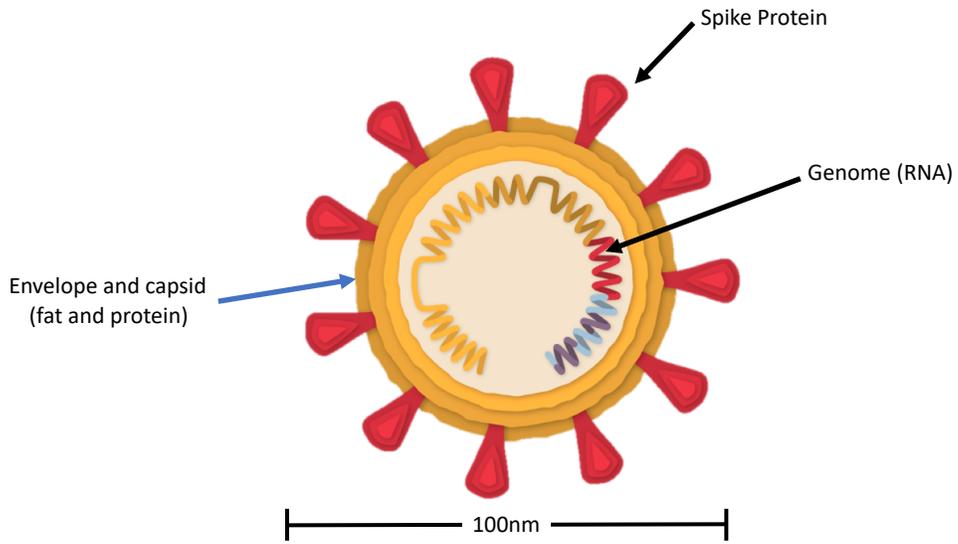


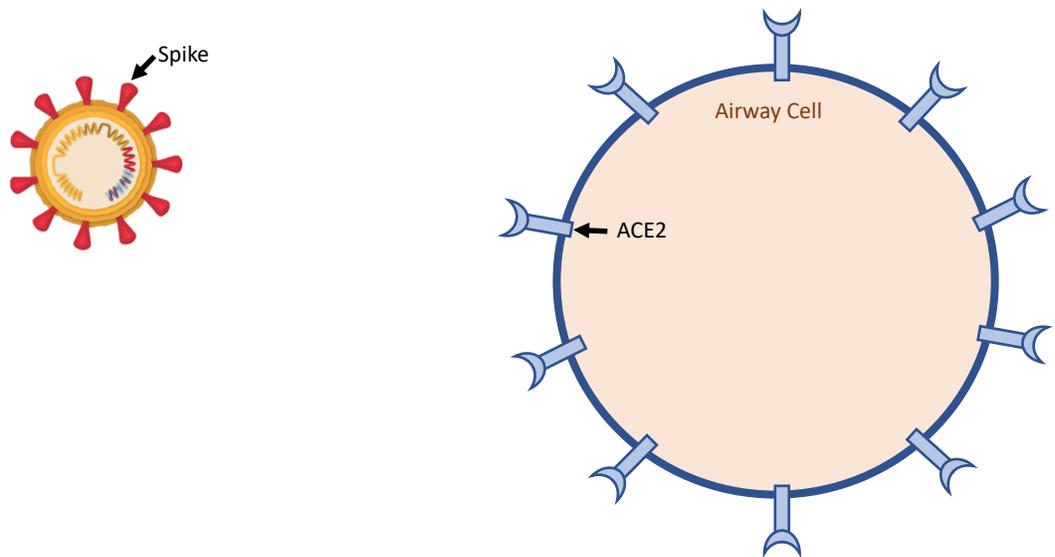
# SARS-CoV2



Picture credit: NYT

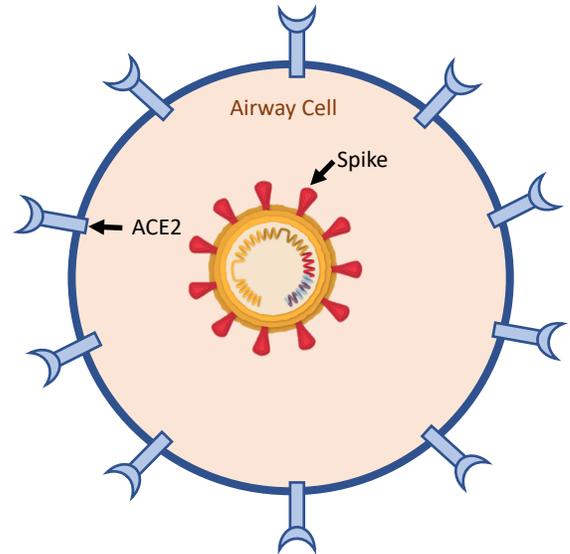
Needs help to replicate

# Infection with SARS-CoV2



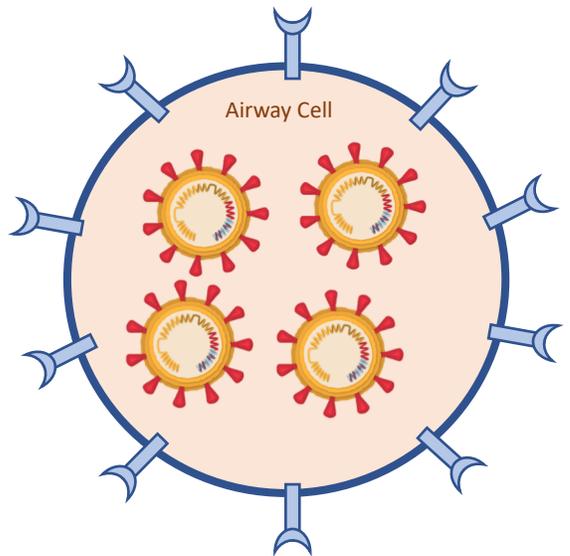
## Infection with SARS-CoV2

1. Spike binds ACE2 and enters cell



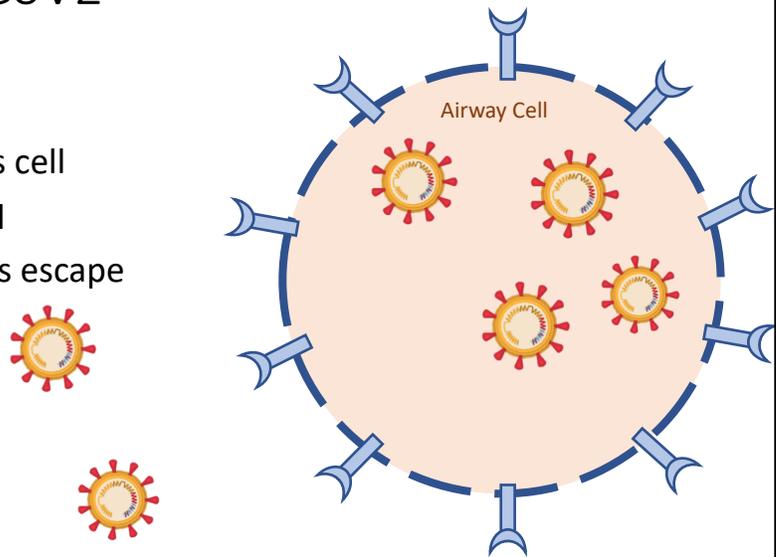
## Infection with SARS-CoV2

1. Spike binds ACE2 and enters cell
2. Virus is replicated
  - RNA genome
  - Capsid and envelope
  - Proteins (including Spike)



