02.03

THE **WATER CYCLE:** A GUIDE FOR STUDENTS

Water is the basic element of nature. It covers 70% of the earth’s surface. It provides life, eases out heat, drains harmful substances and mediates many day-to-day works. Water needs to be replenished, purified and circulated again and again so that it can perform its functions. Nature does this job through a process called the water cycle. Also known as hydrologic cycle, the water cycle is a phenomenon where water moves through the three phases (gas, liquid and solid) over the four spheres (atmosphere, lithosphere, hydrosphere and biosphere) and completes a full cycle. The water cycle has many effects: it regulates the temperature of the surroundings. It changes weather and creates rain. It helps in conversion of rocks to soil. It circulates important minerals through the spheres. It also creates the many geographical features present on earth like the ice caps of mountains, icebergs, the rivers and the valleys, lakes, and more. Hence it is quite important to understand and learn the processes of the water cycle.

**Step 1: Evaporation**

The water cycle starts with evaporation. It is a process where water at the surface turns into water vapors. Water absorbs heat energy from the sun and turns into vapors. Water bodies like the oceans, the seas, the lakes and the river bodies are the main source of evaporation. Through evaporation, water moves from hydrosphere to atmosphere. As water evaporates it reduces the temperature of the bodies.

**Step 2: Condensation**

As water vaporizes into water vapor, it rises up in the atmosphere. At high altitudes the water vapors changes into very tiny particles of ice /water droplets because the temperature at high altitudes is low. This process is called condensation. These particles come close together and form clouds and fogs in the sky.

**Step 3: Sublimation**

Apart from evaporation, sublimation also contributes to water vapors in the air. Sublimation is a process where ice directly converts into water vapors without converting into liquid water. This phenomenon accelerates when the temperature is low or pressure is high. The main sources of water from sublimation are the ice sheets of the North Pole and the South Pole and the ice caps on the mountains. Sublimation is a rather slower process than evaporation.

**Step 4: Precipitation**

The clouds (condensed water vapors) then pour down as precipitation due to wind or temperature change. This occurs because the water droplets combine to make bigger droplets. Also when the air cannot hold any more water, it precipitates. At high altitudes the temperature is low and hence the droplets lose their heat energy. These water droplets fall down as rain. If the temperature is very low (below 0 degrees), the water droplets fall as snow. Water also precipices in the form of drizzle, sleet and hail. Hence water enters lithosphere.

**Step 5: Transpiration**

As water precipitates, some of it is absorbed by the soil. This water enters into the process of transpiration. Transpiration is a process similar to evaporation where liquid water is turned into water vapor by the plants. The roots of the plants absorb the water and push it toward leaves where it is used for photosynthesis. The extra water is moved out of leaves through stomata (very tiny openings on leaves) as water vapor. Thus water enters the biosphere and exits into gaseous phase.

**Step 6: Runoff**

As the water pours down (in whatever form), it leads to runoff. Runoff is the process where water runs over the surface of earth. When the snow melts into water it also leads to runoff. As water runs over the ground it displaces the top soil with it and moves the minerals along with the stream. This runoff combines to form channels and then rivers and ends up into lakes, seas and oceans. Here the water enters hydrosphere.

**Step 7: Infiltration**

Some of the water that precipitates does not runoff into the rivers and is absorbed by the plants or gets evaporated. It moves deep into the soil. This is called infiltration. The water seeps down and increases the level of ground water table. It is called pure water and is drinkable. The infiltration is measured as inches of water-soaked by the soil per hour.

# 09.03

# Rivers

## The steady flow of the clean, fresh water of rivers is essential to human life and a whole host of aquatic species.

RIVERS AND THEIR tributaries are the veins of the planet, pumping freshwater to wetlands and lakes and out to sea. They flush nutrients through aquatic ecosystems, keeping thousands of species alive, and help sustain fisheries worth billions of dollars.

Rivers are also the lifeblood of human civilizations. They supply water to cities, farms, and factories. Rivers carve shipping routes around the globe, and provide us with food, recreation, and energy.

Hydroelectric plants built from bank to bank harness the power of water and convert it to electricity.

But rivers are also often the endpoint for much of our industrial and urban [pollution and runoff](http://www.nationalgeographic.com/environment/global-warming/pollution-quiz/). When it rains, chemical fertilizer and animal waste peppering residential areas and agricultural lands is swept into local streams, rivers, and other bodies of water.

The result: polluted drinking water sources and the decline of aquatic species, in addition to coastal dead zones caused by fertilizer and sewage overload.

Over the course of human history, waterways have been manipulated for irrigation, urban development, navigation, and energy. [Dams](http://www.nationalgeographic.com/environment/global-warming/hydropower/) and levees now alter their flow, interrupting natural fluctuations and the breeding and feeding patterns of fish and other river creatures.

