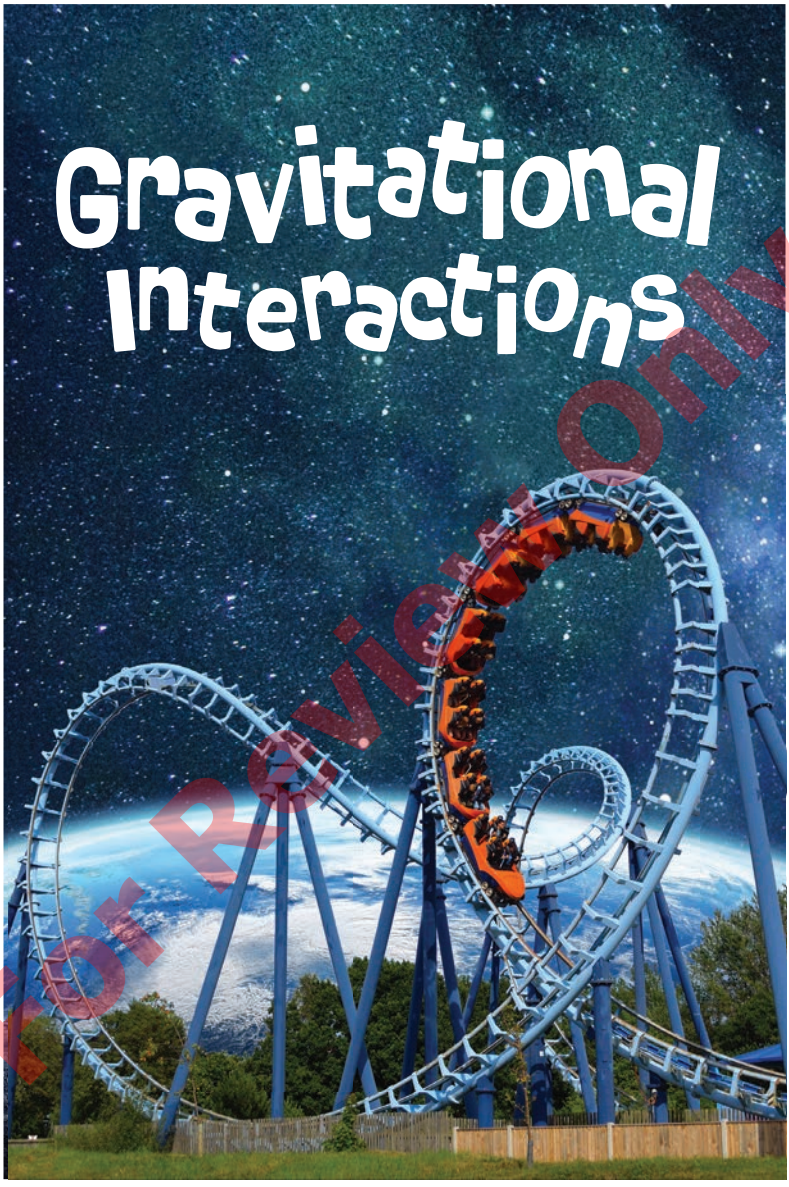

Alyxx Meléndez

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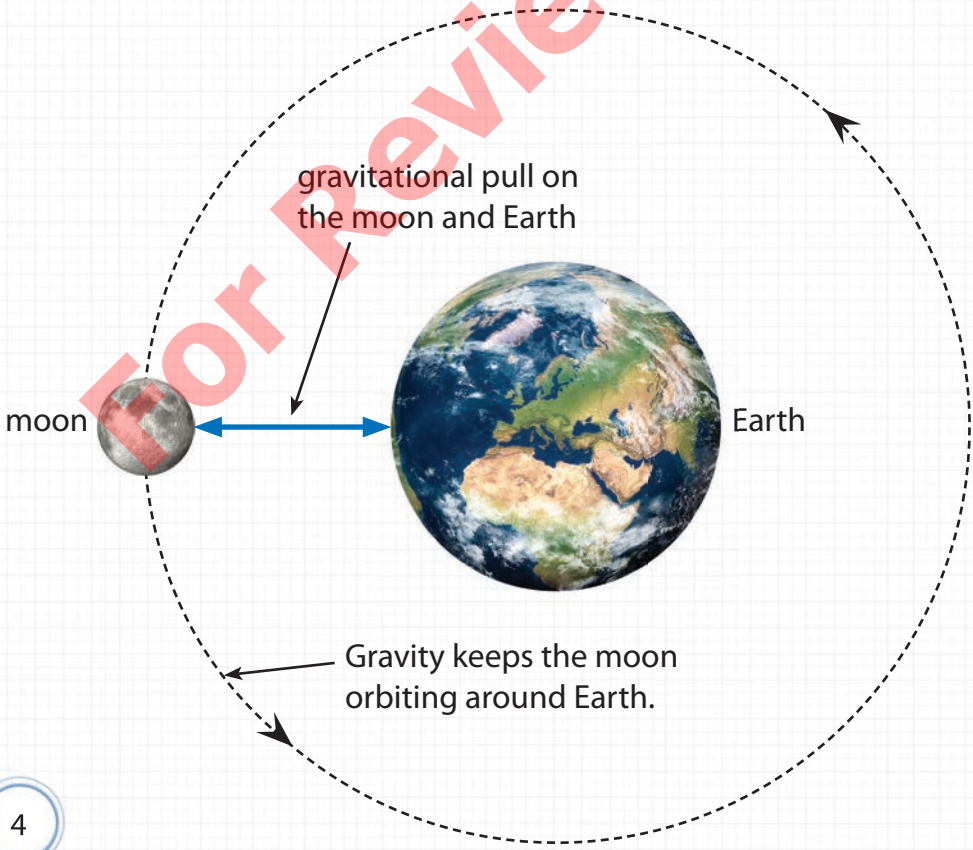
Planetary Pull

Gravity is a force that pulls all objects together. Objects with greater mass have stronger gravitational pulls than objects with less mass. Mass is the amount of matter, or "stuff," in an object. Objects that are very **dense**, such as neutron stars and black holes, also have strong gravitational forces.

So why don't large objects, such as blue whales and skyscrapers, go flying toward one another all the time? The answer lies in their size. Whales and skyscrapers certainly seem massive to humans. But in the grand scheme of things, they are really quite small. From a planet's point of view, even the tallest building on Earth is still miniscule. Only objects as big as stars, moons, and planets are sizeable enough to have gravity that a person can feel.



