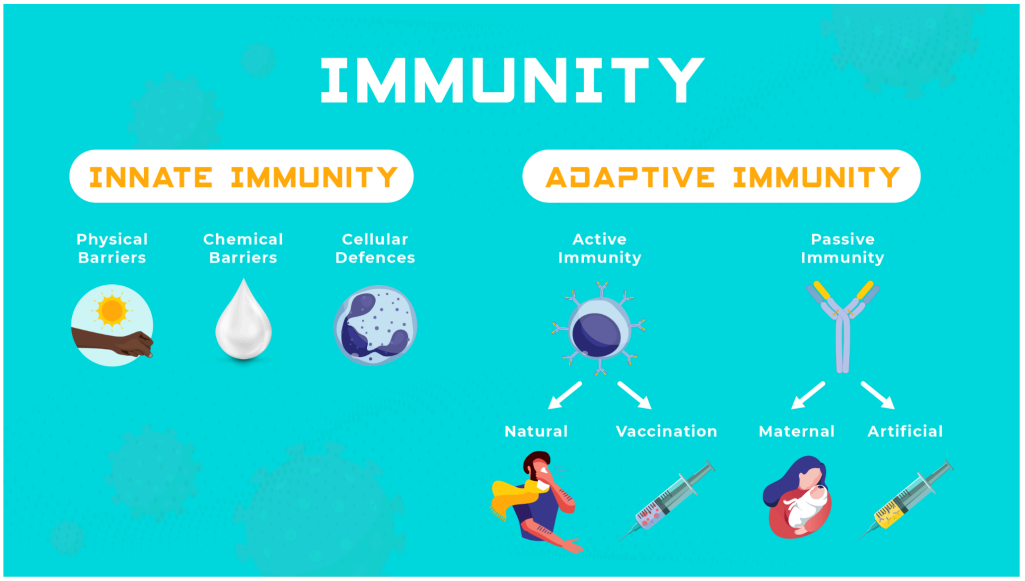
First Line of Defense: Barriers Against Infection

Our body has natural barriers to stop germs before they enter:

- **Skin**: Acts like a wall, blocking germs.
- **Saliva & Tears**: Contain special substances that kill bacteria.
- **Mucus in Lungs & Gut**: Traps germs before they can cause harm.
- **Tiny Hairs in Airways**: Sweep away dirt and germs from the lungs.

If these barriers fail, the immune system steps in to fight the infection.



The immune system has two main parts:

- Innate Immunity (Born-with Defense):
    - First line of defense (skin, mucus, stomach acid).
    - Acts fast but doesn't remember past infections.
    - Includes white blood cells like neutrophils and macrophages that eat germs.

The Innate Immune System (First Response Team)

- **Mast Cells & Basophils**: Release histamine to cause inflammation, helping fight infections.
- **Neutrophils & Macrophages**: Eat and destroy germs (a process called phagocytosis).
- **Natural Killer (NK) Cells**: Destroy infected and cancerous cells.
- **Eosinophils**: Special cells that fight larger parasites, like worms.
- **Complement System**: A group of proteins in the blood that helps destroy bacteria.

In 1796, Edward Jenner, a British physician, discovered that inoculation with cowpox could protect against smallpox, leading to the development of the first successful vaccine and the term "vaccination".

In 1796, **Dr. Edward Jenner**, an English physician, observed that **milkmaids who contracted cowpox (a mild disease in cows) did not get smallpox**. He hypothesized that exposure to cowpox provided immunity against smallpox.

Adaptive Immunity (Learned Defense):

Takes time to respond but remembers past infections.

Includes T cells (which attack infected cells) and B cells (which make antibodies).
Two Types of Adaptive Immune Responses

- **Cellular Immunity (T Cells at Work)**
    - T cells hunt down and kill infected cells.
- **Humoral Immunity (B Cells & Antibodies)**
    - B cells make antibodies that float in the blood and attack germs.

The Adaptive Immune System (Memory & Targeted Defense)

- **B Cells**: Make **antibodies** that stick to germs and mark them for destruction.
- **T Cells**:
    - **Helper T Cells (CD4+):** Tell other immune cells what to do.
    - **Cytotoxic T Cells (CD8+):** Kill infected or cancerous cells.