Technology and engineering have changed the course of nature, and now we are looking for ways to restore flow and function to the planet’s circulatory system.

The [Colorado River](http://video.nationalgeographic.com/video/freshwater-colorado-delta) provides an excellent example of what happens when demand for river water—for cities, industry, energy production, and agriculture—threatens to outpace supply.

## River Trivia

* An unsettling number of large rivers—including the [Colorado](http://www.nationalgeographic.com/americannile/), Rio Grande, Yellow, Indus, Ganges, Amu Darya, Murray, and Nile—are now so overtapped that they discharge little or no water to the sea for months at a time.
* The world's biggest dam, the The Three Gorges dam on China's Yangtze River, is one of the largest power generators in the world, and holds almost 32 million acre-feet (39.3 cubic kilometers) of water. The [hydropower](http://www.nationalgeographic.com/environment/global-warming/hydropower/)-generating dam does have its drawbacks, though: It displaced an [estimated 1.3 million](http://news.nationalgeographic.com/2016/05/160512-china-nu-river-dams-environment/) people and flooded thousands of villages.
* After enduring 19 flood episodes between 1961 and 1997, Napa, California, opted to restore the Napa River floodplain for $366 million, instead of the more conventional flood-control strategy of channelizing and building levees. (See the nearby Oroville Dam's slipway bursting at the seams.)

# 16.03

# Ensuring safe drinking-water – highlighting water safety plans in Tajikistan on World Water Day

While some people in the WHO European Region take clean drinking-water for granted, many communities throughout the Region – and the world – still suffer from water-related issues. World Water Day is a day for action to encourage engagement and share knowledge on safe and sustainable management of water.

This year the campaign shines a light on “leaving no one behind”, providing equitable and safely managed water services for all, including remote rural communities. Tajikistan has introduced water safety plans (WSPs) to central Asia for the first time, with the recent completion of a successful pilot project, implemented by rural communities across the country. The project represents a major step towards achieving Sustainable Development Goal (SDG) 6 on water and sanitation. Marking these achievements, an international film team has captured the experiences and lessons from a Tajik mountain community in the picturesque Varzob valley. This documentary shows the direct impact WSPs can have on communities throughout the Region. The film was recently launched at the project closing ceremony in Dushanbe and is now available online in English and Russian.

WHO/Europe and the Ministry of Health and Social Protection of Tajikistan have been working closely together since 2016 to strengthen drinking-water quality management and surveillance. A national team of water safety planning experts has been established. These facilitators now have the tools and knowledge to guide drinking-water suppliers and authorities through proper risk assessment and safe operational practices under the many different environmental conditions in the country.

Representatives from the national water sector have also compiled national policy and programme guidance on water safety planning. Currently in the final process of ministerial approval, this guidance will help ensure that communities across Tajikistan become more resilient through access to safer drinking-water. The project has helped to raise water safety planning to be a national priority, which is soon to be reflected in a new law on water and sanitation.

### Importance of WSPs in achieving SDG 6

As a health response towards achieving SDG 6, WHO recommends the introduction of a WSP for every drinking-water supply. The approach combines established risk-management principles with prevention-focused operation and monitoring practices. These principles remain the same for large urban suppliers as they do for small rural operators, and they have already been applied in over 80 countries around the world.

The national surveillance authorities responsible for drinking-water quality monitoring showed great interest in strengthening their efforts in alignment with WHO recommendations. The staff of the local, regional and national branches of the Sanitary Epidemiological Service were trained in collaboration with the Dutch National Institute for Public Health and the Environment (RIVM) on risk-based surveillance approaches and the prioritization of water quality parameters to ensure focused and cost-effective monitoring while protecting health.

The project was coordinated by the WHO European Centre for Environment and Health and funded by the Ministry for Foreign Affairs of Finland under Finland's Water Sector Support to Kyrgyzstan and Tajikistan programme.

# 23.03

# Waterfalls can form in a surprising new way. Here's how.

## *For the first time, scientists have demonstrated that it's possible for a river to spontaneously form a waterfall.*

WATERFALLS ARE GRACEFUL monuments to nature's power. In each gentle curve and thrilling plunge, these watery edifices record the dynamic forces thought to be key players in their formation, allowing scientists to tease through the history of the surrounding landscape.

But now, a [study published in *Nature*](https://www.nature.com/articles/s41586-019-0991-z) suggests a new mechanism for creating a waterfall that throws a wet blanket on some of geologists' long-held assumptions.

Until now, scientists largely reckoned that waterfall formation needed some type of external trigger acting on a river. Some waterfall-forming processes could be fast, like an earthquake shifting blocks of land to create a step over which water can fall. Others could be glacially slow, like sea-level changes or even different types of rock eroding away at different speeds.

However, the new work concludes that a dramatic change in the rock or external force isn't always necessary to create these dizzying cascades. Instead, the researchers suggest that a river's turbulence alone is enough to carve steep pitches in a uniform bed of rock, spontaneously forming a waterfall.

