located at the Jugular and Subclavian veins)

As you now know, the clear fluid that circulates the lymphatic system (lymph) is simply the additional 3 liters of plasma that haven't been put back into the blood stream. Lymph also carries white blood cells that are transported around the body to any area of need.



An image of how the Lymphatic and Circulatory system work together.

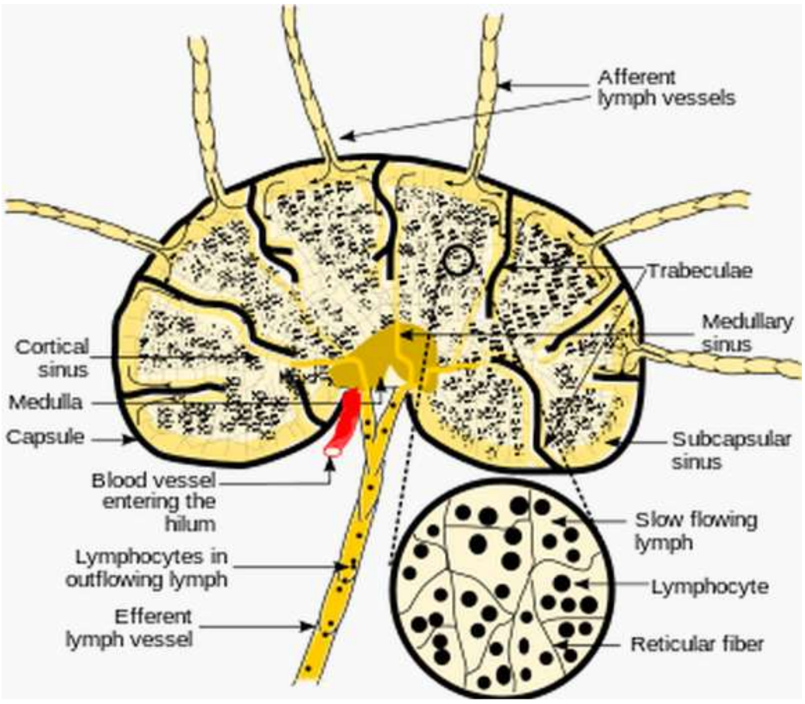
13.1 Lymph nodes

13.1.1 Structure

Lymph nodes are separated into 2 main parts: the outer Cortex and the inner Medulla.

- Outer Cortex: Contains white blood cells that undergo mitosis rapidly in case of antigens.

- Capsule: The Capsule is the outer membrane of the entire lymph node.
- Trabeculae: Trabeculae are strands of tissue that hold the lymph node together.
- Cortical sinuses: Free flowing space for lymph to pass.
- Medulla: Also contains antibody secreting cells that fight off antigens.
- Afferent lymph vessels: Carry unfiltered lymph to lymph nodes.
- Efferent lymph vessels carry filtered lymph away from lymph nodes.



The structure of a lymph node

13.1.2 Function

Lymph nodes are organs of the lymphatic system that are essential for recognising different bacteria. Lymph nodes also filter lymph so that cancer cells and antigens do not continue in the blood stream. (See 2 pages ahead for more detail on filtering)

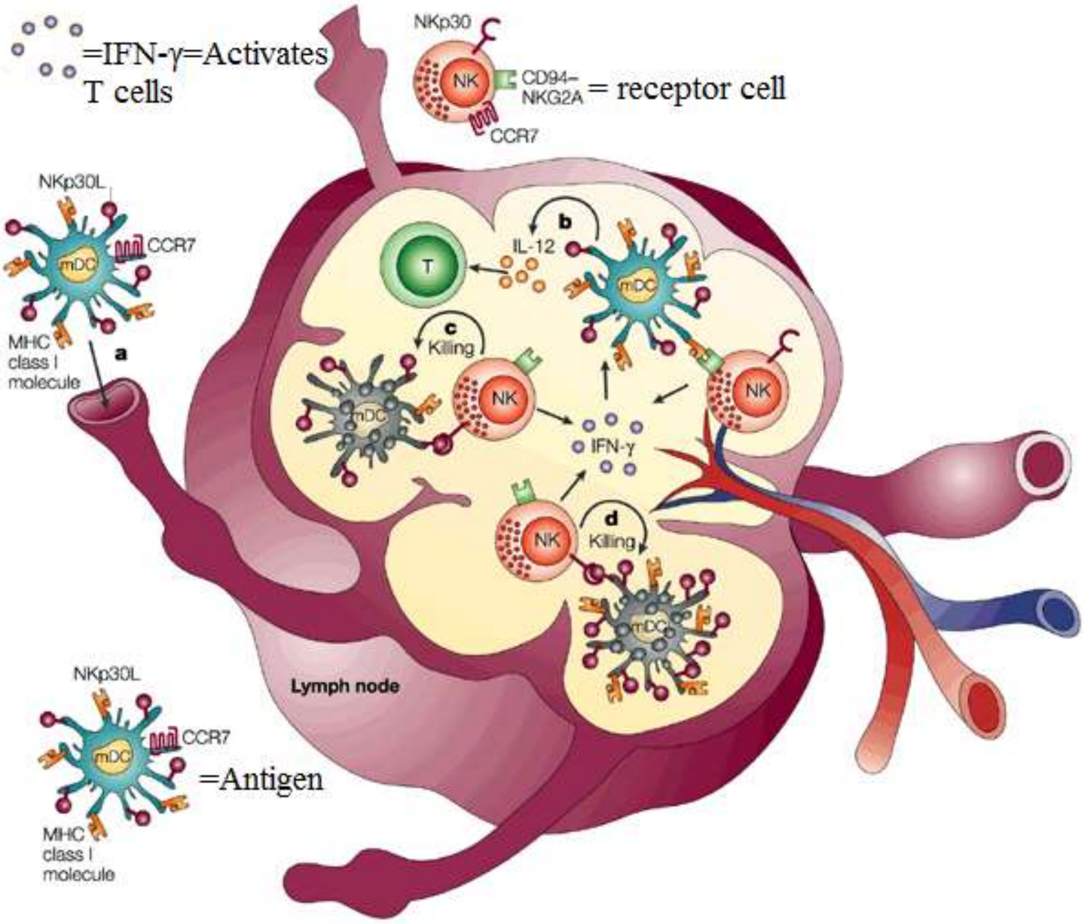
Lymph nodes usually clump and are more abundant in areas that have a higher potential to be affected by foreign material. Such locations are the Axilla (armpit) area, Popliteal (opposite side of the elbow) region, neck region, groin, and chest. The nodes tend to accumulate in these areas as it is prone to be infected much easier and because the region is very moist — the ideal breeding place for bacteria.

Lymph nodes are essential in the early recognition of cancers and viral infections because they swell up in the affected area.

Filtration

Filtration of the lymph does not concern filtering it from toxins. The lymph nodes simply remove bacteria and different antigens found in lymph.

As the lymph passes through the lymph node, receptor cells search for their assigned antigen. Each type of receptor is designated for a specific antigen. If the assigned antigen matches the receptor, the T cells found in the lymph node undergo mitosis and then kill the antigen.



Picture of a lymph node and its response to any foreign antigen.

13.2 AIDS and the effects

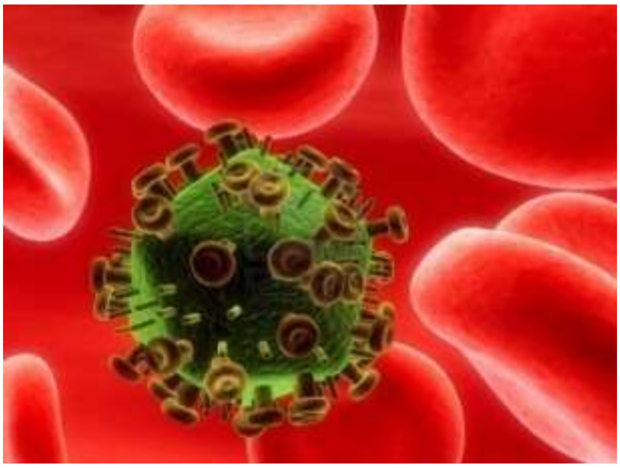
AIDS (Acquired Immune Deficiency Syndrome) is a nearly fatal disease that appeared in the 1980s.

AIDS is the cause of quick spreading of the HIV virus. The HIV virus quickly outnumbers and overthrows the lymph system. By this time the body is not able to protect itself the patient will die.

However, scientists have recently developed drugs to re-activate the immune system of the victim suffering from AIDS.

Now, since you've heard of *the disease* AIDS, let's go a little more in depth about the virus causing the disease.

As you know, AIDS is caused by the HIV virus. The HIV virus then inserts a copy of its DNA. When the cell replicates, instead of becoming a new, healthy cell, it bursts into more tiny HIV viruses.

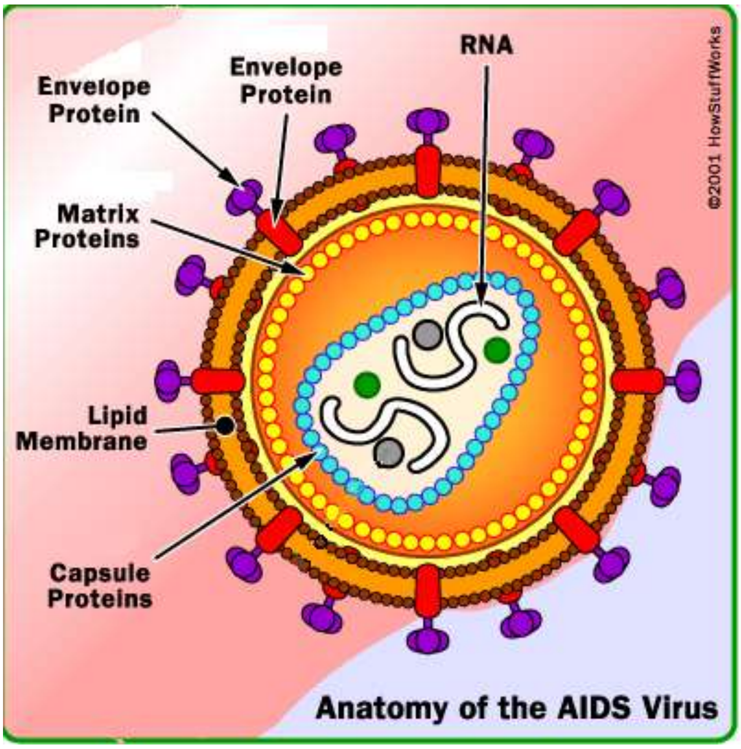


A picture of the HIV virus in the bloodstream.

Some may think the HIV virus is simply a killing machine with no life and components of its own and its only purpose in life is to infect other organisms.
Well, to be honest, that's *half true*! Although one of the only purposes of the HIV virus is to infect other organisms, all viruses have a structure of their own.

As you can see, the outside of the virus is coated by envelope proteins - proteins that allow it to infect other cells. (Envelope proteins are present in every virus)

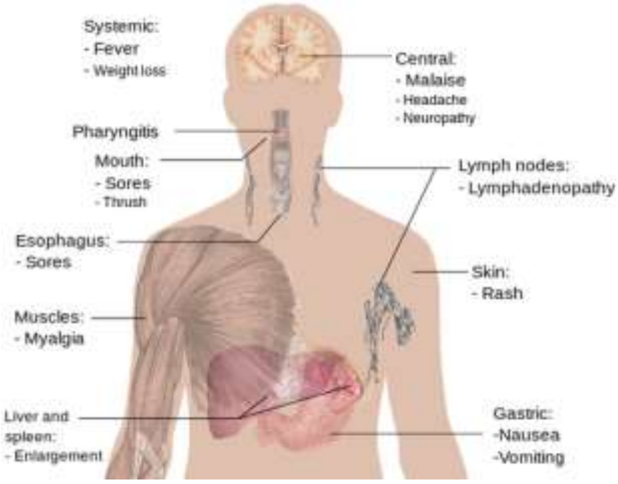
The lipid membrane of the HIV virus is formed of fatty acids and prevents the liquid inside the cell from escaping.



A picture of the HIV virus.

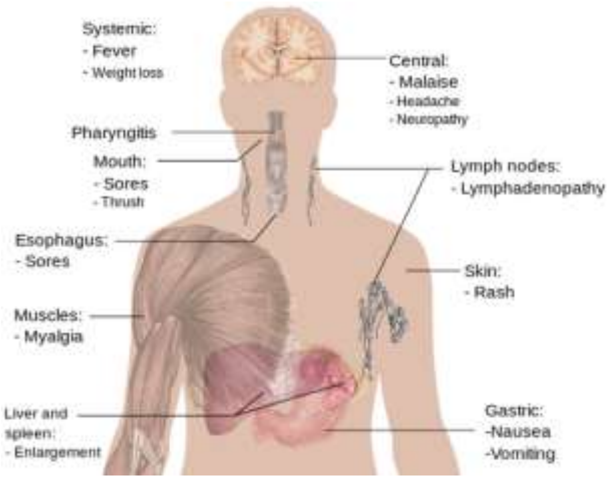
There are multiple symptoms of AIDS, each of them coming at a particular stage in the infection. (There are four main stages in AIDS)

- 1st & 2nd stage: These stages are pretty straightforward,



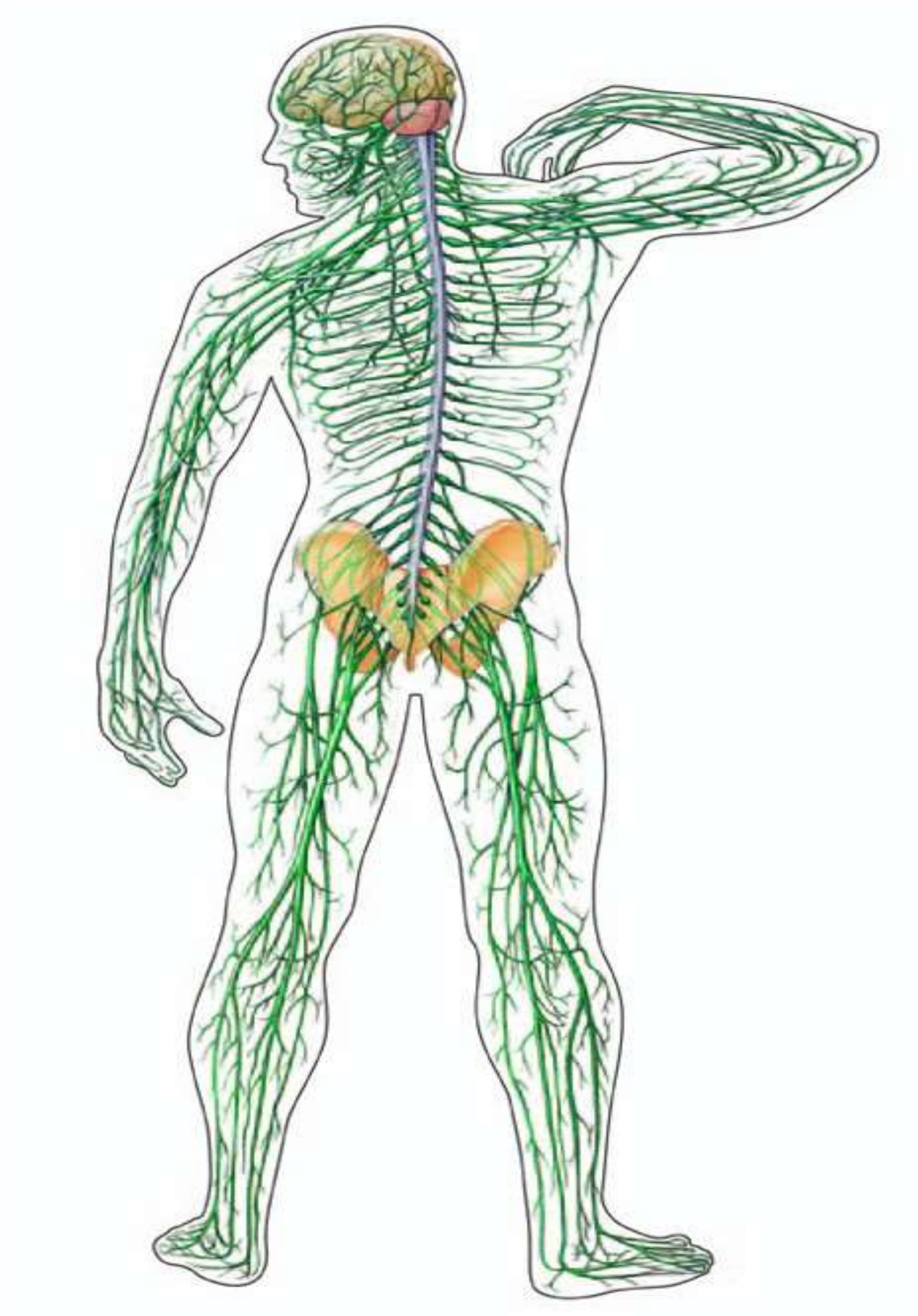
The symptoms of the first and second stage of AIDS.

- 3 & 4 stage: I'll most likely be forever banned from the scientific community for doing this, but so far I've treated *AIDS* like the disease caused by the HIV virus. However, AIDS is only the section where the HIV virus really kicks in. AIDS is when the immune system starts to fail and tumors start appearing. This is because the immune system is unable to defend against different viruses and bacteria that have entered your body.



The symptoms of the third and fourth stage of AIDS

14 The Nervous system



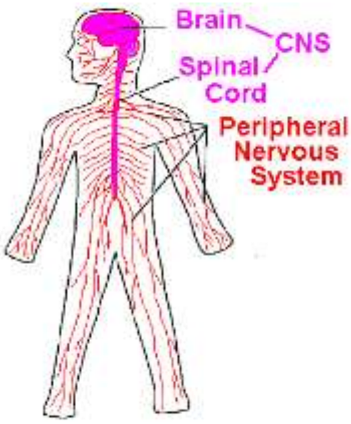
The genius to our complexity

The Nervous system is one of the most complex, intriguing but most fascinating systems. It controls both our conscious and unconscious movements all the way to makes s think the way we do. Get ready to delve in the most fascinating system of them all… the Nervous system!

14.1 Parts of the nervous system

However, (most likely to your disappointment) before we see more about the nervous system, we must firstly list the parts!

- **Brain**: Probably the most renowned organ in our body… The brain is essentially our control center, it controls everything that we do— from talking, walking, running, eating, sleeping, to processes we are not usually aware of, such as breathing, blinking, seeing, digesting, (and for some) even sleep talking!
- **Nerves**: While the Brain controls our actions, nerves are responsible to relay messages to the brain. In fact, you could say that both the spinal cord itself and the Brain are formed by nerves!
- **Spinal cord**: A collection of nerves. These nerves branch out in each direction, going to different parts of the body. Messages going to or sent by the Brain go from the Brain to the desired area— or vice versa.



Parts of the nervous system

14.2 Classifications of the nervous system

The Nervous system is split into 2 main parts: the CNS (Central Nervous system) and PNS. (Peripheral Nervous System)

The other part is called the PNS (Peripheral Nervous system), which includes all the nerves branching of the Spinal cord.

14.2.1 Central Nervous System

The Central Nervous system (as the name suggests) makes up the brain and the Spinal chord. The rest of the body is classified as the Peripheral Nervous system.

The main purpose of the CNS is to receive message from the PNS and process them in the Brain. The message sent by the Brain as a response is transmitted to the PNS to be executed.

14.2.2 Peripheral Nervous System

As mentioned before, the Peripheral Nervous system consists of every part of the Nervous system apart from the Brain and the Spinal chord.

Its job is to send the feedback it's received from the body's senses back to the brain. The PNS' job is to send information to the Brain about both Somatosensation and Visceral sensation.

Somatosensation focuses on the "outside" senses, or the senses we can feel while Visceral sensation is about the "internal" senses, the senses at the organs.

The PNS, is classified into 2 more regions:

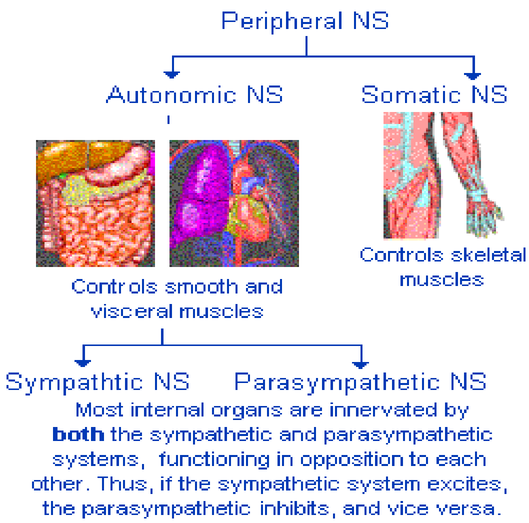
- The SNS (Somatic nervous system) and
- the ANS. (Autonomic Nervous system)

-SNS: The Somatic Nervous system is responsible in receiving messages from the brain to the skeletal muscles. Essentially it is responsible in voluntary movement.

-ANS: The Autonomic Nervous system is essentially the opposite of the Somatic Nervous system, it controls the involuntary muscles (apart from the cardiac muscles. These muscles include the Smooth muscles (See muscular system for more detail) and the Visceral muscles. (The muscles that control the internal organs)

But it's not over! Now, the ANS splits into 2 parts, the Sympathetic and the Parasympathetic Nervous systems.

These two subdivisions initiate the fight or flight response, a process that alerts you when you are either scared or surprised.



An image explaining briefly the function of the Sympathetic and Parasympathetic Nervous System.

14.3 Fight or Flight

On a day to day basis, the Parasympathetic and Sympathetic Nervous system would be balanced at an equal level.

However, in different situations, they may change drastically.

The Sympathetic Nervous system is responsible for increasing your heart rate, making you sweat, diverting more blood to your legs and arms, and opening your

Bronchi and Bronchioles so that more air can enter. This all happens when you are either scared or surprised.
Essentially, the Sympathetic Nervous system initiates what's called the Fight or Flight response — the response initiated when you are either scared or surprised.

The Parasympathetic Nervous system is the opposite of the Sympathetic Nervous system — it's responsible for keeping your heart rate steady and diverting more blood to where is needed, the digestive system.

As a summary, the Sympathetic Nervous system is activated when the body is surprised/scared. On the contrary, the Parasympathetic Nervous system is activated when the body is at rest.

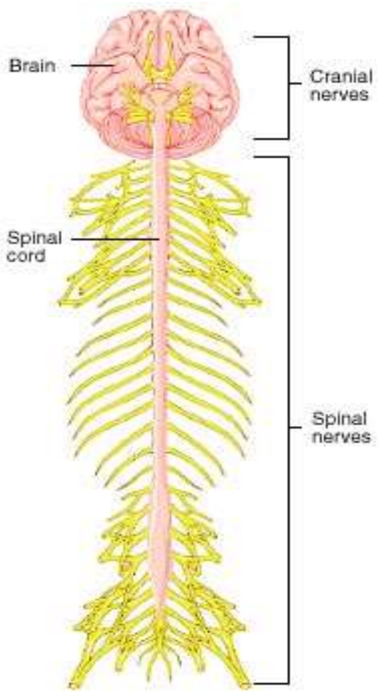
Fight or Flight response is initiated when the body is either surprised or scared.

14.4 Nerves

Nerves are like the veins and arteries of the nervous system — the Nervous system wouldn't exist without them… But, in addition to making up the Nervous system, they relay every message (called action potentials) from the anywhere in the body to our central command post: the Brain.
Every action that we do is controlled by this wonderful system, just how I'm going to show you today.

Similar to the division of the Nervous system's functions, there are also different types of nerves:

- Nerves forming the brain are called Cranial (from *Cranium*) Nerves.
- Nerves found elsewhere in the body are referred to as Spinal Nerves. (Because of the fact that they branch off from the Spine)

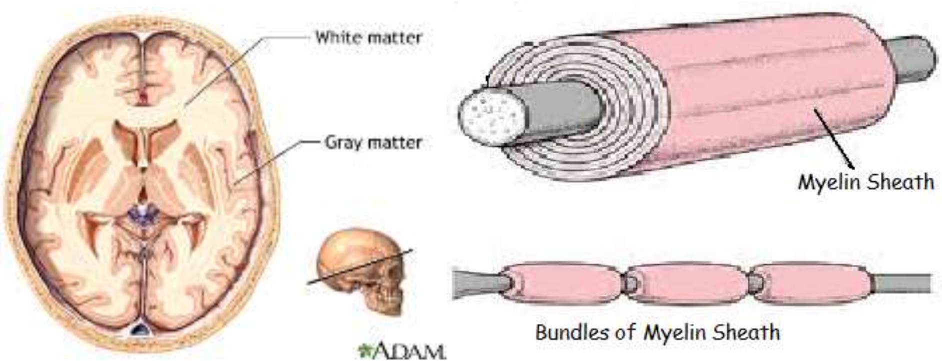


An image of the 2 classifications of nerves.

