COSMOS LESSONS

Chemistry

Solids, Liquids and Gases: Changing states

This lesson is all about states of matter and the search for liquid water beyond Earth.

In this lesson you will investigate the following:

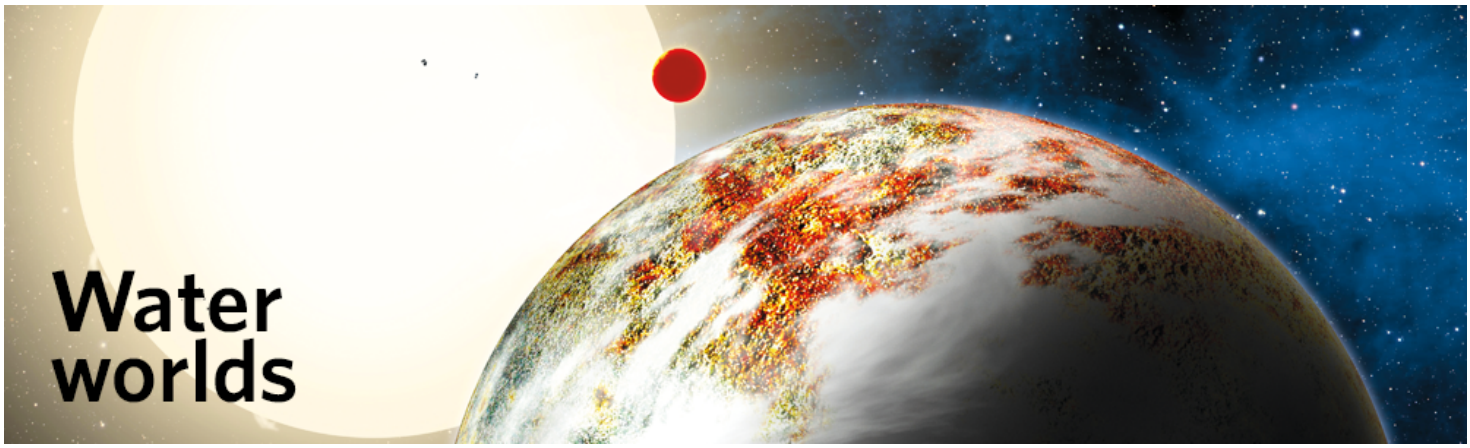
- What is the water cycle?
- How do scientists use the particle model to explain the different properties of solids, liquids and gases?
- How old is the water that you drink every day?
- Why is the presence of an atmosphere important to life on Earth?
- Is it possible for us to live on Mars?

Put your thinking cap on and get in the right state of mind to flow through this lesson!

This is a print version of an interactive online lesson. To sign up for the real thing or for curriculum details about the lesson go to **www.cosmosforschools.com**

Introduction: States of Matter (P1)

COSMOS LIVE LEARNING



We are just getting our first glimpse of new planets millions of light years from our own where, if the conditions are right, scientists hope we may find extraterrestrial life.

The search for extraterrestrial life hinges on finding water, specifically liquid water. Earth is the only planet that we know to harbour liquid water and that's why the space telescope Kepler is searching for planets that are a bit like our own.

To do this, scientists are concentrating on finding planets that are a certain distance from the star they orbit. If a planet is too close to its star, it will be too hot and any water on the planet will boil away and become steam – a gas. If it is too far away, the planet won't be hot enough and any water would remain frozen solid. But if the distance is just right, like the Earth's from the Sun, then lots of water can potentially exist in its liquid state.

So far, the scientists have found a lot of planets, but none like Earth. Still, they are hopeful that – with so many out there – one day they will find a planet with liquid water just like our own.

Read or listen to the full *Cosmos* magazine article here.


Left: False-colour image of gully channels in a crater in the southern highlands of Mars, taken by the High Resolution Imaging Science Experiment (HiRISE) camera on the Mars Reconnaissance Orbiter. The gullies emanating from the rocky cliffs near the crater's rim (upper left) show meandering and braided patterns typical of channels carved by liquid water. Right: Water is essential for life as we know it. Credit: NASA/JPL/University of Arizona and iStock

Question 1

Brainstorm: List as many ways in which you interact with liquid water in your everyday life as you can. When you have completed your list, mark the interactions that are essential for keeping you alive with an asterisk (*).

