Immunity and the Vaccine Development Process: Preventing the Contraction and Limiting the Spread of Viruses

HOSA Health Education

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Target Audience: Middle and high schoolers (7th - 12th grade)

Number of Participants: 35-40 students

James B Conant High School HOSA Chapter

State/Country: Illinois, The United States of America

Division: Secondary

Chapter Number: 20115

Lesson Overview

Lesson Objective: Our aim is to inform students about the vaccine development process, especially in regards to testing and ensuring safety. Furthermore, we want to foster a deeper understanding of the immune system and how it interacts with a vaccine. As part of this, we aim to inculcate healthy practices in warding off pathogens, something especially important in the current pandemic.

Curriculum Overview: *By the end of our lesson, students will be able to…*

- List/explain the basic strategies in regards to vaccine creation
- List/explain the general stages of the vaccine development process
- Identify the major components present in the human immune system
- Explain how parts of the immune system work together to protect against pathogens
- Explain how vaccines bolster the immune response to viruses
- Explain, at a brief level, what herd immunity is and how vaccines help foster it
- Explain, specifically, the type of vaccine being developed to immunize individuals against COVID-19
- List the key strategies needed to stay safe and healthy during the coronavirus pandemic
- Discuss, at a deeper level, potential societal, legislative, and community-based changes that can be made to keep everyone safe during the pandemic and minimize spread

Lesson Goals: *In this lesson, we will be covering the following topics…*

- The differences in types of vaccines
- The vaccine creation, development, and testing process
- How the human immune system works
- How vaccines support the immune system in fighting viruses
- The importance of herd immunity in overcoming a pandemic
- Key safety strategies to avoid spreading COVID until the vaccine becomes widely accessible

Mode of Instruction: This lesson took place over a Zoom call with 22 attendees in order to maximize the safety and accessibility of the information provided.

Materials:

- Zoom Meetings
- “Immunity and the Vaccine Development Process” - Google Slides presentation

- Interactive online simulations from the History of Vaccines website to supplement the lesson through visual learning
  - How Vaccines Work
  - How Vaccines are Made
  - Types of Vaccines
  - Herd Immunity
- Gimkit - question deck on COVID-19 Vaccine and general immunology
- "Thinking Deeper Questions" - open-ended discussion prompts for students to answer in small group breakout rooms
- "Bell Ringer Ending Quiz" - Multiple choice end-of-lesson quiz to assess the level of understanding of materials

Instruction Plan: *Approximately a one-hour lesson*

- **Introduction & Ice Breakers** *(5 minutes)*:
  - Introduce ourselves and allow the audience to get to know each other through quick ice breaker questions.
- **Immunity and Vaccine Development Presentation** *(20 minutes)*:
  - Go through Google Slides presentation to cover all the main topics regarding immunity and vaccines.
- **Interactive Online Simulations** *(5 minutes)*:
  - Go through the four interactive online simulations (over screenshare, but provide links to the audience as well).
  - How Vaccines Work, How Vaccines are Made, Types of Vaccines, Herd Immunity
- **Competitive Group Game** *(5 minutes)*:
  - Engage audiences in an educational Gimkit game, allowing them to participate in friendly competition while revising information covered in presentation
- **Thinking Deeper Discussion** *(12 minutes)*:
  - Introduce the open ended discussion prompts and allow students to share their thoughts in 3-4 person breakout rooms.
- **Bell Ringer Ending Quiz** *(8 minutes)*:
  - Allow students to take Google Forms quiz to assess level of understanding
- **Conclusion** *(5 minutes)*:
  - Wrap up the lesson by answering questions and quickly reviewing the concepts we talked about and giving students the chance to correct their answers

Background/Supporting Information

Immunity, and The Role of Vaccines

The objective of the immune system integral to the survival of all human beings: protecting the human body from invasive microorganisms (e.g. bacteria, fungi, viruses, and toxins). It is composed of different organs (such as tonsils, thymus, and lymph nodes) throughout the entire body, as well as cells that operate in blood and practically every part of the body.When a child is born, they're born with an innate immunity. Innate immunity refers to the immune system that the child inherits from his or her mother, through gestation and the umbilical cord. This serves as the line of first response; it patrols the body. The cells used by the innate immune system are known as phagocytes.

The body also gains immunity throughout life. Known as the adaptive or acquired immune system, this is the system that produces antibodies to fight infections. The adaptive immune system employs B and T cells to fight infection, and B lymphocytes are responsible for the development of specific antibodies after the body has been exposed to a foreign agent. This is where vaccines come into play to help the immune system. In general, vaccines cause an imitation infection, allowing the body to produce specific antibodies for the virus or toxin; the imitation infection is weaker than an actual infection so most people don't experience any real symptoms after getting a vaccine administered. Once the imitation infection is over, the body still has a provision of the antibodies for that specific infection, making it easy to fight in the future.

Vaccines: The Basics

There are three main strategies for vaccines.

Strategy 1: Live Attenuated Vaccines

Weakening the virus is one of the most popular methods used, and many vaccines such as the measles, mumps, and rubella vaccines employ this strategy. Viruses can only spread and cause disease within the body by reproducing thousands of times, so weakening the reproductive capabilities of the virus allows it to reproduce only a handful of times. This means that the body can quickly and effectively fight this virus while training the B-cells to remember *how* to fight the virus, preventing the average person from contracting the vaccinated disease again.

Strategy 2: Inactivated Vaccines

Another popular method is to inactivate the virus altogether. This eliminates any possibility of the virus reproducing, but the host body still stores ‘memory’ of the virus cells, which can be used to fight the illness. This method reduces the possibility of contracting the disease entirely and can be safely administered to immunocompromised and immunosuppressed patients. The main drawback, however, is that multiple doses of inactivated virus are often necessary for the same level of immunity. The polio, Hepatitis A, and rabies vaccines employ this method.

Strategy 3: Subunit/Conjugate Vaccines

A third strategy with the best weighted results is using part of the virus for the vaccine. This only works in the cases where immune response is targeted to a specific part of a virus. The benefits of this strategy are that it can be provided to immunosuppressed patients and maintains the lasting immunity of a weakened virus vaccine after just two doses. Vaccines using this strategy include the hepatitis B, shingles, and HPV vaccines.

The COVID-19 Vaccine

Unlike the vaccines described in the sections above, the COVID-19 vaccine currently being developed is an mRNA vaccine, in which the mRNA of the virus is injected into human muscle cells, producing proteins according to the mRNA strand, allowing the body to build immunity to the virus. The main drawback is that nucleic acids are unstable, and easily digested by the body. At this point, three major biotechnology companies have synthesized vaccines with varying characteristics and efficacy rates: Pfizer-BioNTech, Moderna, and Johnson & Johnson. As the vaccine is becoming available to the public, it is important to continue following all social distancing and mask wearing guidelines to ensure your own, along with everyone else’s, safety.

The Vaccine Development Process

According to the CDC, there are six general stages of the vaccine development process, some of which have their own substages. The six stages are: (1) Exploratory stage, (2) Pre-clinical stage, (3) Clinical development, (4) Regulatory review and approval, (5) Manufacturing, (6) Quality control.

The Exploratory Stage: This stage focuses on basic laboratory research, and can last up to four years. The scientists are trying to identify natural and synthetic antigens that can help treat or prevent a disease. These antigens are generally derivations of a pathogen.

The Preclinical Stage: Scientists use tissue culture, cell culture, or animal testing to test the safety of the identified antigens, as well as the ability of the candidate vaccine to compel an immune response; the phase lasts one-two years. This stage allows scientists to predict human response as well as safe starting doses. This stage constitutes a narrowing of the process, as most vaccines don't make it past this point due to lack of safety or immune response.

