Jennifer A. Surtees, Ph.D.
Dept. Biochemistry, Jacobs School of Medicine and Biomedical Sciences
Co-Director of UB’s Genome, Environment and Microbiome Community of Excellence
University at Buffalo, Buffalo, NY 14203

jsurtees@buffalo.edu
How does the immune system work?

Our body is exposed to Germs (bacteria/virus)

- Food and water we take
- 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
INNATE IMMUNITY

CELLS OF INNATE IMMUNITY

- Neutrophils
- Mast cells
- Basophils
- Dendritic cells
- Eosinophils
- Monocytes
- Macrophage
- Natural killer cells

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)

T-helper

T-Cytotoxic

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
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
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

What is this? Vaccine

I've seen this before… Pathogen

Vaccination

Moderate immune response

Re-introduction

Robust immune response
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.
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)

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**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
Unvaccinated population

- not immunized but still healthy
- not immunized, sick, and contagious

No one is immunized.

Contagious disease spreads through the population.
Partially vaccinated population

- not immunized but still healthy
- immunized and healthy
- not immunized, sick, and contagious

Some of the population gets immunized.
Contagious disease spreads through some of the population.
With widespread immunization, HERD IMMUNITY protects the non-immune!

- blue = not immunized but still healthy
- yellow = immunized and healthy
- red = not immunized, sick, and contagious

Most of the population gets immunized.

Spread of contagious disease is contained.
**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

<table>
<thead>
<tr>
<th>Date</th>
<th>Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 1</td>
<td>Covid-19 illness documented (unpublished Nov 17th)</td>
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<tr>
<td>Jan 10</td>
<td>SARS-CoV-2 virus sequenced</td>
</tr>
<tr>
<td>Jan 15</td>
<td>NIH designs mRNA vaccine in collaboration with Moderna</td>
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<tr>
<td>Mar 16</td>
<td>Moderna Phase 1/2 trial begins</td>
</tr>
<tr>
<td>May 2</td>
<td>Pfizer/BioNTech Phase 1/2 trial begins</td>
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<tr>
<td>July 14</td>
<td>Moderna Phase 1/2 trial published in NEJM</td>
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<tr>
<td>July 27, 28</td>
<td>Moderna and Pfizer/BioNTech Phase 3 trial begins</td>
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<tr>
<td>Aug 12</td>
<td>Pfizer/BioNTech Phase 1/2 published in Nature</td>
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<tr>
<td>October 22,27</td>
<td>Enrollment in both Phase 3 trials complete; &gt;74,000 participants</td>
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<tr>
<td>Nov 9</td>
<td>Pfizer/BioNTech announces interim analysis efficacy &gt; 90%</td>
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<tr>
<td>Nov 16</td>
<td>Moderna announces interim analysis efficacy 94.5%</td>
</tr>
<tr>
<td>Nov 18</td>
<td>Pfizer/BioNTech announces 95% efficacy as final result</td>
</tr>
<tr>
<td>Nov 20</td>
<td>1st EUA submitted by Pfizer/BioNTech</td>
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<tr>
<td>Nov 27</td>
<td>Distribution of vaccine by UAL charter flights throughout US</td>
</tr>
<tr>
<td>Dec 10</td>
<td>FDA External review of Pfizer/BioNTech EUA</td>
</tr>
<tr>
<td>Dec 11</td>
<td>Phase 1a Vaccination begins for health care professionals*</td>
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*Provisional on positive external review
Variants in NYS
## How the Known Variants of Concern Affect COVID-19 and Vaccines

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