What Is Coronavirus?

Comparing Cells, Viruses and SARS-CoV-2

COVID HACKS
Healthy Actions • Community Knowledge • Science

FOR GRADES
9–12

OVERVIEW

Students gather information online to explore differences between viruses and cells, and to learn about the SARS-CoV-2 virus that causes COVID-19. This information is both recent and developing, and it helps illustrate to students that science involves ongoing discovery of new information.

NOTE: Objectives meet two of the TEKS objectives for high school biology.

LEARNING OBJECTIVE

Students will be able to:

- Compare the structures of viruses and cells
- Describe viral reproduction
- Describe the virus that causes COVID-19

SCIENCE, HEALTH AND MATH SKILLS

- Comparing and contrasting
- Interpreting information
- Communicating

SCIENCE STANDARDS

Texas Essential Knowledge and Skills (TEKS)

- Biology (4): The student knows that cells are the basic structures of all living things with specialized parts that perform specific functions and that viruses are different from cells.
- (C): Compare the structures of viruses to cells, describe viral reproduction, and describe the role of viruses in causing diseases such as human immunodeficiency virus (HIV) and influenza.

NGSS SCIENCE AND ENGINEERING PRACTICES

- Obtaining
- Evaluating
- Communicating

MATERIALS FOR SCIENCE INVESTIGATION

Each student will need:

- Device with Internet access to conduct independent research using approved websites
- A copy of each of the three activity sheets (digital or print versions)
  a. What Is Coronavirus?
  b. Viruses vs Cells
  c. Coronavirus: How Does It Work? (Use this sheet as an evaluation or extension activity.)

SET UP AND TEACHING TIPS

Introduce this activity with a brief discussion before directing students to conduct their own informational research about coronaviruses, viruses and cells in general. During the next class session, discuss their responses using the accompanying slides as a guide.

The "Extend and Evaluate" section of this lesson, enables students to learn more about SARS-CoV-2 using an interactive online model of the virus.

TIME

- 2 class periods

PROCEDURE

ENGAGE AND EXPLORE

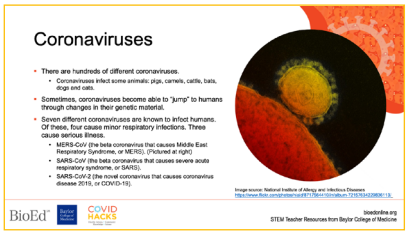
1. Ask students to share any questions they might have about the virus that causes COVID-19. Accept all questions and, if appropriate, make a list to refer to at the end of this activity.
2. Tell students that they are going to learn about viruses, how they function, and how viruses differ from cells. They also will learn how the COVID-19 virus invades lung cells and causes illness. Remind students to consider the online sources of information they find, and to carefully evaluate the reliability and accuracy of the site they consulted.
3. Ask students to complete the questions on the following two student sheets using reliable online information sources: (A) What is Coronavirus?, (B) Viruses vs Cells.

EXPLAIN

4. Use the accompanying slides to review what students learned in their informational research. If students raise a question for which you do not have an answer, have them add it to a "What I Want to Know" list. You also can suggest an online source that might find the information they seek.

NOTE: Additional information is included below for each slide to facilitate your discussion with students.

SLIDE 1

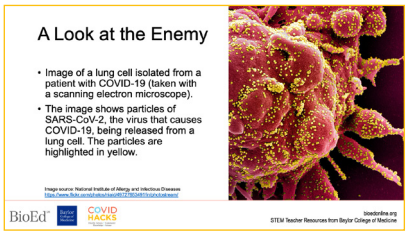


Coronaviruses

- There are hundreds of coronaviruses in the world. Most of them infect animals such as pigs, camels, bats, cattle, dogs and cats. Sometimes, the viruses jump to humans, in what is called a "spillover event." Seven coronaviruses are known to infect people. Four cause only mild to moderate symptoms. The other three have caused more serious illnesses.
- One coronavirus causes SARS, Severe Acute Respiratory Syndrome. A global SARS outbreak in 2002-2003 infected 8,000 people and killed 774, but SARS did not become a pandemic. SARS patients are most likely contagious only when they have symptoms. This factor limited the spread of the disease.[1] The last known case was 2004.
- Another coronavirus causes MERS, Middle East Respiratory Syndrome. It probably moved from camels to humans in the Arabian Peninsula. As with SARS, MERS is transmitted primarily through airborne particles emitted while coughing. Most people who catch MERS have been in contact with infected animals or humans. MERS is still a threat to human populations in some countries.

1 Centers for Disease Control and Prevention. Severe Acute Respiratory Syndrome FAQ. https://www.cdc.gov/sars/about/faq.html.

