Anna & Tommy

All human structures can be both beneficial and harmful.

Really?

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Preface

Anatomy is studied as a mandatory subject for students in schools of medicine, dentistry, health sciences, and arts. A layperson may also learn anatomy to fulfill curiosity regarding human body and help protect his or her health. One might purchase an anatomy book to learn by oneself. However, while the anatomy book has an advantage of containing pictures and descriptions that accurately describe anatomy, it also has a disadvantage of being complex and difficult. Therefore, it is beneficial to read anatomy comics that depict the body in a simple manner and describe the morphology and function of the body efficiently. The purpose of drawing informal comics by a professor who teaches anatomy in a medical school is to aid the college students with the preview of anatomy as well as to help laypeople, including elementary, middle, and high school students, study anatomy.

The comics which are titled “Anna & Tommy” were drawn as follows. The content of the comics was decided then the descriptions in the comics were written. Based on the descriptions, the corresponding drawings were sketched using a pencil then were finished using a computer. Dr. Anatophil, which is composed of four panels for each episode, was drawn in a similar process. Yoon Ik HWANG, Hae Kwon JANG, Beom Sun CHUNG, and Beom Jo CHUNG of the same department aided the revision of the comics. Jiyoon KIM gave major and minor English grammar corrections. All comics may be viewed on anatomy.co.kr.

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1. Introduction

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Anatomy is the foundation of all medicine.

Anatomy enables people to know the morphology and function of the human body.

Anatomy needs to be learned through comics for two main reasons.

and the diseases that affect the human body.

Therefore, understanding anatomy not only satisfies curiosity.

First, comics are easy and fun.

Second, the body structures can be described by being drawn into comics.

I hate difficult stuff.

Since fingers are more employed than toes, they are more vulnerable to arthritis.

What's inside the abdomen?

Skull

Heart

I hate difficult stuff.

Prof. CHUNG drawing comics
However, anatomy comics are not just simple and easy.

In addition, organs cannot be exactly depicted in simple comics.

These comics divide the human body into systems,

and depict some of the related diseases.

Through these comics, the author hopes you will be able to learn anatomy with interest and with ease.

You have cataract, which causes the lens to be opaque.

Other anatomy comic strips by the same author are enjoyable on the homepage (anatomy.co.kr).
2. Skeletal system

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The skeletal system is the very fundamental of the human body.

Medical students learn about the bones first.

Why is there so much to memorize about bones?

Through support by bones, human is able to retain shape,

Without bones, human will look like an octopus.

When we cut and look at a bone, it is recognized that outer compact bone is hard while inner spongy bone is soft.

The compact bone is covered by thin periosteum.

Compact bone
Spongy bone

Have you seen a broken rib bone when eating meat?

Have you tried eating the periosteum tightly surrounding the bone?

Bone marrow fills the spaces within the spongy bone and creates blood cells.

The bone marrow is red since it produces blood cells.

Broken bones can be repaired because there are live cells in bones.

Don't worry too much about a bone fracture.

We can exercise as the muscle pulls on the bone.

The skull protects the brain, while the ribs protect the heart and lungs.

The skull protects the brain, while the ribs protect the heart and lungs.
For the fracture to be fixed correctly, bone pieces have to be in the right position.

It is the patient oneself to reunite the fractured bone.

Among bones, there are big bones such as the femur, and small bones such as the auditory ossicles.

In the ancient times, a femur was used as a weapon.

Bones in the middle ear are so small that they can be blown away by breath.

By its shape, bone can be classified as long bone, short bone, flat bone, or irregular bone.

There are 206 bones in the human body. Among them, 80 are in the head and trunk, 64 are in the upper limbs, and 62 are in the lower limbs.

28 bones compose skull. These bones cannot move because they are stuck tightly to each other.

There is also bone that is strung to tendon, which is called sesamoid bone.

An example of sesamoid bone is patella.

The only movable skull bone is the mandible.

Skull bones can be divided into two types: bones that surround the brain and bones that surround the nasal and oral cavities.

Since the patella is strung to the tendon, it is capable of moving left and right.

To chew food, one’s mandible must move.
The paranasal sinus is found in the bone surrounding the nasal cavity.

The paranasal sinus is a space formed from the degeneration of the spongy bone.

The hyoid bone is found between one’s head and neck.

The hyoid bone can be felt with one’s hand just above the larynx.

The larynx is a cartilage so it is soft, while the hyoid bone is hard.

Unlike bone, cartilage can be cut easily with a knife.

The vertebrae connected to the skull support the head, trunk, and protect the spinal cord.

The cervical and lumbar vertebrae are convex anteriorly; the thoracic vertebrae, sacrum, and coccyx are convex posteriorly.

To see a vertebra, order a T-bone steak. The T-bone is a cow’s vertebra cut in half.

The cervical vertebrae become convex to the front because a human has head up, while the lumbar vertebrae are convex to the front because a human stands up.

The ribs connect the thoracic vertebrae and sternum.

Since there are 12 thoracic vertebrae, there are 12 pairs of ribs.

Some believe that man has one less rib than woman since Eve is made from Adam’s rib.

The bones of upper limb are very similar to those of lower limb. The clavicle and scapula that connect trunk and arm are similar to the hip bone that connects trunk and thigh.

We don’t think we need to get into details that are mentioned in the Bible.

In the ancient times, human used to crawl instead of walk, so bones of the upper and lower limbs were almost the same.

The humerus, ulnar, and radius are comparable to the femur, tibia, and fibula.

Humerus
Ulna
Radius
Femur
Tibia
Fibula

This is about the human evolution.

He’s just like me!
The bones of the upper limb have developed for more detailed movement ever since human started walking.

For example, hand phalanges are longer than foot phalanges and the thumb is 90 degrees rotated in order to grab object.

The internal space of pelvic skeleton is pelvic cavity. Woman has larger pelvic cavity, which makes it easier to deliver a baby.

The pelvic skeleton part that touches a chair is called the ischial tuberosity. When one sits for too long on a hard chair, inflammation may occur in the skin covering the ischial tuberosity.

The bones of the lower limbs which support the whole body became stronger as human started walking.

Foot bones are convex upward so sole is concave.

The bones of the lower limbs are much larger than those of the upper limbs.

If sole is flat, the muscle, nerve, and blood vessel are pressed to the ground whenever he/she walks, which causes pain.

A sole that is not concave is called a flat foot.

Inflammation can also occur when one doesn’t move during sleep.

Human grows in height as limb bones and trunk bones grow longer.

If the pelvic cavity is too narrow, the mother has to undergo Caesarean section.

It’s natural to move bit by bit while sleeping.

Wriggle, wriggle

Trunk bones determine sitting height.

Still, you can’t outrun a four-legged animal like me!

The pelvic skeleton consists of a sacrum and two hip bones.

Pelvic cavity

My soles hurt so I cannot walk long distance. I also cannot join the army.

Pelvic bone

In order for cartilage to change into bone, a body needs calcium.

Cartilage needs to be present to grow taller.

Bones are bit different based on gender and the one most different is the pelvic skeleton.

Bones in upper and lower limbs grow as the cartilage changes into the bone.
There are bones that can be felt from outside the body, such as the clavicle.

The clavicle connects the sternum with the scapula.

Since muscle and ligament are attached to the bone, some bony parts bulge outward.

This is because muscle and ligament are continuously pulling the bone.

There are holes or caved-in parts in bone as blood vessel and nerve pass through the bone.

Medical students must memorize all of these bone structures.
3. Articular system

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The location where the two bones meet each other is called a joint.

According to the tissue between the bones, joints are divided into three types: fibrous, cartilaginous, and synovial joints.

Fibrous Cartilaginous Synovial

Two wood blocks attached together by strong glue is similar to the fibrous joint with blocks as bones and glue as fibrous tissue.

The cartilaginous joint has cartilage between the bones and can move a little bit.

An example of cartilaginous joint is the intervertebral disc between the vertebrae.

The fibrous joint does not move because of the fibrous tissue between the bones.

For example, the bones forming the skull are attached together by the fibrous tissue so they cannot move.

The joint is called suture because it looks as if the bones are sewn together.

The teeth attached to the maxilla and mandible are also considered a type of fibrous joint.

Pulling out a tooth is not an easy task.

One can turn and bend one’s head/trunk because vertebrae are able to move limitedly.

In anatomy, the word fibro-always means tough in nature.

They do not come apart.
Height is slightly less in the evening than in the morning since the intervertebral discs are pressed down throughout the day.

The soft and squishy nucleus pulposus is in the middle of the intervertebral disc, while the tough anulus fibrosus is the outer mater.

Some articular cavities are separated completely by articular disc.

There is synovial fluid in the articular cavity which allows the synovial joint to perform free movement.

These articular cavities are separated incompletely by articular meniscus.

There is more synovial layer if there is articular disc or meniscus which facilitates movement of the synovial joint.

Common location for the herniation is the lumbar intervertebral discs.

Since the synovial joint moves freely, there is a greater risk of arthritis. Arthritis can be divided into degenerative and rheumatoid arthritis.

Animals that walk on four limbs receive less pressure on their intervertebral discs, so they are less prone to the herniation.

The presser spinal nerve causes pain and inhibits motor capability.

The lumbar intervertebral discs receive significant pressure due to gravity.

There is no intervertebral disc in the sacrum.

The meniscus can be found in knee joint.

Articular disc and meniscus decrease the impact on joint.

The synovial joint is composed of fibrous layer, synovial layer, articular cavity, and articular cartilage.

This disease occurs mostly in humans.

Vertebrae

Fibrous layer

Bone

Articular cavity

Articular cartilage

Ouch, my limbs hurt, especially on rainy days.

Degenerative arthritis occurs when one has used joints too much; therefore, older people are more prone to this disease.

It is similar to machine breaking down due to overuse.
The combination of synovial and fibrous layers is called the articular capsule.

Ligament is a tough structure that holds bones together and prevents excessive movement of joint.

When a joint is accidentally flexed out of range, ligament gets stretched out.

In extreme case, the stretched out ligament can be torn apart.

Dislocation can occur when bones that form the joints get displaced.

If one opens his/her mouth too wide, the temporomandibular joint can be dislocated; therefore, one needs to be careful.

The synovial joint movement is determined by the shape of the ligament and the articular surfaces.

If I cannot close my mouth, I need to go see the dentist.

Each joint has its own movement different from those of other joints.

The plane joint has a sliding movement.

The pivot joint has a rotating movement.

It is similar to a screw nail.

Dental clinic
The hinge joint, which has collateral ligaments, performs flexing and extending movements.

The ellipsoid joint has a concave, oval-shaped articular surface on one side and convex, oval-shaped articular surface on other side which move in two directions.

The ellipsoid joint is like the cracked egg shells that are stacked together.

The ball and socket joint is capable of all movements.

In synovial joints, what have 1 axis (plane, pivot, hinge joints) are less movable than joint with 2 axes (ellipsoid joint), while joint with 3 axes (ball and socket joint) is more movable than 2 axes joint.
4. Muscular system

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Humans can move thanks to muscles.

A muscle is divided into skeletal muscle which is contracted voluntarily and smooth and cardiac muscles which are contracted involuntarily.

Under a microscope, we can find striations in skeletal and cardiac muscle cells, while there is no striation in smooth muscle cell.

This chapter will only talk about the skeletal muscle.

Plant cannot move because unlike us it does not have muscles.

