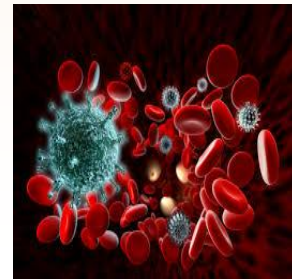
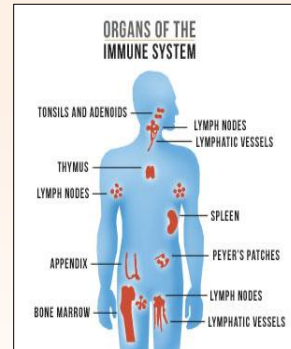


## Ch. 11: Immune Physiology

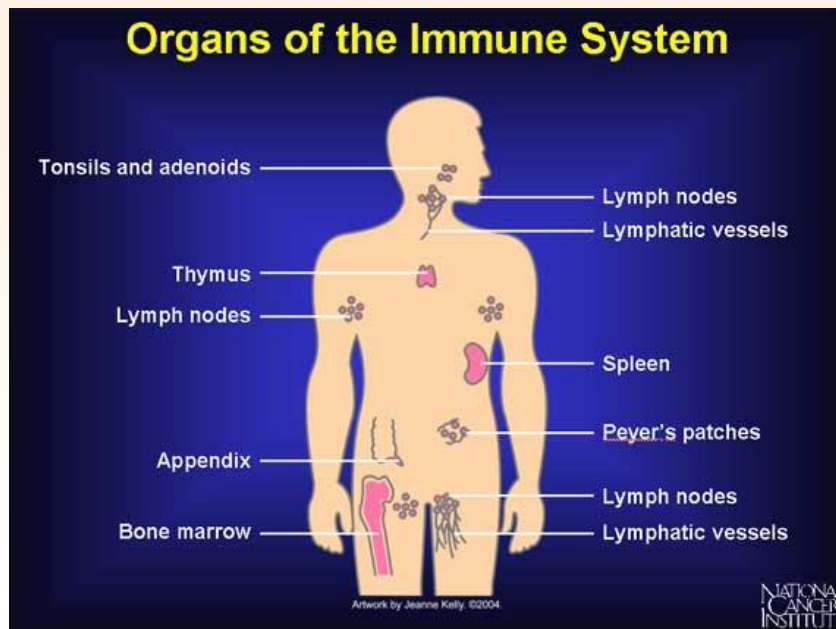
### Objectives:

1. Review immune organs & cells.
2. Two categories of immunity: innate vs adaptive
3. Understand functions of adaptive immunity cells (T-cells and B-cells)
4. Natural vs artificial immunity
4. Understand autoimmunity disorders.



1

### 1. *Review* Immune Organs & Cells.



2

## 1. **Review** Immune Organs & Cells. Pg 164 Wiki text

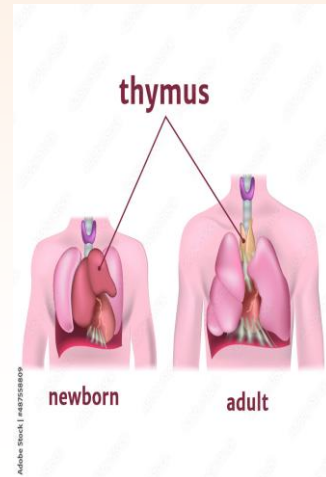
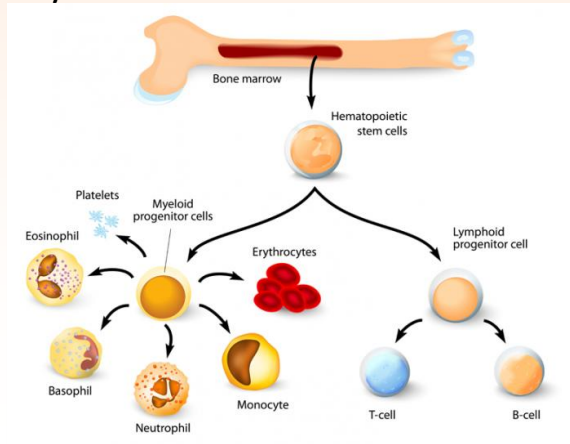
**Immune system** = The cells & organs that defend against pathogens & cancer.

### 1) **Lymph Organs:**

**A. Primary lymph organs** = where lymphocytes develop & mature

> **Bone marrow** -

> **Thymus** -



3

## 1. **Review** Immune Organs & Cells. Pg 164 Wiki text

**Immune system** = The cells & organs that defend against pathogens & cancer.

### 1) **Lymph Organs:**

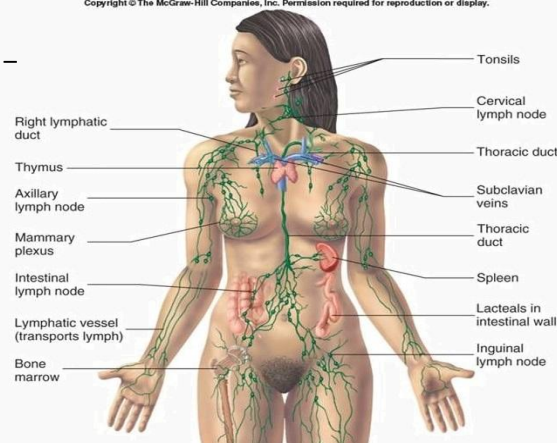
**A. Primary lymph organs**

**B. Secondary lymph organs.** = where immune responses are initiated.

> **Lymph nodes** -

> **Lymphatic & blood vessels** -

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4

## 1. **Review** Immune Organs & Cells. Pg 164 Wiki text

**Immune system** = The cells & organs that defend against pathogens & cancer.

### 1) **Lymph Organs:**

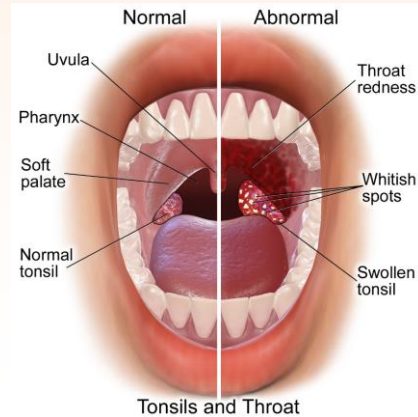
#### A. Primary lymph organs

**B. Secondary lymph organs.** = where immune responses are initiated.

- > Lymph nodes –
- > Lymphatic & blood vessels –

> **Tonsils** –

> **Spleen** –



5

## 1. **Review** Immune Organs & Cells. Pg 164 Wiki text

**Immune system** = The cells & organs that defend against pathogens & cancer.

### 1) **Lymph Organs:**

#### A. Primary lymph organs

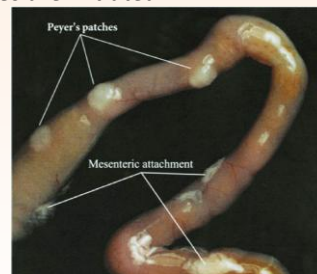
**B. Secondary lymph organs.** = where immune responses are initiated.