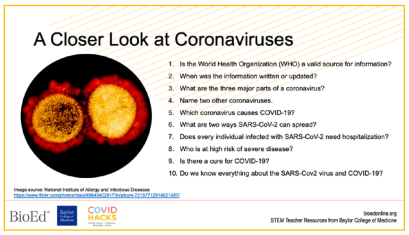
SLIDE 2



A Look at the Enemy

- This is a scanning electron micrograph of a lung cell isolated from a patient with COVID-19. SARS-CoV-2 viruses, the virus that causes COVID-19, are being released from a lung cell.[2]
  - a. The image was taken by the National Institute of Allergy and Infectious Diseases, part of the U.S. federal agency, the National Institutes of Health. *Do you agree that this is a reliable source of science and medical information?* [Yes, ".gov" agencies are reliable sources.]
  - b. *What are the yellow globes?* [The yellow globes are SARS-CoV-2 virus particles being released from the cell.]
  - c. *What is the big pink mass?* [The lung cell.]
  - d. *What kind of electron micrograph (EM) is this and how can you tell?* [A scanning EM because it looks 3D and shows the shadows.]
  - e. *Are lung cells actually pink and viruses yellow?* [No, the color is added to a black and white electron micrograph (photograph taken through a microscope) to make it easier to see the different structures.]
  - f. From your worksheet: *How many virus particles can a single cell release in 10 hours?* [1,000.]
  - g. *Where can those virus particles end up?* [1) They can attach to and infect other lung cells and cells in other parts of the body; or 2) be coughed or breathed out of the patient into the air.]

SLIDE 3



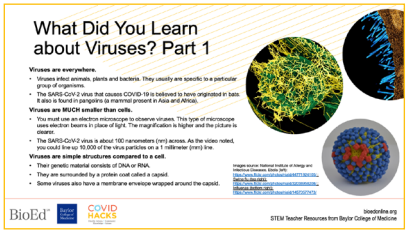
A Closer Look at Coronaviruses

- You watched a video at the World Health Organization (WHO) site about coronaviruses.
  - a. *Did you find the WHO to be a valid source for information?* [Yes.]
  - b. *When was the information written or updated?* [June 15, 2020.]
  - c. *What are the three major parts of a coronavirus?* [Genetic material, lipid envelope, and protein spikes on the outside.]
  - d. *Is the virus that causes COVID-19 the only coronavirus? If not, name two others.* [No, SARS-CoV and MERS-CoV.]
  - e. *What is the name of the coronavirus that causes COVID-19?* [SARS-Cov2.]
  - f. *What are the two ways the SARS-Cov2 virus can spread?* [Person to person transmission by respiratory droplets occurs when an infected person coughs, breathes, sings or talks, thereby ejecting virus-laden droplets of liquid into the air, where they can land on, or be breathed in by another person. The virus also can be transmitted by contact when someone touches a surface contaminated with viruses and then touches their eyes, nose, or mouth.]
  - g. *Does everyone who gets infected with the SARS-CoV-2 virus need hospitalization?* [No, about 80% recover at home without special treatment or hospitalization.]

2 National Institute for Allergy and Infectious Diseases. Novel Coronavirus SARS-CoV-2. https://www.flickr.com/photos/niaid/49727653491/in/photostream/.

h. *Who is at higher risk to become severely ill if they get COVID-19?* [Older people and people of any age with chronic respiratory diseases, obesity, diabetes, high blood pressure, heart disease, or cancer. Some seemingly healthy people, including young people, also develop severe infections.]
i. *Is there a cure for COVID-19?* [No.]
j. *Do we know everything about the SARS-Cov-2 virus and COVID-19?* [No, we are still learning.]

SLIDE 4

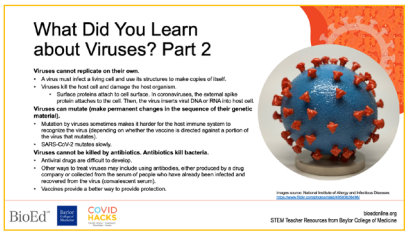


What Did You Learn About Viruses? Part 1

- You read an essay and watched two videos about viruses. *What are some of the things you learned?* Allow students to share what they learned. Accept all answers.
- Viruses are everywhere on Earth.
  a. They infect animals, plants and bacteria. Each virus usually infects a particular group of organisms. For example, plant viruses don't infect animals.
  b. The SARS-CoV-2 virus that causes COVID-19 was found originally in bats. It also has been found in pangolins (a mammal found in Asia and Africa that looks like a scaly anteater). It most likely moved into humans through human-animal contacts.
- Viruses are <u>much</u> smaller than cells.
  a. They are so small that we can't see them with visible light, even under a microscope. We must view them with electron microscopes, which use waves of electrons as the "light" source.
  b. Transmission electron microscopes (TEM) shoot electrons <u>through</u> the sample of tissue to produce an image like an X-ray or CAT scan. Scanning electron microscopes bounce electrons off the surface of the sample, producing a 3D image with shadows and depth. These images are black and white, but sometimes color is added to help clarify structures.
  c. The SARS-CoV-2 virus is about 100 nm across. As the video noted, you could line up 10,000 of the virus particles on a 1 mm line.
- Viruses are simple structures, compared to cells.
  a. Viruses have genetic material – usually a relatively small amount of DNA or RNA – surrounded by a protein coat called a capsid. Some viruses (such as HIV, coronaviruses and influenza) have a membrane envelope wrapped around the capsid. They get the membrane from the cell as they emerge through the cell membrane. Some viruses package enzymes with the capsid.

