Pacific Northwest
NATIONAL LABORATORY

Testing, Testing, 1, 2, 3 (And What's Up with the New Vaccine, Anyways?)

Tuesday, March 23

Featuring: Kristin M. Omberg, PhD
Group Leader, Chemical & Biological Signatures
PNNL-SA-160743

DEMYSTIFYING COVID:

A Special Edition
Seminar Series

COMMUNITY
SCIENCE &
TECHNOLOGY
SEMINAR SERIES
@PNNL

Start the presentation to activate live content

If you see this message in presentation mode, install the add-in or get help at PollEv.com/app

50+ years developing goodwill

Historical	FY 2019
$28.5M	**$0.52M**
Philanthropic Investments	

Historical	FY 2019
347,000	**30,000**
Team Battelle Volunteer Hours	

Historical	FY 2019
>120	**56**
Community Organizations	

Visit **pnnl.gov/events**

COMMUNITY
SCIENCE & TECHNOLOGY
SEMINAR SERIES
@PNNL

DEMYSTIFYING COVID:

A Special Edition Seminar Series

EVERY TUESDAY
IN MARCH
5:00-6:00 P.M.

MARCH02

Hindsight is 2020: The Science Behind COVID-19

Presented by Steve Wiley

What lessons have we learned over the last few months? What's left for us to uncover? And seriously what is the difference between a cold, a flu, and COVID symptoms?

MARCH09

What Do Bats Have to Do with It?

Presented by Amy Sims

Bats, pangolins, and humans—oh my! This talk will explore the role wild animals play in the emergence of new diseases.

MARCH16

Behind the Mask: The Science on Stopping the Spread

Presented by Katrina Waters

What measures keep our communities safe? And why do some strange, sometimes serious health effects linger even after COVID-19 has gone, including a loss of taste and smell or COVID toe? Join us to find out.

MARCH23

Testing, Testing, 1, 2, 3 (And What's Up With The New Vaccine, Anyways?)

Presented by Kristin Omberg

If you're confused about COVID-19 testing and vaccines, you're not alone. This talk will explore the science behind the 400+ diagnostic tests and 200+ vaccine candidates produced over the last year.

MARCH30

Model Me This: COVID-19 Scientific Predictions and Where We Go from Here

Presented by Tim Scheibe

Using mathematical models, scientists across the globe are beginning to arrive at a more complete picture of how and why COVID-19 spread across geographical locations and human populations.

Pacific Northwest
NATIONAL LABORATORY

Pacific Northwest
NATIONAL LABORATORY

COMMUNITY REPRESENTATIVES

EVERY TUESDAY
IN MARCH
5:00-6:00 P.M.

LoAnn Ayers

President & CEO

United Way of Benton
& Franklin Counties

Kate McAteer

Vice Chancellor | Academic and Student Affairs

WSU Tri-Cities

Justin Raffa

Artistic Director

Mid-Columbia
Mastersingers

Martin Valadez

Interim Executive Director

Tri-Cities Hispanic
Chamber of Commerce

Regional Director

Tri-Cities Campus
Heritage University

TODAY'S SPEAKER

EVERY TUESDAY
IN MARCH
5:00-6:00 P.M.

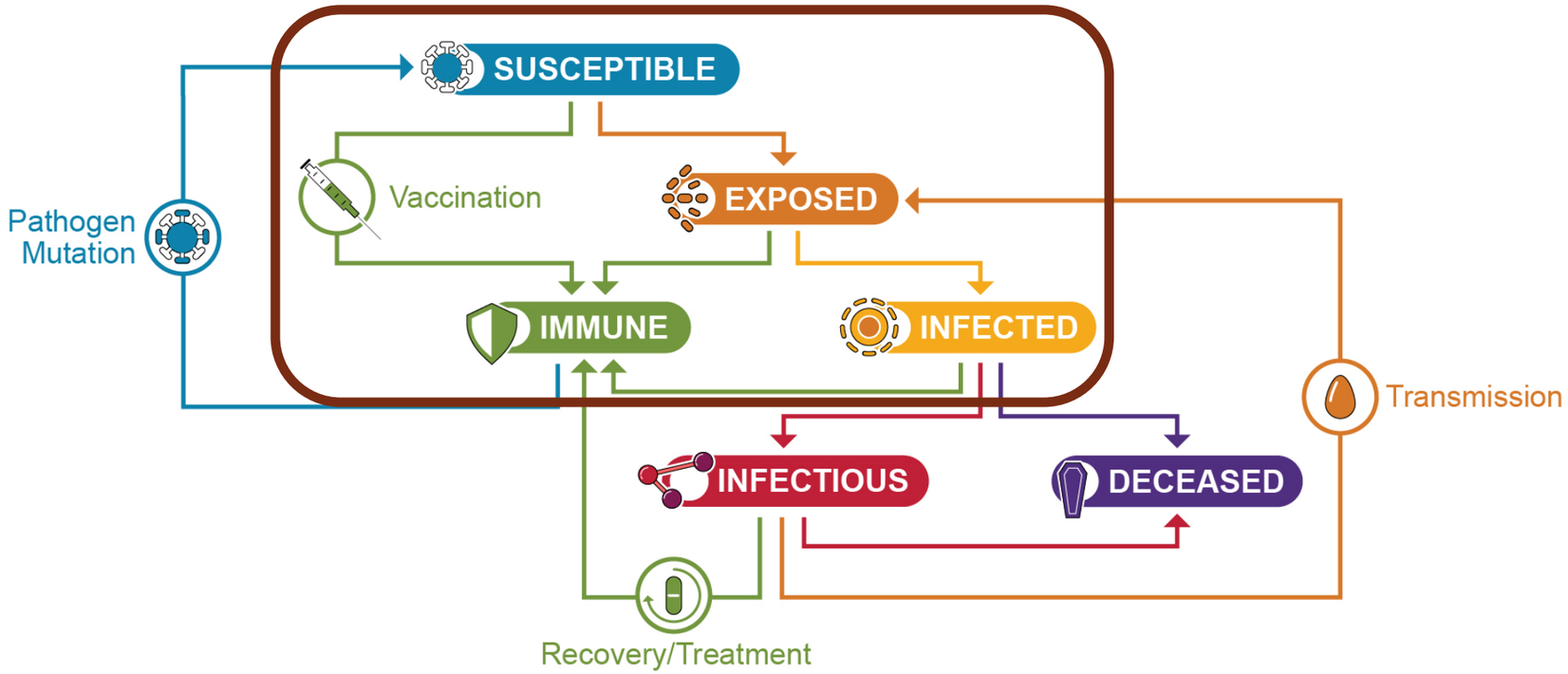
Kristin Omberg

Group Leader
Chemical and Biological Signatures

Pacific Northwest
NATIONAL LABORATORY

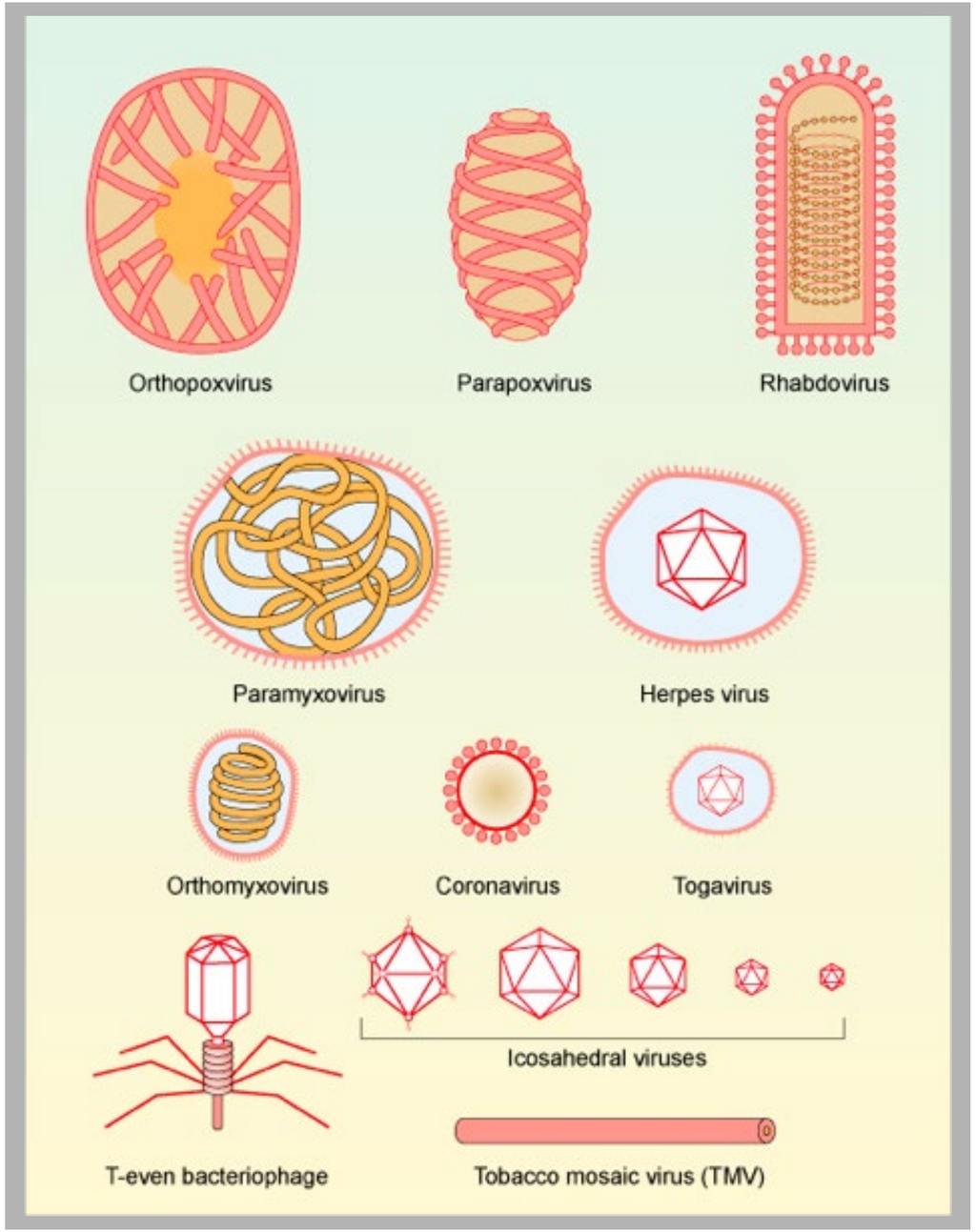
Today's discussion: **detection** of infection **and vaccination**

VIRAL INFECTION OVERVIEW



What is a virus?

- Non-living particle of genetic material
- Your immune system recognizes viruses based on proteins on the virus' surface
- Immune system tags viruses with complementary proteins to disable or destroy
- Virus genetic material and proteins are the basis for both testing and vaccination



Terminology

Pandemic

- An outbreak of a disease that is prevalent over a continent or the world

NOTE: An **epidemic** is more localized

Transmission

- Spreading a disease

Mutation

- Changes to the genome of a pathogen or organism that may affect transmission, symptoms, or prior immunity

Infectious/Contagious

- The state of being able to transmit a disease to another person

Vaccine

- A preventative measure to build immunity against a specific disease

Model

- A representation of a disease or process that can recapitulate key aspects

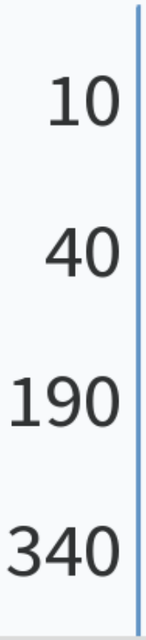
Reservoir

- Any person, animal, plant, soil, or substance in which an infectious agent normally multiplies

When poll is active, respond at **pollev.com/pnnl**

Text **PNNL** to **22333** once to join

The Food & Drug Administration has approved 41 tests for influenza. About how many are currently authorized for COVID-19?



Talk overview

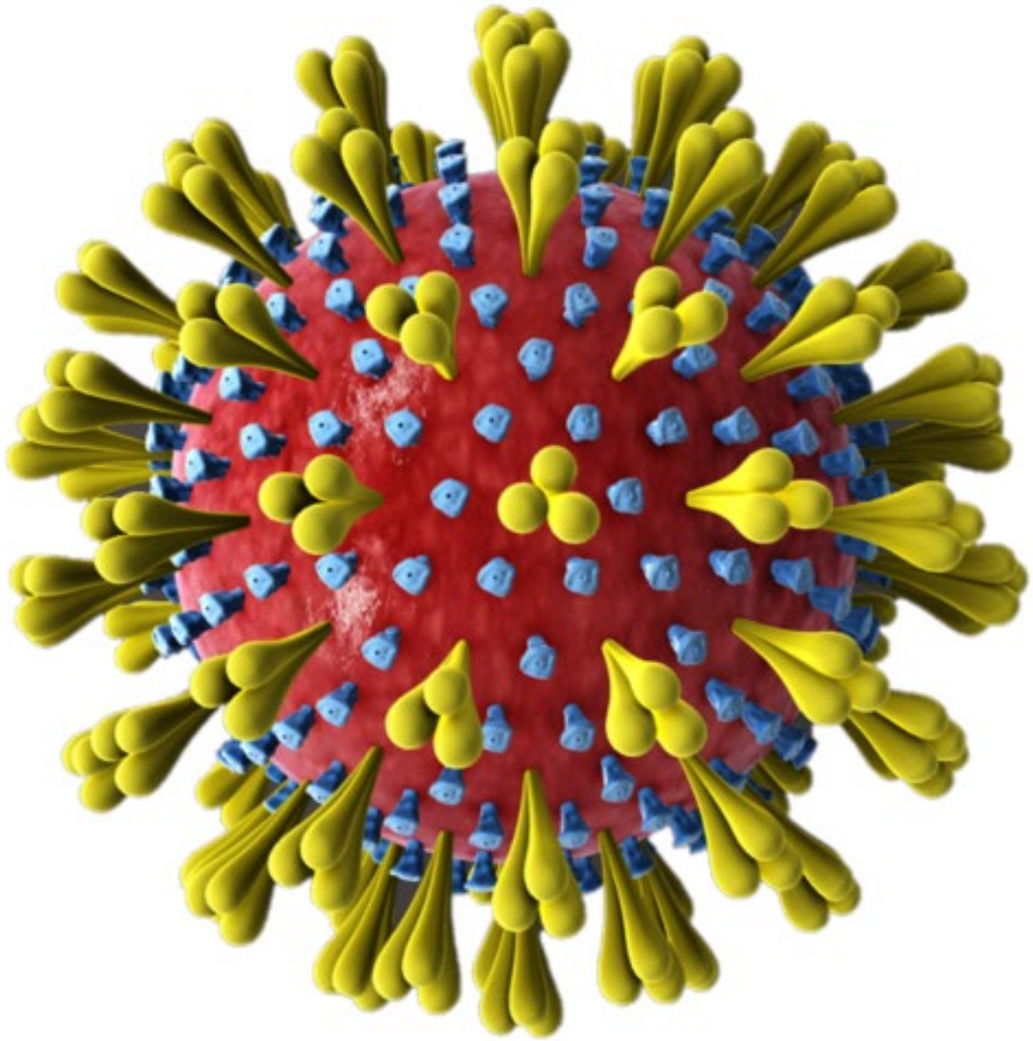
- Components of the coronavirus
- Common testing methods
  - Diagnostic tests
  - Immunoassay tests
  - Home tests
  - Why swab? Or, can't I just spit?
- COVID-19 vaccines
  - The four types of vaccines
  - What about the variants?
- Where do we go from here?

