Making Water Safe

Since 1990, 2 billion people have gained access to improved **drinking water** sources and 1.8 billion people have gained access to improved **sanitation**. However, worldwide, 780 million people still do not have access to improved water sources and an estimated 2.5 billion people — half of the developing world — lack access to adequate **drinking water**.

Terms to Know

Bacteria	microscopic living organisms that can be found everywhere; some **bacteria** are good for your body, while other types can be very harmful
Citizen scientists	people — young or old — who help collect data for research projects conducted by professional scientists
Contagious	able to be passed from one individual to another through contact
Drinking water	water that is or has been made safe to drink
Exposure	to leave without protection, shelter, or care; subject to a harmful condition
Filtration system	a system that removes impurities from water or air
Microorganism	living things that are too small to be seen with the naked eye
Public health	the science of protecting and improving the health of people and their communities
Safe Water System (SWS)	a program that protects communities from harmful water by creating solutions to produce clean water and educating the public about keeping water sources clean
Sanitation	the act or process of making or keeping things free from filth, infection, or other dangers to health

Understanding Drinking Water

Drinking water comes from a variety of sources including public water systems, private wells, or bottled water. In countries like the United States, **drinking water** is made clean through public water systems. These systems clean water using a variety of processes that remove harmful **microorganisms** and chemicals. In other countries, public water systems are not available or not up to date. This threatens the health of their communities, since their water sources are not clean.

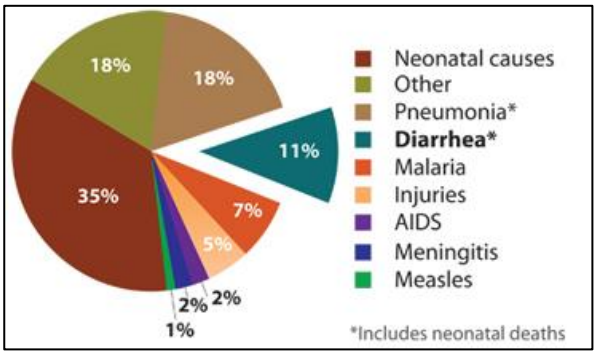
Think About It

1. What are some sources of **drinking water**?
2. Why is clean **drinking water** important?
3. Why do some communities not have access to clean **drinking water**?

Safe Water and the Centers for Disease Control and Prevention (CDC)

Public water systems have existed for thousands of years. These systems were designed not only to provide communities water, but also to take away wastes that contaminate water. However, efforts to **sanitize** water began much later. In the United States, the first efforts to **sanitize** occurred in 1908 in Jersey City, New Jersey. Over the next decade, thousands of cities and towns across the United States followed suit in routinely disinfecting their water, contributing to a dramatic decrease in disease across the country.

Before this, water in the United States had been contaminated with **bacteria** that carried several diseases, including cholera and typhoid. Both diseases caused severe stomach ailments that could lead to death. In 1900, 100 out of every 100,000 citizens would contract typhoid fever. By 1920, **sanitation** efforts across the country helped the number drop to less than 34 out of every 100,000 citizens. As of 2018, CDC estimates that this number dropped to 1.74 out of 100,000, meaning 5,700 people contract typhoid in the United States each year.



Global Leading Cause of Death Among Children Under Five

Though **sanitation** efforts greatly improved water quality in the United States, many countries around the world still struggle to provide safe **drinking water** and waste removal for their communities. More than 2.5 billion people in the world still do not have access to effective **sanitation**, and more than 780 million people do not have access to improved water sources. Even more worrisome, nearly 88% of global deaths due to diarrhea illnesses have been attributed to unsafe water, inadequate **sanitation**, and poor hygiene.

Globally, diarrheal diseases (such as cholera) kill more children than AIDS, malaria, and measles combined, making it the second leading cause of death among children under five (excluding neonatal deaths).

As our world becomes more connected, global **public health** has had an increased importance in our everyday lives. The diseases carried in water in other countries can reach the United States. In 1998, CDC teamed up with the Pan American Health Organization to develop the **Safe Water System (SWS)**. The program aims to protect communities from contaminated water by promoting behavior change and providing affordable and sustainable solutions.