The skeletal muscle means the muscle attached to bones.

Since I do not have striation, I appear smooth.

From now on, we will just call skeletal muscle as muscle.

An example of a smooth muscle is the muscle that moves food down in intestine.

Cardiac muscle pumps out blood from heart.

If we look inside human body, the outermost part is the skin, followed by subcutaneous tissue, fascia, muscle, then bone.

The consecutive contraction by the smooth muscle is called peristalsis.

Smooth and cardiac muscles are involuntary as the autonomic nerve controls them on its own.

A body is cut to see the position of the muscle.

Scary!
If we work out a lot, the fatty subcutaneous tissue gets thinner while the muscle gets thicker. When muscle contracts, it gets thicker.

Because a muscle is attached to at least two bones, a joint moves if the muscle contracts. The bone that does not move is the origin of the muscle, while the bone that moves is its insertion.

If one knows the origin and insertion of a muscle, he/she will be able to figure out how the muscle activates. For most muscles, the insertion is closer to the joint than the origin is.

Medical students have to dissect a cadaver and find the origins and insertions of muscles. The case on the left is more common than the one on the right.

Example is the biceps brachii performing flexion of elbow joint. The bump that appears when flexing is the thickened biceps brachii.

To only move the 2nd joint as shown in the picture, muscle 1 and muscle 2 have to contract together. This muscle moves two joints at once.

In order to exercise as we wish, many muscles have to contract simultaneously.

The muscle’s end parts which attach to the bones are the tendons, which look like bands. When we eat beef, we often eat the cow’s tendon as well.

Muscles collaborate.
Muscular system

After opposition of the thumb and little finger and flexion of the wrist joint, a tendon gets prominent.

The largest tendon in the body is the calcaneal tendon and it can be touched easily from outside.

In the upper limb, the flexor muscles are well-developed, while in the lower limb, the extensor muscles are well-developed.

Facial muscle ends not at the bone but at the skin.

The facial muscle enables one to make facial expressions.

If the calcaneal tendon is torn apart, one cannot raise one’s heel and cannot walk.

A flat muscle becomes an aponeurosis and attaches to bone.

Facial muscle ends not at the bone but at the skin.

The facial muscle enables one to make facial expressions.

The rectus abdominis in the front of our abdomen has intermediate aponeuroses.

When the rectus abdominis gets bigger, the aponeuroses go inward and the six pack appears.

When levator palpebrae superioris is attached to the superior eyelid rather than its end, double eyelid is formed.

The first step in walking is raising heel.

Another word for the calcaneal tendon is Achilles tendon which also means weakness at risk.

Since the muscle is flat, the aponeurosis is also flat.

Due to the facial muscle’s insertion, the skin will move if it contracts.

Happy, angry, and sad expressions are assumed.

Among the facial muscles, there is a muscle that raises the superior eyelid and another that lets it down.

When levator palpebrae superioris is attached to the superior eyelid rather than its end, double eyelid is formed.

Only rectus abdominis is hypertrophied not the aponeuroses, which get relatively depressed.

A double eyelid gets prominent when superior eyelid is raised.

Orbicularis oculi

Insertion

Double eyelid

Double eyelids
When the zygomaticus major, a smiling muscle, ends more laterally than the angle of mouth, a dimple appears.

- **Zygomaticus major**
- **Dimple**

Dimple appears when smiling.

The facial nerve controls the facial muscle so if the nerve breaks, facial muscles cannot contract.

- **Facial nerve**
- **Facial muscle**
- **Skin**

During stroke, facial nerve on one side may get damaged, causing a side of the face to droop.

The fewer the motor unit, the more detailed the muscle can contract.

- **100 m run**

The muscle that delicately moves the eyeball has very few motor units.

A runner with large muscles can run fast.

In animals that walk on their four limbs, muscles attached to the skin are positioned throughout the body and contract when the skin itches.

- **Let's run away.**
- **Bug**
- **Skin twitch**

Since I cannot use forelimbs as freely, these muscles have developed further.

When examining bacon, you can see the thin muscle in the subcutaneous tissue.

- **Subcutaneous tissue**
- **Muscles**

In pigs too, these muscles attached to the skin have developed.

The size of the muscle does not matter much.

All muscles are controlled by the nerves.

- **Nerve**
- **Torn nerve**
- **Muscle**

Muscle unable to contract.

If the nerve is torn, the muscle hypotrophies.

One neuron (nerve cell) and muscle cells, innervated by the neuron, are called the motor unit.

- **Neuron**
- **Muscle cells**

This motor unit has two muscle cells.

Having healthy cardiovascular and respiratory systems is helpful in running long distance.
In order to live, people have to digest food and intake nutrients. The digestive system is responsible for this process.

The digestive system consists of a digestive tract that allows passage of food and digestive glands that secrete digestive juices.

The oral cavity includes teeth, tongue, and palate.

The hard tooth allows us to chew on hard objects.

Even though tooth is tough, it can be damaged once infected with germ.

Digestive glands include salivary gland, liver, and pancreas.

20 deciduous teeth are replaced by 32 permanent teeth.

Go to see the dentist early, then you'll save tooth and money.

I am even harder and stronger than bone.
Among the 32 permanent teeth, there are 8 incisors, 4 canines, 8 premolars, and 12 molars.

Teeth are symmetric left and right as well as up and down.

\[
\begin{array}{c|c|c|c|c|c|c}
| & 3 & 2 & 1 & 2 & 3 & 1 & 2 & 3 \\
\hline
3 & 2 & 1 & 2 & 3 & 1 & 2 & 3 \\
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3 & 2 & 1 & 2 & 3 & 2 & 1 & 2 & 3 \\
\hline
2 & 1 & 2 & 3 \\
\end{array}
\]

Teeth alignment can be summarized to be easily memorized.

In order to perform these tasks, the tongue has to be able to move freely and thus, the tongue is composed of hundreds of small muscles.

When touching the palate with one’s tongue, one can see the frenulum attached underneath tongue.

The roles of tongue include tasting food.

The left and right sides of frenulum are protruded because the submandibular and sublingual glands are opened there to release saliva.

Saliva made from the parotid gland is released into the oral mucosa lateral to the 2nd maxillary molar.

People commonly suffer from inflammation in their gingiva.

There are receptors on tongue that enable one to taste food.

Opening of the glands

Usually, exocrine gland secretion occurs in protruded areas like nipple.

You can find the protrusion if you look closely using a mirror.

Moving food inside oral cavity for easier chewing.

and contributing to the process of shaping laryngeal voice into words.

The anterior part of the palate is called the hard palate consisting of bones, and its posterior part is the soft palate consisting of muscles.

It is common to bite one’s tongue because tongue and teeth move simultaneously.

You have probably seen one with poor pronunciation due to short tongue, right?

Ouch!

Words

Voice

Tongue

Larynx

Palate divides the nasal and oral cavities. Uvula is the posterior end of the palate.

Soft palate   Hard palate

Snoring sound comes from the vibration of the soft palate.
From the soft palate, two arches come down and the tonsil is located between them.

The pharynx is divided into nasopharynx (N), oropharynx (O), and laryngopharynx (L).

The stomach is the most bulging part of the digestive tract.

Food that enters the stomach mixes with peptic acid and gastric juice.

Food in oral cavity should not be allowed to pass through the nasal cavity nor the larynx.

When we swallow food, the soft palate goes upward, blocking the space between the nasopharynx and oropharynx.

When the stomach produces too much peptic acid, the stomach wall is damaged.

People who like to eat spicy food are prone to have stomach cancer.

I sneeze when food enters the nasal cavity.

I cough when food enters the larynx.

You can also see the soft palate going upward with a mirror.

We call this disease stomach ulcer or peptic ulcer.

In the early stage, it is usually asymptomatic.

As larynx goes upward, the epiglottis blocks the space between the laryngopharynx and the larynx.

Food eventually passes through in the order of oral cavity, oropharynx, laryngopharynx, then esophagus.

Stomach cancer has to be diagnosed and treated early.

If the stomach cancer is severe, doctor surgically removes the stomach.

You can see the larynx goes up.

Gastroscopy can detect stomach cancer very well.

We can live without a stomach.
Food from the stomach is passed through the duodenum which is the first part of the small intestine. Digestive enzyme produced from the liver is called bile juice. The bile juice is concentrated once stored in the gallbladder.

Duodenal length is the sum of twelve fingers’ widths. We can live without the gallbladder. Not seriously, bile juice isn’t concentrated.

Duode- means twelve in Greek. Liver juice

When food passes through, the sphincter between stomach and duodenum relaxes. Gallbladder takes out water from the bile juice.

Sphincter Food

Straightened duodenum

Duodenum

The liver, pancreas, and duodenum are vital organs. The liver is positioned toward the right and is covered by ribs.

Liver Duodenum Pancreas

The liver, pancreas, and duodenum are vital organs.

The stomach is located in the epigastric region.

Liver Ribs Umbilicus

Cancer occurs commonly in the liver as well. Hepatitis can progress into liver cancer so it is important not to get hepatitis. Digestive juice produced from liver and pancreas is secreted into duodenum.

Liver Duodenum Pancreas

The liver, pancreas, and duodenum are vital organs.

The liver is positioned toward the right and is covered by ribs.

Liver Ribs Umbilicus

Cancer occurs commonly in the liver as well. Hepatitis can progress into liver cancer so it is important not to get hepatitis.

Liver cancer

Have you received hepatitis prophylactic shot?

Liver cancer

Liver cancer

Other person’s liver

Liver cancer

Pancreas not only makes pancreatic juice but also makes hormones.

Representative hormone, insulin made from the pancreas lowers the glucose level of blood.

Blood Glucose Glucose

Insulin
Small intestine includes jejunum and ileum as well as duodenum.

Jejunum digests and absorbs more than ileum. Therefore, jejunum has thicker wall, more folds, and more blood vessels.

Intestines become longer and more wound up. Small intestine is about 6 m long and large intestine is about 1.5 m long.

Large intestine is shorter but thicker than the small intestine.

However, since food does not stay for long in jejunum, it tends to be empty a lot of the time.

The large intestine consists of cecum, appendix, ascending colon, transverse colon, descending colon, sigmoid colon, rectum, and anal canal.

The large intestine does very little food absorption.

Large intestine does not have folds.

Appendectomy is a surgical procedure for cutting out the appendix with inflammation.

Appendix is not a necessary structure for survival.
Digestive system

Rectum is the place for fecal storage.

Feces go out through the anal canal.

When we have diarrhea, large intestine does not absorb enough water, which makes the feces very watery.

In the anal canal, there are longitudinal folds called the anal columns.

At this point, the abdominal wall muscle (skeletal muscle) contracts and increases the pressure in the abdominal cavity; the muscle (smooth muscle) in the large intestine performs peristalsis to push out feces.

Sphincter (skeletal muscle + smooth muscle) in the anal canal relaxes and opens way for the feces to be excreted.

A disease in which the anal column becomes abnormally swollen is called hemorrhoid.

The stomach, small intestine, and large intestine are collectively the gastrointestinal tract.

Just like this, skeletal and smooth muscles commonly work together in contraction and relaxation.

Constipation is when food stays too long in the large intestine, while diarrhea is when food stays too short.

Gastrointestinal tract's wall is composed of mucosa, submucosa, muscular layer, and serosa.