- > Lymph nodes –
- > Lymphatic & blood vessels –
- > Tonsils –
- > Spleen –

> **Intestines** –

> **Appendix** –

> **Liver** –



**What is the purpose of your appendix?**



6

## 1. **Review** Immune Organs & Cells. Pg 164 Wiki text

**Immune system** = The cells & organs that defend against pathogens & cancer.

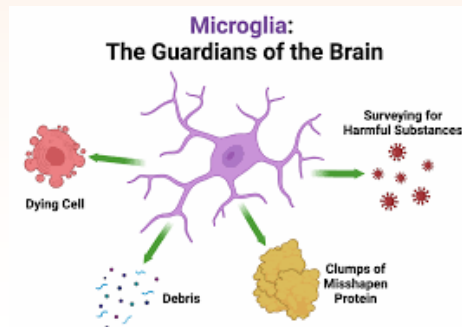
### 1) **Lymph Organs:**

#### A. Primary lymph organs

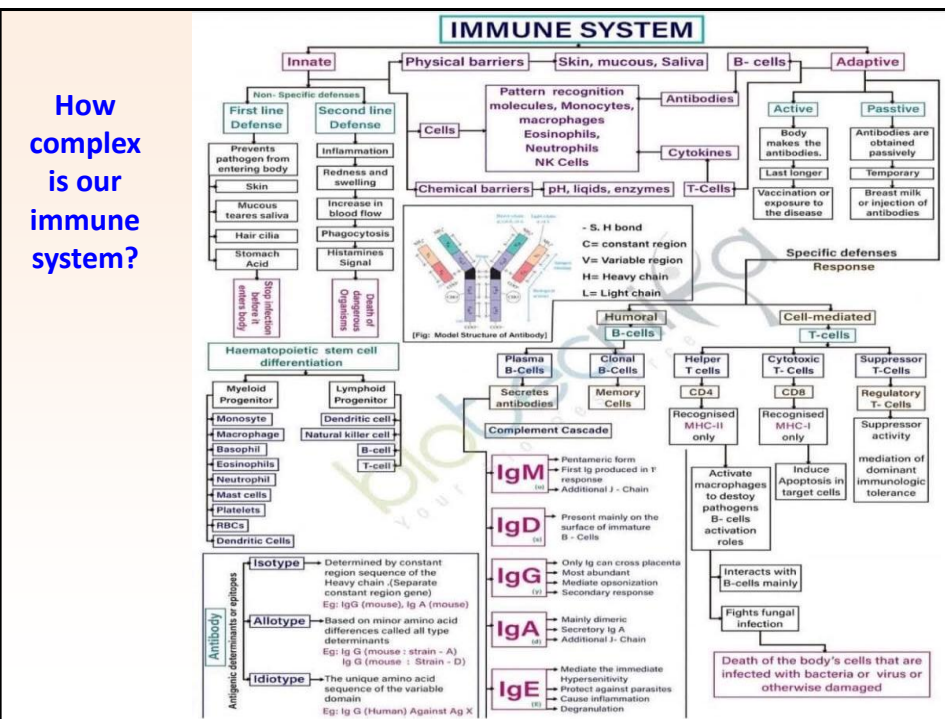
**B. Secondary lymph organs.** = where immune responses are initiated.

- > Lymph nodes –
- > Lymphatic & blood vessels –
- > Tonsils –
- > Spleen –
- > Intestines –
- > Appendix
- > Liver

> Brain –



7



8

## We will be simplifying it a bit ...

You will be able to study this chapter with the aid of some flow diagram:

Click [HERE](#) for sequence of immune response starting with a pathogen gaining entry into your body, from innate immune response to adaptive immune response.

Click [HERE](#) for the outline of the innate immune system (including external and internal innate response) and the adaptive immune response (t-cells and b-cells).

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### 3 Lines of Defense from Pathogens! Pg 162 Wiki text

A) External Innate Immunity (non-specific)

---



B) Internal Innate Immunity (non-specific)

---



Adaptive or Acquired Immunity (specific)

---



---

10

## 1) Innate Immunity (non-specific)

### A. External Innate Defense (barriers to keep things OUT of your body)

- **Epithelial membranes**
  - > skin
  - > sweat
- **Stomach acid –**
- **Respiratory tract –**
- **Urinary / genital defense =**
- **Eyes -**



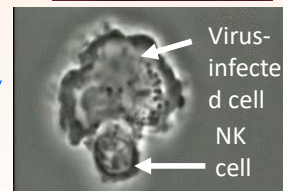
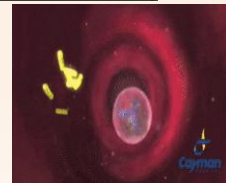
11

## 1) Innate Immunity (non-specific)

### B. Internal innate defense (if things get in, try & kill them without antibodies)

#### Step 1. Phagocytic WBC Cell response.

- > **Neutrophils** & **Monocytes** in blood \_\_\_\_\_
- > WBCs secrete **endogenous pyrogens** \_\_\_\_\_.
- > WBCs secrete **cytokines & chemokines** - \_\_\_\_\_



#### Step 2. Natural killer (NK) cells

- > secrete **interferons** \_\_\_\_\_.
- > **toxic granules** \_\_\_\_\_



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## 1) Innate Immunity (non-specific)

### B. Internal innate defense (if things get in, try & kill them without antibodies)

#### Step 1. Phagocytic WBC Cell response.

- > Neutrophils & Monocytes in blood attack, engulf, & kill pathogens
- > WBCs secrete **endogenous pyrogens** to cause **fever response**.
- > WBCs secrete chemical cries for help (**cytokines & chemokines**)

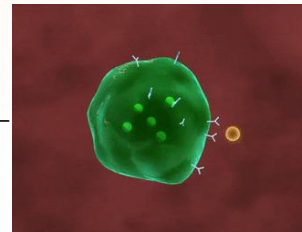
#### Step 2. Natural killer (NK) cells

- > secrete **interferons** to kill viruses.
- > **toxic granules** to kill tumor/cancer cells.