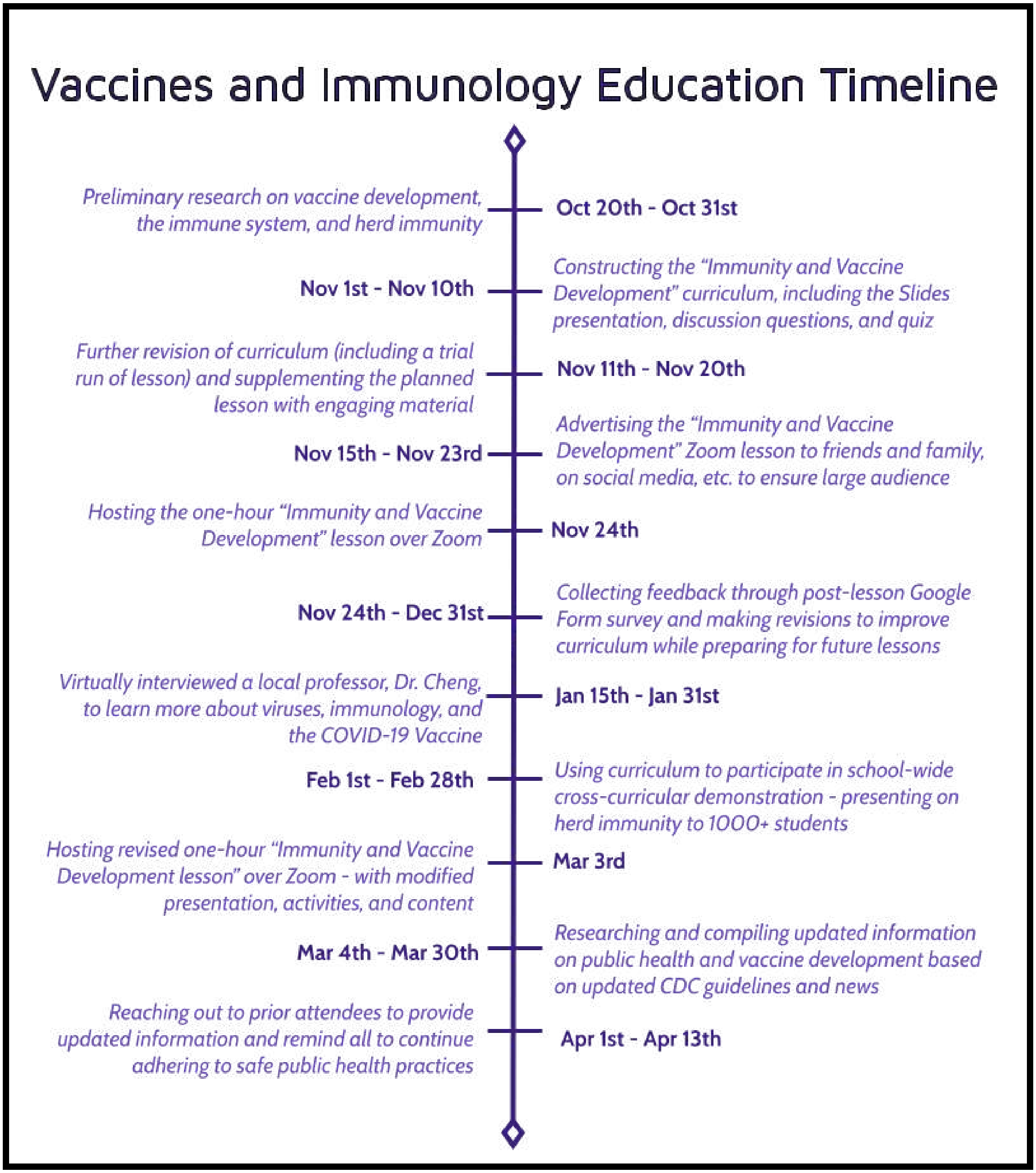
The Clinical Development Stage: The clinical development stage is actually composed of three sub-phases. The first sub-phase consists of small groups of people receiving the formulated vaccine. The second sub-phase expands the clinical trial, and includes people of the same demographic (age, race, gender) as the intended patients of the vaccine. The third sub-phase is perhaps the widest, where the vaccine is administered to thousands of people and evaluated for safety, effectiveness, and efficacy.

Moreover, many vaccines undergo a fourth phase, where they are put through further ongoing studies to make sure that they are truly safe and effective. The other stages of the development process differ based on the country (vaccines made in the US, for example, are regulated by the FDA) and are more self-explanatory. The manufacturing stage constitutes the mass-production of the vaccine for widespread distribution. The quality control stage is integral to the process, where vaccines undergo a final test to certify their efficacy and safety.

<u>Public Health Practices</u>

For most infections, viral and bacterial, the spread of the infection can be contained with good health practices. Many of these practices have become more publicized since the outbreak of the coronavirus. Some of the central tenets of immune practices include: washing your hands thoroughly and often; avoiding touching your face, eyes, and nose with unwashed hands; avoiding close contact in public (six-foot distance from others); wearing a mask to prevent the spread of respiratory diseases; covering coughs & sneezes; and, cleaning and disinfecting frequently-touched surfaces (including phones). Another important public health concept is the concept of herd immunity. Herd immunity requires a sufficient proportion (varying majorities) of the population to be successfully immunized against an infection. Herd immunity allows the vaccinated/immunized majority to protect the unvaccinated minority who perhaps cannot receive the vaccine. For the COVID-19 pandemic, estimates the point of herd immunity to be 70% of the population. This number changes based on the infection though. The steps to achieve this herd immunity involve the creation of an effective COVID-19 vaccine, widespread distribution of the vaccination, and achieving the necessary percentage of immunized people.

Holistic Schedule (preparation to presentation):



Lesson Plan Schedule:

Introductions and Icebreakers: Introduce ourselves, explain what HOSA is and the purpose of our presentation. After that, allow students to get to know each other by having each student introduce themselves with their name and a fun fact about themselves.	5 Min
Main Presentation: Screenshare the Google Slides presentation and discuss the main curriculum topics, including types of vaccines, development process, components of the immune system and how they interact with vaccines, herd immunity, and general safety precautions during a pandemic.	20 Min
Interactive Visual Simulations: Screenshare and run through the Herd Immunity, How Vaccines Work, and How Vaccines are Made simulations found on the History of Vaccines website. Allow students to access the simulations themselves by providing the links through the Zoom Chat.	5 Min
Competitive Group Game: Screenshare and engage audience in a 12 question multiple-choice Gimkit game in order to enhance student understanding of vaccines, immunology, and public health. Students will have the opportunity to engage in friendly competition with this online educator game.	5 Min
Thinking Deeper Discussion Questions: Put students into breakout rooms of 3-4 people and provide them with several open ended discussion questions related to the content. We will go to each breakout room to monitor/supplement discussion if needed. After, students share their ideas in the main room.	12 Min
End of Lesson Multiple Choice Questions: Answer any remaining questions that students have and then provide a link through the Zoom Chat to a Google Forms quiz to help us assess how well the audience was able to absorb the information and content taught.	8 Min
Wrap Up: Thank everyone for coming, answer any final questions, and quickly go through everything that we covered in the session; essentially, summarizing all the key takeaways.	5 Min

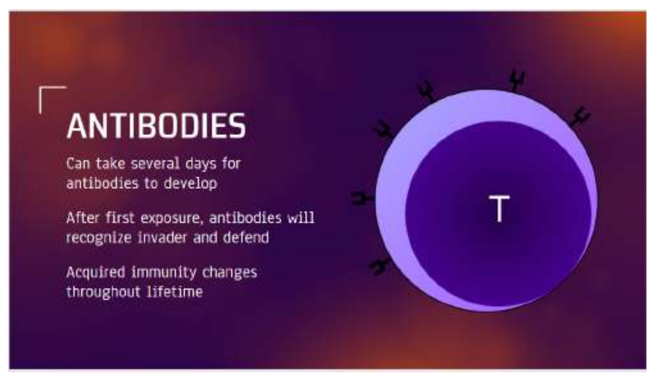
Presentation at cross-curricular vaccine education initiative:

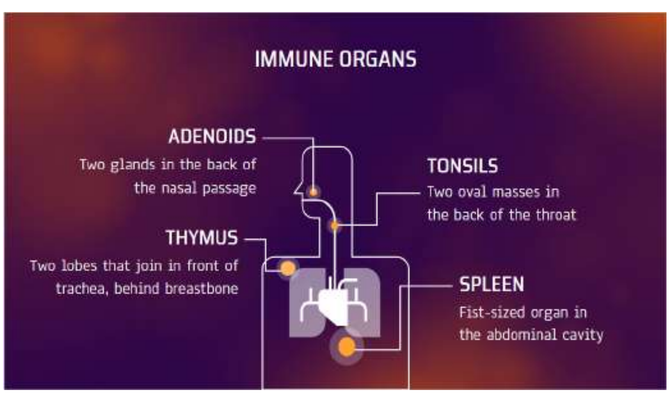
As a part of our health education campaign, we took our outreach to the next level by participating in a cross-curricular vaccine education demonstration at our school. We combined the parts of our curriculum focused on vaccinations and public health in order to present to 1000+ students in a course of two days on what herd immunity is, why it's important, and how we can reach that standard as a society. We were able to impact a much larger magnitude of the student population, and further our goal of increasing public safety in our community.