Talk overview

- **Components of the coronavirus**
- Common testing methods
  - Diagnostic tests
  - Immunoassay tests
  - Home tests
  - Why swab? Or, can't I just spit?
- COVID-19 vaccines
  - The four types of vaccines
  - What about the variants?
- Where do we go from here?

Components of the coronavirus

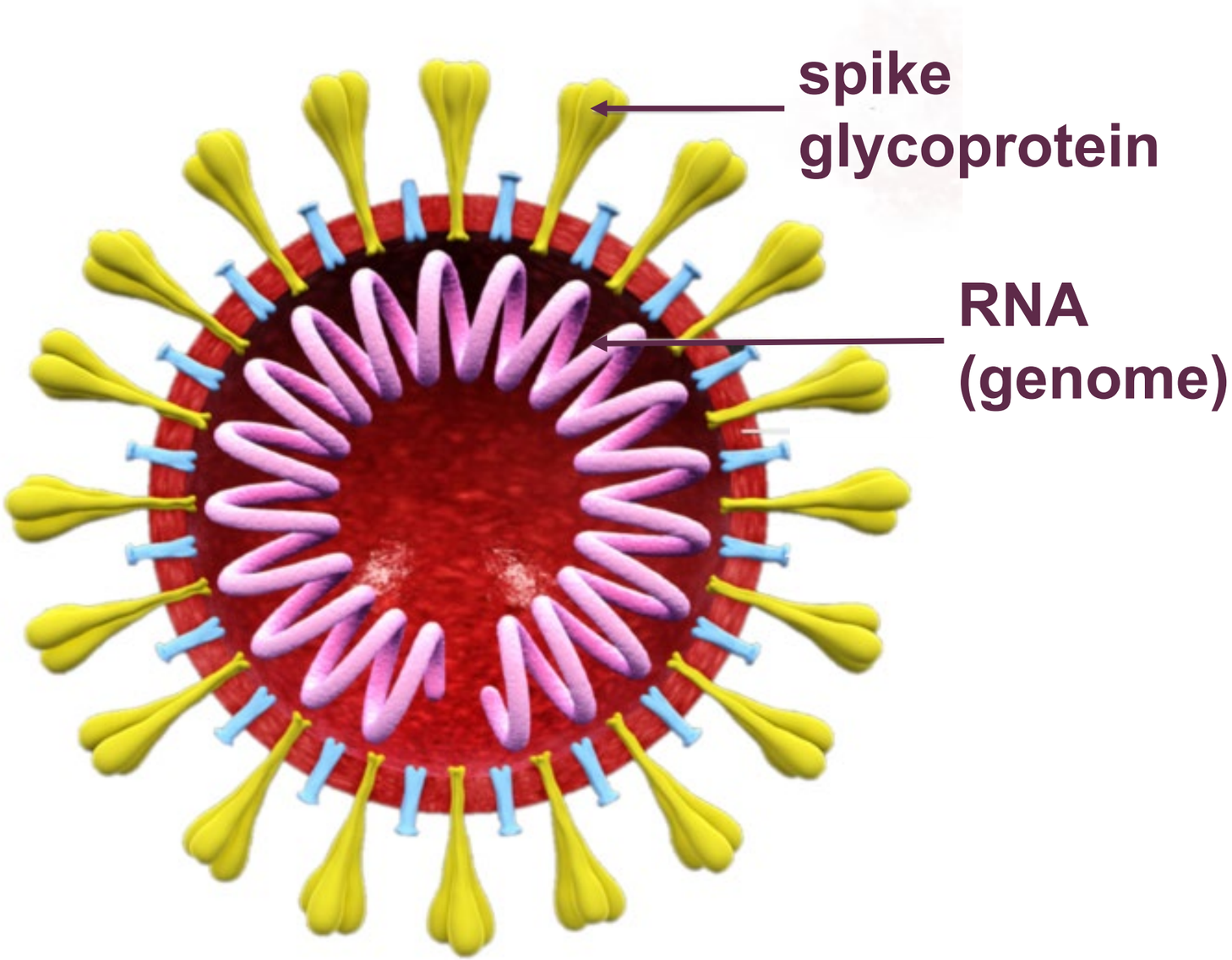
- Coronaviruses are enveloped, single-stranded RNA viruses



Pacific Northwest
NATIONAL LABORATORY

Components of the coronavirus

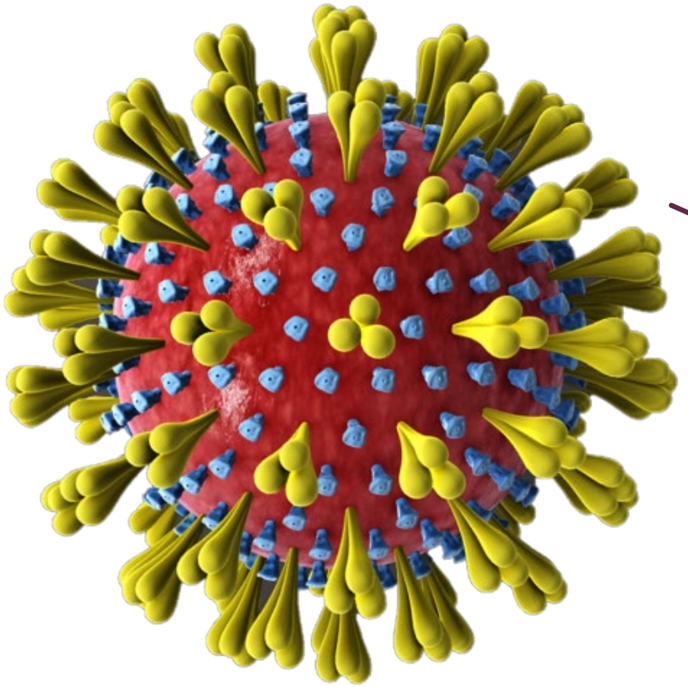
- Spike protein (S) helps the virus get its RNA into human cells so it can replicate
- Diagnostic tests detect either S or the RNA



Talk overview

- Components of the coronavirus
- **Common testing methods**
  - **Diagnostic tests**
  - **Immunoassay tests**
  - **Home tests**
  - **Why swab? Or, can't I just spit?**
- COVID-19 vaccines
  - The four types of vaccines
  - What about the variants?
- Where do we go from here?

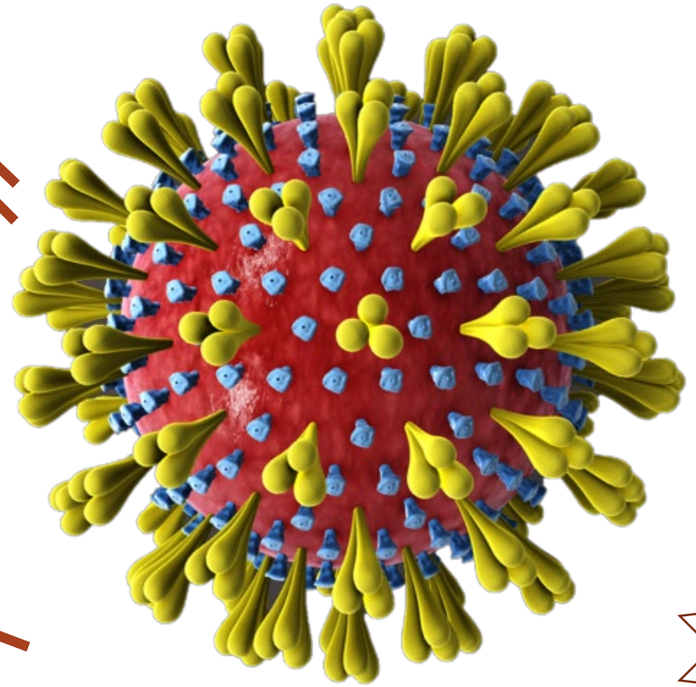
Most rapid/point-of-care tests detect S antigen



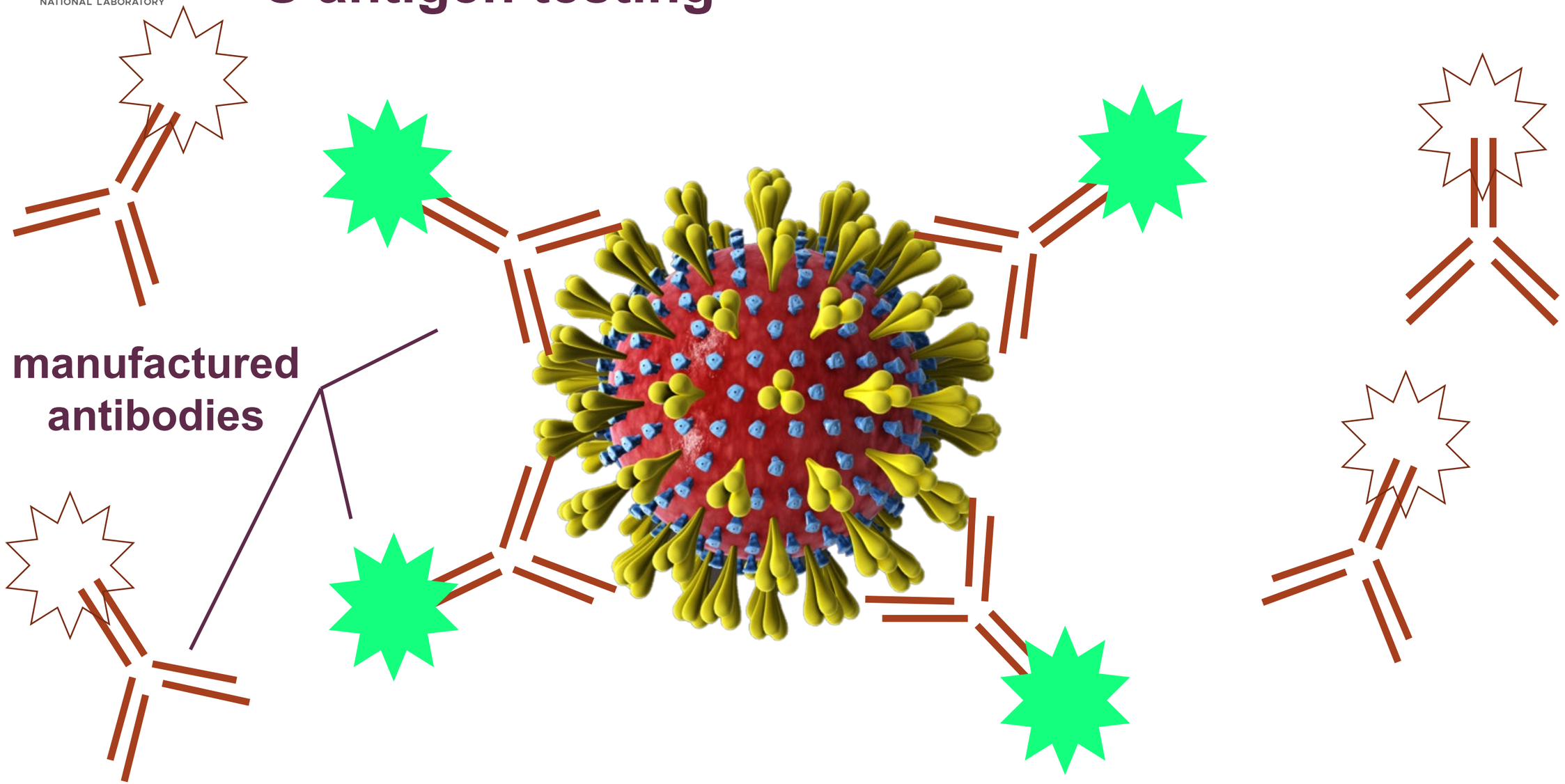
spike glycoprotein
(“antigen”)