#### Step 3. Inflammatory response

- > **Mast cells** – \_\_\_\_\_
- > **Complement proteins** – \_\_\_\_\_

*Mast cell  
secreting  
histamine*



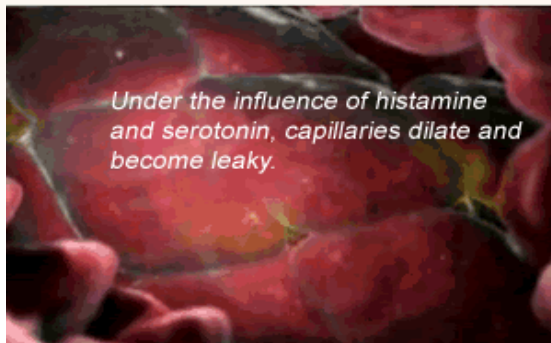
13

#### Step 1: Phagocytic WBC response:

1. In bloodstream - **Neutrophils & Monocytes** are **phagocytes** that destroy pathogens & secrete endogenous pyrogens (cause fever).



2. Histamine secreted by mast (basophil) cells makes blood vessels “leaky” so WBC can escape, especially **monocytes** which “**extravasate**” out of capillary into tissues.



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### Step 1: Phagocytic WBC response:

3. **Monocytes** migrate from blood into tissues by **extravasation** to become \_\_\_\_\_ that destroy pathogens in tissue.

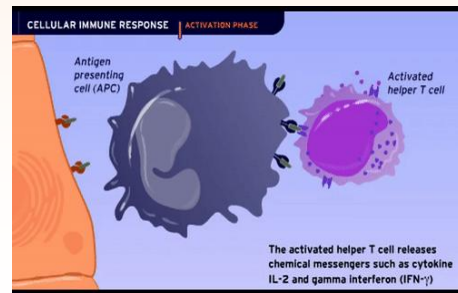
4. Macrophages places pathogen's antigen it cell surface – now macrophage is called an \_\_\_\_\_ (**APC**).

**APCs will activate** \_\_\_\_\_ (see later in notes)

- Phagocytes then send chemical "Cries for help" = **cytokines, chemokines**



A macrophage becoming an APC

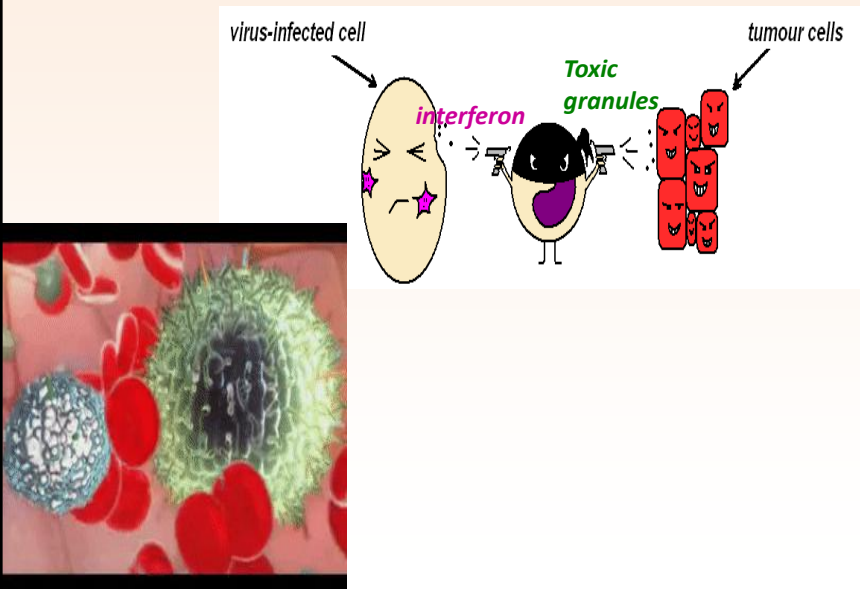


An APC activating a helper T-cell

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### Step 2. Natural Killer (NK) Cell response

- are activated by cries for help (cytokines, chemokines)
- release interferon to kill virus-infected cells.
- release toxic granules to kill tumor cells.

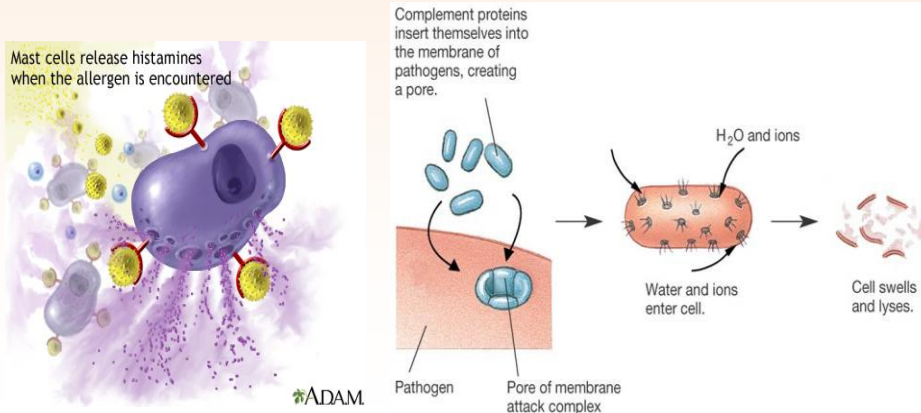


16



### Step 3. Inflammatory Response

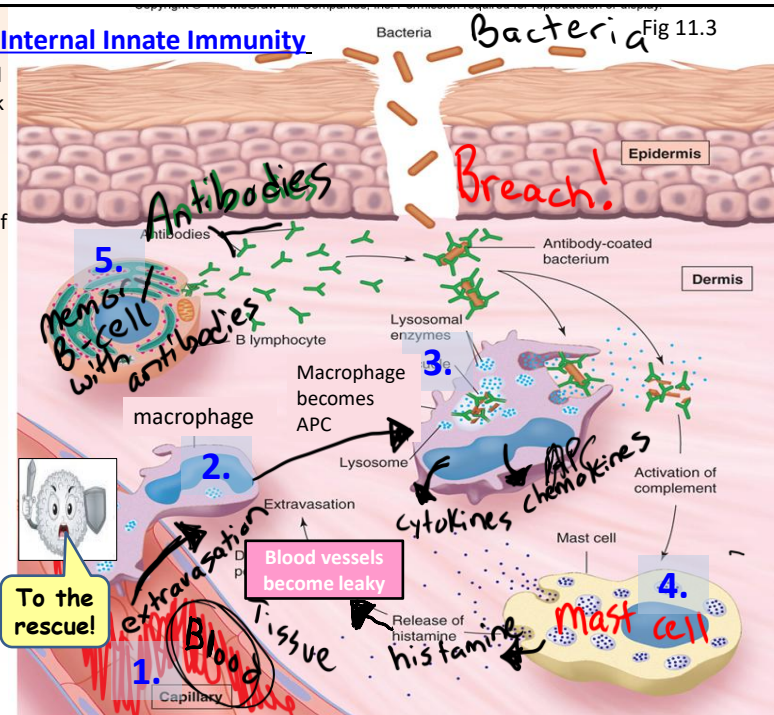
- **Mast cells** – secrete **histamine** for inflammation. Causes vasodilation of blood vessels. (Allows more WBCs to enter into tissue as macrophages!)
- **Complement proteins** - kill bacteria by making holes in them (bacteria burst!) & cause inflammation.