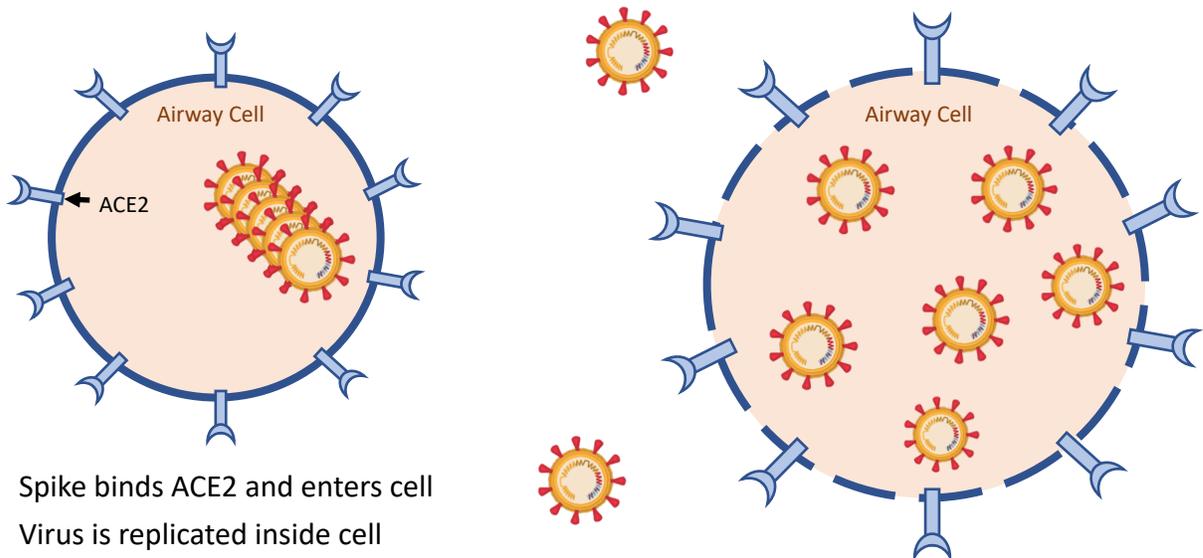
## Infection with SARS-CoV2

1. Spike binds ACE2 and enters cell
2. Virus is replicated inside cell
3. Cell is damaged, new viruses escape

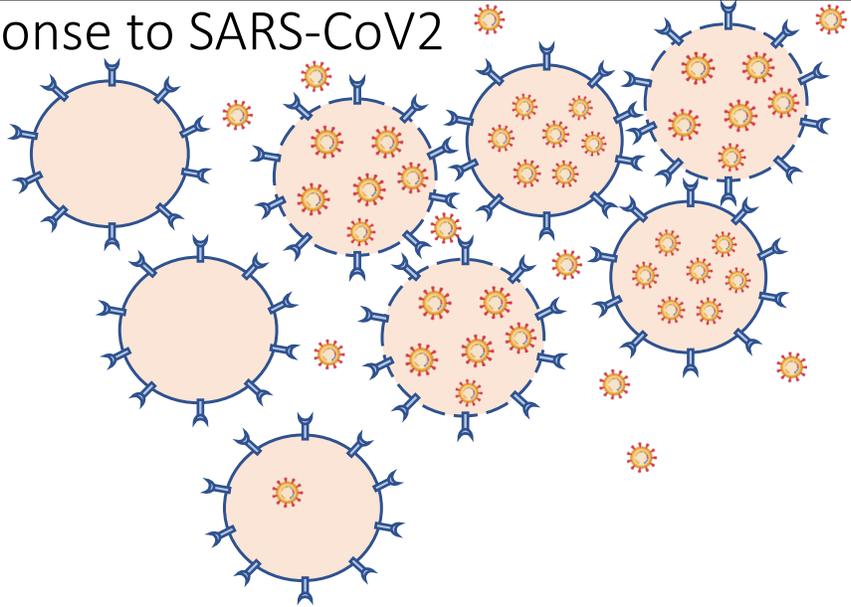


## Infection with SARS-CoV2

1. Spike binds ACE2 and enters cell
2. Virus is replicated inside cell
3. Cell is damaged, new viruses escape
4. New viruses infect other cells

