Unit 2: Lesson 3 – Types of Vaccines and Immunity

LESSON QUESTIONS

- What is the purpose of a vaccine?
- What are the different ways in which vaccines are made?
- How do vaccines protect populations of people?

LESSON OBJECTIVES

- State the purpose of a vaccine.
- Give examples of different ways in which vaccines are made.
- Analyze how vaccines protect populations of people.

OVERVIEW

In this lesson, students investigate the different ways vaccines are made, how passive immunity works, how herd or community immunity works and the role vaccines play in herd immunity. Students explore resources to identify the different types of vaccines and how they are made. Students conduct research to understand the difference between active and passive immunity and use a computer model to simulate herd immunity. Students use statistics and graphs to analyze data and compare how different immunization rates confer varying degrees of protection on vaccinated and unvaccinated populations. In an optional extension activity, students identify different types and functions of vaccine ingredients and fact check the online information they encounter.

LENGTH

Two to four 45-minute sessions

GLOSSARY TERMS

Adjuvant, antibody, antigen, attenuation, byproduct, cell culture adaptation, combination vaccine, conjugate vaccine, contraindication, DNA vaccine, herd immunity, immunity, immunocompromised, inactivated vaccine, live weakened viral vaccine, mRNA vaccine, multivalent vaccine, passive immunity, peptide subunit vaccine, plasmid, polysaccharide subunit vaccine, preservative, protein subunit vaccine, recombinant vaccine, stabilizer, subunit vaccine, toxin, toxoid, toxoid vaccine, vaccine, viral vector vaccine

STANDARDS

- **Next Generation Science Standards**
    - HS-LS1-2.4.1 Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales.
    - HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
    - HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.
    - HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
    - HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
- **Common Core State Standards**
    - RST.11-12.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
    - RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context.
    - RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
    - WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
    - WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
    - WHST.11-12.6 Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

- WHST.11-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

- HSS.IC.B Make inferences and justify conclusions from sample surveys, experiments, and observational studies.

- HSS.IC.A Understand and evaluate random processes underlying statistical experiments.

- HSS.ID.A Summarize, represent, and interpret data on a single count or measurement variable.

MATERIALS

- Student worksheet
  https://vaccinemakers.org/sites/default/files/lessons/HS.student%20worksheet.unit2_.lesson3_FINAL.pdf
- Computer with internet access
- For Activity 1, each group will need:
  - Types of Vaccines worksheet - https://vaccinemakers.org/sites/default/files/lessons/HS.activity1-Types%20of%20Vaccines-.unit2_.lesson3_FINAL.pdf
- For Activity 2, each group will need:
  - Understanding Herd (Community) Immunity sheet - https://vaccinemakers.org/sites/default/files/lessons/HS.activity2-Understanding%20Herd%20Immunity.unit2_.lesson3_FINAL.pdf

BACKGROUND FOR TEACHER

What is a vaccine? Vaccines protect people from disease by preparing our immune systems to fight potential pathogens before we encounter them in the environment. Vaccines provide specific (adaptive) immunity without having to experience the harmful, and sometimes deadly, symptoms of disease.

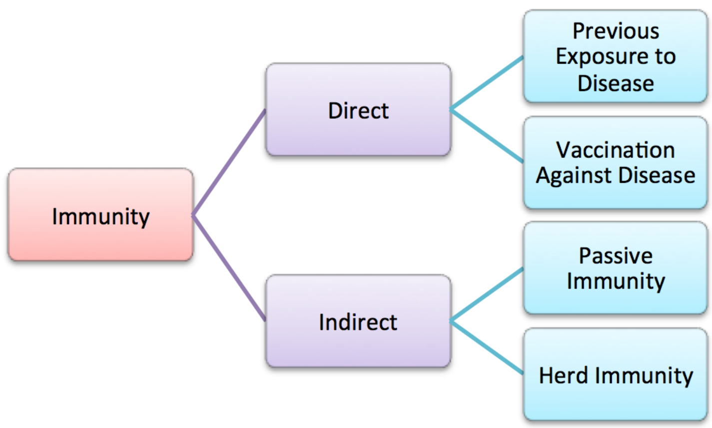
What are the different types of vaccines? Scientists have successfully employed several approaches to making vaccines. Students investigate each approach and consider its advantages and disadvantages. Reference the rubric for Activity 1 in the lesson plan for an overview of vaccine types, how they are made, advantages/disadvantages, and examples of each type.

