

The Story Behind the COVID-19 Vaccine

Lesson for 10-14 year old students

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Slide 1:

[It is recommended that this lesson is covered over 2 hours (either done in back-to-back lessons or during two one-hour lessons on different days). However, if this is not possible due to the classroom schedule, the suggested 55-minute time schedule is noted throughout the slide notes.]

This lesson addresses:

Overview:

Have you ever wondered about the science behind the COVID-19 vaccine? How about who is behind the research? This is an inspiring and insightful lesson that acts as a follow up to the “*Outbreak: One World – One Health*” lesson.

Lesson Objectives:

1. Students will understand the history of the mRNA vaccine development.
2. Students will recall lessons and vocabulary words from the first lesson in this series “*Outbreak: One World – One Health*”
3. Students will understand the immune system and the role of proteins.
4. Students will understand that collaboration between people of various disciplines can make people, animals and the environment healthy.
5. Students will be able to explain the role of vaccines.

United Nations’ Sustainable Development Goals:

Good Health and Well-being (slides 5, 10-11, 27-34)

Quality Education (throughout lesson)

Partnerships for the Goals (slide 4)

(United States’) Next Generation Science Standards:

MS-LS1-3 From Molecules to Organisms: Structures and Processes (slide 11)

MS-LS2-1 Biological Evolution: Unity and Diversity (slide 35)

MS-LS2-4 Biological Evolution: Unity and Diversity (slide 35)

Slide 2:

Review that this is an interactive lesson with an official contest at the end. Throughout the lesson, small points (1-2 at a time) will be handed out to teams based on correct answers.

Encourage the students to take notes.

Request that their teacher assign teams of 4-5 students from this slide going forward. It is ideal to have all of the teams with the same number of participants (as described in slide #40)

Slide 3:

For the next 3 slides, review each in under 1 minute (because these activities and definitions were taught in the previous One Health class entitled “Outbreak: One World – One Health”)

One Health (concept): the interconnection between human health and the health of the environment, animals and plants.

The One Health approach: teamwork between people of different backgrounds, strengths and disciplines to prevent and solve complicated health problems.

Species: A group of living things that are similar enough to one another that they can create offspring together.

Zoonotic disease: Diseases (caused by germs) that can spread between animals and people.

Mutation: A change that affects behavior or development.

Vaccine: A substance that prepares the immune system to fight a disease.

[1 point can go to the team that can define any of these terms]

Slide 4:

Tip: Spend up to 1 minute on this slide.

The One Health approach: teamwork between people of different backgrounds, strengths and disciplines to prevent and solve complicated health problems.

Ask: what other types of people are important to fix big health problems like the loss of biodiversity?

(Any of the student answers will be correct. Here are some answers and the reasons for them:)

1. Physicians (human doctors)- they treat sick people
2. Veterinarians- they understand germs that can come from animals and spread to people (**review** the term: zoonotic disease)
3. Ecologists – they study the interaction between animals and their environment
4. Sociologists- they understand why people make certain decisions
5. Politicians- they create laws to protect the environment, people, animals, plants and more
6. Economists- they help businesses stay open and help livelihoods/income/well-being of families
7. Researchers- they help develop vaccines
8. Teachers- they help spread awareness and knowledge to protect more people

Slide 5:

Spend 30 seconds on this slide.

If the students ask and are curious to learn more about plant “vaccines”, here are some helpful articles:

<https://www.science.org/news/2019/08/new-medicine-could-vaccinate-plants-against-devastating-viruses>

“How Plant 'Vaccines' Could Save Us From a World Without Fruit” at

<https://www.discovermagazine.com/environment/how-plant-vaccines-could-save-us-from-a-world-without-fruit>

Slide 6:

Time check: You should be 5 minutes (or less) into the lesson

These are the new vocabulary words for today’s lesson.

(**Review** this slide in < 20 seconds.)

Slide 7:

Review: Today we will cover a real-life person. She is the person responsible for discovering important information about mRNA (messenger RNA, as described soon) and has an impressive history.

Briefly explain that a PhD stands for: “Doctor of Philosophy”.