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### Activation of Internal Innate Immunity

1. Neutrophil and monocytes attack pathogen in blood, secrete pyrogens (fever)
2. Extravasation of monocyte in tissue
3. macrophages eat pathogen, become APC (will activate T-cells, & cry for help (cytokines & chemokines))
4. Mast cells release histamine (start redness & swelling)
5. Cytokines & chemokines call cells of adaptive immunity



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## Review

### > Review of Immune Organs and Cells

### > Innate Immunity (2 types)

**External innate immunity** (keep pathogens OUT)

**Internal innate immunity** (activate when pathogens get in)



### > Activation of Internal Innate immunity

- **Neutrophils & monocytes** (phagocytic cells in blood that attack pathogens)
  - > secrete endogenous pyrogens (fever)
  - > secrete chemical cries for help (cytokines & chemokines)
- **Phagocytic cells in tissue** (macrophages, which become APC)
- **Natural killer (NK) cells**
  - > interferon to kill viruses & toxic granules to kill tumor cells
- **Mast cells**
  - > secrete histamine for inflammation response (edema, redness, pain, vasodilation)
- **Complement proteins**
  - > poke holes in bacteria to lyse them

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## Activation of Adaptive Immunity – or long term specific defenses

### Adaptive immunity:

#### Provided by lymphocytes

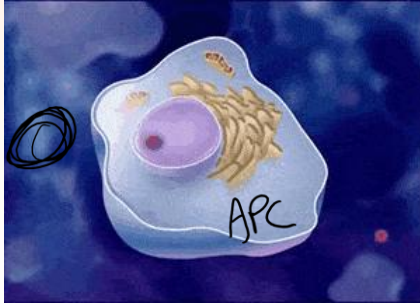
- > Are produced in bone marrow
- > T-lymphocytes (**T-cells**) & B-lymphocytes (**B-cells**)
- > T-cells mature in **thymus**.
  - Are involved in **Cell-Mediated Immunity**
  - T-cells must activate first in order to activate B-cells
- > B-cells mature in lymph nodes & spleen, and produce **antibodies**.
  - Are involved in **Antibody-Mediated Immunity**

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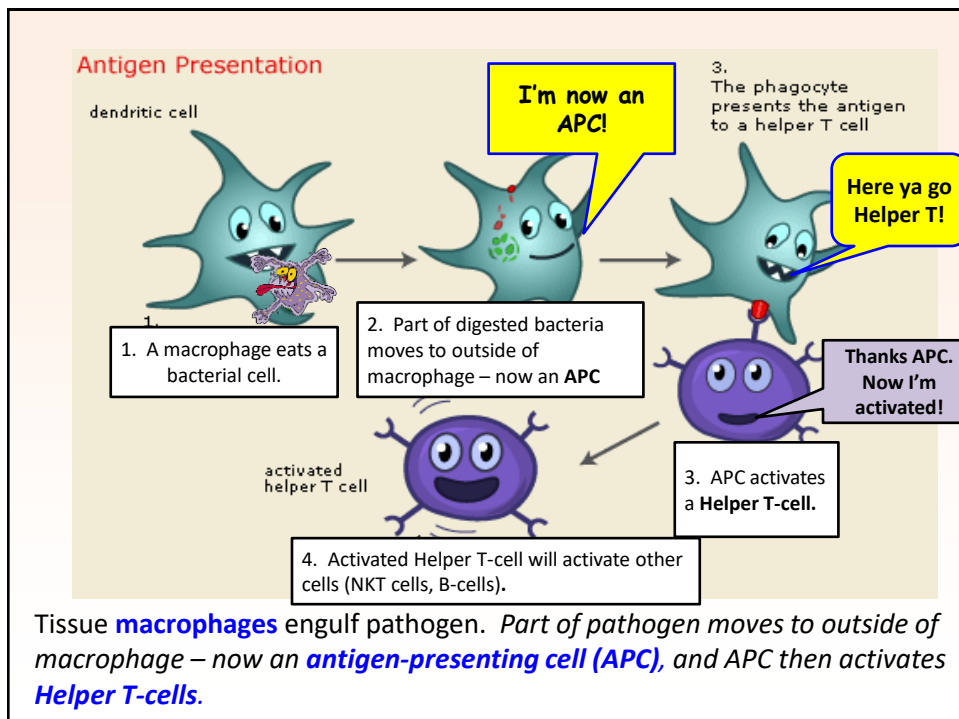
## How do T-cells get “activated”?

### By Antigen-Presenting Cells (APCs) of the internal innate immunity

- APC presents antigen to Helper T-cells
- Helper T-cell then is ACTIVATED!



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## Two types of Adaptive Immunity:

### 1. Cell-Mediated Immunity (T-cells!)

• **Helper T-cells** (activated by APCs)  
Now activates other T-cells:

> **Cytotoxic T cells ( $T_C$ )**

- \_\_\_\_\_

> **Memory T cells ( $T_M$ )**

- \_\_\_\_\_

> **Regulatory T-cells ( $T_{reg}$ )**

– inhibit  $T_C$  and B cells.

– may guard against allergies & autoimmune disease.

• **Helper T-cells** activate **B-cells** to make antibodies.

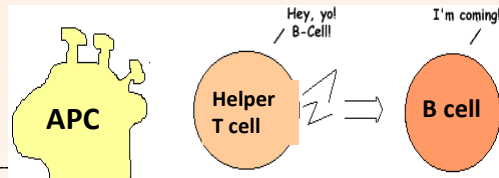


Figure 5  
T-helper cell is activated and triggers the immune response, sending out messages to activate the B-cells.

### 2. Antibody-Mediated Immunity (B-cells)

• **B-cells** are activated by Helper T-cells & make **antibodies** (or immunoglobulins) specific to the pathogen.