“This new formation mechanism really complicates our understanding of being able to use topography and the presence of waterfalls to solve for past changes in Earth history,” says study author [Joel Scheingross](http://joelscheingross.com/), who completed this research as a doctoral student at the California Institute of Technology.

He cautions that the work is still preliminary and is limited to lab-based simulations. But he says it does call for a rethink of how scientists interpret the factors that sculpt landscapes.

“That to me is the golden internal message,” says [Ben Crosby](https://sites.google.com/isu.edu/crosby/), a geomorphologist at Idaho State University who was not involved in the study. “It raises up a hand and says, Wait a minute, everybody. We can’t necessarily attribute these landforms to some external driver or some local driver; they can pop up all on their own.”

## A river runs through it (in the lab)

By simulating rivers in the laboratory, scientists [previously](https://www.cambridge.org/core/journals/journal-of-fluid-mechanics/article/purely-erosional-cyclic-and-solitary-steps-created-by-flow-over-a-cohesive-bed/F9A9D022A58B15539D7432ED5D11A489) [found](https://books.google.com/books?id=Sc8qBgAAQBAJ&pg=PA535&lpg=PA535&dq=Brooks,+2001+cyclical+step+formation&source=bl&ots=8rz_6gRmKa&sig=ACfU3U1FrYMtxkd6ldpg3dHztGIEp7u9WQ&hl=en&sa=X&ved=2ahUKEwjdlLGBnf_gAhUjrlkKHWApCcEQ6AEwCHoECAgQAQ#v=onepage&q=Brooks%2C%202001%20cyclical%20step%20formation&f=false) that the water's motion could form undulating pools along its path. Some even proposed these pools could eventually become the starting point of waterfalls. Scheingross and his colleagues wanted to put this idea to the test.

The process is exceedingly slow in nature, with water shaving down the underlying rocks at just a fraction of the speed at which your fingernails can grow. So the researchers turned to a Pepto Bismol-pink polyurethane foam—similar to the foam florists use for flower arrangements—to model the system. It erodes quickly, but at a rate that's remarkably scalable to different types of rock.

“Instead of having to wait decades or millennia to run these experiments, we can run them on a timescale of a Ph.D. thesis and actually observe changes in the lab,” says Scheingross, who is now an assistant professor at the University of Nevada Reno.

The team set a flat surface of this foam in a flume that stretched 24 feet long and almost a foot across. The surface was tilted to a nearly 20-percent slope, and then the team flooded it with a stream of water and sediment. This grit was a key component to the formation of channels, Scheingross says, since sediments in flowing water act like sandpaper, grinding away layers of underlying rock.

## Behind the falls

With the system flowing, the team waited and watched, pausing the water every so often to evaluate its effects. Within a few minutes, a half moon-shaped channel started to cut its way into the foam. Next, the surface started to undulate. Chutes and pools began taking shape, and that's where the waterfall magic began.

As the pools continued to deepen, the rushing waters eventually lingered in some places so much that the suspended gravel fell out of solution. This formed what Scheingross and his team call an armor layer—a covering of sediment or gravel that protected the soft foam in that pool from eroding away.

Eventually, sediment built up so much in the pool that it was no longer a water-filled pocket, but more of a gritty step that ferried both water and sediments over the lip. Without similar protection, the next pool down began to erode, forming a vertical wall between the two—and thus, a waterfall.

What's more, Crosby notes, these waterfalls lingered. Each lab-made cascade stuck around for about 20 minutes, a period of time that represents 10 to 10,000 years, according to the study.

## Go chasing waterfalls

For now, there's no guarantee that this is happening the same way in nature. The researchers hope to do more experiments and identify characteristics that could help them find places in nature where this process might be at work.

And many scientists are already excited to go out and take a look.

“I think anybody who has spent time looking at a variety of field sites around the world may come up with places that this might be happening,” says river geomorphologist [Ellen Wohl](https://sites.warnercnr.colostate.edu/fluvial-geomorphology/people/34-2/) of Colorado State University. “I can think of one place right off the top of my head,” she says, pointing to the rugged Big Box Canyon of Arizona, an area popular for its waterfalls and swimming holes. The study authors also pointto the plunge pools of the [Seven Teacups](http://ropewiki.com/Seven_Teacups) in California as another candidate.

Overall, the study hints that these magnificent structures may still have some secrets. A slew of mechanisms could contribute to each waterfall's birth, notes Crosby, and scientists must consider this variety when using the features to interpret past landscape-sculpting events.

“Waterfalls are these messengers of change on landscapes,” Crosby says. “As an energetic point, they’re able to carry that message of change through watersheds. That’s why we give them so much attention as geomorphologists, and why taking pause at the attribution of that change is so important.”