The typical progression of somebody who wants to get a PhD goes through:

4 years of Bachelor’s Degree (undergraduate degree)

1-2 years of Master’s Degree (graduate degree)

3-8 years of Doctor of Philosophy Degree (graduate degree)

In total, this means that a person studies for up to 14 years after high school (secondary school).

****This time period may change based on the country of studies.****

Slide 8:

Answer to Question 1: [3 points to the team that answers correctly]

What is a biochemist?

Like a chemist, who studies atoms and molecules and how they interact and react with one another, a **biochemist studies the interactions and chemical reactions of atoms and molecules that support life.**

Within the word, “biochemist”, the “bio” comes from Greek and means “life”, the second part of the word is “chemist”, meaning the person specializing in chemistry.

As a biochemist, she was taught both biology (the study of living things) and chemistry (the study of elements like atoms, molecules, compounds, ions, etc.) and was passionate about the chemistry within a living thing.

Review that: just like everything around you, you are made up of atoms and molecules interacting and reacting with each other all the time!

According to Wikipedia:

Biochemists are scientists who are trained in [biochemistry](#). They study chemical processes and chemical transformations in living [organisms](#). Biochemists study [DNA](#), [proteins](#) and [cell](#) parts. The word "biochemist" is a [portmanteau](#) of "biological chemist." Biochemists also research how certain [chemical reactions](#) happen in cells and [tissues](#) and observe and record the effects of [products](#) in [food additives](#) and [medicines](#). Biochemist researchers focus on planning and conducting [research experiments](#), mainly for developing new products, updating existing products and analyzing said products. It is also the responsibility of a biochemist to present their research findings and create [grant proposals](#) to obtain [funds](#) for future research.^[1] Biochemists study aspects of the [immune system](#), the expressions of [genes](#), isolating, analyzing, and synthesizing different products, mutations that lead to [cancers](#), and manage [laboratory](#) teams and monitor laboratory work. Biochemists also have to have the capabilities of designing and building laboratory equipment and devise new methods of producing correct results for products.^[2] (Source: <https://en.wikipedia.org/wiki/Biochemist>)

Answer to Question 2: *[3 points to the team that answers correctly]*

What can a biochemist contribute to medicine and help the world?

Biochemists can assist in discovering new medications and vaccines and can help other scientists and medical doctors understand how the body works.

Answer to Question 3: *[3 points to the team that answers correctly]*

The answer to this will be found on the next slide.

Slide 9:

Play video of her introduction (of herself and her team at a company called BioNTech).

Review that an important characteristic of a successful scientist and teacher is [curiosity](#).

Slide 10:

Time check: 8 minutes into the lesson

Ask: Can the immune system be seen to the naked eye? *[1 point to the team that answers correctly]*

The **answer** is: No. The Immune System is [invisible](#) to the naked eye but we can see changes in the body when the immune system is working a lot.

For example, with an insect bite, a person or an animal can get a bump or swelling with local redness and itchiness and may even develop a fever. Some people have bigger bumps that develop to certain insects compared to other people. This is because their immune systems are different. Some people have stronger immune systems compared to others. The same thing is seen with animals.

Scientists and medical professionals use the microscope and other pieces of equipment to determine the strength and the state of the immune system by looking at white blood cells and testing for antibodies.

Slide 11:

The picture on the right shows a single type of white blood cells called lymphocytes. The color of these cells is purple because of the staining on the glass slide that is needed to help the scientist see the cells under the microscope.

For a video demonstration of how to stain glass slides with dried blood on them, watch this video: <https://www.youtube.com/watch?v=jkMgku36AYM>

Another interesting YouTube video with sound (and subtitles in multiple languages) is found here (start at 1minutes 45 seconds):
https://www.youtube.com/watch?v=kqiz_63mMwI

If the students ask: this picture of the cells is from a cat that had lymphoma (or a type of cancer or white blood cells). Scientists believe that mutations can lead to cancer because mutations can change the behavior of a cell and causes it to replicate more times than necessary. When there are extremely large groups of identical cells in one place, then cancer is suspected. However, there can be a lot of different types of white blood cells in one place because of inflammation too. Inflammation, however, is often temporary- like after somebody gets a splinter or bumps their big toe on an unseen rock or gets an insect bite.