Nutrient is absorbed into blood vessels through the mucosa and submucosa.
All nutrient goes to the liver through the portal vein.

- Liver
- Portal vein

The portal vein is a blood vessel that connects the gastrointestinal tract and the liver.

- Nutrient

The nutrient is stored in the liver then goes to wherever it is needed.

- Nutrient

Serosa is a part of the peritoneum. Peritoneum is a membrane surrounding the organs in abdominal cavity.

- Gastrointestinal tract
- Muscosa
- Sub-mucosa
- Muscular layer

Peritoneum can cover part of the organ or can cover the whole organ.

- Peritoneum
- Lubricant

Toxic substance absorbed from the gastrointestinal tract is detoxified in the liver.

- Liver
- Toxic substance

However, severely toxic substance can harm the liver.

- Nutrient

Alcohol also is detoxified in the liver.

- Liver

Whether an individual can drink well or not depends on how well one’s liver performs detoxification.

- Beside, taller and bigger people can drink better than others.

Muscular layer in the gastrointestinal tract carries out peristalsis and moves food down the tract.

- Food

If you consider the place where the bacteria live to be outside of the body, then the inside of the digestive tract is also outside of the body.

- Skin
- Bacteria

Bacteria may penetrate the skin or the digestive tract, which is infection.

- When the digestive tract or the skin is damaged, body is infected.

Drinking heavily can damage the liver.

- Drinker

Drinkers are prone to have poorly functioning liver.

- Food

When smooth muscle contracts in order, food is pushed down.

- Bacteria

There are also many bacteria living outside the skin.
In order to protect our digestive system, we need to eat regularly and chew the food thoroughly.

Don't strain digestive system!
6. Respiratory system

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3D models of respiratory system
made from Visible Korean

Respiratory system is in charge of breathing.

The air one inspires passes through the nasal cavity, pharynx, larynx,

Hiccup occurs when one's diaphragm contracts irregularly on its own.

Above the nasal cavity, there are olfactory receptors.

I breathe, therefore I am.

Respiratory system

Nasal cavity

Larynx

Pharynx

Olfactory receptor

But human can't smell better than I can!

When the diaphragm underneath the lungs contracts, one inspires. When the diaphragm relaxes, one expires.

When the diaphragm underneath the lungs contracts, one inspires. When the diaphragm relaxes, one expires.

Nasal cavity includes nasal septum and nasal conchae, which makes it complicated.

Complicated nasal cavity warms and moistens the inspired air.

trachea, bronchi, and then to alveoli.

Breathe in

Contracted diaphragm

Tommy's nose is small but it has all the structures!

Breathe out

Relaxed diaphragm

Nasal cavity is covered with warm and moist mucosa.
Oral cavity is much simpler than nasal cavity, so the air through the oral cavity cannot become warm or moist. This burdens the lungs.

Because nasal cavity is complex, people get stuffy nose easily with inflammation.

When doing long run, it is better to inspire through one's nose.

Having nasal congestion when having a cold is annoying.

Therefore, complex nasal cavity can be both beneficial and harmful.

Front part of the nasal septum is composed of cartilage and its back part is composed of bone.

All human structures can be both beneficial and harmful.

The front part is flexible since it is made of cartilage.

Really?

Without paranasal sinuses, your head would feel heavy and humming would sound bad.

Underneath the eyelids, we can find two small holes opening to the nasolacrimal duct.

When crying tear is released through the nasolacrimal duct to enter the nasal cavity.

Tear coming from nasolacrimal duct

Look at the mirror to find the holes.

Maxillary sinus among the paranasal sinuses is most likely to have inflammation, and this is called maxillary sinusitis.

Even when we are not crying, tear is constantly secreted to protect eyeball.

The tear gets to nasal cavity and dries by the inspired air.

Paranasal sinuses reduce the weight of one's head and enable good nasal voice.

Cave, connected to the nasal cavity, is called the paranasal sinus.

If the bottom of the maxillary sinus is connected to the nasal cavity, it would not have been prone to inflammation.

This is not the actual depiction.

However, since the maxillary sinus' top is connected to the nasal cavity, ponding secretion easily results in inflammation.

Maxillary sinus

Stagnant water is bound to rot.
Dust coming into the nasal cavity is stuck to the nasal secretion, which is swallowed together with saliva.

The secretion and dust do not cause any problem in the digestive tract, so there is no need to worry.

Simply put, we can blow or swallow the nasal secretion.

Stomach is OK.

Tonsilitis, happens because the tonsil eats the infectious viri that come to pharynx.

The tonsil is like the police.

Auditory tube is a tube connecting the nasopharynx with the middle ear.

Inflammation of nasopharynx can be spread through the auditory tube to the middle ear.

In ENT, E means ear, N means nose, and T means throat including pharynx and larynx.

Pharynx can be divided into nasopharynx (N), oropharynx (O), and laryngopharynx (L).

This is a mirror used in ENT, which is also a symbolic object for doctors.

Oropharynx can be seen when one’s mouth is opened widely, but a special mirror is needed to see nasopharynx and laryngopharynx.

The tonsil is between oral cavity and oropharynx and gets bigger when inflammation occurs (tonsilitis).

The frontmost part of the neck is the larynx.

One can feel the hard hyoid bone above the larynx and the tracheal cartilage below the larynx.

Men’s larynx is protruded more than women’s, and some say this is because apple that Adam ate got stuck.

Cartilage is not strong so you have to touch it gently.

Larynx

Uvula

Normal tonsil

Tonsilitis

Ick!

Believe it or not.
When the larynx (L) is cut, we can see the small opening in between two vocal cords.

When bilateral vocal cords get in contact, the air moving out vibrates the vocal cords, which makes sound.

The sound becomes words in mouth.

If the narrow space between the vocal cords is firmly blocked, a doctor forces a hole into the trachea to allow the patient to breathe.

Pleura surrounding lung helps the lung to move easily.

The right lung is bigger than the left lung because the heart is located toward the left side.

The bigger right lung has three lobes and the smaller left lung has two lobes.

If one lobe in the right lung has cancer, the surgeon cuts out just that lobe.

Fissure located between lobes helps the lung move easily and prevents disease from spreading to other lobe.

Each lobe is further divided into 2 to 5 segments.

Lung taken out from smoker usually has many black dots.

Passages toward the lung other than the bronchus are pulmonary artery and pulmonary vein.
Deoxygenated blood passes through the pulmonary artery, while oxygenated blood passes through the pulmonary vein.

Artery is the blood vessel going out from the heart. Thus, pulmonary artery has low oxygenated blood.

Mucus formed in bronchi can be expelled by coughing and this is called sputum.

It is better to swallow the sputum than to spit it out and be charged with a fine.

Most lymph nodes in lung are black. This is because polluted air particles are stored there.

The right bronchus is shorter, thicker, and more vertical than the left one.

When smooth muscle in the bronchus wall contracts without necessity, it is called asthma.

When bronchus successively splits, it becomes alveoli. Likewise, pulmonary artery becomes capillaries.

Lymph nodes are like the tonsil as they eat and clear out pathogen.

This is because the heart is near the left side.

The main cause of asthma is allergy.

When water enters trachea, pneumonia of the right lung usually occurs due to the bronchi shape.

Mucus in the bronchi catches dusts and cilia in the bronchi then force out the mucus toward the mouth.

Oxygen from the alveolus goes into the capillary and the carbon dioxide from the capillary goes into the alveolus.

Oxygen gained from this respiratory system is used for metabolism in body.

Carbon dioxide formed from metabolism is also sent out through this respiratory system.

I need to go to the esophagus, but why did I come into the trachea?
7. Urinary system

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3D models of urinary system made from Visible Korean

Urinary system makes and excretes urine.

Urine is made up of unnecessary body waste and water.

The kidney is located on the posterior abdominal wall.

Of the blood coming in from the renal artery, some become urine and get excreted.

Humans have to force out the body waste made from metabolism.

If I get punched hard in the back, kidney can be damaged.

Water that we drink is absorbed through the gastrointestinal tract then passed onto the urinary system to become urine.

Urinary system consists of kidney, ureter, urinary bladder, and urethra.

The remaining blood goes out through the renal vein.

Renal artery is split and then get twisted; this capillary is called the glomerulus.

Most water does not become feces but urine.

Among these organs, there are pairs of kidney and ureter.

Therefore, Blood going into kidney - Blood going out from kidney Urine

Glomerulus can only be seen with a microscope due to its small size.
From the blood passing through the glomerulus, urine goes into the glomerular capsule.

Urine from the glomerular capsule goes into the tubule.

Both kidneys produce about 1 ml of urine per minute.

When the kidney is damaged, it cannot produce or excrete urine.

Blood vessel coming from the glomerulus winds around the tubule.

99% of the urine inside the tubule is reabsorbed into the blood vessel.

You have to either get hemodialysis, or get peritoneal dialysis.

Part of the blood inside the blood vessel goes into the tubule as well.

Urine inside the tubule passes through the calyx, renal pelvis, then to the ureter.

The dialysis procedure must be done continuously. Therefore, transplanting a kidney should also be considered.

With one kidney donated, the donor can live without a problem with a remaining kidney.

Unnecessary substance should be excreted as urine.

Body waste-containing blood

Body waste-free blood

Body waste-free water

Body waste-containing water

This procedure can be done because peritoneum is rich with blood vessels.

Dialysis machine

The donor is healthy.

The recipient is also healthy.

Hemodialysis and peritoneal dialysis should be done whenever body condition is poor.
Sometimes, the donated kidney is rejected in the recipient’s body for being recognized as a pathogen.

Ureter allows urine to be passed down to the urinary bladder.

When holding back urine, sphincter (smooth muscle) in the urinary bladder and sphincter (skeletal muscle) in the urethra contract.

If one keeps back urine for too long, urine in urinary bladder can leak out through the ureter.

To avoid rejection reaction, the donor and recipient should be genetically compatible.

If the ureter is blocked or damaged, it can lead to a severe problem.

Sphincters

Don’t tolerate urination too much.

Ureter performs peristaltic movement to send urine to the urinary bladder.

Ureter’s start, middle, and end are smaller in diameter, which makes renal stone prone to be stuck in these locations.

During urination, detrusor muscle (smooth muscle) in the urinary bladder and muscle (skeletal muscle) in the abdominal wall contract.

In order to hold back or force out urine, smooth and skeletal muscles must contract together.

Even if I do a hand stand, urine still flows to the urinary bladder.

Drinking lots of water can force the stone to be excreted together with urine.

Smooth muscle is controlled involuntarily by the autonomic nerve and the skeletal muscle is controlled voluntarily.

Common organs for stone formation are gallbladder and kidney.

Urinary bladder is an organ that stores urine.

If muscles controlling urine don’t work properly, urine will be excreted at random times.

Or urine will not be excreted when needed. Its more reason is prostatic hypertrophy in case of old male.

Urinary bladder

Urine

Urethra

Hahaha! Why does urine come out when I laugh?

Squirting

Why can’t I urinate even with the urge?

Liver

Gallstone

Renal stone

When urinary bladder is full with urine, I get urgent.
Male urethra can be divided into three parts: urethra covered with prostate, urethra surrounded by sphincter, and urethra in penis.

If inflammation of urethra happens, does the female need to go to the obstetrics & gynecology or to the urology?

The correct choice is urology which takes care of both sexes' urinary system and male genital system.

Female urethra doesn't belong to the genital system.

