

Résumé en anglais de IMMUNE (partiel)

Immune: A journey in the Mystery that keeps you alive

This is a book written by the creator of the Kurzgesagt channel who made amazing videos about many topics, but my favorite are clearly the ones about the immune system. And recently they came out with a book called "Immune" that goes much deeper than their videos in the immune system.

I find this topic fascinating so I want to read it and I'll summarize it here. I really advise you to checkout those videos and the book by yourself though.

Chapter 1: What is the immune system?

It begins 3.5 billion years ago when some organisms found it much easier to get into a host and leech their resources than competing with them.

Around 541 million years ago, multicellular animal life suddenly exploded and became visible and much more diverse. To find the history of the immune system we can't do archeology as those cells don't preserve well with time and don't make fossils. So instead we have to look into far related animals in the evolution tree to try to go back in time.

By looking in sponges we found out the first primitive immune response in animals is called "humoral immunity", "humor" meaning "bodily fluids" in ancient Greek. Basically it's very tiny stuff made of proteins that floats through the bodily fluids outside of cells and kill microorganisms that have no business being there. This defence was so useful that virtually all animals around today have it and hasn't changed in half a billion years.

But then after some time, specialized defence came in, "cell-mediated immunity" is here for that. They made able to get a very powerful ability: recognizing enemies and quickly producing dedicated weapons against them and even remember them in the future.

The immune system is not inside of you, it is YOU. It's an expression of your biology protecting itself and making your life possible.

Your immune system is not a singular thing, it's a ton of different means of defence, all connected in a network of vessels. Protein weapons, university where cells can learn who to fight and how, the largest biological library in the universe (able to identify and remember every possible invader).

At its very core, it's a tool to distinguish the "other" from the "self", it doesn't matter if it's meant to hurt you or not, if it's not "you", it gets destroyed. But the immune system tries to establish homeostasis: equilibrium, it tries to calm itself down and not overreacting.

Homeostasis is health, the absence of suffering.

Also, not only do you have to worry about life getting inside of you. But you also have to protect yourself against cancer cells, which is also the work of the immune system. But the immune system itself can become a threat when it overreacts, like in the cases of allergies or autoimmune diseases.

Imagine WWII, but 10 times bigger, completely decentralized and happening within days. This is what happens from your body's perspective when you get a cold.

Chapter 2: What is there to defend?

The body is what there is to defend. But it's very big. If you would be a cell, your body would be a mountain of flesh of the size of twenty Mount Everests.

What the body wants to protect the body from "the outside". The outside can be separated by the skin or membranes. There are 20 squares yards (meters) of surface of skin. But skin is already pretty thick and resistant.

Meanwhile membranes are more sensitive parts of the body, membranes can be lungs, digestion tube, etc. There are 200 square yards of membrane. If you would be a cell, this surface would be the size of the US or Central Europe.

Moreover there are 40 Trillion cells to protect.

Chapter 3: What are your cells?

Cells are fundamental building blocks, but they themselves have building blocks, those are the proteins. Just like us, they have organs called "organelles" like mitochondria that convert food and oxygen to energy (ATP).

Proteins are made of amino acids that are coded by DNA. They can make anything, from signals, to walls or organs. There are 10.24 trillion possible protein chains.

They are built by other proteins in cells that code RNA from DNA that gets into the ribosome to be converted to amino acid chains AKA proteins.

A fascinating thing with proteins is that they are dumb individually, but collectively form everything. This isn't linked to the immune system but it's an important thing to understand this for understanding the rest.

Another fascinating thing is the fact they are so small and light that gravity is not meaningful in that scale. Everything is managed by their shape which defines if they repel or attract each other. Those interactions form the "biological pathway" that defines their behavior and functions. Also they can be extremely fast, 5 m/s which is very fast given the fact they are very very small. If you would be a protein, you would be as fast as a jetplane.

Chapter 4: The Empires and Kingdoms of the Immune System

There are two realms of the immune system, the first one is "innate" and the other one is "adaptive".

The innate immune system is the one you are born with, it's an **unspecific** type of defence that everyone has at birth. Without it we would die in just a few days. The main advantage is that it's very fast.

The adaptive immune system however is a specific type of defence. It's very efficient and can be triggered when the innate immune system can't handle things anymore. The main issue is that it's slower, because it has to be trained. This system also contains the largest biological library in the universe, that makes you able to be protected against EVERY disease in the world.

Chapter 5: Meet Your Enemies

It's important to understand that to your invaders, you are not an enemy, but a full ecosystem, a planet.

Your enemies are pathogens, a pathogen is anything that can cause suffering, and anything can be a pathogen under the right circumstances.

One very common type of pathogen are bacteria. Bacteria are a "simpler" type of life, it's also a very old one dating back billions of years. Some estimations estimate there are 10x more mass of bacterias than animals on earth. This is also because they can reproduce very quickly which is a challenge for your immune system.

Not all bacterias are pathogen, life wouldn't be possible without bacterias.

Chapter 6: The Desert Kingdom of the Skin

The skin is a crucial border that protects all parts of your body. It has to be strong, but also regenerate quickly.

Skin dies and regenerate, the dead skin is an added layer on its own. Every single second, you shed around 40 000 dead skin cells.

Sweat also has the effect to make skin salty, which many microbes don't like. Sweat also contains some passive anti-biotics.

From the perspective of a bacteria, your skin is a dry, salty desert fucked with geysers that spit out toxic fluid and flush enemies away.

We could think there is nothing living on the skin but it's wrong there are a million of bacterias living on every centimeter of skin. They aren't harmful to the body, they're in symbiosis. The body provide food, and they provide protection.

We don't know how the immune system decides who is allowed to settle and who's not.

Chapter 7: The Cut

Small actions on the scale of a human can be catastrophic at the scale of a cell.

Let's say you go on a hike and cut yourself, your skin is breached and bacterias enter your body, find amazing nutrients and place to live between helpless cells.

Cells send alarm signals and the macrophages reacts immediatly. Macrophages are really big, if a cell would be the size of a human, macrophages would be the size of a black rhino. They eat the dead cells and living enemies.

When even those macrophages can't handle the attack, they'll start sending help signals, neutrophils then come.

They start hunting and devouring bacterias but with less care for their surroundings, with a lot of collateral damage until they die of exhaustion. They can even commit suicide and release wide and toxic nets around themselves in the process.

Those toxic nets kill bacterias and make it harder for them to escape.

The cells working on the site started the process of INFLAMATION. Which means they ordered the blood vessels to open up and let warm fluid stream into the battlefield. For one it squeeze the nerve cells (which send pain signals)

Now hours after the infection began, it's time for another cell to come, the DENDRITIC CELL. They monitor the battle and collect samples of the battlefield. The dendritic cell will now call the adaptive immune system for help (it takes about a day).

Chapter 8: The Soldiers of the Innate Immune System: Macrophages and Neutrophils

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INSERT IMAGE OF MACROPHAGE HERE

An activated macrophage can swallow up to 100 bacterias before it dies of exhaustion.

Neutrophils are simpler fellow, they kill everything around and they even come with a "kill switch" to kill themselves. 100 billion neutrophils give up their lives voluntarily and dies every day.

Neutrophils can throw acid at ennemies as well as "granules" which are filled with a deadly load (imagine it as little knives and scissors that are made to cut open and cripple intruders).

Chapter 9: Inflammation: Playing with Fire

Inflammation is the universal response from the immune system to any kind of damage. No matter if you cut yourself, get bruise, bacteria, virus, cancer or allergic reaction.

Damage or danger - preceived or real - causes inflammation.

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