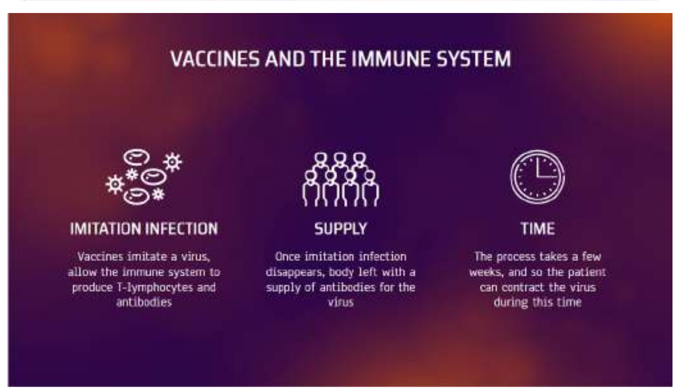
For this initiative, we used a condensed version of the presentation displayed below. Here is a link to the cross-curricular vaccine presentation.

Materials

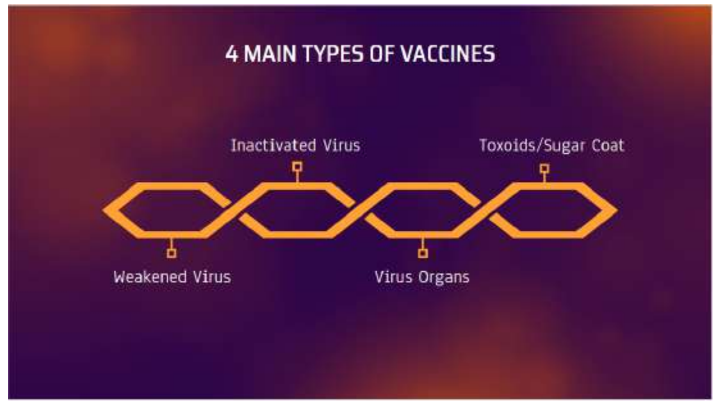
Immunity and the Vaccines Development Slideshow - (link to full presentation)

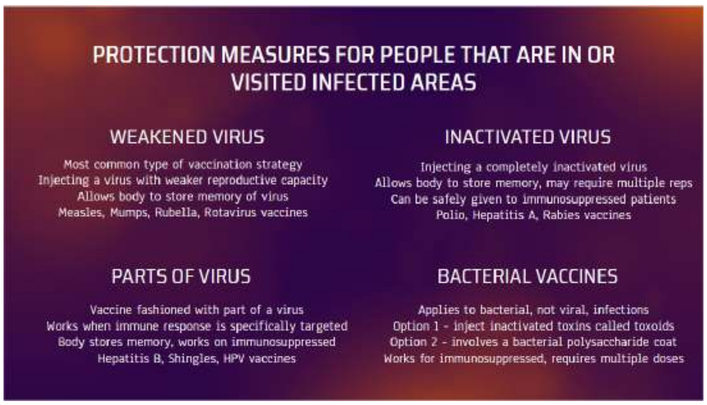




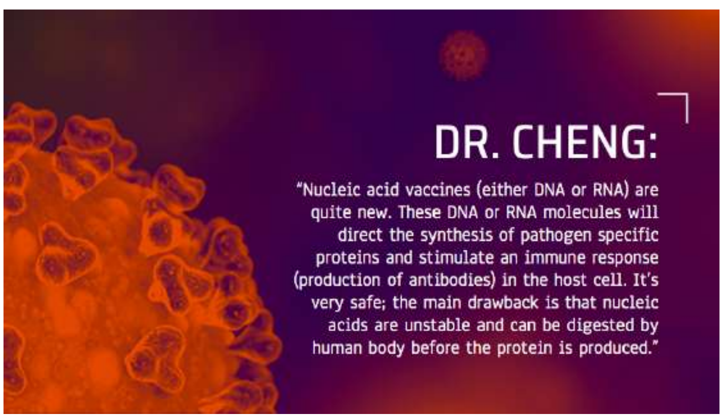


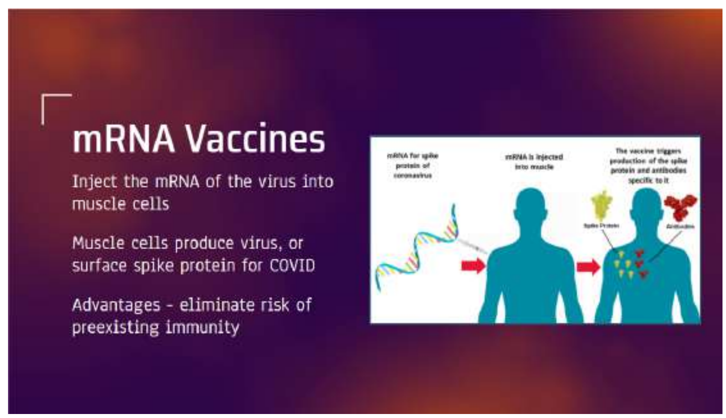

02
VACCINES:
THE BASICS
Drugs? No, I think you mean *deactivated virus.*

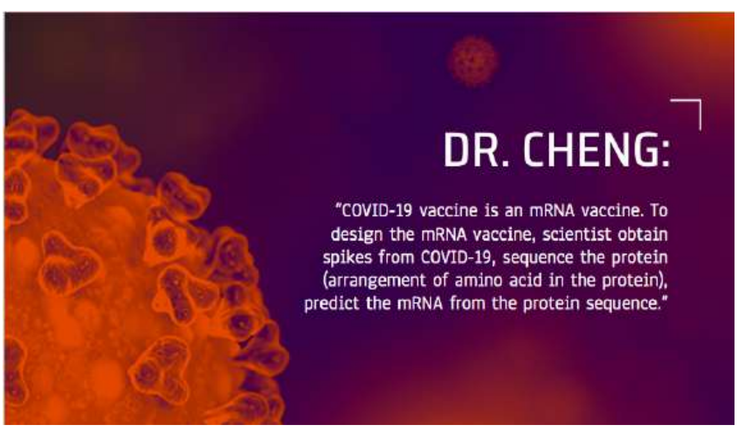

4 MAIN TYPES OF VACCINES
Inactivated Virus
Toxoids/Sugar Coat
Weakened Virus
Virus Organs

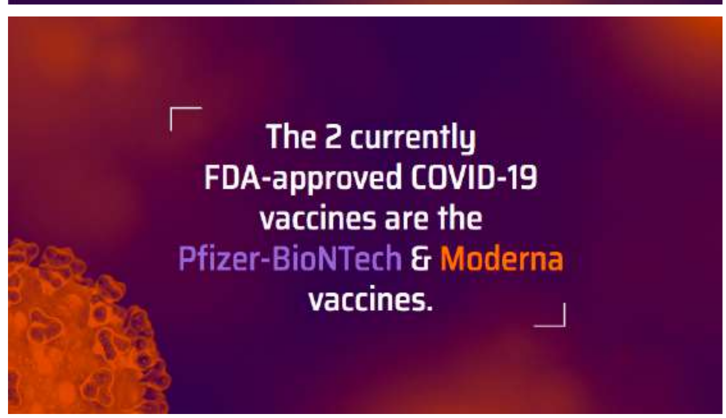

PROTECTION MEASURES FOR PEOPLE THAT ARE IN OR VISITED INFECTED AREAS
WEAKENED VIRUS
Most common type of vaccination strategy
Injecting a virus with weaker reproductive capacity
Allows body to store memory of virus
Measles, Mumps, Rubella, Rotavirus vaccines
INACTIVATED VIRUS
Injecting a completely inactivated virus
Allows body to store memory, may require multiple reps
Can be safely given to immunosuppressed patients
Polio, Hepatitis A, Rabies vaccines
PARTS OF VIRUS
Vaccine fashioned with part of a virus
Works when immune response is specifically targeted
Body stores memory, works on immunosuppressed
Hepatitis B, Shingles, HPV vaccines
BACTERIAL VACCINES
Applies to bacterial, not viral, infections
Option 1 - inject inactivated toxins called toxoids
Option 2 - involves a bacterial polysaccharide coat
Works for immunosuppressed, requires multiple doses