Interestingly, Cranial nerves are classified as well! Nerves in the Brain are classified as either White matter of Gray matter "nerves". ***Note: White and Gray matter is also present in the spinal cord.**

- White matter nerves: White matter "nerves" are wrapped by a layer of fat called Myelin Sheath and are responsible for maintaining analogies and developing the Brain's knowledge. (It also contributes to eyesight)
  White matter nerves are responsible to relay messages quickly around the brain.
  The Myelin Sheath surrounding the nerves enables messages to be transmitted much faster.
  White is matter is usually found under the surface of the Brain.

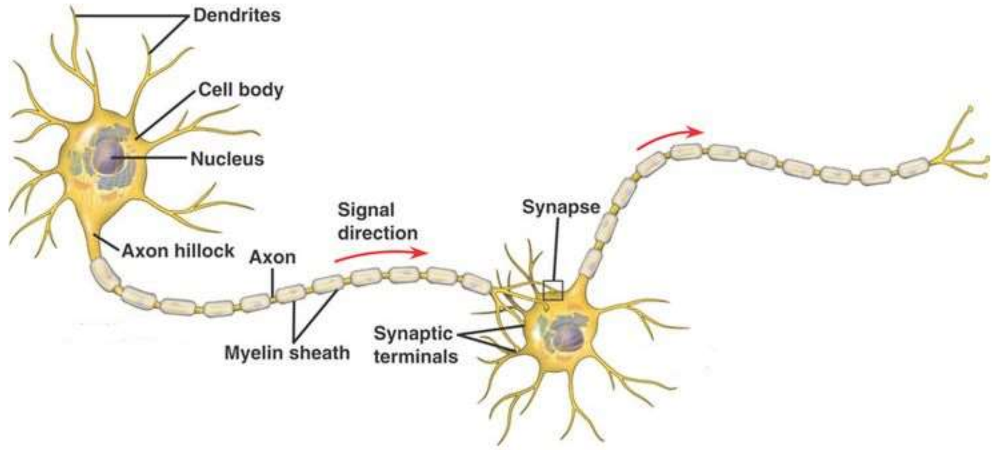
- Gray matter nerves: Gray matter "nerves" (as oppose to White matter) are not wrapped in fatty layer and are found deep in the core and on the surface of the brain. These nerves are responsible for controlling the senses, actions, and homeostasis. It is found capping the white matter as well as deep in the core of the Brain.



Slice of the brain showing areas of white and gray matter as well as White matter "nerves".

14.4.1 Nerve structure

A neuron itself is also split into numerous sections, each serving a different purpose.



The different parts of a neuron

- Nucleus: Contains the DNA and RNA for the neuron.
- Dendrite: The ending branches of a neuron. These branches receive messages from the neighbouring neuron(s).
- Axon hillock: The section where the axon begins.
- Axon: An axon is a strand that passes the message to the next neuron or any tissue. (More about how this message is sent later)
- Myelin Sheath: Myelin Sheath is a layer of fat surrounding the neuron. It enables the neuron to send messages faster.
- Synapse: The gap between the end of the axon and the dendrite. This section is where the message is sent from one nerve to another.

14.5 The Brain

The Brain is organized into different parts — each part designed to focus on a specific part of the body.

This section of the book will explain the different parts and sections of the Brain and their function.

An image of the Brain.

14.5.1 Notable neuroscientists:

People who the study the Brain, and its behavior are called neuroscientists.

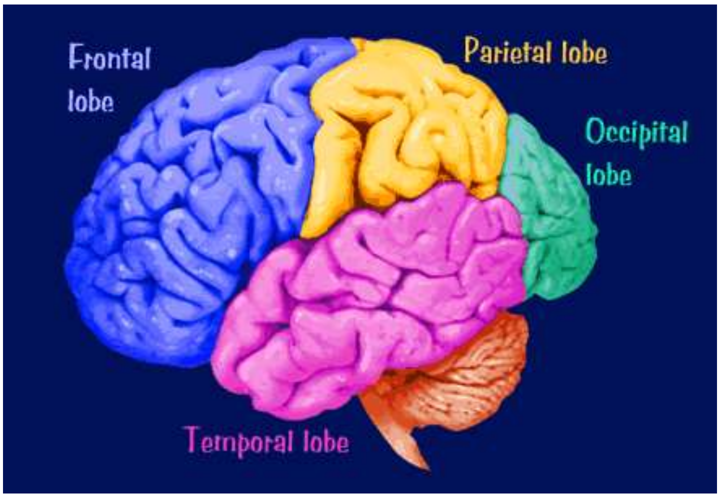
Listed below are numerous neuroscientists that changed the perspective of how we look at the Brain today.

- Paul Broca
- Carl Wernicke
- Alan Lloyd Hodgkin
- Luigi Galvani
- Leah Krubitzer
- Franz Joseph Gall

14.5.2 The Cerebral Cortex

The Cerebral Cortex is a thin layer of gray matter nerves that caps the rest of the “inner” brain. The main function of the cerebral cortex is to regulate/function any processes that concern consciousness.

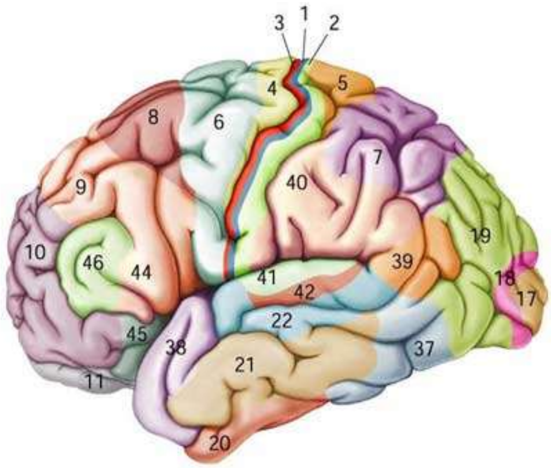
Not surprisingly, the Cerebral Cortex is also split into different parts, each responsible for a different function.



The surface of the brain is divided into these 4 regions.

Other neurologists interpreted the regions of the Brain and the Cerebral Cortex differently. Korbinian Brodmann divided the brain into 50, or so, regions.

Although this interpretation may seen perplexing at first, keep in mind that they are simply a more detailed view of the 4 lobes of the cerebral cortex. (Image is on previous page)



Brodmann’s interpretation of the Brain’s functions.
***Note: Keep in mind that these regions extend well into the brain’s interior as well!**

Legend:

- 4, 6, 8, 9, 44, 46, 10, and 45: These regions make up the frontal lobe (apart from region 11) and is responsible for planning, solving problems, and coordinating.

- 11: This region is responsible for emotion.

- 1, 2, 3, 5, 7, 40, and 39: This region is responsible for the touch sense as well as movement.

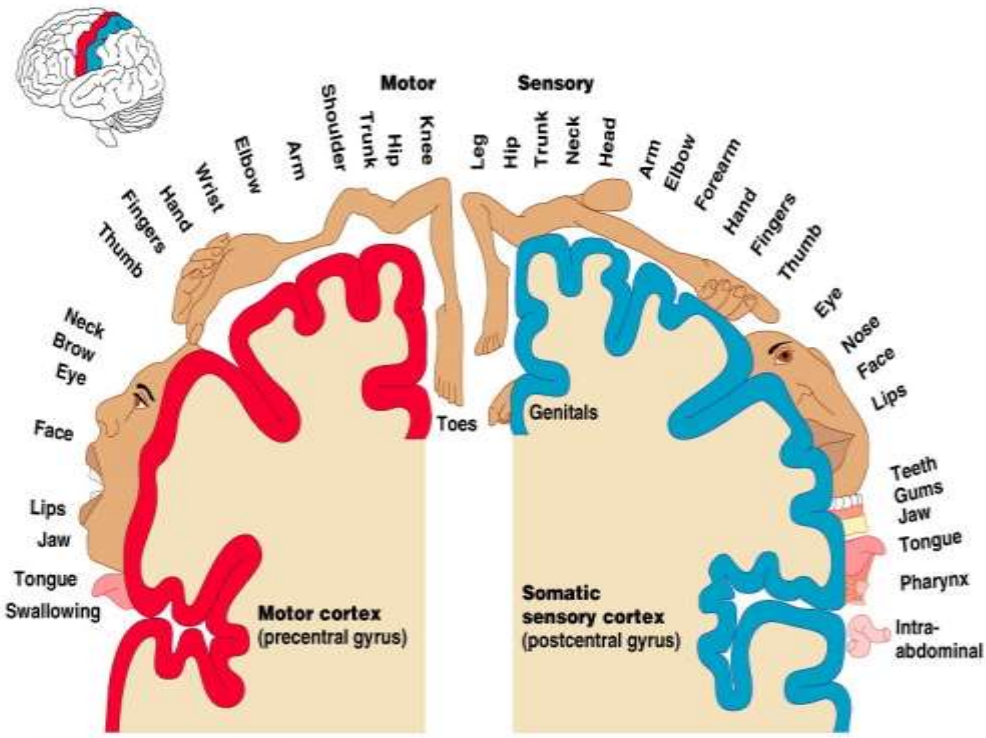
- 19, 18, 17, 37, 21, and 20: This region is responsible for vision,

- 22, 41, and 42: This region is responsible for hearing.

- 38: Other.

In addition, the region responsible for touch and movement (in particular regions 1, 2, AND 3) can be further classified into different regions located at the surface of the brain.

The cortical homunculus (created by Wilder Penfield) shows the different regions of the sensory and motor regions in greater detail.



A homunculus image depicting which regions control which part of the body.
***Note:** The red section depicts the Motor cortex part of the Brain while the blue part depicts the Sensory cortex part of the brain.
For reference, look at the Brain picture at the top left corner of the image.

14.5.3 The Cerebrum

The Cerebrum makes up most of the brain and is the division of the Brain that is responsible for planning, thinking, processing, actions, memory, and in general, *higher level processes/functions*.

Many of the different regions of the cerebral cortex take a similar shape in the cerebrum, so the (surface of the) cerebrum has very similar functions as the cerebral cortex. Deeper in the Cerebrum are found parts of the Brain such as the Hippocampus, Basal Ganglia, and Ventricles.

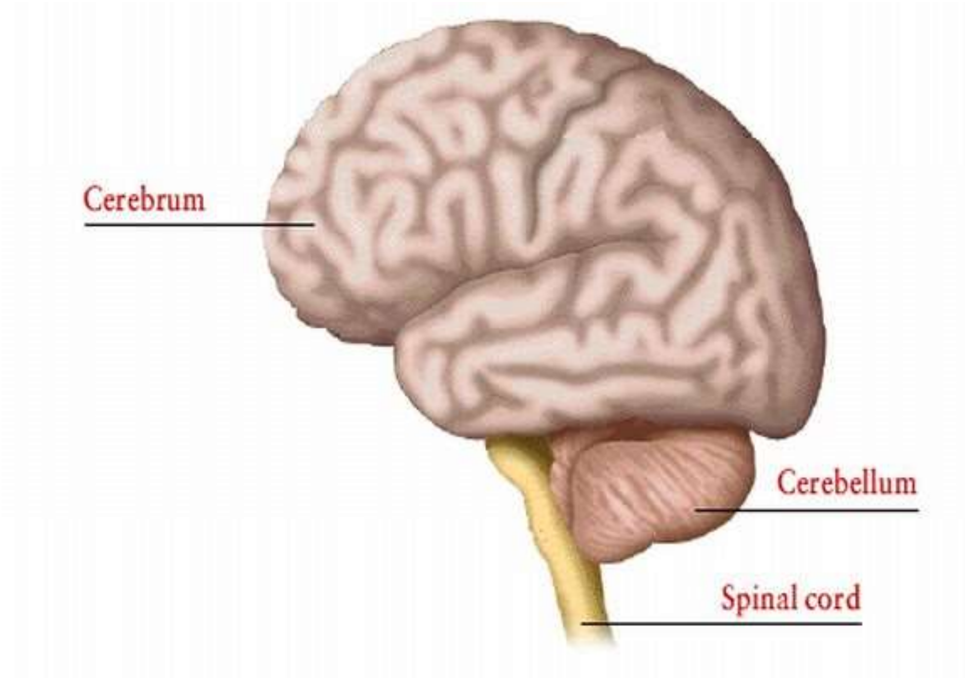
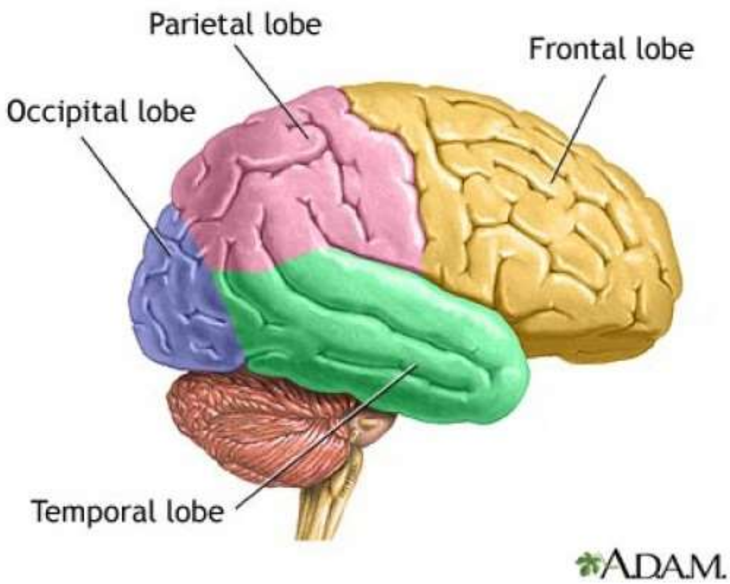


Image of the Cerebrum, Cerebellum and the Spinal Cord.

Just like the Cerebral Cortex, the Cerebrum is also split into lobes: specifically the Frontal, Parietal, Temporal, and Occipital lobe.



This is an image of the 4 lobes of the Cerebrum.

- Frontal Lobe: The Frontal Lobe aids in future planning, considering choices, problem solving, logic, helping us speak fluently, and making up our personality.

It is the largest of the Brain's lobes.

- Parietal Lobe: The Parietal Lobe processes information such as taste, touch, and our temperature.

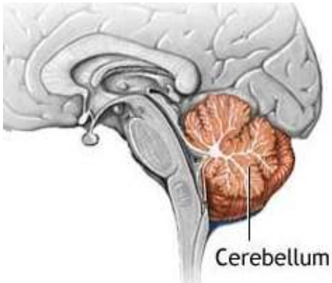
- Temporal Lobe: The Temporal Lobe controls nearly <u>everything</u> involving hearing. In addition of processing what we hear, it also makes us understand the speech that we hear.

- Occipital Lobe: The Occipital Lobe is responsible for seeing and for processing what we see.

14.5.4 The Cerebellum

Under the Cerebrum is another part of the body called the Cerebellum.

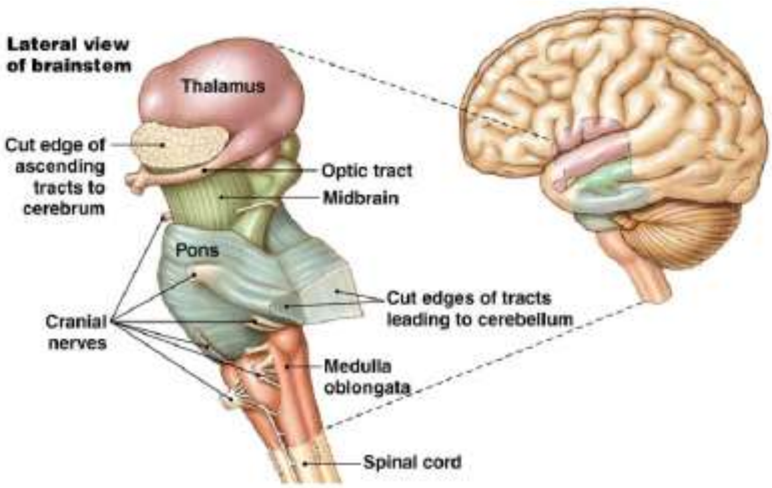
The Cerebellum helps in keeping balance, speech and much more. This provides us with an ability to execute complex and coordinated muscular actions.



An image of the Cerebellum.

14.5.5 The Brain Stem

The Brain Stem is the section where the Spinal Cord (beige) reaches the Brain. The Brain stem is split into two main parts: The Pons (Green-ish color) and the Medulla Oblongata (orange-ish color), which is the part that connects the Pons to the Brain Stem.

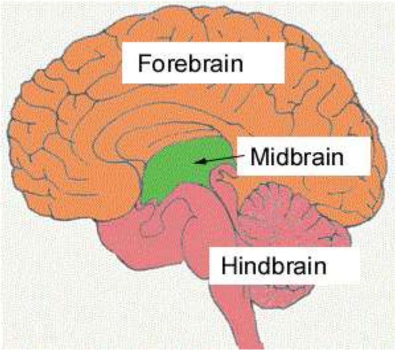


An image of the parts of the Brain stem and nearby Brain parts.

As we can see, above the Pons are the tracts ("nerves") that are going to the Cerebrum. The Cranial Nerves are nerves going to the Brain.

14.5.6 Midbrain

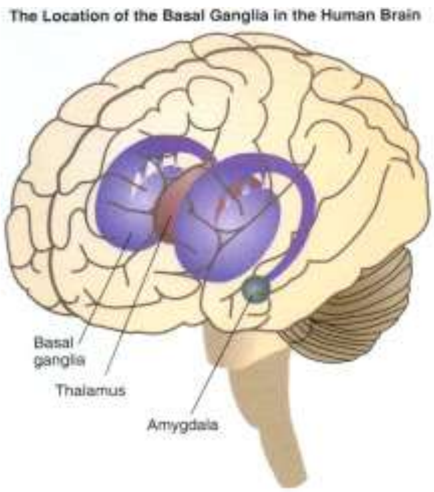
The Midbrain is a lobe of the Brain that is (obviously…) located relatively in the middle of the Brain. It helps control the respiratory muscles as well as the muscles that help us talk.



An image of the location of the Midbrain.

14.5.7 Basal Ganglia

The Basal Ganglia help process information incoming from the Cerebral cortex concerning sensory and motor (movement) information, specifically from the Cerebral Cortex.
This means that the Basal Ganglia process and then send the information to the designated area.



An image of the Basal Ganglia and neighboring Brain parts. (The Thalamus and the Amygdala)

14.5.8 Thalamus

The Thalamus is a gland that controls sleep, and consciousness. However, its main function is to relay messages coming from the Spinal cord to the corresponding part of the Cerebral Cortex. (As you will see for the next part of the Brain.

You may have also noticed (in the spinal chord picture) that the Thalamus is right on top of the Brain stem, which is a crucial observation as it proves that some signals do indeed come to the Thalamus to be redirected to the Cerebral Cortex.

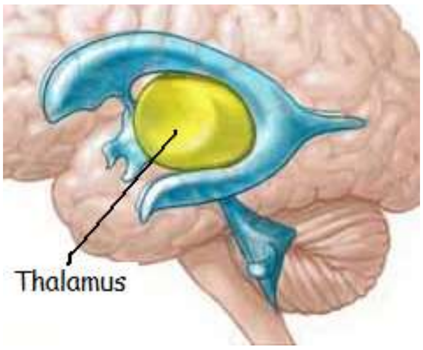
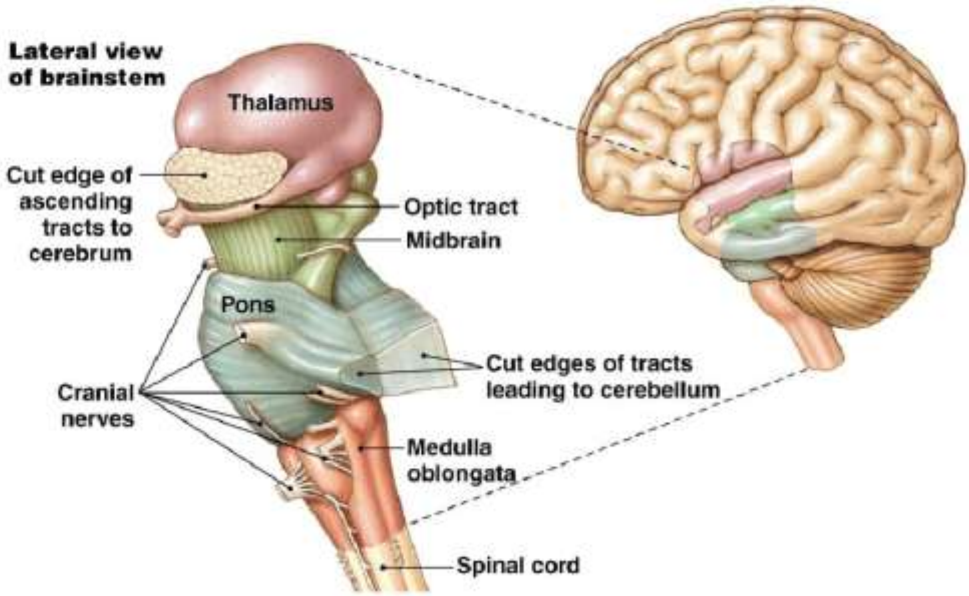


Image of the Thalamus



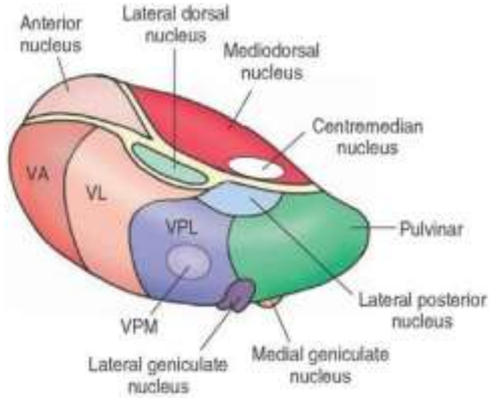
Once again, an image of the parts of the Brain stem and nearby Brain parts.

Thalamic Nuclei

The Thalamic Nuclei are located inside the Thalamus.

The Brain stem leads incoming messages to the Thalamus and it is the role of the Thalamic Nuclei in the Thalamus to decide in which area of the Cerebral Cortex the messages should be directed to.

The Thalamus (along with the Thalamic Nuclei) is covered by the Basal Ganglia (which are covered by the Midbrain) and is therefore also located relatively in the center of the Brain.

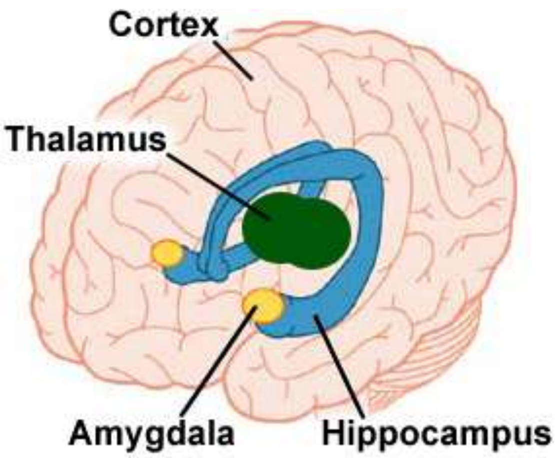


Sections of the Thalamic Nuclei.

Although it is not important to memorize all of the sections of the Thalamic Nucleus, it is important to keep in mind that it's found inside the Thalamus.

14.5.9 Amygdala

The Amygdala gland (despite its tiny size) helps create memories and is responsible for emotions. In my opinion, that's quite unbelievable for a gland that's very small!

