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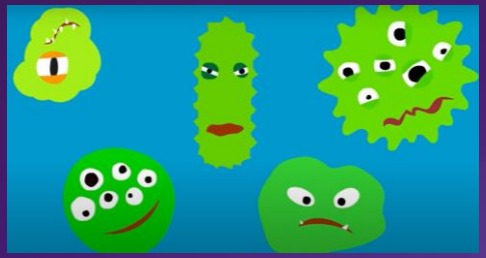
HOW DOES THE IMMUNE SYSTEM WORK?



Germs (bacteria/virus)

Food and water we take

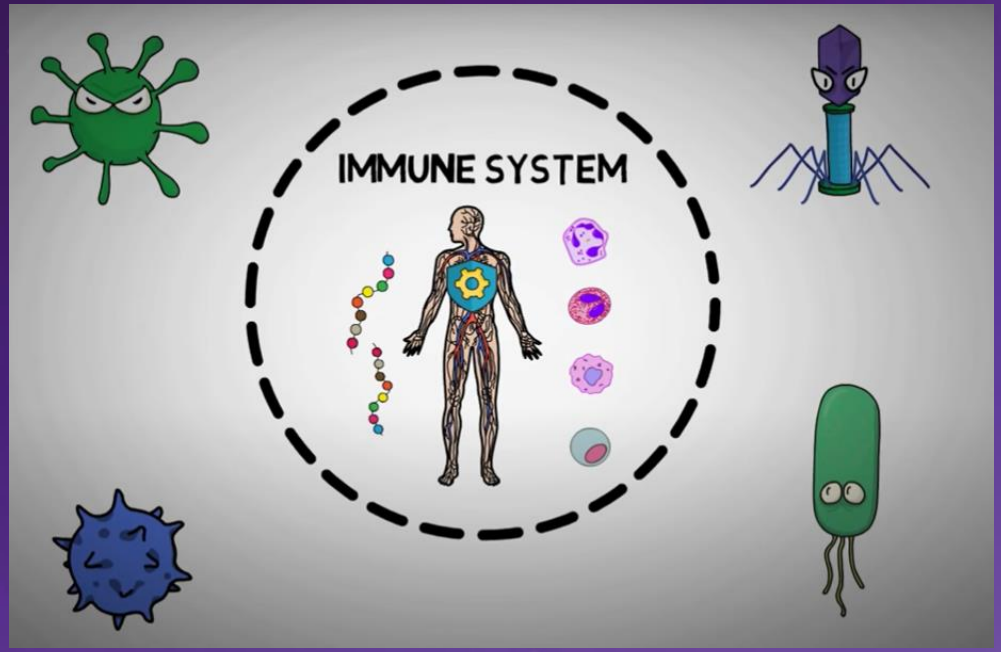
Our body is exposed to

Air we breathe

But we do not fall sick

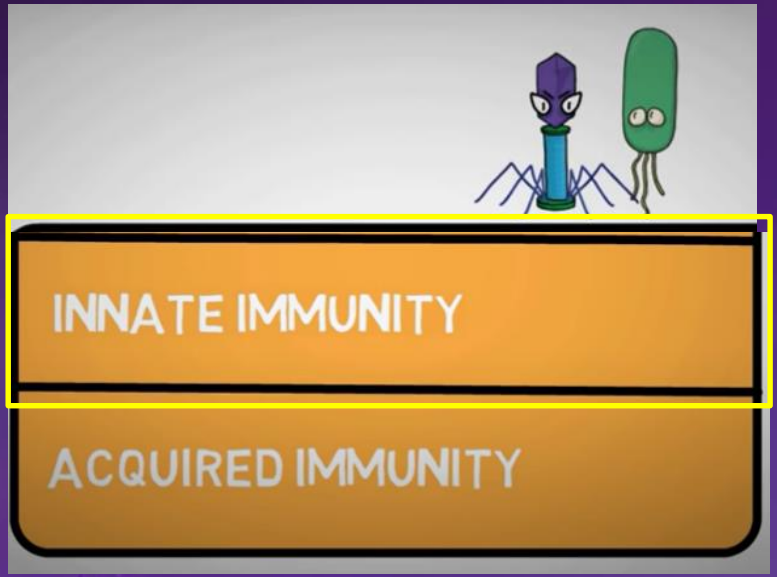
Graphics adapted from Scienceabc.com

ALL THANKS TO OUR IMMUNE SYSTEM

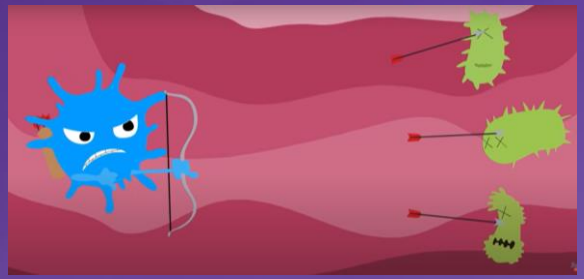


Graphics adapted
from MedSimplified.com

INNATE IMMUNITY

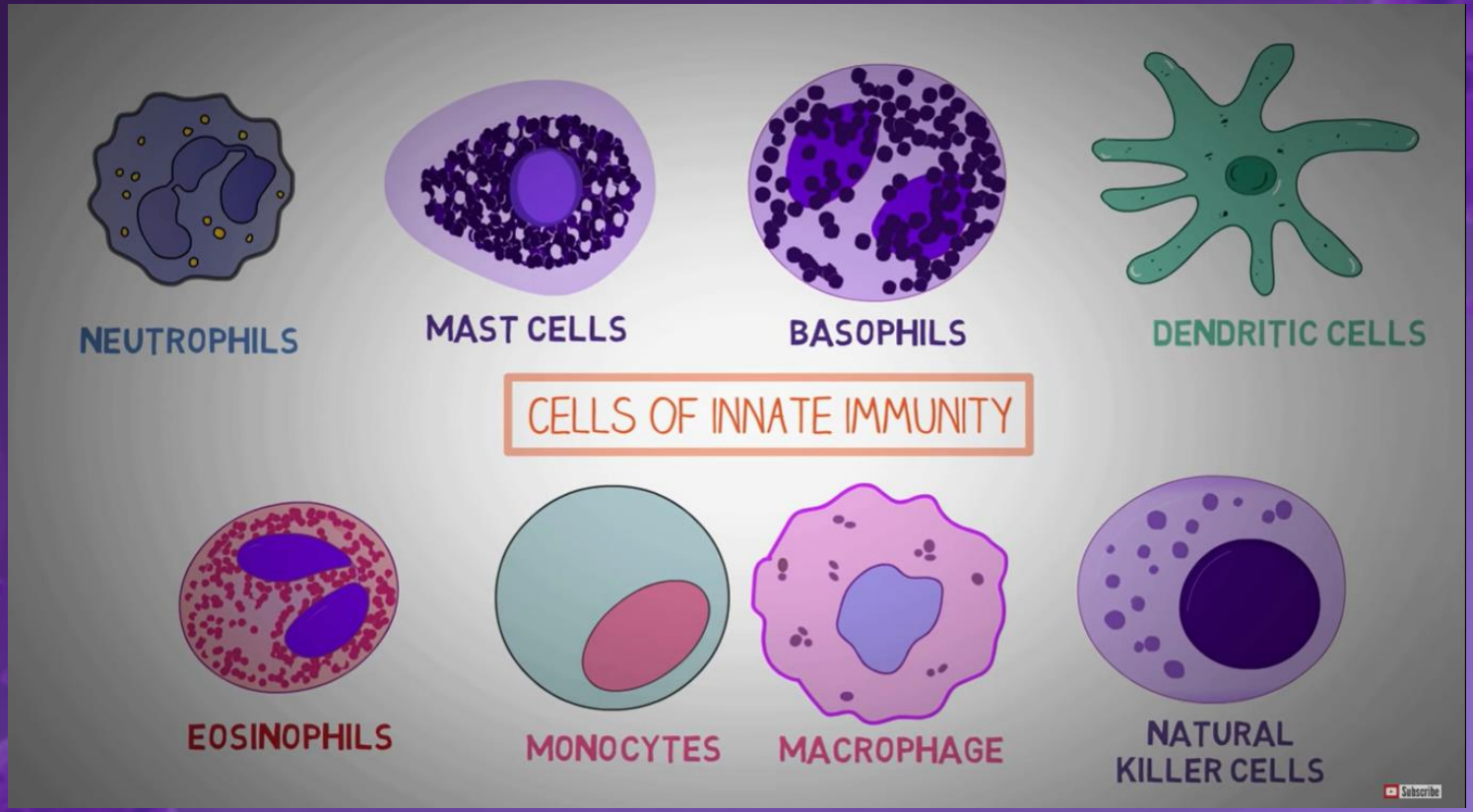


- Immunity we are born with
- Kill bacteria or virus in a non-specific way
- Cells either eat the germs or secrete chemicals to kills them



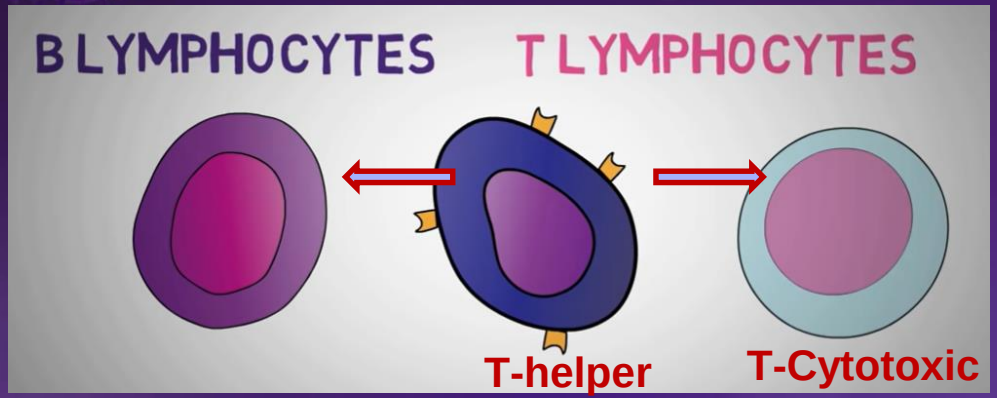
Graphics adapted from MedSimplified.com

INNATE IMMUNITY



Graphics adapted from MedSimplified.com

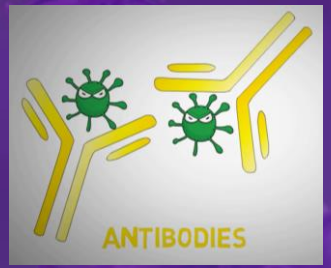
ADAPTIVE IMMUNITY