The **SWS** increases access to safe water by helping individuals treat and safely store water in homes, health facilities, and schools. By treating household water directly, providing safe water storage options, and communicating ways to improve hygiene, **sanitation**, and water and food handling practices, the **Safe Water System** hopes to create a global impact on millions of lives.

Think About It

1. Why was it important for cities to sanitize their public water sources?
2. How many people around the world struggle with access to clean water?
3. How does the **Safe Water System** address global water **sanitation** issues?

From the Expert:

Lack of access to safe water affects more than 1 billion people in the developing world. Annually, 2 to 3 million children under age 5 die of diarrheal diseases, often acquired through **exposure** to contaminated water. Listen to the experts explain CDC-supported programs helping to reduce these numbers. https://youtu.be/FjwPwq9UB2s

Call to Action

Several challenges exist with providing clean water to communities across the world, including communicating safe water practices and filtering harmful materials and organisms from wastewater. As a **citizen scientist**, you can help address these challenges by following these 3 steps:

1. Design a safe water practices infographic. One of the ways CDC uses to reduce the **exposure** communities have to waterborne illnesses is by communicating the ways people can keep themselves safe. Infographics are a great way to communicate information because they are a visual image, such as a chart or diagram, that can be used to represent information or data. You can assist CDC by creating an infographic of the behaviors that reduce the spread of **contagious** diseases found in water.

2. Engineer a water filter. Filtration systems play a large role in sanitizing wastewater. These systems often involve a series of filters to remove debris and organisms from the water. By designing your own system, you will experience the challenges that occur as environmental engineers try to create them in communities across the globe.

3. Share your designs. One of the ways CDC communicates information is through social media. Your designs can help CDC communicate the work it has done and is doing to improve access to clean water and effective **sanitation** across the globe.

Why Participate? A Message from CDC

Human health and well-being are strongly affected by the environment in which we live — the air we breathe, the water we drink, and the food and nutrients we eat. All these things can be affected by unsafe **drinking water**. Community water systems and water safety plans are important ways to ensure the health of the community. For most people who live in developed countries, these systems and plans provide safe **drinking water** that is as close as the nearest faucet. However, many people in developing countries are not so fortunate. They face many challenges in finding, hauling, treating, and storing water. CDC strives to increase access to safe **drinking water** and reduce the effects of poor **sanitation** on health and well-being. Through public support, these efforts can be sustained.

More information can be found at https://www.cdc.gov/healthywater and https://www.cdc.gov/safewater

Think About It

1. What are the dangers associated with diarrheal diseases?
2. Explain the role communication plays in water safety.
3. How can your efforts support the efforts of CDC?

Design a Safe Water Practices Infographic and Water Filter

The engineering design process allows engineers to develop and test solutions to problems. You can use the process to help determine the best way to inform the public about ways to keep themselves safe from waterborne illness and to design your own water filter.

Define the problem

Describe the problem you are trying to solve. There are several questions you could use to guide your investigation:
- What should a safe water practices infographic include?
- What role do water filters play in making water safe?
- What should be included in a water filter design?

Do background research

Find information about the problem. Check out these helpful links from CDC. You may also do your own research.
- https://www.cdc.gov/safewater/behavior-change.html
- https://www.cdc.gov/healthywater/drinking/home-water-treatment/water-filters/step2.html

Specify requirements

Determine what your solution needs to have to succeed.
- What are the key characteristics needed for my infographic?
- What are the key characteristics needed for my water filter?

Brainstorm, choose and develop solutions

For each part of your design, ask yourself the following:
- How many different solutions can I create?
- Which solution seems to be the best one for the problem?
- What steps do I need to take to create my solution?

Build a prototype

Design and build your model.
- Know that it is okay if your prototype is made of different materials than your final solution. After all, it is a prototype.
- Be sure you can explain the use for each material in your prototype.