Vaccine Ingredients
The vaccine ingredients table on page 4 details some vaccine ingredients, what they do, and additional information about each that can be used to answer student inquiry, independently, or in conjunction with the optional lesson Extension. Vaccine ingredient resources can be found in the lesson resources section.

Type of Ingredient	***Purpose***	***Examples/Facts/Info***
Antigen	Antigens are the active ingredient in vaccines. They teach the immune system to respond more quickly to infection from a specific disease-causing agent.	Antigens can be whole pathogens, or parts of pathogens, harvested and purified to provide the strongest possible immune response with the least possible side effects.
Adjuvant	Adjuvants are used in vaccines when the antigen in the vaccine is unlikely to cause a strong immune reaction by itself. By enhancing the immune response, adjuvants reduce the amount of vaccine or number of doses needed for meaningful, long-lasting protection.	The five adjuvants used in the United States are: 1. Aluminum salts: the oldest type of adjuvant, removed from the body by the kidneys. 2. Monophosphoryl lipid A: a lipid isolated from the surface of bacteria. 3. QS21: a soap-based adjuvant isolated from the bark of *Quillaja Saponaria* trees. 4. MF59: an oil-in-water emulsion. 5. CpG: two linked nucleotides, Cytosine (C) and Guanine (G).
Preservative	Prevents bacterial or fungal contamination of the vaccine, especially in multi-dose vaccines from the same vial.	Preservatives are typically used in very small amounts in vaccines. Thimerosal, an ethyl-mercury based preservative, was historically a common vaccine preservative, however, it is no longer used in childhood vaccines in the United States and appears only in multi-dose flu vaccines. Other examples of preservatives include phenol, 2-phenoxyethanol, and, less commonly, benzethonium chloride.
Stabilizer	Used to prevent the breakdown of active ingredients during manufacturing, storage and transport.	Stabilizers are typically made from sugars, amino acids, or proteins. Two common stabilizers are gelatin, a natural protein, and polysorbate 80, which is also used as an emulsifier in food and cosmetic products. Both can cause allergic reactions in some individuals.
Byproduct	Byproducts have no purpose in the final product, they are remnants of vaccine production that may exist in the final vaccine in extremely small quantities.	Some byproducts relate to how the virus or bacteria was grown, like egg proteins, fetal tissues, human proteins and yeasts. Others relate to the sterilization and purification of the bacteria or virus from the vaccine. These include things like trace amounts of antibiotics, formaldehyde, or broken strands of DNA. Rarely, there are concerns about pathogens that survive the purification process but do not infect humans, like the simian virus SV40 that was found in cells used to grow the poliovirus vaccine. However, upon further review these concerns were unfounded, although cell lines containing SV40 are no longer used for vaccine production today.

Herd (Community) Immunity
A key goal of immunization programs is to protect as many people as possible. Practitioners have long recognized that achieving total vaccination among the entire population is difficult, if not impossible. Some people may be unable to be vaccinated due to illness or a compromised immune system, while still others may choose not to vaccinate due to religious beliefs or skepticism of science. However, the principle of herd (or community) immunity relies on the fact that populations with higher rates of protected individuals are more protected. In such a population, a pathogen has less opportunity to move from person to person throughout the community. As students will see in the lesson, herd immunity is a function of probability. As the level of immunity in the population increases, everyone has a decreased chance of being infected. If a high enough proportion of the population is immunized, even unvaccinated people will be protected from the disease, simply because there are so few opportunities for the spread of infection. Herd immunity is, therefore, a type of indirect immunity.

People can be protected from diseases directly or indirectly:



Previous exposure to disease – A person's own immune system responds to an infection and acquires "memory" that affords protection if he or she is exposed to the same disease in the future. However, the person may have symptoms of the disease while acquiring this immunity.

Vaccination against disease – The vaccine stimulates the person's immune system. The immune system acquires memory that provides protection if exposed to the disease in the future. The benefit, compared with having the disease, is that the person will either not experience the symptoms of the illness, or experience milder symptoms.

Passive immunity – When babies are born, they have some antibodies from their mothers, called maternal antibodies. These antibodies will protect the baby for a few weeks or months after birth. Certain vaccines, for example, influenza and pertussis, are recommended during pregnancy to help protect both the mother and the baby. However, once these antibodies are no longer present, the baby will become susceptible to infection.

The infant vaccine schedule is set up so that a baby's immune system has time to build protective responses before a lack of maternal antibodies leaves them vulnerable.