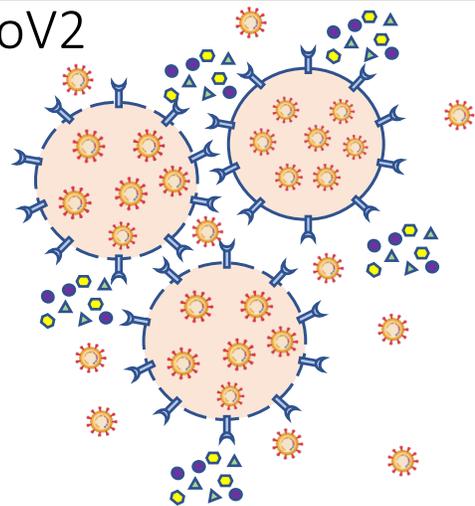


# The immune response to SARS-CoV2



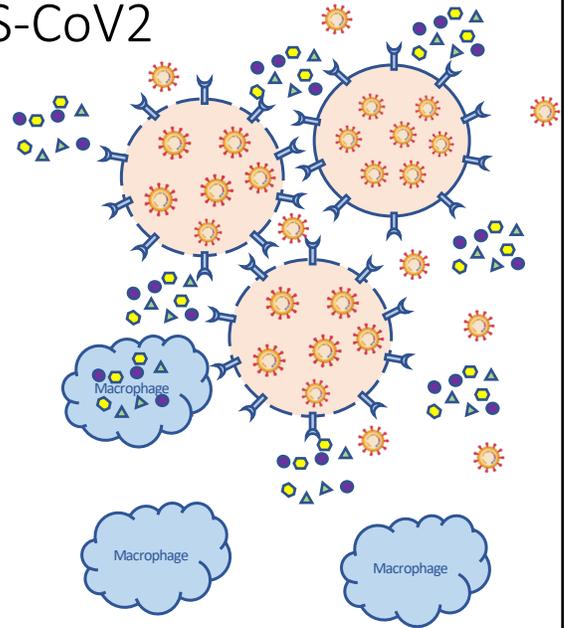
# The immune response to SARS-CoV2

- Damaged cells release "help" signals



# The immune response to SARS-CoV2

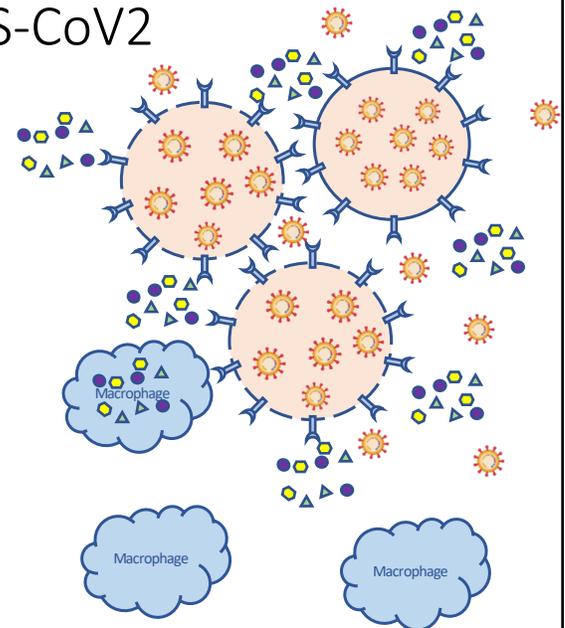
- Damaged cells release “help” signals
- Macrophages rush to site of infection (**EARLY RESPONSE**)
  - Phagocytosis
  - More “help” signal
  - Inflammation