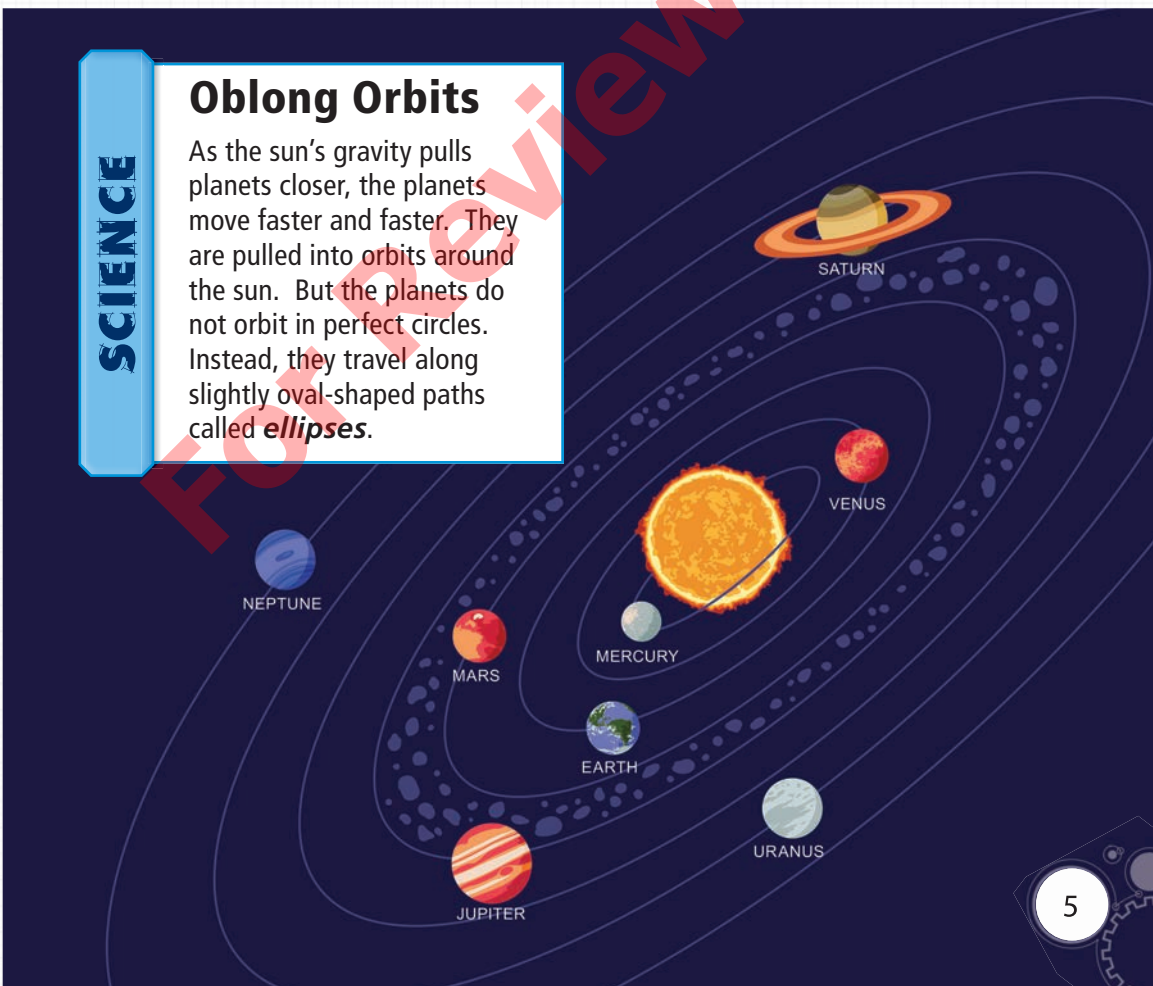
Gravity is what keeps planets in orbit. Planets are pulled toward one another's centers of mass. The objects with the most mass are able to affect the orbits of smaller objects. In our solar system, that large object is the sun. The sun is so massive, it could fit more than a million Earths inside it! That kind of mass allows the sun to send eight planets plus Pluto (a dwarf planet) spinning around it.

Gravity has a profound effect on everything touching Earth's surface. In fact, gravity exists everywhere—and it has different effects depending on where you are.

SCIENCE

Oblong Orbits

As the sun's gravity pulls planets closer, the planets move faster and faster. They are pulled into orbits around the sun. But the planets do not orbit in perfect circles. Instead, they travel along slightly oval-shaped paths called ***ellipses***.