- Immunity we acquire following infection (adapts to the infection)
- Highly specific to the type of bacteria or virus causing infection
- Recognize specific proteins on the surface of germs (antigens)

Help B- and T- cells

Kill infected cells

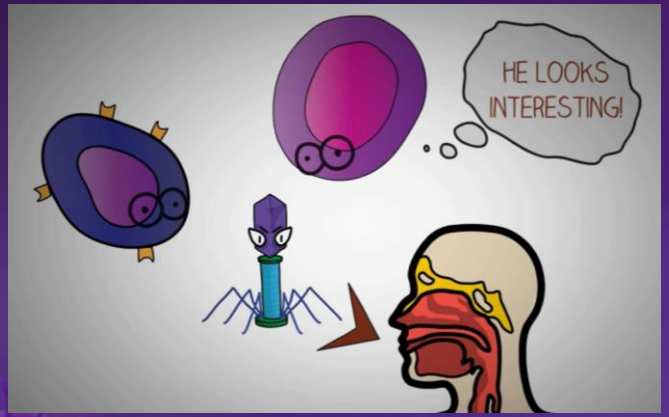


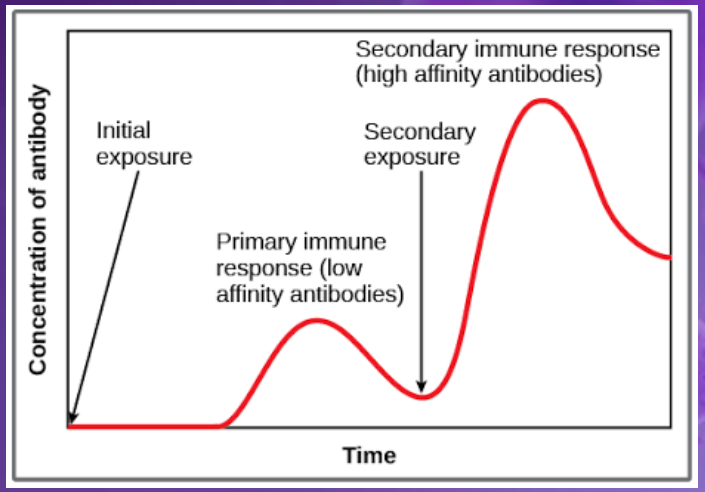
Produce Antibodies
-Bind to the surface of virus/bacteria and blocks it
-Help innate immune cells to find and eat them

Graphics adapted from MedSimplified.com

ADAPTIVE IMMUNITY (RETAIN MEMORY) – THE BASIS OF VACCINATION

1ST TIME EXPOSURE





- **Body produce B- and T-cell response**
- **But is usually slow as it is still adapting**
- **Also retain memory of the virus/bacteria**
- **When challenged again with same antigen, body mounts a fast and strong immune response**

The secondary (and tertiary and subsequent) immune response is: FASTER, GREATER and STRONGER