Diseases can be "communicable" or "non-communicable." Communicable diseases result from the passing of a pathogen (an infectious agent, such as a bacterium, virus, fungi, or parasite) from an infected individual to another individual or group. Non-communicable diseases do not pass directly from one person to another.

SLIDE 5

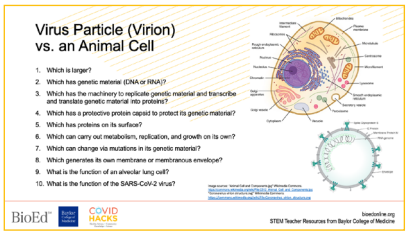


What Did You Learn About Viruses? Part 2

- You read an essay and watched two videos about viruses. *What are some of the things you learned?* Allow students to share what they learned. Accept all answers.
  - **a.** Viruses must infect a living cell and use its structures to make copies of themselves. This process often kills the host cell and damages the host organism.
  - **b.** Proteins on the surface of viruses can attach to specific molecules on the surface of the cells they infect. The viruses then insert their genetic material into the cell or they are pulled inside the cell membrane.
  - **c.** The spike proteins that give coronaviruses a "corona" or "crown" appearance attach to specific proteins on the cell surface. This triggers the process that brings the virus inside the cell, where it takes over the cell's "machinery" and begins replicating more virus particles.
  - **d.** The spike proteins also trigger the body's immune response to SARS-CoV-2. The vaccines for COVID-19 use spike proteins instead of the whole virus to stimulate the immune system.
- Viruses can mutate.
  - **a.** This makes it harder for your body to recognize them and necessitates the creation of new vaccines. The flu virus, for example, mutates frequently. A mutation is a permanent change in the genetic sequence. That is why the flu vaccine is different every year.
  - **b.** Transmission electron microscopes (TEM) shoot electrons through the sample of tissue to produce an image like an X-ray or CAT scan. Scanning electron microscopes bounce electrons off the surface of the sample, producing a 3D image with shadows and depth. These images are black and white, but sometimes color is added to help clarify structures.
  - **c.** The SARS-CoV-2 virus mutates at about half the rate of influenza and a quarter the rate of HIV, but future mutations could impact the effectiveness of treatments or vaccines.[3]
- Viruses cannot be killed by antibiotics.
  - **a.** Antibiotics are effective in killing bacteria and other cellular agents of disease, such as fungi and protozoans.
  - **b.** Antiviral drugs are difficult to develop. Since the virus replicates inside the host cell, antiviral drugs must inhibit or stop viral entry or replication without damaging the host cells.
  - **c.** Other ways to treat viruses may include using antibodies, either produced by a drug company or collected from the serum of people who have already been infected and recovered from the virus (convalescent serum).
  - **d.** Vaccines are a better way to provide disease protection for larger populations. A few viral diseases, such as smallpox, polio, measles, rubella, and mumps have been eradicated or nearly eradicated through vaccines.[4]

3 Callaway, Ewen. 2020. The Coronavirus Is Mutating — Does It Matter? Nature. (585):174–177.
4 Morens, David M. and Anthony S. Fauci. 2020. Emerging Pandemic Diseases: How We Got to COVID-19. Cell. (182):1077–1092.

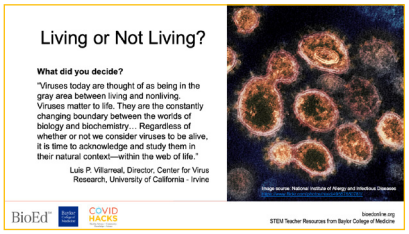
SLIDE 6



Viruses vs Cells

- *Which is larger?* [Cell.]
- *Which has genetic material (DNA or RNA)?* Both.
- *Which has the machinery to replicate genetic material and transcribe and translate genetic material into proteins?* [Cell.]
- *Which has a protein capsid to protect its genetic material?* [Virus.]
- *Which has proteins on its surface?* [Both.]
- *Which can carry out metabolism, replication, and growth on its own?* [Cell.]
- *Which can change via mutations in its genetic material?* [Both.]
- *Which generates its own membrane/membranous envelope?* [Cell. The virus takes part of the cell membrane when it blebs out at the cell surface.]
- *What is the function of an alveolar lung cell?* [To facilitate transport of O2 into, and CO2 out of the blood stream, and to protect the body from outside chemicals and organisms. To do so, it carries out the normal cell functions of metabolism, growth, and replication.]
- *What is the function of the SARS-CoV-2 virus?* [To replicate and disseminate to other host cells and organisms.]