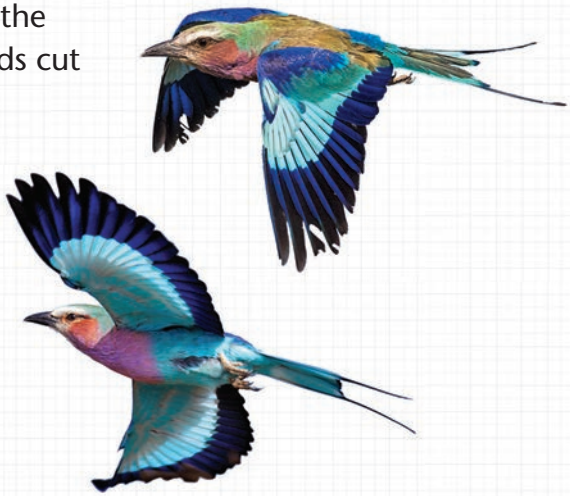


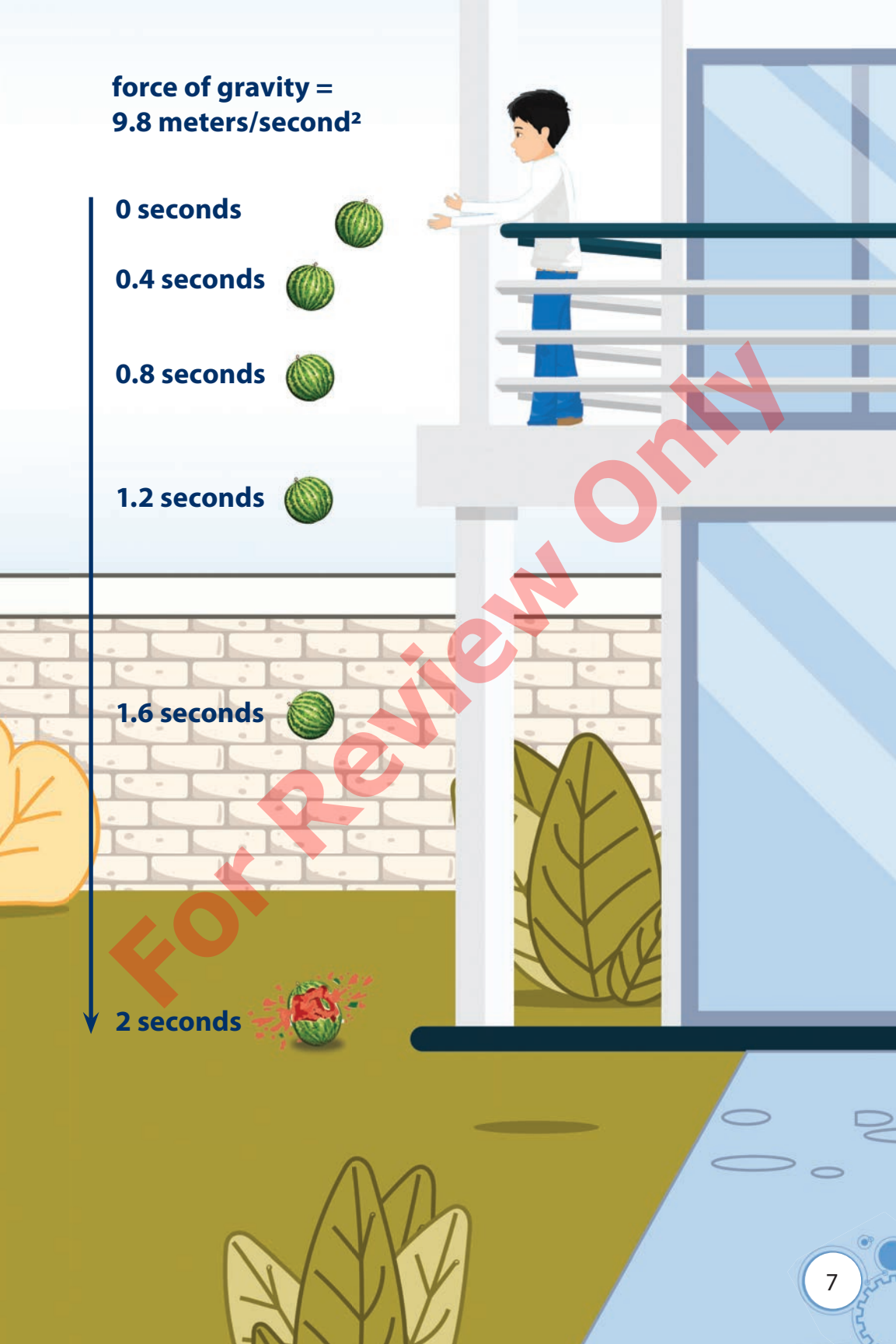
Gravity on Earth

Gravity is measured by how fast an object **accelerates** when it falls through the sky. The acceleration of gravity on Earth is 32 feet (9.8 meters) per second squared. This means that for every second an object spends falling, its speed increases by that amount every second. To put this into perspective, imagine dropping a watermelon from a second-story balcony. As it hurtles toward the ground, it gets faster and faster. Then, it hits with a SPLAT! Dropping it from a lower height would have a much lower gravitational effect. The watermelon would end up bruised instead of split open.

While gravity pulls down toward Earth's surface, air molecules push up against falling objects. Airborne objects, such as parachutes, use air to resist Earth's gravitational pull. Parachutes slow the force of gravity by taking advantage of air resistance. Parachutes give skydivers a larger surface area for air molecules to press against. This helps them slow down as they fall.

In comparison, birds have an even greater command over air resistance. Their wings move air the same way a swimmer's hands move water. Birds flap their wings to push down air molecules faster than gravity can pull their bodies down. To prepare for the next wing flap, they slice their wings forward through the air. This motion lets birds cut through air resistance.