# The immune response to SARS-CoV2

- Damaged cells release “help” signals
- Macrophages rush to site of infection (**EARLY RESPONSE**)
  - Phagocytosis
  - More “help” signal
  - Inflammation
- Inflammation and macrophages activate adaptive response that clears the virus (**LATE RESPONSE**) (10-14 days later)
  - B cells
  - Cytotoxic T cells

\*immunological memory

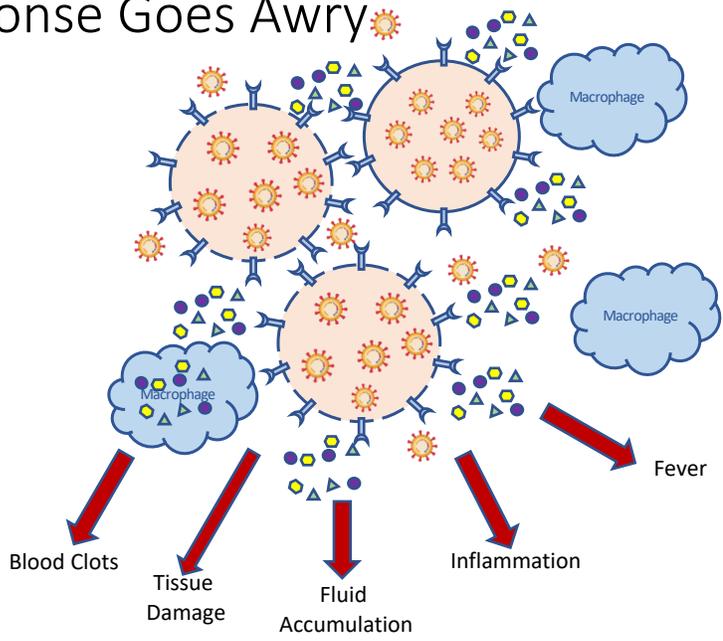


COVID-19 vs SARS CoV2

# COVID-19: Early Response Goes Awry

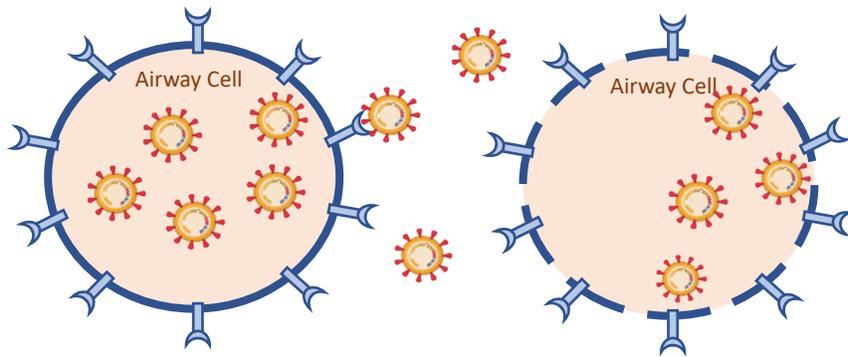
- Damaged cells release “help” signals
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*\*immunological memory*