SLIDE 7



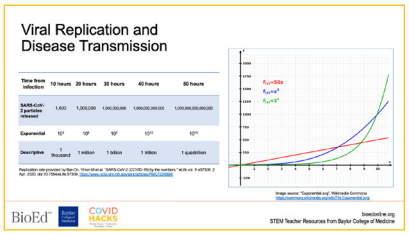
Living or Not Living?

- *What did you decide? Are viruses alive or not?*

"Viruses today are thought of as being in the gray area between living and non-living. Viruses matter to life. They are constantly changing the boundary between the worlds of biology and biochemistry. Regardless of whether or not we consider viruses to be alive, it is time to acknowledge and study them in their natural context—within the web of life."[5]

Luis P. Villarreal, Director, Center for Virus Research
University of California - Irvine

SLIDE 8



Viral Replication and Disease Transmission

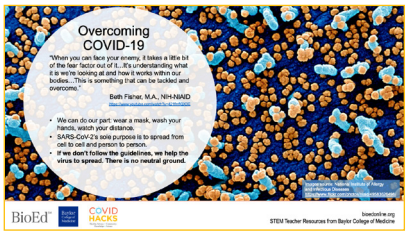
- *What did you learn about the number of virus particles that a single particle can lead to in just over two days?*

Time from Infection	10 Hours	20 Hours	30 Hours	40 Hours	50 Hours
SARS-CoV-2 Particles Released	1,000	1,000,000	1,000,000,000	1,000,000,000,000	1,000,000,000,000,000
Exponential	10^3	10^6	10^9	10^{12}	10^{15}
Descriptive	1 Thousand	1 Million	1 Billion	1 Trillion	1 Quadrillion

[1,000 particles originally released x 1,000 particles created by each = 1,000,000 particles 20 hours after initial infection of the first cell.]

5 Villarreal, Luis P. 2008. Are Viruses Alive? Scientific American.

SLIDE 9



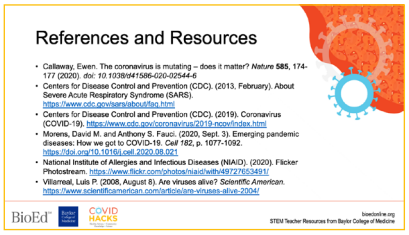
Overcoming COVID-19

"When you can face your enemy, it takes a little bit of the fear factor out of it. It's understanding what it is we're looking at and how it works within our bodies. This is something that can be tackled and overcome."

Beth Fisher, M.A., Chief
RML Microscopy Unit, NIH-NIAID

- Many scientists have stopped other research projects to focus fully on SARS-CoV-2 and COVID-19. They are working as quickly as possible to understand the virus and the disease it causes, develop medications to help patients recover from COVID-19, and vaccines to immunize humans against infection.
- In the meantime, we have important tools to fight the spread of the virus: wear a mask, wash our hands, and keep a safe physical distance from each other. Remember, the sole purpose of this virus is to spread from cell to cell and person to person. If we don't follow the guidelines, we are helping the virus to spread. There is no neutral ground, no doubts.

SLIDE 10



References and Resources

- Callaway, Ewen. 2020. The Coronavirus Is Mutating — Does It Matter? Nature(585):174–177.
- Centers for Disease Control (CDC). About Severe Acute Respiratory Syndrome (SARS). https://www.cdc.gov/sars/about/faq.html.
- Morens, David M. and Anthony S. Fauci. 2020. Emerging Pandemic Diseases: How We Got to COVID-19. Cell. (182):1077–1092.
- National Institute of Allergies and Infectious Diseases (NIAID). Flicker Photostream. https://www.flickr.com/photos/niaid/with/49727653491/.

EXTEND AND EVALUATE

1. (Student Activity C.) Have students explore the interactive SARS-CoV-2 animation at https://www.scientificamerican.com/interactive/inside-the-coronavirus/ and complete the Extend questions on their Activity Sheet C (answers below). Students should submit a copy of their completed activity sheets for evaluation.

   NOTE: If students have difficulties using the interactive model, they can observe and read the static illustrations at https://www.scientificamerican.com/article/a-visual-guide-to-the-sars-cov-2-coronavirus/.