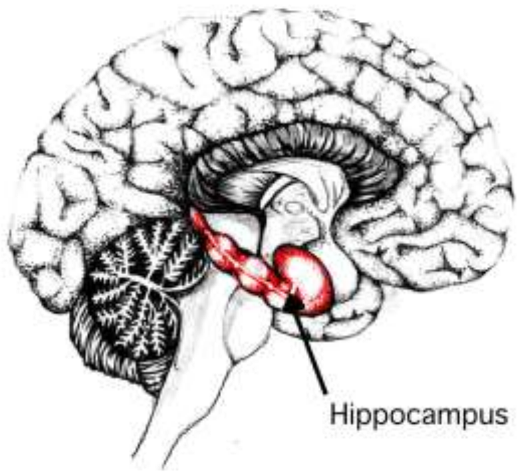


An image of the Amygdala and nearby Brain parts, including the Hippocampus, Thalamus, etc.

As you can see, the Amygdala and Hippocampus are linked together. This is a prominent reason why both the Hippocampus and Amygdala share the function of memory.

14.5.10 Hippocampus

While the Amygdala creates memories, the Hippocampus is responsible to consolidate long term memories.

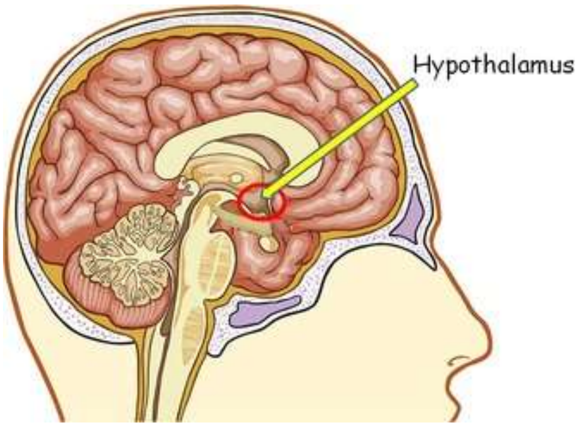


The Hippocampus of the Brain in this image is highlighted/selected in red.

14.5.11 Hypothalamus

The Hypothalamus plays a main role in the Endocrine system by releasing hormones that “order” the pituitary gland to send out a certain hormone.
The Hypothalamus also plays a significant role in maintaining homeostasis as well as plays a part in emotion.

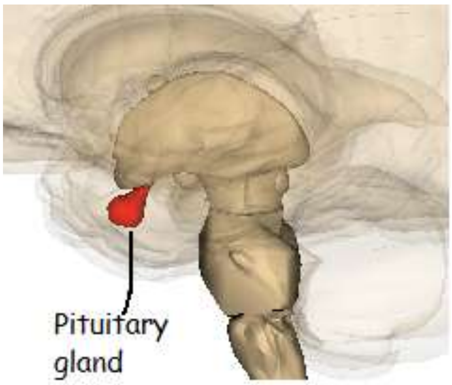
Inside the Hypothalamus are the Hypothalamic Nuclei.



In this image, the Hypothalamus is circled.

14.5.12 Pituitary gland

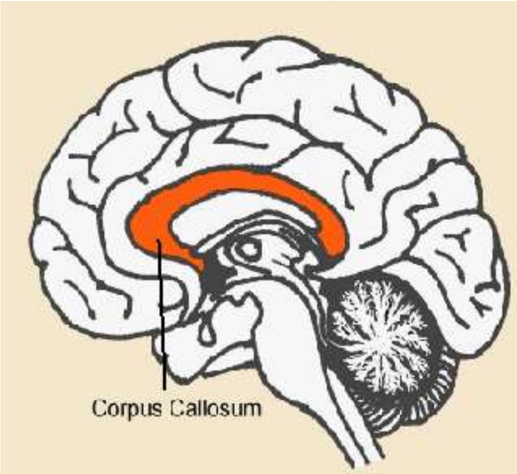
The Pituitary gland is the size of a pea.
The role of the Pituitary gland is to send out hormones to regulate the Endocrine system.



This is an image of the pituitary gland.

14.5.13 Corpus Callosum

The Corpus Callosum connects the 2 hemispheres together. This allows both sides of the Brain to communicate together, allowing organized actions and movements.

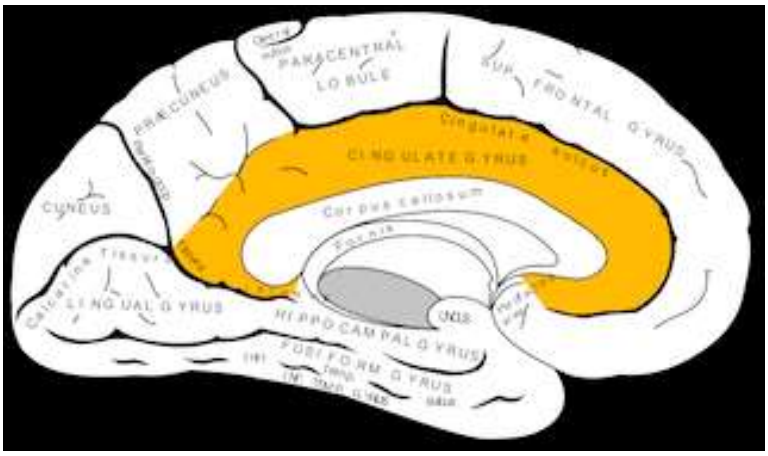


An image of the Corpus Callosum.

14.5.14 Cingulate Gyrus

The Cingulate Gyrus is part of the Brain that encompasses all the other centered “Brain organs”. (Although I said “Brain organs”, keep in mind that there is absolutely no such thing as “*Brain organs”*!)

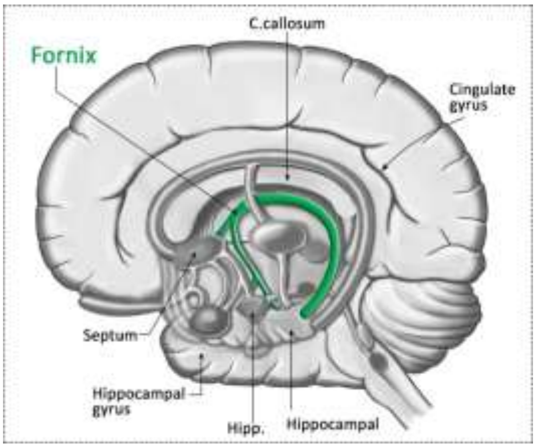
The Cingulate Gyrus plays a major role in expressing emotions through body actions.



An image of the Cingulate Gyrus.

14.5.15 Fornix

The Fornix encompasses all the different interior “Brain organs”. Its function is to connect the amygdala, hippocampus, cingulate gyrus, and other structures in the Brain that help in memory, emotion and the processing of smell.



The Fornix in this image is highlighted in green.

14.5.16 Mammillary body

The Mammillary body is a round structure near the hypothalamus. It is responsible for the memory and recognition of smell and is connected to the Thalamus by the Mammillo-Thalamic duct.

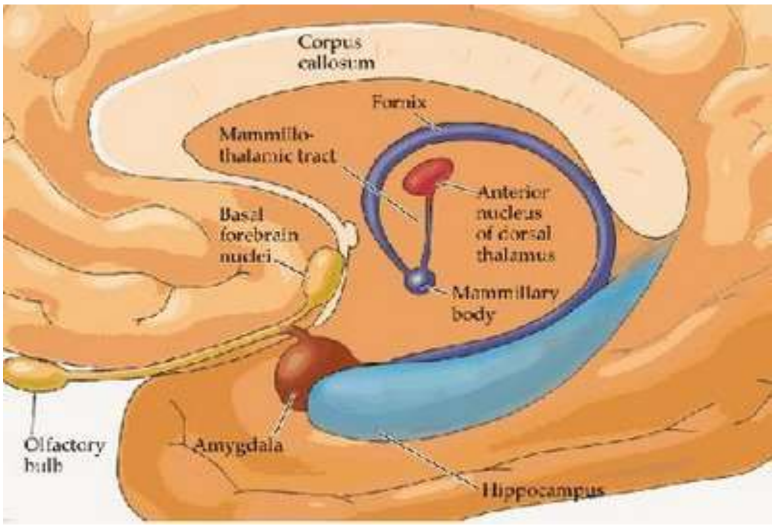


Image of the Mammillary body and near structures.

14.5.17 Dentate Gyrus, Indusium Griseum & Septal Nucleus

These 3 structures form an extended "C" around all the internal Brain structures except the Cingulate Gyrus.

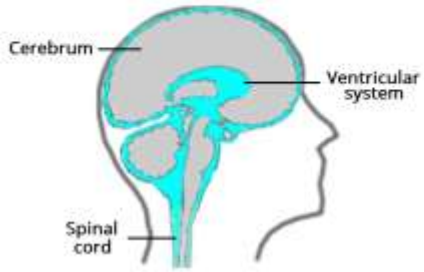
- Dentate Gyrus: This part of the "extended C" contributes to memory and may be also correlated with depression.
- Indusium Griseum: The Indusium Griseum is postulated to be a remnant extension of the hippocampus.
- Septal Nucleus: This structure is solely involved in the felling of pleasure.

14.5.18 Ventricles

The Ventricles play a crucial part in protecting the Brain against trauma. It does this by secreting Cerebrospinal fluid (CSF).

CFS goes in between the brain and the Dura Mater of the Brain, and the Spinal cord and the Dura Mater of the Spinal cord. CFS therefore acts like a liquid cushion for the Brain and the Spinal cord.

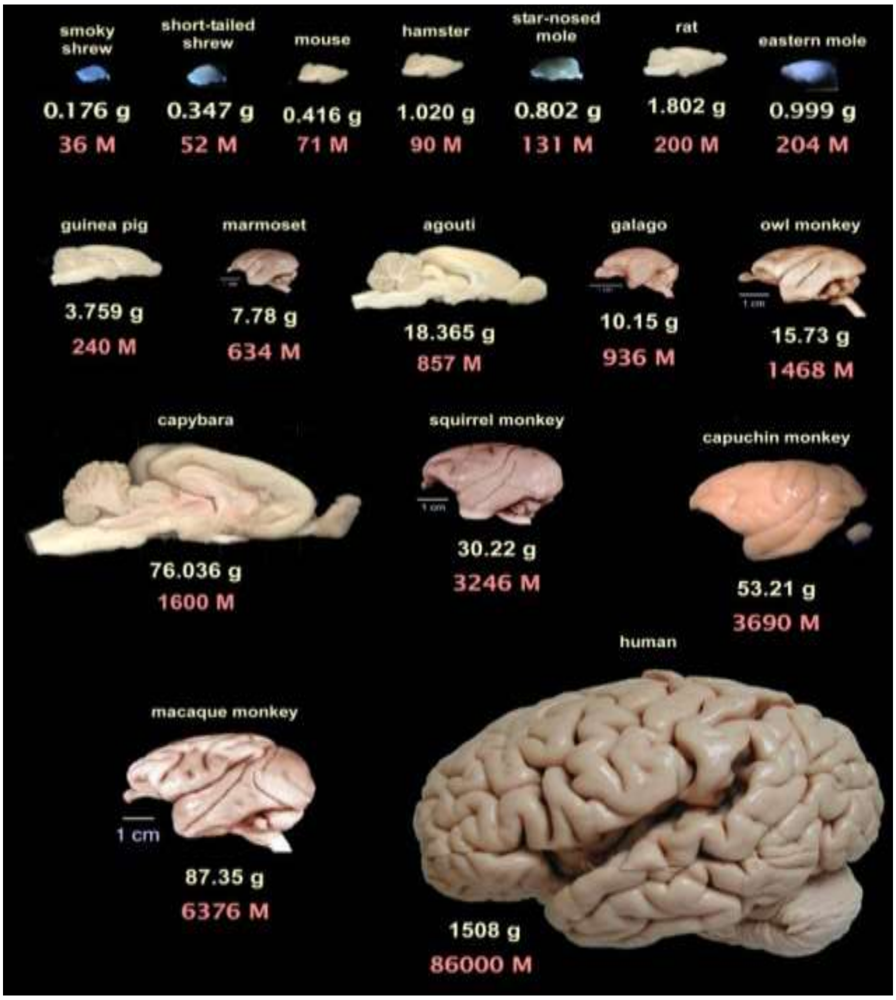
In addition to acting like a cushion, CSF also provides nutrients to the Brain and also decreases the net weight (overall weight) of the Brain.



The blue colored area is the CSF created by the Ventricles.

14.6 Comparing animal brains

Over the course of evolution, us humans have evolved to have a more complex brain than other creatures.



An image of different Brains of different creatures and some information about each one.

First is first, each brain is different for a reason: Each animal brain has adapted to their surroundings, therefore parts that may not be needed as much to survive have shrunk overtime.

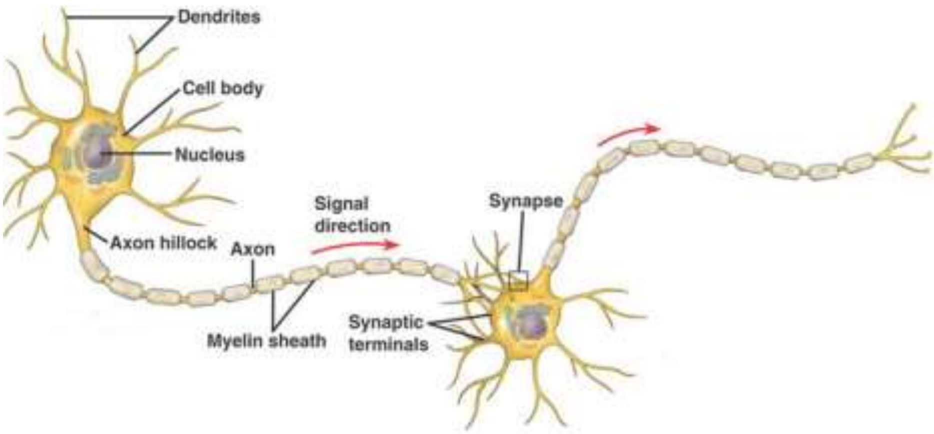
But even with that said, each brain has both a Cerebellum and a Cerebrum.

However, as you may have noticed, the brain of humans and animals such as monkeys and other primates have a larger Cerebrum compared to the Cerebellum. (Proportionally, of course)

14.7 Nerves overview & Synapses

14.7.1 Nerve overview

A neuron itself is also split into numerous sections, each serving a different purpose.



The different parts of a neuron are shown here.

- Nucleus: Contains the DNA and RNA for the neuron.

- Dendrite: The ending branches of a neuron. These branches receive messages from the neighboring neuron(s).

- Axon hillock: The section where the axon begins.

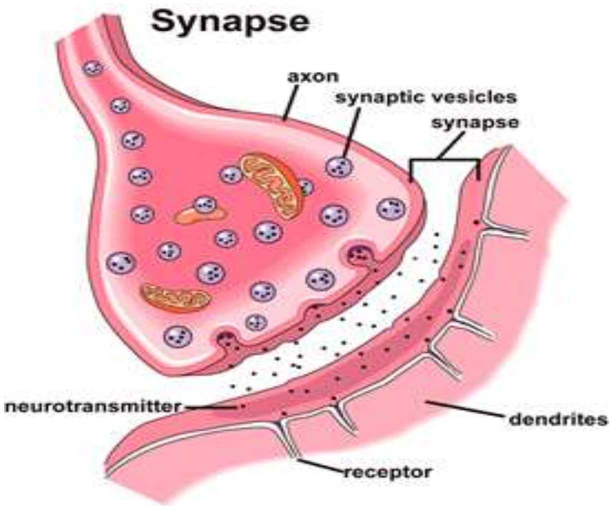
- Axon: An axon is a strand that passes the message to the next neuron or any tissue. (More about how this message is sent later)

- Myelin Sheath: Myelin Sheath is a layer of fat surrounding the neuron. It enables the neuron to send messages faster.

- Synapse: The gap between the end of the axon and the dendrite. This section is where the message is sent from one nerve to another.

14.7.2 Synapse

Synapses, as mentioned above, are gaps in between 2 neurons.
But if there is a gap, how can the signal cross from one neuron to the other?



An image of a synapse and the neurotransmitters in action.

Use the image above as reference to the explanation below.

At the end of the axon, there are pouch-like sacs containing *neurotransmitters*. For different purposes, there are different types of neurotransmitters.

These chemicals, when a signal is coming, are sent to cross the synapse to the dendrite of the other nerve.

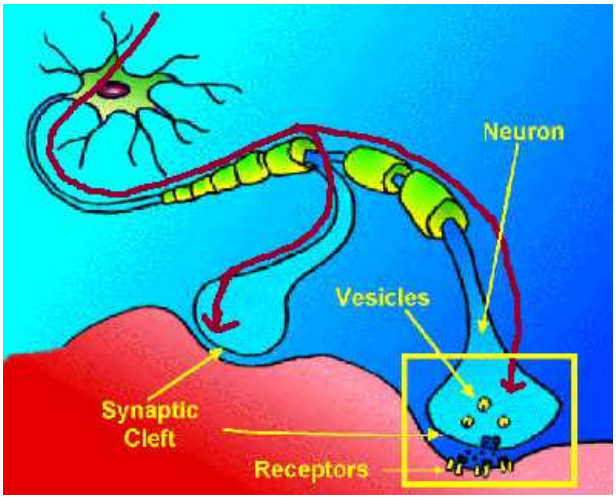
On the receiving neuron there are receptors that receive a certain kind of neurotransmitter. When the neurotransmitters find and get to the corresponding receptor, they act like a “key to a lock”.

The receptors open and let the message continue. The neurotransmitters (depending on their type) are either destroyed or recycled.

14.8 The physiology of nerves

The function of nerves is quite straightforward, but how they work is a different story!

To start off, it is a common misconception to think that an action potential (the signal) is simply an electrical current flowing through the nerves.



An image of the path of an action potential.

In fact, the action potential *is* a form of electricity — the electricity in the form of ions, not the common electricity used in light bulbs or for computers!
***Note: The positive ions are Sodium (Na+) ions while the negative ions are Potassium (K+) ions.**

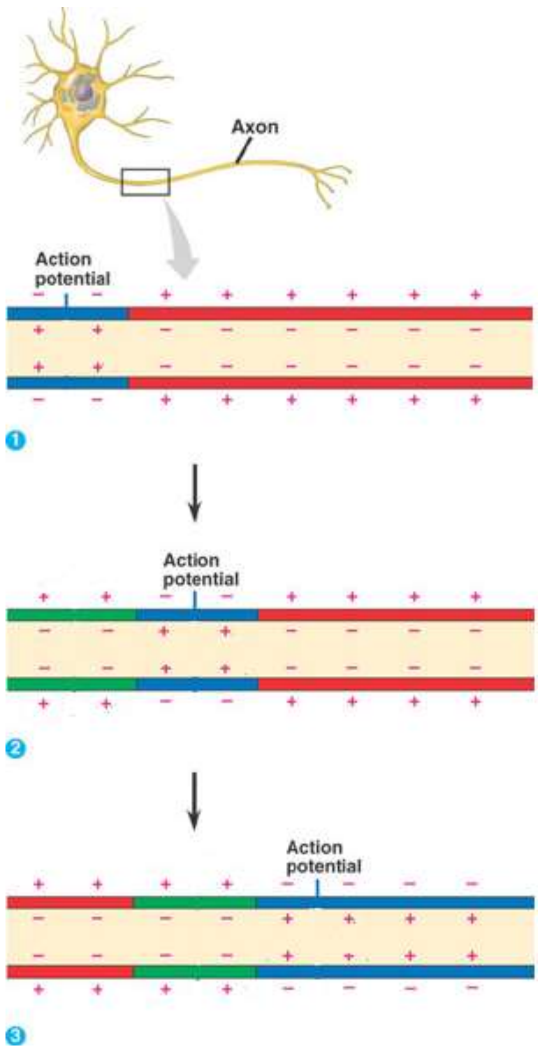
So now that we know what action potentials are <u>really</u> formed out of, we can move on to how they are relayed across the nerves and to their desired location.

To start off, when there is no action potential, neurons have the Sodium ions lining the exterior walls of the neuron while the Potassium ions line the interior wall.

However, when the action potential reaches the axon, the Na+ ions (at the area where the action potential is found) diffuse into the interior of the neuron while the negative potassium ions go to the outside of the neuron. As you may have figured out, this means that now the area where the action potential is has positive ions in the <u>inside</u> of the neuron, while the negative ions are in the <u>outside</u>.
This is called depolarization.

Once depolarization has happened in that region, the action potential can move on. Now, in that area depolarization occurs. This process is repeated until the action potential reaches the synapse.

After the action potential has passed an area, the area undergoes repolarization — where the area returns to its normal, polarized, state.



A visual explanation of how an action potential works.

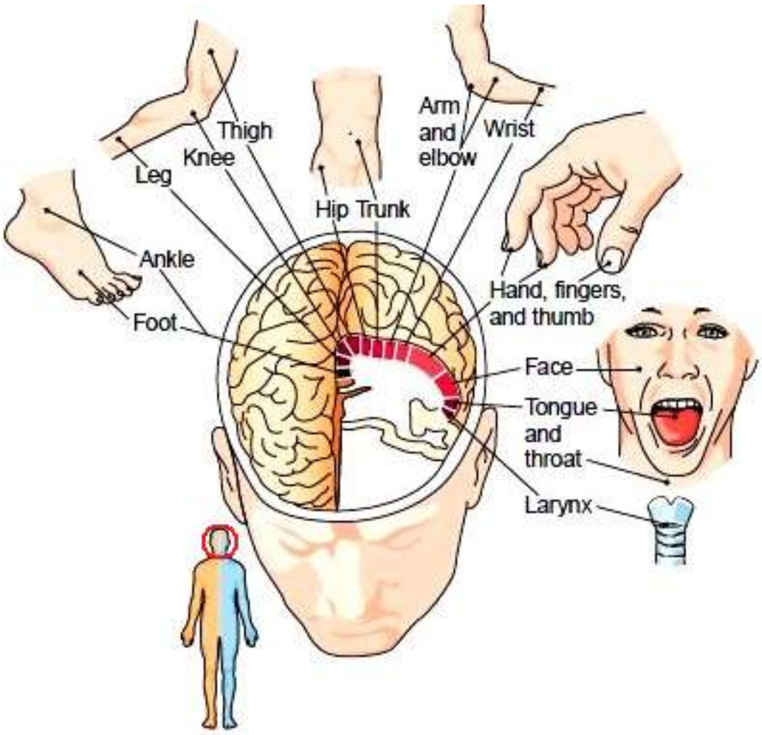
The blue section is the depolarized section, the green section is the section being repolarized, and the red is the section that is in its normal state — polarized.

14.9 What a nerve message really is

There is a lot of confusion around what an action potential really is: when someone says that the message is sent through a neuron to the Brain, they don’t actually mean a “message”. In other words, no “language” or signs are used to tell the brain what the action potential is about.

How the Brain knows what the message is, is because it recognizes where the signal came from. The brain is capable of doing this as it has (as explained before) different sections, each designated to a certain part of the body.

For example, if you stepped on a pin, the neuron would lead the information to the region of the brain designated to the pain of the foot. This way it can send signals to the muscles of the feet to retract the foot from the pin.



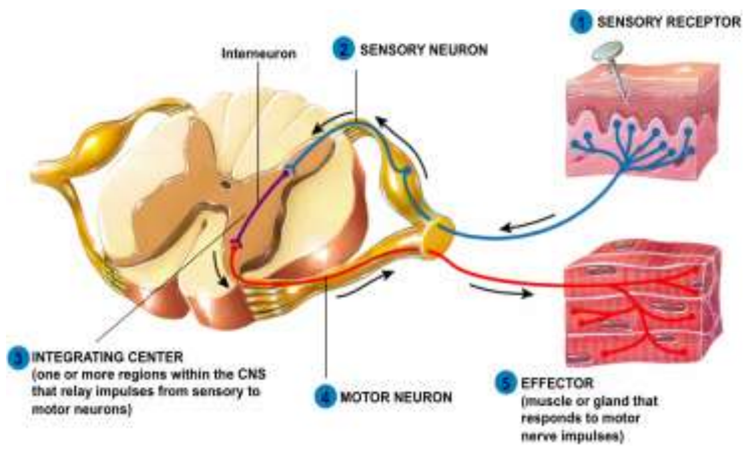
An image of the regions found on the cerebral cortex that are meant for different parts of the body.

14.10 Quick reflexes

When you burn your hand, you would expect the signals to be relayed to the brain, and then the brain would respond by sending a signal back to retract your hand.

However, this process is slow and would result in more consequences as perhaps a second degree burn.