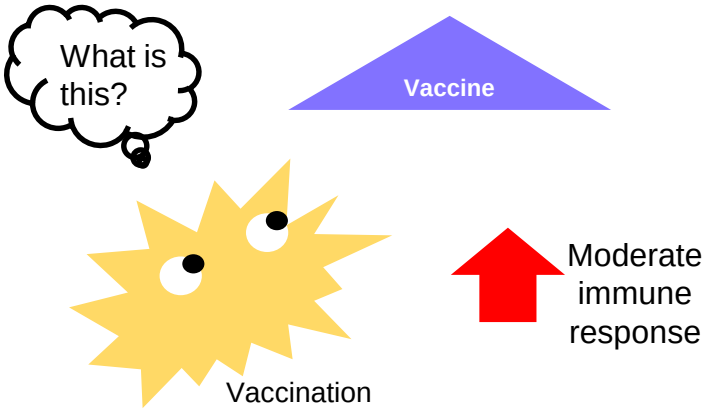
Graphics adapted from MedSimplified.com

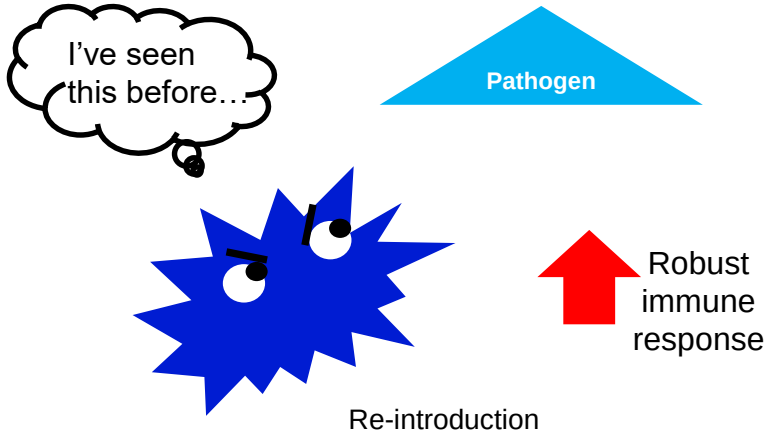
PRACTICE MAKES PROGRESS

- Practicing is a great way to learn a new skill or reach a new goal
  - Learning an instrument
  - Running a set distance
  - Scoring high marks on a test
  - Landing that job
  - Practice makes perfect

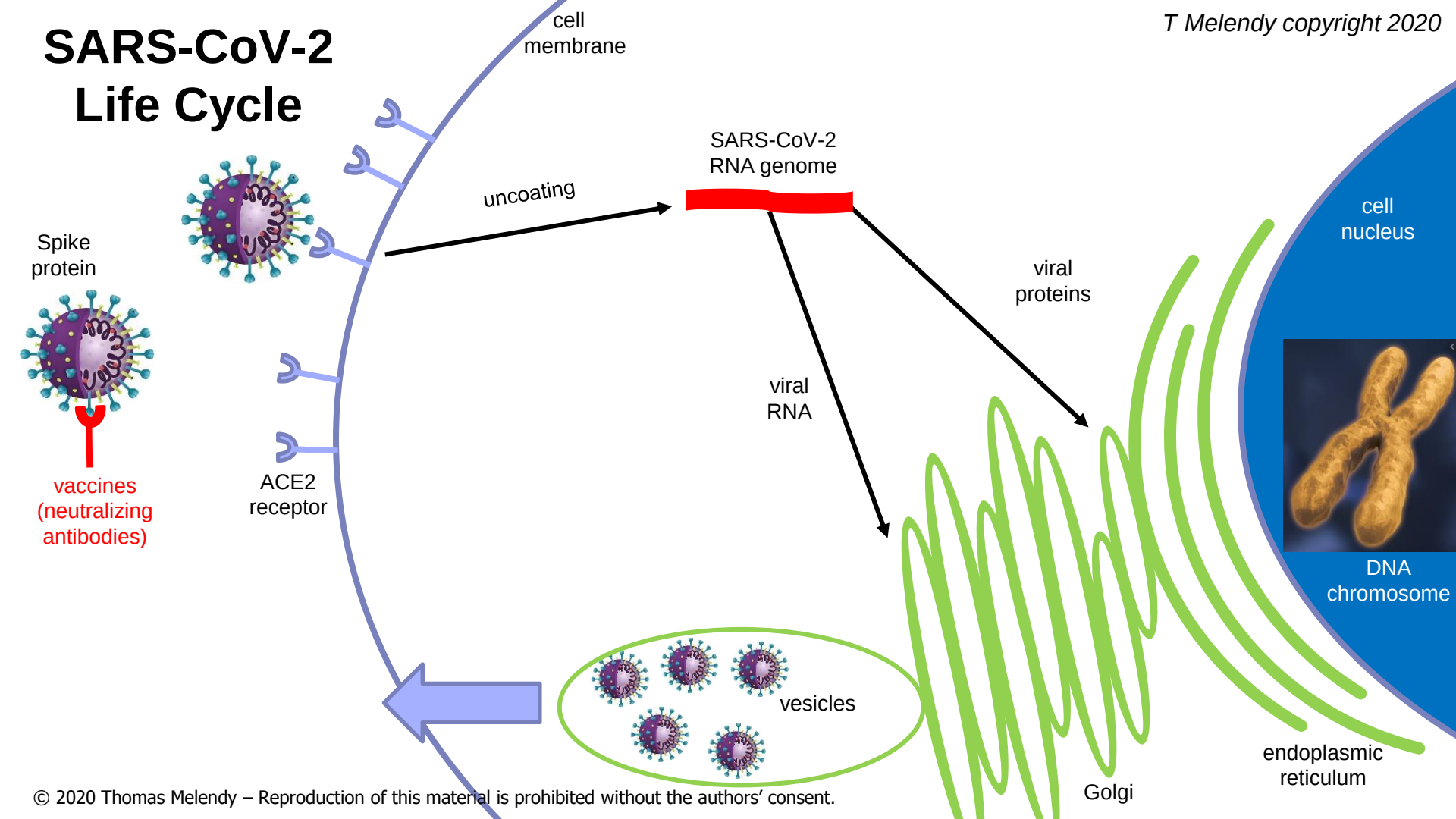
VACCINATION IS PRACTICE FOR THE IMMUNE SYSTEM – WITHOUT GETTING SICK!