Gather: States of Matter (P1)

COSMOS LIVE LEARNING

Credit: NASA / YouTube.

Question 1

Recall: How much of Earth's water is available as fresh water?

- 97%
- 50%
- 20%
- 3%

Question 2

Recall: Where is most of Earth's fresh water?

- Oceans
- Lakes and rivers
- Polar ice caps
- Reservoirs and dams

Question 3

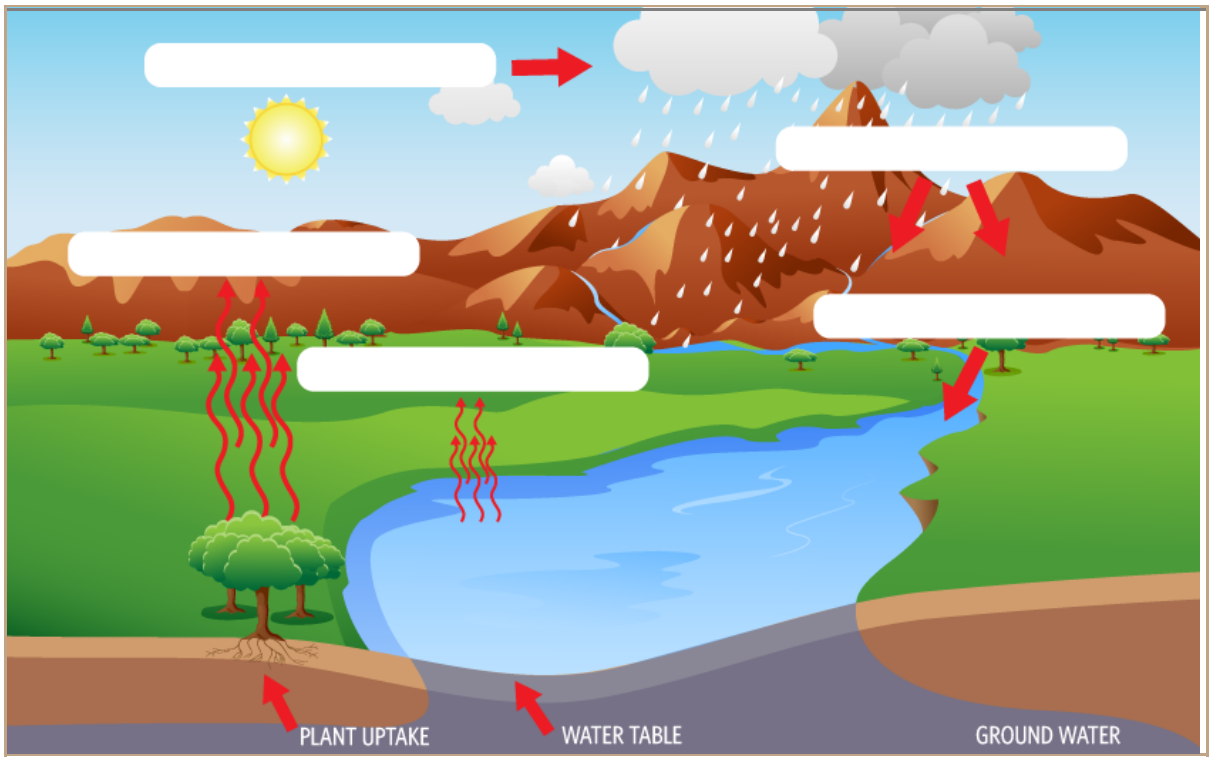
Identify: Complete the table below by stating an example of where you might find water on Earth as a solid, a liquid and a gas.

State of matter	Solid	Liquid	Gas
Example			

Question 4

Select: Use the text tool to label the diagram below with the following terms:

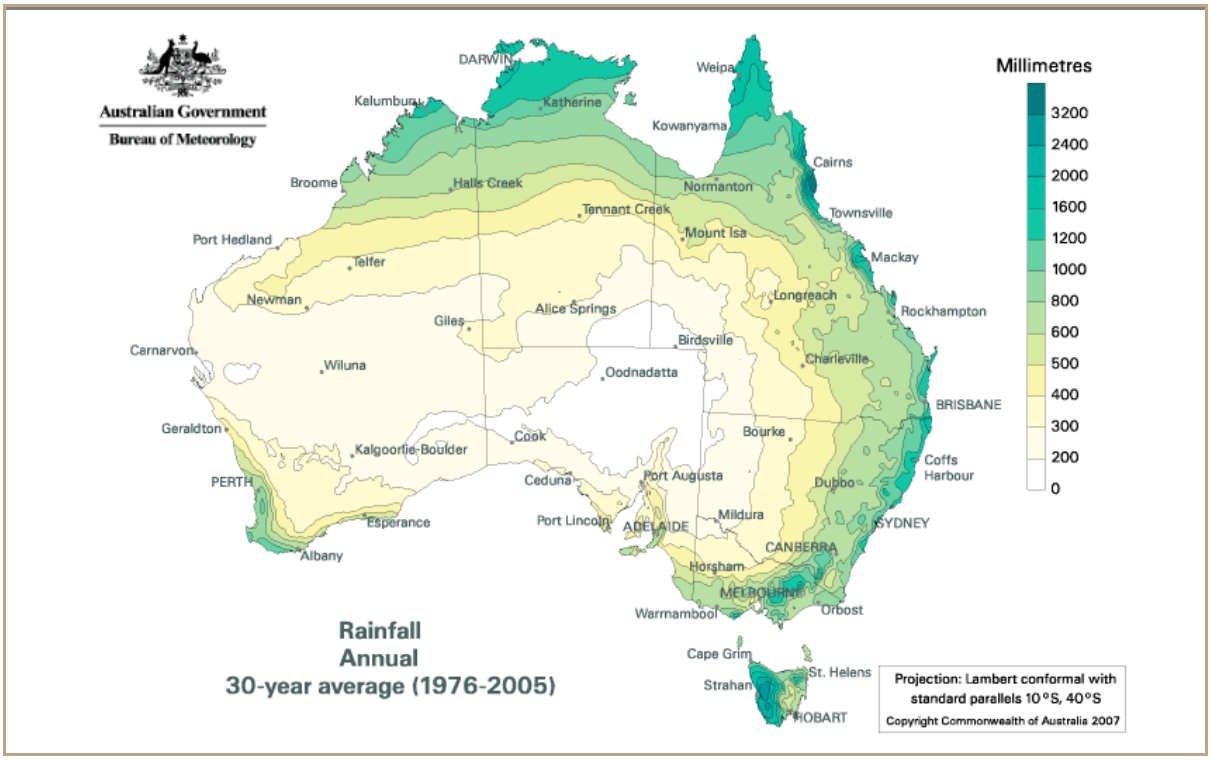
surface runoff; condensation; precipitation; evaporation; transpiration.



Water availability depends on where you are and the time of year. This affects the type and abundance of plants that can grow in the region, which in turn affects the type and abundance of animals that can live there too.

Question 5

Identify: Use the rectangle drawing tool to show which Australian cities have an average rainfall of more than 3200 mm, between 300 mm and 400 mm, and less than 200 mm. Use a green rectangle for cities with an average rainfall of more than 3200 mm, an orange rectangle for cities with an average rainfall of between 300 mm and 400 mm, and a red rectangle for cities with an average rainfall of less than 200 mm.



Question 6

Infer: Describe the types and abundance of plants that you would expect to find in each of these areas.

For best results when printing activities, enable your web browser to print background colours and images.

Process: States of matter (P1)