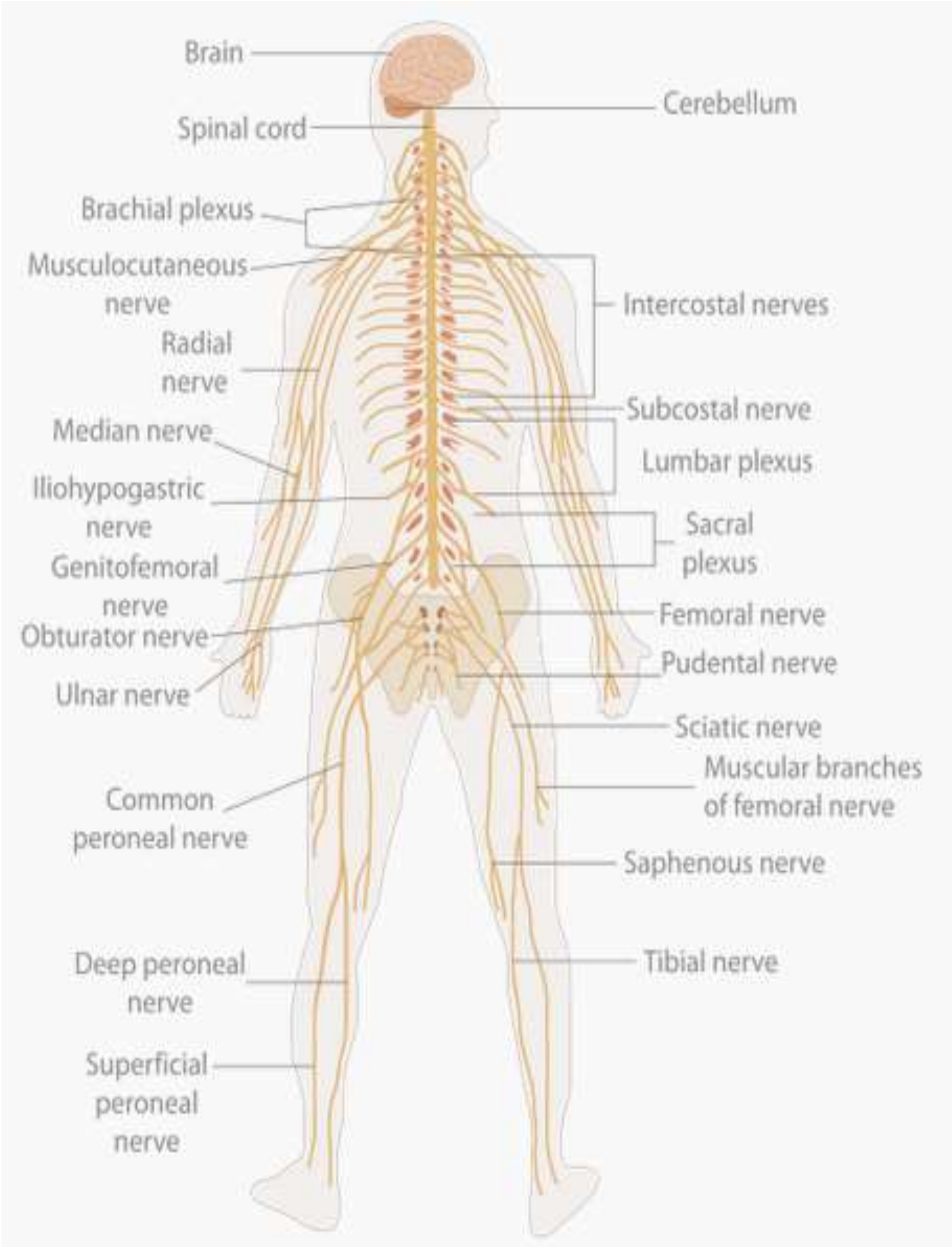
So, to shorten the time of reaction, the body has developed reflexes. Instead of directing the signal to the brain and back, it is relayed to the spinal cord and back to the muscle which retracts the hand that was burnt.



This image displays the different steps during a quick reflex.

1. The sensory receptor on the skin detects the pain and sends the message to the spinal cord.
2. The neuron that relays the message that the sensory receptor sent ends at the spinal cord and is called the sensory neuron. It delivers the message to the integrating center.

3. The integrating center is the region of the spinal cord that transfers the signal from the sensory neuron (2) to the motor neuron. (3) Essentially, it sends a signal to the muscles of the area being burnt (5) via the motor neuron.
4. The motor neuron starts at the spinal cord and goes until the muscles where it delivers the signal sent by the integrating center.
5. The effector is the group of muscles that will retract the area of the body that is in pain.



This is an image of the nerves of the nervous system.

Notice that the names of the nerves resemble the names of the arteries and/or the veins as well as the names of the regions of the body.

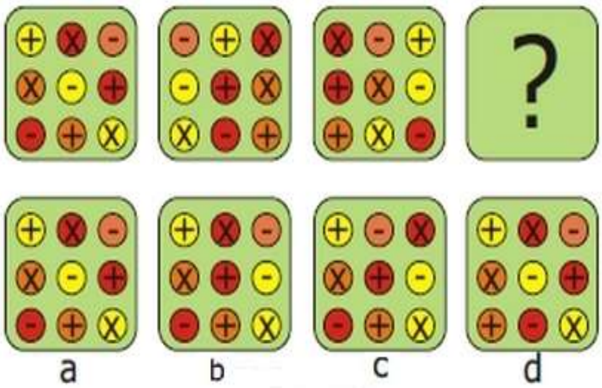
14.11 Psychology

Psychology is a science focused entirely on the brain, its processes and its behavior. In fact, the exact definition is that psychology is the study of *cognitive processes and mental behavior*.

Psychology is very useful for predicting behavior and for understanding the brain.

Although you may have not known the name, psychology is applied in everything around us: from IQ tests to marketing.

14.11.1 Example of an IQ question:



This is an example of an IQ test used to measure the intelligence of a person.

Answer: a)

14.11.2 Example of psychology in marketing:

In most stores, you will find that more expensive products are found to the <u>left</u> side in the shelf.

WHY?

Since we read from left to right (or most of us), we have a natural tendency to face left, thus we see and then buy more expensive products!

Another example you may find is that sugary foods or toys are found lower in the shelves than other products.

WHY?

Since children are shorter, they are more likely to see these products and ask their parents to buy it.

14.11.3 Babies

Babies are born with only reflexes, so all the skills they will need in life have to be learned in their early years.

As evolution has it, babies are naturally curious, this was a necessary trait for newborns to survive in the wild. For example, if you give a baby a teddy bear, it will start to investigate it. It will bang it, stretch it or maybe even chew on it.

The baby will keep on investigating until it understands what that teddy bear is and what it is meant for.


A baby investigating a stethoscope

However, not only do babies have to learn about their surroundings, but they also have to learn a language. Amazingly, babies are capable to learn more information in their first years than in the rest of their lives.

For example, it has been found that babies will learn approximately 11 words per day — a huge amount compared to the amount of words you would learn while learning a language later in life.

Baby test

Since babies can't communicate with scientists verbally, tests performed on babies are required to figure out their behavior.

This section will explain one of the many tests performed on babies.

Firstly, scientists placed a toy in front of a baby. While the baby was still looking it was quickly covered with a piece of cloth. It appeared to the scientists that the baby had lost interest and therefore no longer thought that it had existed.

This theory was widely circulated among psychologists until another test proved it wrong.

Scientists now placed a toy elephant in front of the baby. As the baby continues to track the toy elephant, it is then placed behind a screen.

Notice, at this point (according to the previous theory, the baby would have lost interest), the baby would have lost interest. However, it continued to look at the screen waiting for the elephant to reappear. However, when the elephant was replaced with a toy giraffe and then shown to the baby, the baby appeared shocked.

This theory meant that the baby knew where the elephant was even if the baby couldn't see it.

So, then what made the first theory wrong?
Well, it is worth noting that the experiments were performed on different babies with different skills and the first theory shouldn't necessarily be called *wrong* or *incorrect*.

This is because the first theory was pronounced wrong as soon as the scientists declared the second theory right. Therefore, if the scientists (or psychologists) that had done the tests had forgotten a factor, that could mean that the first theory is in fact correct — we will probably never know.

Another test

As you know, the previous 2 tests weren't the only tests ever to be performed on babies. However, babies aren't the only ones to have been tested.

Another one explained here is called the *cup size test*.
The test involved 2 same cups filled with the same amount of water. A four year old child was asked to agree if the water level was equal.

As soon as they agreed, the water from one cup was poured into a *taller but thinner* cup while the water in the other cup was paced in a broader but not as tall cup. The child was then asked which cup had more water.

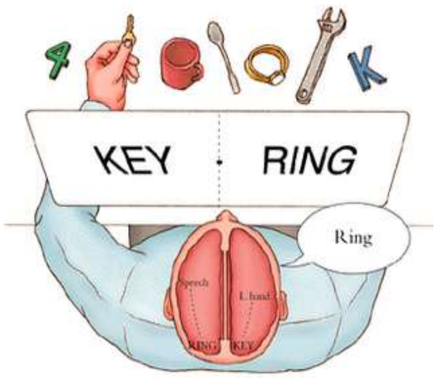
Surprisingly for us, the child pointed to the taller but thinner cup. Of course, the correct answer would be neither as the same volume of water was poured into both cups!

The final test that will be explained here involves a patient with their Corpus Callosum removed.
If you remember correctly, the Corpus Callosum helps the hemispheres communicate together.

It is also worth noting that you see "cross-eyed" — the optic nerve of the left eye directs the signal to the right hemisphere of the brain.

So as you may have figured out, if the Corpus Callosum is cut, the patient will then see cross eyed.

Scientists put a set of objects in front of them with some titles. These objects where split in two groups. On the left, there was a title named key. On the right side there was another title, named ring. When the scientists asked the patient which side the ring was on, they pointed to the key section — enforcing the theory that patients with their corpus Callosum cut see "cross-eyed". (Image on the next page)



An image depicting the test explained.

14.12 Memory

Memory is our "storage". When we remember something, it is stored in different parts of the brain.

Adding to this, there are two kinds of memory: short and long term memory.

- Short term memory: Short term memory is there simply for the brain to keep record of something for a short period of time. If the memory continues to be stored, it will become a long term memory.

Short memory is stored in the frontal lobe of the brain. Another thing to keep in mind is that, unlike long term memory, short term memory is limited and can only be stored for a maximum of 20 to 30 seconds.

- Long term memory: Long term memory, is unlimited.

The reason being is because long term memory is stored mainly every where in the brain. (Although the hippocampus is the main part of the brain that stores long term memory)

Short term memories are constantly coming to the brain. For example, if you try to remember this sequence of numbers, they will eventually be replaced: **1-7-6-4-7-8-3-5-4-6-5-7** by different short term memories.

Unlike short term memory, long term memories can be stored for several hours, weeks, years or event for life.

How memories are formed

A memory starts when the Brain has processed information. No matter how important the memory, it is firstly stored as short memory.

If the memory continues to be stored in the Brain, it is transferred to the long term memory. But the question is, how is long term memory stored?

It is thought that the Brain does not create any additional brain nerve cells during your lifetime, so instead, it creates connections between different nerve cells already created. These connections are essentially new axons connecting in between the already created nerve cells.

When you think of a memory, it is the action potential sent from that region that has notified the conscious brain about that specific memory.

An interesting fact is that memories that have more significance, or that are linked to something prized to you have a greater chance of become a long term memory. Scientists believe this is the reason why some people can excel at certain subjects.

A “graphic” image of a neuron and its connections.

Tricks for short memory

Try remembering these letters:
F-Q-S-X-M-T-L-J-R
Now do the same with the second set:
G-V-D-P-E-G-T-C-B

Which set were you more successful on?

Most people have more success with the first set rather than the second since the second set contains letters all ending with the same sound.
(Gee-Vee-Dee-Pee-Eee-Gee-Tee-Cee-Bee)

Another example that is rather common involves shopping. Say you're going shopping and need to bring back quite a few stuff. You *could* bring a list, but you're sure you'll lose it along the way.

A solution may be to link all the items you want to buy together and string them into a story.

This can also be applied to remembering long sequences of numbers such as the never ending number pi. (π=3.14159265358979323846...)

This can be done by incorporating the numbers of pi into a song such as the alphabet song or creating a story with each number.

14.13 Consciousness

The brain has two "modes": consciousness, and unconsciousness.

- Consciousness: Consciousness is what you are thinking about right know. For example, the words in this book are now "part" of your consciousness since you are paying attention to them right now.
- Unconsciousness: Although consciousness is also fascinating, unconsciousness is where it all gets <u>super</u> interesting!
-

Unconsciousness is when we are unaware of what we are doing. Examples of unconsciousness are dreaming, breathing, digesting, and most interestingly, *Freudian slips*.

Freudian slips are when someone means to say a specific word but accidentally says something else instead.

Some examples:
- David Cameron once said "We are raising money for the rich!". However, he had actually wanted to say "We are raising money for the poor!".
- Another example may be that someone meant to say "I'm glad you're here", however says "I'm mad you're here".

You may have speculated that these *slips of the tongue* weren't entirely accidental. In fact, in the eyes of Sigmund Freud, (a psychologist renown for his studies of the conscious mind) what had accidentally slipped out of the mouth was actually what the person was trying to hide, or what they truly thought.


An image of Sigmund Freud.

He believed that unconsciousness was when we are unaware of what is happening around us.

14.14 Sleeping

Not surprisingly, sleeping is another example of unconsciousness. This is because when you are sleeping, you are not aware what is around you.

Unfortunately, scientists are not entirely sure why humans and other living beings sleep nor are we sure what exactly happens when we sleep, but there are some theories that are worth mentioning:

- Inactivity theory: This theory suggests that inactivity and no movement would make a vulnerable animal not as likely to be found when it is most vulnerable — at night.

The theory suggests that sleep evolved first from creatures staying very still for long periods of time. This habit soon became the process of sleeping.

However, one can easily find a way to rival this theory: It would surely be better to be able to react quickly if anything happened to the organism, therefore eliminating the need for sleep.


Sleeping animals

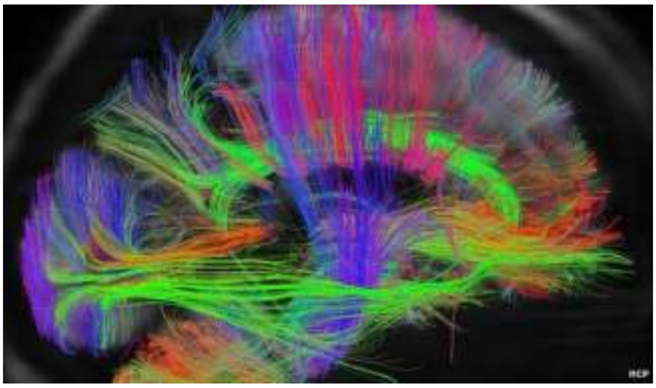
- Conservation theory: The conservation theory suggests (like the name says) that animals have evolved to sleep to conserve their energy when they are most vulnerable or when they are less at an advantage when hunting.

***Note:** The Conservation theory is considered part of the inactivity theory and is also considered an unreliable theory.

- Restorative theory: This theory of why we sleep is relatively new and suggests that sleep provides time for the body and the brain to repair any damages that have happened.

Researchers have found that a total deprivation of sleep in mice degenerates their immune system completely and the mice then die.
Scientists have added on to this by postulating that sleep evolved when creatures slept because their immune system was boosted, preparing for any predator attack.

- “Waste” theory: This newly developed theory (created in 2013) suggests that even the Brain creates some waste — simply every system does. The theory itself suggests that sleeping is the time when the Brain eliminates this waste through microscopic fluid channels.



An image of the channels that excrete “brain waste”.

- “Memory” theory: This theory is widely accepted and suggests that during sleep, the Brain organizes information processed during the day and transfers short term memories that have still remained to long term memories.

This theory is widely accepted mainly because it explains why we dream — dreams are about what happened during your day, so that information may be processed by the brain while dreaming.

Although these are only several theories, it doesn’t suggest that only <u>one of them</u> is correct, sleep can be a combination of numerous of these or other theories.

14.14.1 Different stages of sleep

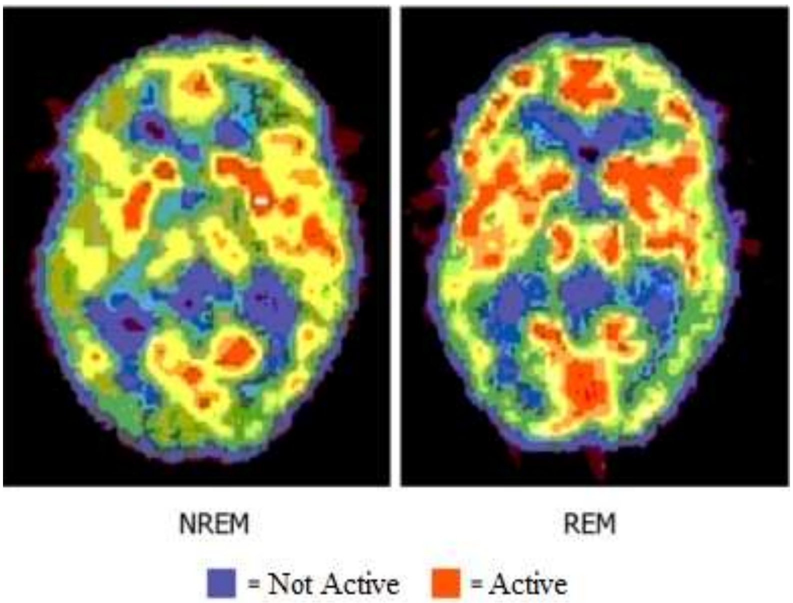
Even if scientists aren’t sure why we sleep, fortunately we know the different stages of sleeping. In fact, there are two types of sleep: REM and NREM.

- REM: REM stands for Rapid Eye Movement. This is the stage of sleep when it is believed that you dream. Interestingly enough, REM is only present in mammals. REM is characterized (apart from dreaming) by random eye movement.

Essentially, during REM sleep, the Brain is much more active than in NREM.

- NREM: NREM (non rapid eye movement) is when you are in deep sleep and the brain is not as active.

Normally, people fall into NREM sleep and then drift into REM sleep but the brain constantly switches in between the 2 stages.
NREM is characterized by deep sleep where it is very hard to wake the person up.



As you can see, the Brain has more active areas during REM, indicating that it's more active during REM.
However, NREM has less active areas, indicating that the brain is less active during the NREM stage. That is the reason why it is very hard to wake someone up that is in the NREM stage.

14.15 Brain defects

The brain can go wrong just like any other part of your body. These defects can widely range from diseases to disorders, strokes to tumors and can cause loss of memory, uncontrollable shaking, paralysis, or even death.

14.15.1 Schizophrenia

Schizophrenia is a disease that causes the patient to lose control of their own thinking. The patient suffers delusions, meaning that they believe stuff that is not true.

There are different types of delusions: (Some of which are not listed here)

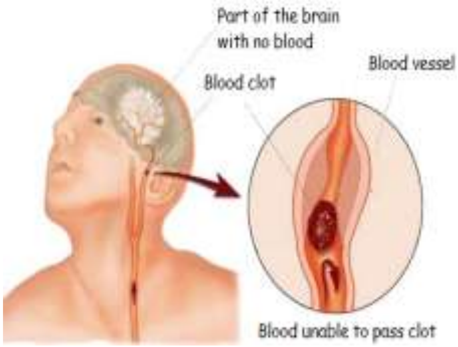
- Delusion of Grandeur: Patients that have this think of themselves as a great and grand person. Patients with Grandiose delusions often think that they have uncontrollable power, vast knowledge, and think that they have a great destiny or that they have made a new revolutionary discovery.
- Somatic Delusions: A patient with somatic delusions believes that he or she has a medical defect or problem.
- Persecutory Delusions: This type of delusion causes the patient to think that they are (or someone close to them) being harmed or spied on.

This can result in multiple calls to authorities.
(Another name for persecutory delusions is *Paranoid Delusions*.)

14.15.2 Strokes & hemorrhages

It is crucial to understanding that strokes and hemorrhages are 2 separate things.

Strokes are when blood flow is partially or completely obstructed. Cerebral strokes are strokes that take place in the brain.



This is an image depicting what happens during a blood clot.

On the contrary, cerebral hemorrhages are leakages of blood into the brain.

But what causes hemorrhages? Well, to start, there are 2 main types of hemorrhages:

- Intracerebral hemorrhage: As the name suggests, this type of hemorrhage is when blood leaks into the brain by a tiny fissure in the arteries that supply brain tissue with oxygen.

Common causes of intracerebral hemorrhage is high blood pressure, although trauma or the malformation of the cerebral blood vessels can all play a part.

- Subarachnoid hemorrhage: As mentioned in the explanation of an intracerebral hemorrhage, it can be caused by the malformation of arteries.

Subarachnoid hemorrhages are just that. Since malformed arteries are weaker than others, they are prone to inflammation because of blood pressure. An arterial inflammation in the brain is called an aneurysm and if not treated, the artery wall could rupture. What would ensue is called a subarachnoid hemorrhage.

Now that you know about hemorrhages, we can move on to strokes. Cerebral strokes are caused when the brain tissue starts to die because arteries reaching that area have been obstructed by a clot.

Symptoms of strokes include sudden inability to speak fluently (slurred talking), fuzzy vision (or becoming blind), inability to move a certain part of the body, headache, dizziness, pain, fatigue, numbness or paralysis, inability to walk, and much more.

14.15.3 Motor Neuron Disease

Motor Neuron Disease (MND) causes significant loss of movement control.

Patients with motor neuron disease (such as the great physicist Stephen Hawking) become more and more paralyzed over time, resulting in death because of the paralysis of the lungs, causing an inability to breathe.

Patients suffering from motor neuron disease have an average of 4-5 years of life after they've been diagnosed with MND. However, Stephen Hawking has been living MND for more than 50 years, which suggests there are huge advancements in this field.

MND is caused by the degeneration of motor nerve cells in the cerebral cortex, brain or spinal cord. Over time, messages aren't able to be sent through the axons of the nerve resulting in the paralysis of the area affected.

The great physicist Stephen Hawking is an example of a patient with motor neuron disease.

14.15.4 Tumors

A tumor is a group of cells that starts replicating out of control and that can seriously damage the brain.

Tumors can happen virtually anywhere in the body, including the Brain and spinal cord.

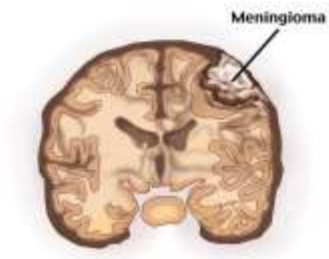
There are 2 types of tumors: benign and malignant.

- Benign tumors are tumors that are only able to grow in a certain area of your body and are unable to spread around the body via the blood stream or by other tissues. These tumors are usually treated with surgery.
- Malignant tumors are a form of cancer. They can spread to neighbouring tissues by "invading" them or the tumor can spread by the blood stream. Malignant tumors are more aggressive and therefore more dangerous that benign tumors.

Malignant tumors are often treated by radiotherapy and very rarely by different drugs.

Not surprisingly, there are different types of tumors, each one arising from different kind of cells:

- Meningioma: This type of tumor starts at the Dura Matter (a membrane surrounding the brain) and expands by the cerebral cortex, therefore disabling motor or sensory function in that area. Because of that, symptoms of Meningioma include numbness or the inability to move a certain part of the body.



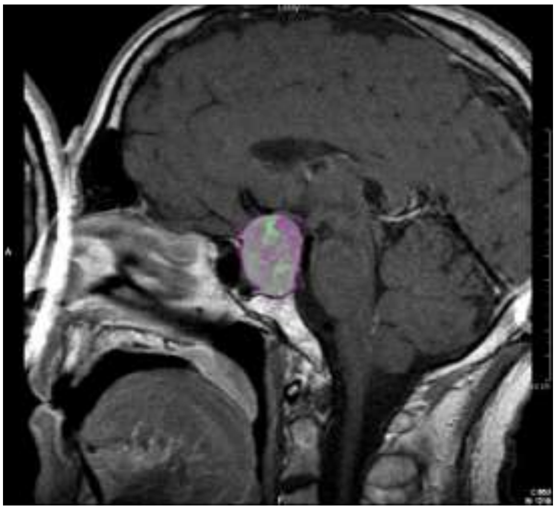
An image depicting the damage of a meningioma.

As you can see, a Meningioma "dents" the brain, damaging certain functions.