- Controlled exposure to an exogenous molecule to illicit a mild immune response
  - Molecule may be
    - Weakened/inert form of the pathogen
    - Protein expressed by the pathogen
  - Trains the immune system to more rapidly recognize the pathogen in the future





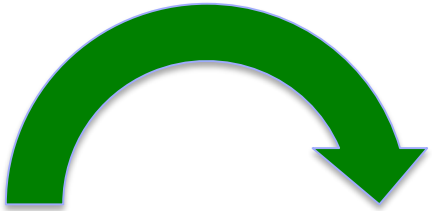
SARS-CoV-2 Life Cycle

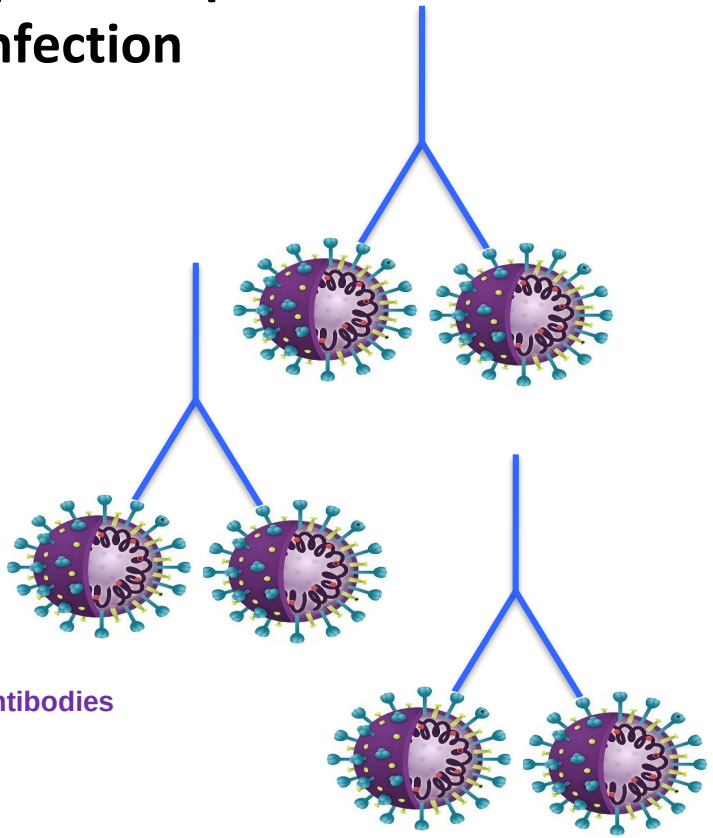


All vaccines work in the same general way – they present a target for the immune system, to “educate” the immune system to recognize a pathogen.

Many different “targets” can be used.

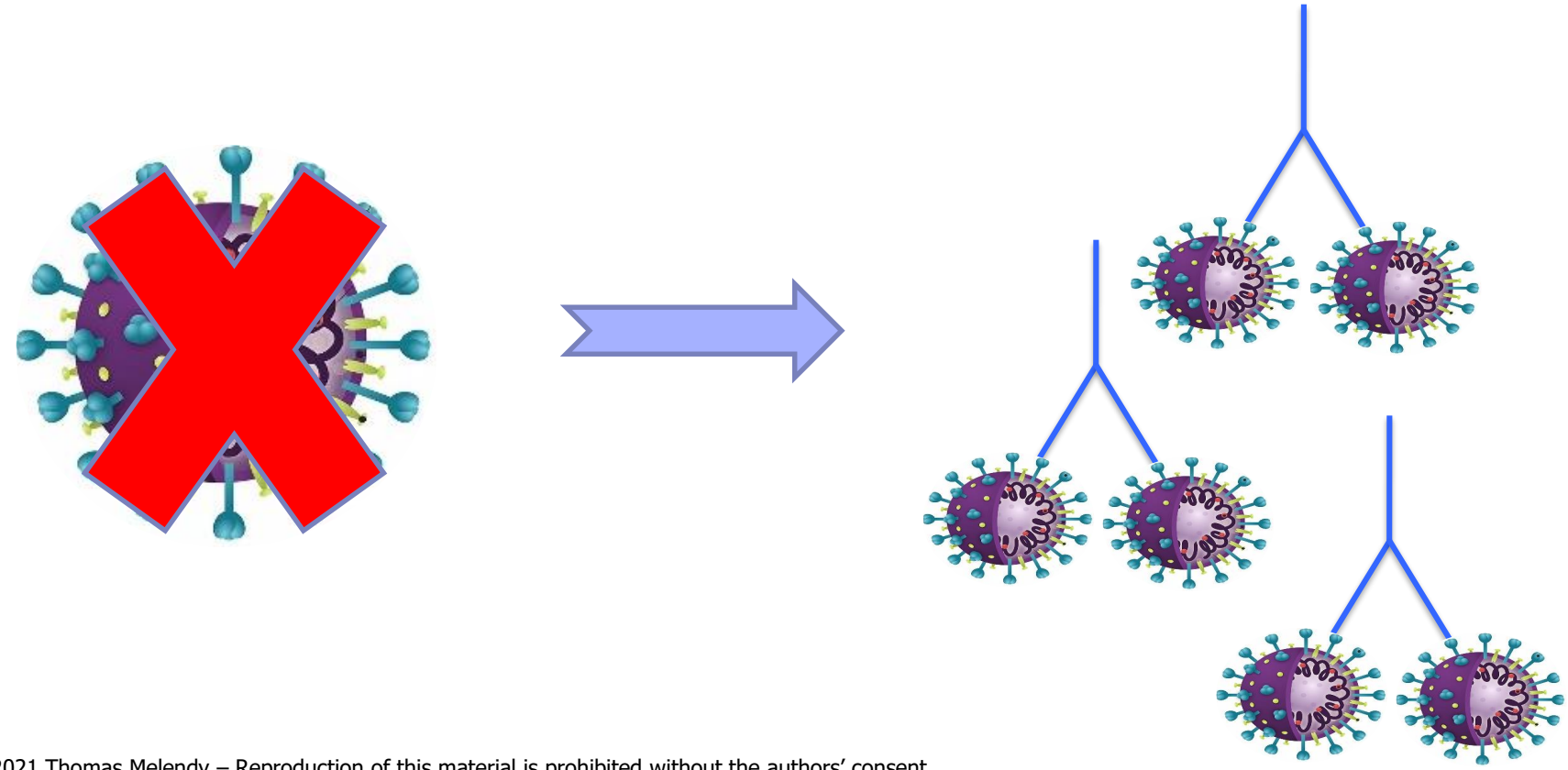
Vaccines against SARS-CoV-2 train your immune system to recognize the virus, or parts of it, to produce protective antibodies that prevent infection