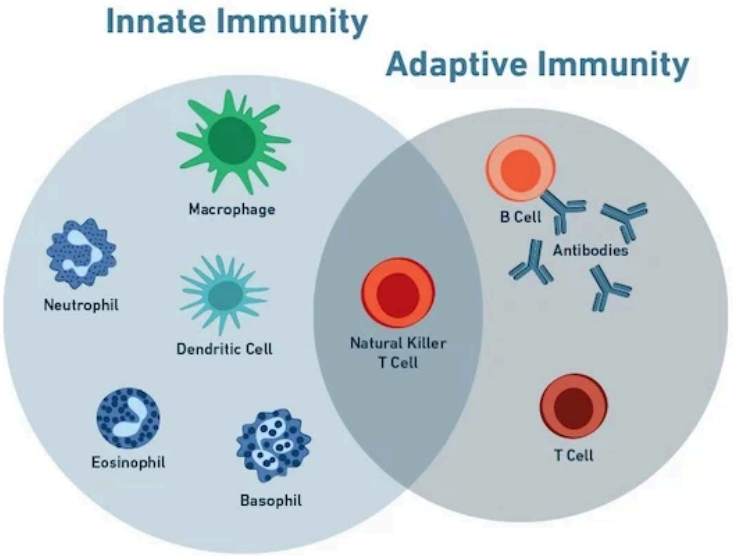
All immune cells are made in the **bone marrow**.

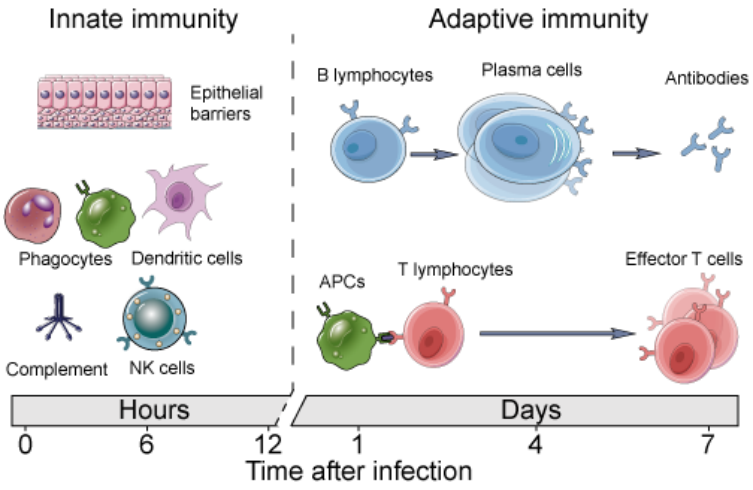
- **T cells** mature in the **thymus**.

- Immune cells are stored in places like the **lymph nodes, spleen, and mucosal tissues** (gut & lungs).

The **lymphatic system** helps move immune cells and fight infections.

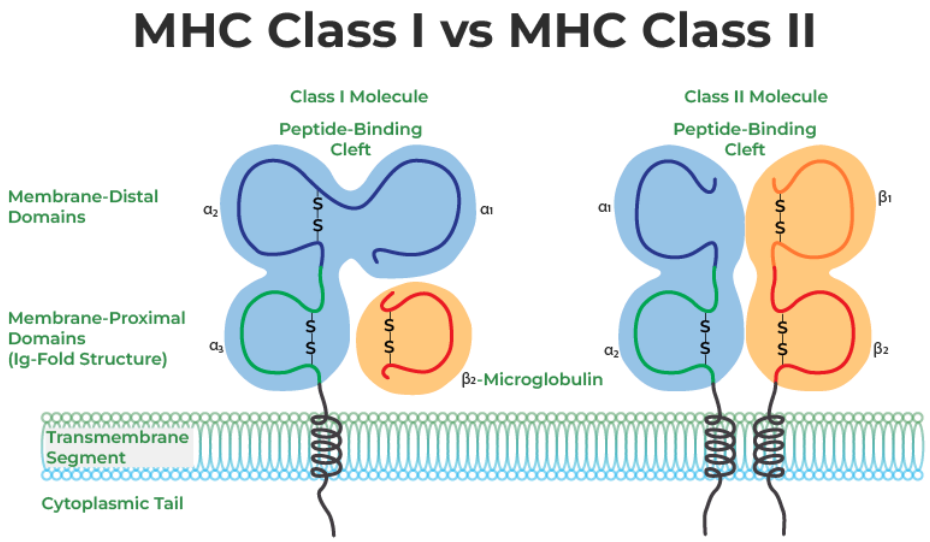
- White Blood Cells (WBCs): The body's soldiers that fight germs.
  - Neutrophils: The first to fight germs.
  - Macrophages: Eat germs and show the pieces to T cells.
  - T Cells:
    - **Helper T cells (CD4+): Tell other immune cells to act.**
    - **Cytotoxic T cells (CD8+): Kill infected cells.**
  - B Cells: Make antibodies that stick to germs and help destroy them.
  - Natural Killer (NK) Cells: Kill virus-infected and cancerous cells.