- Pituitary tumors: A pituitary tumor is a benign tumor that grows in the pituitary region and that affects vision, weight and in short, the endocrine system.

Symptoms of this tumor include nausea, vomiting, loss of vision, high fever, epilepsy, and much more.

Since pituitary tumors are benign, they are usually removed using surgery.



In analyzing the image, you can see that the purple and region of the brain is where the pituitary tumor was located. (Using an MRI scan)

- Glioma: Glioma tumors are the most common brain tumors and originate from brain cells called Glioma cells.

Since Glioma tumors are malignant, they are potentially life threatening and are treated using radiotherapy.

Removal using surgery is nearly or completely impossible due to the fact that glioblastomas (Glial cells that have turned into cancerous cells and that cause Glial tumors) replicate so quickly that the tumor expands so rapidly that surgeons can not find the exact boundaries of the tumor.

- Secondary brain tumors: Secondary brain tumors do not originate in the brain.

In general, secondary tumors are tumors that have invaded a certain part of the body although they have originated elsewhere. So, secondary brain tumors are tumors that originate somewhere else in the body and expand to the brain by the bloodstream, tissue and other methods. Quite obviously, secondary tumors are malignant.

14.15.5 Parkinson's disease

Parkinson's disease is a disease that affects people over 60 years old, but some are treated with a similar version of Parkinson's disease at 40 years old.

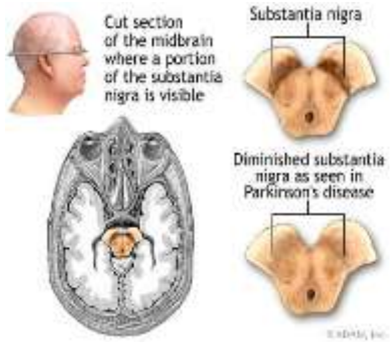
Symptoms of Parkinson's disease include uncontrollable shaking, depression, anxiety, and changes in mood.

The brain of patients with Parkinson's disease is also unable to control blood pressure, digestion, heart rate, and more.

Parkinson's disease is caused by the lack of cells that create a type of neurotransmitter called Dopamine. The cells that create dopamine are called Substantia Nigra and are located in the basal ganglia. (Remember that the basal ganglia help control movement? It does thanks to the Substantia Nigra cells which produce dopamine)

Dopamine aids significantly in movement control, so if the body lacks dopamine the basal ganglia aren't able to function properly, thus making the patient shake uncontrollably — disabling them to perform simply tasks such as turning a door handle. Although there is no cure, there are therapies and drugs to relieve the effects of Parkinson's disease.

Parkinson's disease is believed to be caused by mutated genes. The mutated genes caused a lack of proteins that control dopamine levels, resulting in the creation of an abnormal protein that destroys Substantia Nigra cells.



…

A comparison in between healthy levels of Substantia Nigra cells and the levels of Substantia Nigra found in patients with Parkinson's disease.

Very interestingly, it has been found that caffeine does decrease the chance of having Parkinson's disease by an insignificant amount of 5 percent.

14.15.6 Alzheimer's disease

Alzheimer's disease is a disease that affects and disables everything from cognitive and intellectual function, memory and thinking to the simplest of tasks. This is due to significant deterioration and atrophy (shrinking) of Brain tissue.

A comparison of the brain of a patient with Alzheimer's and a healthy brain.
Alzheimer's affects more females than males.

As for now, little is known about the cause of Alzheimer's disease, but research points to both genetic and non-genetic factors, indicating that both methods cause the same effect somehow.

14.15.7 Phobias

The word *phobia* originates from the ancient Greek word *φόβος (phobos)* and literally translated to morbid fear.

Therefore, phobias are when a certain person is very afraid of a certain topic. As Wikipedia puts it:

A phobia is a type of anxiety disorder, usually defined as a persistent fear of an object or situation in which the sufferer commits to great lengths in avoiding, typically disproportional to the actual danger posed, often being recognized as irrational.

Essentially, a phobia is a topic that someone will try to avoid extensively due to the fact that they have a great fear of it.

But you now may be wondering, what causes a phobia?

An obvious and rather self-explanatory reason is because of previous experiences.

However, phobias aren't limited to only the object that had affected the person. The person may then start fearing his or her surroundings and the surroundings may also develop into a phobia.

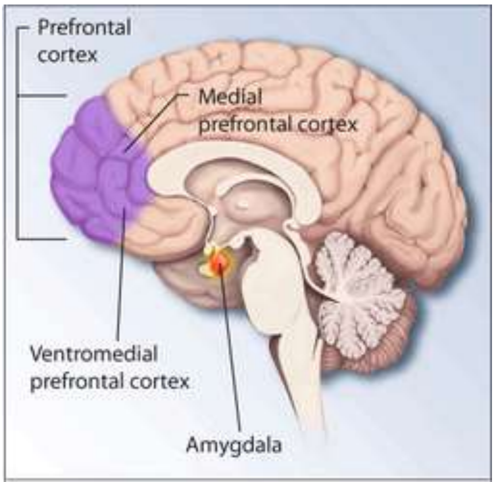
For example, getting stuck (elevator malfunction) in a tiny elevator may not only result in a fear of elevators but also a fear of tight spaces. (Claustrophobia)

Phobias that occur early in life may not have been caused by previous events but by observing the fearful reaction of others. The child may then take that into consideration.

(This is an evolutionary trait that has helped creatures stay alive: if a baby penguin sees its mother "running" from a seal, it will then also try to prevent to get close to seals)

Keep in mind that phobias are not diseases and can be treated psychologically.

Also, the areas of the brain that play a role in phobias include the prefrontal cortex (located at the Frontal lobe) and the amygdala.



Brain Structures Involved in Dealing with Fear and Stress

The purple and red highlighted sections are the sections that play a role in phobias.

For fun, here is a list of 45 out of the 530 documented phobias:

- Achluophobia - Fear of darkness.
- Acrophobia - Fear of heights.
- Aerophobia - Fear of flying.
- Algophobia - Fear of pain.
- Agoraphobia - Fear of open spaces or crowds.
- Aichmophobia - Fear of needles or pointed objects.
- Amaxophobia - Fear of riding in a car.
- Anthropophobia - Fear of people or society.
- Aphenphosmphobia - Fear of being touched.
- Arachnophobia - Fear of spiders.
- Arithmophobia - Fear of numbers.
- Ataxophobia - Fear of disorder or untidiness.
- Atelophobia - Fear of imperfection.
- Atychiphobia - Fear of failure.
- Autophobia - Fear of being alone.
- Bacteriophobia - Fear of bacteria.

- Barophobia - Fear of gravity.
- Bathmophobia - Fear of stairs or steep slopes.
- Bibliophobia - Fear of books.
- Catoptrophobia - Fear of mirrors.
- Chionophobia - Fear of snow.
- Claustrophobia - Fear of confined spaces.
- Chromophobia - Fear of colors.
- Chronomentrophobia - Fear of clocks.
- Coulrophobia - Fear of clowns.
- Cyberphobia - Fear of computers.
- Dentophobia - Fear of dentists.
- Ecophobia - Fear of the home.
- Genuphobia - Fear of knees.
- Glossophobia - Fear of speaking in public.
- Heliophobia - Fear of the sun.
- Hemophobia - Fear of blood.
- Noctiphobia - Fear of the night.
- Nyctophobia - Fear of the dark.
- Papyrophobia - Fear of paper.
- Pathophobia - Fear of disease.
- Phobophobia - Fear of phobias.
- Scolionophobia - Fear of school.
- Selenophobia - Fear of the moon.
- Tachophobia - Fear of speed.
- Technophobia - Fear of technology.
- Verminophobia - Fear of germs.
- Wiccaphobia - Fear of witches and witchcraft.
- Xenophobia - Fear of strangers or foreigners.
- Zoophobia - Fear of animals.

Note that the name of a phobia is composed of 2 parts: a name describing the phobia followed by the word "phobia".

Let us take the example Heliophobia. (Fear of the sun)

Helio (comes from the Greek god Helios — god of the sun) **phobia**. This (with some manipulation) translates to sun-fear.

Another example is Selenophobia. (Fear of the moon)

Seleno (Greek god of the moon was Selene) **phobia.**

14.16 Animal intelligence

It is a common belief among us is to believe that we, humans, are at the top of the intelligence chain and that all other creatures are in superior to us.

It may surprise a lot of us that other animals also have different types of intelligence — each depending on their surroundings.

For example, chimpanzees may use different tools such as sticks, and rocks to obtain essentials.

Other intelligent creatures include dolphins, which can paint pictures and perform simple arithmetic tasks.

It has also been found that bees have a certain way of communicating:

When a bee finds a concentration of pollen in a certain area, they return to their bee hive to show all the other bees where it was.

However, since they don't use words to communicate, they have another method to communicate.

The bee does a dance that indicates where the batch of pollen is by comparing the angle of where the flower is and the sun.

An example of how bees communicate.

This is possible since the bees are able to calculate the angle between the sun and the flower. Once the bee has finished its dance, the other bees follow the pattern to find the pollen.

A final example here includes the reaction of a sea slug to a jet of water.

This example will demonstrate that even creatures classified very low on the "intelligence scale" can adapt.

In the experiment, researchers touches a sea slug on its side. Although it did nothing, they then sprayed it with a jet of water, making the sea slug curl up.

Once they repeated this the second time, they saw the same outcome. However, once the researchers had repeated this numerous times, the outcome changed — as the researchers touched the sea slug, it immediately curled up and prepared for the jet of water.

This experiment just goes to show that even sea slugs can learn and adapt to the situation.

An image of a sea slug.

15 The reproductive system

The reproductive system serves the sole purpose of creating a new life form.

Although the reproductive organs are one of the only organs that can be removed without the patient dying, they still play a vital role in the continuation of the species.

How everyone was born:

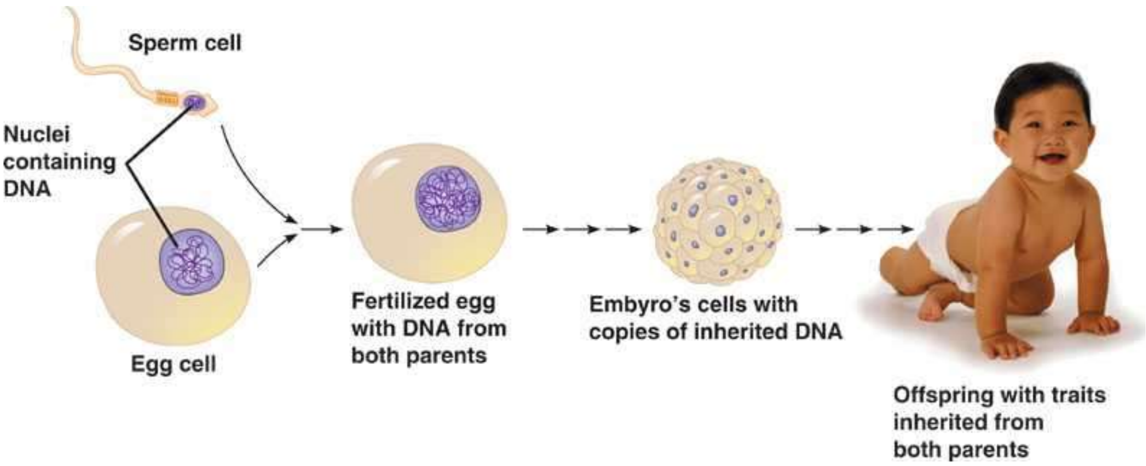
In the beginning, there was just a single cell inside your mother's reproductive system. This cell is referred to as an egg or ova cell.

To "give life to this egg", sperm from your dad must come and fertilize the egg cell. Once the sperm has fertilized the egg cell and shared it's genetic information, the egg cell starts to divide in 2 cells repeatedly, so that the number of cells goes from 1 to 2, 4, 8, 16, 32, 64, 128, etc.

Over time the number of cells increased immensely, and different parts of your body started to form.

It would take nine months before you are fully developed as a baby and ready to experience the outside world. At the time you are born, you have around 26 billion cells.

***Note: These topics will be explained more in depth later.**



A step-by-step image of how a baby is born.

15.1 Life cycle

Everyone will have a start and an end of a lifetime.

However, in between these two stages of your lifetime, there is whole journey of development, learning, adapting and experiencing. All these happen in 5 stages of life.

15.1.1 Infancy

Infancy is the stage of the life when the infant is just starting to learn and interact with objects and form simple connections. Infancy ends at around three years old.

This is an infant.

15.1.2 Childhood

The second stage of life is childhood where babies become children and form deeper and more complicated connections.

In this time of their life, children grow and develop the ability to form more complicated connections.

The age of when childhood ends is still disputed. A survey asked parents when they thought that their child ceased to be “childlike” and the outcome indicated that around 70% of parents said 12 years old.
So, for the sake of simplicity, let’s just say childhood ends at 12.

This is a child.

15.1.3 Adolescence

The stage marked in between childhood and adulthood is called adolescence. Another, more common word for adolescence is teenager.

At this time, the personality changes as teens learn how to manage on their own and become increasingly independent on themselves. Adolescence is also marked by a huge growth spurt.

In teen years, the reproductive system is activated and the body becomes mature for reproduction.

All of the changes above are part of a process called puberty.

In addition, only well-connected memories remain remembered in brain — the rest are forgotten.

This is an adolescent.

15.1.4 Adulthood

By the age of around 18 to 20, the body has reached full maturity and is generally at its final height.

Adulthood is when we are able to have children and we are more mature. Adulthood is also when we take a lot of responsibility with work and the family.

This is someone in adulthood

15.1.5 Old age

As you age, your body gets weaker and can't repair itself as quickly.

This is the process of aging and starts to be evident at 60 years old.

Aging starts and is evident at around 60 years old. The visible effects of aging include hair that turns gray, and skin that becomes wrinkled. Non-visible effects include your muscles and bones, which become weaker, increasing the chance of bone fractures.

Why we age is unknown, but we know how their effects happen.

For example, skin gets wrinkled because cells that create a protein (collagen) that keeps the skin elastic begin to ware out.

Having a healthy and active lifestyle can slow down the process of aging.

In addition, during old age, the brain shrinks from its original size. Keeping the brain functioning well is very important and can be done by solving puzzles or learning a new language or doing any activity that requires thinking that does not depend on memory.

This is an elderly

15.2 Male reproductive system

To create a life form, a sperm and an egg are needed. Without, there can be no baby.

This is caused by the fact that the egg cell contains all the nutrients to create a life form while the sperm must give genetic information from the father. This happens during fertilization and is when one sperm breaches the shell of the egg and mixes its genetic information with the information of the egg cell.

However, it is worth noting that only one sperm will enter and fertilize the egg.

15.2.1 The male reproductive system parts

In the male reproductive system there are several parts:

- The Testes: The testes are the glands of the reproductive system that create sperm. They dangle down in a sac called the scrotum because sperm only grow in a moist condition. (25° or 24° Celsius) In the upper part of the men's reproductive system, the temperature rises and sperm will not be made.

- Epididymis: The Epididymis connects the Testes to the Vas Deferens. The Epididymis is divided into 2 simple parts, the head and the lower extremity. The head attaches to the Vas Deferens the lower extremity attaches to the Testes.

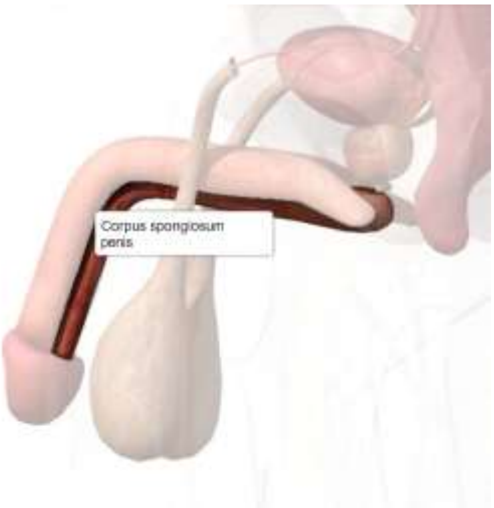
- Vas deferens: The Vas Deferens is simply a cord that carries the sperm from the Testes to the Prostate.

- Seminal vesicle: The Seminal vesicle creates fluid called Semen that combines with Sperm to create a "grey" fluid. Semen contains all the nutrients that Sperm need to survive their journey to the egg.

- Prostate gland: The Prostate helps control the flow urine as well as helps the Seminal vesicle to make Semen. (This is possible because the Seminal vesicle is attached to the Prostate)

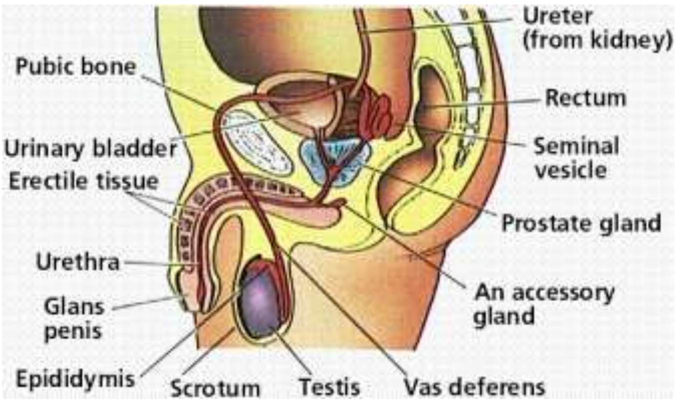
- Cowper's gland: Also known as the accessory gland, Cowper's gland is a gland that creates mucus to eliminate harmful bacteria from the Urethra. If that doesn't happen, it will interfere with the Sperm when it will travel down the Urethra to the women's reproductive system.

- Corpus Spongiosum: Attached to the Cowper's gland by ducts is another part of the men's reproductive system called the Corpus Spongiosum. The Corpus Spongiosum helps keep the urethra open while Sperm travel through. If there were no Corpus Spongiosum, the Urethra would close and not let the sperm pass.
  Although the indication of the Corpus Spongiosum isn't shown in the male reproductive image at the bottom of the page, it surrounds the urethra.



The section in red is the Corpus Spongiosum.

- The Glans Penis: The last part of the male reproductive system is called the Glans Penis and is the bulk at the end.



An image of the male reproductive system.

15.2.2 The journey of sperm

When a male has reached adolescence his reproductive system will activate, meaning that the reproductive system will begin to produce sperm.

Once the sperm is ready, it will travel from the male reproductive system to the female reproductive system. However, it is not only one sperm that makes the journey. Thousands and thousands of sperm cells will also go, to increase the chance of fertilizing the egg cells amidst all the perils of the journey.

This is an image of a sperm cell

Sperm will travel all the way to the female's reproductive system from the male's reproductive system and then fertilize the egg cell in the fallopian tube. (For more detail, see the section of the woman's reproductive system)

However, along the way, sperm have to cope with dangers of traveling to the fallopian tubes to fertilize the egg. To do this, they have adapted to an ideal shape.

As mentioned before, there are numerous dangers along the way to the fallopian tubes. (Such as several types of immune cells)

To increase the chance of survival, sperm have adapted to the perfect and ideal form. However, it is still a mystery to scientists how sperm knew how to adapt to the conditions, as once the sperm reach the female reproductive system, they never return.

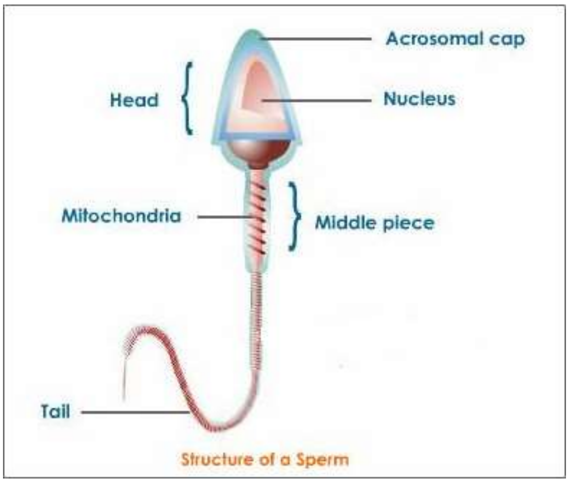
But pushing that aside, we can now focus on the structure of sperm itself.
Sperm has 3 main parts:

- The tail: The tail, also known as the flagellum, acts like the propeller for the sperm, and enables the sperm to "swim" to the fallopian tube.

- The middle piece: The middles piece contains the mitochondria of the sperm, providing it with an "energy supply".

- The head: The head contains the nucleus of the sperm cell. The nucleus contains the DNA necessary for creating a newborn.

It is worth noting that the Acrosomal cap surrounds the nucleus. In fact, the Acrosomal cap keeps an enzyme that degrades the wall of the egg so that one sperm can penetrate and fertilization can occur.



The structure of sperm

15.3 Female reproductive system

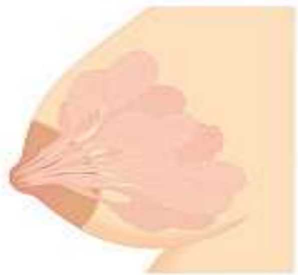
15.3.1 The female reproductive system parts

The female reproductive system has around 9 main parts.

In the upper body (Pectoral region) there are the mammary glands that creates milk that the new born baby will drink. The baby will keep on drinking their mother's milk until the age of one.

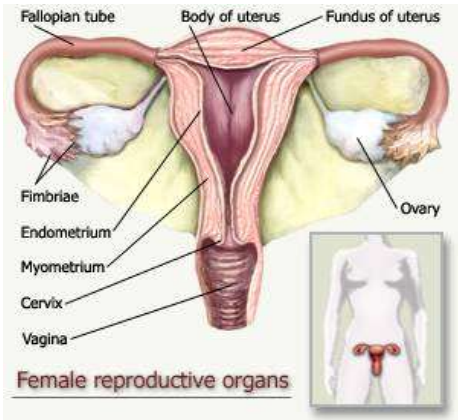
The reason why women create milk is because milk provides a soft alternative to food and contains every thing they need to develop such as antibiotics, proteins, fats, vitamins and carbohydrates.

(In case you didn't know, antibiotics help kill bacteria. The word derives from the 2 Greek words: *Anti* means against and *bios* means life. In this case, life signifies bacteria, not the baby!)



An image of a mammary gland. Different parts perform different functions.

The rest of the female reproductive system is located at the pubic region.



This is an image of the woman's reproductive system. Note that there are also other parts of the woman's reproductive system that are not mention

There are eight parts in this region:

- Ovaries: The ovaries produce egg cells. The egg cells go through the Fallopian tube and if fertilized, they will settle in the Uterus.

- Fallopian tube: The Fallopian tubes sprout from the sides of the Uterus. These tubes carry the egg cells around the tube from the Ovaries and will eventually go to the Uterus if the egg is fertilized.

- Fimbraie: The Fimbraie connects the Ovaries to the Fallopian tube. They are not present in the picture at the bottom of the next page.

- The Uterus: The Uterus helps to nourish the egg cell after it is fertilized by Sperm until it becomes ready to come in the outside world.

- Vagina: Going down from the Uterus is the Vagina. The Vagina's role in the women's reproductive system is to let the baby out once it is fully developed after 9 months. It is also where Sperm first start their journey to find the egg cell.

- Vestibule, Labia Minora & Prepuce: These are the 3 main muscles that area present at the exit of the woman's reproductive system.

15.3.2 The journey of the egg cell

Egg cells are the reproductive cells for females. If an egg cell gets fertilized it shares it's genetic material (half of a full genetic set) with the genetic material from the sperm. (Which is also half of a full genetic set) The genetic material combines and forms a full set, which is the genetic makeup of the baby that is to come.

An egg cell is the biggest kind of cell since it can be seen without the need of a microscope. Unlike the male reproductive system, a girl is born with all the egg cells that she will need in her life. One egg cell is sent out from the ovaries every month case fertilization happens.

In the very likely case that it is not fertilized, the egg cell will dissolve before reaching the Uterus.

An egg cell is designed to only let one sperm penetrate its surface and fertilize the egg cell. However, in some rare cases, 2 sperm may end up fertilizing the same egg. This will result in having twins.

There is 2 ways that twins can develop: Twins can either be Monozygotic or Dizygotic. Monozygotic twins are when two sperm fertilize the same egg. Dizygotic twins happen when one Sperm ends up fertilizing 1 egg and another Sperm ends up fertilizing another egg.

In rare conditions, Monozygotic twins can share something called the Umbilical cord. (Explained later)

A girl starts off with all the eggs that she will need in a lifetime. As explained before, one egg cell will be released from the Ovaries every month in case fertilization will happen.