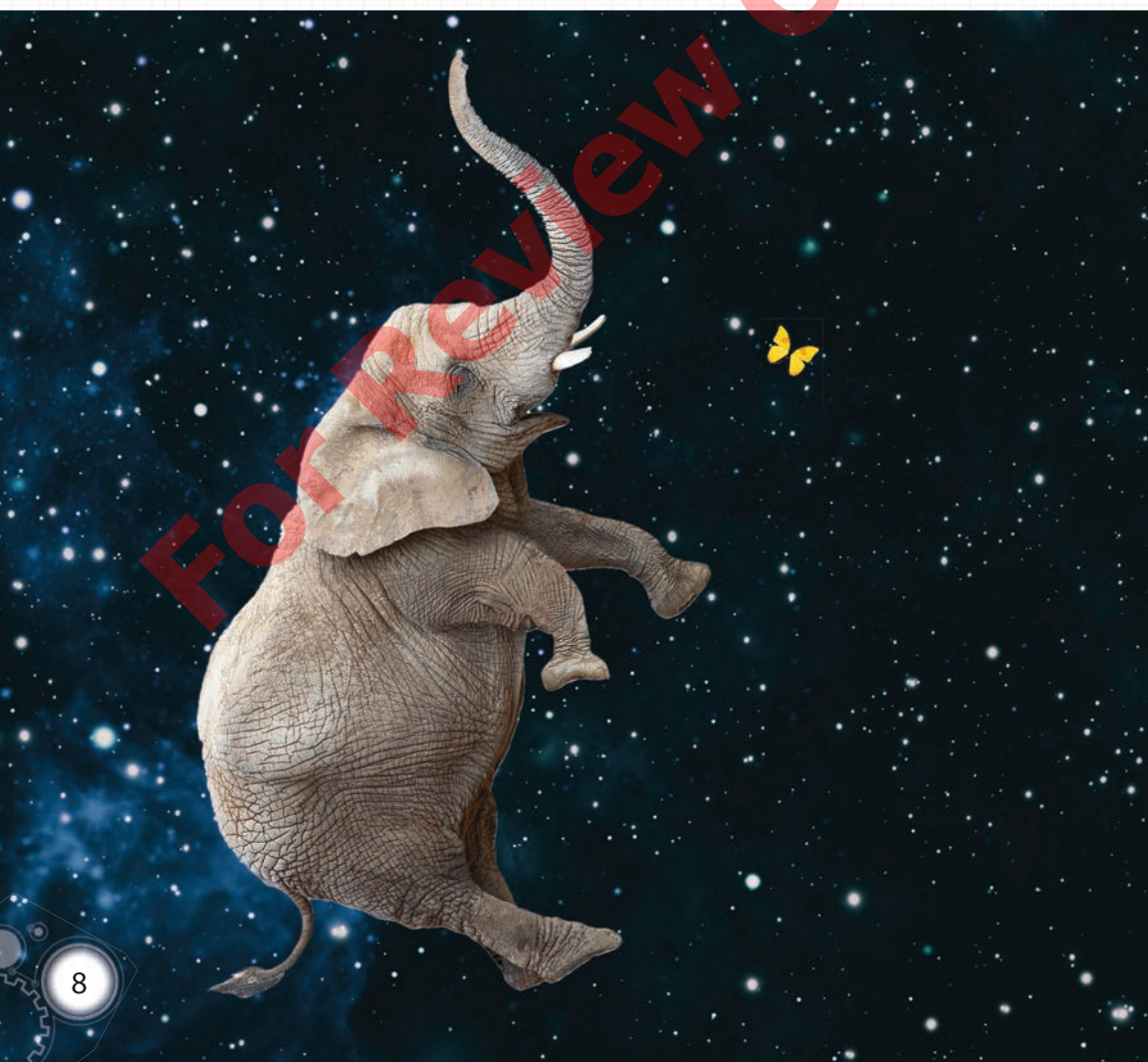




Mass versus Weight

On Earth, anybody can lift a butterfly. But nobody can lift an elephant—not without machinery, at least. But in space, butterflies and elephants would appear to weigh the same. In fact, they would both float as if they were weightless. An astronaut could move both animals with a single tap.

How can something as large as an elephant seem weightless? The answer has to do with gravity. No matter what planet they're on, elephants always have lots of mass, and butterflies always have much less mass. Weight, on the other hand, depends on gravity. It is the measure of gravity's force on an object.



Every **celestial body** has its own gravitational pull. Celestial bodies with lots of mass, such as Jupiter, have stronger gravity. Celestial bodies with less mass, such as the moon, have weak gravity. And in outer space, far away from any celestial body, there's hardly any gravity at all. If an astronaut stepped on a scale in space, their weight would read "zero." So, to measure mass in space, a special scale is needed. This scale measures objects by moving them with a certain amount of applied force. Then, the scale shows how much the object accelerated. These special scales can use mathematical properties to calculate an object's mass!

An astronaut uses the special scale on the space station.

MATHEMATICS

Newton's Laws