Herd immunity – Herd (or community) immunity occurs when a certain percentage of people in a population are immune. The pathogen has less opportunity to infect the low numbers of susceptible people in the community. Vaccinated people protect the few who are not immunized by insulating them from disease. As the numbers of unvaccinated people rise, the effects of herd immunity weaken, setting the stage for outbreaks.

TEACHER NOTES

Even if students just completed studies of the immune system, they may not be aware of direct and indirect immunity, described in "background for teacher" section. In order to provide context for the materials covered in the next few lessons, you may want to introduce the diagram and discuss the ways immunity can be achieved prior to starting the lesson.

LESSON RESOURCES

- Lesson glossary - https://vaccinemakers.org/sites/default/files/resources/HS.student%20glossary.unit2_.lesson3_FINAL.pdf

- Lesson diagram supplement (Diagrams Related to Herd Immunity) - https://vaccinemakers.org/sites/default/files/resources/HS.student%20diagram%20supplement-Herd%20Immunity.unit2_.lesson3_FINAL.pdf

- Types of Vaccine Resources
  - See RUBRIC - ACTIVITY 1: Types of Vaccines on page 12 of this document
  - Webpage - Vaccine Science: How are Vaccines Made?, VEC, https://www.chop.edu/vaccine-education-center/science-history/vaccine-science/how-are-vaccines-made
  - PDF - "Influenza" Infographic, VEC,
  - https://www.chop.edu/sites/default/files/2025-04/vec-influenza-infographic.pdf
  - PDF - "COVID-19: The Disease VS The Vaccine" Infographic, VEC, https://www.chop.edu/sites/default/files/vec-covid-vs-vaccine-infographic.pdf
  - Animation- *How COVID-19 mRNA Vaccines Work*, VMP, https://vimeo.com/579667076
  - Animation - *How COVID-19 Viral Vector Vaccines Work*, VMP, https://vimeo.com/618385339
  - Animation - *Attenuation: How Scientists Make Live Vaccines*, VMP, https://vimeo.com/227180098
  - Animation - *Using Genetic Engineering to Make Vaccines*, VMP, https://vimeo.com/227180912

- Active/passive immunity resources
    - Webpage - Types of Immunity, VEC, https://www.chop.edu/vaccine-education-center/human-immune-system/types-immunity
    - Video - *Parents PACK Science Made Easy: Maternal Antibodies and Vaccines*, The Children's Hospital of Philadelphia, https://www.youtube.com/watch?v=yKIjHeezblI&list=PLUv9oht3hC6QXyTjllQVBIFqqASDOdnAa&index=2&t=11s
    - Article – "A Closer Look: Maternal Antibodies – Actively Providing Passive Immunity," Hilleman Film, https://hillemanfilm.com/news/closer-look-maternal-antibodies-actively-providing-passive-immunity
    - Animation - *How do Antibodies Work?*, VMP, https://vimeo.com/227176366
    - Webpage - Immunity Types, CDC, https://www.cdc.gov/vaccines/basics/immunity-types.html

- Webpage - Herd Immunity Simulation:
    - http://www.software3d.com/Home/Vax/Immunity.php

- Vaccine ingredients resources:
    - Webpage - "Vaccine Ingredients," VEC, https://www.chop.edu/vaccine-education-center/vaccine-safety/vaccine-ingredients
    - PDF - "Vaccine Ingredients: What You Should Know" Q&A, VEC, https://www.chop.edu/sites/default/files/vaccine-education-center-vaccine-ingredients.pdf
    - PDF - "Flu Vaccine: What's in the Vial?" Infographic, VEC, https://www.chop.edu/sites/default/files/2025-03/flu-whats-in-the-vial-infographic.pdf
    - PDF - "COVID-19 Vaccines: What's in the Vial?" Infographic, VEC, https://www.chop.edu/sites/default/files/vec-covid-ingred-infographic.pdf
    - PDF - "Aluminum & Vaccines: 3 Things to Know" Infographic, VEC, https://www.chop.edu/sites/default/files/vec-aluminum-qa-infographic.pdf
    - Short Film - *Stanley Plotkin: Pioneering the use of fetal cells to make rubella vaccine*, VMP, https://vimeo.com/339593360

