

Systems Guide



This guide lists the ten body systems with parts included in Complexity. Mnemonic clues are explained in the heading of each part, followed by facts that are well documented in textbooks and science journals. Some information may change, however, as scientists continue their quest to unravel the mysteries of life.

Nervous p1

Immune-Lymph p5

Endocrine p2

Integumentary p5

Respiratory p3

Circulatory p6

Digestive p3

Muscular p5

Urinary p5

Skeletal p6

1. NERVOUS SYSTEM: Control ♦ *central control and communications*

The human brain demonstrates unmatched design, purpose, and interdependence.

Structural division: Central (brain and spinal cord) and peripheral nervous system (rest of nerves and sensory organs)

Functional division: Somatic (voluntary control) and autonomic (involuntary).

N1 Frontal Lobe: *The captain of your ship who makes executive decisions*



Left *frontal lobe*: more abstract functions, e.g., logic. Right *frontal lobe*: creative functions, e.g., music.

1. Thought, reason, language, speech, and voluntary actions. Strengthen the captain (exercise, study, volunteer, juggle) to improve concentration, problem-solving, and control.
2. Consciousness, memory storage, and social behavior. The captain can override the limbic system's drives. Thoughts are formed in *cliques* of up to 11 mathematical dimensions.

N2 Limbic System: *Centers for emotions and emotional memory; located in various areas of your brain*



It seems that the *amygdala*, deep inside the temporal lobe, is the central emotional office. It has radar to detect danger and a big alarm button. It makes complex connections to many centers such as the *thalamus*, *hypothalamus*, and the *hippocampus* via the *cingulate gyrus*. The limbic system:

1. Controls mood and basic emotions (fear, pleasure, love, anger).
2. Facilitates drives (hunger, dominance, protection), emotional learning, and memory. Beware the "amygdala hijack" (intense emotional response) when sensing danger.

Warning: Over stimulation of the limbic system (i.e. excessive digital musical entertainment, chronic traumatic events, etc.) negatively impacts your frontal lobe (N1).

N3 Parietal Lobe: *The sensory office of the homunculus - what your brain thinks you look like*



1. This office contains a curled map of everything you feel. Sensitive body areas with a higher density of receptors (touch, temperature, taste, visual input) occupy more space on the map.
2. Two functional regions. One area integrates sensory information to form single perceptions (coincidence); the other constructs 3-D spatial maps based on visual input from the occipital lobe.

Image used with permission from *Max Planck Florida Institute for Neuroscience*. Visit www.maxplanckflorida.org/fitzpatricklab/homunculus to map your brain.

N4 Occipital Lobe: *Television screen that displays images for your brain to see*



1. This center turns everything your eyes detect right side up and interpret images to make sense of colors, patterns, size, and depth.
2. It forwards results to other centers, such as the *frontal* and *parietal* lobes. Damage can cause hallucinations, abnormal coloring or no colors, distorted perceptions (objects larger/smaller), or blindness.

N5 Cerebellum: *Controller of voluntary movements, the "small brain"*



1. Automatically adjusts coordination, balance, and ability to judge distance.
2. Regulates muscle tone, including those of speech muscles. Damage can cause loss of coordination, the inability to judge distance, movement tremors, staggering walking (ataxia), weak muscles, slurred speech, and even abnormal eye movements (nystagmus).



N6 Eye: *An incredible video recorder*



1. Specialized sensor equipment detects photons, and converts it into electrical impulses.
2. Auto-focus, self-cleaning, self-lubricating with 3D rotation, and internal stabilizers. Signals from the rods and cones cells travel along optic nerves to the *occipital lobes* (N4) of opposite hemispheres.

3. RESPIRATORY SYSTEM: Fuel & Waste ♦ *gas exchange*

R1 Nose:



Twin air conditioners with intake, filters, and detectors – more than a fleshy flap on your face. The 2 intake tubes connect with a system of pockets and canals (sinus cavities).

1. Your nose has hairs to trap junk, and a warm damp (mucous) lining to “condition” the air
2. Smell receptors in olfactory clefts. The lymph nodes in the back are called adenoids.

R2 Epiglottis: Trachea:



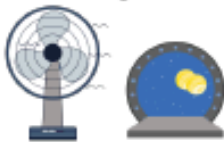
Hatch: a peculiar flexible lid that prevents food and foreign objects from entering the airway.

Windpipe with a microscopic conveyer belt system:

1. An airway tube that is kept rigid by C-rings. Connects the voice box (larynx) to the lungs.
2. The tube wall has 4 layers. The inside lining is a built-in conveyer belt that moves particles up and out of the lungs. It consists of columnar cells with tiny hair-like cilia and a sticky mucus belt.



R3 Lungs:



Two spongy bi-directional fans with gas-exchange portals

1. **Gas exchange:** **Intake** - Oxygen (O_2) rich air needed for cellular respiration. **Outlet** - Disposal of carbon dioxide (CO_2), the respiration waste product.
2. Intricate tree of tubes (bronchi) that ends in ~400 million microscopic portals (alveoli). Tiny blood vessels (capillaries) wrap around every portal to transport the gases. The diaphragm is the fan motor that drives the airflow.