Isaac Newton was an English mathematician and physicist. He had a lot of important ideas about gravity. In 1687, he published an idea to explain the motions of the planets and their moons. Today, that idea is known as Newton's law of gravitation.

STEAM CHALLENGE

Define the Problem

People have long been trying to defy gravity and use it for thrills. You can see this clearly at amusement parks. An amusement park near you is planning to put in a new roller coaster. To engage young engineers, they are having a contest. Your task is to engineer a model section of a roller coaster that a marble can safely "ride." If it works, your design could be chosen to be included in a part of the new roller coaster.

Constraints: You may only use the materials provided to you.

Criteria: Your model roller coaster section must stand up straight. It must have one upside-down loop in it, and the marble must stay on the track from beginning to end.

CAREER ADVICE
from Smithsonian

Do you dream of becoming an astronaut?

Here are some tips to keep in mind for the future.

"Astronauts usually have other jobs first. They may be teachers, pilots, engineers, scientists, or doctors. Focus on what you enjoy, and try to learn as much math and science as you can, too."

– Samantha M. Thompson, Curator of Science and Technology, National Air and Space Museum

"Be curious and learn as much as you can. I'm a firm believer that all kinds of knowledge can turn out to be useful in any kind of career."

– Margaret Weitekamp, Chair of Space History and Curator, National Air and Space Museum