If fertilization occurs, the egg will continue to the Uterus. If it is not fertilized, it will dissolve before it reaches the Uterus. So, let us start on the journey of an egg cell.

Every month, an egg is released and travels past the Fimbraie, through the Fallopian tube. In the Fallopian tube, the egg will have its chance to be fertilized. It will drift lonely through the Fallopian tube and if the egg cell is not fertilized, it will then dissolve. If the egg <u>is</u> fertilized by sperm, it will continue to the uterus. The uterus is actually a food-rich bed where the developing baby will receive all its nutrients.

For nine months, the baby will stay in the uterus and continue to develop and grow. However, at nine months, the baby will exit the female reproductive system.

To get out of the uterus and out of the female reproductive system, the Vagina will have to open wider and the baby will have to do specific rotations to get through the Pelvis bowl.

In fact, the female pelvis bowl is larger than the male pelvis bowl, and this is because the baby must get through the pelvis.

This is the journey of a fertilized egg cell

15.3.3 Fertilization and development of a baby

When fertilization occurs, it is the sperm trying to penetrate the egg cell's membrane so that genetic material can combine to form what is called an offspring.

Usually, (and almost always) one sperm cell out of millions will succeed to penetrate the egg's outer membrane. Once one sperm has penetrated the surface of the egg, the egg will then release a chemical which enables no other Sperm cells to penetrate the egg cell.

Meanwhile, the Sperm cell that has succeeded at penetrating the outer egg membrane is combining genetic information with the egg cell.

Eventually, the egg cell will start to transform into the baby. It does that by splitting itself into 2, and then 2 again, and again, and this process continues.

After the baby has been born, it would have approximately 26 billion cells.

So, now that you know a little more about fertilization, we can move on to the development of a baby while it's still in the uterus of the mother.

While the baby is still in the uterus of its mother, it continues to develop. In fact, there are 2 stages of baby development in the uterus.

- Embryo: When a baby is an embryo, its organs will start to develop, but its limbs are simply little "bumps". An embryo will be the size of a bean.


A 5 week Embryo.

- Fetus: The next stage is the Fetus stage. An Embryo will become a Fetus at around 8 weeks, when the Fetus' body and Brain will be growing rapidly.
  At 11 weeks, the Fetus is about the size of a lemon and has developed fingers, toes and (compared to the other parts of its body), a very big head.
  At 25 weeks, the Fetus contains small details like eyelashes and hairs from the eyebrows. It can blink and may contain very little strands of hair. The mother can also feel it move, which means it can punch and kick.
  The baby will come out when ever it is ready.

An 11 week Fetus

15.4 Meiosis

There are 2 kinds of cell division, Mitosis and Meiosis.

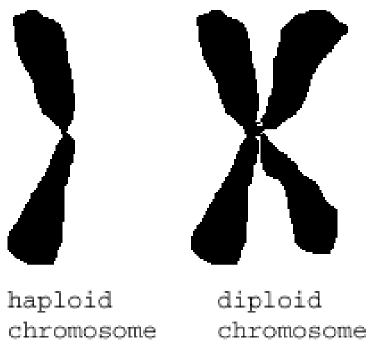
Mitosis happens all the time everywhere in the body, and is when cells duplicate to form 2 young cells.

However, Meiosis is when sperm and egg cells reproduce. Meiosis is different from Mitosis, as sperm and egg cells have only 23 chromosomes, instead of 46.

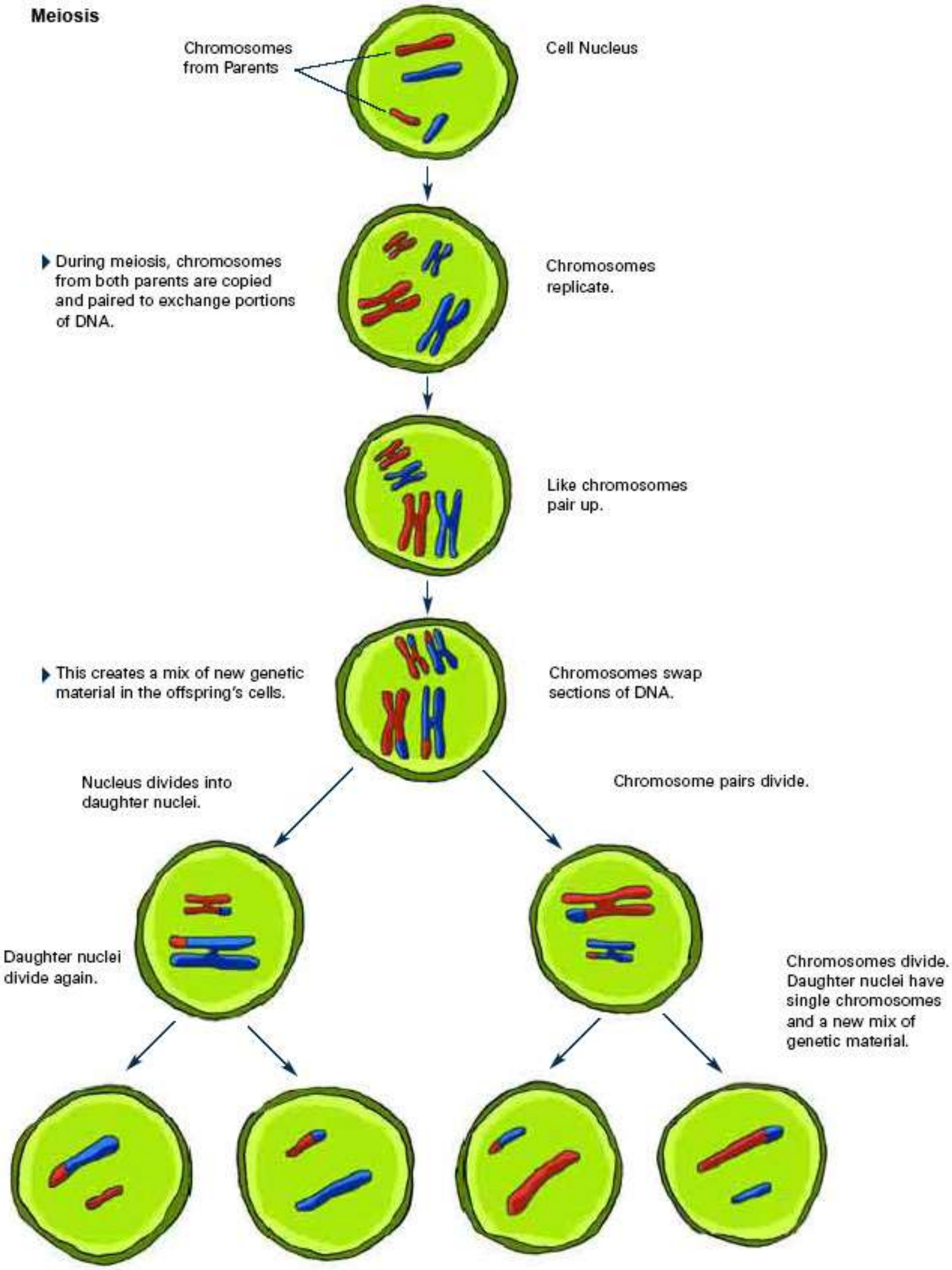
***Note: Cells that only have 23 chromosomes instead of 46 chromosomes are called Haploid cells. Cells with a full set of chromosomes are called Diploid cells.**

During Meiosis, homologous chromosomes (chromosomes that are homologous are chromosomes that have the same number) pair up with their pair and then "cross over". This is an action where the homologous chromosomes mix their genetic material, and is the principal action that creates cells with diverse genetic material, thus, is the principal factor that makes different humans unique.

After the chromosomes have crossed over, the cells splits into 2 daughter cells. This step is repeated one more time to finish off meiosis. In fact, it is worth noting that meiosis is simply mitosis repeated 2 times!



Comparison of a haploid chromosome to a diploid chromosome.



Process of meiosis

15.5 Heritage

When you inherit something from your parents, it is a certain phenotypic characteristic that is passed on from either your mom or dad to you.

***Note: Your phenotype is your appearance while your genotype is your genetic makeup.**

Also, a gene is a certain characteristic that someone can have, such as

color of your hair.
An allele is a version of a gene. For example, an allele of the gene that determines your hair color can be the allele of brown hair.

***Note #2: There are 2 alleles that form a gene, one allele is dominant, and one allele is recessive. The dominant allele “overpowers” the recessive allele.**
For example, two alleles for the eye color gene may be the green eye color allele and the blue eye color allele. It is a fact that the green eye color allele is the dominant allele while the blue eye color allele is the recessive allele.
Therefore, the gene with the green and blue eye color (let us just assume that the allele for eye color is represented by the letter A for the dominant allele and a for the recessive allele) with be represented like Aa. (Make sure to put the dominant allele letter first, if there is any)

***Note #3: A gene that contains a dominant and recessive allele is called a heterozygous gene, while a gene containing 2 recessive or 2 dominant alleles is called a homozygous gene)**

Inheritance is possible because when the first sperm and egg cell met, they contained the genetic material from both your dad (brought by the sperm cell) and your mom. (Brought by the egg cell)

This genetic material (through the process of meiosis) was applied to make *you*! Therefore, if you have a certain phenotypic trait that your mom or dad has, their allele has been passed on to you.

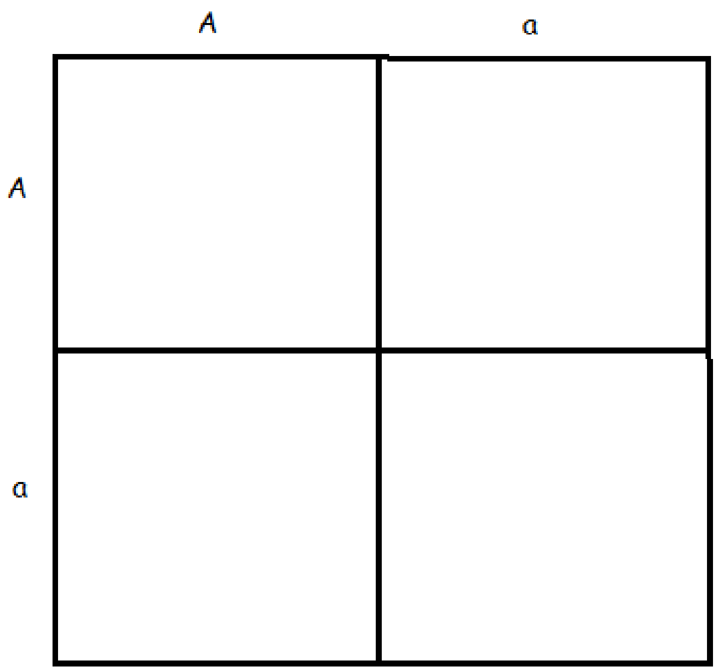
Gregor Mendel

However, all of this knowledge would not be known were it not for a man called Gregor Mendel.

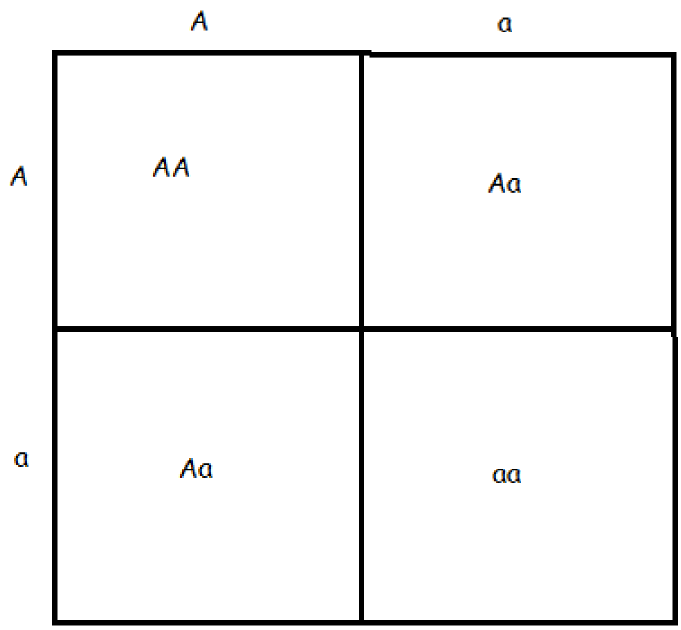
An image of Gregor Mendel.

Gregor Mendel was a scientist that studied the heritage of pea plants. It was him that postulated (but did not manage to prove) the theory with alleles.
He also created a method of finding out the genetic makeup of the next generation for a certain gene. This method is called the Punnett square method.

To use a Punnet square, you firstly put the two alleles of the gene you want to study from both the mom and the Dad.



Next, fill in the chart. To fill in the chart, simply track down the letters to their meeting point just like you would do on a multiplication chart. Always, the bigger letter which represents the dominant gene goes first while the smaller letter that represents the recessive gene goes after.



This should be the result.

However, this method is pointless without finding out the possibilities of a certain trait that the next generation has. To verify the possibilities, you need to firstly find out how much possibilities there are, and in all Punnett squares with 4 compartments (these types of Punnett squares are called Monohybrid crosses), there are 4 possibilities.

Now, find the ratio of the different possibilities to the total number of possibilities. (4)

Well, there is 1 AA, 2 Aa and 1 aa possibility out of the 4 possibilities available.

Using this information, we can find out the chance of a certain one of these possibilities happening, by creating a ratio from the number of those results to the total number of possibilities.

15.6 Parenting

Parenting is very important. Without parents, a baby could not learn how to talk, and it would be incapable to do many essential tasks. In fact, if there is no one to raise a baby, it will die within several days.

When a baby is born, it will be it's most dangerous part of its life since it can not help itself at anything. This is why parenting is so important for a baby. However, even after the baby has developed, it still needs support and help so it can learn how to talk, grab, eat, etc.

However, while a baby is learning and growing, they are also making connections. Good parents would let their baby explore almost everything around them so they can learn where they are and what is their surrounding. A baby will always grow no matter how much or less their parents teach them. This means that the period of time for their parents to teach them some basic and important stuff is limited. A parent must use their time wisely to teach their babies rules of life, how to talk, to respect, to explore, and much more.

However, there is much more to parenting than that, such as parenting styles. (Which is what this section will be explaining about)
To start off, what *are* parenting styles? Well, parenting styles are how parents teach their kids. There are four parenting styles:

- Permissive: A permissive parent would let their kid do anything they wanted. They are nice but they make very few rules for their child to follow. For example, they might let their kid watch TV before they do their homework.

People with such parents tend to be aggressive, ignoring, and have a hard time controlling their behaviour.

- Uninvolved: Uninvolved parents don't think and care about the development of their child and how it will affect their child. They are usually uninvolved.

Children with these kinds of parents tend to have little self-confidence, and tend to friends with the exact same personality.

- Authoritarian: Authoritarian parents are very demanding and think that the only thing that is correct is their thoughts. They are very strict and get angry very easily for simple mistakes. Instead of telling their child what they did wrong, they employ other, more harsh methods. In this way, the child learns the rules by being frightened and scared.

The child will turn to be unfriendly, unhappy, easy to be upset, moody, aggressive, mean and very stressful.

- Authoritative: An Authoritative parent is a parent which encourages discipline but in a nice way. They explain the mistakes that a child made in a nice way so the child understands why they did something wrong. Instead of immediately judging their child's opinion on something they give their opinion and compare them. They are always gentle, and set rules so their child can control themselves. Even if they set limits they don't need to worry to set very strict limits. They usually tend to be friendly, do jokes, play and be around their child.

A child raised with such parents would usually be very self esteemed, cheerful, happy, nice, curious, cooperative and usually has good friends.

15.7 True or false

Answer each question by putting a check on the right answer. The answers will be put after all the questions. **Good Luck!**

- #1 Was Gregor Mendeleev the one that created Punnet squares?

Yes __
No __

- #2 Is Semen the liquid that is released by the male?

Yes __
No __

- #3 Is meiosis ordinary cell reproduction?

Yes __
No __

- #4 Is a Haploid Chromosome a full normal Chromosome?

Yes __
No __

- #5 Is an Authoritative parent a nice and good parent?

Yes __
No __

- #6 Is an Egg cell created in the Uterus?

Yes __
No __

- #7 Does an Egg cell fertilize the Sperm?

Yes __
No __

- #8 Is the Fetus stage the 1^{st} for a baby inside the mom's Uterus?

Yes __
No __

- #9 Is the Acrosomal cap at the top of the Sperm?

Yes __

No __

- #10 Is infancy the 1st stage?

Yes __
No __

- #11 Is Keratin the substance that makes skin elastic?

Yes __
No __

- #12 Does an Egg cell normally get fertilized in the Fallopian tube?

Yes __
No __

- #13 Does the word Antibodies come from Latin?

Yes __
No __

Answers:

#1: No,

#2: Yes,

#3: No,

#4: No,

#5: Yes,

#6: No,

#7: No,

#8: No,

#9: Yes,

#10: Yes,

#11: No,

#12:Yes,

#13: No.

16 The Sensory system

The Sensory system allows us to feel, see, taste, smell and hear. Balancing is considered to be the 6^{th} sense.

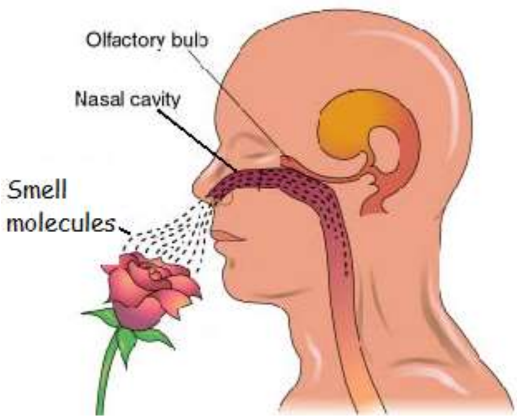
But the Sensory system's definition is how you sense information and transfer it to your Brain. This requires several steps.

Even though there are 5 main and well known senses, there are actually about 25 senses, although a lot of these are considered not to actually be senses. Some other senses are temperature, pain, acceleration, kinesthetic and internal senses.

16.1 Smell

Smell is a sense that is not essential for humans but is for other animals. Most animals need smell to find hidden food or to detect danger.

To smell an object you first take a deep breath. What this does is that it brings the smell molecules of that object you want to smell into the nose.

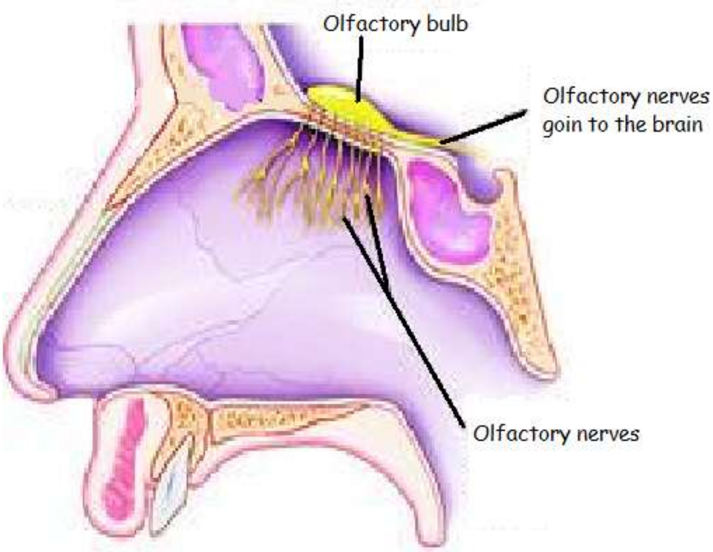


Smelling

At the top of the Nasal cavity there is the Olfactory bulb. The Olfactory bulb contains an unique type of neuron called Olfactory receptors. These are unique because they are the only type of neuron that is out in the open air. On each neuron, there are hair-like objects called Cilia that increase their surface area.

Located on each membrane of the cilia, there is an OR. Every OR has a specific gene for one smell molecule, meaning it is shaped in the shape of that smell molecule.

The smell molecules, once in the nose, will bind to the OR that has their shape. Once chemicals have attached to the ORs, action potentials are sent through the Olfactory Nerves to the Brain. The Brain turns the action potentials into the sensation of a smell. If there are more action potentials, the smell is perceived as being stronger.



The Olfactory bulb and the Olfactory Nerves

16.2 Vision

For us or any living object that has the ability to see, vision is a very important aspect. It enables us to see what is going on around us in our daily lives and enables us to do much more.

We are able to see because of light that passes through our pupil and on to the back of our eyes called the retina. There, light hits cells called Rod and Cone cells that bend a protein called Rhodopsin, which in turn sends an action potential to our back part of the Brain called the Optical lobe. But when the action potential arrives there, the brain identifies the action potentials into a real image. This will be explained with greater detail later on.

16.2.1 The eye


Our eyes

If you look at someone's eye you can several parts.

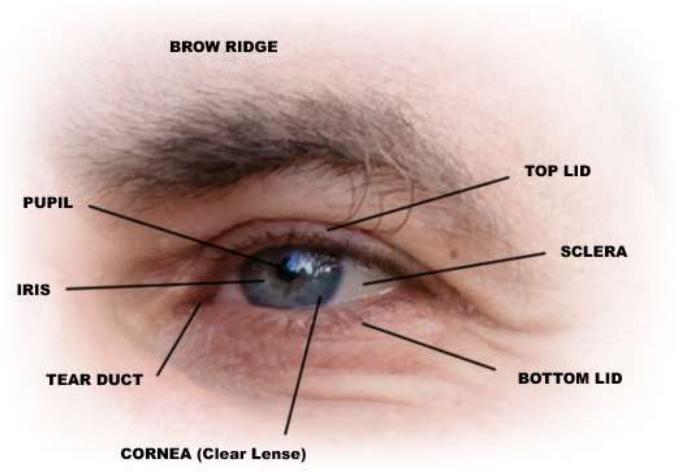
The white outside part is called the Sclera, the colored part is called the Iris, which regulates the size of the Pupil to let more or less light come in, and the black circle in the center of your eye is called the Pupil. The Pupil allows light to enter the eye and shine on the back of the eye and is black to absorb all the light it can.

At the inner side of the eye there the tear duct. The tear duct brings liquid onto the eye, making it moist and additionally, killing bacteria. The tears are created by the tear gland, which cannot be seen externally.

Don't get mixed up with the tear gland and the tear duct. The tear gland is a gland that <u>produces</u> the tears found on the eye. The tear duct is a duct that <u>delivers</u> the tears to the eye.

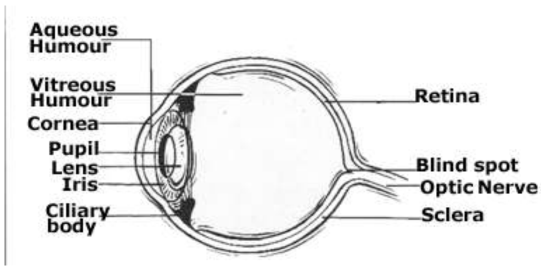
Protecting our eye is the Eyelid. When something is going for your eye, the

Eyelid shuts to protect your eye from injury. It also helps clear dust of the eye with the help of the tear gland. First the tear gland releases tears that go through the tear duct to the eye. The tears are actually acidic so they kill the bacteria. Then the eyelid washes them away.



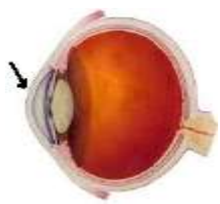
The exterior of the eye

In the interior of the eye you can see the Cornea, tear gland, the Pupil, Lens, Iris, the Optic nerve, the Retina and more. As you can see, the Retina contains numerous layers.



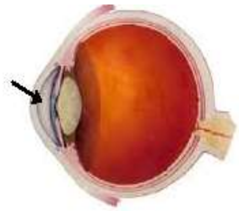
The interior of the eye

In front of the Pupil there is a clear dome called the Cornea. The Cornea is very clear but is also as hard as plastic, so it has 2 basic functions. The Cornea focuses and controls the entry of light coming in to the eye, making sure it is directed right on the Lens which does the further process. Additionally, it protects the eye from dust, bacteria and other harmful particles.



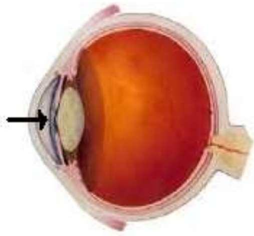
Cornea

You can also see a space between the Cornea and the Pupil. In that space there is a liquid called the Aqueous Humour. Although the majority of the Aqueous Humour is composed of water, it helps to give nutrients to numerous parts of the eye such as the layers of the Retina and controls the balance of pressure in the eye.