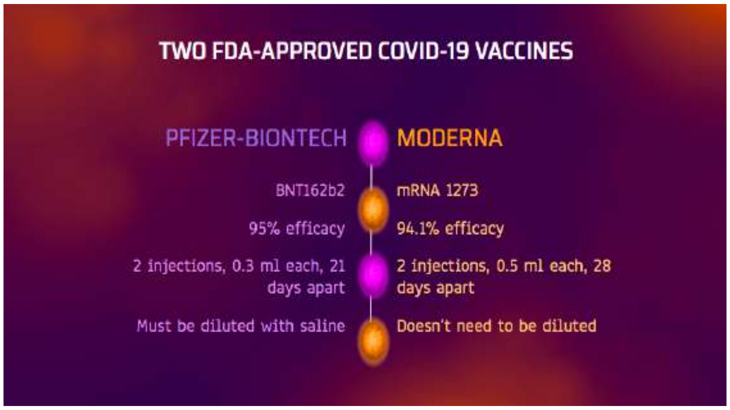

THE COVID-19 VACCINE
The part we've all been waiting an eternity for*
**eight months*

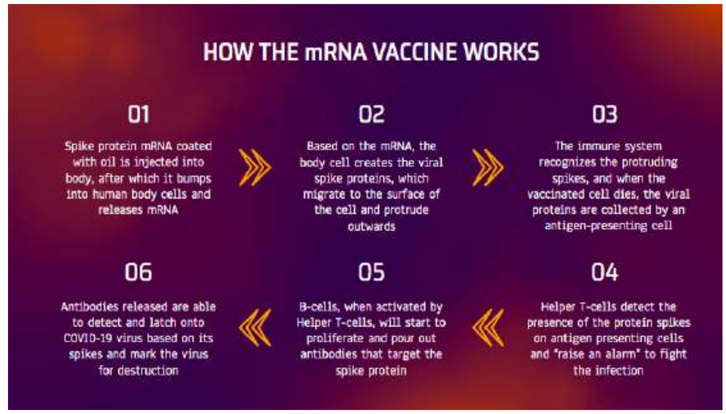

DR. CHENG:
"Nucleic acid vaccines (either DNA or RNA) are quite new. These DNA or RNA molecules will direct the synthesis of pathogen specific proteins and stimulate an immune response (production of antibodies) in the host cell. It's very safe; the main drawback is that nucleic acids are unstable and can be digested by human body before the protein is produced."

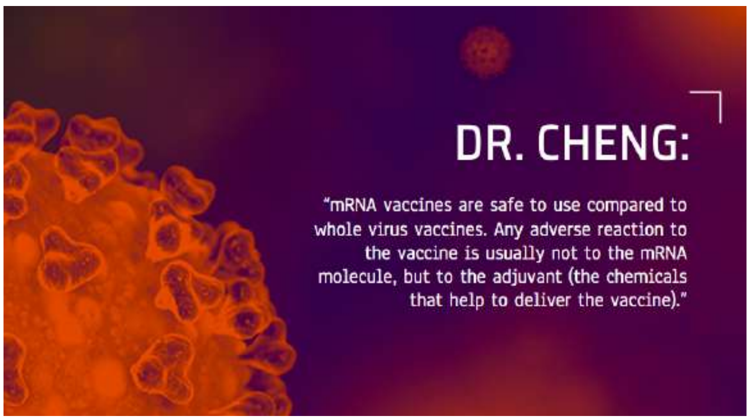

mRNA Vaccines
Inject the mRNA of the virus into muscle cells
Muscle cells produce virus, or surface spike protein for COVID
Advantages - eliminate risk of preexisting immunity


DR. CHENG:
"COVID-19 vaccine is an mRNA vaccine. To design the mRNA vaccine, scientist obtain spikes from COVID-19, sequence the protein (arrangement of amino acid in the protein), predict the mRNA from the protein sequence."

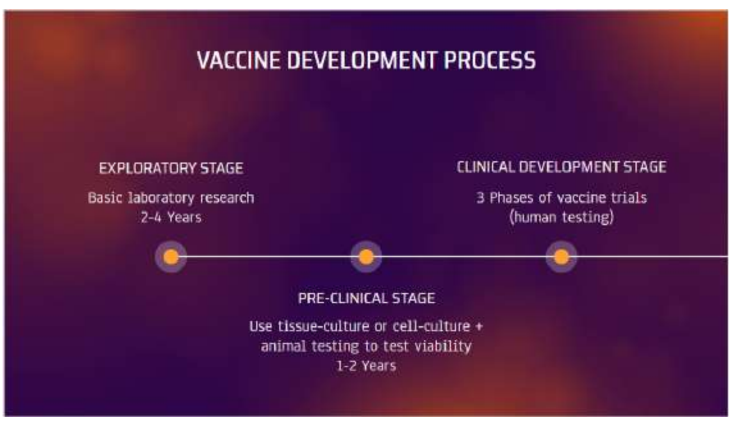

The 2 currently FDA-approved COVID-19 vaccines are the Pfizer-BioNTech & Moderna vaccines.

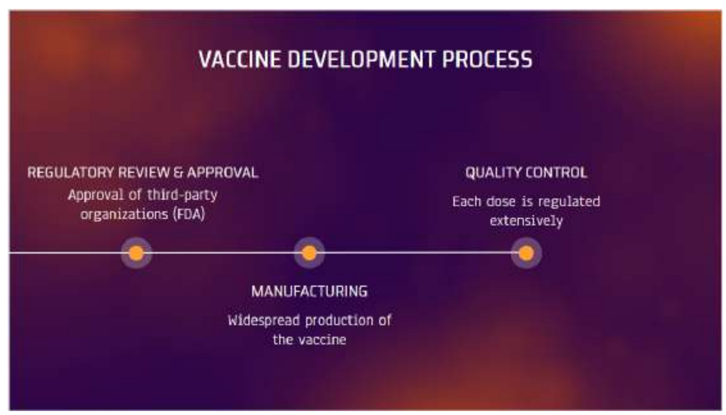

TWO FDA-APPROVED COVID-19 VACCINES
PFIZER-BIONTECH
MODERNA
BNT162b2
mRNA 1273
95% efficacy
94.1% efficacy
2 injections, 0.3 ml each, 21 days apart
2 injections, 0.5 ml each, 28 days apart
Must be diluted with saline
Doesn't need to be diluted


HOW THE mRNA VACCINE WORKS
01
Spike protein mRNA coated with oil is injected into body, after which it bumps into human body cells and releases mRNA
02
Based on the mRNA, the body cell creates the viral spike proteins, which migrate to the surface of the cell and protrude outwards
03
The immune system recognizes the protruding spikes, and when the vaccinated cell dies, the viral proteins are collected by an antigen-presenting cell
04
Helper T-cells detect the presence of the protein spikes on antigen presenting cells and "raise an alarm" to fight the infection
05
B-cells, when activated by Helper T-cells, will start to proliferate and pour out antibodies that target the spike protein
06
Antibodies released are able to detect and latch onto COVID-19 virus based on its spikes and mark the virus for destruction


DR. CHENG:
"mRNA vaccines are safe to use compared to whole virus vaccines. Any adverse reaction to the vaccine is usually not to the mRNA molecule, but to the adjuvant (the chemicals that help to deliver the vaccine)."