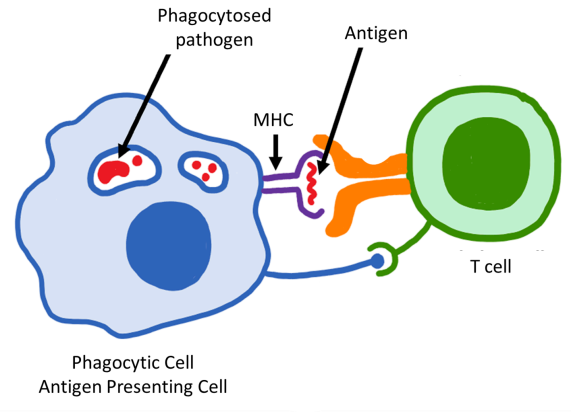




How Does the Body Start an Immune Response?

- **Antigen-Presenting Cells (APCs)**: Special cells (like dendritic cells and macrophages) grab pieces of germs and show them to T cells, telling them to fight.
- **MHC (Major Histocompatibility Complex)**: Helps immune cells recognize invaders.
    - **MHC Class I**: Helps cytotoxic T cells recognize infected cells.
    - **MHC Class II**: Helps helper T cells guide immune responses.





MHC and Mate Selection: Why Does It Matter?

Some animals (and even humans) prefer mates with **different MHC genes** from their own. Why?

- A child with **diverse MHC genes** will have a **stronger immune system**.
- Some species (like sand lizards) can detect MHC differences **through smell** and choose mates accordingly.

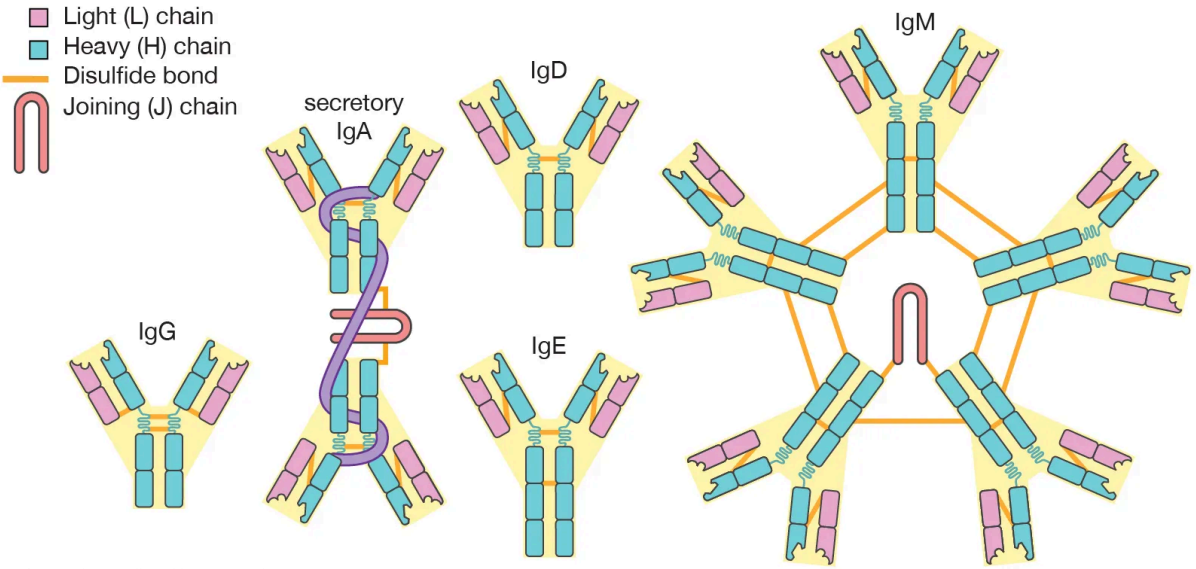
Does This Happen in Humans?