Aqueous Humour

Next is the Pupil that permits light to come in the eye. Its size can be adjusted by the Iris which is in fact a muscle, classified as a circular muscle.



Pupil

The Lens helps to change the focal distance of the eye, enabling the eye to see from different ranges. To see from different distances, the Lens need to change size.

Lens

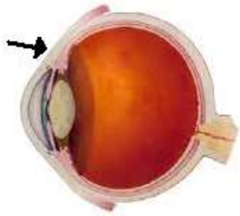
The Ciliary body helps produce the Aqueous Humour and to controls the size of the Lens.

The Ciliary body is divided into two main parts. The Ciliary muscle that is attached to the top and bottom of the eye, pulls and relaxes to create the shape of the lens. Next are the Zonules, which are attached to the Ciliary muscles and to the Lens. The Ciliary Body is located on both sides of the Lens.

For close vision, the Ciliary muscles tighten making the Lens into a more round shape. For further vision, the Ciliary muscles relax, turning the Lens into a more oval shape.

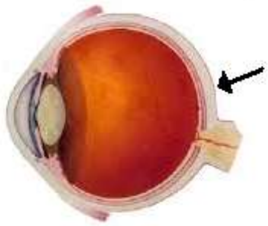
Ciliary Body

The Sclera is the white part of the eye and is everywhere around the eye. It has several functions such as providing an attachment for muscles to move the eye.



Sclera

In the inside of the eye, there are several more layers of the eye and the last one is called the Retina. It serves as a projection of the image on the back of the eye. It has special cells called Rod and Cone cells.



Retina

The Optic nerve is a nerve that sends all the information to the brain and is made out of all the nerves around the eye which all join at the back of the eye and form a big cluster of nerves going to the Brain. It is also known as the blind spot because there are no Rod or Cone cells there to analyze the image, but you almost never see it because the other eye sees the hidden parts of the image.

Optic nerve

16.2.2 How vision works

The process of sight is described here in greater detail:

First, a certain color of light will be reflected off an object, depending what color the original object is.

The light will next land on the Cornea which will precisely focus the light onto the Lens.

On its way to the Lens, the light will pass through the Pupil, which permits light to pass though. The Pupil can be adjusted by the Iris to let just the right amount of light in the eye. If the room is dark, the Iris will contract, letting the maximum possible light come in the eye. Or if the room is too bright, the Pupil will shrink to let just the desired amount of light to come into the eye.

Next, the light will land on the Lens, which will change dimension if required, to see from closer or further away.

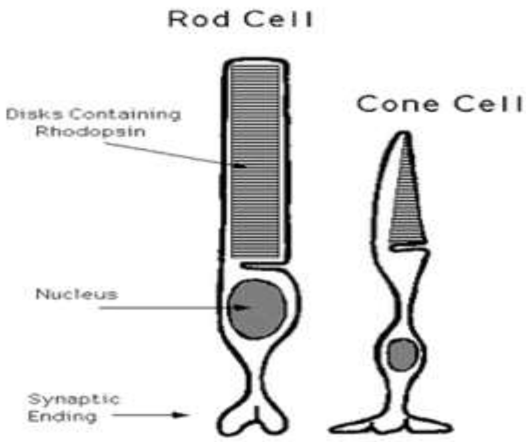
The light will now continue onto the Retina where the Cone cells matching that specific color are activated, sending action potentials to the Brain. For example, if purple light lands on the Retina, the Red and Blue Cone cells are activated.

Rod and Cone cells permit us to see what is around us and are found on the Retina.

Cone cells tend to be more in the middle of the eye, sensing color. Rod cells tend to be located on the sides of the eye and sense low light and see the image as black and white.

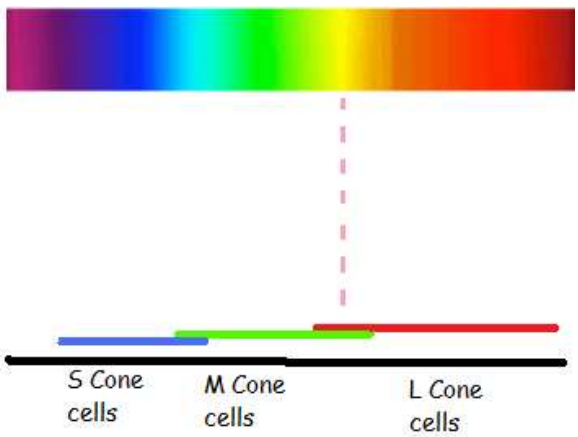
To analyze the image, the Brain receives action potentials. To receive action potentials, Rods contain a protein called Rhodopsin that bends when light comes in contact with it. When the Rhodopsin bends an action potential is sent to the Brain.

Cone cells work similar to how Rod cells work but additionally, there are three kinds of Cone cells. L Cone cells receive colors close to red, M Cone cells receive greenish colors and S Cone cells which receive bluish color. Once the light hit's the Rhodopsin, it bends sending an action potential to the Brain.



Rod and cone cells

But to receive other colors such as yellow, it is a combination of two types of cone cells making one color.



An image that shows which types of Cone cells make each color.

As you can see, yellow is in between the M and L Cone cells, meaning that M and L Cone cells makeup the color yellow. When the light falls on the Cone cells, they both send an action potential to the Brain. When an action potential is sent to the Brain saying that light fell on the L and M Cone cells, the Brain knows that it is the color yellow.

For example, if you were to look at ripe banana peel, you would notice that its color is yellow. The banana is subtractive yellow, meaning that it absorbs all the colors of light except yellow, which lands on the Retina.

Absorbsion and reflection of light

But electronic devices such as computers or mobile phones can produce only green, blue or red light. What the screen does is trick your brain. By having the same 3 colors that the Cone cells have, the screen can just display the 2 colors that makeup the color on the Retina.

So if the screen wants to display the color yellow, it just needs to display a little bit of red and green, which are the same colors that the Brain makes yellow out of. As long as the pixels are small enough not to be seen, the screen manages to trick the Brain.

16.2.3 Vision diseases

Sometimes the eyes don't work properly and give us hallucinations, color or movement blindness or simply a blurry view.

This may be caused by a failure of the Lens, the Brain misinterpreting the displayed image, Retinal display diseases, and more. Although these are only several of the causes of vision diseases, some of their causes are unknown.

Hallucinations

Hallucinations give a person a different image than the original image and can often be frightening.

There are more kinds of Hallucinations such as audio, visual, olfactory, tactile, gustatory. Most causes of these hallucinations are mostly unknown.

The way that the visual hallucinations work is that the image is projected on the Retina but then when the image is transferred to the Brain, the Brain perceives the image into a slightly different image. But when the brain doesn't recognize the image, it slightly twitches in your view to make it look like something familiar.

Other hallucinations such as audio hallucinations are caused when the cells that perceive sounds are irritated and don't function properly so when the signals go to the Brain, the Brain also mistakes the sounds and makes different sounds than the actual thing that the person had said.

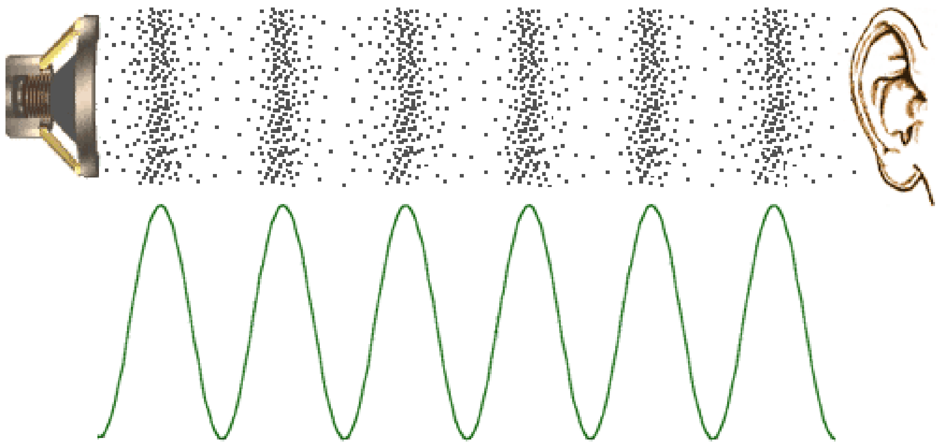
16.3 Hearing

Hearing permits us to convert sound waves created by molecules that push each other in one direction.

Once one of the molecules move forwards it pushes another one which pushes another molecule creating a chain reaction.

During this, the air pressure goes from up to down and to up again and to down. (Waves) The densely packed group of dots is where the molecules are pushing the next group of molecules forwards.

You can also see this when you roll a marble that hits the next marble that takes off and hits and pushes the next marble forwards...

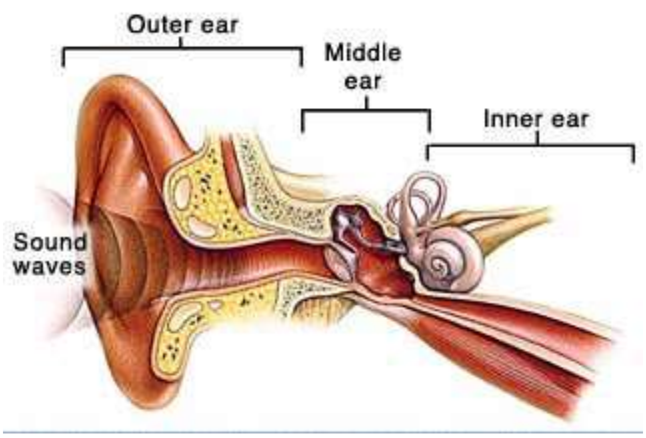


Sound propagation (the dots are molecules)

The spots where there are more molecules is where the molecules are presently pushing the next group of molecules which are going to get pushed forwards which pushes the next group of molecules and so on.

Parts of the ear

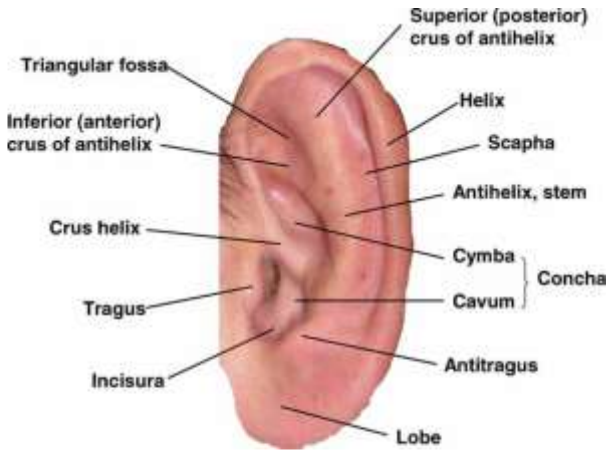
There are three sections of the ear: the inner ear, the middle ear and the inner ear.



The three sections of the ear

The Outer Ear

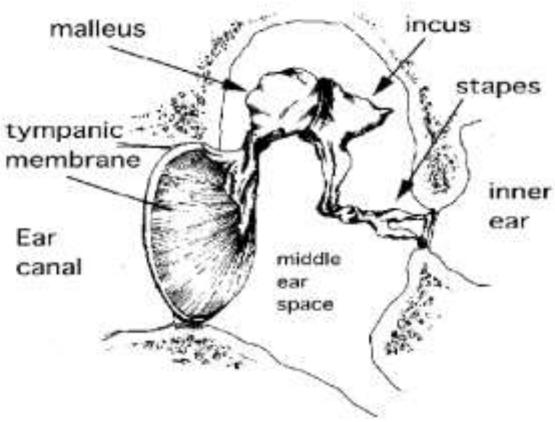
The outer ear is the only visible part of the ear. Its role is to capture the sound waves and forward them to the middle ear. It has different sections, such as the Helix, Scapha, Antihelix, Lobe (Pinna) and a lot more. Most of the parts of the outer ear have mysterious useless functions.



The parts of the outer ear.

The middle ear

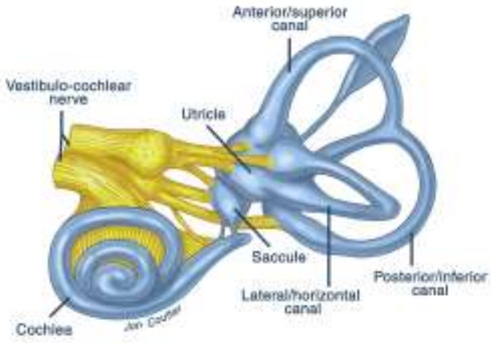
The middle ear consists of the eardrum, also known as the Tympanic membrane, and three small bones located behind the eardrum.



The parts of the middle ear.

The inner ear

The inner ear contains the Cochlea, Semicircular canals and nerves sending the information to the brain.



The inner ear

How the ear works is described below:

- Outer ear

First, the sound enters the outer ear and continues through the Ear Canal leading to the eardrum.

- Middle ear

Once the sound hits the eardrum, the eardrum vibrates. Next, three small bones in our ear vibrate. The first bone called the Malleus, is attached to the eardrum and moves when the eardrum vibrates, moving the Incus and the Incus moves the Stapes. The Stapes moves a fluid in the Cochlea.

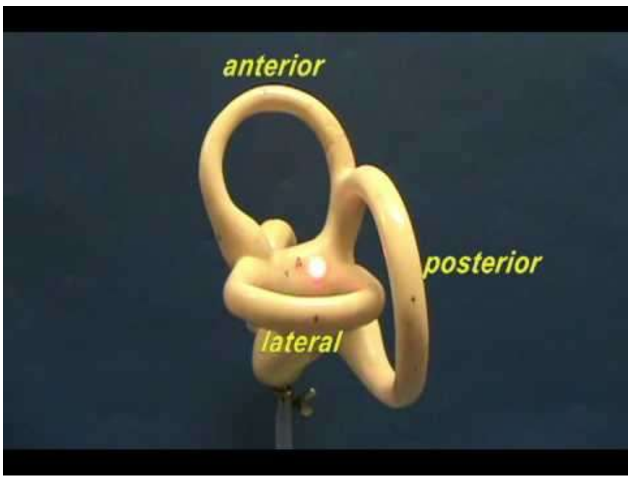
- Inner ear

The Cochlea is a long circular tube filled with fluid, which moves when the Stapes vibrates. The fluid, when moving, moves tiny hairs located on the walls of the Cochlea. When these hairs move, they are activated and send action potentials are sent to the Temporal lobe. If the fluid vibrates more it means the sound is stronger. The brain combines all these things and identifies the sound.

Balance

Balance helps us keep upright. First, the Brain needs to know if the body is upright or not and the Semicircular Canals play an important role.

The Semicircular Canals have three tubes. One is facing forwards, one facing horizontally and another one facing vertically. In these tubes there is fluid which moves when you move your head in a different direction.

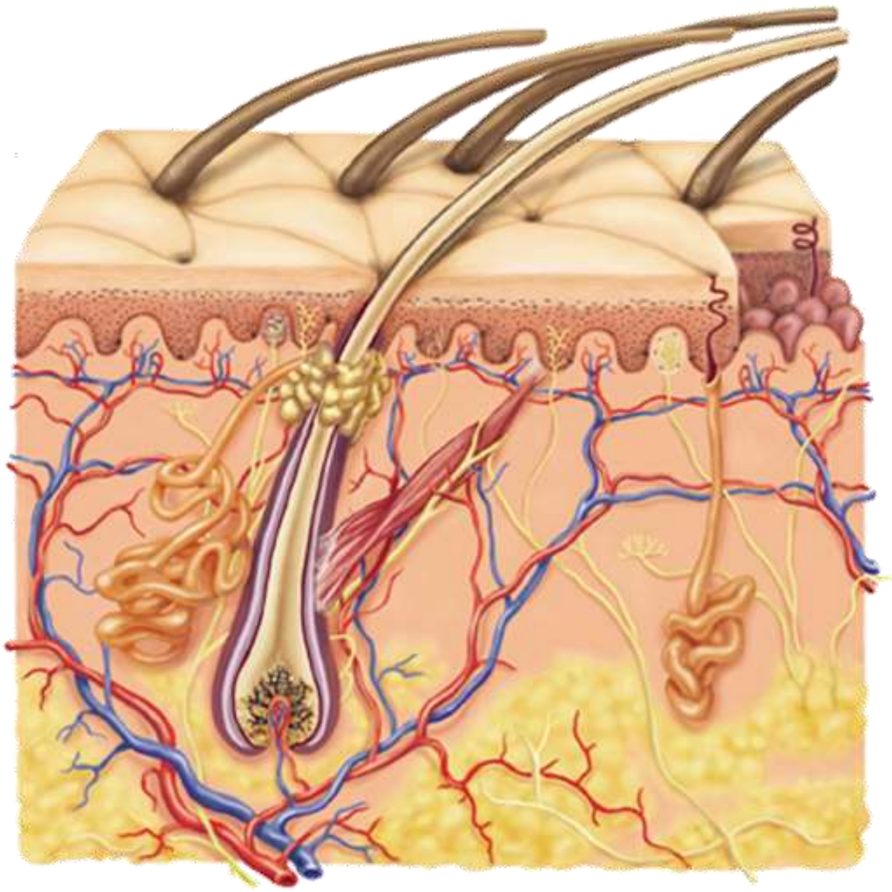


The Semicircular canals

When you move your head, the fluid moves and then sends action potentials to the Brain. Like this, the Brain knows if your head is tilted or not.

Dizziness is when the fluid in the Semicircular is moving everywhere and the Brain thinks the body is in a certain position but then receives another signal that says that he is in another position and so on.

17 Integumentary system



17.1 Skin

The Integumentary performs several important functions, protecting the inside of your body from bacteria, controls heat regulation using sweat, and makes a waterproof barrier against water to avoid water to come in and wash out important chemicals.

The Skin is also the largest organ, weighing approximately 20 pounds (9.7 kilograms) for an average adult.

It has several layers:

- the Epidermis which is the top part of the skin that contains dead skin flakes,
- the Dermis, which are where all the roots of hairs are, or were the sweat glands are located,
- Subcutaneous layer, located under the Dermis, a layer of fat which insulates your body, keeping it warm.

Although skin is covering your whole body, it differs in size in different parts of the body. For example the skin at the bottom of the feet is thicker than the skin on the forehead.

External view of the skin

Cold or Warm?

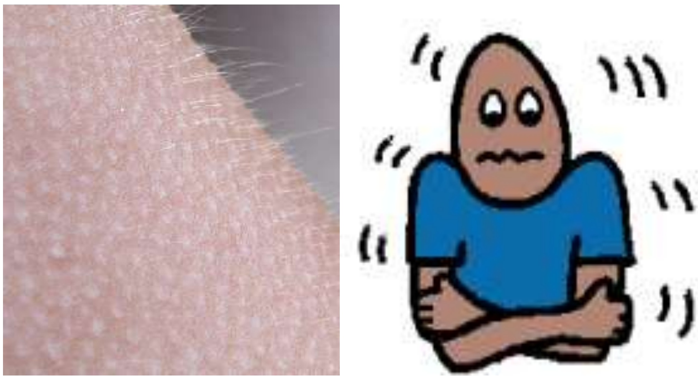
If you are cold the body loses heat but if you are warm the body is overheating.

If we lose heat our muscles can’t function well. But when it comes to conserving heat when we’re cold, the body has several tricks up its sleeve.

To conserve heat, the body produces goosebumps which are made from tiny muscles all over the body called Arrector Pili muscles. These muscles pull on the hairs of the skin making them stand up which traps all the heat between their layers keeping you warm.

Another method that the body uses to keep warm is shivering. The reason why we shiver is because when we shiver, we contract and relax a lot of our muscles meaning that we are producing chemical energy and heat. By producing this heat, the body can still keep warm.

Often when we shiver, we tend to cross our arms, which is the cause that we are trapping heat from escaping.


Goosebumps

But when we are hot, the body doesn't shiver or produce more energy because he doesn't need it. Instead, the body has to lose energy to avoid overheating.

What the body does is that it releases sweat out of the sweat glands which are located in the Dermis. By doing so, the sweat evaporates taking with it some of the body's energy including some of our body heat.


Sweating

The Epidermis

The Epidermis is the outermost layer of skin containing only dead skin cells. At average, it is about 0.1 millimetres thick.

Although the Epidermis is only made of dead skin flakes, there are sweat pores which secrete sweat onto the skin when needed.

The Dermis

Since there are no living skin organs on the Epidermis, they are all located in the Dermis.

Some things that can be found in the Dermis layer are: Sweat glands, Arrector Pili muscles, Corpuscles, Sebaceous glands, Arterioles and Venules, etc.

Sweat glands produce sweat with water from the body, meaning it is consuming the body's water fairly quickly, which is the reason why you need to drink lots of water during a hot sunny day. The sweat glands produce and then send the sweat up to the sweat glands on the Epidermis.

The Arrector Pili muscles are each connected to one hair, letting them "stand on end" to conserve heat when you are cold.

Also located in the Dermis layer are Corpuscles. There are numerous kinds of Corpuscles such as touch Corpuscles, which detect different kind of touches: stinging, pushing, smooth, squeezing, etc.

The hair follicle is where the root of the hair is located.

Sebaceous glands are found right beside the hair before reaching the Epidermis, which secrete an oily substance making the hair moist.

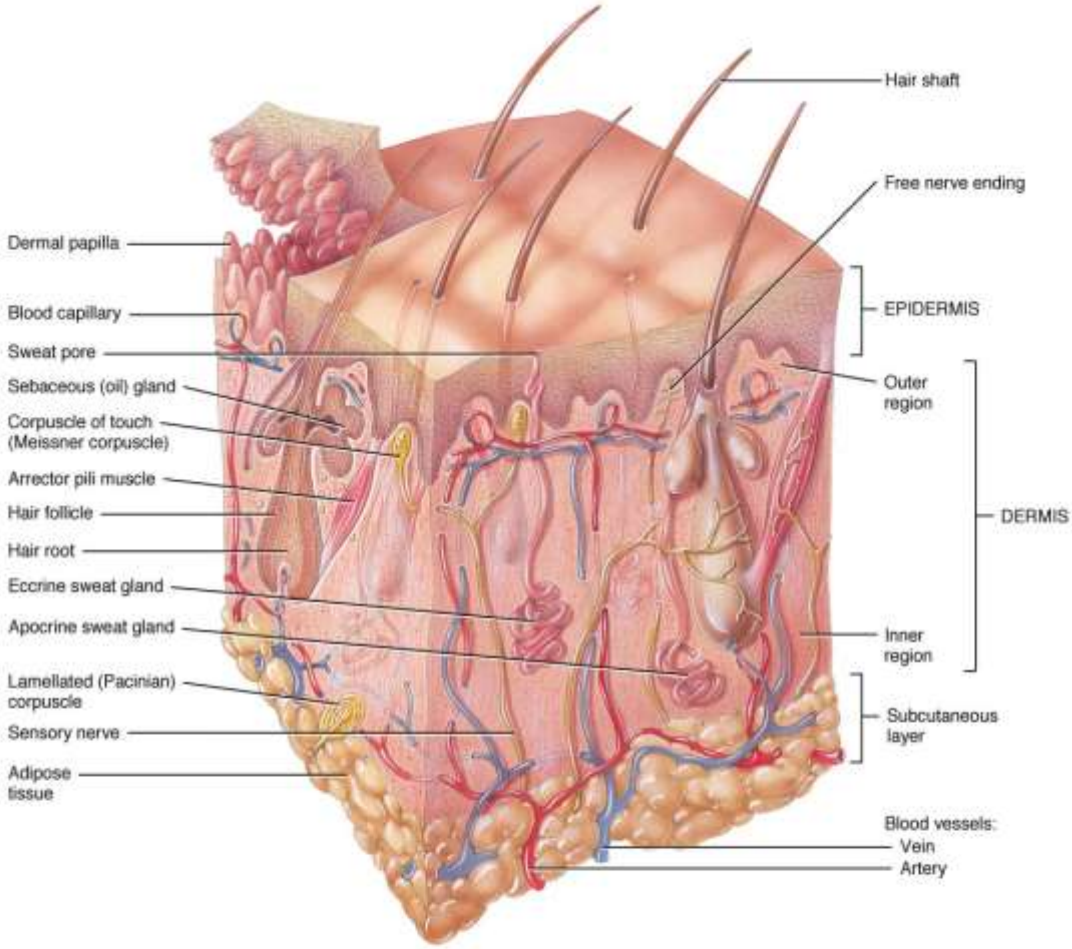
There is also a lot of Arteries and Veins which split in to Arterioles and Venules which are smaller types of Arteries and Veins. These split up into Capillaries that feed every cell with oxygen.