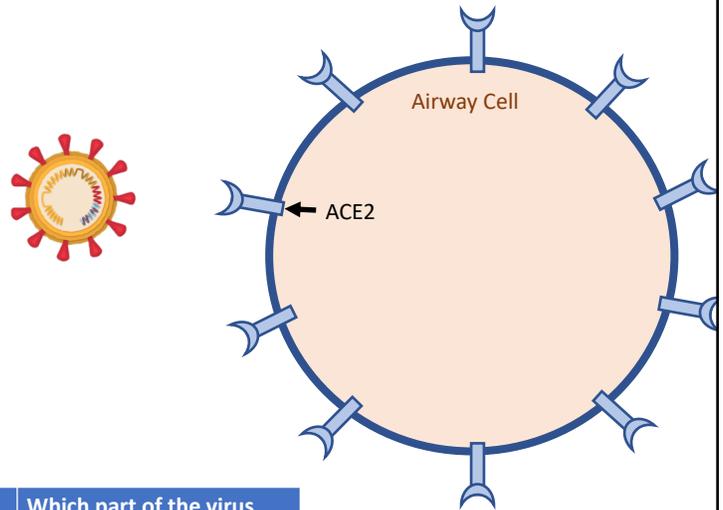
Asymptomatic vs. COVID-19

# Adaptive (**LATE**) Immune Response Clears Virus



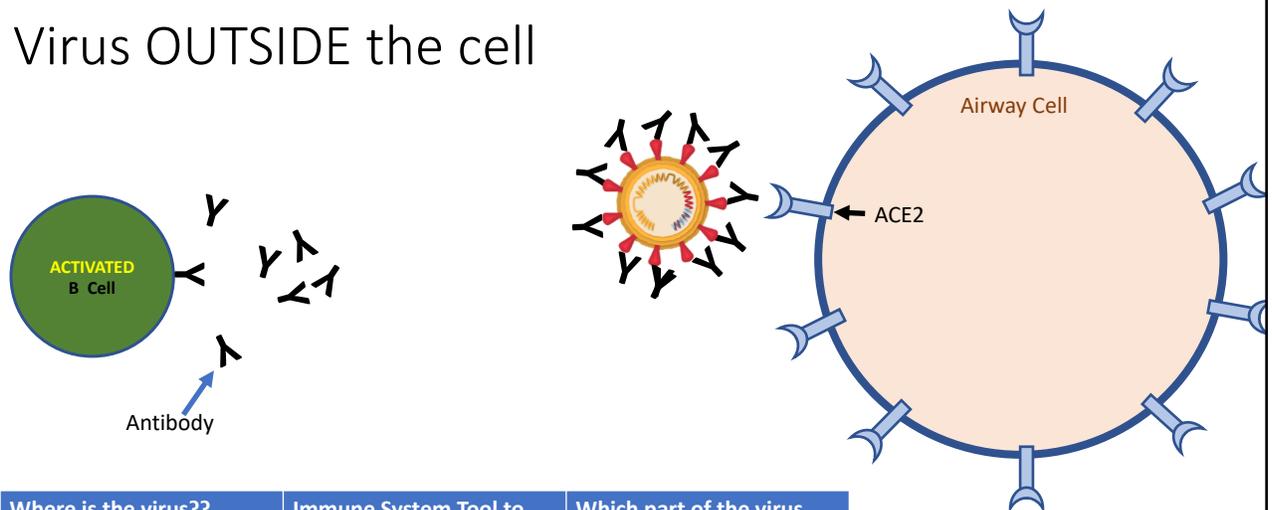
Where is the virus??	Immune System Tool to Get Rid of It	Which part of the virus does the immune system respond to?
1. Outside of the cell		
2. Inside of the cell		

## Virus OUTSIDE the cell



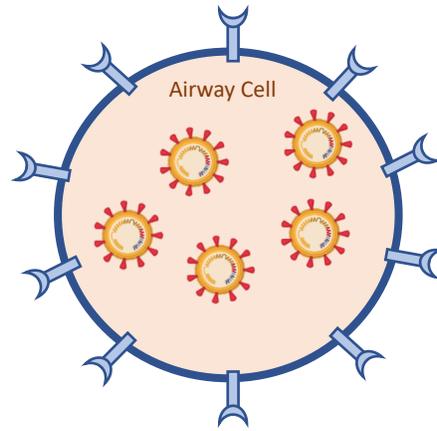
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## Virus OUTSIDE the cell



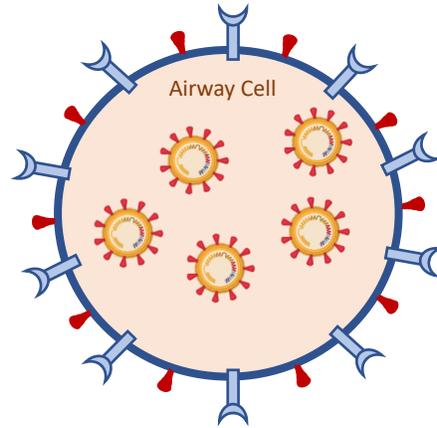
Where is the virus??	Immune System Tool to Get Rid of It	Which part of the virus does the immune system respond to?
1. Outside of Cells	B cells make antibodies	Spike protein
2. Inside of Cells		

## Virus INSIDE of cell



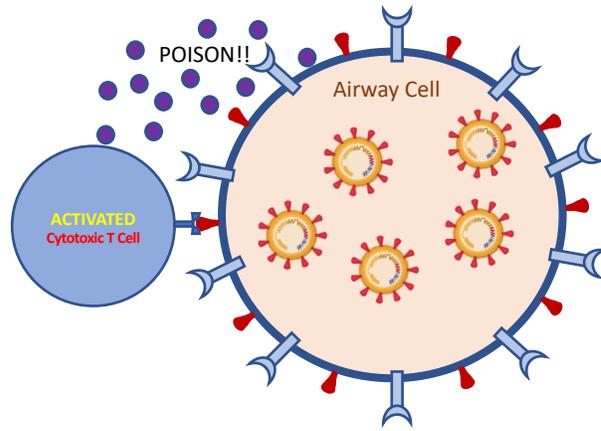
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## Virus INSIDE of cell