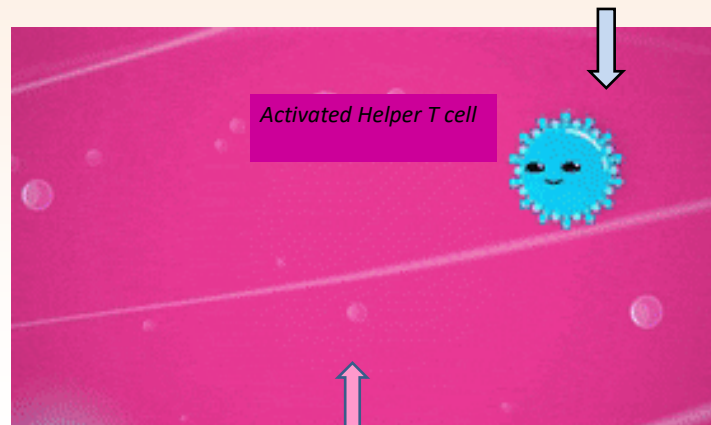
• Results in formation 2 types of B-cells

> \_\_\_\_\_

> \_\_\_\_\_

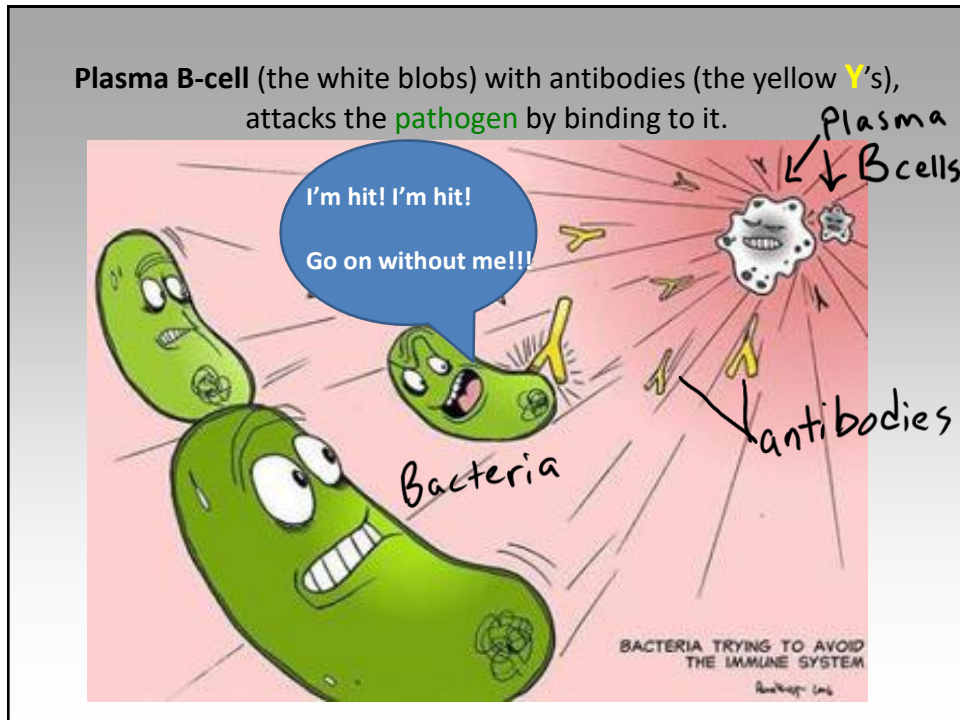
23

**Activated T-cells stimulate B-cells (plasma cells) to make antibodies to an antigen.**

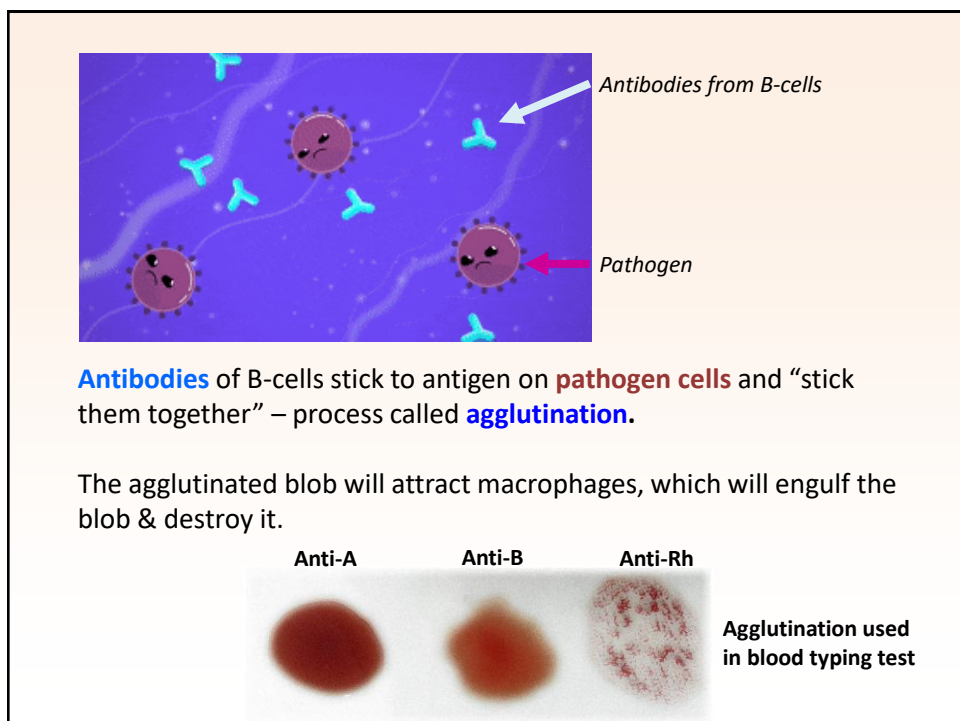


Helper T cell activating a B cell to make antibodies specific to pathogen

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## More about B-Cells

- > Activated by stimulation by activated Helper T-cells.
- > produce **antibodies (immunoglobulins)** to specific antigens
- > Provides **humoral (or antibody-mediated, or specific immunity)**

> Exposure of B-cell to its specific antigen causes release of antibodies to bind to antigens.

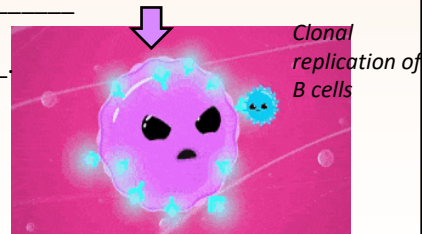
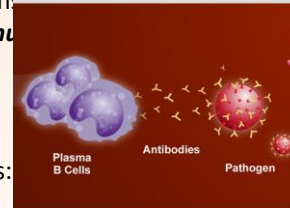
> causes clonal production of 2 types B-cells with antibodies:

A) **plasma B cells** \_\_\_\_\_

B) **memory B cells** \_\_\_\_\_

### Effects of antibodies:

- **Activate complement proteins**
- \_\_\_\_\_
- **Agglutination reaction** (antibodies sticks antigen-bearing cells together)  
"tags" pathogenic cells so they're recognized & destroyed by phagocytes.



