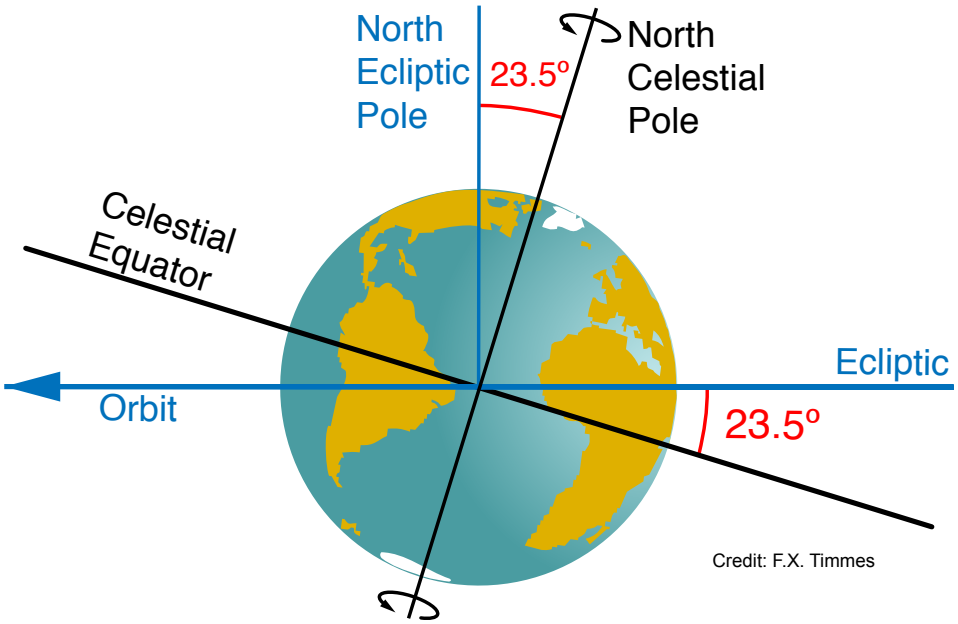
All people everywhere should have free energy sources - Electric Power is everywhere present in unlimited quantities and can drive the world's machinery without the need for coal, oil or gas.
Nikola Tesla

Reason for the Season

Hi everyone. In this module we're going to talk about the reason for the seasons. And as we get toward the end, you may discover you're not the astrological sign you thought you were.