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## Virus INSIDE of cell



Where is the virus??	Immune System Tool to Get Rid of It	Which part of the virus does the immune system respond to?
1. Outside of Cells	B cells make antibodies	Spike Protein
2. Inside of Cells	Cytotoxic T cells	Spike protein

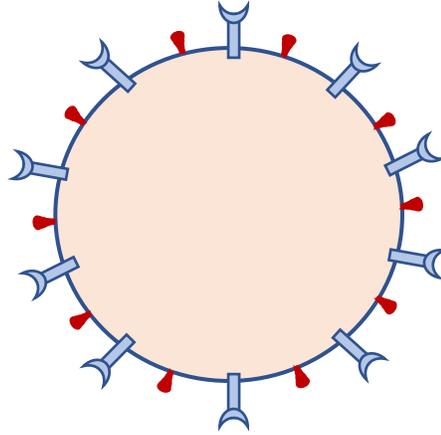
## The immune memory response to SARS-CoV2



Where is the virus??	Immune System Tool to Get Rid of It	Which part of the virus does the immune system respond to?
1. Outside of Cells	B cells make antibodies	Spike Protein
2. Inside of Cells	Cytotoxic T cells	Spike Protein

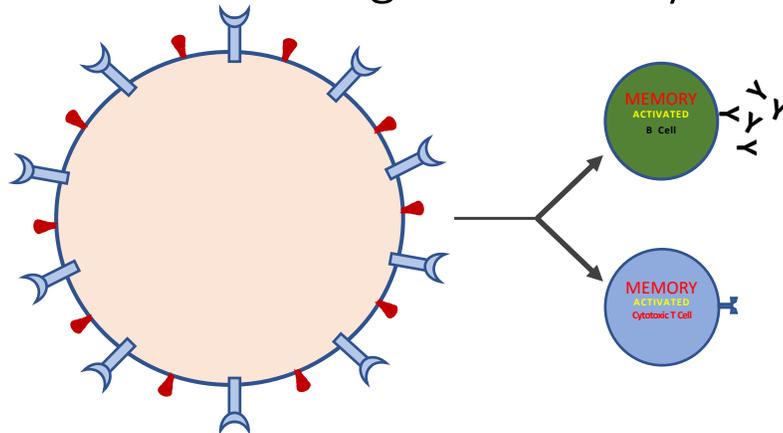
Memory B Cells and T Cells

## Vaccines: Generate Immunological Memory



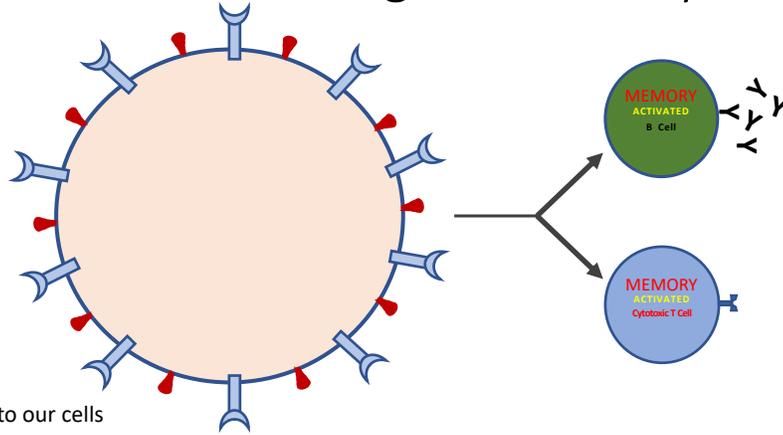
1. Somehow get spike proteins into our cells
2. Activate B cells and T cells to become MEMORY B cells and T cells

## Vaccines: Generate Immunological Memory



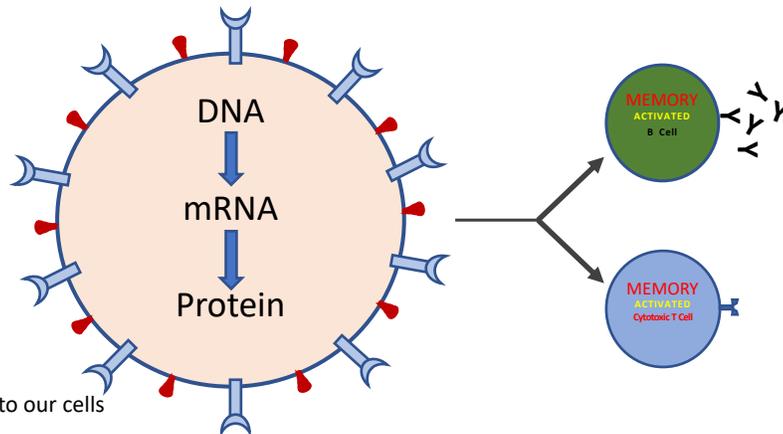
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## Vaccines : Generate Immunological Memory