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## Action of B Lymphocytes

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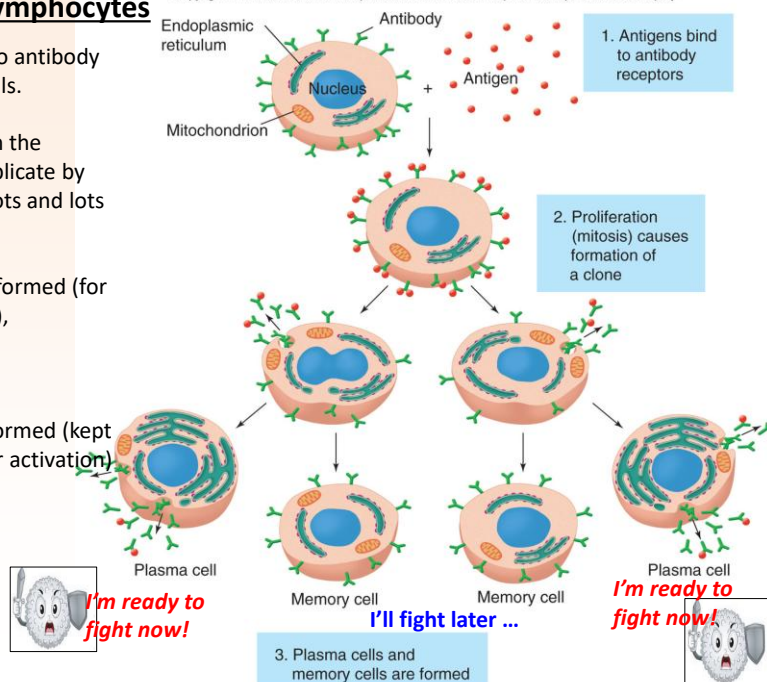
**1. Antigen binds to antibody receptors on B-cells.**

**2. On contact with the antigen B-cells replicate by cloning to make lots and lots more B-cells.**

**3. Plasma B-cells formed (for immediate action),**

and

**Memory B-cells formed (kept in storage for later activation)**



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### Sequence of events, from entry of pathogen into the body to the formation of antibodies:

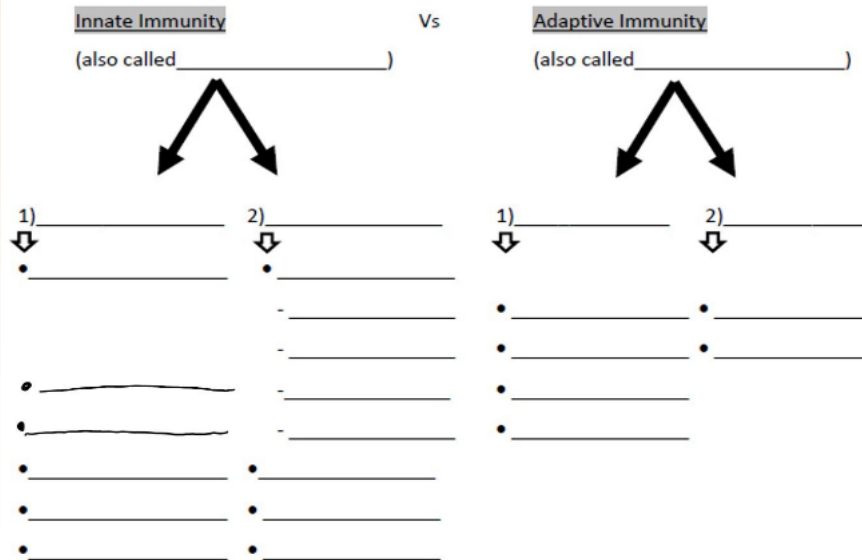
1. Bacteria enters tissue from a break in skin.
2. \_\_\_\_\_ = Phagocytic non-specific WBC in the blood stream.
3. \_\_\_\_\_ = Cell that extravasates from blood vessel into tissue. (is now called an \_\_\_\_\_)
4. \_\_\_\_\_ = Phagocytic cell in tissue, which finds pathogen, kills it, and puts antigen on its surface.
5. \_\_\_\_\_ = Cell of cell-mediated adaptive immunity, which becomes activated by interaction with the cell in #4 above.
6. Activated cell from #5 above can now activate these cells:
  - A. \_\_\_\_\_ = Cell of cell-mediated adaptive immunity, which directly kills pathogen.
  - B. \_\_\_\_\_ = Cell of cell-mediated adaptive immunity, which keeps a memory of pathogen.
  - C. \_\_\_\_\_ = Cell that is part of antibody-mediated adaptive immunity)
7. Cell from 6C above can make \_\_\_\_\_ (otherwise known as immunoglobulins)
8. Cell from 6C above encounters its pathogen and the following happens:
  - A. \_\_\_\_\_
  - B. \_\_\_\_\_

Click [HERE](#) for blank flow diagram.

Click [HERE](#) for KEY

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### CATEGORIES OF IMMUNITY:



Click [HERE](#) for blank flow diagram of immune categories

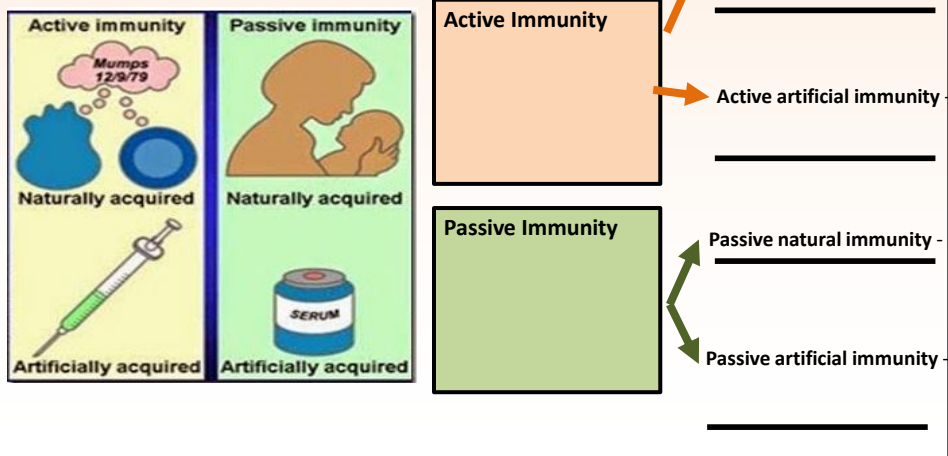
Click [HERE](#) for KEY

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## Classification of Immunity

1) **Active immunity** = get immunity (antibodies) that you produce from actual exposure (natural) to disease organism or from vaccination (artificial exposure).