S antigen testing

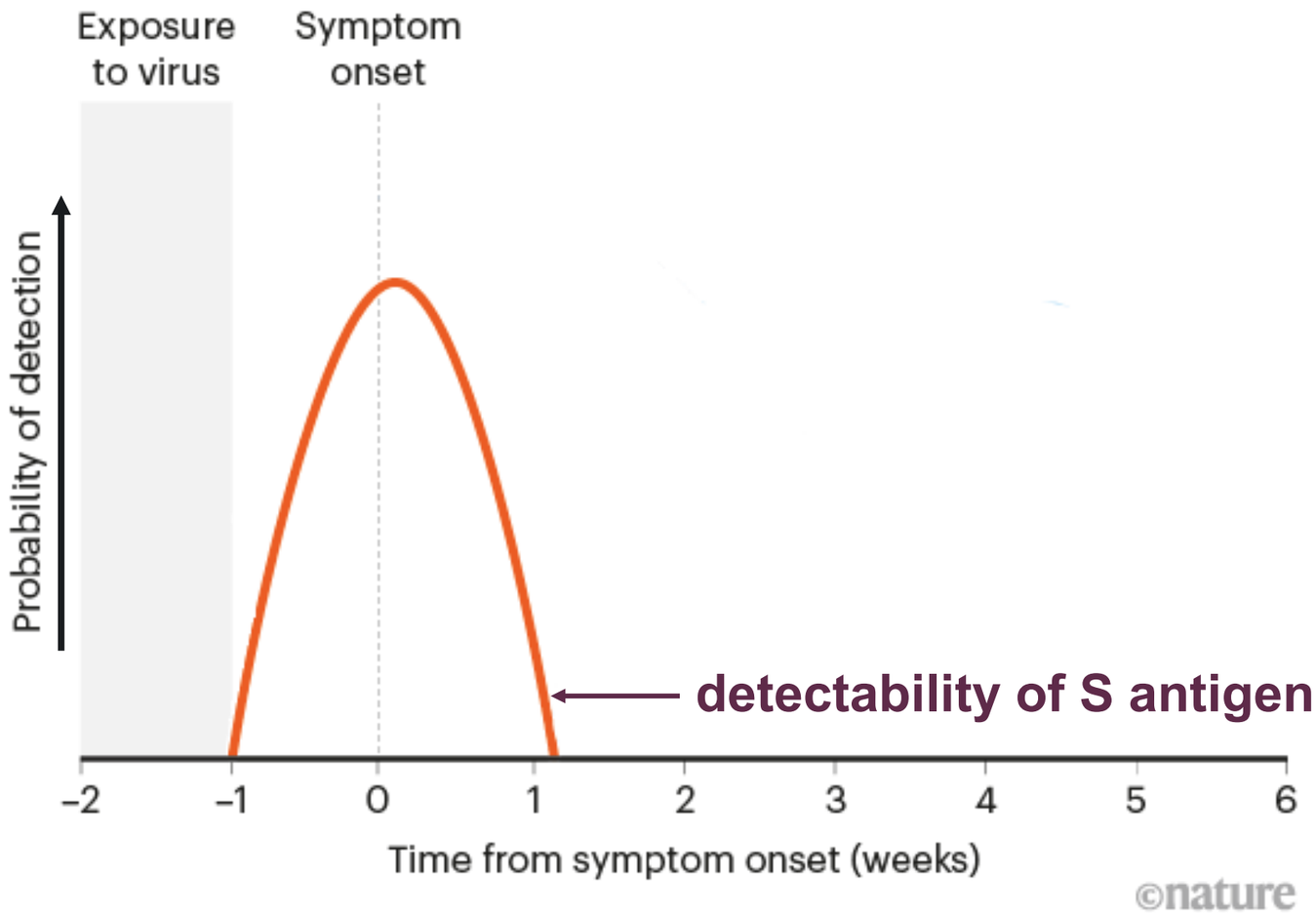
manufactured antibodies



S antigen testing



S antigen can be detected just before symptoms start and up to a week after

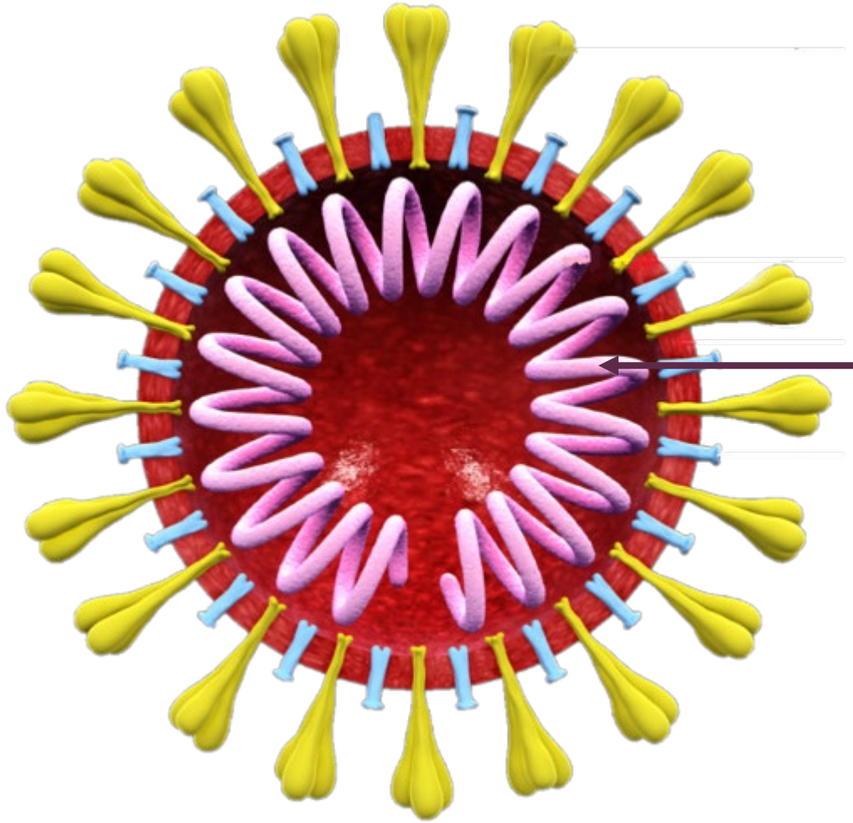


https://www.nature.com/articles/d41586-020-02661-2

S antigen diagnostic tests

- Benefits
  - Can be run in a doctor's office
  - 15 minutes from swab to result
  - Positive result indicates current infection
- Drawbacks
  - Relatively insensitive
    - ✓ Infected people may still receive negative results
  - Narrow window of detection
    - ✓ Unlikely to detect pre- or late-symptomatic people

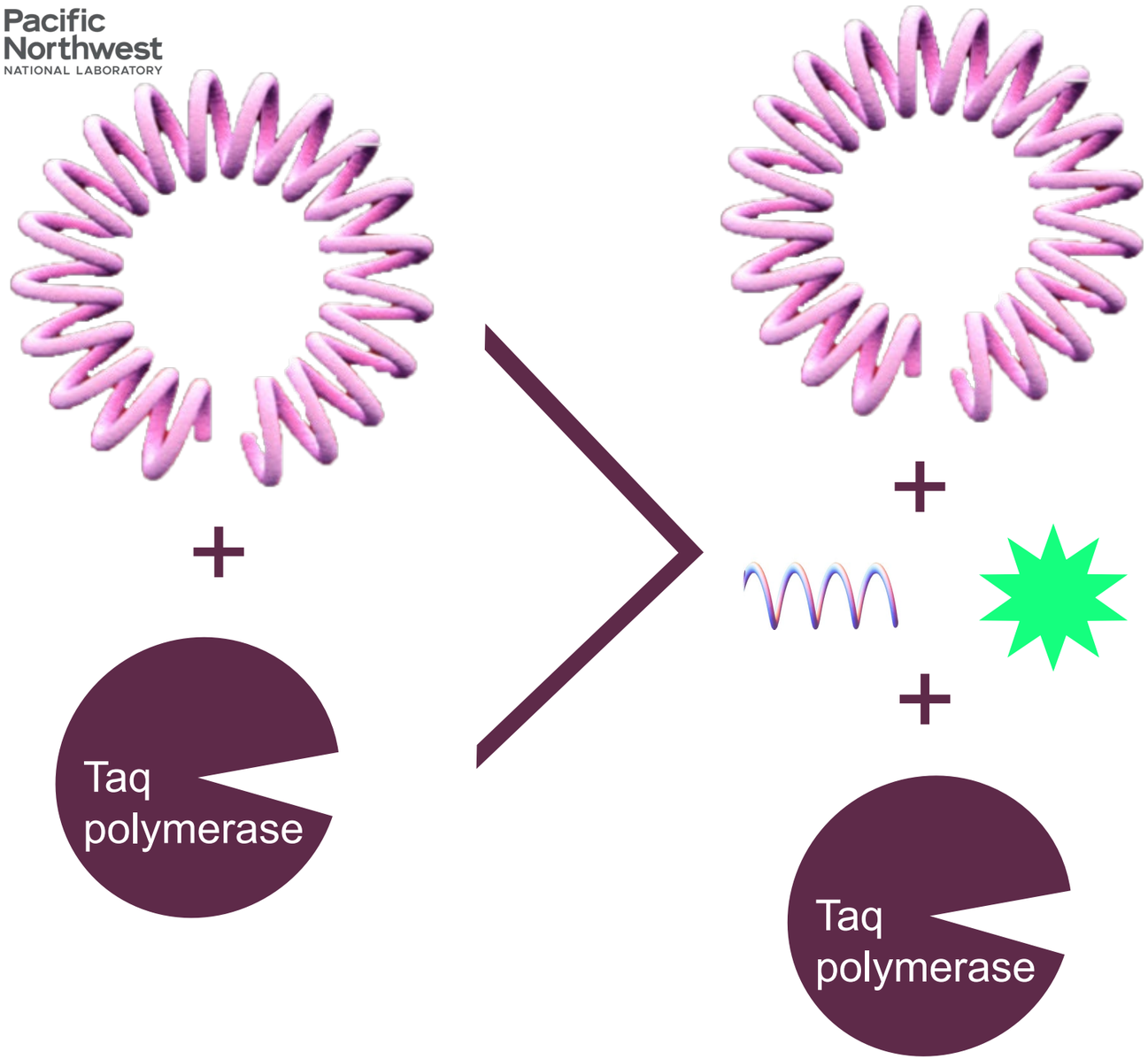
Most laboratory-based tests detect RNA

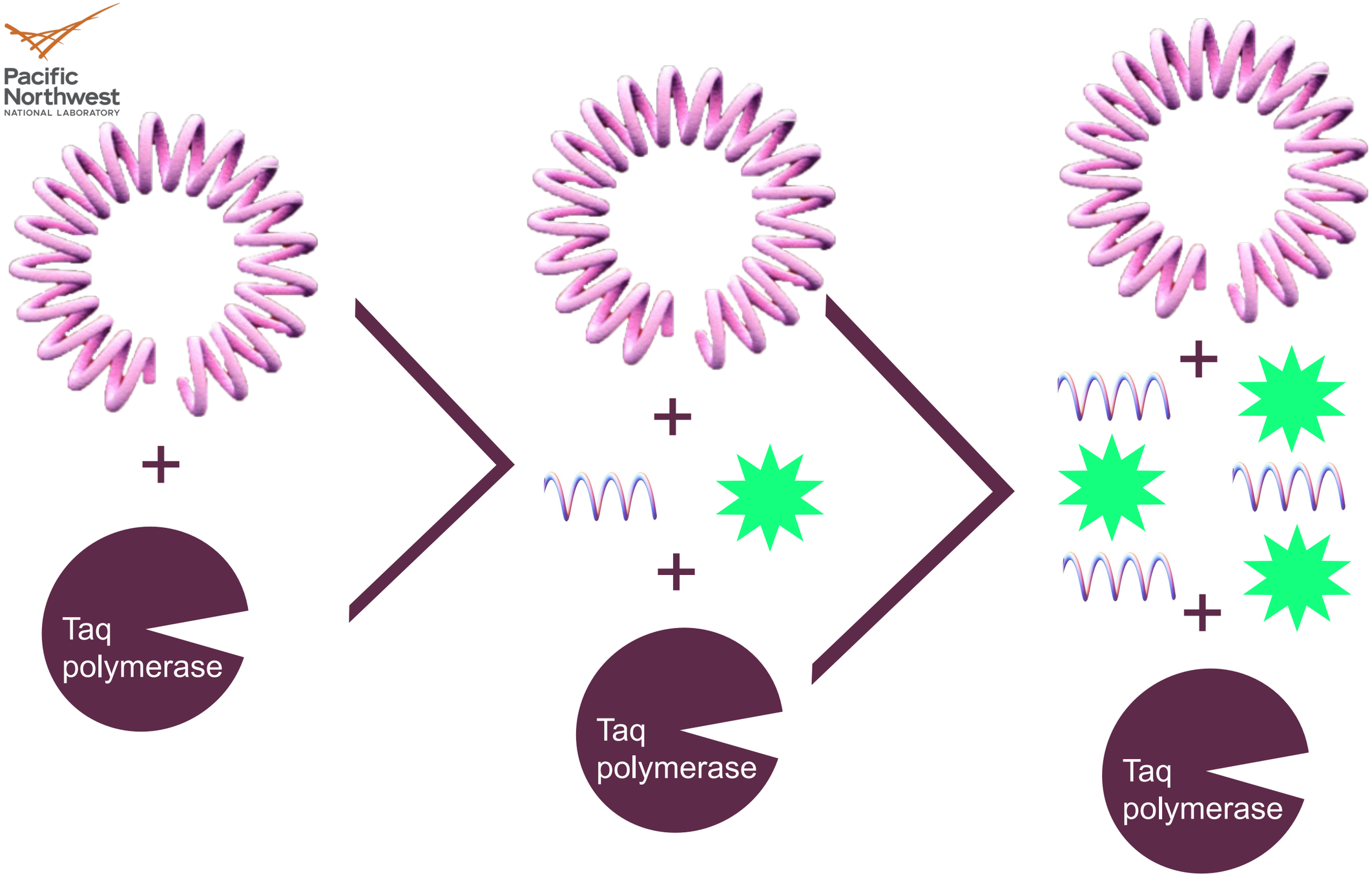


RNA (ribonucleic acid)
(“genome” or “nucleic acid”)

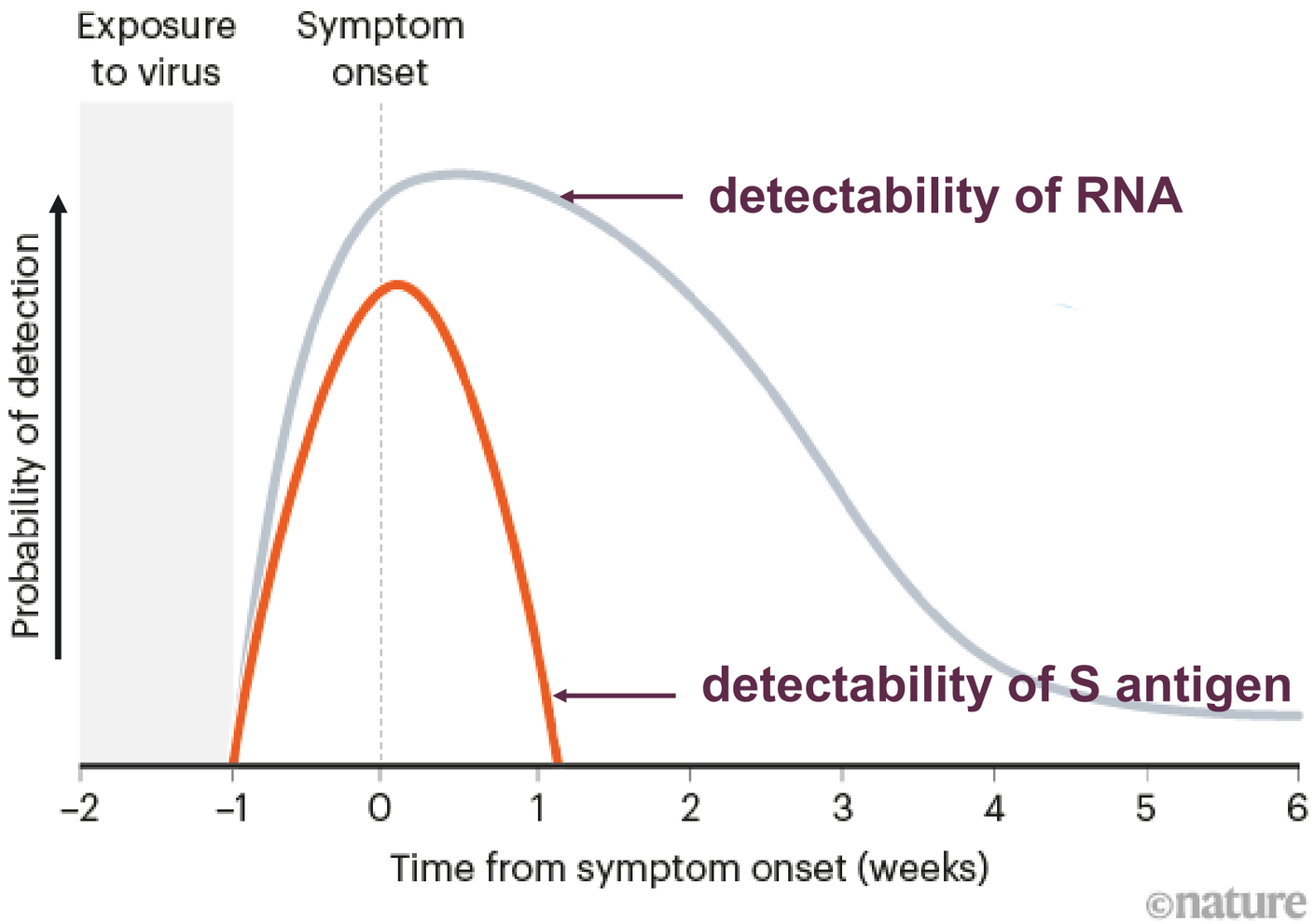
Pacific Northwest
NATIONAL LABORATORY

+


Taq
polymerase
Taq
polymerase


Taq
polymerase
Taq
polymerase
Taq
polymerase

RNA (nucleic acid) is detectable several days before symptoms start and many weeks after