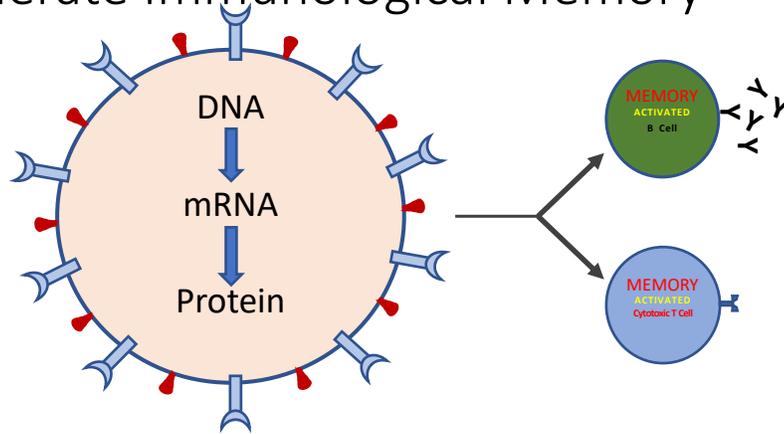
1. Somehow get spike proteins into our cells
  - Vaccinate with spike proteins
2. Activate B cells and T cells to become MEMORY B cells and T cells

## Vaccines: Generate Immunological Memory



1. Somehow get spike proteins into our cells
  - Vaccinate with spike proteins
  - Vaccinate with genetic information so that the cell makes spike proteins
2. Activate B cells and T cells to become MEMORY B cells and T cells

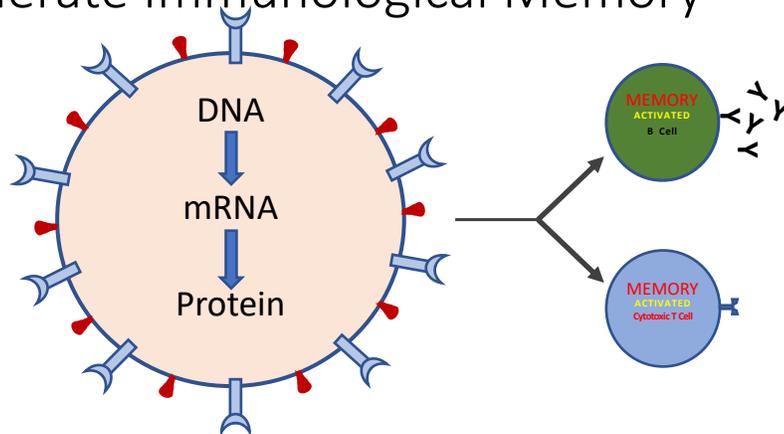
# Vaccines : Generate Immunological Memory



Manufacturer	Type of Vaccine	Target for the Immune System
Pfizer-BioNTech, Moderna	mRNA 	Spike Protein
Johnson and Johnson (J&J)	Adenovirus 	Spike Protein

<https://www.nytimes.com/interactive/2021/health/how-covid-19-vaccines-work.html>

# Vaccines : Generate Immunological Memory



Manufacturer	Type of Vaccine	Target for the Immune System	Efficacy
Pfizer-BioNTech, Moderna	mRNA 	Spike Protein	95%/94.5%
Johnson and Johnson (J&J)	Adenovirus 	Spike Protein	72%

52 million doses of all vaccines world wide

# Vaccines protect the people around you too!

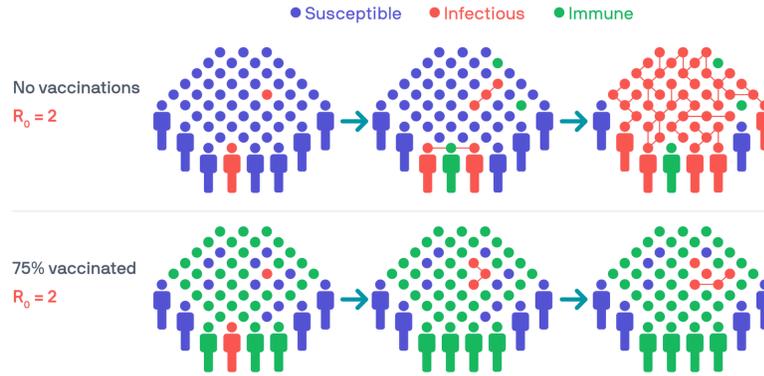
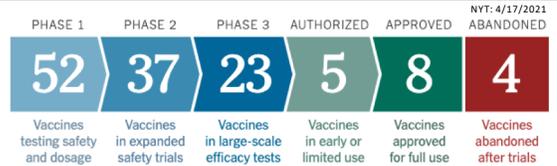