4. DIGESTIVE SYSTEM: Fuel & Waste ♦ *energy recycling, waste management*

D1 Mouth:



Busy port of entry, protected by a network of battle stations (tonsils, etc.)

1. **Tongue:** Mechanical movement of nutrients, speech, taste buds.
2. **Salivary glands:** Secrete lubrication fluid as well as digestive enzymes to digest food (chop at the molecular level). **Teeth:** Mechanical nutrient breakdown, speech. The mouth hosts natural microbes but also defends against invaders (tonsils and other lymph nodes)



D2 Esophagus:



Active nutrient conveyer belt about 25 cm (10") long

1. Waves of muscular contractions called peristalses push food down. Mainly southbound. Can reverse when needed, but it is most unpleasant.
2. You need about 50 pairs of muscles to move food from your mouth to your stomach. Valves at the top and bottom regulate pass-through. If the bottom one leaks, you get acid reflux and ‘heartburn’.

D3 Stomach:



Mechanical food mixer

1. A muscular bag that mixes food with acid and enzymes. The specialized lining can withstand the extremely acidic (sour, $pH=2$) environment.
2. The stomach secretes hydrochloric acid to:
 - kill harmful invaders, such as bacteria
 - facilitate protein breakdown (it activates the enzyme pepsinogen).

D4 Pancreas:



Food preparation supplier (cleaver knives and baking soda) – see also E4

1. Two important *secretory functions*:
 - a. Enzymes to chop up protein (proteases), fat (lipase), and sugars (amylase)
 - b. Baking soda (bicarbonate) to neutralize stomach acid.
2. Secretes up to 8 cups of pancreatic juice a day.
Warning: Handle with care. Pancreatic knives (enzymes) cause severe damage when they leak out.

5. URINARY SYSTEM: Waste ♦ fluid management

U1 Kidneys:



Blood filter and messaging system

1. An ultra-compact system of *micro-filters* that selectively filters ~ 120 liters (30 gallons) of blood/day and produces urine as a waste product. Kidneys maintain the blood electrolyte and fluid balance.
2. Balance *calcium* and *phosphorus* levels in the blood to maintain bone density.
Send **erythropoietin** hormone messages to trigger red blood cell production in the bone marrow.
Monitor blood pressure and send feedback signals to arteries and adrenal glands.

U2 Bladder:



Holding tank for urine

1. Stores *urine* and signals the control centers in the brain when full so you can know it's time to urinate. The bladder muscles contract to empty urine when the brain stops telling it to relax.
2. Special protective and stretchable lining made of *transitional epithelium*.
The *outlet valve* is under voluntary (somatic) and involuntary (autonomic, brainstem) control.

6. IMMUNE-LYMPHATIC SYSTEM: Defense ♦ security and drainage

The **immune system** is a vast network of specialized cells (lymphocytes or white blood cells) and tissues throughout the body. It protects you against the invasion of the pathogenic microbes, and rogue body cells (cancer).

The **lymphatic system** is a widespread web of conduits that act as bilge pumps to your body.

IL1 Lymph nodes: *Security and defense*



1. Hundreds of small bean-shaped structures filter incoming lymphatic fluid, to trap invaders. *Bodyguards* on duty attack and immobilize these pathogens (disease causing bacteria, viruses, protozoa, worms, etc.)
2. Detect and remove *foreign material* and *rogue body cells* (cancer cells)

IL2 Thymus:



Boot camp – see also E3

1. *Training facility* for specialized *T-lymphocytes*. Boot camp lasts 3 weeks.
2. The thymus is critical for your survival from birth to puberty; it will start to shrink after that. The trained T-lymphocytes divide to keep the numbers up after puberty.
The thymus resembles the shape of a thyme leaf, hence the name.

IL3 Spleen:



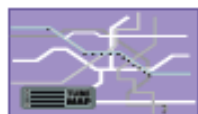
Blood filter, quality control, and blood storage

- *Red pulp*: “test drive” red blood cells to check flexibility (force the cells through slits, so that the older fragile cells break). Saves and stores useful components, e.g., iron.
- *White pulp*: stores about ¼ of all the body's guards (white blood cells) to provide a fast response to invaders in the blood.

The spleen is the largest organ of the lymphatic system; it looks dark purple.



IL4 Lymphatic system: *Vessels for lymph transport and drainage, runs beside your blood vessels*



1. It transports white blood cells, fats, and hormones.
Like bilge pumps, it drains fluid that leaked into the tissues, back to the circulatory system.
2. *Lymph flows away* from tissues to lymph nodes, and eventually into larger thoracic ducts before entering the *subclavian veins*.
This system depends on *skeletal muscle movement* to pump the lymph, which another reason why an active lifestyle is essential for your health!