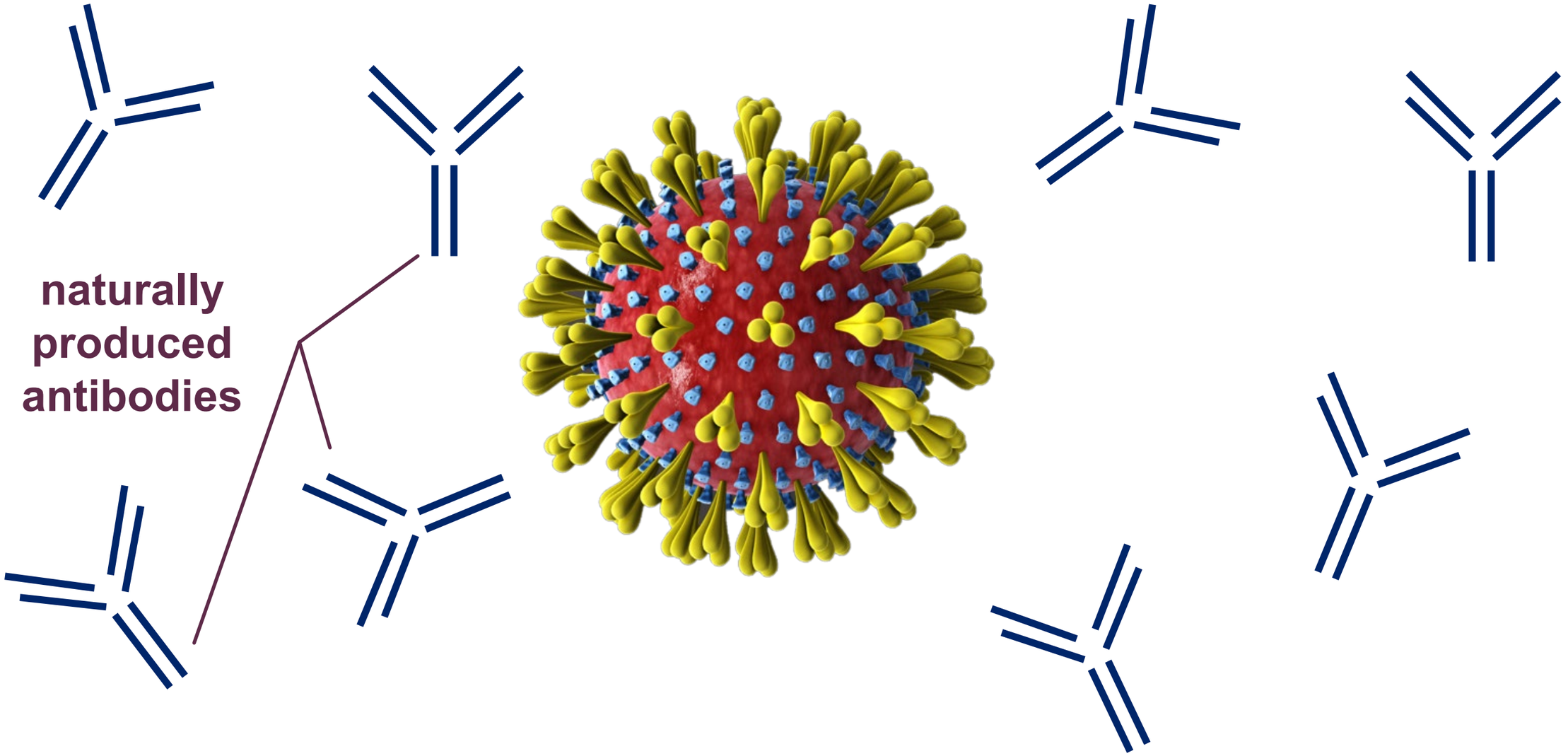


https://www.nature.com/articles/d41586-020-02661-2

Nucleic acid diagnostic tests

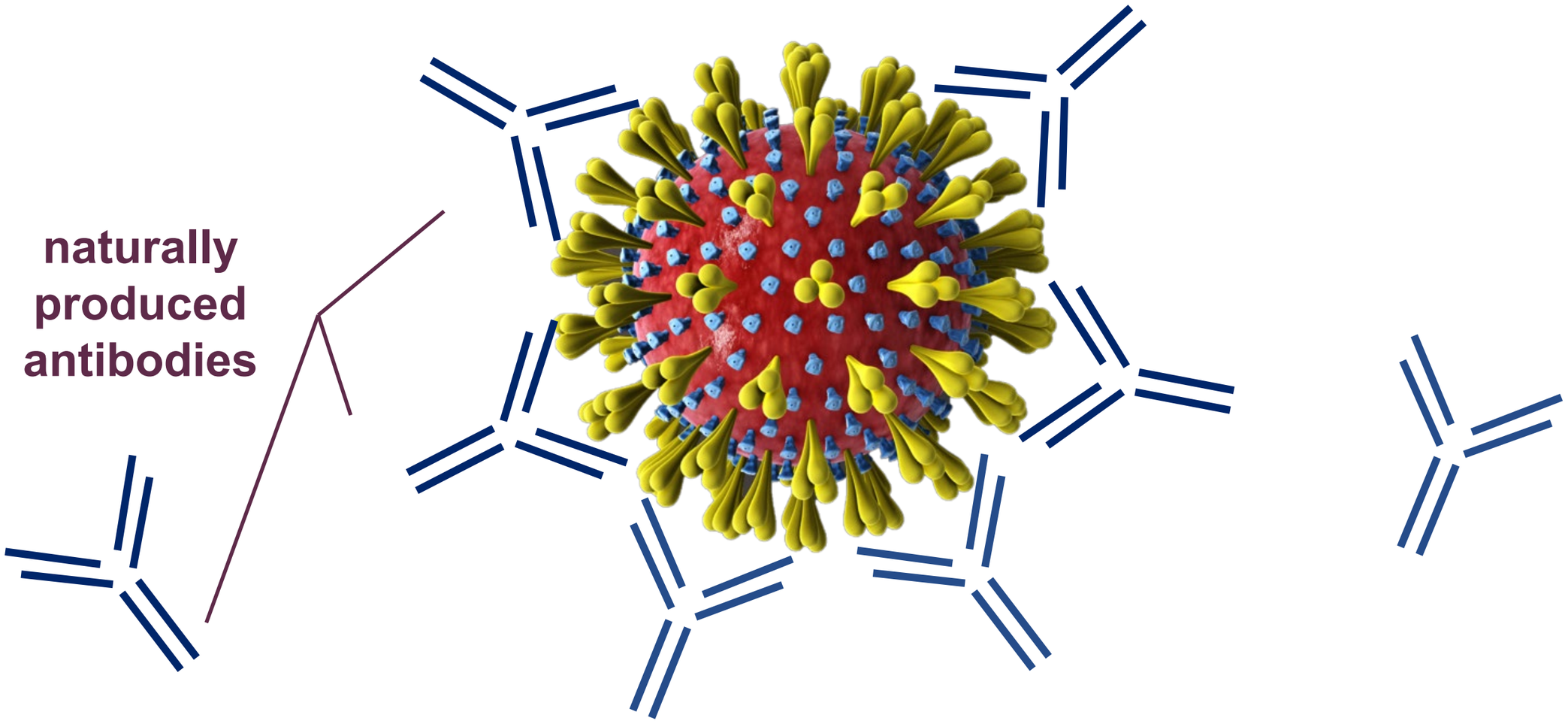
- Also known as “nucleic acid amplification tests” (NAAT) or polymerase chain reaction (PCR)
- Benefits
  - Gold standard of diagnostic tests
  - Extremely sensitive
  - Extremely specific; unlikely to detect anything other than the 2019 strain
  - May identify people who are infected but pre-symptomatic
- Drawbacks
  - Usually takes 4–6 hours in a laboratory to get results
  - Results indicate current or recent infection
  - Infected people may test positive for months after symptoms subside

Antibody tests determine whether you were exposed

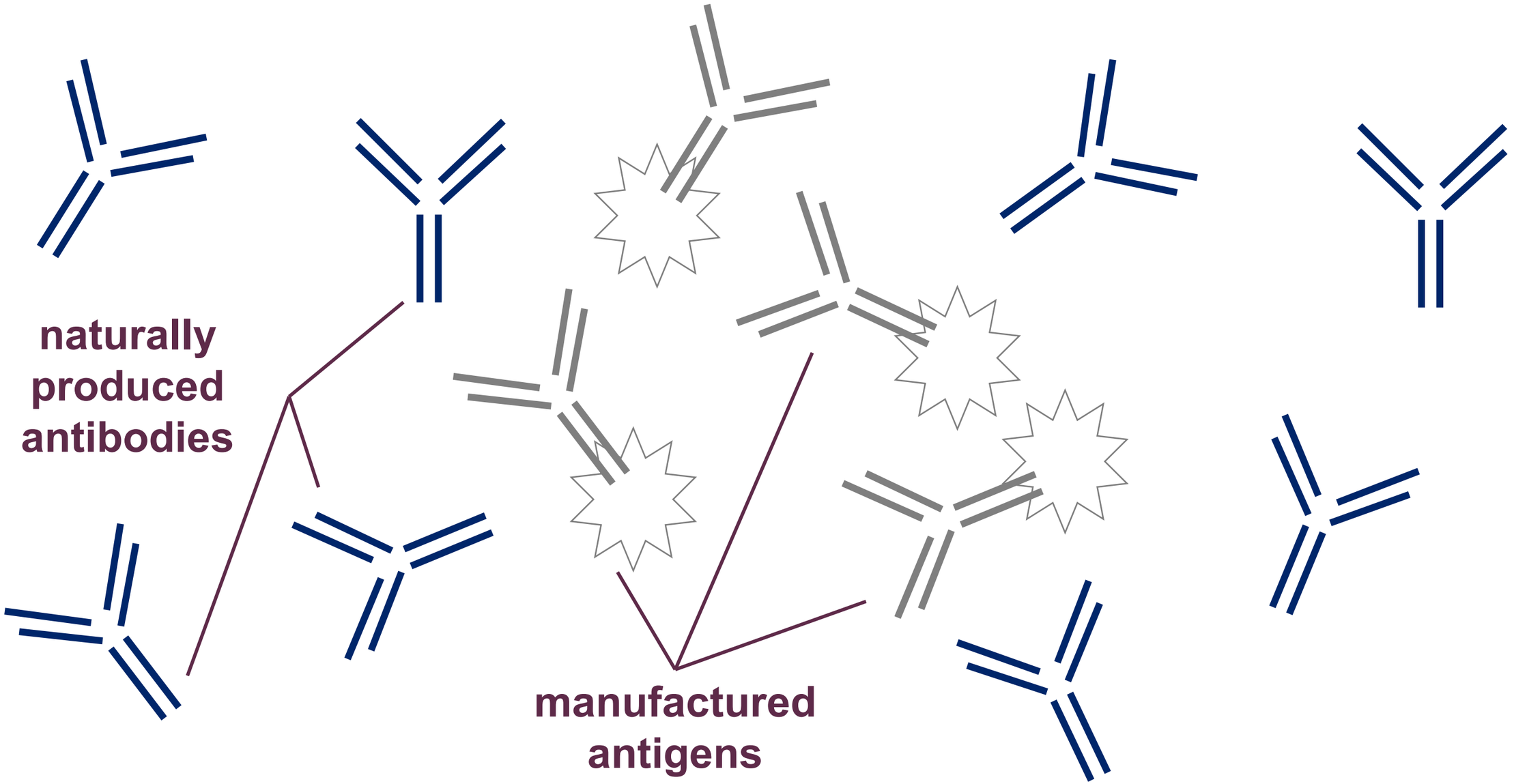


Your immune system makes antibodies to stop a virus from attaching to cells or to destroy it

