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# Immune System Rap (Parts 1 and 2)

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## Part 1: Non-Specific (Innate) Immunity

It's a dangerous world full of pathogenic germs  
Viruses and fungi and bacteria and worms  
They're trying to invade you, to them you're food and shelter,  
And once they get inside it sends your system helter skelter

But you've got a system for fighting back,  
For recovering your health from infectious attack  
With weapons that leave these pathogens in ruins  
Yeah we're talking 'bout the system that makes us immune

### CHORUS

*It's the immune system  
Sworn to protect you  
From dangerous pathogens that try to infect you  
Three layers of defense keep the germs away  
Letting us live yet another day,*

*Skin and mucous membranes first, then innate defenses,  
For fending off invaders that breach our fences,  
Then specific responses, with lymphocytes B and T  
Let's learn about immunity!*

Our outermost defense is our impermeable skin  
Dead outer cells lined with fibrous keratin  
Covered with secreted lactic acid and lysozyme  
A bacteria dissolving enzyme

At openings like noses there's a mucus-membrane lining,  
A viscous protein fluid trap for pathogen confining,  
And pathogens that enter through the mouth can die quite miserably  
When they're dissolved inside our stomach's sour acidity.

But even with these barriers, some pathogens break through  
Entering through cuts or riding mucus into you  
The next step in defense is non-specific and innate  
We share it with the plants and fungi and invertebrates!

You're born with these defenses that's why they're called  
"innate."

They're implemented when infection starts, no need to wait  
They consist of cells and proteins that make non-specific moves  
Against those foreign entities that enter into you.

The primary components here are white blood cells  
Sentinels or guards who respond when all's not well  
They're leukocytes, they fight invaders in generic ways  
Engulfing them or chemically blowing them away

### CHORUS

Inflammation's a key part of the innate response  
You know it from the swelling and the way a wound feels hot  
Tissue damage from infections or injuries  
Causes leukocytes like mast cells to release histamines

Which makes capillaries leak though vasodilation,  
Leads to redness and to swelling and a painful sensation  
Sentinel cells and tissues emit chemical alarms  
That draw defenders to the scene defending us from harm.

The first cell to arrive could be a neutrophil  
The most abundant type of white blood cell  
They're phagocytes, engulfing viruses and germs  
Devouring pathogens like robins eating worms

These neutrophils gorge themselves until they die defending us  
Their cellular remains accumulate as pus  
Innate responses, they're anything but simple  
Remember that each time you see the pus inside a pimple

Another phagocyte is called a macrophage  
Which means "big eater" they attack with rage  
Dendritic cells are phagocytes too  
Patrolling 'neath the skin and in the lungs and other tissues

A fever is a body-wide systemic inflammation,  
The higher temperature inhibits germ replication,  
And might also enhance immune cells' phagocytic action  
As fever ramps up our body's chemical reactions.

### CHORUS

Natural killer cells are also on the innate team  
Detecting body cells that display abnormal proteins  
Indicating viral infection or cancer  
And when they meet abnormal cells here's their deadly answer

These killers release perforins that perforate with holes  
Infected cells' membranes making them explode  
Along with secretion of deadly granzymes  
That induce infected cells to commit suicide

Even the infected cells try to do their part  
Secreting interferons, proteins that make it hard  
For viruses to penetrate the cell membranes  
Of uninfected nearby cells which keeps them in the game

Complement's another part of innate immunity  
It's made of 30 proteins, that work as a community  
To open holes in membranes of invading bacteria  
Destroying them and clearing out infection from that area.

Now that's innate immunity, part one of our song,  
So join us in immune part two so you can sing along,  
As we learn 'bout defenses acquired and specific  
Immunity, it's really terrific!

### CHORUS

## Part 2: Non-Specific (Innate) Immunity

Welcome to immune system rap part two

Now we'll learn what the specific responses can do,  
When innate defenses start to be breached,  
Antibodies and Killer T cells are unleashed

The specific response has three distinct components  
Recognize, overcome, remember your opponent.  
It's acquired, adaptive, improving over time.  
It lets you beat back pathogens it keeps you in your prime

The cells that carry out specific immunity,  
Are known as lymphocytes they go by letters B and T  
They're often found in lymph nodes, your body fluid's filters  
You feel them get swollen when your system gets off-kilter

These specific responses are a vertebrate feature,  
Not found in bugs or worms or any lacking-backbone creature  
The response is elicited by what's called an antigen  
A portion of a molecule on an invading pathogen

"Antigen" means "antibody generator"  
Polysaccharides or proteins on the cells of an invader  
Antibodies are proteins B lymphocytes secrete  
To bind with unique antigens and lead them to defeat

Both Bs and Ts can recognize specific pathogens  
Through receptors on their membranes that bind with antigens  
A B-cell receptor's made of four polypeptide chains,  
With forms a kind of Y the stem is stuck into the membrane