Test and redesign

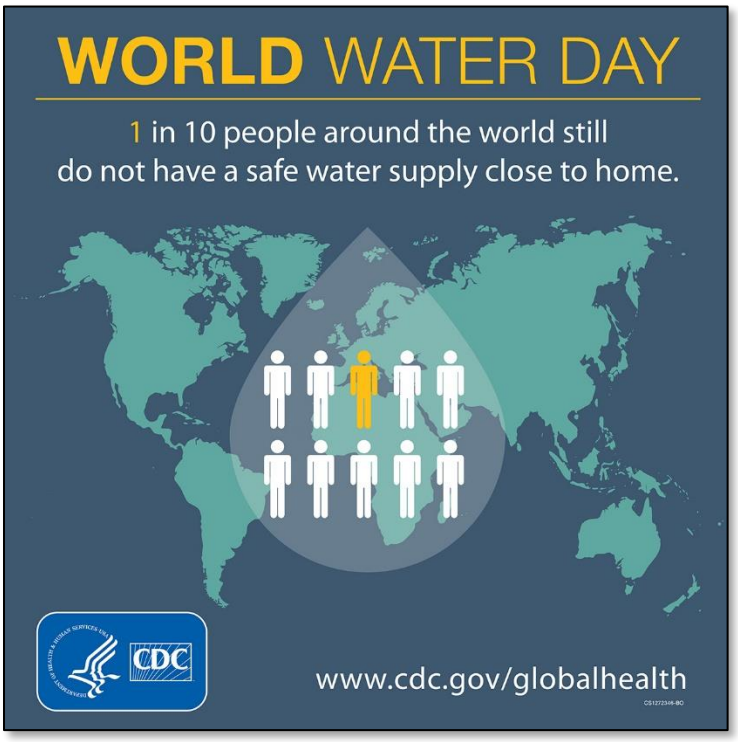
Test the prototype you made.
- For your infographic, a peer can review it to see if your images communicate your meaning and help you redesign.
- Test your water filter by pouring dirty water in the filter and evaluating how well it cleans. Redesign to improve any

Communicate results

Sharing the information you collect is key!
- Share your information using social media with the CDC accounts listed.

Design a Safe Water Practice Infographic

An infographic is a visual representation of information. Often, these images give people a better understanding of the information being shared. The information is organized in a way that gives visual meaning to data. CDC often uses infographics to share information with the public to make sure each person understands the information being shared. Check out this infographic about World Water Day:



In this infographic, you can see that yellow is used to indicate important information. The "1" stands out for readers. Similarly, having one of the person icons colored yellow reminds the viewer of the one person in ten who doesn't have safe water. Having a water droplet and a world map helps the viewers connect the topic of water and lets them know it's a global issue.

Steps to Design

1. When you are making your design, you can use the following links for information:

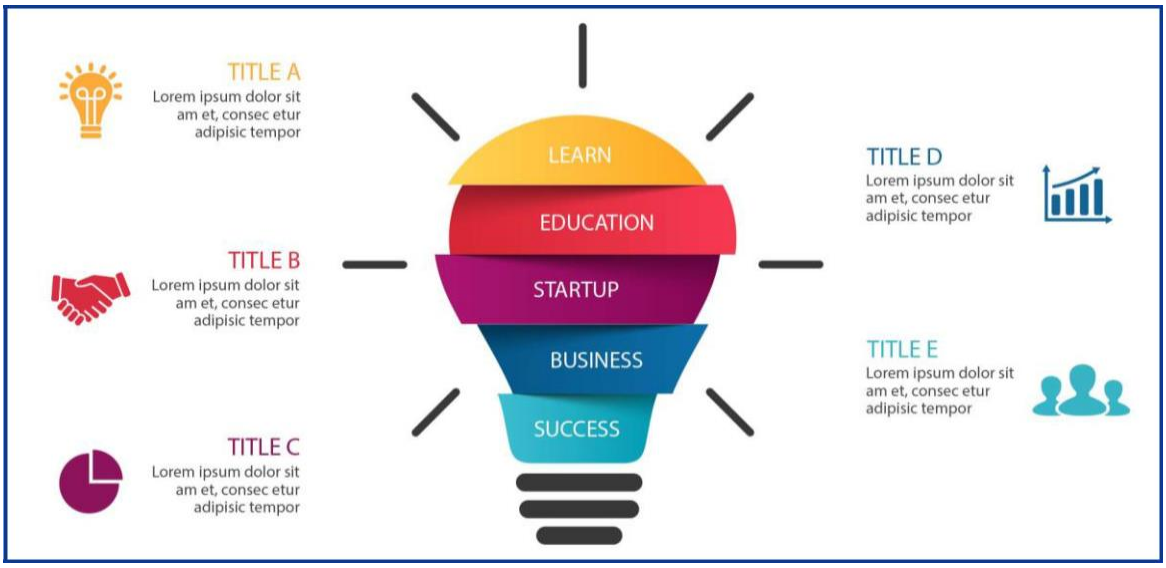
   Handwashing - https://www.cdc.gov/healthywater/hygiene/hand/handwashing.html