<table>
<thead>
<tr>
<th>Urinary</th>
<th>Genital</th>
</tr>
</thead>
<tbody>
<tr>
<td>♂ Urology</td>
<td>Urology</td>
</tr>
<tr>
<td>♀ Urology</td>
<td>OBGYN</td>
</tr>
</tbody>
</table>

Male expels both urine and sperm through the urethra.

Therefore, men's urethra is considered to be in the urinary system and genital system as well.

Urethra in penis enables man to pee standing up.

Female does not have prostate and penis, so female urethra is shorter than male's.

The short female urethra is close to vagina and anus,

making it easy for pathogen to be spread through the urethra to the urinary bladder.

So woman's vagina and anus should be kept clean.
8. Genital system

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All organisms desire to live eternal life. But in the end, they all perish.

Therefore, organisms, in exchange for eternal life, reproduce offspring.

The male genital system include testis, epididymis, ductus deferens, seminal vesicle, prostate, urethra, and penis.

Testis generates sperm and male hormone.

Reproduction is to make offsprings like themselves.

We will start with the male genital system.

Humans go through sexual reproduction not asexual reproduction. Thus, male and female genital systems look and work differently.

Without testis which produces male hormone, a man would be less like men and more like women.

Testis takes place in the abdominal cavity and passes through the inguinal canal reaching the scrotum.

If we do not reproduce, our species become extinct.

I want to know about the female genital system.

Is someone talking about me?

Eunuch who used to be in China and Korea

Testis comes down before the baby is born.
Ductus deferens also passes through the inguinal canal together with testis.

If testis does not come down to the scrotum from abdominal cavity, testis cannot produce sperm.

So if the testis does not descend, surgery must be performed.

In contrast, when the testis becomes too cold, cremaster muscle contracts to bring the testis upward, keeping it warm.

When the sperm gets ejaculated, sphincter in the urinary bladder contracts, and sphincter in the urethra relaxes.

Starting from puberty, testis makes lots of sperm.

When ejaculating, about 100 to 300 million sperms go out.

Then, when ejaculated, the sperm goes through ductus deferens and urethra.

Smooth muscle in the ductus deferens undergoes peristalsis in order to ejaculate sperm.

When the urine gets excreted, both sphincters in the urinary bladder and urethra relax.
When ejaculation occurs, sperm as well as secretion made in the seminal vesicle and prostate are excreted.

The secretion helps the sperm meet the ovum.

Male urethra is surrounded by prostate, sphincter, and penis.

The sperm and secretion are collectively called semen.

In this situation, in order for better urination, the doctor performs a urethra enlarging surgery.

Vasectomy is partial resection of ductus deferens on both sides, so that sperm cannot go out.

In senior male, it is common to have narrower urethra because the prostate becomes pathologically enlarged.

When ejaculating, 2 ml to 6 ml of semen is released.

Cutting the penis anatomically, we can see that it is made up of three sponges.

When the surgery is performed, only secretion made from the seminal vesicle and prostate get ejaculated.

When the blood fills up the sponges, erection occurs.

The erection results from the widened artery to penis and the narrowed vein from penis.
The end part of the penis is called glans penis and the skin covering it is called prepuce.

A procedure called circumcision is to cut off the prepuce of penis.

Ovary unlike testis does not come down from the abdominal cavity.

Ovary produces ovum, starting from menarche (1st menstruation) to menopause (last menstruation).

If the ovum does not meet the sperm, tissue and blood fall off from the uterus wall.

Uterus wall repeats becoming thick and thin according to the menstrual cycle.

Female genital system includes ovary, uterine tube, uterus, vagina, and external genitalia.

Ovary elaborates ovum and female hormone.

Ovary matures into corpus luteum.

Ovulated ovum goes into the uterine tube and waits for the sperm.

Ovum is manufactured in the ovarian follicle and then ovulated.

Right ovary | Left ovary
---|---
Jan. | Ovum
Feb. | Ovum
Mar. | Ovum
Apr. | Ovum

Therefore, it’s one ovum per month.

After ovulation, ovarian follicle changes into corpus luteum.

Ovarian follicle and corpus luteum make female hormone.

Who will be my mate?

Blood and tissue fallen off from uterus wall

This is called menstruation.

Billions of ourselves are produced a month.

Female can get pregnant in this time period.

I get produced just once a month.

Testis produces a lot of sperm, but ovary only produces one ovum a month.

I can produce ovum even in warm temperature.
Menstrual cycle (28 days) includes menstrual phase (4 days), follicular phase (10 days), and luteal phase (14 days).

During the follicular phase, hormone produced from the ovarian follicle thickens the uterus wall.

Uterus wall thickening is a preparation for the baby to be incubated.

At the end of the follicular phase, ovum is ovulated, and when that ovum meets sperm, the female gets pregnant.

Without pregnancy, during the luteal phase, hormone made from the corpus luteum thins the uterus wall.

The tissue and blood fallen off from the uterus wall become piled up.

As previously stated, during menstrual phase, the menstrual substance leave the body through vagina.

Menstruation makes female get sensitive.

It is very understandable since her part of the body gets detached and forced outside.

Menstrual tube

Nonpregnant uterus’ size is about the size of her fist.

Uterus consists of fundus, body, and cervix.

Usually, uterine cancer is cancer made in the cervix.

Third world countries have higher rates of cervical cancer.

The cervix cancer should be diagnosed early.

Female adults should have regular check ups for cervix cancer.

It is a simple tissue test.

Vagina is used when having sex, and is also a way for the menstrual substance or baby to come out.

Hymen in the vaginal opening is torn when having sex for the first time.

Glands located near the hymen secretes lubricant to make sexual intercourse more comfortable.
Female external genitalia consists of labium majus, labium minus, and clitoris.

Labium majus is large, containing lots of fat, while labium minus is small, containing little fat.

Labium majus is a skin and labium minus is a mucosa.

When the genital system is made, male organ A and female organ B may start from the same structure. The A and B are called homologous organs. Homologous organs are similar in character.

Clitoris, like penis, is made up of sponge, so it gets bigger when aroused.

For example, scrotum and labium majus are homologous.

Another examples is penis and clitoris.

Scrotum includes testis, but labium majus does not include ovary.

Female breast is the modified skin and subcutaneous tissue. Breast, related to other female genital organs, is discussed in this chapter.

Breast becomes bigger from puberty with hormonal influence.

Male breast can also get bigger if a male is injected with female hormone.

Inside the breast, there are mammary glands to produce milk and subcutaneous tissue.

Subcutaneous tissue determines the size of the breast.

Women like me with small breast also have enough mammary glands. It is just that subcutaneous tissue is smaller.

Therefore, having a big breast does not necessarily mean it will produce milk well.

Mammary glands get bigger when pregnant, and get even bigger after giving birth.

It's similar in that a bigger school bag doesn't necessarily mean a better grade.

A bag only containing lunch box

A woman prepares breast milk to feed baby.
Milk is stored in the lactiferous sinus then comes out of the breast when the baby sucks on the nipple.

The areolar glands surrounding the nipple produce oil, which helps the baby suck.

Even a baby knows that breast milk is better than formula milk.

Oil produced from the areolar glands makes the skin very soft.

An animal like a dog gives birth to many offsprings so it has many breasts.

Male and female genital systems are not something to be ashamed of.

Many breasts and nipples are located in the line between the axilla and groin.

Therefore, keeping a problem to yourself is a very foolish thing to do.

If you are worried about something, it is smart to talk to people with knowledge and experience in that field of expertise.

There is a saying “to show off your problem and illness.”
9. Embryology

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Life begins at the moment when a sperm meets an ovum to become a cell.

When the cell goes through countless cell divisions, it is eventually born as a baby. This process is called development.

Embryology: Anatomy = Cause : Result

We can comprehend the result if we are aware of the cause.

The study of this development is embryology.

A human cell has 46 chromosomes.

Thus, when a sperm and an ovum form a cell, it has 46 chromosomes. The union is called fertilization.

For cells made from meiosis, such as sperm and ovum, the number of chromosomes is reduced to half the original number.

There are two types of cell division: mitosis and meiosis.

The cell division is when a cell divides into 2 daughter cells.

Among 200 million to 600 million ejaculated sperms, only one fertilizes.
If the successful sperm has the Y chromosome, the baby becomes male. If X chromosome, the baby becomes female.

Ejaculated sperm and ovulated egg have the lifespan of 24 hours.

An ectopic pregnancy is when the embryo implants outside the uterus.

The inner lining of the not implanted uterus sheds during menstruation.

Therefore, sperm must be ejaculated before or after 24 hours from the time of ovulation in order to fertilize.

The time of ovulation differs for everyone, but it is usually 14 days after the start of the menstrual phase.

When fertilized, the uterus wall thickens and becomes half of the placenta.

The other half of the placenta is filled by the embryo going through cell divisions.

Ovulation

<table>
<thead>
<tr>
<th>Ovulation</th>
<th>Ovulation</th>
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<tbody>
<tr>
<td>-24 hours</td>
<td>+24 hours</td>
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</table>

Fertilization becomes difficult when ejaculation happens too far from time of ovulation.

Whether the goal is pregnancy or contraception...

The placenta is where the mother and baby exchange substances.

The mother provides oxygen and nutrient to the baby, while receiving carbon dioxide and body waste from the baby.

Fertilization occurs in the uterine tube. After fertilization, the sperm-ovum combination is called an embryo.

The process in which the embryo attaches to the uterus is called implantation.

Uterine wall

Placenta

Embryo

Umbilical cord

Nutrient

O₂

CO₂

Body waste

I have to share food with the baby.

Sperms can travel far by swimming with their tails.

The uterus is where the embryo grows.
The weeks after fertilization and implantation are called week 1 and week 2, respectively.

Implantation occurs 7 days after fertilization.

The embryo is divided into the ectoderm and endoderm in week 2 and into the ectoderm, mesoderm, and endoderm in week 3.

From week 4 to 8, mothers have morning sickness.

During this period, misuse of drug or exposure to radiation could result in congenital malformation.

The endoderm becomes the digestive system.

A more developed endoderm leads to greater weight due to overeating.

The organs of the embryo are formed at the head first and the tail last.

For example, upper limbs are made before the lower limbs.

We can assume how human evolved by studying the development of the embryo.

For example, because the embryo has a tail, human probably had a tail in the past.

Organs in the embryo are made from week 4 to 8.

We feel nausea whenever I smell something bad.

It’s because creating organs is a difficult task.

It’s because the organs could be deformed by drug and radiation.

Order of organ formation

It’s because the head is more important.

But for frog, hind legs are made first because it needs to swim early.

A more developed endoderm becomes over-sensitive and skinny.

Likewise, a more developed mesoderm leads to a stronger build.

The mesoderm becomes the skeletal and muscular systems.

Some people believe that a baby who has a more developed ectoderm becomes oversensitive and skinny.
Since the heart of the embryo consists of one atrium and one ventricle, human probably evolved from fish.

From week 9 to 38, the created organs just grow in size. During this time, the term fetus is used instead of embryo.

When the vaginal delivery becomes problematic, a Caesarean section, in which incisions are made through the abdominal wall and uterus wall, is performed.

After the fetus is delivered. The umbilical cord is pulled to take the placenta out.

In week 20, the sitting height of the fetus is 20 cm, so it’s hard to hide the mother’s pregnancy.