2) **Passive Immunity** = get immunity (antibodies) from source outside your body: Natural (breast milk) or artificial (injection of antibodies).



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## 4. Autoimmunity Disorders

### Problems with the Immune Response

**autoimmunity** – when immune cells attack self; can be B or T cells.

\*\*\* Abnormal T-cells from Thymus associated with most autoimmune disorders!

**Ex. Of autoimmune disorders we've covered:**

- > *rheumatoid arthritis* – attack on connective tissue of synovial joints.
- > *rheumatic heart disease* – antibodies produced from strep throat attack heart valves.
- > *multiple sclerosis* – attacks myelin sheaths on neurons.
- > *Grave's disease* – attack on thyroid gland TSH receptor.
- > *Myasthenia gravis* – destruction of nicotinic cholinergic receptors on skeletal muscles.

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## Review

### Adaptive Immunity

- Cell-mediated adaptive immunity
- Antibody-mediated adaptive immunity

### Types of T and B Cells

- T-cell formation and activity
- $T_H$ ,  $T_C$ , and  $T_{reg}$
- B-cell formation and activity

### Classification of Immunity (active vs passive)

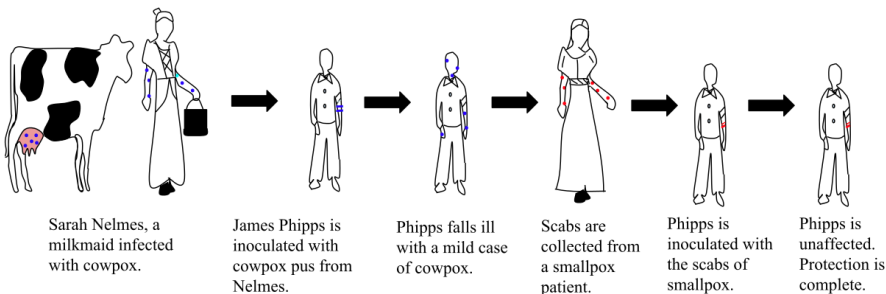
### Autoimmune Disorders

End of immune material!

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## Vaccinations

- Late 1700s → Edward Jenner noticed milkmaids rarely had smallpox.
- Jenner reasoned that milkmaids were immune to smallpox because they had been exposed to cowpox.
- To test his hypothesis, he inoculated a boy with cowpox pathogens and then with smallpox pathogens. As predicted, the boy did not contract smallpox.

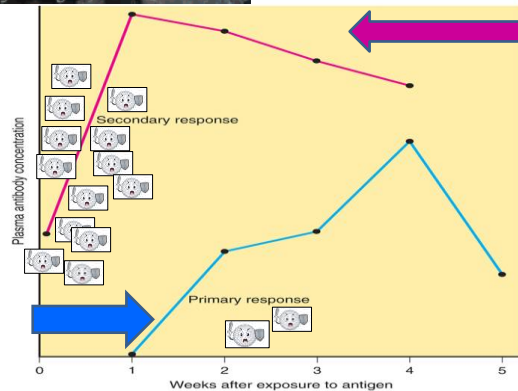


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vaccination → 1° immune response → memory cells



**Primary response:** takes ~ 2 weeks for good production of plasma B-cells with antibodies (**high antibody titer,**) and memory B-cells after 1<sup>st</sup> exposure.



**Secondary response:** have lots of memory B-cells that were stored & waiting for future exposure = **stronger, faster immune response!**

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## Vaccinations and Halt of Communicable Disease: **THE SCIENCE**

### Example of Vaccine Effectiveness:

In the United States, before measles vaccine became available in the mid-1960s was estimated over 530,000 cases with 500 deaths per year. After vaccine – has been **99.9% decrease** in incidence of the disease.



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**WORLD HISTORY ENCYCLOPEDIA**

## SEVEN CRUCIAL VACCINES IN HISTORY

Vaccines are biological preparations that train the immune system to recognize and fight harmful pathogens. They work by introducing a harmless form of a virus or bacterium, prompting the body to build immunity without causing disease. Throughout history, vaccines have saved millions of lives, preventing the spread of deadly diseases & even eradicating some entirely.

SMALLPOX VACCINE	RABIES VACCINE	TUBERCULOSIS VACCINE	DTP VACCINE	INFLUENZA VACCINE	POLIO VACCINE	MEASLES VACCINE
1796 E. JENNER	1885 L. PASTEUR	1921 A. CALMETTE & C. GUÉRIN	1940s MULTIPLE RESEARCHERS	1940s J. SALK & T. FRANCIS JR.	1955 J. SALK & A. SABIN	1963 J. ENDERS & COLLEAGUES
type: live attenuated virus (cowpox virus)	type: inactivated virus	type: live attenuated bacteria	type: toxoid (diphtheria & tetanus) inactivated bacteria (pertussis)	type: inactivated / live attenuated virus	type: inactivated/live attenuated virus	type: live attenuated virus
the first vaccine ever created  eradicated smallpox in 1980, saving millions of lives	first vaccine for a fatal disease  proved vaccines could save lives even after infection	one of the most widely used globally,  prevents tuberculosis in children, less effective in adults	combination vaccine,  cornerstone of childhood immunization	most widely administered globally,  first vaccine to target a rapidly mutating virus	the oral polio vaccine (OPV) provides community protection,  95% global cases' reduction	most cost-effective vaccine,  95% coverage needed to prevent outbreaks

VARIOLA VIRUS	RABIES VIRUS	Mycobacterium tuberculosis	Clostridium tetani Bordetella pertussis Corynebacterium diphtheriae	Influenza virus	Poliovirus	Measles morbillivirus
high fever; severe skin pustules, & scarring, 30% mortality rate, survivors often suffered blindness or disfigurement  killed 300-500 million people in the 20th century alone	attacks the nervous system, causing hydrophobia, paralysis, violent seizures, nearly 100% fatality rate  still kills around 58,000 people annually	causes chronic cough, weight loss, fever, lung damage, can spread to the brain and spine  one of the deadliest infectious diseases - 1.8 million deaths annually over 10 million new cases each year	diphtheria: throat swelling, suffocation tetanus: muscle spasms, lockjaw pertussis: severe coughing fits, deadly in infants, young children	high fever, body aches, pneumonia, respiratory failure  kills 290,000-650,000 people/year,  with pandemics like the 1918 Spanish Flu killing up to 50 million people	fever, paralysis, lifelong disability, particularly in children: 5-30% of paralyzed patients die from respiratory failure  During the 1940s-50s, paralyzed over 500,000 people/year	highly contagious, high fever, rash, pneumonia, brain swelling, up to 10% fatality rate  killed 2.6 million people annually,  will over 100,000 deaths/year in unvaccinated populations