Image credit: PATH.org

## Vaccine Trials



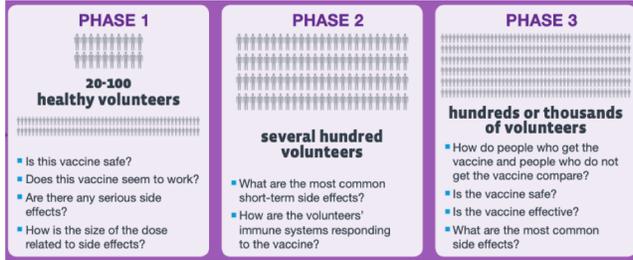
PHASE 1	PHASE 2	PHASE 3
<p><b>20-100 healthy volunteers</b></p> <ul style="list-style-type: none"> <li>Is this vaccine safe?</li> <li>Does this vaccine seem to work?</li> <li>Are there any serious side effects?</li> <li>How is the size of the dose related to side effects?</li> </ul>	<p><b>several hundred volunteers</b></p> <ul style="list-style-type: none"> <li>What are the most common short-term side effects?</li> <li>How are the volunteers' immune systems responding to the vaccine?</li> </ul>	<p><b>hundreds or thousands of volunteers</b></p> <ul style="list-style-type: none"> <li>How do people who get the vaccine and people who do not get the vaccine compare?</li> <li>Is the vaccine safe?</li> <li>Is the vaccine effective?</li> <li>What are the most common side effects?</li> </ul> <p>From: CDC</p>

### Pfizer/BioNTech:

- 44K people in Phase 3
- Waited for 170 people to get sick
- 162 of the cases were in placebo group
- Efficacy: 95% (relative difference)
- Continued monitoring: 200+ million doses (P&M)

- Approval and/or Emergency Use Authorization: FDA, CDC

# Johnson and Johnson Vaccine



- 43,783 people in Phase 3
- Waited for 468 symptomatic cases
- No deaths in the vaccine group, 16 in placebo group = high efficacy against severe COVID-19
- Efficacy: 72% (relative difference)
- Continued monitoring: more than 6.8 million doses

Vaccine Pause: 6 cases of blood clots, occur in women between 18-48YO, 1-2 weeks after vaccination

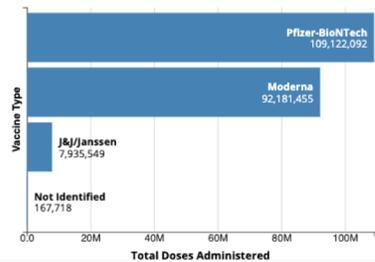
## COVID-19 Vaccinations in the United States

209M total vaccines administered

Overall US COVID-19 Vaccine | Deliveries and Administration; Maps, charts, and data provided by CDC, updates daily by 8 pm ET<sup>†</sup>  
 Represents all vaccine partners including jurisdictional partner clinics, retail pharmacies, long-term care facilities, dialysis centers, Federal Emergency Management Agency and Health Resources and Services Administration partner sites, and federal entity facilities.

Total Vaccine Doses	People Vaccinated	
	At Least One Dose	Fully Vaccinated
Delivered <b>264,505,725</b>	<b>131,247,546</b>	<b>84,263,408</b>
Administered <b>209,406,814</b>	<b>39.5%</b>	<b>25.4%</b>
Learn more about the distribution of vaccines.	Population ≥ 18 Years of Age	83,976,957
	<b>50.4%</b>	<b>32.5%</b>
	Population ≥ 65 Years of Age	36,019,475
	<b>81%</b>	<b>65.9%</b>

U.S. COVID-19 Vaccine Administration by Vaccine Type

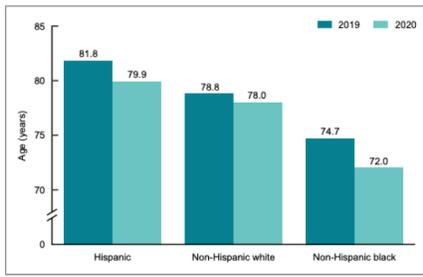


<https://covid.cdc.gov/covid-data-tracker/#vaccinations>

# Disproportionate Impact of COVID-19

Risk for COVID-19 Infection, Hospitalization, and Death By Race/Ethnicity				
Rate ratios compared to White, Non-Hispanic persons	American Indian or Alaska Native, Non-Hispanic persons	Asian, Non-Hispanic persons	Black or African American, Non-Hispanic persons	Hispanic or Latino persons
Cases <sup>1</sup>	1.6x	0.7x	1.1x	2.0x
Hospitalization <sup>2</sup>	3.5x	1.0x	2.8x	3.0x
Death <sup>3</sup>	2.4x	1.0x	1.9x	2.3x

 Race and ethnicity are risk markers for other underlying conditions that affect health, including socioeconomic status, access to health care, and exposure to the virus related to occupation, e.g., among frontline, essential, and critical infrastructure workers.



NOTES: Life expectancies for 2019 by Hispanic origin and race are not final estimates; see Technical Notes. Estimates are based on provisional data from January 2020 through June 2020.  
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality data.