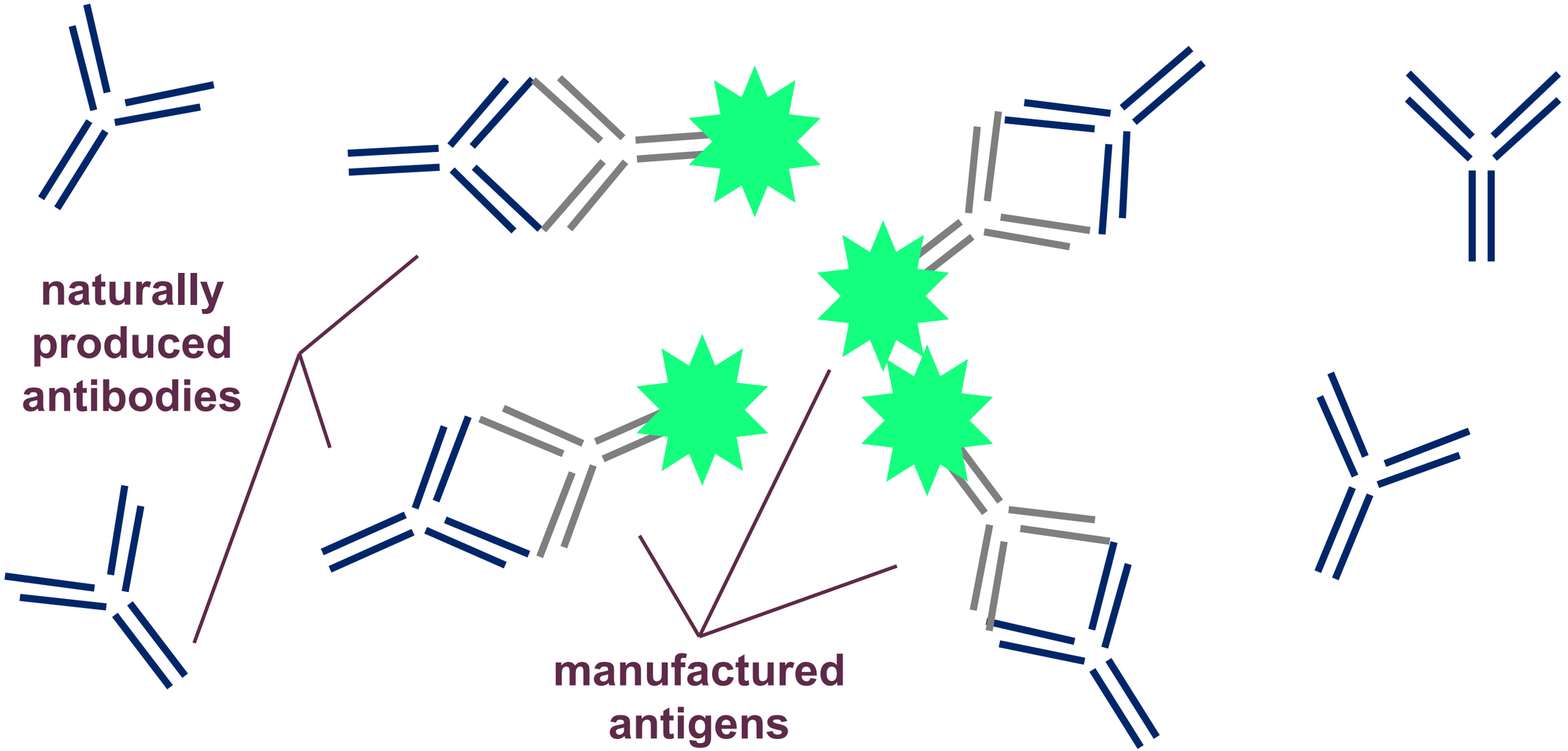
naturally produced antibodies



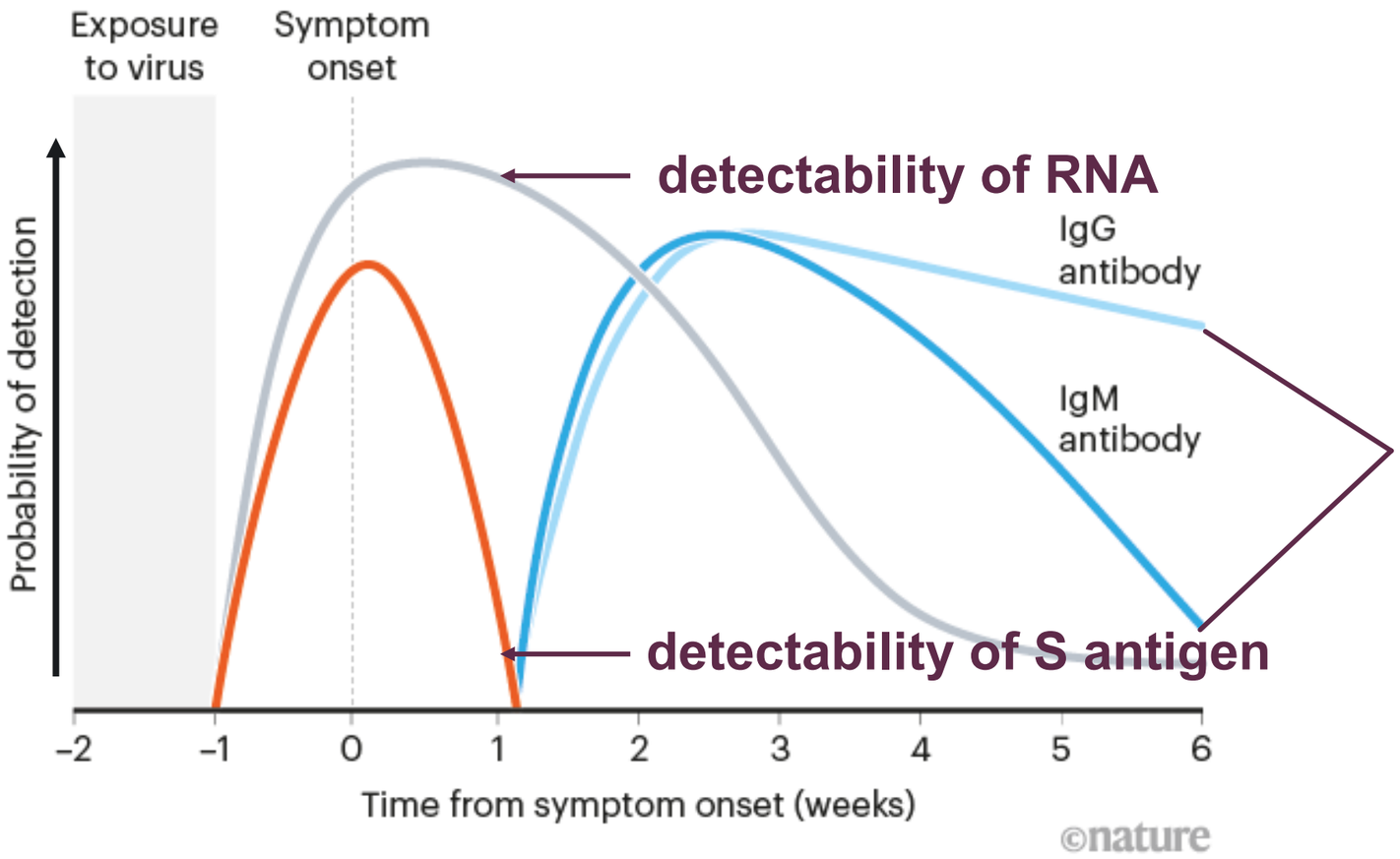
Antibody tests determine whether you were exposed



Antibody tests determine whether you were exposed



Natural antibodies are detectable about a week after symptoms start and decline over time



detectability of natural antibodies

https://www.nature.com/articles/d41586-020-02661-2

Immunoassay tests

- Benefits
  - Allows identification of potential plasma donors to help treat patients fighting infection
  - May provide retrospective information on the presence of disease in a community
- Drawbacks
  - Not likely to detect infectious people
  - Not very sensitive, which can lead to false negative results
  - Prone to detect antibodies from other, milder human coronaviruses (cross-reactivity), can lead to false positive results

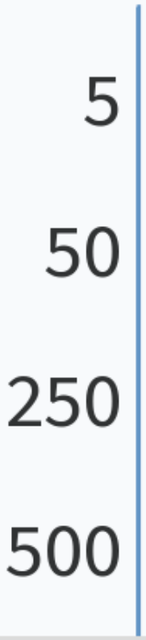
Home tests

- FDA has authorized about 10 home diagnostic tests
- All are molecular (nucleic acid) tests

When poll is active, respond at **pollev.com/pnnl**

Text **PNNL** to **22333** once to join

About 70 COVID-19 antibody tests are currently authorized for use in the U.S. How many antibody tests has the FDA removed from the U.S. market?



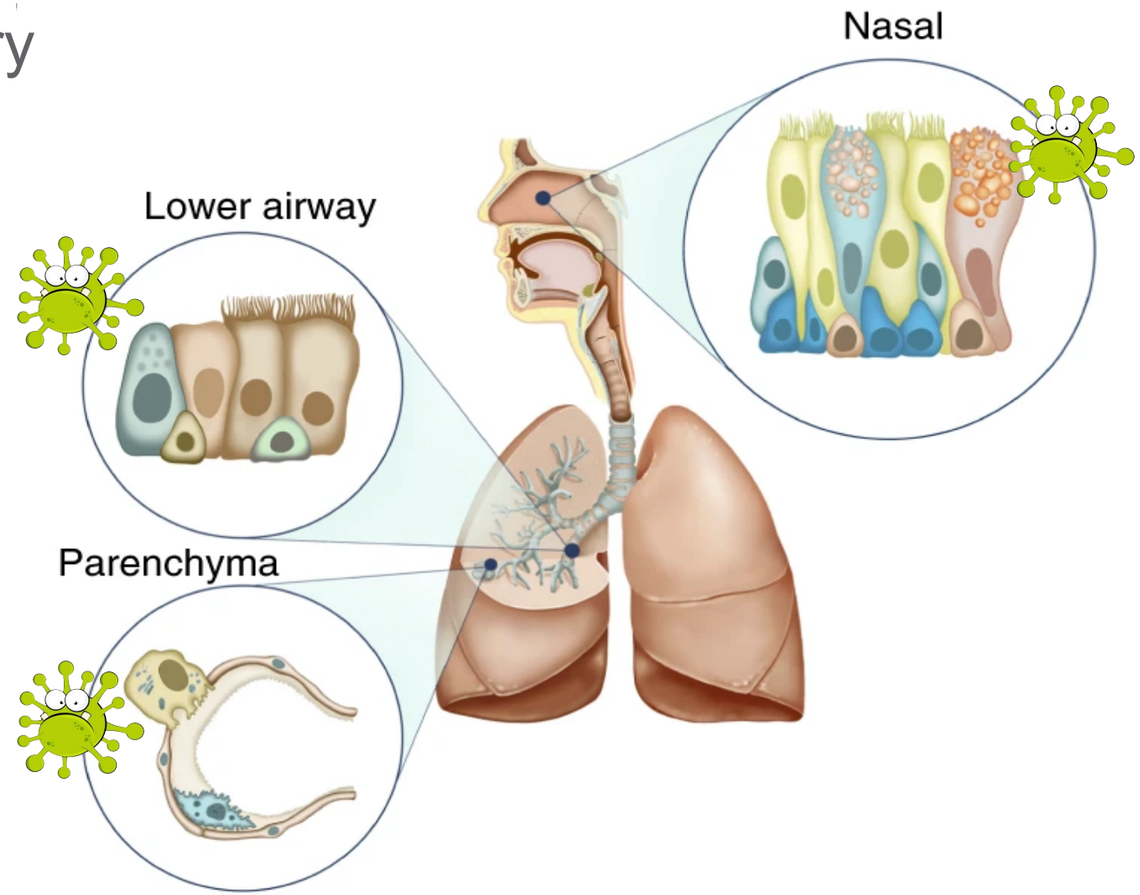
Pacific Northwest NATIONAL LABORATORY

Summary of common test methods

Antigen diagnostic tests	Molecular diagnostic tests (NAAT, PCR)	Immunoassay tests
• Detects current infections • Unlikely to detect pre- or late-symptomatic infections	• Gold standard to detect current infections • Can identify pre- and late-symptomatic infections	• Identifies previous infections
• Relatively insensitive • Infected people may still test negative	• Extremely sensitive • Infected people may test positive for months after symptoms subside	• Prone to false positive and negative results
• Takes about 15 minutes in a doctor's office	• Takes 4–6 hours in a lab	• Takes about 15 minutes in a lab
• Often used in settings where tests are repeated frequently	• All authorized home tests are molecular	

Why swab?

- SARS-CoV-2 replicates in the respiratory tract
  - Test results are more sensitive from respiratory tract samples (sorry!)
- Can’t I just spit?
  - Many common things interfere with molecular diagnostics
    - ✓ Toothpaste, mouthwash
    - ✓ Caffeine
    - ✓ Fruit
    - ✓ Milk
    - ✓ Chocolate
  - Fasting before a saliva test may improve results



www.nature.com/articles/s41591-020-0868-6/figures/1

Where do we go from here scientifically?

- Defining the correlation between detection and infectiousness
- Making diagnostic tests less expensive, faster, and more convenient
- Increasing specificity and sensitivity so immunoassay tests become reliable and meaningful

Talk overview

- Components of the coronavirus
- Common testing methods
  - Diagnostic tests
  - Immunoassay tests
  - Home tests
  - Why swab? Or, can't I just spit?
- **COVID-19 vaccines**
  - **The four types of vaccines**
  - **What about the variants?**
- Where do we go from here?

When poll is active, respond at **pollev.com/pnnl**

Text **PNNL** to **22333** once to join

26 different flu vaccines are available in the U.S. About how many COVID-19 vaccines are available or in development?

12

57

70

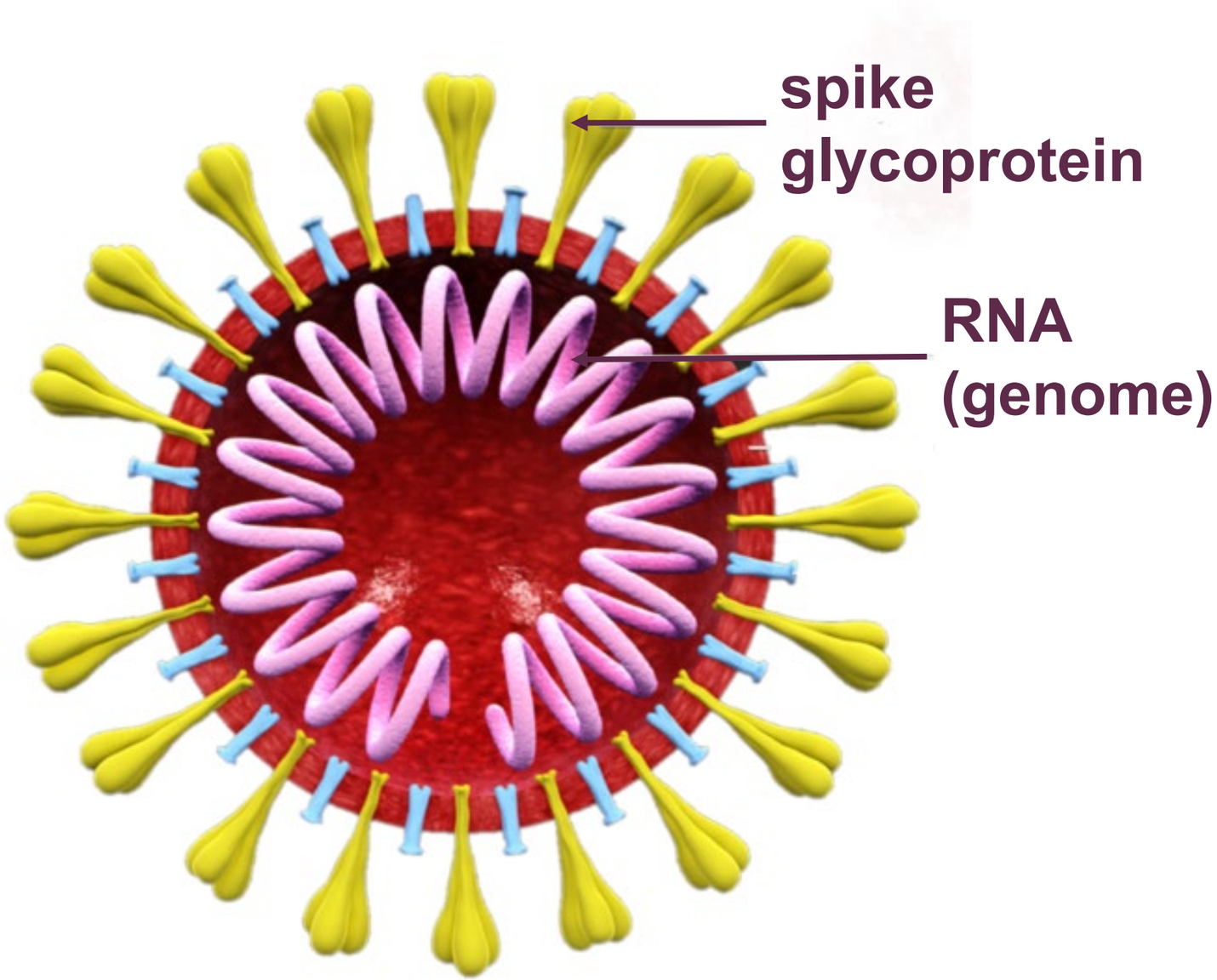
100

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**

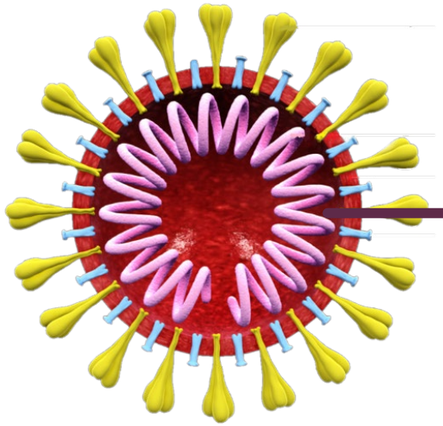
Pacific Northwest
NATIONAL LABORATORY

Components of the coronavirus

- Spike protein (S) helps the virus get its RNA into human cells so it can replicate
- RNA is a code that tells the cell what to make