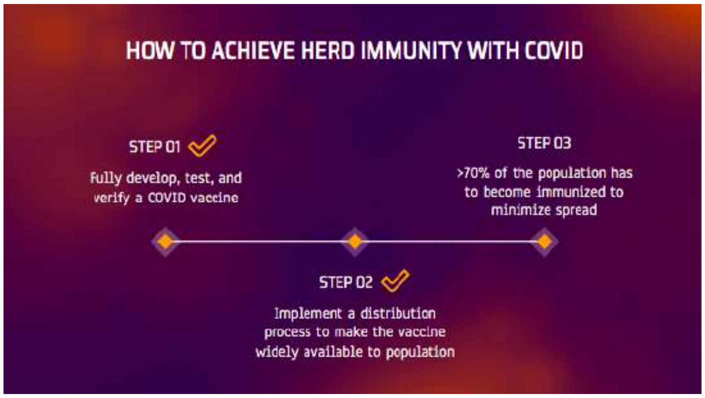

03
THE VACCINE DEVELOPMENT PROCESS
Petri-Dish-to-Table Cultivation

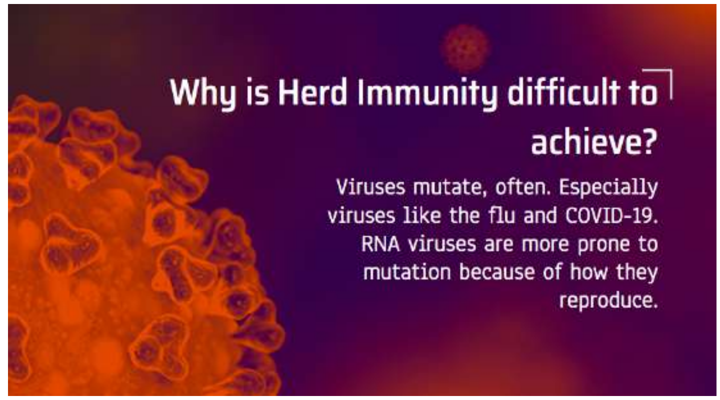

VACCINE DEVELOPMENT PROCESS
EXPLORATORY STAGE
Basic laboratory research
2-4 Years
CLINICAL DEVELOPMENT STAGE
3 Phases of vaccine trials
(human testing)
PRE-CLINICAL STAGE
Use tissue-culture or cell-culture + animal testing to test viability
1-2 Years

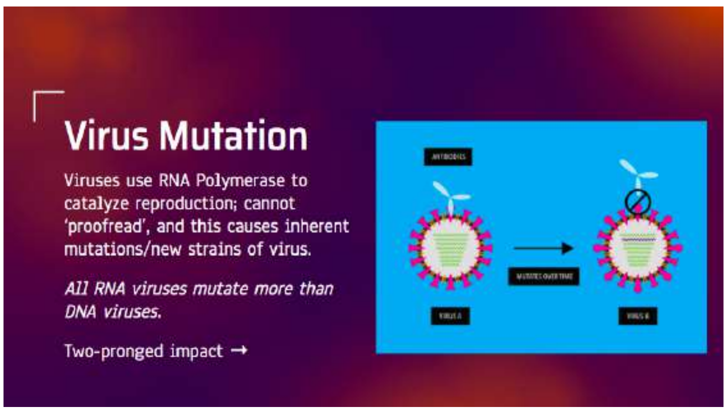

VACCINE DEVELOPMENT PROCESS
REGULATORY REVIEW & APPROVAL
Approval of third-party organizations (FDA)
QUALITY CONTROL
Each dose is regulated extensively
MANUFACTURING
Widespread production of the vaccine

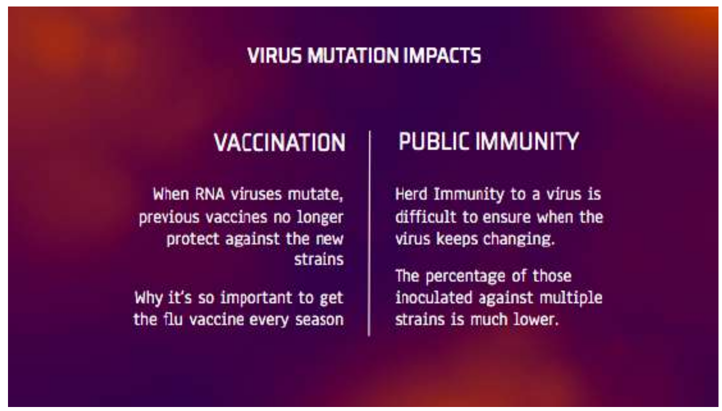

04
General Public Health
Step Aside, Darwin: "Survival of the Fittest" is over.


HERD IMMUNITY
When a sufficient proportion of the population is immunized from the contagious disease
Acquired either through prior illness or vaccination
Also known as community immunity

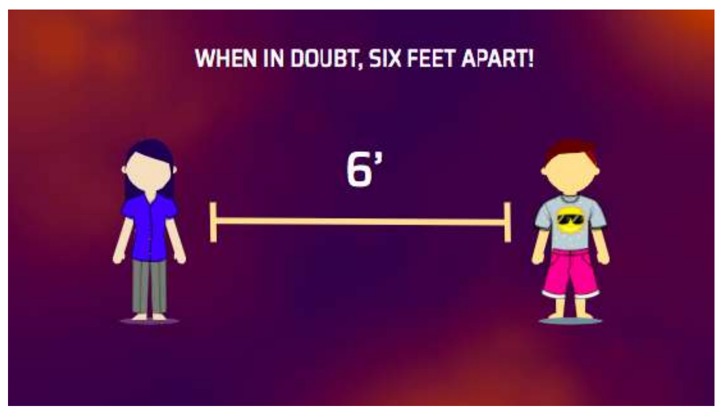

HOW TO ACHIEVE HERD IMMUNITY WITH COVID
STEP 01
Fully develop, test, and verify a COVID vaccine
STEP 02
Implement a distribution process to make the vaccine widely available to population
STEP 03
>70% of the population has to become immunized to minimize spread


Why is Herd Immunity difficult to achieve?
Viruses mutate, often. Especially viruses like the flu and COVID-19. RNA viruses are more prone to mutation because of how they reproduce.


Virus Mutation
Viruses use RNA Polymerase to catalyze reproduction; cannot 'proofread', and this causes inherent mutations/new strains of virus.
All RNA viruses mutate more than DNA viruses.
Two-pronged impact →


VIRUS MUTATION IMPACTS
VACCINATION
When RNA viruses mutate, previous vaccines no longer protect against the new strains
Why it's so important to get the flu vaccine every season
PUBLIC IMMUNITY
Herd Immunity to a virus is difficult to ensure when the virus keeps changing.
The percentage of those inoculated against multiple strains is much lower.