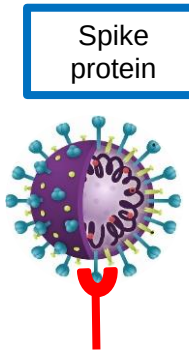


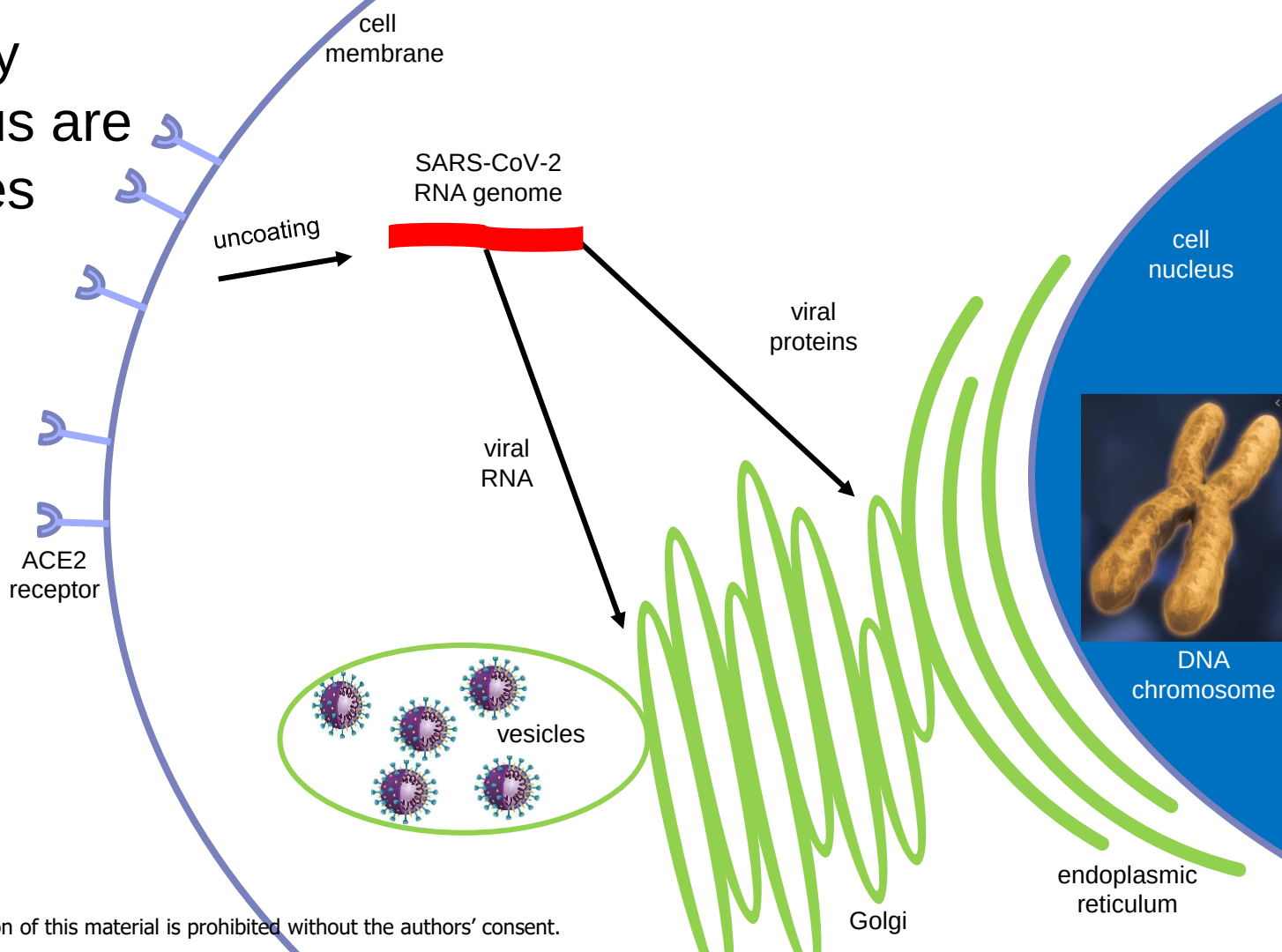
Anti-SARS-CoV-2 antibodies

Sometimes inactivated or attenuated virus is used in vaccines to produce an immune response



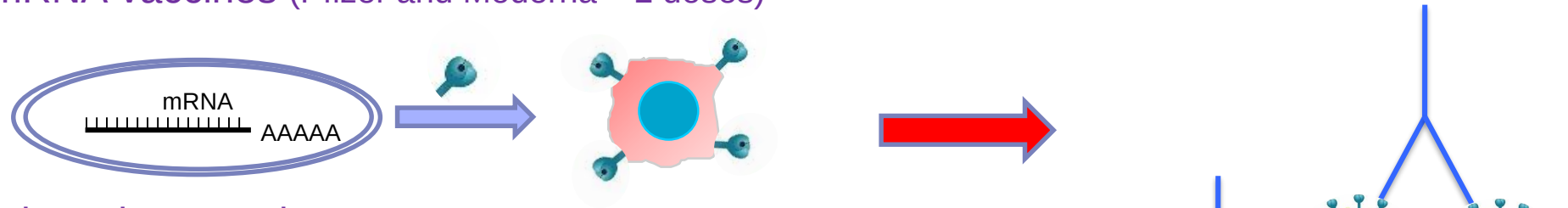
Sometimes only parts of the virus are used in vaccines



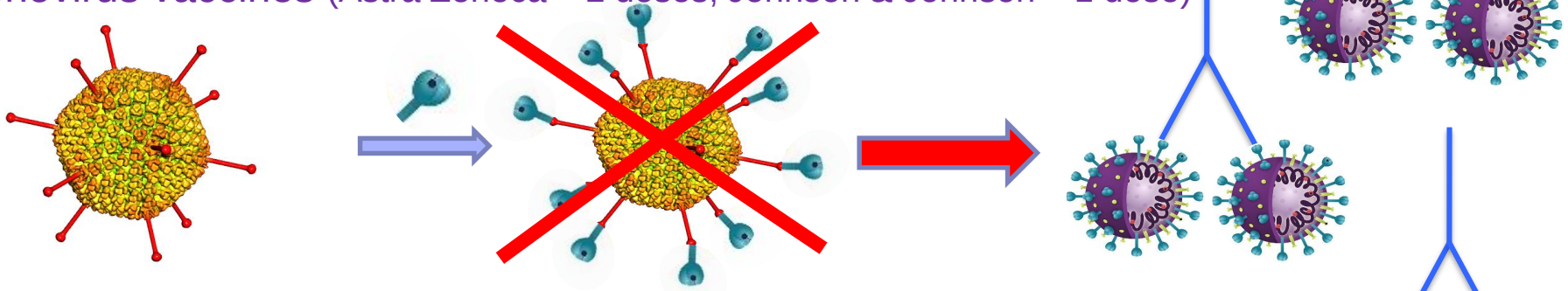


Different approaches to display the spike protein for the immune system

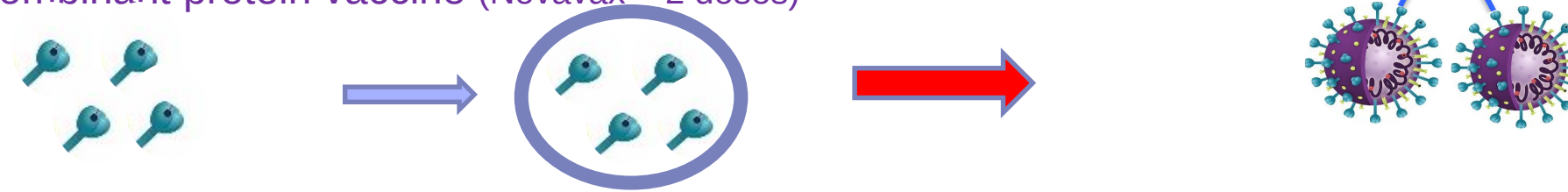
mRNA vaccines (Pfizer and Moderna – 2 doses)