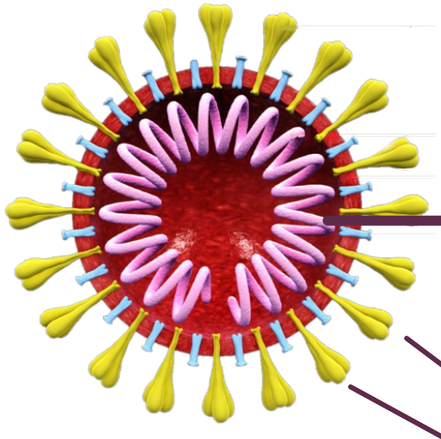
mRNA vaccines



30,000 nucleotides (nt)

CCGGAT…

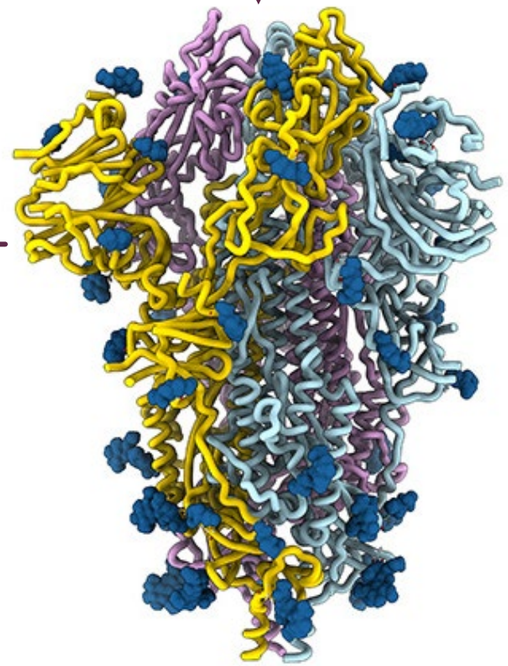
mRNA vaccines



S gene

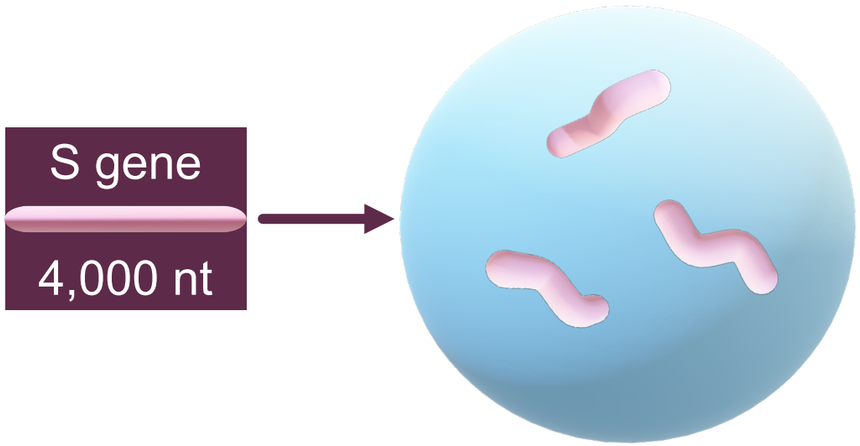
4,000 nt

spike glycoprotein



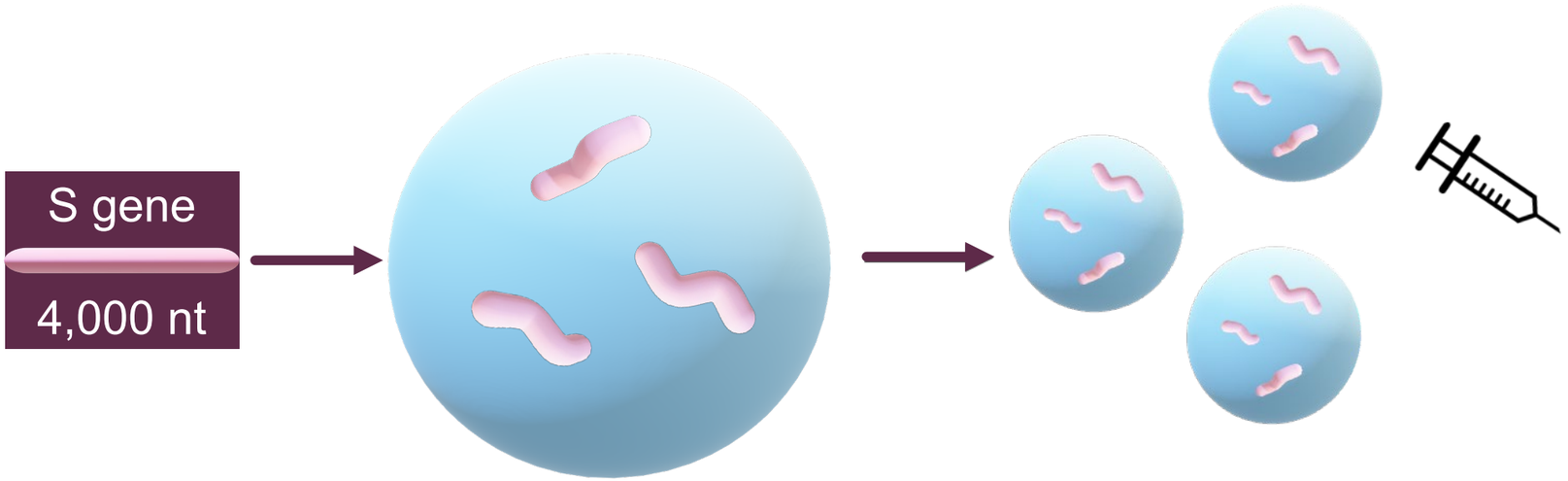
Spike gene structure from newsroom.uw.edu/news/covid-19-coronavirus-spike-holds-infectivity-details

mRNA vaccines



“lipid nanoparticle”
(fat globule)

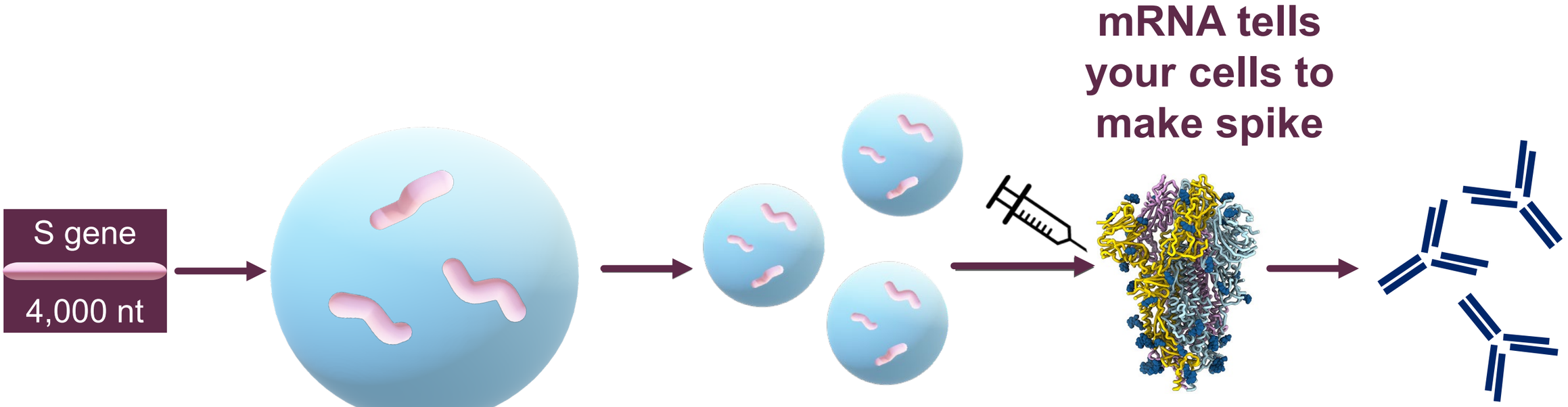
mRNA vaccines



“lipid nanoparticle”
(fat globule)

mRNA vaccine

mRNA vaccines



“lipid nanoparticle” (fat globule)

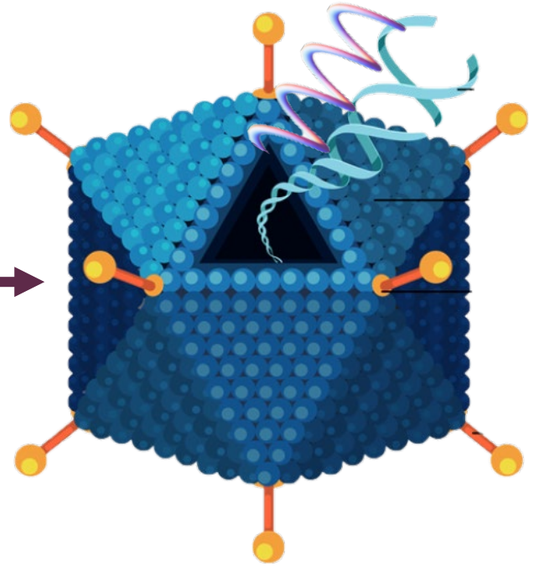
mRNA vaccine

your immune system makes antibodies

Viral vector vaccines

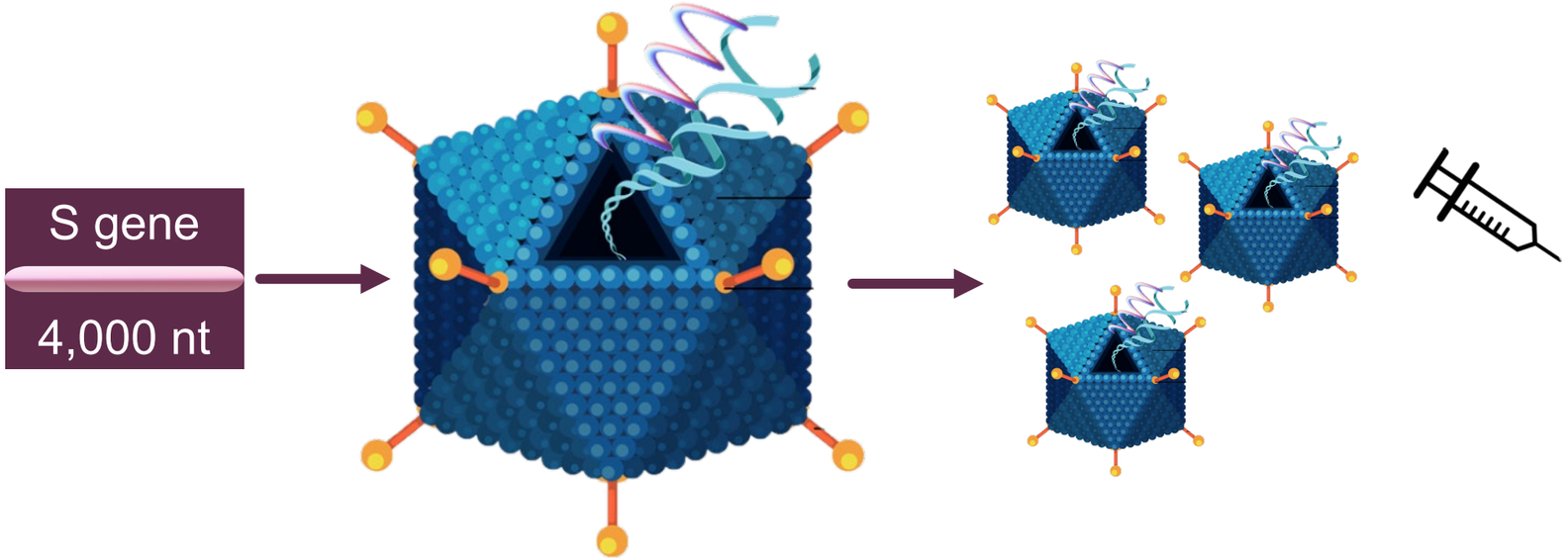
S gene

4,000 nt



“viral vector”
(virus that can infect cells but can’t replicate itself)

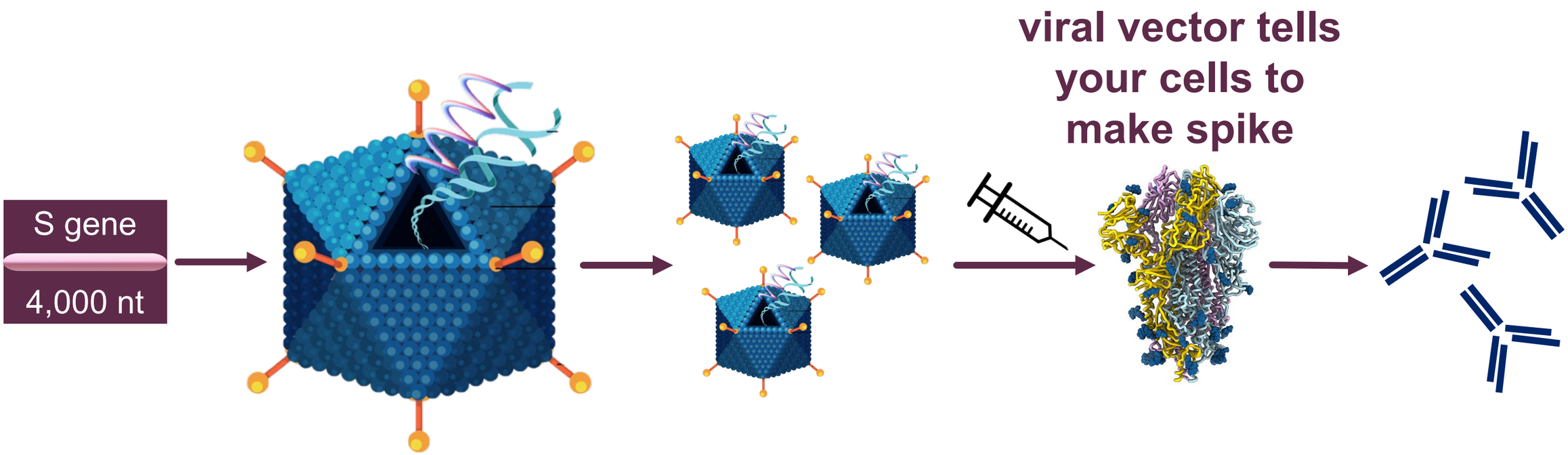
Viral vector vaccines



“viral vector” (virus that can infect cells but can’t replicate itself)

viral vector vaccine

Viral vector vaccines



"viral vector" (virus that can infect cells but can't replicate itself)