Review that: while you cannot actually see the immune system, like you can see the heart or the skin of a person or animal, you CAN see the results of the immune system. For example, when there is inflammation in both humans and animals, you see the problematic area get:

Red

Swollen

Painful

Warm

Loss of function (ex. trouble moving a joint if a person or animal has arthritis)

Slide 12:

Time check: 11 minutes into the lesson

This is the first activity. Time to get the students excited to participate! Encourage the students to use the chat box to identify the changes they see between the next two images in the upcoming slide.

Slide 13:

Here are the 4 differences between the two images: [*1 point for each correct answer*]
The musical notes are highlighted in one and not the other.
More of the insect is found in the right picture.

Less grass under the bush in the left picture.
6 points to the sun on the right. 5 points to the sun on the left.

Slide 14:

Give only 10 seconds for the students to find the only difference and ask for somebody to explain what the difference is.

[3 points for the student team that correctly answers first]

Slide 15:

Remind the students that the immune system seeks to find anything that is “out of the ordinary” for the body and then attack it.

Discuss how a minor change like this (at the very end of the key) could change how the key would function inside of a lock. It might make the key not functional or it may change the key to a “master key” which can open any door in a building. Just like any other mutation, this change could strengthen, weaken or simply (neutrally) change the protein’s function or power.

Use the **example** of SARS-CoV-2 (the virus responsible for COVID-19) here. The proteins on the outside of the virus (called the “spike protein”) are responsible for entering human and animal cells. A similar mutation can occur on the spike protein of SARS-CoV-2! (More information about this will be reviewed soon.)

Slide 16:

Review that memory is very useful for the immune system because the body wants to remove any sensed “invader” (otherwise known as a “pathogen” to scientists). Vaccine use this characteristic of the immune system to protect the body as well as possible against such invaders

Answers to these questions: *[2 points for each correct answer]*

1- The One Health CONCEPT is: the interconnection between human health and the health of the environment, plants and animals. The One Health APPROACH is teamwork between people of different backgrounds, strengths and disciplines to prevent and solve complicated health problems.

2- The students can answer 2 of the following 4 changes seen in the first “Find the Differences” activity are:

- The musical notes are highlighted in one and not the other.
- More of the insect is found in the right picture.
- Less grass under the bush in the left picture.
- 6 points to the sun on the right. 5 points to the sun on the left.

3- A vaccine typically is given to a person or animal BEFORE they get sick (to strengthen the immune system). A medication is typically given AFTER a person or animal gets sick.

Slide 17:

Time check: 15 minutes into the lesson

Proteins make up your hair, nails, bones, and muscles (like the meat that people eat). **Protein** gives your body and the cells inside your body structure, shape, function. Antibodies and antigens have to do with your immune system. Collagen can be found at the tip of your nose and ear lobes and can be found in the dorsal fins of dolphins and the hooves of horses!

If the students ask:

An antibody comes from your own body.

An antigen comes from the germ.

Tip: a helpful video to explain protein structure (including amino acids and many other details) can be found here: <https://www.youtube.com/watch?v=vvTv8TqWC48>

Another important example of a protein:

Cats are missing a particular type of protein that helps with the processing of a particular type of anti-fever medication meant for humans. Because of this, a cat could die if given one tablet of this human medication. This is why it is always a good idea to ask a veterinarian for advice before giving any medication to pets and other animals.

(More information can be found here: <https://vcahospitals.com/know-your-pet/acetaminophen-toxicity-in-cats>)

A helpful website to review functions of proteins can be found here:

<https://medlineplus.gov/genetics/understanding/howgeneswork/protein/>

A helpful video to explain protein structure (including amino acids and many other details) can be found here: <https://www.youtube.com/watch?v=vvTv8TqWC48>

Slide 18:

Review: the outside “shell” of the virus is responsible for entering into a human or animal cell. This “cell” is otherwise known as a “host” cell.

The spike protein acts like a key because it attaches to a host cell’s binding site (a receptor, like a lock in a door knob) and allows the virus to enter into the cell.

Review: The SARS-CoV-2 virus NEEDS to enter a host (human or animal) cell in order to replicate and spread.