Credit:Chris Hanson
http://xenon.arcticus.com/tree-swing-quadtych

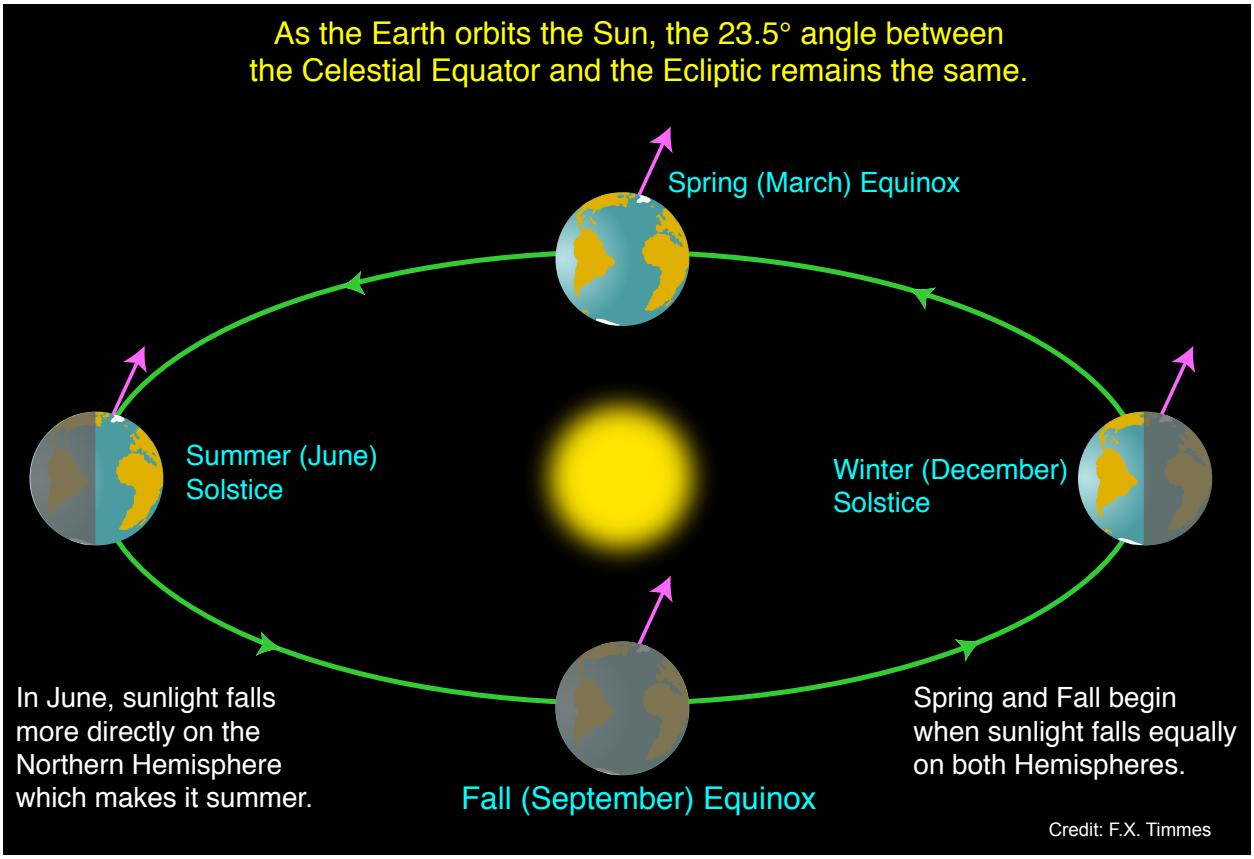
Our learning goal for this module are the reasons for the seasons. What causes the seasons and how does the orientation of the earth change with time? So the image above is sort of the same tree-- well, it is the same tree, it's just some of the objects in there changed. Somebody put a bench in there and then they moved the bench out. But you can see that same tree as it goes through the seasons of spring, summer, fall, and winter.



Credit: F.X. Timmes

What causes the seasons? Well, what causes the seasons is that the Earth, as we've talked a little bit about, is tilted at 23 and 1/2 degrees relative to the ecliptic. So if you have the Earth's equator-- that's the celestial equator-- the ecliptic is inclined at 23 and 1/2 degrees. Or another way to take look at it is this is the sun right here. This is the Earth. This is the rotation axis of the Earth, and the Earth is tilted at 23 and 1/2 degrees.

The seasons do not depend on how far Earth is from the sun. That's a very common, wrong answer, because the Earth's path around sun is pretty darn circular. And so that distance doesn't vary much at all. And it has everything to do with whether that axis is pointed towards the sun or away from the sun. In fact, if you want to get picky, the Earth is actually closer to the sun in the northern hemisphere winter, thereby definitely proving that it's not the distance, and it has everything to do with this angle of 23 and 1/2 degrees.