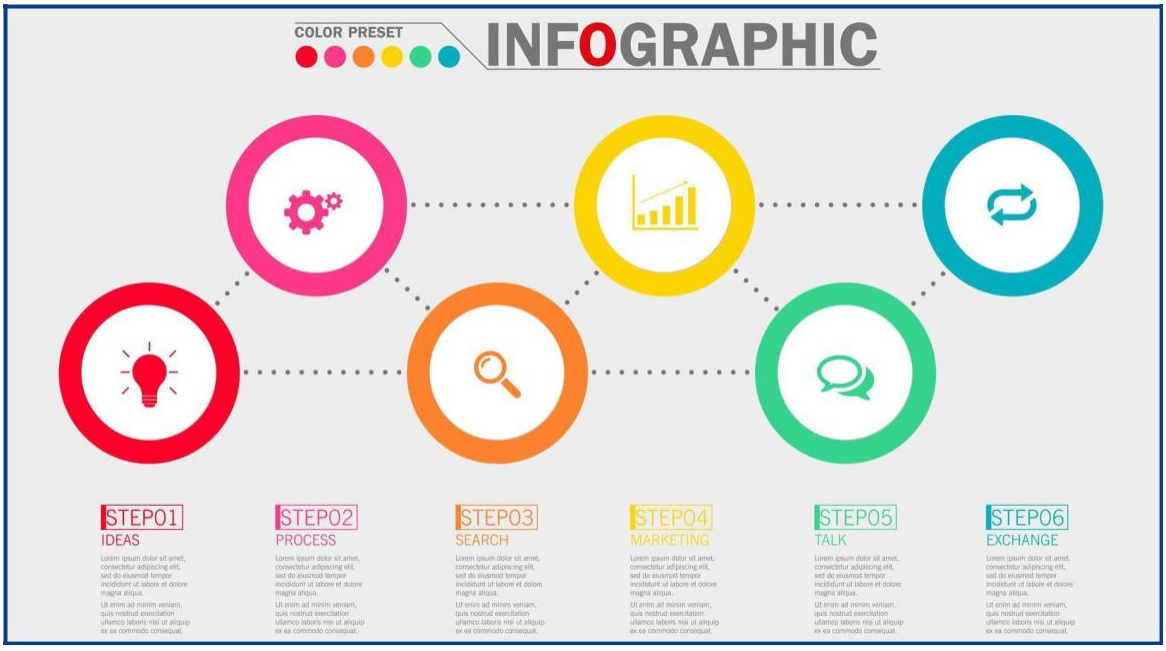
   Sanitation - https://www.cdc.gov/healthywater/global/sanitation/index.html

   Safe Water Handling - https://www.cdc.gov/healthywater/emergency/making-water-safe.html

2. Choose an image to go with each practice. Make sure the images help to explain each action a person should take.
3. Organize your design. Page 6 gives you examples of how you can organize your images.
4. Share your infographic with CDC on Facebook, Twitter and Instagram using @CDCgov!

Infographic Layout Examples





Engineer a Water Filter

Tools of the Trade

To test whether your filter works, you will need a water sample that is not clean. For the water sample you will need:

1 quart of water	**½ cup soil or dirt**	**¼ cup sand**
2-quart pitcher	**1 long-handled spoon**	**8 cups (8 oz size)**
¼ cup measuring cup	**½ cup measuring cup**	**1 permanent marker**

Your filter will need to be housed inside a container. To test different ideas, it is recommended you get 3 of the containers you choose. You can use any container that has a neck. The following containers work well for design:

2-liter soda bottles	**20-ounce water bottles**	**½ gallon milk containers**

Since you are creating your filter using your own design, you can choose what materials you feel would be best to remove the soil/dirt and sand from your water sample. Recommended materials include:

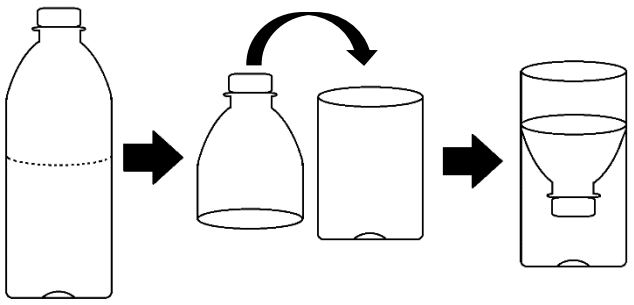
cotton balls	**tulle or netting**	**gauze or cloth bandages**
paper towels or napkins	**coffee filters**	**aquarium gravel**
tissue	**sand**	**cloth squares**

Prepare the Water Sample

1. Pour the water into the pitcher.
2. Add the soil/dirt to the pitcher and stir with the spoon.
3. Carefully fill 4 cups with the mixture. Label one of the cups "A" with the permanent marker.
4. In a fifth cup, pour ½ cup of the mixture into the cup, then fill the rest of the cup with water. Label this cup "B" with the marker.
5. In a sixth cup, pour ¼ cup of the mixture into a cup, then fill the rest of the cup with water. Label this cup "C" with the marker.
6. Fill a seventh cup with clean water. Label this cup "D." The last cup will be used later.

Prepare the Containers

7. Start with your first container. Take the cap off the container.
8. Cut the container in half, as shown in the image below. You may need an adult's help.
9. Turn the top half of the container upside down and place the top half of the container into the bottom half of the container. The top half will hold your filter, while the bottom half collects the filtered water.
10. Repeat this process with each container.
11. Write out the steps you took for your procedure on a sheet of paper. Include drawings of your containers for each step.

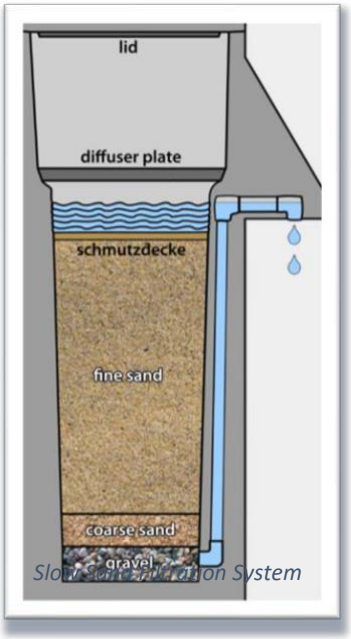


Build the Prototype

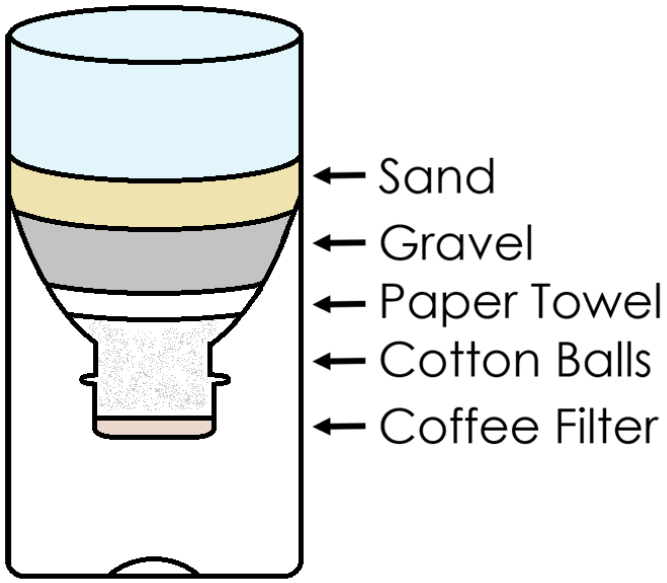
Now that you have your container built, it is time to prototype your filter. Remember, this is your design, and it may or may not work well the first time. You will measure success by how much soil/dirt and sand you can remove from your three water samples, **and** how much water you are able to gather from the filter. After all, if your filter does not let water through, it is not really a filter. Once you have decided on the materials you will use to filter your water, you need to decide the order you want them to go inside the container.