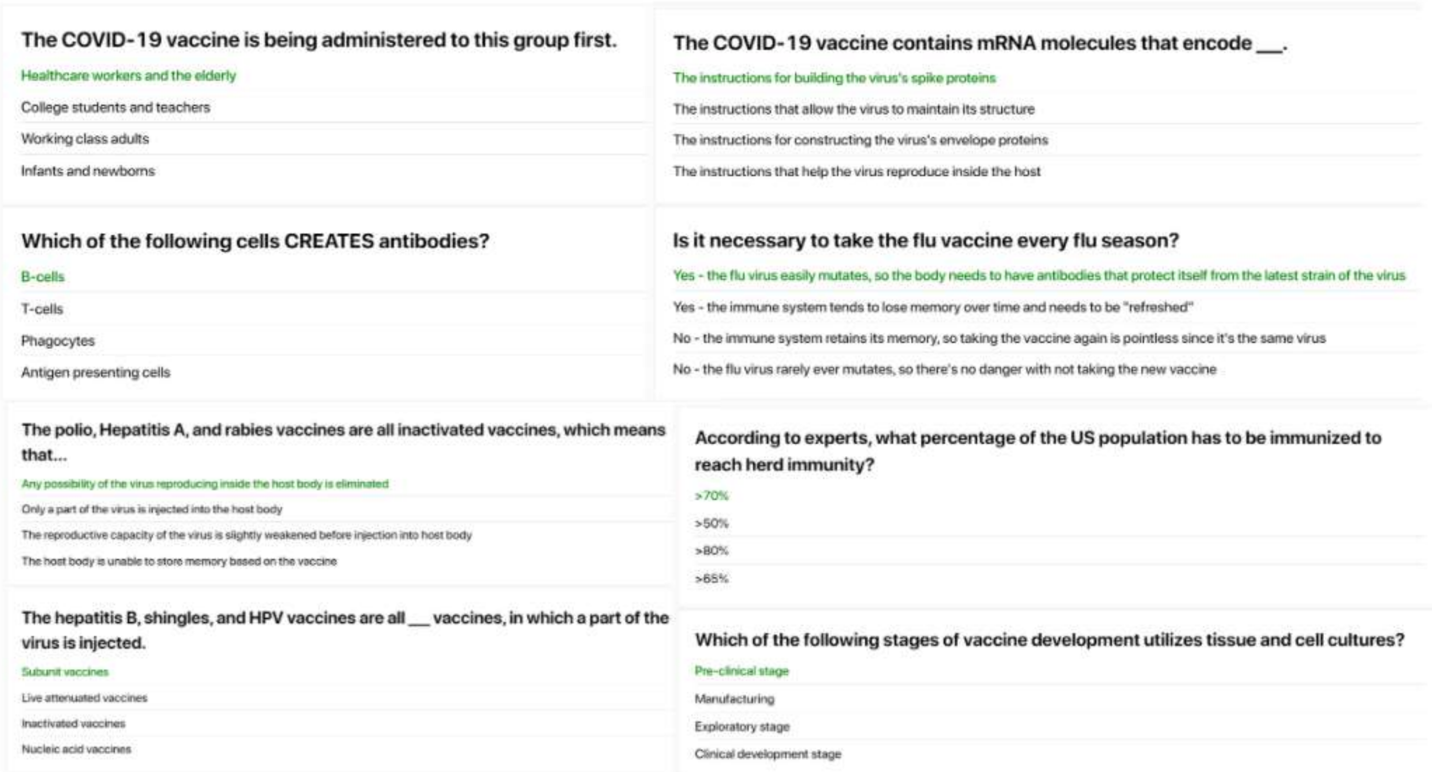

PROTECTING YOURSELF AND PREVENTING THE SPREAD OF INFECTIOUS DISEASE
Wash your hands thoroughly with soap and water.
Vaccines and immunity aren't everything; preventing the spread of disease through healthy habits is best!
Minimize touching face, nose, mouth, ears.
Cover your mouth & nose when you cough or sneeze.
Seek medical attention if need be, and stay home if you are sick!
Pay attention to local and state health regulations.


WHEN IN DOUBT, SIX FEET APART!
6'


VACCINE AND IMMUNITY SIMULATIONS
Types of Vaccines
Herd Immunity
How Vaccines are Made
How Vaccines Work
Click on icon to access simulation


REFERENCES
https://www.publichealth.org/public-awareness/understanding-vaccines/vaccines-work/
https://www.chop.edu/centers-programs/vaccine-education-center/human-immune-system/parts-immune-system
https://www.cdc.gov/vaccines/basics/test-approve.html
https://www.mayoclinic.org/diseases-conditions/coronavirus/in-depth/herd-immunity-and-coronavirus/art-20486808
https://www.historyofvaccines.org/content/herd-immunity-0
https://www.historyofvaccines.org/content/how-vaccines-work
https://www.historyofvaccines.org/content/how-vaccines-are-made
https://www.historyofvaccines.org/content/types-vaccines

Interactive Gimkit


The COVID-19 vaccine is being administered to this group first.
- Healthcare workers and the elderly
- College students and teachers
- Working class adults
- Infants and newborns

The COVID-19 vaccine contains mRNA molecules that encode ___.
- The instructions for building the virus's spike proteins
- The instructions that allow the virus to maintain its structure
- The instructions for constructing the virus's envelope proteins
- The instructions that help the virus reproduce inside the host

Which of the following cells CREATES antibodies?
- B-cells
- T-cells
- Phagocytes
- Antigen presenting cells

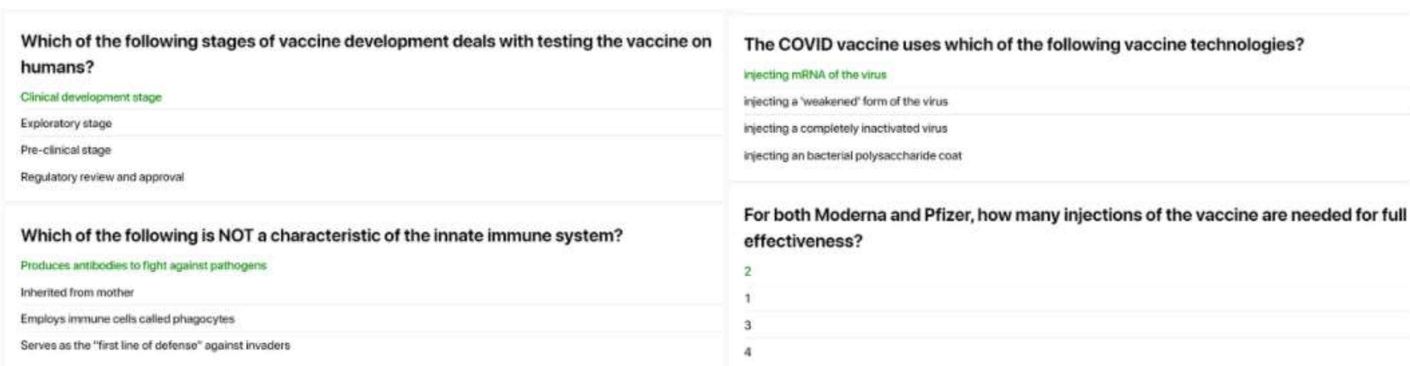
Is it necessary to take the flu vaccine every flu season?
- Yes - the flu virus easily mutates, so the body needs to have antibodies that protect itself from the latest strain of the virus
- Yes - the immune system tends to lose memory over time and needs to be "refreshed"
- No - the immune system retains its memory, so taking the vaccine again is pointless since it's the same virus
- No - the flu virus rarely ever mutates, so there's no danger with not taking the new vaccine

The polio, Hepatitis A, and rabies vaccines are all inactivated vaccines, which means that...
- Any possibility of the virus reproducing inside the host body is eliminated
- Only a part of the virus is injected into the host body
- The reproductive capacity of the virus is slightly weakened before injection into host body
- The host body is unable to store memory based on the vaccine

According to experts, what percentage of the US population has to be immunized to reach herd immunity?
- >70%
- >50%
- >80%
- >65%

The hepatitis B, shingles, and HPV vaccines are all __ vaccines, in which a part of the virus is injected.
- Subunit vaccines
- Live attenuated vaccines
- Inactivated vaccines
- Nucleic acid vaccines

Which of the following stages of vaccine development utilizes tissue and cell cultures?
- Pre-clinical stage
- Manufacturing
- Exploratory stage
- Clinical development stage


Which of the following stages of vaccine development deals with testing the vaccine on humans?
- Clinical development stage
- Exploratory stage
- Pre-clinical stage
- Regulatory review and approval

The COVID vaccine uses which of the following vaccine technologies?
- injecting mRNA of the virus
- injecting a 'weakened' form of the virus
- injecting a completely inactivated virus
- injecting an bacterial polysaccharide coat

Which of the following is NOT a characteristic of the innate immune system?
- Produces antibodies to fight against pathogens
- Inherited from mother
- Employs immune cells called phagocytes
- Serves as the "first line of defense" against invaders

For both Moderna and Pfizer, how many injections of the vaccine are needed for full effectiveness?
- 2
- 1
- 3
- 4

Thinking Deeper Questions

1. Using the main characteristics of how vaccines work, describe how the overuse of vaccines can be detrimental towards overall public health in the future.

2. Describe how the proper implementation of and overarching access to vaccines can promote a healthier and safer population.