- Additional resources that may be helpful:
    - Webpage - Vaccine Science: Vaccines and the Immune System – How Do vaccines work?, VEC, http://www.chop.edu/centers-programs/vaccine-education-center/vaccine-science/vaccines-and-immune-system
    - PDF – "Vaccinated or Unvaccinated: What You Should Know" Q&A, VEC, https://media.chop.edu/data/files/pdfs/vaccine-education-center-vaccinated-unvaccinated.pdf
    - PDF - "Vaccinated vs Unvaccinated Diagram" illustrating SARS-CoV-2 infection, VMP, https://vaccinemakers.org/sites/default/files/Vaccinated%20vs%20unvaccinated%20diagram.pdf

- Video Series -Dr. Offit Answers YOUR Vaccine Questions, VEC, https://youtube.com/playlist?list=PL29xQkYy63IS-a61lksRJUbKvdPd3EeiO&si=NYnozaV1aDSlvwoQ
- Animation - *The Adaptive Immune System*, VMP, https://vimeo.com/227178817
- Video - *What is Herd Immunity?*, Royal College of Pathologists https://www.youtube.com/watch?v=tC47JjakPSA
- Video - *What are the Different Types of Vaccines*, VEC, https://www.youtube.com/watch?v=bg6lHRxuc3M&list=PLUv9oht3hC6TTY-k6FbWQDWS-aR-KGRGZ&index=16
- Animation Expedition #7 - Genetic Engineering and Vaccines, VMP, https://vaccinemakers.org/news-events/animation-expedition-7-genetic-engineering-and-vaccines
- Video - *Herd Immunity*, Robert Rohde, https://www.youtube.com/watch?v=XJFoOCmJsdg
- Webpage - Measles Simulator, https://fred.publichealth.pitt.edu/measles
- Animation - *How Do Cells Defend Against Foreign DNA?*, VMP, https://www.youtube.com/watch?v=gPkKI7JV9Vw
- Video - *Thimerosal in Multidose Vaccine Vials: Then and Now*, VEC, https://www.youtube.com/watch?v=ooxkDWfILbo
- Video - *Aluminum in Vaccines: Is it Safe?*, VEC, https://www.youtube.com/watch?v=JlYWqj37gPM

ENGAGE

1. Ask students to collectively brainstorm a list of different vaccines they have heard of.
2. See if students can use prior knowledge about diseases and lesson clues to guess the type of any vaccine on the list.
3. Encourage further analysis by including any vaccine ingredients students have heard of.
4. Explain to students that they will learn how vaccines are made and how vaccines provide immunity.

EXPLORE 1

1. Students use online sources and the lesson glossary to complete the vocabulary table.
2. Explain to students that their task is to research how a particular type of vaccine is made.
3. Working in small groups, students complete the activity Types of Vaccines (Activity 1). Each group is assigned or chooses one of the different vaccine types. If students are choosing the type of vaccine to research, ensure that each type of vaccine is chosen by at least one group. You may choose to include all types of vaccines listed in the rubric (including different subunit types) or select only the types from the main categories.
4. Each group researches their chosen vaccine and completes the corresponding sections of the table.

EXPLAIN 1

1. Groups create a presentation to share their findings with the class. Guide students as needed to choose an appropriate presentation format. (To save time, a simple oral presentation would be appropriate.)
2. Each group presents its findings to the class.
3. During the presentations, students complete the Activity 1 Types of Vaccines table.
4. Lead a class discussion on the various approaches, reviewing vaccine types, method of production, advantages, disadvantages and examples.

EXPLORE 2

1. Students explore online sources about the differences between active and passive immunity. See teacher resources for suggested options.
2. Inform students that their task is to explain how active and passive immunity function.

EXPLAIN 2

1. Assign or let students choose from the following options:
    a. Students write a short paragraph summarizing the difference between passive and active immunity providing examples of each.
    b. Students develop a learning tool (infographic, PSA, video, etc.) that explains passive vs. active immunity.

ELABORATE

1. Explain to students that their task is to explore a computer simulation of herd immunity.
2. Propose a guiding question to students: *How does immunization rate affect the proportion of people who are protected?*
3. Working in small groups, students complete the Understanding Herd Immunity activity (Activity 2). Ensure students read the background passage in the activity that briefly explains the principles of herd immunity. If needed, allow students to explore additional resources to understand herd immunity.
4. Students work in pairs to conduct the simulation. Assign each pair an immunization rate from 0.1 to 0.9 to use in their simulation. Ensure each rate is assigned to at least one pair of students. If you have fewer than nine pairs of students, you can assign more than one rate to a pair.
5. Students conduct 15 trials for their assigned immunization rate and then calculate the mean and standard deviation for four percentages displayed in the simulation: percent of the *total* population infected, percent of the *vaccinated* population infected, percent of the *unvaccinated* population infected and percent of those infected that had been vaccinated.
6. To demonstrate the effect of herd immunity, students will need to pool their data to create a class data set.