   1. Questions on the 3D model
   - a. *What are the orange spikes and what is their role in infection?* [They are the S proteins that grab onto the human cell and start the entry process. S proteins get their name because of their "spiked" appearance.]
   - b. *What is the protective shell made of and what is its role?* [It is a lipid bi-layer and it protects the viral genetic material (RNA).]
   - c. *What is the purpose of the viral RNA?* [It is the genetic material that allows the virus to replicate inside the lung or other cell. Replication is the process of making more copies of the viral genetic material and proteins.]
   - d. *What is the purpose of the N protein?* [It keeps the RNA stable.]
   - e. *Where do you find the E and M proteins, and what is their role?* [On the virus surface and embedded in the lipid bi-layer. Both proteins help new virus particles to form.]

   2. Scroll down to the section, "How the Virus Invades"
   - a. *To what kind of receptor does the virus bind?* [ACE2 receptor.]
   - b. *What does that receptor normally do for the body?* [Helps regulate blood pressure.]
   - c. *What slices off the spike protein's head?* [A protease enzyme on the cell surface.]
   - d. *What does the "spring" in the spike protein's stem do?* [Pulls the viral and cell membranes together so they fuse and create a channel.]
   - e. *What enters the lung cell through that channel?* [Virus RNA and N proteins.]
   - f. *What happens in the endoplasmic reticulum?* [The virus genes are translated into virus proteins. They stretch the ER creating vesicles with virus proteins inside, including an RNA polymerase.]
   - g. *The virus RNA polymerase inside the vesicles makes copies of the virus RNA. What links to the RNA to keep it stable?* [N proteins.]
   - h. *Where do the spike proteins come from?* [Vesicles from the ER and Golgi complex.]
   - i. *How do the new virus particles get out of the lung cell?* [The vesicles of virus particles merge with the cell membranes.]

COVID HACKS
Healthy Actions • Community Knowledge • Science

COVID HEALTHY ACTIONS, COMMUNITY KNOWLEDGE AND SCIENCE

A SCIENCE-BASED CURRICULUM FOR THE COVID-19 PANDEMIC

We are grateful to Laura and John Arnold and other community donors for their generous support, which enabled development of the COVID HACKS curriculum materials. We also thank the many scientists, educators and physicians from Baylor College of Medicine (BCM) who provided content, feedback and technical reviews.

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- Author: **Marsha Matyas**
- Web and Design Director: **Travis Kelleher**
- Copy Editor: **James Denk**
- Graphic Designer: **Jose Chavero Rivera**
- Technical Reviewers: **Katherine Breaux**, **Stacey Rose**
- Project Director and Series Editor: **Nancy Moreno**

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Baylor College of Medicine

Department of Education, Innovation and Technology
Baylor College of Medicine
One Baylor Plaza, BCM411
Houston, Texas 77030
713.798.8200 | 800.798.8244
bioedonline.org | edoutreach@bcm.edu

STUDENT PAGE A

What Is Coronavirus? Student Activity Sheet

COVID HACKS
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LEARNING OBJECTIVES

After completing this exploration, you will be able to:

- Compare the structures of viruses and cells
- Describe viral reproduction
- Describe the virus that causes COVID-19

ENGAGE

1. Everyone's life has been affected by the virus that causes COVID-19.
   - List at least two questions you have about this virus.
     NOTE: If you wrote some questions in a previous activity, copy them here.
     a.

     b.

     c.

2. Let's get a quick overview of COVID-19. Watch the 5-minute World Health Organization (WHO) video: https://www.youtube.com/watch?v=i0ZabxXmH4Y, and answer the questions below.
   - *Is this a valid source of scientific and medical information?*
     (Use the questions below to determine whether the source is valid and reliable.).
     a. *Was it written by people/groups with scientific expertise?*
     b. *Why did they write it?* (Purpose of organization or publication.)
     c. *How current is the information?*
     d. *If they cite research, do they link to studies?*

   - *What are the three major parts of a coronavirus?*

   - *Is the virus that causes COVID-19 the only coronavirus?* If not, name two others.

- *What is the name of the coronavirus that causes COVID-19?*

- *What are the two ways the SARS-Cov2 virus can spread?*

- *Does everyone who gets the virus need hospitalization?*

- *Who is at high risk of becoming severely ill from COVID-19 infection?*

- *Is there a cure for COVID-19?*

- *Do we know everything about the SARS-Cov2 virus and COVID-19?*

EXPLORE

1. Read/watch these resources to learn more about viruses. Take notes on what you learn.
   - National Human Genome Research Institute description of viruses: https://www.genome.gov/genetics-glossary/Virus.
     NOTES:

   - "Viruses (Updated)" by the Amoeba Sisters, an animated overview of viruses and viral replication: https://www.youtube.com/watch?v=8FqlTslU22s.
     NOTES:

   - *Do you think these information sources are valid? Why or why not?*
     (**REMINDER:** Use the four questions for evaluating websites provided above.)