COSMOS LIVE LEARNING

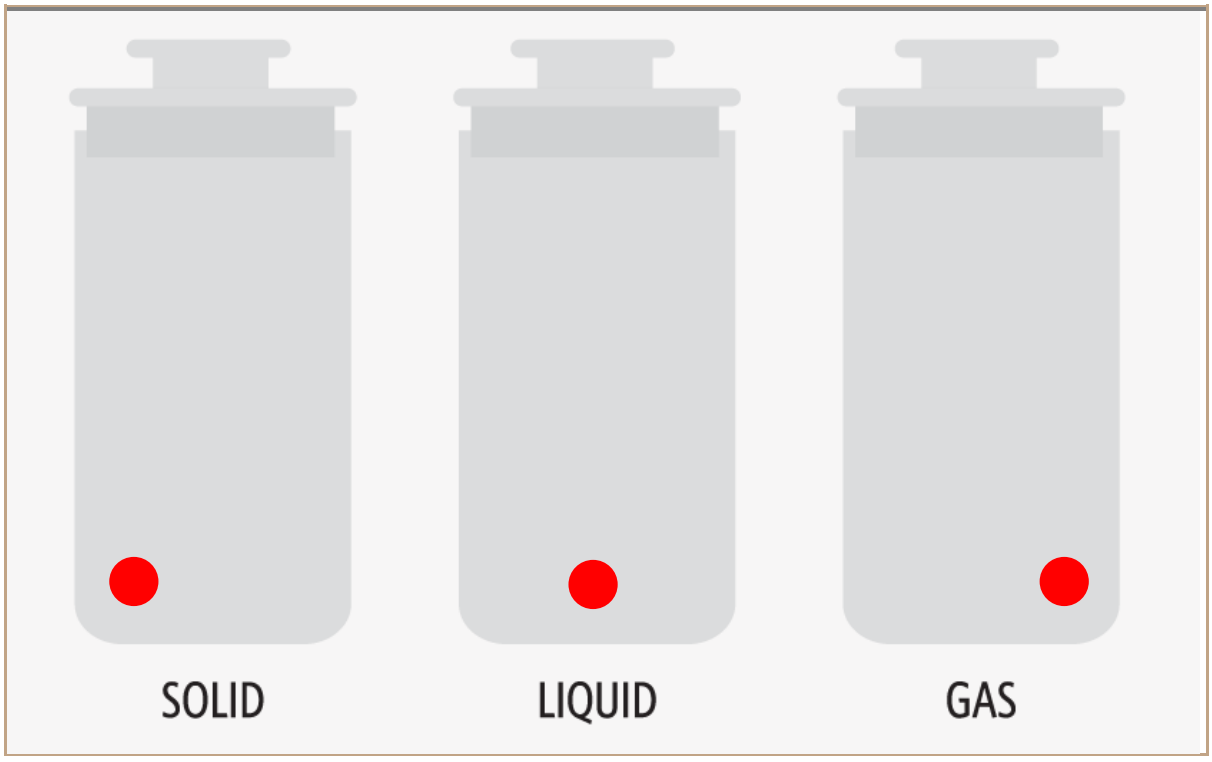
Credit: Funza Academy / YouTube.

Scientists often use models to help them communicate their ideas. The *particle model* helps us to understand concepts in chemistry. In the video, the presenter represents particles as small balls. Representing particles in this way helps us to visualise their arrangement and interaction between them.

Note that it is important to remember that models are just that, models. They are tools to help us understand concepts but may not accurately represent what is going on. For example, particles are not *actually* coloured balls and are in fact far more complex in nature.