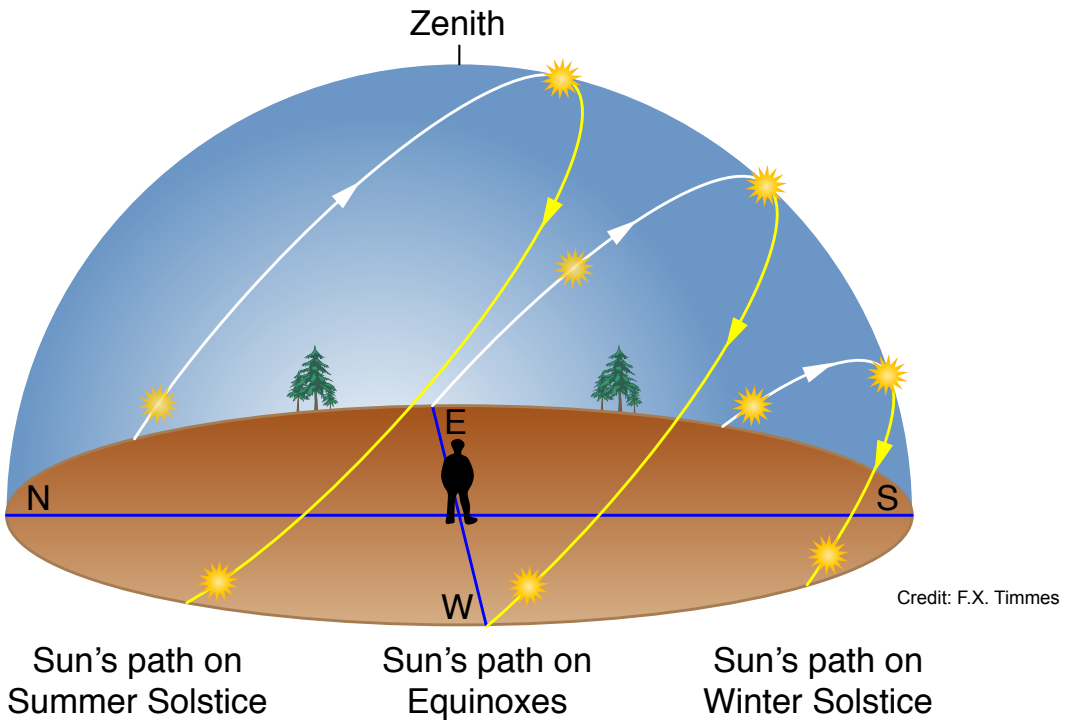
A little bit of detail here as the Earth and Sun do their orbital dance. When the axis is pointed away from the Sun, it is winter in the northern hemisphere. Now the Earth goes around the Sun, and when 90 degrees away, the rotation axis is not pointed directly toward or away, that's referred to as one of the equinoxes, in particular, spring equinox. And as the Earth goes around, and that axis becomes pointed towards the sun, that is summer in the northern hemisphere. And then it goes around, and we get another equinox-- equinox meaning equal day and equal night. So this is when there's 12 hours a day and 12 hours a night. And back to the , when the nights

are long and the day are short. Do you take a little bit of time to go over this image as it'll give you a a good understanding that the seasons are caused by the tilt.

You can also do the extreme cases. Suppose this was the Sun, and suppose Earth's axis axis tilt and it was straight up, zero degrees. What season would it be? Well, it would depend where you were. And as you orbit the Sun, there would be no change in seasons. So a planet that has a rotation axis straight up has no seasons. If you wanted to ski, you'd head toward the north. If you wanted to go to the beach, you head south.

Take the other extreme case. Suppose the axis tilt is all the way over, 90 degrees, like Uranus. Uranus is tilted all the way over on its side. Its winter when the northern rotation axis is pointed away from the Sun. Uranus is spinning on its side doesn't have anything to do with it. And the winter would last "six months" until the orbit takes Uranus to the other side and then it would be daytime for "six months". So that would be the extreme case, as it would be on Uranus.

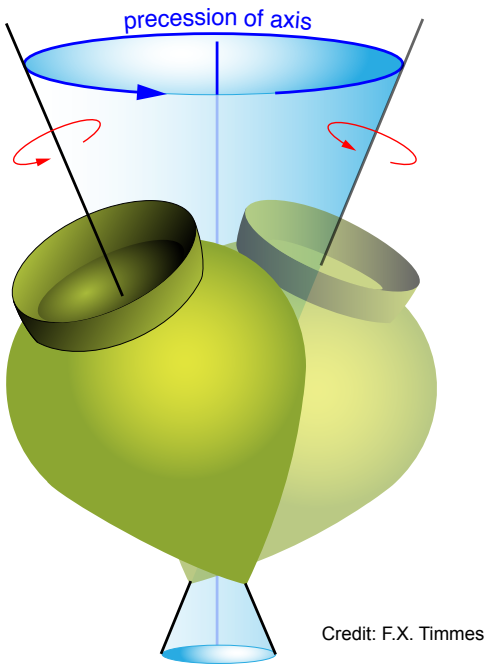
Earth has a relatively modest 23.5 degrees. So we get a very mild change in our seasons.