Viruses cannot make more of themselves without hijacking some of the machinery in host cells. The spike protein allows viruses to stick to a host cell and enter it, like having a key to open a locked door. Without a key (or if the virus’s spike protein key is permanently covered by something like an antibody), the virus cannot enter the host cell.

Review: Scientists who develop vaccines (known as vaccinologists) wanted to focus on this spike protein for the following reasons:

1- it was expected that this protein (like a key) would have only limited mutations because this is the only thing that would allow the virus to enter into a cell.

→ **Metaphor:** If a key is altered too much, it will likely not unlock a door.

→ However, it is possible that one (or several) mutation(s) could strengthen the function of the protein. This was seen with the delta variant when compared to the original SARS-CoV-2 virus. The delta variant binds better to the host cell’s receptor, allowing it to enter into the cell more easily. (Think of this like a master key.)

2- if the immune system can recognize the spike protein, then it can make antibodies to bind to the spike protein and prevent the virus from entering into a cell.

→ **Metaphor:** If a key has bubble gum added to the end of it, it will no longer be able to fit into the door’s lock.

Slide 19:

Tell the students to think of mRNA like instructions to build a protein.

(**Tip:** if the students already know about DNA, then it is okay to say that mRNA is originally made from DNA. And RNA is typically a single stranded molecule. To be more specific (**if the students ask**): The messenger RNA carries the directions from the DNA to create proteins.)

Ask: Why did vaccinologists want to focus on mRNA vaccines?

1- they tend to work very well

2- they could be quickly made (compared to the more traditional type of vaccine)

3- they tend to cost less to develop (compared to the more traditional type of vaccine)

4- they tend to be safe

(More information about mRNA vaccines, for the advanced science student) can be found here: <https://www.nature.com/articles/nrd.2017.243>

However, the messenger RNA (and RNA in general) tends to be much more fragile compared to the double-stranded DNA. It can be easily destroyed when the temperature is too high. That was one of the reasons why so many scientists did not believe in the future of mRNA research- RNA was thought to be too fragile to handle. This is also the reason why mRNA vaccines need to be stored at extremely cold temperatures prior to being used in people and animals (and why wealthier countries with their faster ways to transport vaccines tend to use these types of vaccines).

Some extra background information:

Conventional vaccines usually contain weakened or killed disease-causing bacteria, viruses, etc. (or sections of those pathogens). This typically stimulates a body's immune response in a similar way as the mRNA vaccine.

Image source:

<https://usermanual.wiki/Ikea/IkeaLackBookcase41X75AssemblyInstruction.794742831>

Slide 20:

Translation is the process of building a protein. The protein in this example is represented by the bookcase. The bookcase has a function.

Ask the students what the function is in this example. (The answer is that a bookcase holds books.)

Emphasize that proteins have a function.

Image source:

<https://usermanual.wiki/Ikea/IkeaLackBookcase41X75AssemblyInstruction.794742831>

Slide 21:

Choose one student volunteer before moving to the next slide.

Review: This activity models what happens during translation. A mutation can happen at any time. For instance, the instructive message is found on the mRNA but the final protein was not expected.

Scientists today have seen mutations in the spike protein of the SARS-CoV-2 virus and such mutations have led to multiple variants. It is likely that future vaccines will be altered to address future variants. At the time of developing this lesson (July 2021), many scientists expect that the mRNA vaccine will need to be adjusted, just like the flu vaccine is changed each year.

Just like what was discussed in the last lesson (entitled “Outbreak: One World – One Health”, particularly slide #18), this is why it is important for scientists to track the trends

in the mutation (through “sequencing”). More information on this subject can be found at: <https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/variant-surveillance.html>

Slide 22:

This activity is using a model. Translation is the process of following instructions (mRNA) to create a protein. This model uses verbal instructions to follow in order to create a final product.

The lesson instructor, while not being seen by the students, first demonstrates the activity by clasping their hands together and changing the position of their wrists and fingers and elbows to create a new unique position for their hands. After instructing the rest of the class to follow the 4 steps of changes described to their hands/wrists/etc., **ask** the class to show what they have created based on the instructor’s original instructions. [Often, there will be a variety of hand positions based on misunderstanding instructions. These variations would be like mutations. Translation is the process of following instructions (mRNA) to make a protein. If the final product (the “protein” or a student’s clasped hands) looks different than the instructors, there was a problem with the translation process.