Some tips:

- Sand and aquarium gravel are excellent filters. In fact, one of the home **filtration systems** CDC has implemented in communities without access to adequate **filtration systems** is the slow sand **filtration system**.
- However, neither sand nor aquarium gravel can be the bottom layer of the filter because they will fall right through it.
- Tissue can be an excellent way to plug the neck so that water can come through the filter without the other filter materials falling through. However, water can weaken the tissue and cause it to break apart.
- Coffee filters are, well, filters. However, water moves very slowly through a coffee filter.
- Tulle and netting will let small debris like sand through them. However, they are both strong enough to hold all the other filter materials to keep them from falling through the filter.



Once you have determined your order, draw a diagram with each layer labeled in the container.



Test the Prototype

1. Construct your prototype based on your design. Once you have it constructed, test your filter by pouring the sample water into the prototype.
2. While your sample water works through your filter, line up cups A, B, C, and D. These will serve as comparison cups. You will compare your filtered water to the cups to test how well your filter works.
3. Once your water has finished filtering, pour the filtered water into the 8th cup. Hold your cup up to cups A-D to determine which cup matches your filtered water the best. The closer your filtered water looks to cup D, the better your water filter works.
4. Compare the amount of filtered water you recovered to the amount of water in cup D.
5. Record your results by circling them in the chart below:

Prototype 1: Data Table

Filtration: How close does your filtered water look to the clean water?	My filtered water looks like cup A. 1 point	My filtered water looks like cup B. 2 points	My filtered water looks like cup C. 3 points	My filtered water looks like cup D. 4 points
Recovery: How much water did your filter let through?	My filter let none of the water through. 1 point	My filter let less than half of the water through. 2 points	My filter let more than half of the water through. 3 points	My filter let all the water through. 4 points

6. Add up the point values for your filtered water. A good filter will earn at least 5 points. A better filter will earn at least 6 points. A great filter will earn 7 or more points.
7. If your prototype scores a 4 or less, think about improvements that could be made. Run the engineering design process again, this time changing the layers you use to filter. This could involve changing the materials themselves, the order of the materials, or both.
8. If your prototype scores well, try to replicate the results by building a second prototype of the same kind. Again, repeat the engineering design process.
9. For your third prototype, focus either on recovery or filtration. Repeat the engineering design process.
10. Record your results for your second and third prototype by circling them in the tables below:

Prototype 2: Data Table

Filtration: How close does your filtered water look to the clean water?	My filtered water looks like cup A. 1 point	My filtered water looks like cup B. 2 points	My filtered water looks like cup C. 3 points	My filtered water looks like cup D. 4 points
Recovery: How much water did your filter let through?	My filter let none of the water through. 1 point	My filter let less than half of the water through. 2 points	My filter let more than half of the water through. 3 points	My filter let all the water through. 4 points

Prototype 3: Data Table

Filtration: How close does your filtered water look to the clean water?	My filtered water looks like cup A. 1 point	My filtered water looks like cup B. 2 points	My filtered water looks like cup C. 3 points	My filtered water looks like cup D. 4 points
Recovery: How much water did your filter let through?	My filter let none of the water through. 1 point	My filter let less than half of the water through. 2 points	My filter let more than half of the water through. 3 points	My filter let all the water through. 4 points

Share Your Designs

CDC uses a variety of social networks to raise awareness about the diseases/ conditions with which they are working and their efforts to make the world a healthier place for all people. Water safety may not be at the forefront of the minds of communities within the United States, but it does play a big role in the world at large. You can aid CDC with these efforts by sharing your infographic and pictures/videos of your most successful prototype.

- Instagram: Share with David J. Sencer CDC Museum **@CDCmuseum**.
- Twitter: Share with CDC **@CDC**.
- Facebook: Share with CDC **@CDCgov**.

Name: _____

Reflections

Now that you have completed this design challenge, think about what you learned from your research and engineering design process. Answer the questions below.

1. What is the role **sanitation** plays in keeping us healthy?

   _____

   _____

   _____

2. What are some challenges communities experience with their **drinking water**?

   _____

   _____

   _____

3. Why is it important to raise awareness about global **public health**?

   _____

   _____

   _____

4. What are the effects of unsafe water in the environment?

   _____

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   _____

5. Should money from the United States be used to support clean water efforts in other countries? Why or why not?

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6. Should international health organizations focus only on countries without clean water? Why or why not?

   _____

   _____

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