When the fetus is born before week 20, doctors cannot save it. But if it’s born after week 20, doctors can.

After the fetus is delivered. The umbilical cord is attached to the umbilicus.

After week 38, the fetus is born.

The fetus is usually upside down.

Week 20 fetus

Week 20 fetus

Week 20 fetus

20 cm

Being bigger than me doesn’t necessarily mean that it can survive.

Then, the doctor cuts the umbilical cord.

Umbilical cord

Umbilicus

This part of the umbilical cord naturally rots away.

Fetus born after week 38 has the sitting height of 36 cm and weighs 3.4 kg.

Fetus born after week 38 has the sitting height of 36 cm and weighs 3.4 kg.

36 cm

3.4 kg

This is how medical students memorize it: 38 (weeks) → 36 (sitting height) → 3.4 (weight)

There are many cases where a fetus is born too soon or too late.

Let's look at a woman who's wondering if she's pregnant.

The fetus comes out through the vagina.

Contracted uterus

Widened vagina

When it contracts, the mother feels pain.

A premature infant needs to be nursed in the hospital.

Premature Infant Care

I'm not having menstruation this month!

February
She confirms her pregnancy with the urine test. Hormone is found in urine if one's pregnant.

The woman wants to know the expected date of confinement (= delivery). She knows that her last menstruation before pregnancy started on January 1.

But I don't know the date of fertilization.

The expected date in this case is 40 weeks (2 weeks + 38 weeks) after January 1.

40 weeks are equivalent to 9 months and 7 days. Therefore, the due date is October 8.

The baby will be delivered on October 8.

Monozygotic twins are created from one sperm (S) and one ovum (O) to form one embryo (E) that divides into two embryos.

Monzygotic twins

Dizygotic twins occur when 2 sperms (S) and 2 ovula (O) fertilize and become 2 embryos (E).

Dizygotic twins

In vitro fertilization is that sperm and ovum are fertilized in a test tube and implanted in the mother's uterus.

Since many ova are used to increase the survival rate, there's a high probability of having twins.

If both ova are fertilized, dizygotic twins like ourselves are born.

While heredity is determined before fertilization, environment is determined after fertilization.

For example, a baby's inheritance of healthy genetic trait from parents is hereditary.

The baby is healthy thanks to the gene given by parents.
Fixing the body by oneself is the environment.

People are influenced by both heredity and environment.

The baby is healthy because he exercises regularly.

If one excels academically, it is thanks to both one's ancestor and oneself.
10. Endocrine system

Gland secretes substance that the body needs.

There are two types of glands: exocrine gland and endocrine gland.

Substance produced in endocrine gland, known as hormone, is discharged through blood vessel.

Because hormone can reach very far through blood vessels, it can affect distant organs.

Substance produced in exocrine gland is discharged through the secretory duct.

Take the salivary gland for example.

Endocrine glands include the pituitary gland, pineal gland, thyroid gland, parathyroid gland, pancreas, adrenal gland, ovary, and testis.

These are collectively called the endocrine system.

Recall that blood vessels are stretched throughout the whole body.

Saliva made in the salivary gland is released into the oral cavity through the duct.

Unlike other systems, the endocrine system has organs that are far away from one another.
The pituitary gland is at the base of the brain and can be classified into anterior adenohypophysis and posterior neurohypophysis.

The hormone secreted from the adenohypophysis stimulates the secretion of other endocrine glands.

The pineal gland is on the back of the brain and secretes melatonin related to the testis and ovary.

The thyroid gland is in front of the larynx.

Thus, adenohypophysis is like the headquarter to control others.

The adenohypophysis also secretes prolactin and growth hormone.

Thyroid gland secretes the hormone that controls the metabolism.

The parathyroid glands are four small glands on the back of the thyroid gland.

Excessive growth hormone results in excessive growth. Deficiency of growth hormone leads to short stature.

The neurohypophysis secretes the oxytocin that contracts the uterus as well as the antidiuretic hormone that stimulates water retention.

The parathyroid hormone increases the blood calcium level.

The pancreas has both exocrine and endocrine glands that secrete digestive juice and hormone, respectively.
As the pancreatic hormone, insulin decreases the blood glucose level while glucagon increases it.

Diabetes is a condition in which blood glucose level rises because the pancreas doesn’t secrete insulin.

Although diabetes is an adult disease, young people can have it too.

Adrenal cortex secretes aldosterone that controls kidney function as well as cortisol that enhances metabolism.

Steroid drug is similar to the cortisol hormone.

Steroid is a panacea, a cure-all medicine.

Diabetes is a shortened version of diabetes mellitus, which means sweet substance passing through in Greek.

High blood glucose level causes many complications such as high blood pressure and kidney disease due to problems in blood vessels.

Common in diabetic patients, glucose in urine tastes sweet.

I’m not feeling well.

Diabetic complications occur in many organs.

If excessive amount of steroid is taken, one may experience painful side effect.

Adrenal medulla secretes hormone that increases the heart rate.

Lub-dub, lub-dub

Its function is similar to that of sympathetic nerve.

To treat diabetes, patient injects insulin shot and changes his/her diet.

The adrenal gland, also known as the suprarenal gland, sits on top of the kidney. It can be divided into cortex and medulla.

The testis and ovary secrete androgen and estrogen, respectively.

The endocrine system operates the body along with the autonomic nervous system.

Sperms and ova are made in the testis and ovary as well.

These two systems promote human adaptation to the changing environment.
11. Cardiovascular system

The cardiovascular system consists of the heart, artery which carries blood away from the heart, vein which carries blood into the heart, and capillary between artery and vein.

The function of the heart is to pump blood throughout the body. Cardiac muscle contracts and relaxes non-stop to do the job.

The heart is about the size of two hands clasped together, and sits slightly left from the center of the thorax.

If the heart stops beating, manual heart massage is necessary to squeeze blood into brain.

To do so, one must push the sternum very hard.

It's because the heart is located behind the sternum.

The heart is composed twice every second.
The heart consists of two atria and two ventricles.

Having two atria and two ventricles is a distinct characteristic of mammals.

Right atrium
Left atrium
Right ventricle
Left ventricle

From the left atrium, blood is passed to the left ventricle to be pumped throughout the whole body via artery.

Deoxygenated blood flows to the right atrium via vein.

Blood is deoxygenated because the body absorbs oxygen from blood.

Blood in the right atrium goes through the right ventricle, pulmonary artery, and then to the lung.

Very few people are born with a hole between the atria or ventricles.

So the ventricle wall is thicker than the atrium wall.

The left ventricle pumps blood throughout the entire body, unlike the right ventricle which only passes blood to the lung.

Cardiovascular system

After picking up oxygen in the lungs, blood flows through the pulmonary vein and into the left atrium.

Pulmonary vein
Left atrium

Lung oxygenates blood.

That's because some of the oxygenated blood flows back to the lung.

In this case, the heart is unable to provide oxygenated blood to the body enough.

When oxygenated blood is provided insufficiently, it is difficult to study or exercise.

Oxygen must be sent sufficiently to the entire body when studying or exercising.

Therefore, an operation is necessary to block the foramen.

The surgery is relatively simple.

The blood even goes to the head against gravity.

The atrium passes blood to the neighboring ventricle, but the ventricle must pump the blood much farther.

Congenital heart disease

Just like muscles, which are stronger if they're thicker.

The lung is close to the heart.
So the left ventricle wall is thicker than of the right ventricle wall.

The valves in the heart make sure that blood flows one way.

When a valve closes, its sound can be heard by auscultation.

Doctors can diagnose many heart diseases by hearing the closing sound with a stethoscope.

The blood pressure is higher in left ventricle than in right ventricle.

Since ventricles contract and expand simply, the valves are mandatory.

Just like a door, a valve sounds louder when it closes.

Valve sound must be heard.

The entrances and exits of the two ventricles have valves each.

If a valve does not open properly, blood wouldn't flow well.

Since the heart needs blood as well, it has artery of its own, called coronary artery.

Coronary artery is the first arterial branch.

If valve does not close properly, blood would flow backwards.

If a valve does not function properly, it can be replaced with an artificial valve via surgery.

The name of coronary artery was decided since its main branch looks like a crown.

When a branch of the coronary artery is blocked, the correspondent cardiac muscle dies.

I'm going to implement this artificial valve made of synthetic material.

It looks as if the heart is wearing a crown.

Arteriosclerosis is the main cause of arterial blockage.
Angina pectoris is when the dead cardiac muscle comes back to life, and myocardial infarction is when it's completely dead.

The blood supplied by coronary artery is passed to cardiac vein.

If there is artery, there must be vein.

Through the cardiac vein, blood is sent to the right atrium, then to the lung.

Oxygen and nutrient to a heart separated from the body, it'd still be beating.

Since the blood is deoxygenated, it goes to the lung.

That's because the heart has independent nerve.

The sinuatrial node generates contraction of atria and stimulates the atroventricular node and bundle.

Electricity runs through nerve in the heart, and the electricity can be depicted as a graph (electrocardiograph).

The sinuatrial node is innervated by sympathetic and parasympathetic nerves.

For instance, sympathetic nerve influences the heart when exercising, because the body requires more blood.

The heart usually beats 80 times per minute, but beats faster if it’s influenced by sympathetic nerve.

Cardiovascular system
In electrocardiograph, P wave represents electricity directed from the sinuatrial node, while Q, R, and S waves represent electricity from the atrioventricular node and bundle. Therefore, thin arteries have lower blood pressure than thick arteries. Generally, blood pressure usually refers to the blood pressure of the brachial artery.

Physician can make many diagnosis based on the electrocardiograph. The artery coming out of the heart splits into branches. The systolic and diastolic blood pressures are measured when the left ventricle contracts and expands, respectively. The systolic pressure is gauged as follows. Wrap the cuff around the arm.

The artery coming out of the heart is as thick as a thumb, but capillaries are extremely thin and invisible to the naked eye. Because the thin arteries outnumber the thick arteries, the thin ones will be thicker if they are combined. Increase the cuff pressure to 200 mmHg. This will prevent blood from flowing through the brachial artery. If the cuff pressure is gradually lowered, blood starts flowing through the brachial artery again. At this moment, the systolic pressure is measured.

Capillary thickness = red blood cell

These can only be seen with a microscope.
We can feel the pulse of arteries that are close to the skin surface.

On the other hand, arteries that are deeply embedded cannot be felt.

Superficial artery

Deep artery

We feel the pulse of arteries in the neck.

Superficial temporal artery

Common carotid artery

Check your pulse, too.

For example, the superficial temporal artery can be felt in front of the auricle; common carotid artery in neck.

Superficial temporal artery

Common carotid artery

Arteriovenous anastomosis is a connection between an artery and a vein. The connection channel is sometimes opened and sometimes closed.

Arteriovenous anastomosis

Vein

Artery

It usually remains closed so that blood flows through capillary.

If the anastomosis is opened, blood does not flow into capillary.

Arteriovenous anastomosis

Capillary

It acts as a shortcut for blood flow.

The radial and ulnar arteries are palpable at the wrist, while the femoral artery is palpable at the thigh.

Radial artery

Femoral artery

Ulnar artery

Since radial and ulnar arteries are anastomosed with one another.

Radial artery

Ulnar artery

I can see the anastomosis when dissecting.

When it is cold, arteriovenous anastomosis in skin allows blood to take the shortcut instead of going through capillary.