7. Create a collaborative spreadsheet (such as a Google Sheet) where students can add the data from their simulations. Student activity sheet refers to “pooling” data in a collaborative document in step 12.
8. Students add the means of the four percentages to the collaborative document. If more than one group is working on the same immunization rate, they should pool their data before calculating the mean.
9. Students work in their pairs or individually to graph the pooled data from the collaborative document.
10. Use your projector or smart board to show students the Figures 1 and 2 from the Diagrams Related to Herd Immunity supplemental document. The figures show sample data from the simulations.

EVALUATE

1. Evaluate students based on their “Types of Vaccines” presentations in Activity 1. Use the Activity 1 rubric as a guide to the correct responses.
2. Assess students based on their completion of the active and passive immunity writing/learning tool activity.
3. Assess students for Activity 2 based on their completion of the activity questions. Use the Activity 2 rubric as a guide to the correct responses.

EXTENSION (Optional)

See the “Vaccine Ingredients” table in the teacher resources section for additional information and resources. The extension activity can be done individually or in small groups, with students choosing or being assigned one ingredient or more than one.

1. Students research different vaccine ingredients using both recommended resources as well as general online searching. Students compile a list of the statements about ingredients that they have discovered online.
2. Students fact check the information they encountered.
3. Students compose a brief paragraph explaining the role of different vaccine ingredients and common misperceptions about each.

RUBRIC – STUDENT WORKSHEET

Vocabulary table - Refer to the lesson glossary for correct definitions of the components of the innate immune system.

RUBRIC - ACTIVITY 1: Types of Vaccines

Note that some vaccines may fit into more than one category.

Vaccine Type	Method	Advantages	Disadvantages	Examples
Inactivated virus	Use formaldehyde to kill the target virus, which prevents the virus from reproducing.	Cannot cause the disease it is preventing, so can be given to people with weakened immune systems.	Immune response not as strong, so several doses usually needed.	Polio shot, hepatitis A, rabies, influenza shot
Live, weakened virus	Use viruses grown repeatedly in the laboratory in a different cell type than they typically infect so they change and become weaker when given as a vaccine.	Strong immune response. Typically, only one or two doses needed for immunity.	May cause side effects due to low level viral replication. Should not be given for certain populations, such as pregnant or immunocompromised individuals. Relatively short shelf-life.	Measles, mumps, rubella, rotavirus, chickenpox, influenza (intranasal version)
Recombinant	Technically considered a type of subunit vaccine. Only the gene that codes for the surface proteins of a virus is put into the plasmids of yeast or bacterial cells allowing those cells to make copies of the surface protein and trigger immune response. Purified protein is used for the vaccine.	Cannot cause disease. The more targeted immune response can confer long-term immunity.	Technically complicated and expensive to produce. Typically require multiple doses.	Hepatitis B, HPV, shingles (Shingrix)
Toxoid	Use inactivated disease-causing toxins produced by the bacteria (called toxoids). Technically can also be classified as a type of subunit vaccine.	Cannot cause disease. Relatively long shelf life.	Typically require multiple doses.	Diphtheria, tetanus, pertussis (whooping cough)

Vaccine Type	Method	Advantages	Disadvantages	Examples
Viral vector	Place the gene for the target virus protein into another, harmless, virus, called the vector virus, to deliver the target genetic data to the immune system without risk of severe infection.	Cannot cause disease. Triggers strong, long-lasting immune response.	Pre-existing immunity to the vector virus can reduce the efficacy of the vaccine.	Ebola, COVID-19 non-USA (AstraZeneca and Johnson & Johnson)
mRNA	Use mRNA (messenger RNA) to provide the blueprint for a viral protein which prompts the body to generate the protein and produce an immune response against it.	Cannot cause disease.	Typically require multiple doses. Relatively short shelf life.	COVID-19 mRNA vaccines (Pfizer and Moderna)
DNA	A segment of genetic information (DNA) of a target virus' protein is injected into the body via plasmid. The body transcribes the DNA into mRNA, which is then translated into the target protein and generates an immune response.	Cannot cause disease. Stable and longer lasting at room temperature. Relatively long shelf life.	Has lower efficacy and requires a higher dose than mRNA vaccines.	Not used in human vaccines. West Nile Virus (Horses), Melanoma (dogs)
Subunit	A broad category of vaccines (see specifics below) that use only purified parts of a pathogen rather than a whole killed or weakened pathogen to more safely stimulate an immune response. This category of vaccine includes conjugate vaccines, protein vaccines, polysaccharide vaccines, and peptide vaccines.	Few side effects, low cost.	Antigens alone are not always enough to induce long-term immunity, so adjuvants are often necessary in subunit vaccines.	Conjugate vaccines Protein subunit vaccines Polysaccharide subunit vaccines Peptide subunit vaccines
Conjugate (subunit)	A type of subunit vaccine. Isolate a protein from the outer coating of a target bacteria and attach a harmless "helper" protein that causes a stronger immune response.	Cannot cause disease.	Typically require multiple doses.	Pneumococcal, *Haemophilus influenzae* type b