2. Complete the "Viruses vs Cells" Sheet (Activity Sheet B). Using what you learned, write a short description that compares and contrasts the cell and the virus in terms of:
   - Structure:

   - Function:

3. Biologists often list properties that are shown by living organisms. Living things grow, reproduce, respond to stimuli, maintain homeostasis, and carry out various metabolic processes. In addition, they are composed of cells, and populations of living organisms evolve over time. *We know that cells meet all these criteria, but what about viruses?* There is ongoing debate and discussion among biologists and other scientists about whether viruses should be considered living organisms. *What do you think? Based on what you have learned, do you think viruses are living organisms? Why or why not?* Provide a justification for your answer in the space below.

4. Consider the size difference between a SARS-CoV-2 virus particle and the cell it infects (the Type 1 alveolar epithelial cell deep in the lung). Those lung cells are around 80 µm (or 80,000 nm) across.[1] You could line up 800 viral particles across the diameter of a single lung cell.

   More important, on average, a single viral particle that infects a single lung cell can, over the next 10 hours, release 1,000 replicated viral particles.[2] Each of these particles can infect other lung cells or be breathed out through the lung into the air in droplets (cough or sneeze) or microdroplets (breathing). *How many particles would be released if each of the 1,000 original particles continue to infect cells and create 1,000 more particles each in 10 additional hours (e.g., by 20 hours)?*

   What happens in the next ten hours? Calculate and fill in the number or particles released at 30 hours. Do the same for 40 hours and 50 hours. On the bottom row, change the numbers to exponential notation.

TIME FROM INFECTION	10 Hours	20 Hours	30 Hours	40 Hours	50 Hours
SARS-COV-2 PARTICLES RELEASED	1,000	1,000,000			
EXPONENTIAL	10^3				

5. We know that infected people can breathe out virus particles before they experience any symptoms of COVID-19. *Based on this information, explain why wearing a mask, washing your hands, and maintaining social distancing is important in preventing the spread of COVID-19.*

1 Bar-On, Y. M., Flamholz, A., Phillips, R., & Milo, R. 2020. SARS-CoV-2 (COVID-19) by the Numbers. eLife. 9(e57309).

STUDENT PAGE B

Viruses vs Cells
Student Activity Sheet

COVID HACKS
Healthy Actions • Community Knowledge • Science

LEARNING OBJECTIVES

How does a virus differ from a cell?

Let's compare! On page 3, you will find the following:

- **Figure 1:** Cell Drawing
- **Figure 2:** Cell TEM
- **Figure 3:** Virus Drawing
- **Figure 4:** Virus TEM

INSTRUCTIONS

Your Task:

1. If you can print the page with the images of cells and viruses, do so. The printout does not have to be in color. If you can't print the page, make a sketch and mark as many components as you can or annotate an electronic version of the images
2. Look at Figure 1. *Which of the components listed in the table below can you find on the cell drawing?* Check them off in the "Cell Drawing" column. Note: You may not find all components in the table on the cell drawing.
3. Look at Figure 2. Using the letters "A" through "M" for different components, label as many as you can on your printout or sketch. Note: "G" and "M" already are labeled for you.
4. Look at Figure 3. *Which components listed in the table below can you find on the virus drawing?* Check them off in the "Virus Drawing" column. Note: You may not find all components in the table on the virus drawing.
5. Look at Figure 4. Using the letters "A" through "M" for different components, label as many as you can on your printout or sketch.
6. Using what you already have learned about cell structure and function (or refer to this page at the National Cancer Institute: https://training.seer.cancer.gov/anatomy/cells_tissues_membranes/cells/structure.html). Fill in the "purpose or function" column for the components you identified in cells Figure 1 or 2.

FIGURE REFERENCES

Figure 1: File: 0312 Animal Cell and Components.jpg. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:0312_Animal_Cell_and_Components.jpg.
Figure 2: Johnson, Meshell. 2007. Ion Transport in Alveolar Type 1 Cells. Molecular Biosystems 3(3):178–86. Type I cell. Transmission electron micrograph of rat alveolar septum. Original magnification 2500. Image courtesy of Meshell Johnson, M.D., Chief, Division of Pulmonary, Critical Care, and Sleep Medicine, San Francisco Veterans Affairs Health Care System and Professor of Medicine, University of California San Francisco.
Figure 3: File: Coronavirus virion structure.svg. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Coronavirus_virion_structure.svg.
Figure 4: SARS-CoV-2, National Institute of Allergy and Infectious Disease. https://www.flickr.com/photos/niaid/albums/72157712914621487.