The autonomic nerve performs the process for us.

Arteriovenous anastomosis in skin

Capillary

This prevents us from losing too much body heat.

Since blood does not flow through skin capillary, the sensation of the skin becomes weird.

The anastomosis is also established between veins such as cutaneous veins, which can be found on the dorsum of the hand.

Cutaneous vein

Without the collateral circulation, tissue in the thumb area would die.

It can be seen by naked eye.

When we eat, arteriovenous anastomosis in the brain opens to prevent blood from flowing into capillary.

Arteriovenous anastomosis in brain

Capillary

There is no reserved blood for the brain.

Instead, blood flows into the digestive system to help us digest food.

The blood does not remain in capillary in the brain, causing drowsiness.
The total cross sectional area of capillaries is massive.

By moving slowly, blood can exchange substance with extravascular fluid more efficiently.

Vein of the upper/lower limbs have valves to prevent blood from flowing downwards because of gravity.

Some portions of cutaneous vein in the limbs remained popped up because of the valves.

Blood moves slowly through capillaries since there are so many of capillaries.

CO₂

O₂

Nutrient

Body waste

Veins in the head do not have valves.

On the other hand, artery bleeds more than vein when torn, so it is located deeper and safer location.

If the artery is torn during operation, it spills blood like a fountain.

For example, there is portal vein between the gastrointestinal tract and the liver.

Since vein is thicker than artery, it has lower blood pressure.

Therefore, vein bleeds slowly when it is torn.

If the artery is torn during operation, it spills blood like a fountain.

Both organs have the capillaries.

Only the cutaneous vein, not the cutaneous artery, is present in the subcutaneous tissue.

Drawing blood or injecting drug into the blood stream are usually performed through the cutaneous vein in upper limb.

This portal vein sends nutrient absorbed in the gastrointestinal tract to the liver.

The cardiovascular system can be viewed as a highway for delivering substance.

It's because artery must be in deeper place.

The cutaneous vein pops up if arm is tied with a rubber band.

What a clear road!
12. Blood

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Blood carries oxygen, carbon dioxide, nutrient (N), body waste (W), and so on.

If the cardiovascular system is a highway, blood is a car driving down the road.

Blood consists of red blood cell, white blood cell, platelet, and liquid called plasma.

Red blood cell carries oxygen and carbon dioxide, while plasma carries nutrient and body waste.

A normal adult has about 5 L of blood, which is equivalent to the amount the heart pumps per minute.

Therefore, the time it takes for the blood to circulate the body and come back to the heart is 1 minute.

Red blood cell doesn’t have nucleus and is shaped as a biconcave disc.

Red blood cell has hemoglobin, which easily binds to oxygen.

Transfusion is necessary if bleeding is excessive.

That’s easy.

It has dumbbell-shaped cross section.

As hemoglobin is red, blood is red as well.
Anemia develops when there is not enough hemoglobin in the blood.

To treat anemia, the patient needs to take iron, the main element of hemoglobin.

Therefore, white blood cell needs to pass through blood vessel wall.

White blood cell outside the blood vessel protects tissue.

The lack of hemoglobin means the lack of oxygen, which leads to dizziness.

That doesn’t mean one should eat a chunk of iron.

Red blood cell and platelet cannot pass through it.

I’m the police protecting both inside and outside.

White blood cell defends the body.

For example, when pathogen enters the body, some white blood cell ingests it.

Some white blood cells have granules while others don’t.

White blood cells with granules can be classified according to their dye.

I have nucleus, am round, and am white as my name.

I have a round nucleus.

I’m dyed red.

I’m dyed blue.

I’m dyed red and blue.

White blood cell like police

Pathogen

Granule

Nucleus

Those with granules have more than one nucleus while those with none have one.

Eosinophil

Basophil

Neutrophil

while other white blood cell shoots antibody to destroy pathogen.

White blood cell’s defense is needed not only inside but also outside of the blood vessel.

White blood cells without granules can be categorized according to the nucleus shape.

Just like red blood cell, platelet has no nucleus and is shaped like biconvex disc.

Blood vessel

Pathogen

Because I’m both inside and outside the blood vessel.

I have a round nucleus.

Lymphocyte

Monocyte

I have a bent nucleus.

Platelet

Red blood cell is biconcave disc.
When blood vessel is torn, it needs to be mended immediately. To do so, blood needs to be clotted.

No clotting is a serious concern. Clotting too much to block the artery is also problematic.

The clotted blood can be easily seen in the cut of skin.

Hemophilia, a genetic disease that occurs in male

For instance, nose bleed won’t stop.

Without blood flowing into the brain, I cannot stay alive.

The first step of clotting is the aggregation of platelets.

The second step is tying the platelets with fibrins that are in the plasma.

Is there blood cancer? Yes.

Leukemia patient has abnormal white blood cells.

Platelets are analogous to paramedics.

During this time, nearby red blood cells and white blood cells are also tied together.

Hemato-oncology

Leukemia patient

Blood cancer is called leukemia.

These white blood cells are cancer cells.

The plasma without clotting fibrins is called the serum.

Blood is clotted when exposed to air.

Blood cells (red blood cell, white blood cell, and platelet) are made in bone marrow.

Since blood cells are made in bone marrow of axial skeleton that is in trunk,

Thus, the serum does not clot and is useful in diagnosis.

Clotting of the blood raises scab formation.

Bone marrow

Bone

Blood cell

Location of working bone marrow
a hole must be drilled in the axial skeleton to obtain bone marrow for diagnosis.

It hurts!

Patience is a virtue.

The spleen is an organ that catches and destroys old blood cells.

It gets bigger as more blood cells are removed.

The plasma can perform many tasks because it contains not only nutrient (N) and body waste (W) but also antibody (Ab), fibrin (Fbr), and hormone (Hr).

Physician can make diagnosis by analyzing the described substances in the plasma.

Since there is so much glucose in the plasma, it must be diabetes.

Blood donation won’t do any harm to healthy people, because bone marrow creates abundant amount of blood.

The gift of blood is the gift of life.
White blood cell and plasma move out of and in capillary. Some of lymphocyte and plasma move into lymphatic vessel. The lymph finally flows into vein through lymphatic vessel. Therefore, it can be said that the lymphatic vessel’s role is very similar to that of the vein.

But red blood cell and platelet cannot go through capillary. Simply put, it leaves and comes back into blood vessel. Lymphatic vessel is regarded as part of vein.

The ones in lymphatic vessels are called the lymph. Because the lymph has lymphocyte, a type of white blood cell, but not red blood cell, it is white. Generally, lymphatic vessel is impossible to see with a naked eye because it is too thin. However, the lymphatic vessel that goes into the vein is visible as many lymphatic vessels merge.

The word lymph comes from lympha which means water in Latin. Of course, blood is red because it contains red blood cells. Lymphatic vessel is thinner than the artery or vein. The thickest lymphatic vessel is the thoracic duct.
Lymphocytes sometimes form an organ called the lymphoid organ.

The lymphoid system includes lymphatic vessels and lymphoid organs.

Without a properly working immune response, the body cannot protect itself from pathogens.

A well-known disease due to a failed immune response is acquired immune deficiency syndrome (AIDS).

Lymphocytes in the lymphoid system protect the body from pathogens by destroying it.

Killing pathogens with lymphocytes is called the immune response.

On the other hand, excessive immune response could also be a problem.

For example, the lymphocyte could recognize normal cells as pathogens and attack it.

Pathogen is the infectious microorganism, harmful cell and substance.

I'm like a lymphocyte because I protect the family from burglars.

Although immune response is essential, it becomes problematic if it is excessive.

Why are you hitting me?

It's called an autoimmune disease.

As one immune response, lymphocytes appoint other white blood cells to ingest pathogens.

As the other response, lymphocytes shoot antibodies that demolish pathogens.

Sometimes, the lymphocyte recognizes unharmful foreign body as pathogen and becomes unnecessarily responsive.

It could also attack a transplanted organ after falsely recognizing it as a pathogen.

It's called cell-mediated immune response.

It's called humoral immune response.

You don't need to attack me!

It's called allergy.

I wasn't transplanted to harm you!

This becomes a big problem when transplanting organs.
Lymphoid organs are lymph node, spleen, thymus, and tonsil. Since lymph node is located in lymphatic vessel, the lymph must go through the lymph node while traveling.

The spleen is a lymphoid organ located at the end of pancreas. The spleen deteriorates pathogen in the blood. It's similar to how the lymph node kill the pathogen in the lymph.

The spleen is also an organ that has formed from a group of lymphocytes. The spleen also destroys old or abnormal blood cells. When the spleen does excessive work, it becomes enlarged.

If inflammatory or cancer cell enters lymph node through lymphatic vessel, it grows inside the lymph node. The invaded lymph node becomes swollen.

That's because pathogen or blood cells pile up in the spleen.

The tonsil, another lymphoid organ, is located near the fauces. The tonsil, lingual tonsil, and pharyngeal tonsil are located around the fauces. The palatine tonsil can be seen when one widely opens his/her mouth.

This lymph node in the neck is bulging. When a lymph node gets swollen, the clinician must identify the origin of the inflammatory or cancer cell.

When resecting cancer through surgery, lymph node that the cancer has invaded must be resected as well.
The tonsil usually ingests common cold virus that invade the fauces.

Since enlarged tonsil causes inconvenience, sometimes it is removed through surgery.

The lymphoid system is essential in defending the body.

The last lymphoid organ is the thymus which is behind the sternum.

Therefore, the thymus cannot be felt from the outside.

T lymphocyte is distributed throughout the body and is responsible for the cell-mediated immune response, which ingests pathogen.

There is also B lymphocyte that triggers the humoral immune response, in which antibody is shot to kill pathogen.

The ultimate action film

Cell-mediated immune response
Starring: T lymphocyte
Coming soon

The terrifying violence movie

Humoral immune response
Starring: B lymphocyte
Full up
The nervous system consists of the central nervous system, which contains the brain and spinal cord, and the peripheral nervous system, which includes cranial and spinal nerves.

The outer part of the cerebrum is called cerebral cortex, and the inner part is called cerebral medulla.

The cerebral cortex is the main part of the cerebrum. The cerebral cortex and medulla are gray and white, respectively.

The cerebral cortex merely connects different parts of the cerebral cortex.

The brain is divided into cerebrum, cerebellum, and brainstem.

The cerebrum is the biggest part of the brain and consists of a pair of cerebral hemispheres.

The cerebral cortex enables one to recognize sensation, analyze the sensation, He's touching my hand.

I don't like being touched by him.

The cerebral hemispheres are connected to each other.
and execute motion.

In other words, the cerebral cortex analyzes feelings based on the person’s experience and tells the body to make appropriate moves.

Cerebral cortex is like the mainboard of computer.

The most prominent sulcus is the lateral sulcus.

The iris controls the amount of light reaching the retina.

Lateral sulcus

It’s the longest and the deepest.

For example, the postcentral gyrus is the primary sensory area while the precentral gyrus is the primary motor area.

For example, if the transverse temporal gyrus is hurt, one will become deaf.

The folds are composed of sulci and gyri.

The transverse temporal gyrus is for recognizing sound.

Since there’s a myriad of sensory and motor nerves in the head and hands, the gyrus responsible for them is spacious.

Since human cerebral cortex is bigger than that of animals, human can do more advanced work.