Vaccine Type	Method	Advantages	Disadvantages	Examples
Protein subunit	A type of subunit vaccine. Uses harmless, cultivated fragments of proteins from a bacteria or virus as the primary vaccine ingredient to teach the immune system to recognize those proteins without risk of infection.	Cannot cause disease. Easy to produce.	Require adjuvants to enhance the immune system response. May require multiple doses.	Hepatitis B, Human Papillomavirus, acellular pertussis (whooping cough), COVID-19 (Novavax)
Polysaccharide subunit	A type of subunit vaccine. Uses sugar molecules isolated from the surface of cultured bacteria to teach the immune system to recognize a pathogen. Stimulates antibody production without T cell response.	Cannot cause disease.	Does not work in children under 2 years old who will not be able to mount an effective immune response without T-cell involvement.	Meningococcal, typhoid, pneumococcal
Peptide subunit	A type of subunit vaccine. Uses engineered peptides, short chains of amino acids, to create a vaccine that imitates an antigen's epitopes, or the regions of an antigen that are recognized by the immune system's antibodies and T cells.	Cannot cause disease. Low cost, easy to make, stable.	Requires adjuvants, carrier proteins, and multiple doses.	Prostate cancer (Sipuleucel-T), COVID-19 (EpiVacCorona)
Multivalent	Combines antigens from different strains of a pathogen either directly into a vaccine (by mixing them, conjugation, or mRNA) or by using vectors that can be modified to express multiple antigens.	A single injection can provide broad immunity, protecting an individual against multiple strains of a disease.	Harder to determine which antigen caused a reaction.	Poliovirus, pneumococcal, Human Papillomavirus, seasonal influenza
Combination	Combines antigens from different pathogens together into a single vaccine, either by mixing them directly into one product, or by filling separate chambers of a dual-chamber syringe.	Reduced number of doses, one vaccine can provide immunity for multiple diseases. Helpful for catching up children who are behind schedule for immunizations. Reduced cost of stocking and administering multiple vaccines.	Increased difficulty finding the cause of an adverse reaction. Ingredients may be incompatible or cause immunologic interference, reducing effectiveness. Can complicate vaccine schedules.	MMR (measles, mumps, rubella), DTaP(diphtheria, tetanus, pertussis) Dual-chamber syringe vaccines include MR (measles and rubella only), and DTP-IPV (diphtheria, tetanus and pertussis with inactivated poliovirus vaccine)

RUBRIC – ACTIVITY 2: Understanding Herd (Community) Immunity

Activity 2 Questions

1. Explain the relationship between immunization rate and percent of population infected.
    - A higher immunization rate results in lower infection rate.
2. How does the percent of the unvaccinated population who are infected change as the immunization rate increases?
    - As the immunization rate increases, the percent of unvaccinated that become infected decreases (demonstration of herd immunity).
3. Is there a point in your data where the unvaccinated population seems to be protected from infection? Explain your answer.
    - Unvaccinated population may become protected from infection around 50% immunization rate, based on graph of percentage of unvaccinated population infected and immunization rate.
4. Predict what happens when the immunization rate is 0 and then 1.0. Explain your answer.
    - When the immunization rate is 0 all people will be infected because without vaccination the only direct protection is disease. When the immunization rate is 1.0, no one will be infected because everyone is protected.
5. Check your answer to #4 by running the simulation with the immunization rate at 0 and then 1.0. Did you predict the simulation result correctly? Explain the simulation result.
    - Answers will vary depending on answer to #4. Students should demonstrate that they understand how immunization rate determines the proportion of population protected and at risk of infection.