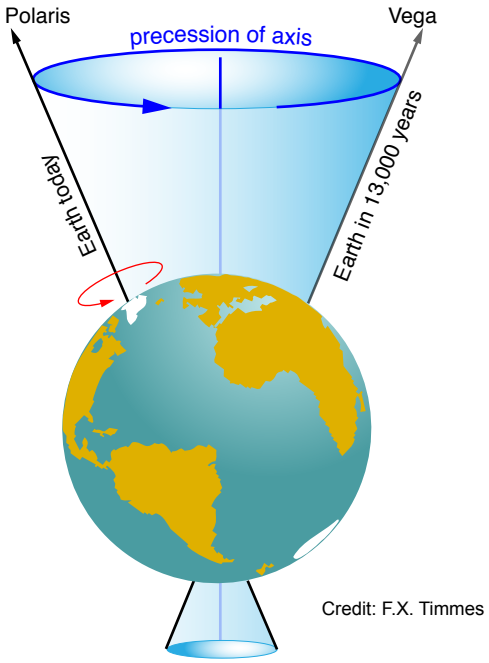
The altitude of the sun above the horizon also changes with time. Hopefully, you've noticed this on the years you've been on this planet. In the winter, the sun is low on the horizon. The sun is very low. And then as you come up to the equinox, the sun rises high, and then during the summer months, the sun is very high in the sky. So the image on the left is showing tracking the sun at different points in year, whether it's slow in the sky, medium in the sky, or high in the sky.

If you go outside and you take a picture of the sun every day-- or every other day, something like that-- against a fixed object like a building, you will find that the sun traces out a figure eight pattern. This is referred to as an analemma.

You see this on every globe. If you go into map store, you look on any globe, you look on any map, you always see this figure eight. Maybe you've never noticed it before, but hopefully now, if you go in and look at map, you will. And that's the analemma, showing the position of the sun as a function of time on a globe. That's the 23 and 1/2 degrees.



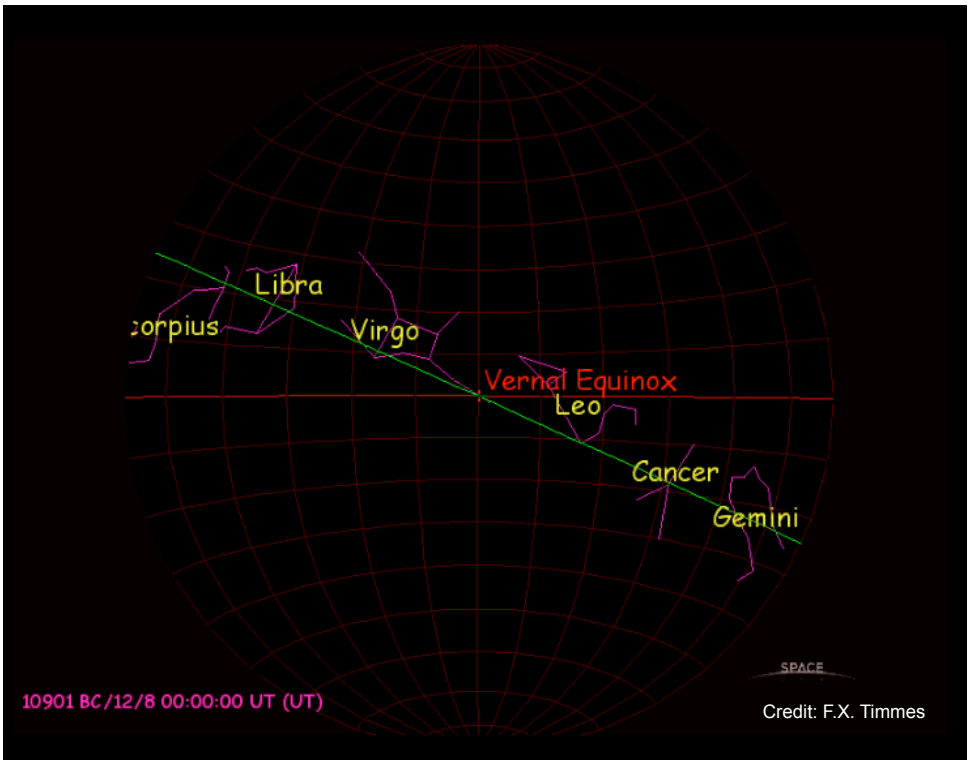
Does that 23 and 1/2 degrees ever change with time? The answer is no. But there is a wobble. You've all seen a top. You've all played with a top. You take a top and you let it go. And what happens? The top spins and eventually-- the top is still spinning, and it starts to wobble. It starts to carve out a path. And that path as refer to as precession. And because the Earth is rotating, the Earth is just like a top. There'll be an axis, and the Earth's 23 and 1/2 degree axis is going to rotate around. It takes about 26,000 years for the Earth to complete one top wobble, if you like.