It is means that the human cerebral cortex is big compared to the human body.

Human brain

Whale has bigger brain than human, but its brain is small compared to its size.

Postcentral gyrus

Central gyrus

Precentral gyrus

Whale brain

Premature gyrus

For example, if a gyrus is damaged, its specific role cannot be accomplished.

Undamaged gyrus

Damaged gyrus

Humans has become the ruler of the earth thanks to the highly developed cerebral cortex.

Moreover, the human cerebral cortex has folds.

Thanks to the folds, the cerebral cortex can have larger volume and contains more neurons.

Sulci

Gyri

Cerebral medulla

Cerebral cortex

They are similar to furrows in farm.
Thus, the head and hands are sensitive and capable of doing complex motor activities.

For example, I am able to speak because I delicately move the muscles located in the mouth.

Since the cerebral cortex performs many tasks, it needs to take a rest by sleeping.

It works non-stop while being awake.

While the cerebrum is mostly responsible for thinking, the cerebellum is responsible for motor control.

Motor activity ordered from the cerebrum is executed properly by the assistance of cerebellum.

Athletic and crafty people have highly developed cerebellum.

Specifically, the cerebellum enables one to balance, contract muscle with appropriate force,

I can walk on this beam.

I can control how hard I grab the egg.

The human cerebellum is larger than that of other animals, because only human is capable of performing such delicate activity.

Writing is a very delicate motor activity.

Have you seen a writing monkey?

Since the brainstem connects the cerebrum, cerebellum, and spinal cord, plenty of sensory and motor nerves pass through it.

Brainstem is the hub of central nerve.

Therefore, if the brainstem is damaged, sensory and motor activities becomes severely restricted.

Without the brainstem, the cerebrum and cerebellum won't be able to function.
Since the brainstem is also responsible for respiration and circulation, one cannot survive if it is damaged.

No one can live if he/she doesn't breathe and his/her heart stops beating.

Simply put, one can still live if a good portion of the brain is removed.

But one will become mentally retarded.

The brain needs sufficient amount of oxygen and glucose to work.

Breathing fresh air... and eating well (glucose intake) help me stay smart.

If artery blocked or torn, part of the brain dies.

This is stroke and is very common.

Because the brainstem is essential for survival, the size of the human brainstem doesn't differ much from that of animals.

Thus, the brainstem is deeply hidden halfway between the ears.

The condition in which the brainstem is damaged beyond repair is called brain death.

The logic applies to the fact that both human and pig have roughly same-sized heart.

When brain death occurs, the patient becomes unconscious and cannot survive without external help such as a respirator.

In summary, the human cerebrum and cerebellum are much bigger compared to other animals, but the human brainstem is about the same size.

Although the weight of the brain including the cerebrum, cerebellum, and brainstem is merely 2% of the whole body weight, the brain receives 15% of blood.

In many cases, other organ is still alive.

In this case, the organ can be transplanted to other patient.

The cerebrum of a rat is about the same size as its brainstem.

This is why the artery to the brain is thick.

A dead brain cannot resurrect.

It's the noblest way to use the patient's organ.
Inside the brain is a ventricle filled with cerebrospinal fluid. Cerebrospinal fluid is found in the space between the pia and arachnoid matters. Spinal cord connects brain with spinal nerve. Example is that the sensory nerve from hand passes through the spinal nerve and spinal cord to approach the brain.

Outside the brain and spinal cord are pia mater, arachnoid mater, and dura mater. These three membranes, collectively known as the meninges, are prone to inflammation. If the spinal cord is disconnected, the stimulus won't be transmitted below the disconnection site. Once disconnected, the spinal cord cannot be repaired.

For diagnosis, cerebrospinal fluid is extracted, which requires the injection of a needle under the spinal cord. It's because the brain and the spinal cord should not be damaged. Some people pull the chair as prank. However, this could lead to a severe spinal cord injury.

Spinal nerves that extend to the upper and lower limbs are attached to the cervical and lumbosacral enlargements, respectively. There are two enlarged parts in the spinal cord, known as the cervical and lumbosacral enlargements.

Reversely, motor nerve from the brain goes through the spinal cord and spinal nerve and reaches hand.

Brain

Spinal nerve

Sensory nerve

Brain

Spinal nerve

Sensory nerve

Brain

Spinal nerve

Motor nerve

Brain

Spinal cord

Cervical enlargement

Lumbosacral enlargement

Spinal cord

Cervical enlargement

Lumbosacral enlargement

Spinal nerves to upper limb

Spinal nerves to lower limb

68 - Nervous system
Human has cervical and lumbar enlargements because of limbs.

On the other hand, whale has no cervical and lumbar enlargements because its limbs had degenerated.

A neuron consists of a cell body, dendrites, and an axon.

There are numerous sensory and motor nerves going through the upper and lower limbs.

Vestigial upper limb
Vestigial lower limb

I hold neuron in place like glue. (Glia means glue.)

Although the number of dendrites vary, there is always one axon per neuron.

Among peripheral nerves, cranial nerves are mostly in the head, while spinal nerves are in the trunk and limbs.

12 pairs of cranial nerves go through the skull.

12
Since the brain is inside the skull, cranial nerves need to penetrate the skull in order to come out.

12

A space between connected neurons is called a synapse.

12

Neuron is able to transmit stimulus because it is electrically excitable.

The nervous system consists of neuron, which transmits stimulus.

31 pairs of spinal nerves go through between vertebrae.

Thus, the numbers of spinal nerves and vertebrae are similar.

Vertebra
Vertebra
Spinal cord
Spinal nerve

It is the cellular unit of the nervous system.

Stimulus is transmitted from dendrites to the cell body, then to the axon.

A neuron consists of a cell body, dendrites, and an axon.

Three dendrite
Nucleus in cell body
Axon

Neuron

Signal is also transmitted through synapse.

Electricity

It’s just like how electricity runs through telephone wire.

Neurotransmitter

The stimulus is transmitted through synapse due to neurotransmitter.
For illness related to the nervous system, neurotransmitter may be prescribed.

**Neurotransmitter** is the key to solving the mystery of the nervous system.

A sensory nerve consists of three neurons.

**Central nerve**

**Peripheral nerve**

Because it's sensory, the stimulus is transmitted from peripheral nerve to central nerve.

A motor nerve consists of two neurons. The 1st neuron from the cerebral cortex meets the 2nd one, which reaches the skeletal muscle via peripheral nerve.

**Neurotransmitter**

**Cell body**

**Axon**

The short dendrites are often not drawn.

In a simple drawing, a neuron looks like this.

**Cerebral cortex**

**Stimulus**

**Central nerve**

**Skeletal muscle**

We can control skeletal muscle voluntarily.

**Dendrite**

**Receptor**

Example of receptor is taste bud in the tongue which allows us to enjoy food.

Beginning of the 1st neuron is receptor responsible for receiving external stimulus.

**Sensory nerve**

**Motor nerve**

When a sensory nerve is directly connected to a motor nerve, it's called a reflex arc.

**Sensory nerve**

**Motor nerve**

Due to the reflex arc, when the patellar tendon is tapped just below the patella, the leg kicks forward by contraction of the quadriceps femoris.

After entering central nerve, the 1st neuron meets the 2nd neuron.

**Central nerve**

**2nd neuron**

The 2nd neuron meets the 3rd one, which extends to the cerebral cortex.

**Cerebral cortex**

**2nd neuron**

You can finally feel sensory stimulus when it reaches the cerebral cortex.

Because the reflex arc does not go through the cerebral cortex, it happens involuntarily.

**Central nerve**

**2nd neuron**

The knee jerk allows the doctor to check if there's a problem in the nervous system.

**As depicted, knee jerk does not happen if either of sensory or motor nerves is disconnected.**

This is known as knee jerk.
Automatic nerve is the motor nerve for smooth and cardiac muscles.

Autonomic nerve

Smooth muscle, cardiac muscle

Since we can't control neither smooth nor cardiac muscles at will, they need to be moved by the automatic nerve.

As the name suggests, automatic nerve allows the muscles to move automatically.

In other words, sympathetic nerve puts the body in a fight mode, while parasympathetic nerve does the exact opposite.

It's important to maintain the balance between the sympathetic and parasympathetic nerves.

Automatic nerve consists of sympathetic and parasympathetic nerves.

S

P

S

P

Sympathetic and parasympathetic nerves play opposite roles.

Simpson = Sympathetic nerve

But I would not be sympathetic with the student.

Imagine that a student is caught smoking in the school bathroom by a teacher, Mr. Simpson.

An automatic nerve consists of three neurons.

Central nerve

Hypothalamus

2nd neuron

It's different from skeletal muscle’s motor nerve, which only has two neurons.

The hypothalamus is a region in the cerebrum that plays a pivotal role for automatic nerve.

Automatic nerve’s 1st neuron extends from the hypothalamus to the 2nd neuron.

Through peripheral nerve, the 2nd neuron meets the 3rd one, which is distributed in smooth and cardiac muscles.

Sympathetic nerve has the short 2nd neuron, while parasympathetic nerve has the short 3rd neuron.

The student will have an increased heartbeat, trouble with digestion,

Rapid heartbeat

Can't digest well

enlarged pupils, and dry mouth.

Surprised pupil

Gasping mouth

Such reactions occur because sympathetic nerve stimulates smooth and cardiac muscles.

Central nerve

2nd neuron

Peripheral nerve

Smooth muscle, cardiac muscle

71 - Nervous system
There are still much to be discovered about the nervous system, especially about the brain.

There exist much unknown about the nervous system compared to other systems in the body.

I'll do your homework.

We still do not have a robot with complete artificial intelligence.
15. Sensory system

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Receptor senses external stimulus.

- Sensory nerve
- Receptor
- External stimulus

Receptor is the beginning of sensory nerve.

But when referring to the sensory system, this generally includes only eye and ear.

That's because the only purpose for both eye and ear is to sense.

Since receptors are distributed throughout the body, the whole body can be the sensory system.

A few exceptions are hair and fingernail.

The eyeball is protected by the eyelids.

Superior eyelid
Inferior eyelid

Human has bigger superior eyelid than Inferior one.

We can raise and take down superior eyelid with the muscles in there.

Muscles

We can open eye or close eye.

We can see it by turning inside of the eyelid out.

The conjunctiva is slightly red because there are blood vessels.

The conjunctiva of anemia patient

In the case of anemia, it appears less red.

The conjunctiva is not only lining the eyelid, but also covering the sclera of the eyeball.

Thus, you can see blood vessels in the white sclera.

Under the eyelid is lined by the conjunctiva.
We can roll the eyeball because muscles are attached to it.

The eyeball has three layers, and the innermost layer is the retina.

The iris, ciliary body, and choroid are in the middle layer of the eyeball.

The iris controls the amount of light reaching the retina.

If one stares at the star, the image of the star will be formed on the retina because of the convex lens.

We can experiment this with a convex lens.

One can see in the mirror that one's pupil shrinks when it gets suddenly bright.

In contrast, walking into a dark place, pupil will be enlarged.

The image formed on the retina stimulates receptor, and the stimulus is transmitted to the cerebral cortex through a cranial nerve.

To prevent the image on the retina from reflecting back, the choroid covering the transparent retina is black.

The ciliary body is attached to the lens. When the ciliary body makes it more convex, closer object can be seen.

If the ciliary body makes the less convex, farther object is visible.

The cerebral cortex realizes that one is looking at the star.