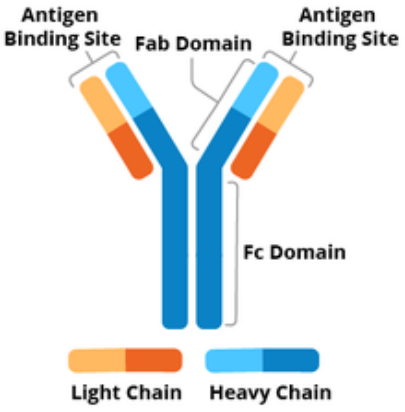
Research suggests that humans **might** prefer mates with different MHC genes. Some studies show that people are more attracted to the smell of someone with **different MHC genes**, but cultural factors also play a role in mate choice.

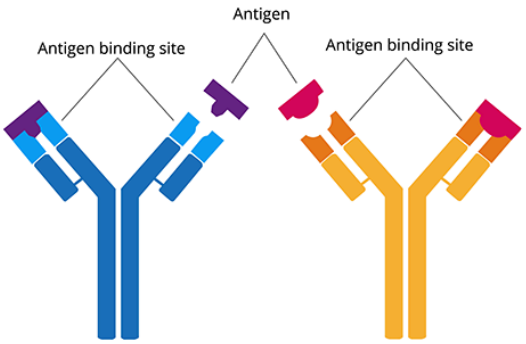
4. What Are Antibodies?

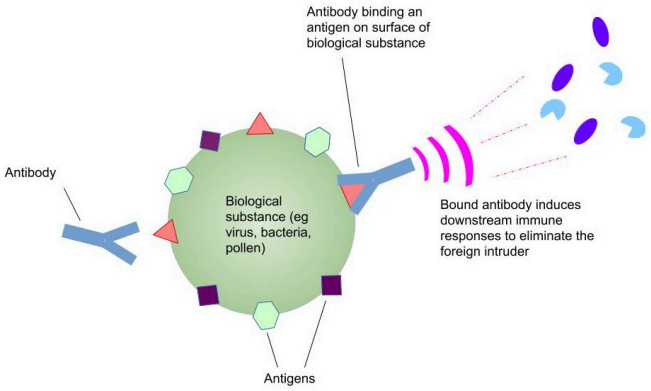
Antibodies are special proteins made by B cells to fight infections. Different types of antibodies have different jobs:

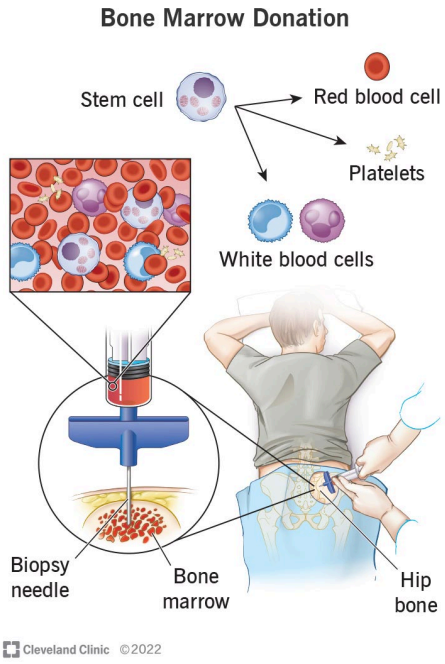
- IgG: The most common, helps fight infections.
- IgA: Found in tears, saliva, and mucus (guards entry points).
- IgM: The first antibody made when infection starts.
- IgE: Helps fight parasites and causes allergies.
- IgD: Helps B cells get ready to fight.