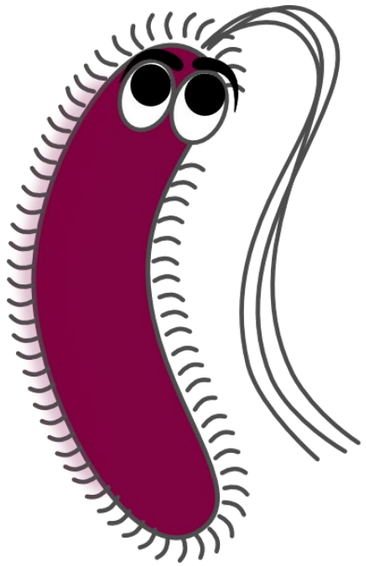
viral vector vaccine

your immune system makes antibodies

Subunit or peptide vaccines

S gene

4,000 nt

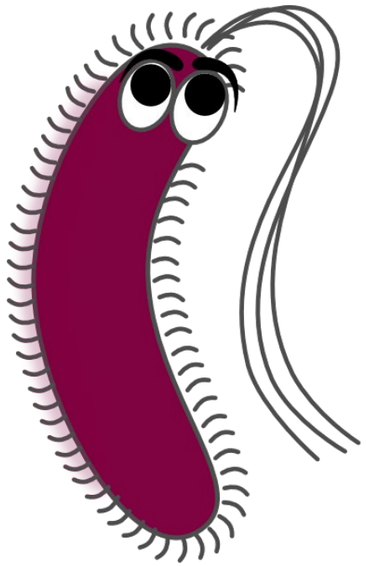


friendly bacterium or yeast

Subunit or peptide vaccines

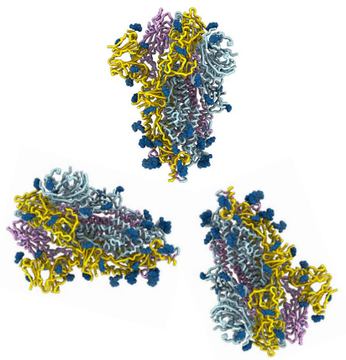
S gene

4,000 nt



friendly bacterium
or yeast

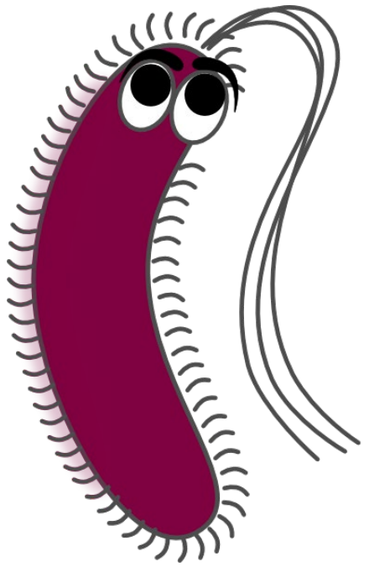
spike + stabilizers



Subunit or peptide vaccines

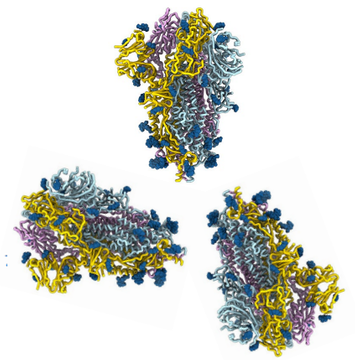
S gene

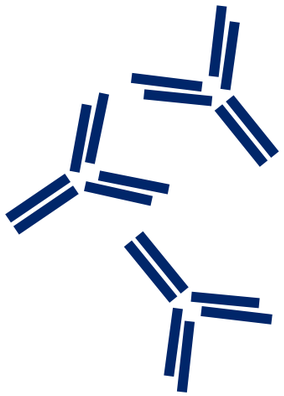
4,000 nt



friendly bacterium
or yeast

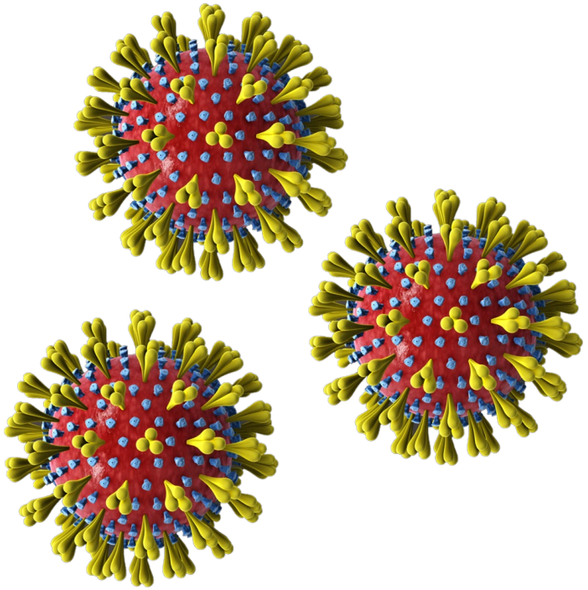
spike + stabilizers





your immune system
makes antibodies

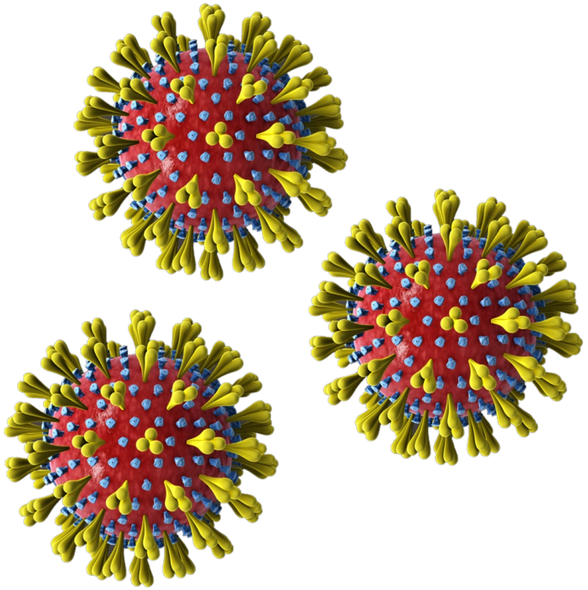
Inactivated or attenuated virus vaccines



virus + heat, radiation or chemicals

Inactivated virus image from www.bharatbiotech.com

Inactivated or attenuated virus vaccines

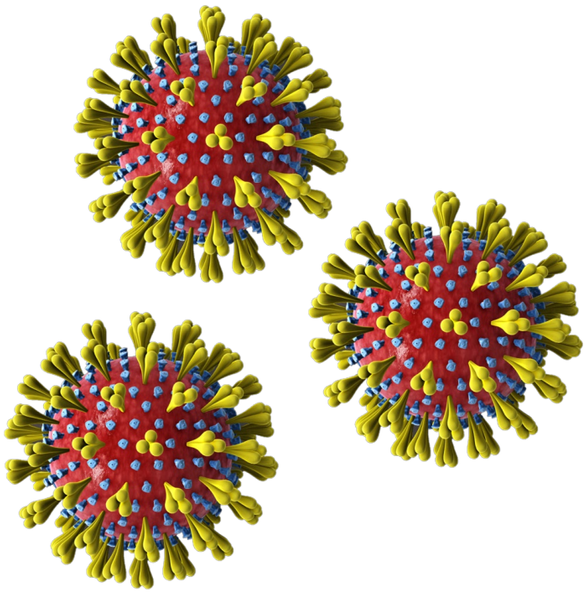


virus + heat, radiation or chemicals

inactivated (“killed”) virus

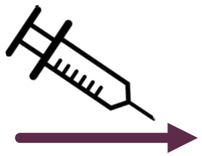
Inactivated virus image from www.bharatbiotech.com

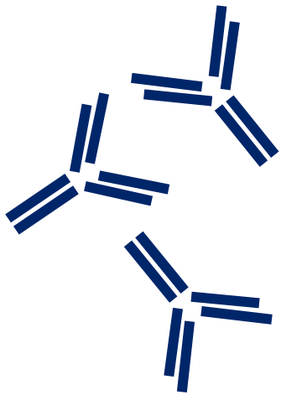
Inactivated or attenuated virus vaccines



virus + heat, radiation or chemicals

inactivated (“killed”) virus





your immune system makes antibodies

Inactivated virus image from www.bharatbiotech.com

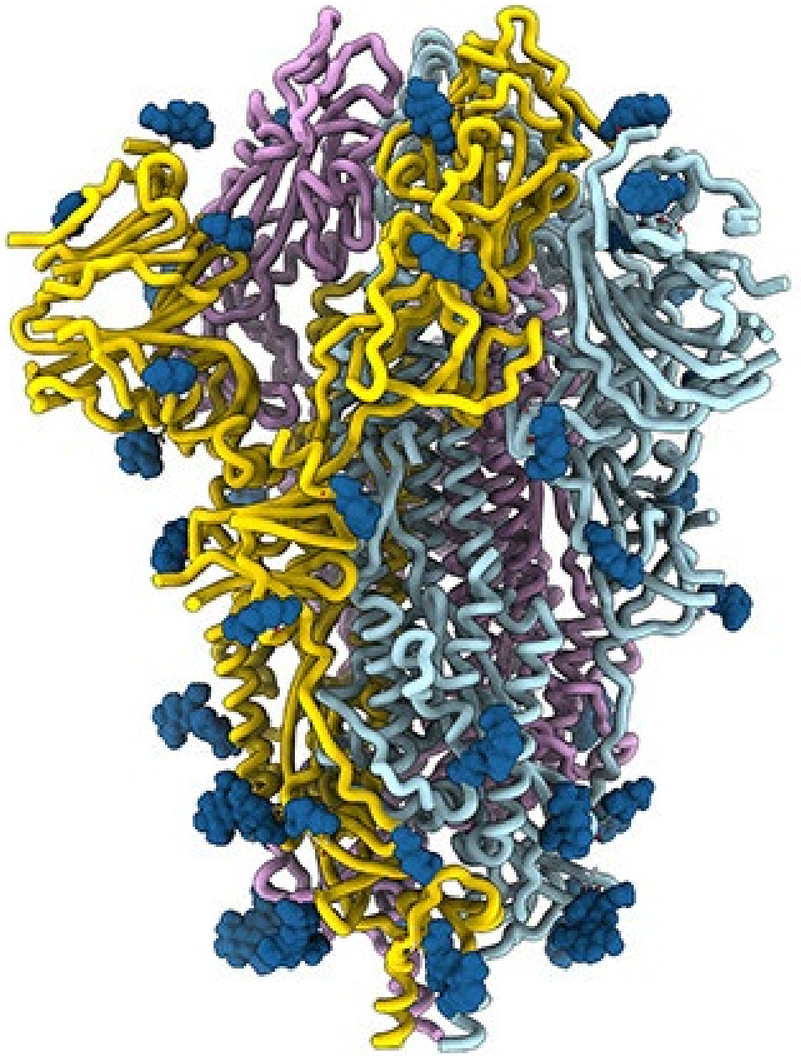
Summary of the four types of vaccines

- mRNA (Moderna, Pfizer-BioNTech)
- Viral vector (Oxford-AstraZeneca, Johnson & Johnson)
- Subunit or peptide
- Inactivated or attenuated virus
- All four types trigger an immune response leading to production of antibodies
  - Pain and swelling at the vaccine site
  - Low-grade fever
  - Chills
  - Fatigue
  - Headache
- An immune response to a vaccine doesn’t mean you’re infected or infectious

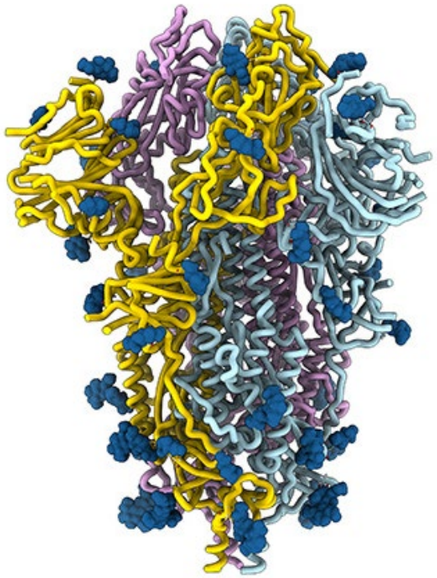
Pacific Northwest
NATIONAL LABORATORY

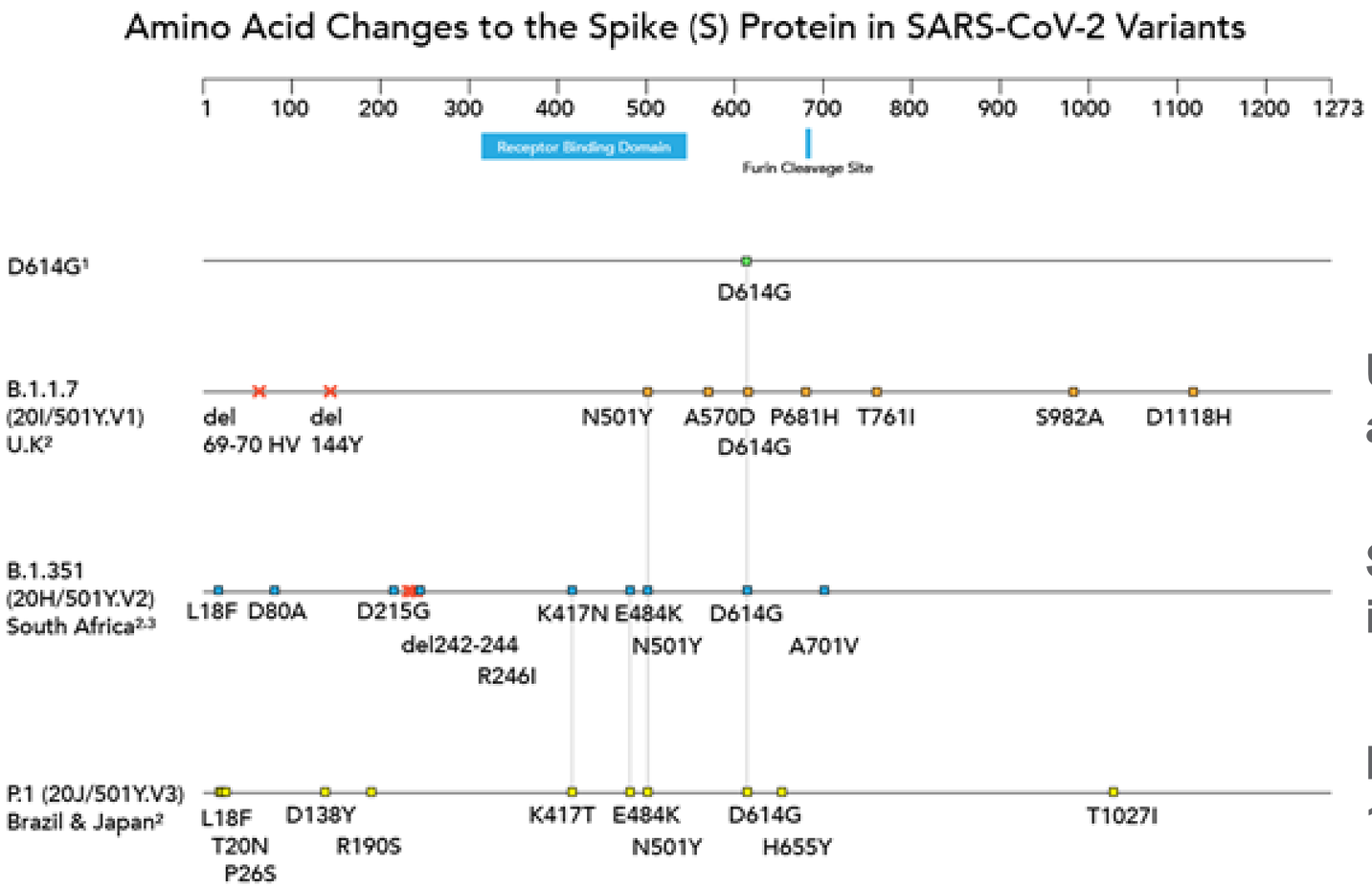
What about the variants?