Adenovirus vaccines (Astra Zeneca – 2 doses; Johnson & Johnson – 1 dose)



Recombinant protein vaccine (Novavax – 2 doses)



mRNA vaccine

cell membrane

fusion

mRNA

AAAAA

mRNA

AAAAA

translates Spike protein

cell nucleus

DNA chromosome

ACE2 receptor

vesicles

endoplasmic reticulum

Golgi

HERD IMMUNITY

Indirect protection of population

- If enough people are immune
- Reduces chance others will get infected
- For COVID-19, estimated:
  - 70-90% of population will need to be vaccinated
  - NY state is at 1% fully vaccinated

For COVID-19, herd immunity can protect:

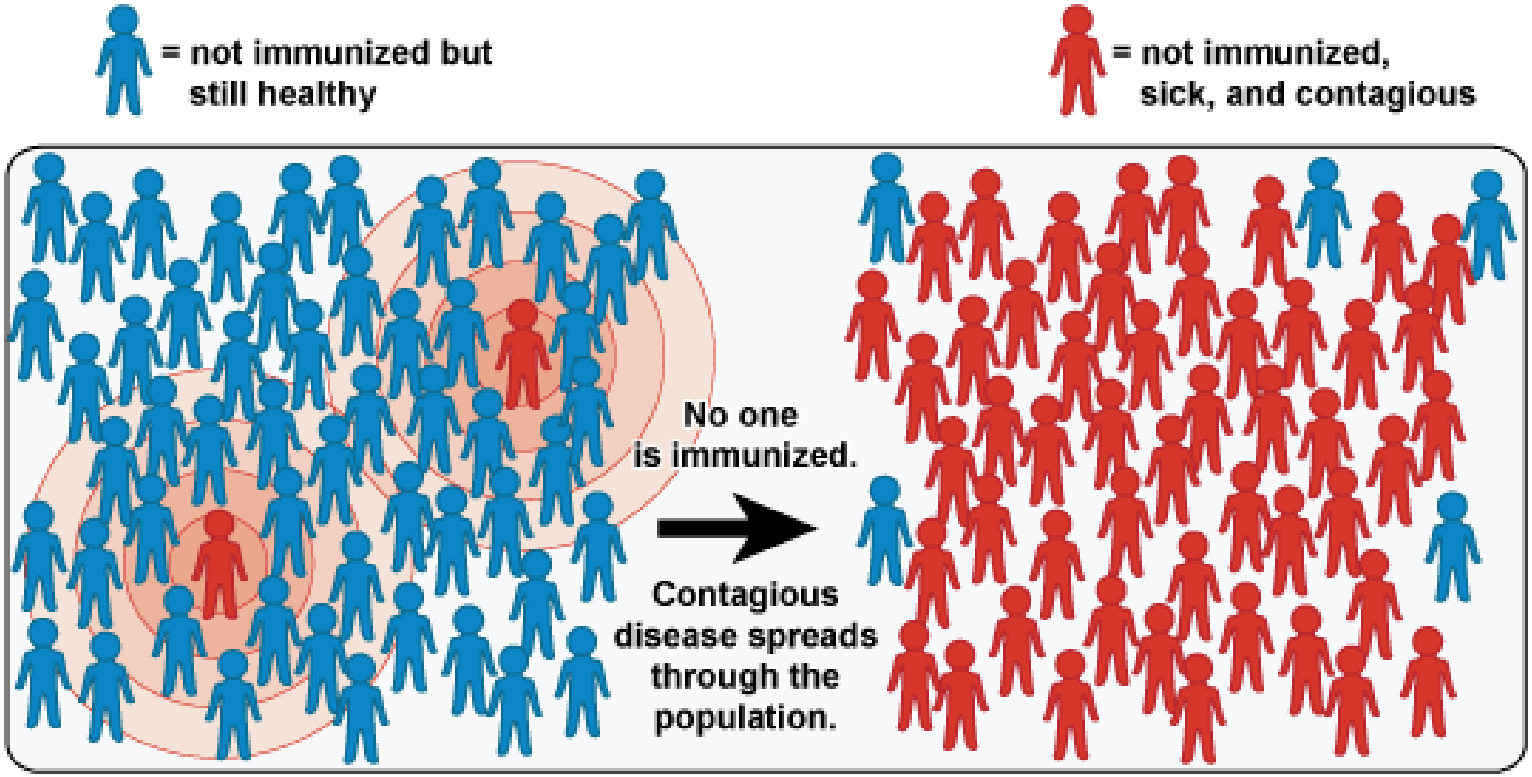
- Kids
- Vaccinated, but vaccine didn’t work
- Others who didn’t get vaccine