Bone marrow donation, or bone marrow harvesting, is the procedure healthcare providers use to obtain blood-forming cells (stem cells) for bone marrow transplant. To do the procedure, healthcare providers use large hollow needles that pull bone marrow from donors' hips (pelvic bones). Donating bone marrow doesn't hurt and may cure someone who has blood cancer or a blood disorder.

How Does the Immune System Adapt to a Bone Marrow Transplant?

A **bone marrow transplant (BMT)** replaces damaged or diseased bone marrow with healthy stem cells from a donor. Since bone marrow produces blood cells, including immune cells, the recipient's immune system must adapt to the new donor cells. This process involves several key steps:

1. **Eliminating the Old Immune System** – Before the transplant, patients undergo chemotherapy and/or radiation to destroy their existing bone marrow, reducing the risk of the body rejecting the new stem cells.
2. **Engraftment & Immune Rebuilding** – The donated stem cells settle in the recipient's bone marrow and begin producing new blood cells, including immune cells. This process, called *engraftment*, takes a few weeks.
3. **Graft-versus-Host Disease (GVHD) Risk** – In cases of mismatched donor transplants, the donor's immune cells may attack the recipient's body, leading to *GVHD*. Doctors manage this with immunosuppressive drugs to help the immune system tolerate the new cells.

4. **Long-Term Adaptation** – Over months to a year, the immune system rebuilds itself, recognizing the new cells as "self" while still fighting infections. Vaccinations may be needed to restore immunity lost during the transplant process.

Leukemia is a cancer of the blood-forming tissues, including **bone marrow** and the lymphatic system, characterized by the abnormal and rapid production of white blood cells. These abnormal cells crowd out healthy blood cells, impairing the body's ability to fight infection, carry oxygen, and control bleeding.

https://www.malariagen.net/resource/34/

Simplified Explanation of the Pf7 Malaria Dataset

The **Pf7 dataset** is a large-scale collection of **genetic data from over 20,000 samples of *Plasmodium falciparum***, the parasite that causes malaria. It was developed by the **MalariaGEN network** to help scientists study malaria genetics, drug resistance, and parasite evolution. This dataset is nearly **three times larger** than its previous version (Pf6, 2021) and includes data from **33 countries**.

Scientists use **whole genome sequencing (WGS)** and **genetic variation analysis** to:

- Track how the malaria parasite evolves and spreads.
- Identify **drug resistance mutations** to improve treatment strategies.
- Study **genetic differences** in the parasite across different regions.

Older Data Tools:

- **Pf3k Exploration Tool** – Contains **2,512 samples from 14 countries** (now outdated).
- **P. vivax Data Tool** – Contains **228 samples from 13 countries** (still useful).
- **Pf Community Project Tool** – Includes **3,488 samples from 23 countries** (now outdated).
- **P. falciparum Genetic Crosses Tool** – Analyzes **98 samples from genetic studies** (still relevant).

The dataset includes information on **82 contributing studies**, sample collection details, and **genetic markers linked to resistance against 10 malaria drugs**. All data are available for **open-access research**, and tools like the Pf7 app and Python-based resources help researchers analyze the data without downloading it. This dataset is a key resource for **malaria control, drug development, and vaccine research** worldwide. 🌍🔬

Key Bioinformatics Tools & Databases

- **Microbiome Analysis:** Tools like **Greengenes, SILVA, and Human Oral Microbiome Database (HOMD)** help identify bacteria in the body.
- **Pathogen Detection:** Tools like **MG-RAST, PathSeq, and ezVIR** analyze sequencing data to find known and unknown viruses, bacteria, and fungi in patient samples.
- **Drug Resistance Studies:** Databases like **CARD, ARDB, and ResFinder** help identify genes that make bacteria resistant to antibiotics.

- https://ardb.cbcb.umd.edu/
- https://card.mcmaster.ca/
- https://www.cancer.gov/ccg/research/genome-sequencing/tcga
- **Pathogenicity & Virulence:** Tools like **PathogenFinder and PATRIC** help predict whether a newly discovered bacterium is harmful.
- https://cge.food.dtu.dk/services/PathogenFinder/
- https://www.mg-rast.org/
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