TABLE

CELL AND/OR VIRUS COMPONENTS	*Did you find this on the ___?*		PURPOSE OR FUNCTION	*Did you find this on the ___?*		PURPOSE OR FUNCTION
	CELL DRAWING	CELL TEM		VIRUS DRAWING	VIRUS TEM	
A. Genetic Material (e.g., DNA or RNA, Nucleus, Chromosomes)						
B. Nuclear Membrane						
C. Nucleolus						
D. Cell Membrane						
E. Endoplasmic Reticulum (RER + SER)						
F. Cytoplasm						
G. Golgi Apparatus						
H. Ribosomes						
I. Microtubules						
J. Lysozyme						
K. Capsid						
L. Membranous Envelope						
M. Mitochondria						

IMAGES

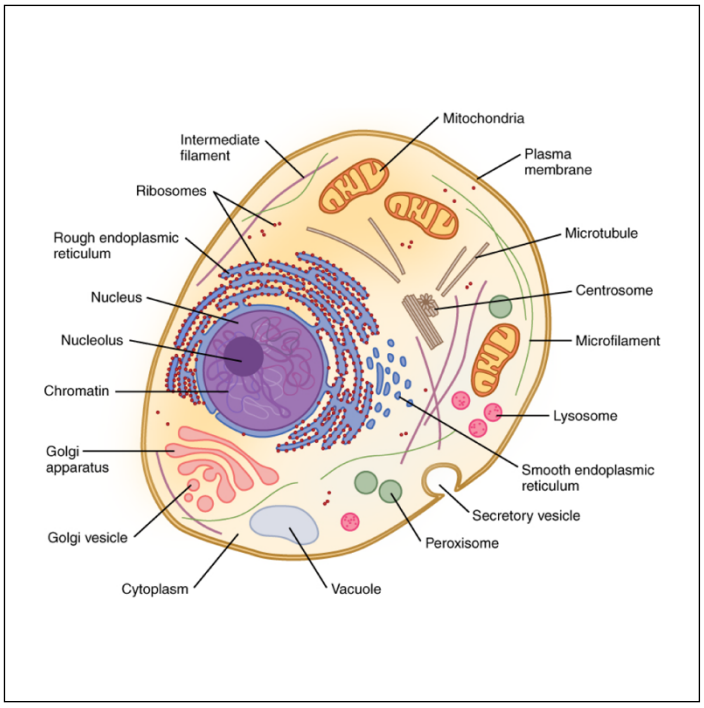

Figure 1. Diagram of a typical animal cell with the organelles labeled.

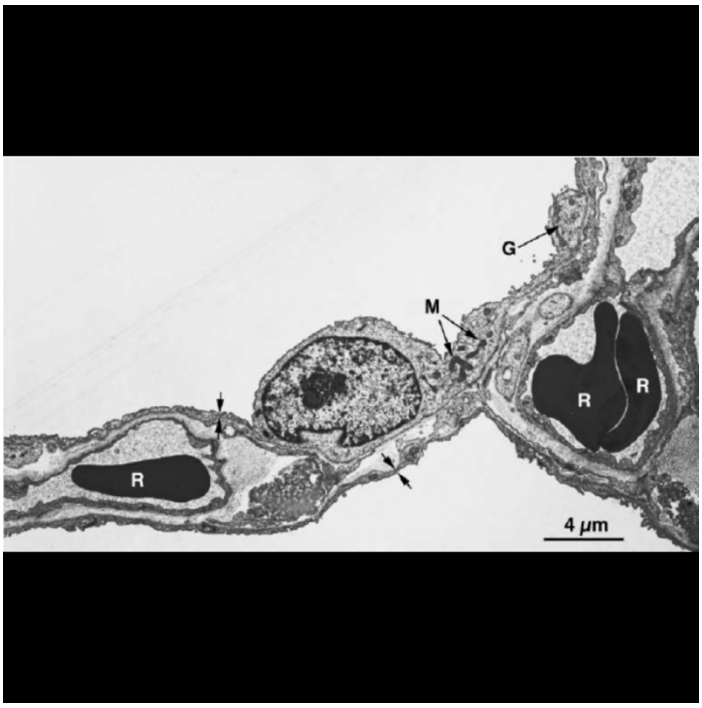

Figure 2. Image of an alveolar lung cell taken with a (TEM) Transmission Electron Microscope. Note the open space at the top of the picture. That is an alveolus, the tiny air sacs in the lung. Also note the capillaries with red blood cells (R) inside.