Some important organs in the Dermis layer that are not shown on the next page's picture are Melanocytes, which release a pigment called Melanin. This is a liquid that is secreted on the skin if there is a lot of sun. This makes your skin color.

Another important organ in the Dermis is Collagen fibers, which make the skin elastic. For example, if you were to pull your skin, it would settle down quickly into its previous position. Since older people don't have as much Collagen fibers, if you were to pull their skin, it will take more time to settle down.

Subcutaneous Layer

Below the Dermis, there is a layer of fat and connective tissue called the subcutaneous layer, which keeps us warm. The subcutaneous layer also acts like a cushion and helps in absorbing shock.



A diagram of the skin

The Skin Under a Microscope

The skin, if seen with the bare eye can seem quite simple and smooth, but if you were to magnify it with a microscope, it would give a totally different impression.

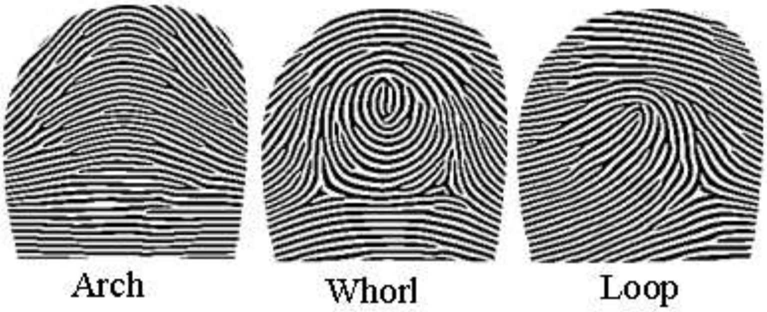
For bacteria, life on the skin is not that easy. This is because the dead skin flakes from the Epidermis are constantly shedding and are replaced by newer ones.

An image of skin cells

The dead skin falls on the ground and create house dust.

Fingerprints

As you can see, your hand has fingerprints, which are most visible at the very tip of the finger. Although there are five types of fingerprints, there are three main ones.



The three basic types of fingerprints.

Flexion creases

If you look at the palm of your hand you can see strikes across the palm. Some people believe that these represent symbols such as the line of the head, heart or life. But what they really are is lines where the skin can fold. Some of them are even there before we are born! To prove it, you can bend the palm of your hand and you will see that the hand bends where the strikes are. Their names differ among different people, ranging from Vanes to Flexion creases.

These are the flexion creases on a person's hand

Itching

Sometimes we feel something bothering us, which makes us itch. There are multiple reasons why sometimes we itch.

Some serious reasons are when you have allergies, infections, diseases or other conditions.

But everyday itching is caused by bugs, dust, or hair. It might as well just be a mosquito.

Itching is meant to alert the body if something is harming it.

But itching will not happen right when the mosquito lands on the skin, it might happen a little later. This is because at first, when the bug lands, you might not feel it. But when the bug starts moving, it rubs against the skin. This causes receptors in the Dermis layer to be irritated which send action potentials to the Brain, which has a natural response, to scratch.

Tickling

When someone tickles you, the nerves send action potentials to the brain, but because there are the same corpuscles qualify for pain <u>and</u> tickling the brain doesn't know if there is actually danger or not. So it starts to panic and as a result, you laugh. In other words, because the receptors of pain are the same as the ones of tickling the body gets confused between those two factors.

If you tickle yourself, you won't laugh because the brain isn't panicked about danger because it knows already what is happening. This is caused by the Cerebellum, which supervises our movements. So when we try to tickle ourselves, the Cerebellum knows that we are trying to tickle ourselves and informs the rest of the brain that nothing bad is happening so there is no reason to laugh.

Skin Inflammation

There are 2 kinds of skin inflammation, Acute and Chronic.

Acute inflammation is the first stage of tissue reparation. It can be caused from UV exposure, injuries which damage tissue, allergies, stings (such as from poison ivy or bees), or sometimes chemicals that irritate the skin and cause it to swell.

Chronic inflammation is more serious and results in serious damage to the tissue and lasts longer to heal than the Acute inflammation. Chronic inflammation is repaired by white blood cells which remove/destroy damaged tissue and then skin reparation begins.

The reason why skin swells is still not understood completely. But if the skin is irritated by chemical or UV light, skin cells produce hormones called Cytokines and Chemokines. These hormones bind to target cells (receptor cells that receive different kinds of hormones). This causes the production of more hormones.

There are different types of Cytokines and Chemokines, meaning that they do different things.

Some cause Vasodilatation (when Vanes expand) or activate nerve endings making you sensitive in a particular area.

Other Cytokines can release enzymes, other hormones or chemicals that damage the skin. All of these ways are designed to keep bacteria out and make the skin swell, although it causes damage to the skin itself.

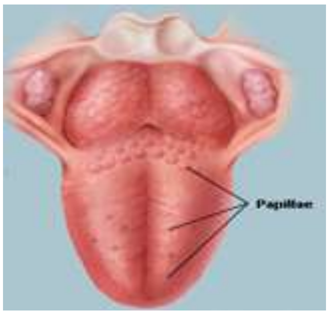

Skin that is swollen because of a bee sting

17.2 Taste

These are several kinds of tastes that are known by us: sweet, sour, salty, bitter, spicy. These tastes can be sensed because of tiny things on our tongue called papilla, which permit us to taste almost any taste that we come along.

On the Papilla, you can see taste buds. On the taste buds there are even smaller things called taste receptor cells.

So if someone sticks their tongue out, you don't see their taste buds, you see their papillae.



The tongue

Kinds of papilla

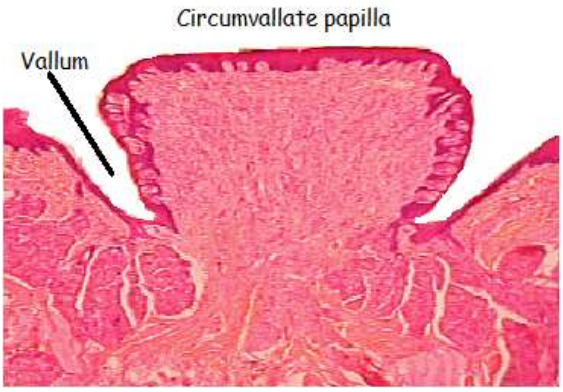
There are three kinds of papillae: Fungiform papillae, Filiform papillae and Circumvallate papillae.

The *Fungiform papilla* are scattered all over the tongue, but are mainly located on the sides and the tip of the tongue. Like the name suggests, Fungiform papillae are in the shape of mushrooms and contain 3-5 taste buds.


An image of a Fungiform papilla

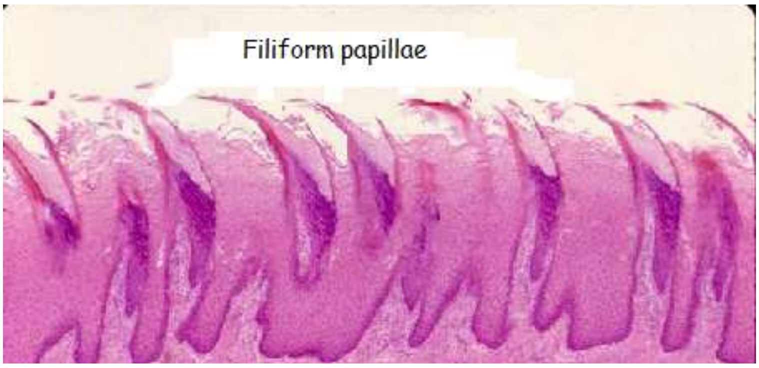
Circumvallate papilla are located at the back of the tongue and, unlike the

Fungiform papilla, they have more than 100 taste buds. They are arranged in a V shape towards the throat. The Circumvallate papilla resemble a round upside down cone shaped papilla. Their size ranges from 1-2 millimetres. They are named after the Latin word Vallum, which means small ditch with a steep wall in front of it.



An image of a Circumvallate papilla

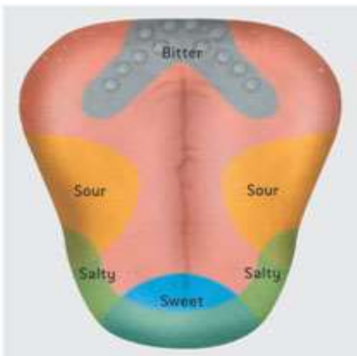
The most numerous kinds of papillae are called the *Filiform papillae*. Filiform papillae don't have taste buds on them. Instead, they do functions such as cleaning the mouth or spreading the saliva around the mouth.



Filiform papilae

Tastes on the tongue

A lot of people think that there are four main tastes on the tongue: sweet, salty, sour, and bitter.



The 4 main taste areas on the tongue

A lot of people and scientists consider that there are separate areas where we can taste different tastes, however some scientists don't agree. They say that wherever there are taste buds, you can taste. Even though scientists have known this for a long time, the idea came from the 1800s and scientists weren't able to correct this belief.

How we Taste

First your salivary glands send saliva through the salivary duct into the mouth.

When the food is in your mouth you chew it up. The molecules of food will then bind to a taste receptor which is meant exactly for that food molecule.

Once the food binds to the correct receptor, then an action potential is sent to the brain.

With hundreds of action potentials coming per second the brain can analyze the taste of what we are eating. If it is a new taste the brain will make new connections.

18 Activities

18.1 Experimenting with the sensory system!

These are some fun activities that you can do that involves your sensory system. Have fun!

Touch/feeling

1. Tell a friend or a family member to bring an object to you. Do not look at it. Then, try to use your finger to figure out what the object. When you touch the object you can figure out what shape it is. If you want to make it more challenging, warp the object with plasticine and use a tooth pick to figure out what the object is.

2. Fill three cups with water. The first cup has to have warm water, the second cup has to have normal temperature water and the third cup has to have cold water. Now put one hand in the warm water and one hand in the cold water. Hold them there for several seconds. Then put both hands in the normal water. One hand will feel relaxed while the other hand will feel uncomfortable. Which hand feels stressed and which one fells relaxed?

3. In this activity, you will figure out which part of your body is the most sensitive. Take a surface with different kinds of textures on their surface. First, rub each surface on any part of your body except your hands (knees, feet, elbows, nose, ears, etc.) After you have felt all surfaces with every other part of your body, rub them on your hands. Now compare what you felt with the parts of the body with what you felt with your hands. Which part of your body is more sensitive?

Eye sight

1. <u>CAUTION: This activity must be done under adult supervision and permission.</u> First take a small pocket lamp that is not too strong and place it under your eye. (Never place it in front of your eyes) Next, look ahead at a white wall. Wiggle the small pocket lamp side to side, still keeping it under your eye. You should see the arteries that are on your Retina.

2. Hold two pencils horizontally with the ends facing each other. Now try to touch them together. Now try this with one eye open. Do you miss? What does that prove?

3. This experiment involves your blind spot. First look at the letters A and B below or draw the letters A and B about 10 cm apart.

A   B

Start with your head 40 cm away from the image. Now close one of your eyes and look at the A very closely. Start to back up away from the image still focusing on the A. While you are doing this what happens to the B?

Taste

1. Take some foods that are approximately the same size and shape so you can't tell what they are. Now, mix them up. Close your eyes and plug your nose. Then, take a bite of each of the objects. Can you tell the difference? How much and why?

2. For this experiment you will need all kinds of flavours such as bitter, sour, sweet, salty. Now place these flavours on all parts of the tongue. Is any part of the tongue more sensitive than other parts for different flavours?

3. First dry your tongue with a paper towel, making sure there is no saliva. Try different foods while keeping your tongue dry. After each test rinse your tongue and dry it up again. Can you taste anything? Why do you think so?

Hearing

1. For this experiment you will need a partner. First, mark an X on a piece of cardboard and place it on the floor. Make each line about 1-2 meters. Make your partner stand in the middle of the X and tell him to close their eyes or blindfold them. Take something that makes some noise and place yourself on one of the corners. After you make the noise ask your friend on what side of the X you are on. Do this with one ear open and both ears open. Are the results better with 1 ear or 2 ears?

2. First, you will need some speakers. Now, turn on the music and put your hand on the speakers. Do you feel anything? If yes then what is it? If you want a challenge, then turn the music up and down and change the pitch of the music. Is there any difference? If yes, why do you think this?

3. First you'll need some elastics. Stretch each of them out differently. Then, pluck each elastic. What do you notice? How does this work?

Smell

1. First, have a friend to gather foods or any objects that you are surely to know. Now, close your eyes and smell each object. Now, try to figure out each object. Ask your friend if your guesses are correct or not. Does this have to do with animals? Why or why not?

2. <u>This experiment requires adult supervision.</u> Have an adult help you collect some foods. (Beans, peas, carrots, etc.) Have the adult put them in the microwave, or put it in the freezer. After they have done that, take the food and eat it. Is there any difference between the normal food and the frozen or heated food? Why?

18.2 Human Body Quiz

This quiz is going to be about the whole human body and every system. It will include all the information that you have learned and it will also have some more challenging questions. Good luck!

1. What century did medical students start snatching dead bodies from cemeteries to study?

2. What specific Greek doctor was very well known for medicine?

3. What are the 3 parts of the Aorta?

4. What are strokes?

5. Translate these words from Latin to English: Carpi, Hallux, Adductor, Pollex, Extensor and Digitorum.

6. What do you call people whose jobs are to determine the face of someone only using the skull?

7. Who created Punnet Squares?

8. What are Papilla?

9. What are joints?

10. Where in the body is the Greater Omentum located, and what does it do?

11. What organs are on top of the Kidneys, and what system do they help?

12. What is a Circadian body clock, what system is it in, and what does it do?

13. Name all the systems that the Pancreas helps in.

14. What is AIDS and what system does it affect?

15. What is PNS and SNS and what they do?

16. Name all the stages of life.

18.3 Useful links

These are just some of the basic questions of the human body. If you want more questions here are some links:

Easy:
http://www.prongo.com/human/game.html
http://www.funtrivia.com/html5/index.cfm?qid=86078
http://learnenglishkids.britishcouncil.org/en/play-with-friends/quiz-human-body

Medium/ Challenging:
http://www.sciencekids.co.nz/quizzes/humanbody.html
http://health.howstuffworks.com/human-body/parts/human-body-quiz.htm
http://bodyquiz.net/bones/quiz1?qlang=en
http://www.abc.net.au/science/games/quizzes/2006/humanbody/?site=science
http://www.medindia.net/medical-quiz/quiz-on-interesting-facts-about-human-anatomy.asp

Medical:
http://www.livescience.com/19234-human-body-parts-quiz.html
http://www.msmedia.com.au/quiz/medquiz.html

18.4 Cool Facts About the Human Body

1. The pupil is black not because of the fact that black object absorbs the most light

than any other color. It is because the light that enters the eye is not reflected back.

2. You use about only 5% of all your muscle fibers in your legs to run if you try to run as fast as you could! Only if you are in an emergency situation, can you use almost all of your muscle fibers. Athletes are able to use almost all of their muscle fibers and run almost their complete fastest.

3. The brain is much more active during the night instead of the day. Normally, you would think that the brain is more active during the work hours of the day because you are doing different activities and general interactions on a daily basis. Scientists have not quite well understood why this is the case of the opposite but one theory is that while you are sleeping, the brain is organising the events that happened to you during the day. That might be why you often dream of what you did during the day.

4. The brain itself cannot actually feel pain. Even if the brain is the center of pain when you burn yourself or cut yourself, the brain contains no pain receptors. But you can still hurt your head. This is because the brain, although it cannot feel pain itself, it is surrounded by a lot of nerves, tissues and blood vessels that still detect pain and can give you a massive headache.

5. Men’s hair is double the times of diameter of women’s hair.

6. The fastest growing nail is on your middle finger. It is not completely understood why, but because the middle finger is the longest finger it might grow faster. This means that the nail on the shortest finger of the hand will grow slowest.

7. You constantly are getting new stomach lining every couple days. Because of the fact that the stomach acid can dissolve almost anything, layers of the stomach wall are constantly being broken down so as a result, new layers to replace the fallen layers of stomach have to be produced.

8. People with blond hair have the most hair follicles. This means that people with blond hair will have the most hair that any other kind of hair color. Average humans have about 100,000 hair follicles on their scalp (head) People with blond hair contain approximately 146,000 hair follicles, followed by people with black hair that have an average of 110,000 hair follicles. People with brown hair have about 100,000, while people with reddish hair contain the least hair follicles (86,000 hair follicles).

9. Women blink about 2 times more than men. An average person blinks about 12 times every minute.

10. Babies, if they were to be as big as it, they would be stronger than an ox. Although a baby at its normal size will certainly not be able to pull a wagon, if it were to be as big as an ox, it might as well be stronger!

11. Babies are very often born with blue eyes. Eye color depends on your parent’s genes but when babies are born, it appears that almost all babies are born with blue eyes. This is because of the fact that pigment melanin which is the substance that characterizes our eye color needs time to darken by ultraviolet light, therefore the real color of the person’s eyes are later revealed.

12. If saliva in incapable to dissolve something in the mouth, you cannot taste it. This is because in order to taste something, molecules from the food have to be broken off the object and attach to the taste buds on the tongue.

13. Your nose and ears never stop growing. Eyes on the other hand, will never grow.

14. Monday is the day when most heart attacks happen. This is probably because people have too much fun on the weekend days and then suddenly return to the stress of working.

15. If you eat too much, your hearing is less precise.

16. Right handed people live about 9 years longer than left handed people. This is not bases on genetics, but just because much of the machines in our present world are designed for people that are right handed resulting in many injuries and deaths among left handed people.

17. We are about 1.2 centimetres taller in the morning compared to us in the afternoon. This is because during the day, the cartilage gets compressed by numerous things like standing, sitting, jumping etc.

18. Humans are the one and only living beings that can create emotional tears.

18.5 The Future Human Body

In the future, humans will rely more on medications and will have more and more artificial parts to replace our own. They will also be much more reliable than artificial parts today.

Since humans in the future will start to use and rely on medications more, some scientists believe that our Immune system might get weaker and weaker. The most popular thing of the human future is Nanotechnology. The term Nanotechnology comes from the words Nano, microscopic, and technology.

These are rumoured to be tiny robotic creatures that are sent in the blood and cure diseases by killing the virus or germs.

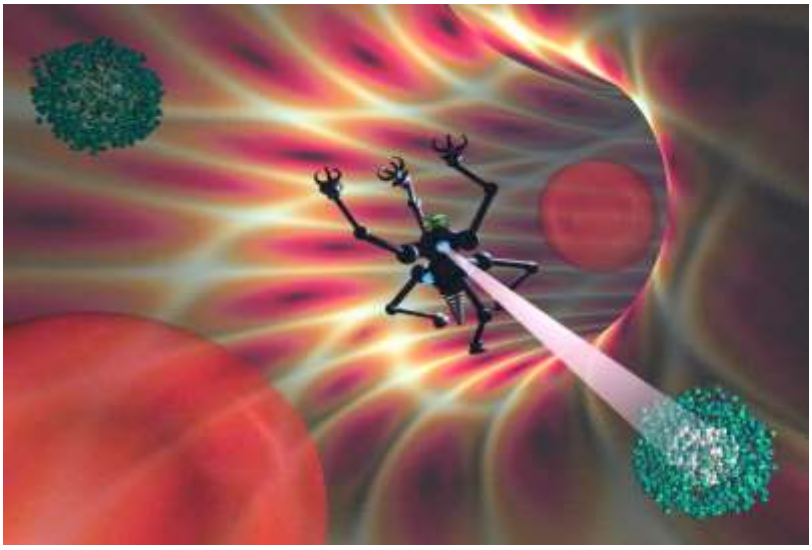
Not surprisingly Nanotechnology can be used for more than just the body but for computers as well.

Nanorobots at work

Already, scientists have come with evidence that this may exist not so far in the future but have also seen that they carry problems on their own.

Some of these problems are that the Nano particles may be so small, that they may cross a barrier between the blood vessels and the brain that keeps the brain safe from harmful chemicals.

Although Nanotechnology may be possible, the majority of pictures of Nanotechnology are over-exaggerated.

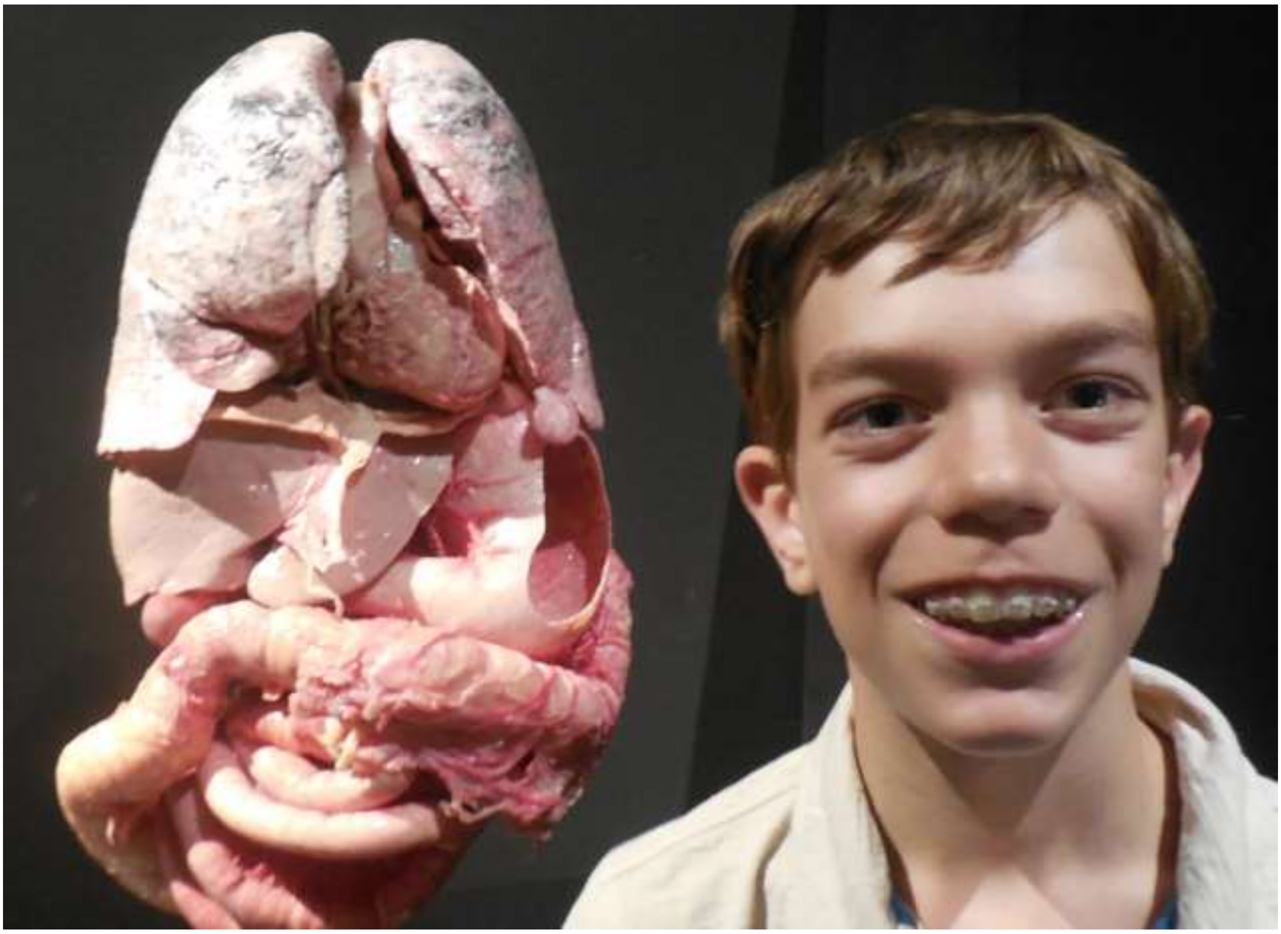


Nanorobot zapping “bad guys”

DISSECTION COURSE - 2012

DISSECTION COURSE - 2013

BODY WORLDS EXHIBITION - 2015



BODY WORLDS EXHIBITION - 2015