It's the same reason why the inside of camera is black.

One is farsighted if one has trouble with this.

One is nearsighted if one has trouble with this.
Farsightedness can be corrected with convex lens in eyeglasses.

Cataract is the clouding of lens.

For nearsightedness, the cornea can be reshaped with laser to become concave.

Because the sclera is not transparent, you can’t see the ciliary body or choroid from the outside.

The outermost layer of the eyeball is the cornea and sclera.

We can see the iris and pupil because the cornea is transparent.

If the sclera turns yellow, it may be a sign of jaundice.

Between the cornea and lens, there’s fluid called the aqueous humor.

The color of iris varies among different ethnicities.

The pupil is black because of the choroid inside.

Glaucoma is the disease in which the aqueous humor has high pressure.

On the back of the lens is a fluid called the vitreous body, where dusts float around.

Blue eye means that iris is blue.

The pupil is black regardless of ethnicity.

The high pressure may affect the rear retina to yield blindness.

Just like the aqueous humor, the vitreous body is a clear fluid.
The ear is composed of external, middle and internal ears. The external ear consists of the auricle and external acoustic meatus.

The tympanic membrane can be examined with otoscope after pulling the auricle upward and backward.

The middle ear inside the tympanic membrane goes through auditory tube and is connected to the nasopharynx.

The cartilage surrounds the auricle and the outer part of external acoustic meatus.

The auditory tube that is closed at ordinary times is opened when one swallows or yawns.

The main role of the ear is to hear sound, which is air pressure.

The internal ear, middle ear and inner part of the external acoustic meatus are surrounded by the temporal bone.

When air pressures the tympanic membrane, the auditory ossicles attached to it push the oval window.

The pressure generated by pushing the oval window creates the fluid flow in the scala vestibule, scala tympani, and finally cochlear duct.
The fluid flow in the cochlear duct stimulates the receptor.

This stimulus is then passed to the cerebral cortex through a cranial nerve.

When the body spins, the fluid in the semicircular duct flows to the opposite direction.

One feels the body spinning because the fluid flow stimulates the receptors.

Other than the cochlea, the internal ear also has vestibule and semicircular duct.

The vestibule and semicircular duct sense the body's movement.

There are 3 semicircular ducts (SD) and each of them are mutually right-angled.

In summary, the vestibule senses linear movement while the semicircular duct senses rotational movement.

For example, when the car accelerates, the fluid in the vestibule flows backward.

The flow stimulates the receptor and goes to the cerebral cortex via cranial nerve.

You need to be able to sense body movement in order to keep the body balanced.

Thus, one can sense the car moving with eyes closed.

The cerebellum is deeply involved with body balance.
16. Integumentary system

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The human body is covered with skin.

Meanwhile, the body is lined with mucosa.

Skin
Mucosa

It prevents internal necessary water from exiting and excretes body waste as sweat.

Sweat
Water

Sweat

Skin

It can also sense external stimulus with receptors.

Dead skin cells

Epidermis

No need to peel it off intentionally.

UV light

Epidermis

Melanin

The skin prevents harmful substance or infectious microorganism from invading the body.

Since the skin covers the body, it’s more resilient than the mucosa.

The skin consists of epidermis and dermis. The epidermis has multiple cell layers.

Skin
Epidermis
Dermis

The dermis is connective tissue beneath the epidermis.

Cell division

Cells in the innermost layer go through cell division and grow outward.

Cells in the outermost layer eventually die and are desquamated.

The innermost layer of the epidermis produces a pigment called melanin, which protects the body from ultraviolet (UV) light.
If the body absorbs too much UV light, more melanin is created.

Africans are born with abundant melanin because their ancestors were exposed to much UV light.

The palm has the second thickest skin.

The eyelid has the thinnest skin layer.

Under the skin is the subcutaneous tissue, which has muscle beneath it.

The subcutaneous tissue consists of fat and determines how much one is obese.

Fingerprints are the foldings of the skin.

Fingerprints inhibit slipping while grabbing object.

These three layers are seen in a butcher shop.

Regular person

Athlete

If one exercises hard, it becomes thinner.

Palm and sole also have skin foldings just like fingerprints.

Because everyone has distinctive fingerprints, they are used for identification.

Palm crease is formed when the skin is attached to the muscle beneath.

One can pinch the skin because of the subcutaneous tissue.

The sole of the foot has the thickest skin.

It has not only the thickest skin, but also a very thick subcutaneous tissue to endure impact from the body weight.

Since it’s made of lipid, it moves well.

Korean social security

Skin

Palm crease

Subcutaneous tissue

Fingerprints

Since palm crease does not have a subcutaneous tissue, it looks caved in.
The palm creases help folding of the thick palm skin when moving fingers.

For human to move fingers freely is extremely crucial.

Sweat gland turns body waste into sweat and excretes it out of the body.

Sweat gland

It is an exocrine gland.

Hair grows from the hair follicle.

When I pluck a hair, the hair follicle is also plucked partially.

Hair falls out naturally and is recovered as much as it is lost. But sometimes hair doesn't grow back.

About a half of adult males go bald.

The excreted sweat vaporizes and drops the body temperature.

That's why we sweat so much during summer.

During winter, the amount of urine increases as we sweat less.

Going to the bathroom too often is annoying.

Can one win the Nobel prize for inventing a complete medication for baldness? He/She wouldn't need Nobel prize.

Why not take the prize?

It's because he/she would make so much money that he/she could find a more prestigious prize himself/herself.

There's a reason why we have hair. For example, without eyebrow, sweat would fall down into our eyes.

Hair is all over the body except palm and sole.

Of course, some parts have more hair while others have less.

Mona Lisa?

Hair has a sebaceous gland attached to it. The oil made in the gland is secreted along the hair.

The blockage of the duct, through which the oil is secreted, causes acne.

Many adolescent females are concerned about their acne.
17. Histology

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The cell is the basic unit of the human body.

Due to its small size, which is usually 0.02 mm, a cell is visible only under a microscope.

A chromosome contains many genes.

Gene determines an individual’s characteristics. The reason why everyone looks different is because everyone has different gene.

The cell consists of the nucleus and cytoplasm.

There are 46 chromosomes in a nucleus.

Gene is inherited from parent to offspring.

Theoretically, if the gene of watermelon are inserted into tomato, we can make the tomato as big as watermelon.

Monozygotic twins look the same because they share the same gene.

The center of atom is the nucleus as well.

Only 6 were drawn due to limited space.

This is known as heredity.
When gene in the nucleus moves out to the cytoplasm, protein is made correspondingly.

The protein directly determines the individual's characteristics.

Thus, it can be concluded that gene indirectly determines one's characteristics.

Lysosome breaks down waste material.

Enclosed within a cell membrane, the cytoplasm contains ribosome, golgi complex, lysosome, and mitochondria.

Mitochondria generates energy.

The cell membrane protects the cell from its surroundings and is selectively permeable.

Ribosome gathers amino acids so that protein can be made in the cytoplasm.

Golgi complex transfers protein in the cytoplasm.

A protein is the collection of amino acids.

It's like a delivery truck.

It's like a power plant.

It's like a national border.

For example, when a white blood cell ingests a pathogen, the lysosome in the cell's cytoplasm dissolves it.

White blood cell

Pathogen

Lysosome

Disappeared

Of course, it needs nutrient to produce energy.

Since muscle cell requires much energy, it has a lot of mitochondria.

There are countless types of cells. Similar cells are usually grouped together.

Cells similar in shape and function are gathered because that is efficient.
A tissue is made up of cells with similar traits. The study of the tissues is histology.

Similar people also form a group.

Epithelial tissue covers outside and lines inside the body.

Think of the tissue as material used for the exterior and interior of a building.

Sometimes epithelial tissue forms a gland.

Gland synthesizes substance that the body needs.

Epithelial tissue can be classified into 4 types: the epithelial, connective, muscle, and nerve tissues.

To protect other tissue that lies beneath the epithelial tissue, cells are packed and strongly bonded.

A solid tissue needs to be built that way.

Connective tissue provides the structural framework for the body.

It is like the framework and concrete of the building.

For example, skin's epidermis is an epithelial tissue, while dermis and subcutaneous tissue are connective tissues.

Connective tissue also includes cartilage, bone, and blood.

The demis and subcutaneous tissue support the epidermis.

Connective tissue moves the body.

Think of the tissue as people moving inside the building.

Muscle tissue moves the body.

Think of the tissue as material used for the exterior and interior of a building.

The appropriate combination of the four tissues makes up an organ.

Official Certificate
This is to acknowledge that cartilage, bone, and blood have maintained the body's structural framework.

Lastly, nerve tissue delivers stimulus.

Nervous tissue acts as the telephone line in the building.

For example, the heart has all four tissue types.
In short, cells make up a tissue, and tissues make up an organ.

Electron microscope can notice cells.
Optical microscope can view tissues.

and naked eye can see organs.
The Use of Educational Comics in Learning Anatomy Among Multiple Student Groups

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Understanding basic human anatomy can be beneficial for all students, regardless of when, or if, they will later undertake a formal course in the subject. For students who are preparing to undertake a formal anatomy course, educational comics on basic anatomy can serve as a concise and approachable review of the material. For other students, these comics can serve as a helpful and fun introduction to the human body. The objective of the comics in this study was to promote an understanding of fundamental human anatomy through self-learning among students. Based on the authors’ previous teaching experience, these anatomy comics were produced in a simple, direct style. The comics were titled after the two main characters, “Anna” (a girl) and “Tommy” (a boy). These comics were then presented to groups of elementary school students, high school students, premedical students, and medical students to assess the comics’ ability to enhance student interest and comprehension of basic anatomy. Quiz scores among high school students and premedical students were significantly higher among participants who read the educational comics, indicating a deeper comprehension of the subject. Among medical students, close reading of the comics was associated with improved course grades. These educational anatomy comics may be helpful tools to enrich a broad spectrum of different students in learning basic human anatomy. Anat Sci Educ 00: 000–000. © 2016 American Association of Anatomists.

Key words: gross anatomy education; anatomy cartoons; comics in education; science education; nonprofessional education; undergraduate education; medical education

INTRODUCTION

Students planning on enrolling in a formal anatomy course can significantly improve their learning potential by reviewing the subject material before the course begins (Bohn et al., 2014). Many premedical students are encouraged to do so to maximize their learning potential, especially considering the recent trend of decreasing the time spent on anatomy coursework in medical schools (Drake et al., 2009). In addition, medical, veterinary, or allied health students may also find it helpful to review basic human anatomy before enrolling in a formal course (Cantwell et al., 2015; McNulty et al., 2016).

Beyond these considerations, however, a basic knowledge of human anatomy is also beneficial to many others who never plan to enroll in an anatomy course. By learning essential human anatomy, these members of the lay public may not only satisfy their latent curiosity about the human body (Weigold, 2001), but as patients they may additionally benefit from improved communication with physicians and health care staff, which may also result in higher compliance (Arkesy, 1994; Evans, 2007, 2013). Indeed, public health is closely related to medical literacy and knowledge of fundamental medical information (Williams et al., 1998; Williams, 2012). Finally, for younger students in high school, knowledge of basic human anatomy may be an influential factor in choosing a future career in the health sciences.

For students setting out to study anatomy for the first time, comics consisting of simple and concise illustrations may be superior learning tools over others. Anatomy is a