Tip: For virtual (online) learning, have your hands away from the camera so the students do not see your hands until you are ready to show them. For in-person learning, turn your back to your students or hide your hands below a desk when giving the instructions to the students.

Have the one volunteer do the same and see if there are any mutations seen in the rest of the class, based on their instructions.

Image source:

<https://usermanual.wiki/Ikea/IkeaLackBookcase41X75AssemblyInstruction.794742831>

Slide 23:

Time check: 20 minutes into the lesson

[5 points for each correct answer]

Proteins are responsible for the function of cells and the function of the body.

For a more specific answer: Several possible functions include antibody, enzyme, messenger, structural component, transport/storage. A helpful list of protein functions can be found at: <https://medlineplus.gov/genetics/understanding/howgeneswork/protein/> mRNA (or messenger RNA) is the (genetic) instructions to create a protein

Slide 24:

Ask the students: What would you have done with so many rejections?

Review:

She was often rejected because scientists knew that mRNA is single-stranded and is very delicate. It is not stable with heat and changes of temperature compared to a double-stranded structure like DNA. The concern with mRNA vaccine is that all of these vaccines need to be kept very cold until given to a person. This could be difficult in isolated communities (that is why the adenovirus vaccines, covered in slides #34-35, are more often used in such communities).

Slide 25:

[7 points for the correct answer]

Answer:

If we can create proteins like that of the spike protein, then the immune system will see it as a foreign invader and will build up a reaction in the white blood cells to attack any future spike proteins seen (using antibodies). In addition, mRNA is very powerful because proteins are one of the most basic forms that contribute to viruses and living cells.

A helpful video to further explain this can be found at:

<https://www.youtube.com/watch?v=Ha6yUxze1vk> (it is suggested to start at the time stamp of 2 minutes 50 seconds, viewers can turn on closed captioning in multiple languages)

Slide 26:

Explain this: In 1998, Dr. Karikó was going to make photocopies at her university where she worked. At the photocopier machine, she met and introduced herself to somebody who took an interest in her work and mission. This colleague listened closely to what she was saying and agreed that mRNA was an important and under-appreciated topic of research. Ultimately, after several years, Dr. Karikó and he started a company to advance mRNA research.

Photo source:

https://gwcopiers.com/product/333?gclid=Cj0KCQjwvaeJBhCvARIsABgTDM69fkk-UYAla6AFPuVB82XAk4vEiRq-HENlvntoS9mv6LchooKJv7AaAv8rEALw_wcB

An inspiring podcast (associated with the New York Times) explaining this event can be found here: <https://www.nytimes.com/2021/06/10/podcasts/the-daily/mrna-vaccines-katalin-kariko.html>

Slide 27:

Info about cancer and mRNA vaccine research: <https://molecular-cancer.biomedcentral.com/articles/10.1186/s12943-021-01335-5>

mRNA and cancer: <https://www.cancer.gov/about-cancer/treatment/clinical-trials/intervention/mrna-based-personalized-cancer-vaccine-mrna-4157>

Photo source: https://www.researchgate.net/figure/Canine-cutaneous-melanoma-left-and-human-nodular-melanoma-right-Photo-credit-P_fig5_334137386

Slide 28:

Time check: 25 minutes into the lesson

[5 points for the correct answer]

Answer:

1- The spike protein acts like a key to enter into a host (human or animal) cell. If the virus does not enter into a cell, then it cannot make more copies of itself (this is an extremely important point and will be covered again soon). If these proteins are bound by antibodies, then the virus cannot enter a host cell. These host cells are mostly found in the lungs of the host.

2- In addition, scientists believed the spike protein would be unlikely to mutate in a substantial way and had thought it would be the best target for vaccines (like what was described in slide #22).

Spike proteins allow the coronavirus to get into cells so it can make more copies of itself. It does this by binding to proteins called ACE2 receptors, especially on lung cells of hosts (such as people, susceptible animals like hamsters, primates, etc.). Without it, this virus can't infect those organisms.