Two of the chains are heavy, two of the chains are light  
The two tips of the Y form the antigen binding sites.  
Activated B cells secrete their receptors,  
As antibodies they're our system's number 1 protector

Random recombining within B and T receptor genes  
Generates amazing receptor shape diversity  
The staggering assortment of B and T receptors,  
Lets us recognize specific invaders when they enter

T receptors are quite different but their function is the same.  
They can bind with almost any antigen that can be named,  
They're just two chains, and right at their tip  
Is the specific shape that binds invaders in their grip

T cells come in two main varieties.  
The Helper T's the general in the immune system army,  
And cytotoxic, killer T cells: they're assassins  
They kill those zombie cells controlled by viral pathogens

### CHORUS

Let's examine how our B cells respond to an infection.  
The big picture here's called clonal selection.  
A B-cell receptor binds an antigen with matching shape  
This activates the B cell which divides and makes

A clone of plasma cells whose job is to secrete,  
Antibodies for that specific antigen they'll meet  
Antibody action through our body fluids is called humoral.  
We'll see below the ways it send invaders to their funerals

B cell activation starts when phagocytic cells  
Dendritic cells or macrophages, all these sentinels  
Devour a pathogen, then break it down  
Then hold it up as antigen showing what they found

The antigen's displayed on special protein  
Part of a family called MHC  
"MHC's" for "Major Histocompatibility  
Complex," it's used to say "this is me I'm on your team

And here's a little something, that's trying to infect us."  
We gotta do something, or this'll be the end of us."  
Our phagocytic sentinels use MHC class 2,  
And holding up their antigen they make their move

To lymph nodes, where they bind with a Helper T  
Whose receptor is also complementary,  
To the antigen that the phagocyte's displaying  
This is the connection for which we've been praying

The Helper T grabs on with its CD4 protein,  
Which connects antigen presenting cell and Helper T  
And now the two cells, messages exchange  
Inducing the Helper T to change

The messages are in the form of cytokines,  
Secreted proteins that are used to define  
Other cells' function, and even their form,  
In this case they induce a Helper T swarm

Helper T clones itself into identical versions  
Each of which has the receptor for the antigen  
These helper Ts wait in a lymph node till they find,  
A B cell to whom the same antigen did bind

Which means both B and Helper T have receptors  
That complement the shape of this antigen infector,  
Cytokines from Helper T get B cell to start division.  
Makes a plasma cell army that's devoted to the mission

Of secreting antibodies 2000 per second per cell  
These bind with antigens on pathogens which feel like hell  
Was unleashed as antibodies act like a tag  
So that phagocytes can put those germs inside the bag

It's called opsonization, an antibody trick,  
Here's another antibody move that's pretty sick  
By binding viral proteins antibodies prevent  
Viruses from binding to cells they might infect

Gumming up these viruses is neutralization.  
Another immune system way of pathogen negation  
Antibodies also boost the complement system  
Infected cells and germs explode they're antibody victims!

### CHORUS

Killer T is an assassin, not to be under-rated.  
These cytotoxic killers do a cell mediated response,  
Like Bs, Killer-Ts, need prior activation  
By a phagocytic cell that makes a presentation

Of antigen displayed in an MHC protein  
And often Helper Ts assist this activation scene  
Once activated Killer Ts clone themselves into a platoon  
That roams the body to bring about the doom

Of body cells with cancer or an infection,  
And here's how Killer T's do target detection  
Their T cell receptor binds with the antigen  
Held aloft by tissue cells which are infected

The antigen's held up in their class one MHC  
The sickly tissue cell's, saying "look what inside of me!  
So the killer T grabs hold with protein CD8  
And then proceeds to assassinate

The infected cell, it's a mercy killing  
Using perforins for membrane drilling  
And granzymes to induce apoptosis  
Infected cells die from these lethal doses

Remembering's the last step in immunity  
Allowing you to face repeat invaders with impunity  
B and T memory cells are the trick  
That build up your immunity – keeps you from getting sick.

Every time your specific responses have a victory,  
There's not only effector cells there's also cells for memory  
These memory cells stay behind with their receptors  
Waiting to bind the same disease-causing vector

So in the next infection you skip all the preliminaries,  
And go right to cloning plasma cells and even Killer-Ts  
This mobilization means you'll bring germs to their knees  
You'll wipe them out before you feel the symptoms of disease!

That's why the first immune response you have is rather weak,  
You beat the pathogen but mobilizing took you weeks  
But the second response you have can really be fine!  
Many, many, many more antibodies made much less time!

And that's how vaccination works to keep away disease,  
Injecting harmless antigens to develop memory  
Cells with receptors that detect and arm  
The specific immune response that keeps us from harm