Healthy,
Not immunized

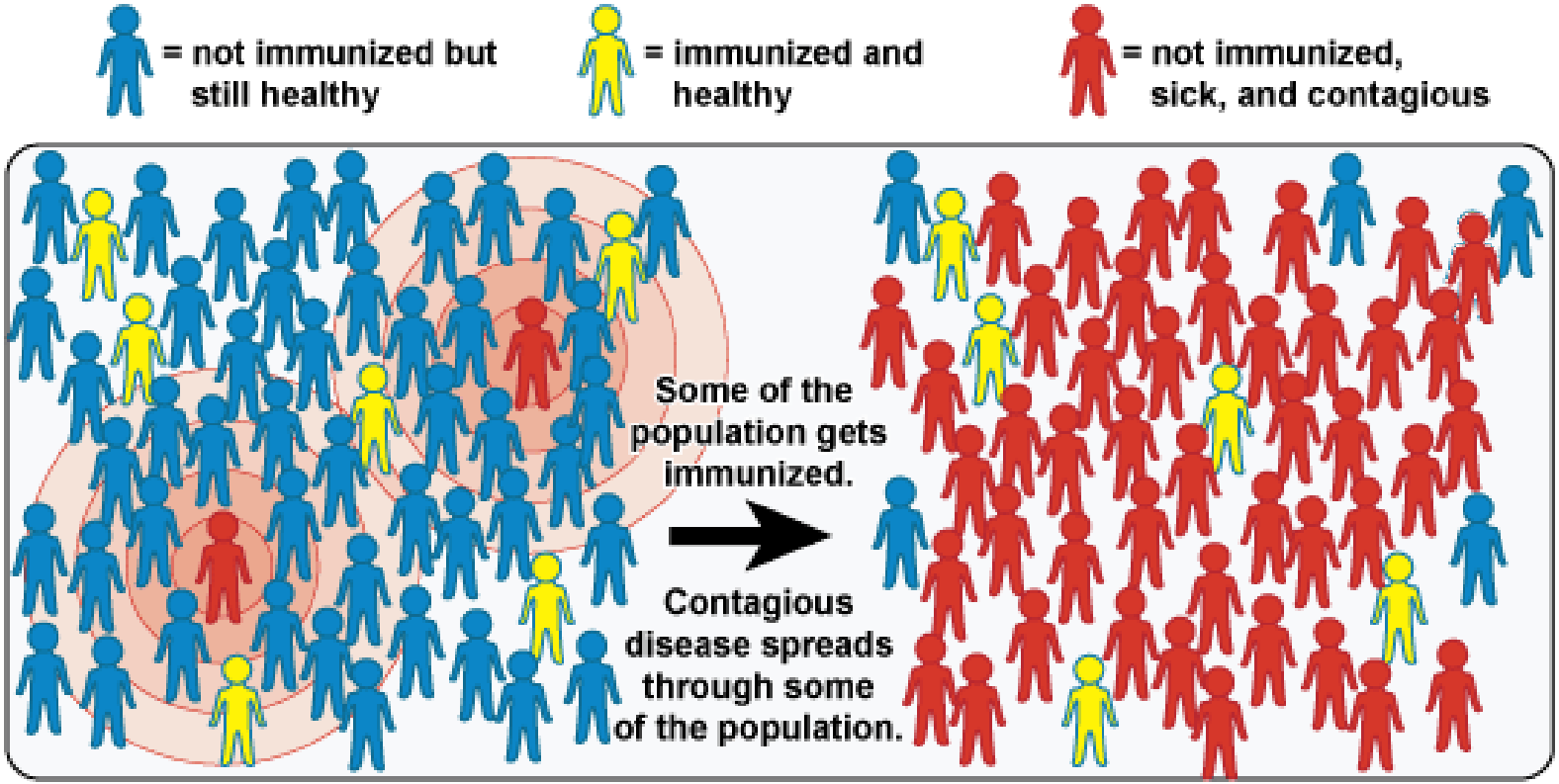
Sick,
Not immunized

Healthy,
Immunized

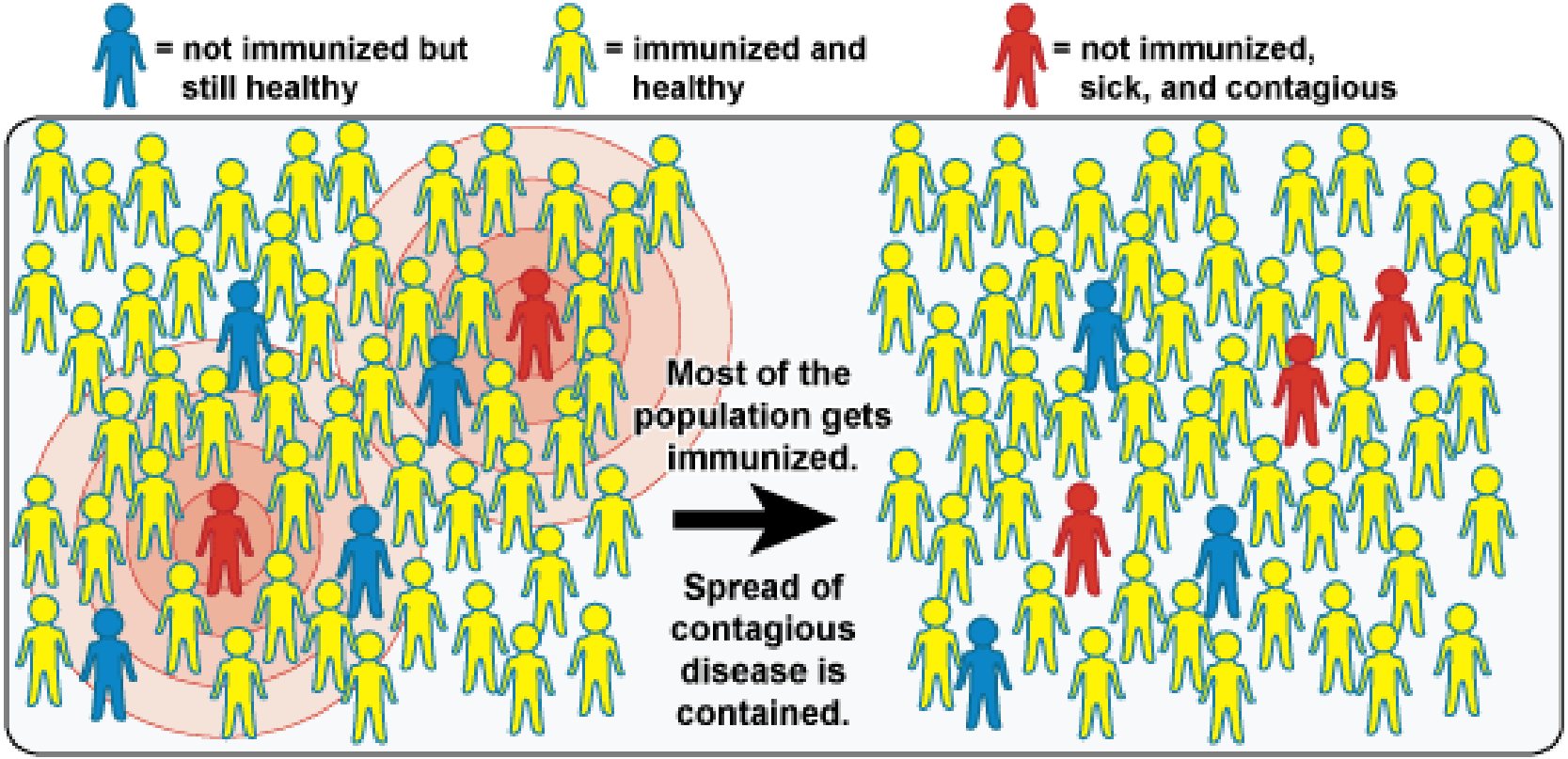
Unvaccinated population



Partially vaccinated population



With widespread immunization, HERD IMMUNITY protects the non-immune!