Slide 29:

This type of vaccine is the Pfizer and Moderna COVID-19 vaccines.

For advanced students: Each piece of the bookcase represents an amino acid. All proteins are made up of amino acids. More information about amino acids can be found at: <https://medlineplus.gov/ency/article/002222.htm>

Slide 30:

This is like the AstraZeneca and the Johnson & Johnson COVID-19 vaccines.

Instead of only mRNA being carried in the vaccine, the gene that creates the mRNA had been added to another (mostly harmless) virus (known as an adenovirus, which has a double-stranded DNA inside of it) that can easily enter cells. Once this new (mostly harmless) virus enters into a host cell, the virus hijacks the cell's internal equipment and creates spike protein mRNA. The rest of the process is similar to the mRNA vaccine.

More information can be found here: <https://wexnermedical.osu.edu/blog/explaining-johnson-johnson-astrazeneca-vaccines>

This video can be read in many language through various closed captioning:

A helpful video from the University of New South Wales describes the differences of COVID-19 vaccines (mRNA vs adenovirus vaccine) and can be found at:
<https://www.youtube.com/watch?v=0Zhwc8jQIVM>

For a highly detailed article about the adenovirus vaccine, this New York Times article is available and has helpful images:
<https://www.nytimes.com/interactive/2020/health/johnson-johnson-covid-19-vaccine.html>

Slide 31:

The entire virus enters the host cell and injects its DNA into the nucleus of the cell. The cell's nucleus eventually creates mRNA and then the rest of the cell makes the spike protein.

This type of vaccine is much more stable in warm temperatures (compared to the mRNA vaccine) because DNA is double-stranded. Therefore, this type of vaccine is likely more accessible to people around the world.

Image source: <https://www.nytimes.com/interactive/2020/health/johnson-johnson-covid-19-vaccine.html>

Additional supplemental material about other vaccines can be found at:
<https://www.who.int/news-room/feature-stories/detail/the-race-for-a-covid-19-vaccine-explained>

To learn about all four types of COVID-19 vaccines (written in scientific jargon) can be found here: <https://www.gavi.org/vaccineswork/there-are-four-types-covid-19-vaccines-heres-how-they-work>

Slide 32:

Time check: 30 minutes into the lesson

Recall -- Ask: What is the “immune system”?

Ask: Do they prevent a person from getting the virus? → answer: NO!

Review: If a vaccinated person and an unvaccinated person walk through a room full of SARS-CoV-2 without a mask and take deep breathes, then they will likely BOTH test positive for COVID-19. The difference between these two people is that the unvaccinated person would MORE likely end up in the hospital (with much more serious sickness) and is at an increased risk of dying from the virus compared to the vaccinated person.

Remember, vaccines do not put a shield around a person or animal so germs can get into a body. However, the vaccine allows the body to quickly identify the virus (the invader) and attack it so that it does not have as much time to multiply and make the person (or animal) deathly sick.

Slide 33:

[5 points for each correct answer]

How to stop the pandemic: you need to stop replication of the virus. --

<https://www.youtube.com/watch?v=Ha6yUxze1vk>

Remember, the only way a virus can replicate is INSIDE of a host cell. It cannot replicate on its own!

Therefore, how can we prevent the virus from entering into cells?

Answer:

- 1- vaccinate people (and animals– like what is happening with zoo animals) because antibodies can bind to the spike protein and prevent entrance as well as help eliminate free-floating viruses in the body (that are not yet attached to host cells)
- 2- if you are sick, stay away from all other people and animals for at least 14 days

Some added background information:

- Zoo animals have started receiving a COVID-19 vaccine so that their immune systems become stronger to fight the virus. In addition, the vaccine minimizes the chance that the virus can then jump back into the people near those zoo animals. Their type of COVID-19 vaccine is a modified adenovirus vaccine.

There have been pet dogs and cats testing positive for the SARS-CoV-2 virus. It is believed that these animals caught the virus from their owners. Therefore, if a pet owner is sick, it is best to keep a good distance away from family members, housemates and pets to the best of the ability (until told otherwise by their physician).

