**DJORGOVSKI:** Well, where do planets get their atmospheres? There are three sources of it. First of all, you have planetesimals with light elements-- like comets-- hit, and that stuff can evaporate. And if the planet's massive enough it will retain the gaseous envelope. And that's probably were water on the moon comes from.

Then there was certainly some stuff. The evaporation operation from protoplanetary nebula wasn't 100% efficient. And so there's still probably some water and other things, gases, mixed in with rocky planetesimals. And then as a planet settles down the stuff slowly outgasses out, goes to the surface. And then that process can continue through volcanoes, which again are pulling out stuff from inner parts of the planet. And I gasses that can evaporate do evaporate.

So now how much atmosphere you keep depends on the surface gravity of the planet, higher gravity, more atmosphere. And Earth is unique among the Rocky planets in having-- well it's not unique. Venus does also-- but, say, less usual among the rocky planets to keep an atmosphere. The moon doesn't have much of an atmosphere, Mercury doesn't have any. Mars has very little. But on the other hand, gaseous giants are very massive, plenty of gravity they retained all of this stuff in very thick envelopes, which is hardly an atmosphere, really are fluffy envelopes of giants. So that's where the atmospheres come from.

Then what happens to the atmospheres? Well the winds happen. And there are two reasons how that gets to be. The first one is sunlight. Near the equator you get more sunlight because it falls directly, right. Near a pole you get much less because it's an oblique angle. So you have temperature differential. That causes convection along the meridian. The heat from equator rises. It goes up. The cold air near the poles will sink. It goes down. And so you'd expect then that everywhere in the world there'll be winds blowing away from the-- I'm sorry upper atmosphere is away from equator, lower near surface, down from the poles would be very cold.

But that's not all. Earth also rotates. Any planet rotates. Now if there was no

differentiation, if there was no sun, then atmosphere would tend to lag behind the planet in rotation, just out of sheer inertia. And because friction is very low between gas and solid. And so you tend to have east-west winds in the opposite direction of the rotation.

I combine these two things. There's Coriolis force. And you'll learn in mechanics where that comes from. It's essentially due to the conservation of the momentum. If you push something on a radial or within a spinning disc, or on a spinning sphere, it's going to get decelerated because of conservation of angular momentum. So what that does, it breaks these convection cells. And on planet Earth there are three of those on each hemisphere, from equator to the pole. They are called Hadley cells. And so within each one of those, those convection mechanism-- more heat closer to the equator, less heat up there-- causes the circulation. But Coriolis force breaks them up.

Now on the other hand, in a really fast rotating planet, like Jupiter or Saturn, which also doesn't have proper surface but the whole thing kind of drags itself, you're going to completely dominate atmospheric circulation by the planetary rotation. And this is why Jupiter and Saturn they have all these horizontal looking belts. So the winds on fast-rotating, thick-atmosphere planet go east-west. On Venus, which doesn't rotate very much at all, they go north-south. And Earth, which is in between, they kind of go diagonal. This is what the trade winds are.

OK we ran out of time. And so next time we'll continue with some other interesting things about planets, such as where does global warming come from, and then about extrasolar planets as well.