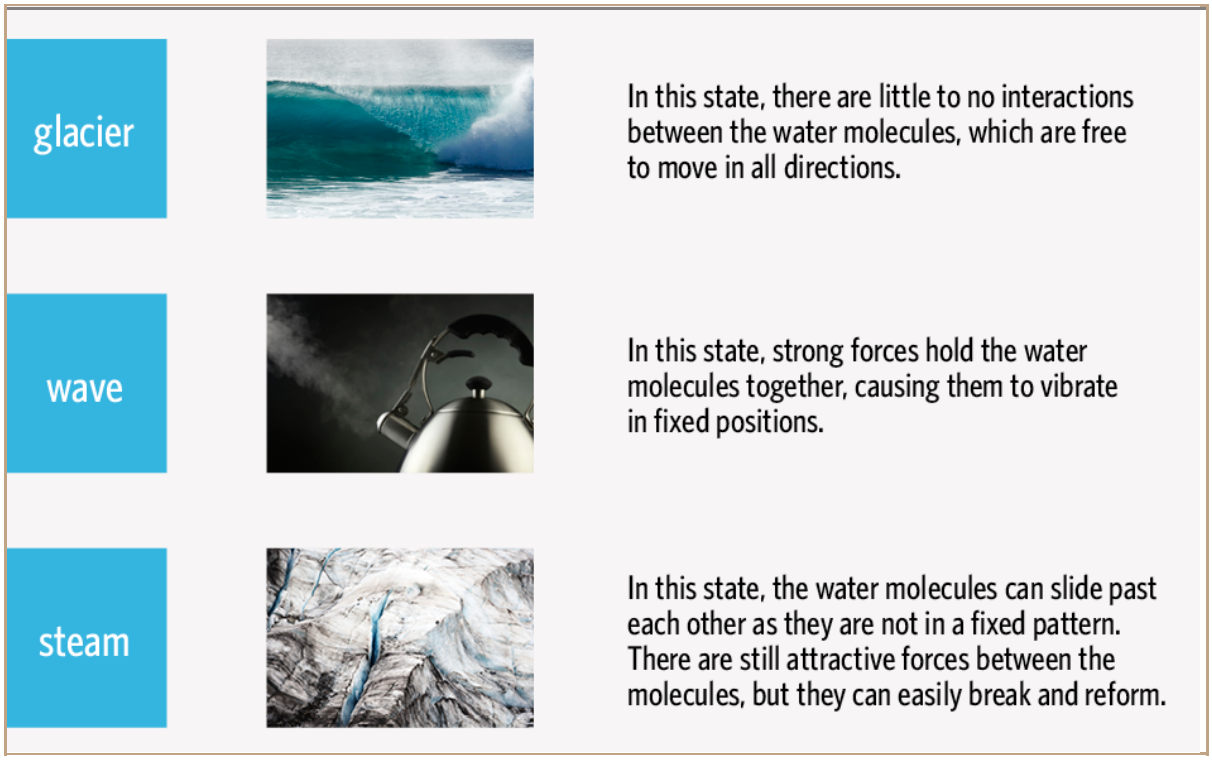
Question 1

Compare: Add seven red balls into each of the three containers in the diagram to show how particles are arranged in solids, liquids and gases.



Question 2

Connect: Use the line drawing tool to connect the nouns on the left with their matching image and molecular description.



Question 3

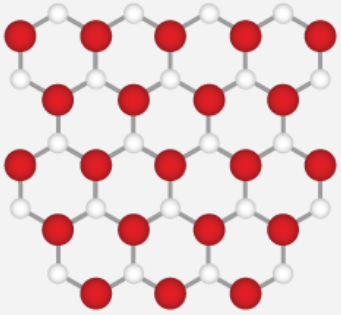
Distinguish: Changes in state are known as physical changes. Physical changes are reversible and can be made by adding or removing heat. Complete the table below by adding the term used to describe each physical change and stating whether the change requires the addition or removal of heat.

Physical Change	Term	Addition or removal of heat?
Solid → Liquid	Melting	Addition of heat
Liquid → Gas		
Gas → Liquid		
Liquid → Solid		
Solid → Gas		

Question 4

Explain: All matter has a mass and a volume. Density is a measure of how much mass is packed into a certain volume. Typically solids are more dense than liquids and gases. Use the particle model of solids, liquids and gases to explain why this is the case.

CRYSTALLINE STRUCTURES



Ice - solid water

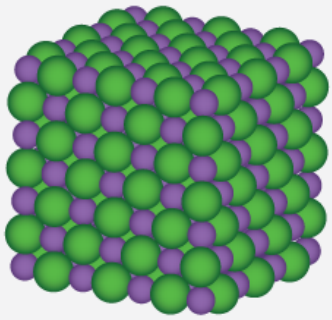


Table salt - sodium chloride

Question 5

Contrast: Unlike most substances, solid water (ice) is less dense than liquid water. This is made evident by the fact that ice floats in liquid water. Above is a picture of the molecular arrangements of two crystalline structures: water ice and sodium chloride (table salt). Look at the illustrations and suggest why you think that ice can float in water.

Question 6

Sequence: Imagine pouring some water into a glass and asking someone to guess how old the water is. The water may have fallen as rain just last week, however, where was it before it fell as rain? In a river or a lake or some snow? What about a well on someone's farm? Those water molecules may have been around when dinosaurs roamed the planet, or when the first four legged fish wandered onto land and took its first breath of air.

Write a short creative story that describes the life of the water molecules in the glass of water. Make sure to explain how the water molecules in the glass have been cycling around from a solid, liquid and gas for millions of years.

Hint: Make sure to describe the various changes in state that your water has undergone throughout its life.

Note: While most of the Earth's water molecules have existed for a long time, small quantities are created and destroyed via processes such as combustion and photosynthesis.