Slide 34:

Review this slide in less than one minute

Link to source of the slide's information:

<https://www.cdc.gov/coronavirus/2019-ncov/if-you-are-sick/steps-when-sick.html>

Slide 35:

Time check: 35 minutes into the lesson

Review this slide in 1-2 minutes.

Ask: what are the three parts of the One Health concept? [*3 points for the correct answer*]

For the first point- Emphasize that up to 70% of new (infectious) diseases (or diseases that can be spread) come from animals. Therefore, we need to respect the natural distance between humans and wild animals. We also need to ensure that our pets and other domesticated animals keep a safe distance from wildlife. We can do this by ensuring that wild animals keep their natural habitats.

For the second point- it takes many people of different backgrounds and skills to develop a vaccine and then also bring the vaccine out to communities. **Encourage** students to name more.

For the last point- any answer is the correct answer to this question

Slide 36:

This is a rhetorical question. Do not expect the students to answer it. Proceed immediately into the next slide where there is a video of Dr. Karikó answering the question.

Slide 37:

This is a 40-second video

Slide 38:

This is a rhetorical question. Do not expect the students to answer it. Proceed immediately into the next slide where there is a video of Dr. Karikó answering the question.

Slide 39:

(15 second video)

Video Source: "These Researchers Paved The Way For The Covid Vaccine" from NBC Nightly News (<https://www.youtube.com/watch?v=cIYZOBnW9eA>)

Update: After this interview was recorded, it was discovered that Dr. Karikó did not win the Nobel Prize in 2021.

Slide 40:

Time check: 40 minutes into the lesson

If there are teams of 5, then the fifth student can be: 1 "politician" or 1 "teacher" (or any other profession you think of)

Slide 41:

Answer found on slide #8 (copied and pasted here):

What is a biochemist?

Like a chemist, who studies atoms and molecules and how they interact and react with one another, a **biochemist studies the interactions and chemical reactions of atoms and molecules that support life.**

Within the word, "biochemist", the "bio" comes from Greek and means "life", the second part of the word is "chemist", meaning the person specializing in chemistry.

As a biochemist, she was taught both biology (the study of living things) and chemistry (the study of elements like atoms, molecules, compounds, ions, etc.) and was passionate about the chemistry within a living thing.

Review that: just like everything around you, you are made up of atoms and molecules interacting and reacting with each other all the time!

According to Wikipedia:

Biochemists are scientists who are trained in [biochemistry](#). They study chemical processes and chemical transformations in living [organisms](#). Biochemists study [DNA](#), [proteins](#) and [cell](#) parts. The word "biochemist" is a [portmanteau](#) of "biological chemist."

Biochemists also research how certain [chemical reactions](#) happen in cells and [tissues](#) and observe and record the effects of [products](#) in [food additives](#) and [medicines](#).

Biochemist researchers focus on planning and conducting [research experiments](#), mainly for developing new products, updating existing products and analyzing said products. It is also the responsibility of a biochemist to present their research findings and create [grant proposals](#) to obtain [funds](#) for future research.^[1]

Biochemists study aspects of the [immune system](#), the expressions of [genes](#), isolating, analyzing, and synthesizing different products, mutations that lead to [cancers](#), and manage [laboratory](#) teams and monitor laboratory work. Biochemists also have to have the capabilities of designing and building laboratory equipment and devise new methods of producing correct results for products.^[2]

(Source: <https://en.wikipedia.org/wiki/Biochemist>)

Slide 42:

Several professions can be involved in developing and bringing a vaccine out to the public:

- Regulators/reviewers at the government (ex. Food and Drug Administration in the United States) and other government workers at regulatory agencies
- Bioethicists (people who ensure that scientific research is performed ethically)
- Veterinarians and veterinary technicians (lab animals are used in early vaccine development trials)
- Nurses
- Physicians
- Biochemists
- Chemists
- Pharmacologists
- Clinical study coordinators (managers)
- Data scientists and software/database engineers/developers
- Statisticians
- Drivers (bringing the vaccines from the site of development to the general public)
- Physicists (people who work with temperature/thermodynamics, especially for the mRNA vaccine since it is so sensitive to heat)
- Teachers (who help explain the science behind vaccines)
- Volunteers (Clinical trial participants!!!) – **Remember** that, without them, the vaccine could not have been produced in its current state. In general, sometimes these volunteers get paid and other times they do not (it depends on the medication or vaccine or whatever else is being tested)

Slide 43:

Answer (found on slide #4):

Teamwork

Slide 44:

Answer:
change

Slide 45:

Answer (found on slide #17):

Proteins

Slide 46:

Answer (from slide #20):

Translation

Slide 47:

Answer (from slide #8):
Hungary

Slide 48:

Answer (refer to slides 28-31):
They both target the spike protein!