CONCERNS ABOUT VACCINES AGAINST SARS-COV-2

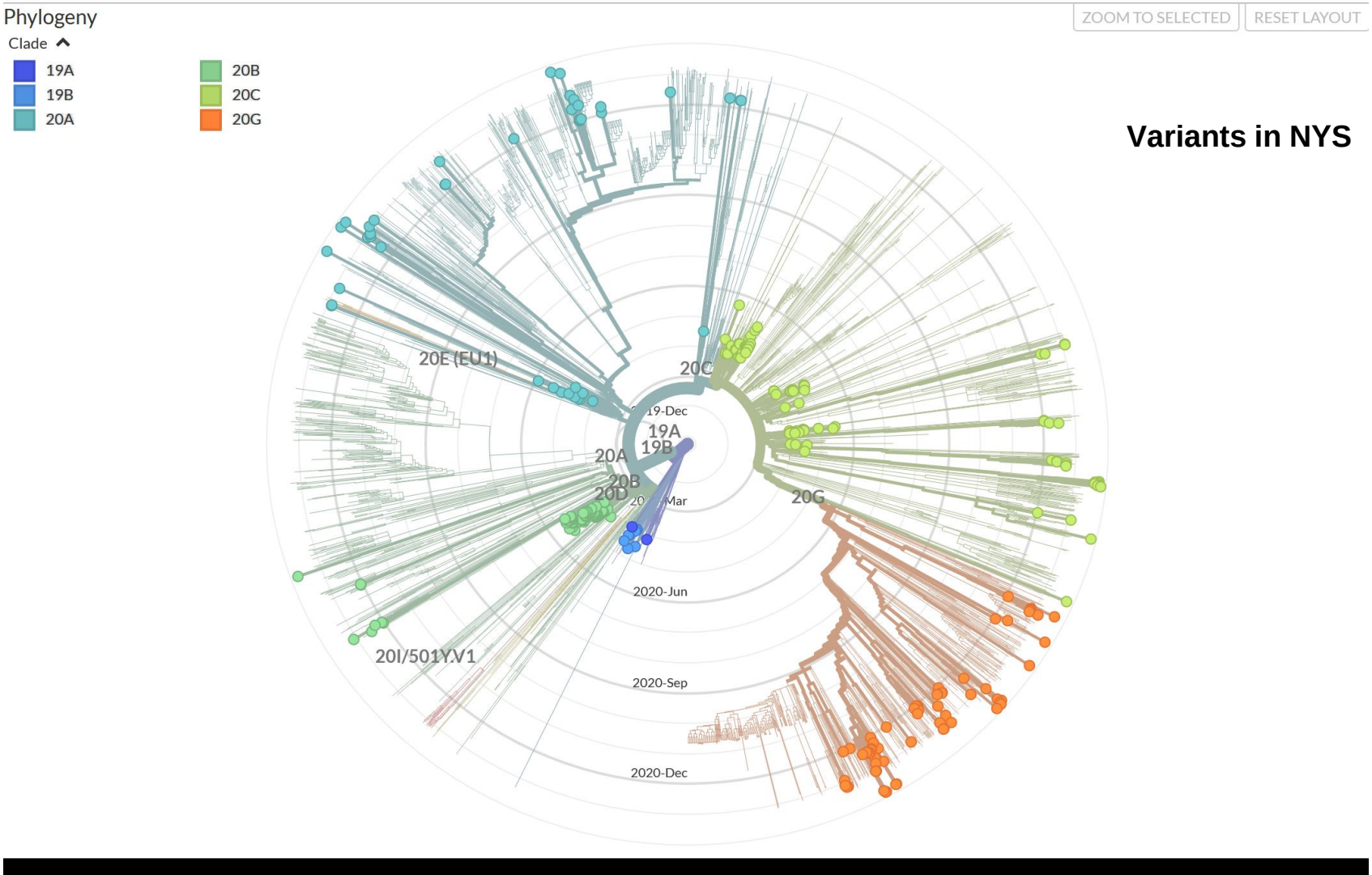
- mRNA will integrate into my DNA
- There are fertility concerns with the vaccines
- The side effects aren't worth it
- The vaccines won't work in older people
- The vaccines were rushed – how is it possible to have had this happen so quickly?
- The variants we are hearing about will make the vaccines moot

POSSIBLE WITH SIGNIFICANT FUNDS TO ALLOW PARALLEL TRACKS OF SCIENCE AND PRODUCTION

BACKED BY DECADES OF BASIC SCIENCE RESEARCH

Date	Milestone
Dec 1	Covid-19 illness documented (unpublicized Nov 17th)
Jan 10	SARS-CoV-2 virus sequenced
Jan 15	NIH designs mRNA vaccine in collaboration with Moderna
Mar 16	Moderna Phase 1l2 trial begins
May 2	Pfizer/BioNTech Phase 1l2 trial begins
July 14	Moderna Phase 1l2 trial published in NEJM
July 27, 28	Moderna and Pfizer/BioNTech Phase 3 trial begins
Aug 12	Pfizer/BioNTech Phase 1l2 published in Nature
October 22,27	Enrollment in both Phase 3 trials complete; >74,000 participants
Nov 9	Pfizer/BioNTech announces interim analysis efficacy > 90%
Nov 16	Moderna announces interim analysis efficacy 94.5%
Nov 18	Pfizer/BioNTech announces 95% efficacy as final result
Nov 20	1st EUA submitted by Pfizer/BioNTech
Nov 27	Distribution of vaccine by UAL charter flights throughout US
Dec 10	FDA External review of Pfizer/BioNTech EUA
Dec 11	Phase 1a Vaccination begins for health care professionals*

*Provisional on positive external review


Phylogeny
Clade
19A
19B
20A
20B
20C
20G
ZOOM TO SELECTED
RESET LAYOUT
Variants in NYS
20E (EU1)
20C
19-Dec
19A
19B
20A
20B
20D
Mar
20G
2020-Jun
20I/501Y.V1
2020-Sep
2020-Dec

HOW THE KNOWN VARIANTS OF CONCERN AFFECT COVID-19 AND VACCINES

	B.1.1.7	B.1.351	P.1
Alternate name	501Y.V1	501Y.V2	501Y.V3
Country identified	United Kingdom	South Africa	Brazil
Mutations	23	21	17
Spike mutations	8	9	10
Key RBD, spike mutations beyond N501Y in all	E69/70 deletion, P681H 144Y deletion, A570D	E484K, K417N, orf1b deletion	E484K, K417T, orf1b deletion
Other mutations, including N-terminal	T7161, S982A, D1118H	L18F, D80A, D215G, Δ242-244, R264I, A701V	L18F, T20N, P26S, D138Y, R190S, H655Y, T10271
Transmissibility Δ	>50% increased	No	Not established
Lethality Δ	Not resolved	?	?
Immune evasion	Unclear	Yes	Yes, less than B.1.351
Vaccine efficacy (preserved vs severe infections in all so far)	Modest reduction ~10% point decline in 2 trials (Novavax, AZ)	Yes, reduced in 2 (J&J, Novavax ~20-30% point decline. No efficacy v mild infections w/AZ	Preserved in J&J trial
Countries reported	94	48	25
US States reported	46	17	5