3. Construct an analogy to explain the role and relationship between phagocytes and B & T

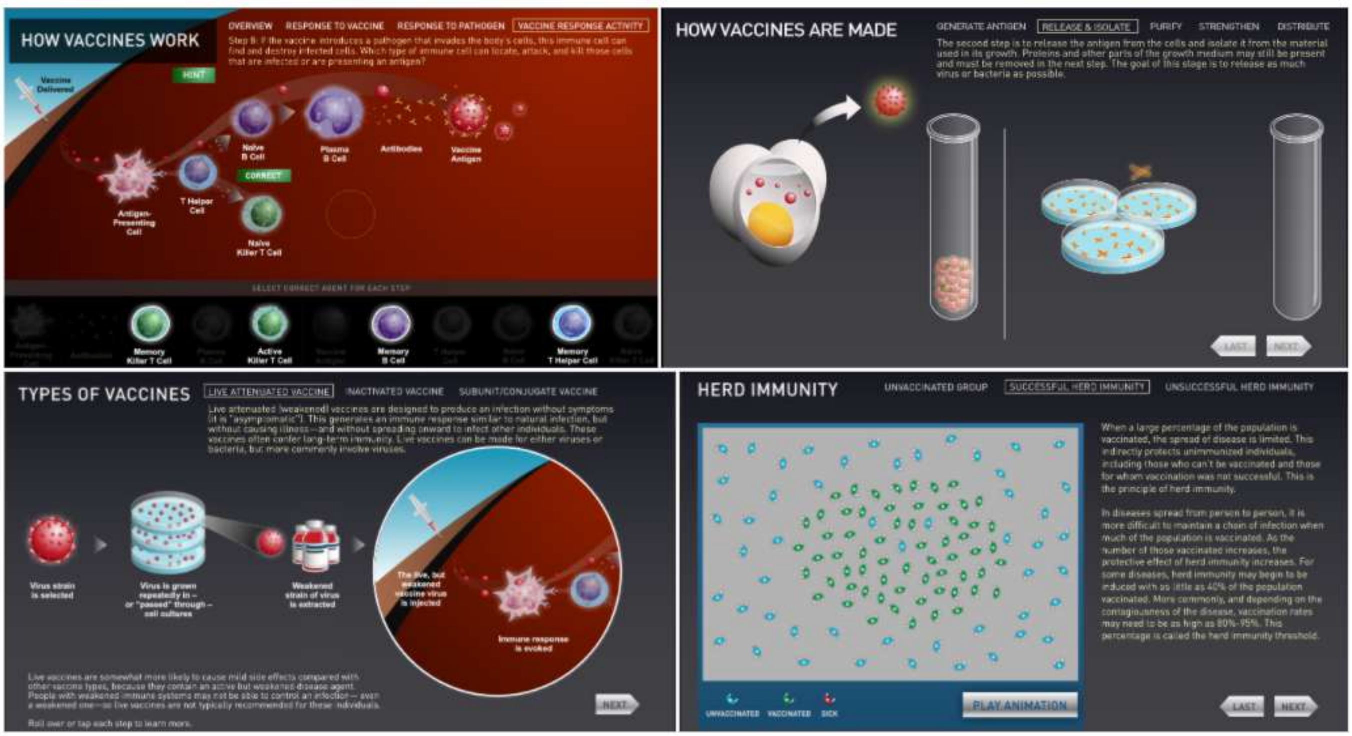
cells.

4. What would be potential consequences of a society not being able to achieve the minimum threshold for herd immunity?

5. How can we help convince the greater population of the safety & effectiveness of the upcoming COVID-19 vaccine?

6. What are potential changes we can make, either legislative or community-based, to ensure that more individuals follow mask-wearing and social distancing guidelines?

Vaccine Development and Immunity Interactive Simulations



Interview Transcripts with Dr. Cheng

1. **Could you tell us more about the biological concepts behind mRNA vaccines, as well as why they would be preferred over traditional vaccines?**

Vaccine can be whole vaccine (the whole body of the inactivated bacterial cell, or virus) or subunit (part of the bacterial, or virus) such as protein (spikes) or polysaccharide from the surface of COVID-19.

Nucleic acid vaccine (either DNA or RNA) is quite new. It is expected that these DNA or RNA molecule will direct the synthesis of pathogen specific protein and stimulate immune response (production of antibodies) in host cells. It is very safe; the drawback is that nucleic acids are unstable and can be digested by human body before the protein is produced.

COVID-19 vaccine is mRNA vaccine. To design mRNA vaccine, scientist obtain spikes from COVID-19, sequence the protein (arrangement of amino acid in the protein), predict the mRNA from the protein sequence. This process (from protein to mRNA) is known as reverse genetics (traditional genetics starts from DNA -mRNA-protein). mRNA molecule can then be synthesized and used as vaccine.

When mRNA (vaccine) is injected, it will be translated into viral protein in human body. This will stimulate the production of antibodies against virus protein. When human is exposed to the real COVID-19 virus later on, these antibodies will bind to the spikes of the viruses and block them from further damaging the host cells. It is important to know that vaccine is usually designed based on the surface marker, because this is the first molecule recognized by host cells.

mRNA vaccine is safe to use compared to whole vaccine. The adverse reaction to vaccine is usually not the mRNA molecule, it is usually to the adjuvant (the chemicals that help to deliver the vaccine).

2. Focusing on prevalent viral diseases, such as the flu, the common cold, or COVID-19, why do viruses mutate quickly, and what contributes to the variation in the rate of mutation? Also, what would it mean for a virus to become vaccine-resistant? Is that even possible?

Flu and COVID-19 viruses are RNA virus. In other words, the genome (the brain) of the virus is RNA molecules. To reproduce more viral particles, virus will use the machinery of the host cells to replicate their RNA molecules. This process is catalyzed by the enzyme called RNA polymerase. RNA polymerase does not have the function of "proof reading", so it can easily make mistake (mutate) during RNA replication. For example, A is supposed to pair with U, but a C is incorporated in the RNA molecule. RNA polymerase will not recognize this mistake, nor it will correct it.

All RNA viruses tend to mutate more than DNA virus.

Common cold is caused by a whole spectrum of viruses, including RNA virus, thus, they also tend to mutate.

4. At a molecular level, how exactly do B- and T- cells work together to create antibodies? Moreover, where and how are they able to store such detailed information about different types of pathogens? Is it a part of their DNA?

B cells and T cells are different types of immune cells and they have different function.

The main function of B cells to produce antibodies that help to eliminate pathogens. That is how vaccine works. Vaccines educate B cells to produce antibody and block the infection for the "real pathogens" when they are encountered.

T cells are different. They DO NOT produce antibody. There are different types of T cells, for example, cytotoxic T cells (Tc) produce enzymes that will kill virus infected cells or cancer cell.

Both B cells and T cells have memory, they stored the information of pathogen by memorizing the surface molecules such as proteins or polysaccharide of the pathogen, NOT nucleic acid of the pathogen. Rembert, viral nucleic acids are covered by protein coat, they cannot be seen directly by the host cells.

Vaccines and Immunology Multiple Choice Quiz

Which of the following vaccine types is most commonly used in vaccine development? * 2 points

- (●) Injecting a weakened virus
- (○) Injecting part of a virus
- (○) Injecting a completely inactivated virus
- (○) Injecting toxoids to fight bacterial toxins

Select all of the activities that should be AVOIDED in a pandemic: * 3 points

- [ ] Wearing masks in public settings
- [x] Going to parties with a large crowd
- [x] Taking your mask down in a big group of people
- [ ] Washing your hands frequently
- [x] Touching your face a lot, especially your eyes, mouth, nose, and ears
- [ ] Keeping a bottle of hand sanitizer at all times
- [ ] Keeping a distance of 6 feet between you and everyone else

The COVID-19 virus injects which of the following substances into the patient? * 2 points

- (●) Bacterial polysaccharide coating of the COVID-19 virus
- (○) mRNA (or messenger RNA) of the COVID-19 virus
- (○) Completely inactivated strand of the COVID-19 virus
- (○) Toxoids that fights against the toxins released by the COVID-19 virus

Which of the following correctly defines herd immunity? * 2 points

- (○) Herd immunity is when a virus, bacterial strand, or other pathogen becomes resistant to certain human-developed drugs or vaccines due to rapid genetic evolution. This resistance allows disease to continue to be present, even after the intake drugs or vaccines.
- (○) Herd immunity is the widespread, instantaneous implementation of an antibiotic or vaccine, effectively killing off 100% of the pathogen, ensuring that there is no possibility for the virus to reproduce, and making the whole population completely immune to the disease.
- (●) Herd immunity is when a sufficient proportion of a population is immunized, either through prior contraction or through vaccination, from the contagious disease, thus severely limiting the spread of that disease.
- (○) Herd immunity is when, during a pandemic, everyone completely avoids contact with the disease, meaning that no one is exposed at any point in time. Due to this lack of contact and spread, the population is quickly and efficiently "level off the curve" and resume normal activity.