Slide 49:

Answer (from slide #33):
No.

There are two steps that are needed to help end the pandemic. **Remember, the only way a virus can replicate is INSIDE of a host cell.** It cannot replicate on its own!

Therefore, we need:

to prevent the virus from entering into human and animal bodies (wear masks, keep appropriate distance, stay away from others if sick, wash hands at least 20 seconds—covered on slide #39) and
become fully vaccinated (example: single or multiple vaccines based on up-to-date scientific findings)

Added information can be seen on the following video:

“How to stop the pandemic: you need to stop replication of the virus.” --

<https://www.youtube.com/watch?v=Ha6yUxze1vk>

Slide 50:

Answer (covered in slides #4, 16, 27, 35):

By bringing people together from different backgrounds and strengths, risk factors leading to fast disease spread can be minimized if everybody is:

- 1- looking out for early signs of sickness in a community (in both people and/or animals)
- 2- conscientious to protect the environment (clean water, clean air, healthy soil, healthy plants, etc.)
- 3- minimizing the occurrence of bringing species close together unnaturally (like what happens with habitat destruction or often at wildlife markets as discussed in the “*Outbreak: One World – One Health*” lesson)
- 4- protecting the diversity of different species in the environment (biodiversity) to protect the natural food web in the local ecosystem

Slide 51:

Answer (found on next slide, #52):

1. **Teach** family and friends about what you learned today.
2. **Create a community project** focused on the health of people, animals, plants and the environment in your community.

3. **Create social media videos** to explain how the vaccine works and inspire healthy actions in others. Be sure to tag One Health Lessons!
4. **Compete** in One Health Lessons contests (posted on social media: YouTube, Facebook, Twitter, TikTok, and LinkedIn).
5. **Create connection** with another classroom that prioritizes One Health through the One Health Lessons' **Pen Pal Program**
6. **Celebrate One Health** during International One Health Day (November 3rd) and throughout January (One Health Awareness Month) and during Earth Day (April 22nd).
7. **Contact** influencers in your community (ex. journalists, reporters, celebrities) and inspire them to care about One Health.

Slide 52:

More information about the Pen Pal Program can be found at www.OneHealthLessons.com and on its YouTube channel (<https://www.youtube.com/c/OneHealthLessons>).

Slide 53:

Full-time teachers (not the science guest): please complete the survey found at <https://www.surveymonkey.com/r/COVID-19VaccineLesson>

Links to supplemental material according to topic is found below:

Inspiring material about Dr. Karikó can be found here:

<https://www.statnews.com/2020/11/10/the-story-of-mrna-how-a-once-dismissed-idea-became-a-leading-technology-in-the-covid-vaccine-race/>
https://en.wikipedia.org/wiki/Katalin_Karikó

Information about vaccine technology:

About the COVID-19 vaccine status (updated regularly):

<https://www.cdc.gov/coronavirus/2019-ncov/vaccines/index.html>

mRNA vaccines:

<https://www.cdc.gov/coronavirus/2019-ncov/vaccines/different-vaccines/mrna.html>

Plant-based vaccine technology:

<https://www.nature.com/articles/d43747-020-00537-y>
<https://www.nationalgeographic.com/science/article/your-next-vaccine-could-be-grown-in-a-tobacco-plant>

For advanced science students:

This Nature (journal) article from 2018 reviews mRNA vaccines and has one of the authors as a colleague of Dr. Karikó: <https://www.nature.com/articles/nrd.2017.243>

Animal vaccine story:

Story of an animal vaccine to protect against the Hendra virus in Australia:

<https://www.csiro.au/en/research/animals/livestock/Hendra>