- spike glycoprotein contains 1,273 amino acids



What about the variants?





UK strain – 9 changes in 1,273 amino acids

S. Africa strain – 11 changes in 1,273 amino acids

Brazil strain – 10 changes in 1,273 amino acids

https://asm.org/Articles/2021/February/SARS-CoV-2-Variants-vs-Vaccines

Talk overview

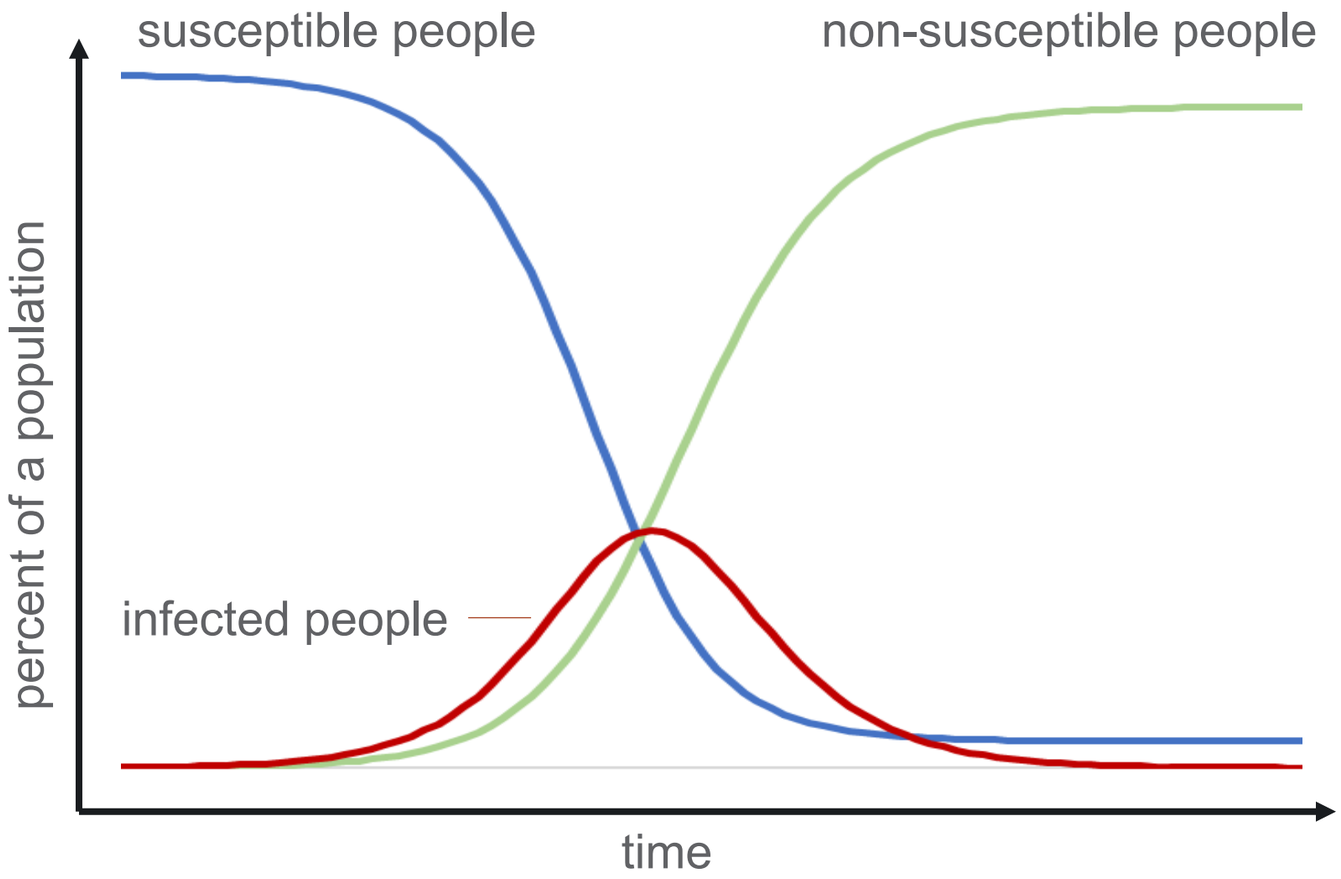
- Components of the coronavirus
- Common testing methods
  - Diagnostic tests
  - Immunoassay tests
  - Home tests
  - Why swab? Or, can't I just spit?
- COVID-19 vaccines
  - The four types of vaccines
  - What about the variants?
- **Where do we go from here?**

Where do we go from here scientifically?

- Defining the correlation between detection and infectiousness
- Making diagnostic tests less expensive, faster and more convenient
- Increasing specificity and sensitivity so immunoassay tests become reliable and meaningful
- Determining how many amino acids in spike can change before the virus starts to evade vaccines
- Expanding the mRNA and adenovirus vaccine platforms
  - Viral vector vaccines are relatively new
    - ✓ Ebola virus and tuberculosis vaccines in development
  - mRNA vaccines are brand new
    - ✓ Zika and Epstein-Barr virus vaccines in development

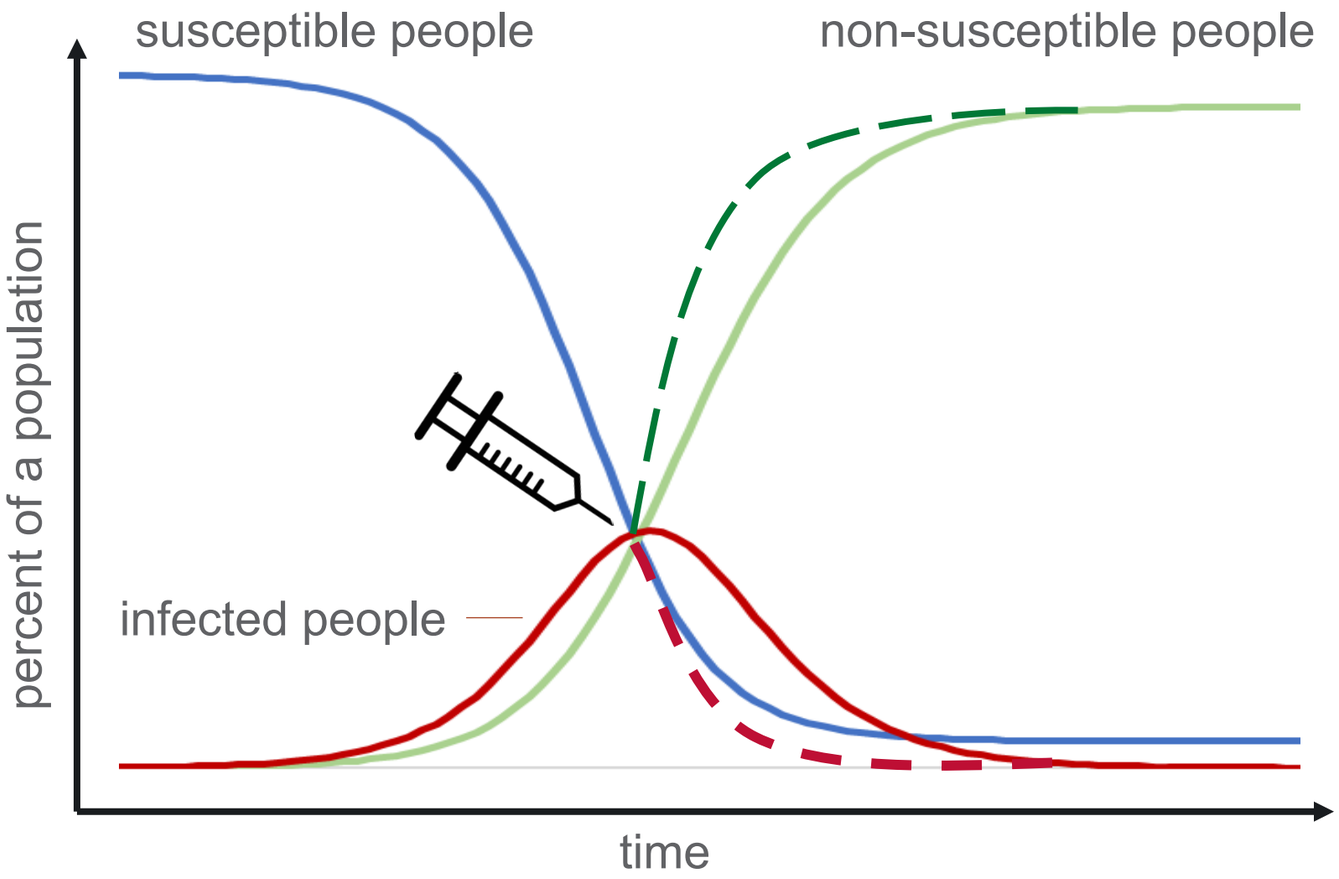
Pacific Northwest
NATIONAL LABORATORY

Where do we go from here in general?



Where do we go from here in general?

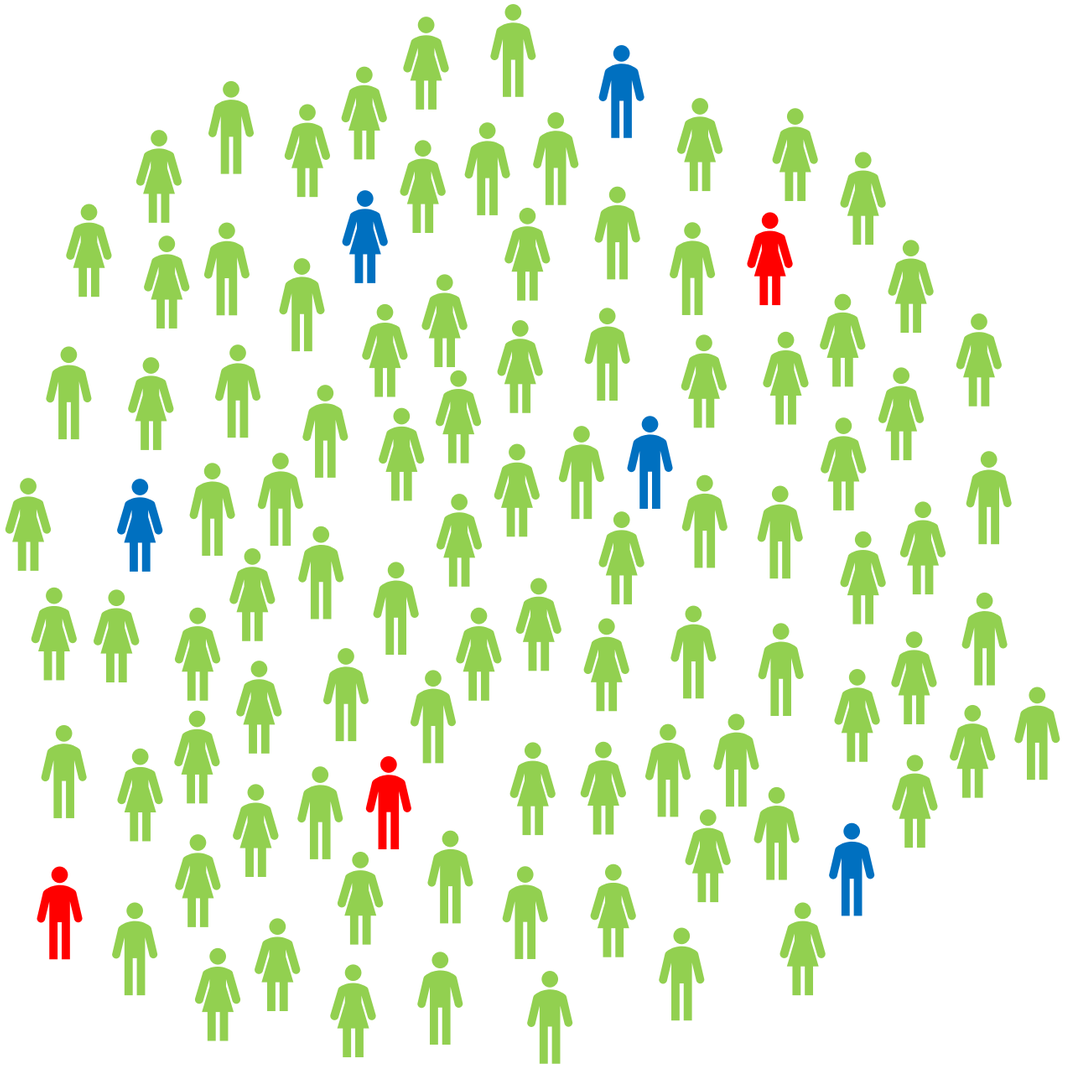
- Vaccination moves people directly from susceptible to non-susceptible
- By reducing the number of susceptible people, the chance of transmission is lower



Pacific Northwest
NATIONAL LABORATORY

Where do we go from here in general?

- “Herd immunity”



Pacific Northwest
NATIONAL LABORATORY

SUBMIT YOUR QUESTIONS VIA THE DISCUSSION CHAT

EVERY TUESDAY
IN MARCH
5:00-6:00 P.M.

Your questions?

- Send questions via the discussion chat

UPCOMING EVENTS

EVERY TUESDAY IN MARCH
5:00-6:00 P.M.

30 MAR

Model Me This: COVID-19 Scientific Predictions and Where We Go from Here

Tim Scheibe
Lead Scientist
River Corridor Scientific Focus Area Project

COMMUNITY
SCIENCE &
TECHNOLOGY
SEMINAR SERIES
@PNNL

DEMYSTIFYING COVID:

A Special Edition
Seminar Series

Thank you

Pacific Northwest
NATIONAL LABORATORY