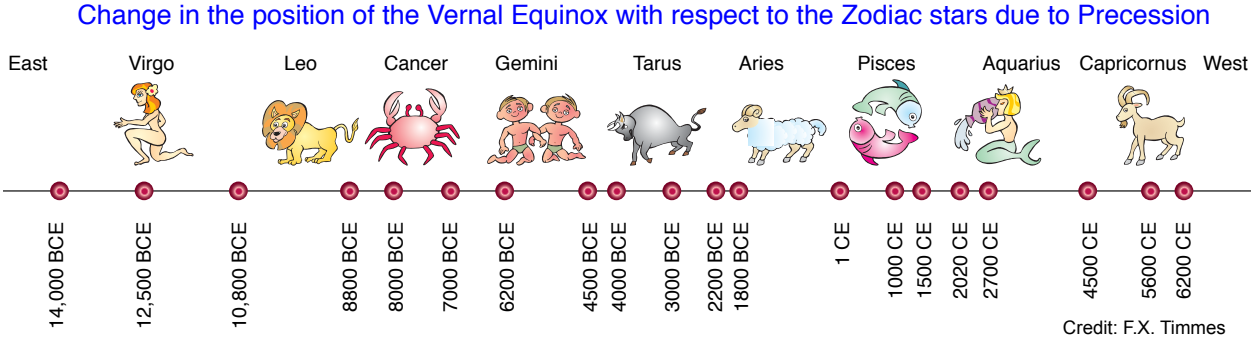
Precession doesn't change the axis tilt (staying at 23.5°), but it does change the constellations associated with solstices and equinoxes. For example, ~3000 years ago the Sun appeared in the constellation of Cancer at summer solstice, but now it appears in Gemini. You can see the impact of precession on any world map: the latitude at which the Sun is directly overhead on the summer solstice (23.5° N) is called the Tropic of Cancer, it got its name when the Sun used to appear in Cancer on summer solstice. The image below shows the location of where the Sun is directly overhead near the topic of Cancer in Mexico changes with time.

You can see that on any map. When you go see Cancer, for example, on the map, you have the constellation of cancer-- the tropic of cancer, sorry-- the tropic of Capricorn. And those are on the maps because about 3,000 years ago, that is where the sun appeared at summer solstice. So 3,000 years ago, when the Babylonian were setting a lot of this up, the sun at solstice, appeared in Cancer. And so the northernmost point where the sun appear directly overhead defined the boundary of the tropic of cancer. And you can see that on any given map, and there's a monument to it there on the image on the right.

The image below is a frame from a movie of the different constellations as you go through precession. This movie goes from 10,000 minus 10,000 before common era to about 15,000 after common era. And you can see that as the movie plays, the position of the sun changes in the constellations as it goes through its 26,000 year wobble, our precession cycle.



This is the only time I will ever mention astrology in this course, so pay attention. When astrology began about 3,000 years ago, your sign was supposed to represent the constellation in which the Sun appeared on your birthday. However, that's no longer the case because of precession.



The image above -- same as the movie above but flattened out — shows the position of the Sun at the Vernal equinox (spring equinox) changes with time as Earth executes its precessional wobble. If your birthday is June 1 and you take a look at a common horoscope, it will tell you that you're a Gemini. Well, that was true 3,000 years ago, but it's not true now. The Sun now appears on Taurus on that date. And so technically, you're a Taurus, you're not a Gemini. So you are probably not the astrological sign that you thought were.

Thanks! Bye Bye!