Select all of the organs that are associated with the body's immune response. * 3 points

- [ ] Lungs
- [x] Tonsils
- [x] Adenoids
- [ ] Liver
- [ ] Pharynx
- [x] Spleen
- [ ] Trachea

Which of the following correctly describes the differences between acquired/adaptive and innate immunity? * 2 points

- (○) Innate immunity is developed throughout the life as a person is exposed to different diseases, whereas acquired immunity is inherited at birth from his or her mother.
- (●) The innate immune system patrols the body in search of invaders while the adaptive immune system produces specific antibodies based on what the innate system detects.
- (○) The innate immune system employs B and T cells while the adaptive immune system employs phagocytes to protect the body from invaders.
- (○) Innate immunity includes everything a person's immunity system already has, while adaptive immunity includes all types of drugs, vaccines, and other treatments that help fight the disease.

Results

<u>Trial Lesson Run #1 - Held over Discord</u>

Main Takeaways:

- Increase audience involvement and interaction, in the form of games and engaging activities
- Spend less time on presentation and more time on discussion
- Take breaks throughout the lesson to answer questions (not just at the end)

<u>Lesson Run #2 - Held over Zoom</u>

(We got most of them to turn their cameras on and smile for the picture during a break!)

<u>Sample Student Responses (Anonymous) from Thinking Deeper Discussion Questions</u>

Using the main characteristics of how vaccines work, describe how the overuse of vaccines can be detrimental towards overall public health in the future.

> *"When vaccines lose their effectiveness, then the entire public does not have herd immunity and this could impact everyone, including those who aren't able to be vaccinated in the first place. They would lose effectiveness because an overuse of vaccines could cause super-evolving viruses, which evolve too quickly to have a proper vaccine. There's also the possibility of vaccine-resistant viruses, just like there are antibiotic-resistant bacteria."*

Describe how the proper implementation of and overarching access to vaccines can promote a healthier and safer population.

> *"The proper implementation of vaccines can help immunize a greater population of people, which would lead to greater benefits both for general wellbeing and increased life expectancy. Distributing a surplus of vaccines allows people that need it but can't afford it to access it, which stops the spread of the disease caused by the virus at hand."*

Come up with an analogy to explain the role and relationship between phagocytes and B & T cells.

> *"We thought of a security system. The security camera is the sensor, which can detect when something looks off. However, the camera itself doesn't change its actions based on what it senses. The person watching the feed behind the camera is the one who might signal guards or ring an alarm. Phagocytes represent the camera because they are always looking for invaders while B & T cells represent the person because they have a specific immune response based on the type of invader."*

What would be potential consequences of a society not being able to achieve the minimum threshold for herd immunity?

> *"The consequences of not being able to reach the minimum threshold for herd immunity would be a mass spread of the disease. If not enough people are vaccinated, the disease will continue to spread and affect all vulnerable people, while people are still under the impression that they are safe."*

How can we help convince the greater population of the safety & effectiveness of the upcoming

COVID-19 vaccine?

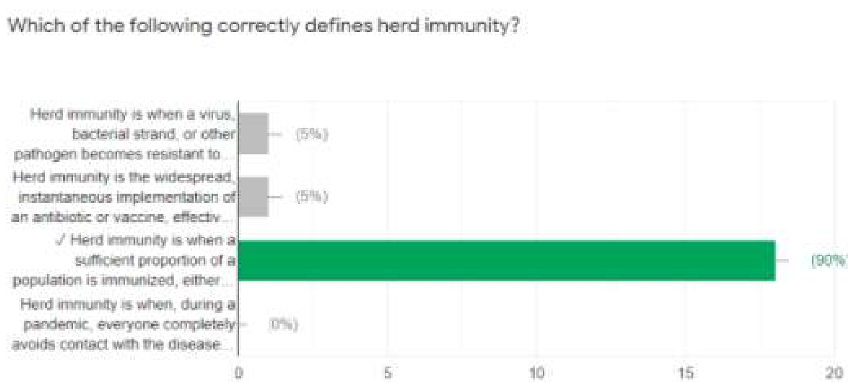
> *"The best route is probably education, just explaining how the vaccine will work together with the immune system to protect people against COVID-19. It's also important to show people that to some extent, it's a social responsibility to take the vaccine, since we will need to reach herd immunity."*

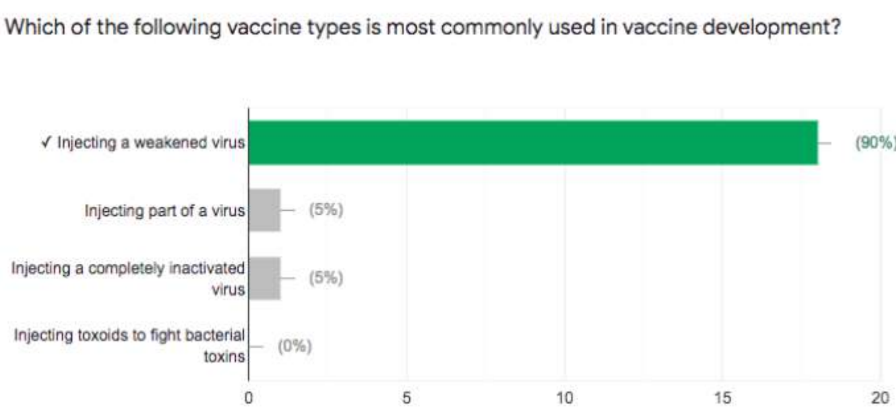
What are potential changes we can make, either legislative or community-based, to ensure that more individuals follow mask-wearing and social distancing guidelines?

> *"One potential change for communities is strict mask mandates with fines. While this may be highly controversial, it has proven to be effective in many countries, and doing so will reduce the spread of COVID-19 and reduce the drastic increase in cases. These mandates should be accompanied with fines to ensure individuals follow the law, causing most to wear a mask."*

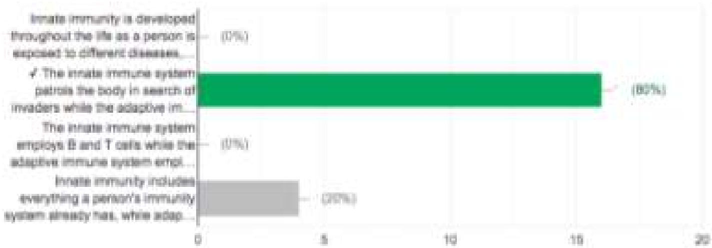
<u>Multiple Choice Quiz Results</u>

Taken at the end of the lesson - following presentation, simulations, discussion, Gimkit, and opportunities for Q/A

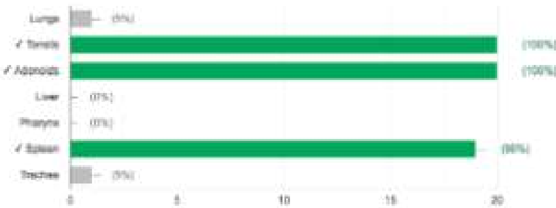




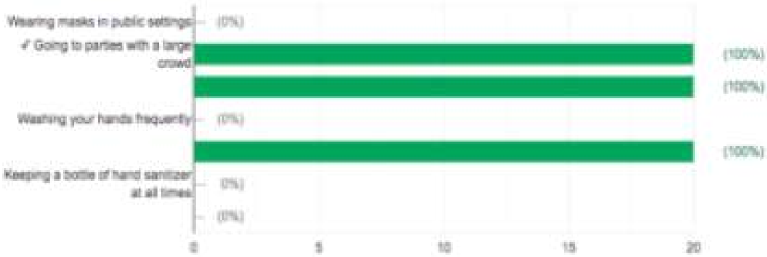
Which of the following correctly describes the differences between acquired/adaptive and innate immunity?



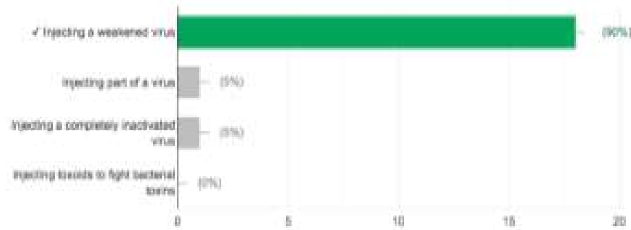
Select all of the organs that are associated with the body's immune response.



Select all of the activities that should be AVOIDED in a pandemic:



Which of the following vaccine types is most commonly used in vaccine development?



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