Apply: States of matter (P2)

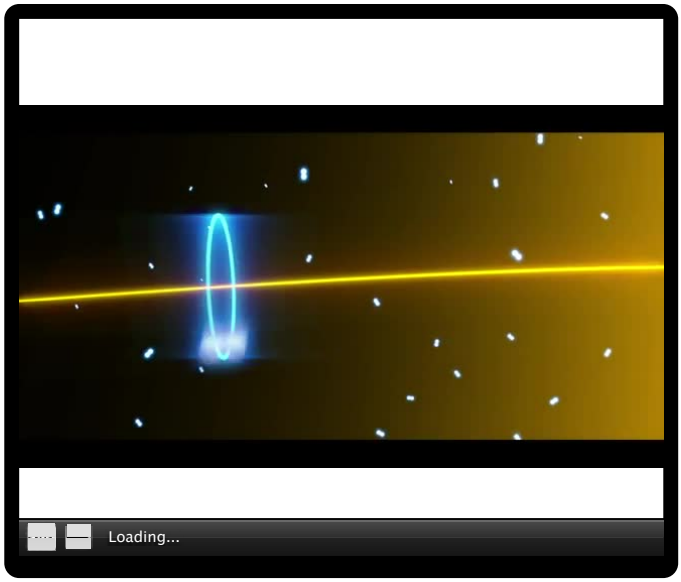
COSMOS LIVE LEARNING

Could we live on Mars?

Left: Clouds and sand on the horizon of Mars captured by the Opportunity rover. Right: The moon and Earth's atmosphere as seen from the International Space Station. Credits: Mars Exploration Rover Mission/Cornell/JPL/NASA and NASA.

Mars has long been the main focus in our search for extraterrestrial life. Initially, scientists wanted to find out if there was water on the planet. We now know that there is, thanks to a range of technology such as telescopes, spacecraft imagery, remote sensing techniques and investigating the surface with landers and rovers. But it only exists as ice.

Credit: NASA / YouTube.



Credit: NASA / YouTube.

Question 1

Apply: The *Cosmos* article refers to a red dwarf planet described by Ofer Cohen as having "pleasant temperatures" but a "fearsome stellar wind" which could strip away its atmosphere. Why is the presence of Earth's atmosphere important for life as we know it?

Question 2

Research: In the *Cosmos* article David Latham says: “If life has taken over a planet and polluted its atmosphere with waste gases, like oxygen, we have actually got a chance of sensing those gases with spectroscopy.”

Use the internet to define the term spectroscopy and explain why it would be useful for discovering extraterrestrial life.

Question 3

Research: There is currently a team of scientists working on the Mars One project which is aiming to build the first human settlement on Mars. Explore the Mars One website to find out what the Mars One team are doing and what how they propose to achieve their aim. Briefly summarise your findings below.

Question 4

Research: The Mars One project involves setting up contained settlements for humans on Mars. Use the internet and any other resources to investigate how we might be able to *terraform* Mars, that is, make Mars habitable by humans. Make specific reference to what we would have to do to the martian atmosphere and how we could make liquid water free available.

Career: States of matter (P2)

Brought to you by Queensland University of Technology

We're all used to watching the weather forecast to find out what weather to expect in the coming week. Now imagine a weatherman on a cosmic scale, forecasting what an entire galaxy might look like in the future. At the Harvard-Smithsonian Center for Astrophysics, Ofer Cohen develops highly detailed computer models that help scientists do just that.

Ofer is a computational and data physicist – a fancy way of saying he designs and works with maths and models used for research in the physical sciences. The computer models he develops are for the Sun's atmosphere, and can be used to study the atmospheres of other stars, as well as their interactions with planets orbiting close by. His models, created using NASA supercomputers, help forecast the evolution of galaxies.

His decision to become a scientist was an impulsive one. As a kid in Israel, Ofer loved studying maps and going stargazing. But from a young age, he was first and foremost a musician, playing the electric guitar. About three months before signing up for university – when he was pretty much already a professional musician – he happened upon a booklet for Tel Aviv University. In it, he found information on the department for geophysics and planetary science, which combined all the things he was interested in – geology, astronomy, and astrophysics. So he just decided to sign up for the course instead of pursuing a full-time music career.

Ofer is still a jazz musician on the side, and he also enjoys watching sports. He has followed soccer his entire life, but since moving to the US, he has become a big fan of American football too.

Question 1

Discover: Use the internet to research three other jobs in science that involve using models to predict future events.

COSMOS LIVE LEARNING

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