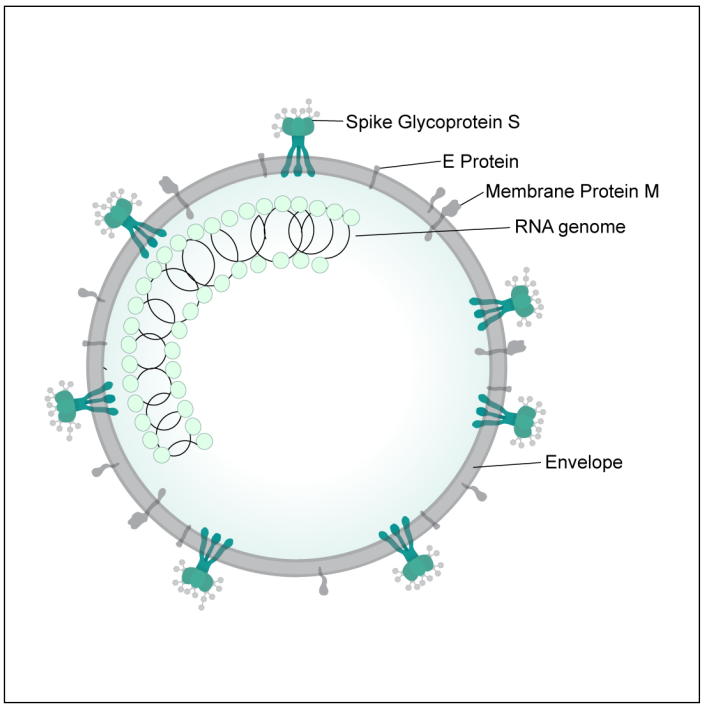

Figure 4. Diagram of the SARS-CoV-2 virus particle, the coronavirus that causes COVID-19.

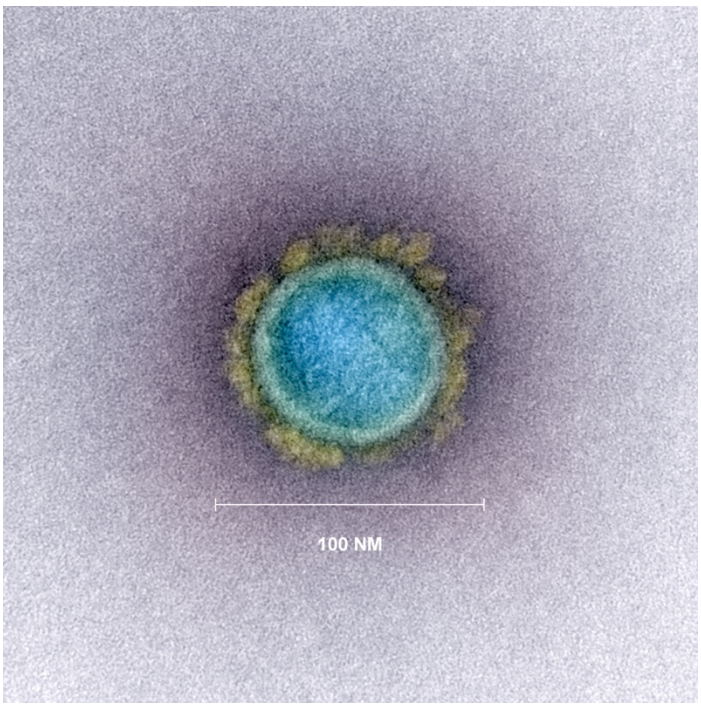

Figure 3. SARS-CoV-2 virus particle taken with a Transmission Electron Microscope (TEM).

STUDENT PAGE C

Coronavirus: How Does It Work?

COVID HACKS
Healthy Actions • Community Knowledge • Science

OVERVIEW

- View the interactive SARS-CoV-2 animation. https://www.scientificamerican.com/interactive/inside-the-coronavirus/.
- Scroll down to the 3D interactive model with parts labeled 1 to 6.
  HINT: Click on the "full screen" mode. If you have difficulties using the interactive model, you can view the illustrations at: https://www.scientificamerican.com/article/a-visual-guide-to-the-sars-cov-2-coronavirus/.
- Rotate the model so you see the outside (back side).

QUESTIONS

1. Questions on the 3D Model
   - *What are the orange spikes and what is their role in infection?*
   - *What is the protective shell made of and what is its role?*
   - *What is the purpose of the viral RNA?*
   - *What is the purpose of the N protein?*
   - *Where do you find the E and M proteins and what is their role?*

2. How the Virus Invades (scroll to this section)
   - *To what kind of receptor does the virus bind?*
   - *What does that receptor normally do for the body?*
   - *What slices off the spike protein's head?*
   - *What does the "spring" in the spike protein's stem do?*
   - *What enters the lung cell through that channel?*
   - *What happens in the endoplasmic reticulum?*
   - *The virus RNA polymerase inside the vesicles makes copies of the virus RNA. What links to the RNA to keep it stable?*
   - *Where do the spike proteins come from?*
   - *How do the new virus particles get out of the lung cell?*

3. If you want to see how the human body's immune system responds to the virus and how vaccines and antiviral medications work, scroll further down on the page in the same article. (Optional: take notes on what you learn.)
   - **NOTES:**