worldhistory.org

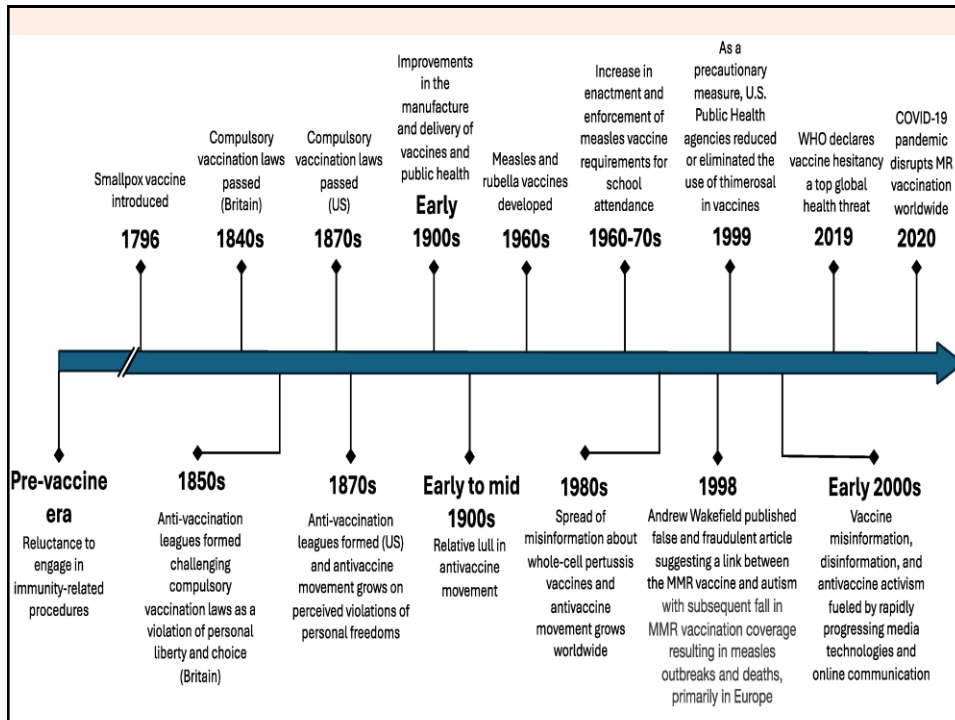
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## Vaccinations and Halt of Communicable Disease: THE SCIENCE

DISEASE	PRE-VACCINE ERA ESTIMATED ANNUAL MORBIDITY*	MOST RECENT REPORTS OR ESTIMATES† OF U.S. CASES	PERCENT DECREASE
Diphtheria	21,053	0†	100%
<i>H. influenzae</i> (invasive, <5 years of age)	20,000	31‡	>99%
Hepatitis A	117,333	2,890§	98%
Hepatitis B (acute)	66,232	18,800§	72%
Measles	530,217	187†	>99%
Mumps	162,344	584†	>99%
Pertussis	200,752	28,639†	86%
Pneumococcal disease (invasive, <5 years of age)	16,069	1,900††	88%
Polio (paralytic)	16,316	1†	>99%
Rotavirus (hospitalizations, <3 years of age)	62,500**	12,500††	80%
Rubella	47,745	9†	>99%
Congenital Rubella Syndrome	152	1†	99%
Smallpox	29,005	0†	100%
Tetanus	580	26†	96%
Varicella	4,085,120	167,490§§	96%

<http://www.immunize.org/catg.d/p4037.pdf>

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## Vaccinations and Halt of Communicable Disease: **THE CONTROVERSY**

Do vaccinations cause Autism????

# NO!

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## Vaccinations and Halt of Communicable Disease: **THE CONTROVERSY**

### Where did the controversy start?

A study originally published in journal ***Lancet*** by **Andrew Wakefield** in **1995** claimed that his study of **12 children** showed that the 3 MMR (measles, mumps, rubella) vaccines taken together (1<sup>st</sup> at 1 year, then at 5-6 yrs) could alter immune systems, causing intestinal woes that then reach, and damage, the brain (autism?)

### Scientific community responded:

- > Dozens of epidemiological studies found no merit to his work
- > His claims were based on a tiny sample size.
- > The British Medical Journal called his research “fraudulent.”
- > The British journal ***Lancet*** retracted his publication.
- > The British medical authorities stripped him of his license.

### Problem:

People still believe Wakefield. Groups of people began to NOT vaccinate their children.

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## Vaccinations and Halt of Communicable Disease:



- Nationwide, vaccination rate against diseases has stayed at 90 % or higher, but % in some of the country now well below that, making those communities more vulnerable to disease outbreak.

- There has been an increase in cases of **Measles in the US** – especially in counties where vaccination rate below 90%.

- Medical doctors & epidemiology experts say that vaccination rate of ~95 % needed to protect a community by “herd immunity”.

**Herd immunity** = indirect protection from infectious disease when a large % of population has become immune (natural or vaccination-acquired) it reduces potential exposure of non-immune people (aren't or can't be vaccinated) to that disease.

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## New Secretary of the U.S. Department of Health and Human Services: RFK Jr. (Feb 2025)

*How bad is this??*

**BAD** (he has long been an anti-vaxxer)

> Recommended giving vitamin A to treat measles in children.

Vitamin A is stored in the liver, and high levels are toxic and can lead to liver damage.

[https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(24\)02603-5/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(24)02603-5/fulltext)

<https://edition.cnn.com/2025/03/05/health/measles-rfk-vitamin-a-misinformation/index.html>

<https://www.cnn.com/2025/03/26/health/texas-measles-vitamin-a-toxicity/index.html>

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**Legend:**  
■ = not immunized but still healthy  
■ = immunized and healthy  
■ = not immunized, sick, and contagious

**Top Box:** No one is immunized. Contagious disease spreads through the population.

**Middle Box:** Some of the population gets immunized. Contagious disease spreads through some of the population.

**Bottom Box:** Most of the population gets immunized. Spread of contagious disease is contained.

### Herd Immunity

The **top box** shows an outbreak in a community in which a **few people are infected (shown in red)** and the **rest are healthy but unimmunized (shown in blue)**; the illness spreads freely through the population.

The **middle box** shows a population where a **small number have been immunized (shown in yellow)**; those not immunized become infected while those immunized do not.

In the **bottom box**, a large proportion of the population have been immunized (yellow); this prevents the illness from spreading significantly, including to unimmunized people.

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## Review

### Vaccination

- History of vaccination

- Action of vaccinations on immunity

- Controversy on vaccinations

- [There shouldn't be!!! - Vaccines work!]*