Today we’re gonna be talking about ancient astronomy, things that were known thousands of years ago — or at least hundreds of years ago. So we’re not gonna be discussing anything that we’ve found out in the last couple of centuries. We’re gonna be talking about those basic things that people thousands of years ago were aware of but you might not be aware of.

And the difference is that thousands of years ago we didn’t have lighting in the streets, we didn’t have television. And so thousands of years ago people did not have anything else to do at night except look at the stars or sit by a fire. And the skies were very dark and so people were able to study the constellations, study the night sky, and so they all became familiar with it. Today we’re in the middle of a city. You can walk around at night in the city and still not be able to see anything up in the sky.

And so probably people thousands of years ago knew a lot more about how the sky worked than you do. And so today we’re gonna go over some of those things that you should know about, as far as what’s happening up in the sky, but you may not be familiar with.

This is a drawing showing you standing in the middle of a field and we’re gonna have some definitions so we know where we are when we look up at the sky. For example, anything that is straight over your head — if you’re standing on level ground, on the earth, the point directly over your head is the zenith. So we start with the zenith, the point directly over your head. Ninety degrees down from the zenith in any direction is the horizon. So when we talk about the horizon astronomically, we are referring to a circle around the sky 90 degrees from the zenith. Now, that may not be your actual horizon. If
you were standing down in a valley somewhere and there were mountains around you, your horizon might be the tops of the mountains all the way around. That would be up in the air a little bit. Or, if you were on the top of a mountain and you were looking out, you could see down below what we would call the astronomical horizon because you’re actually higher. But the astronomical horizon officially is designated as 90 degrees from the zenith, and so it is what should be level with your eyes all the way around when the zenith is directly over your head.

We also have other definitions you’re probably familiar with. In this direction along the horizon we have the direction of north. We sometimes refer to that as the north point. It is an actual point directly north of you along the horizon. We also have east. Ninety degrees around from north is east. Ninety degrees around from east is south and, as you might have guessed, ninety degrees around from south is west. So you’re familiar with those.

If you’re watching the sky at night, you would notice that anything that came up comes up in the east. If you’re sitting out and the sky is clear, and you’re looking at the stars and you’re out there for a while, you will notice that things tend to rise in the eastern part of the sky, go around the sky, and then down in the west. When they get to the middle of the sky, they’re easiest to view. So if something is rising in the east, it may be kind of hard to see because it’s down low. It goes up high in the sky and then it goes down to the west and sets. When it gets to the middle of the sky, we say that it is on the meridian. So the meridian is a line that runs from the north point of the horizon up over through the zenith and down to the south point on the horizon.
So if you can imagine this line, imaginary line, across the sky from the north point on the horizon, up through the zenith, down to the south point on the horizon, that is your meridian. Keep in mind this is all with respect to you. Your zenith is over your head, your meridian runs from north through your zenith to the south. And so if you’re outside looking at the sky, you will see things come up in the east, go across the meridian — that’s when they will be highest in the sky — and then they go down toward the west.

And it’s always symmetrical. If something starts out down here in the southeast, it goes up partway, reaches the meridian, and then goes back down into the southwest. Notice it never goes over toward the north at all. It starts out in the southeast, goes up, crosses the meridian — so you would say it was directly south but up a ways — and then it sets in the southwest.

If there’s something rising directly in the east, it goes up, crosses the meridian — notice it’s not over your head. Something rising in the east does not go through your zenith. It goes up at an angle, crosses the meridian fairly high in the sky but not straight overhead, and then goes back down and sets directly in the west. Now, there’s not a line on this drawing. But if you were to have an object rise up here in the northeast, it would go up the sky, across your meridian, and then come back down and set in the northwest.

So actually in order to have an object cross your zenith, it would have to rise north of east and go up the sky over your head and then back down and set in the northwest. Thousands of years ago people knew about this all the time because they saw it every night. You don’t necessarily watch the sky for many hours at a time. You might not even notice which way the stars are moving. But they always go from east through the
meridian and down to the west. Any question on that?

Now, let’s back off a little bit. That was a very local view. That was you standing in
a field. Let’s back off so we can see the entire earth. Is that fairly clear? Okay. Here you
are now, standing in that field on the earth. Now I’m showing you that the earth is round.
On the previous drawing it looked kind of flat. Well, if you stand out in a field, it does look
kind of flat because it’s large enough you don’t notice the curvature. But on a large scale,
you are standing on a spherical earth. Straight up is still your zenith. This is south, this is
north. We are now seeing how the earth is tilted with respect to the heavens. The earth’s
axis, its rotation axis, is pointed in a particular direction in space and the earth is spinning
around that axis.

And so as you look up at that point in space, the entire sky will seem to go around
that axis. So what you see is stars rising in the east, crossing the meridian and going
down in the west is actually the reflection of the earth going the other way. You’re
standing on a moving earth. It’s moving toward the east. And so you see things appear to
come up in the east and go toward the west.

So when we’re just standing in a field, it’s not obvious what’s actually happening.
But if we back off and look at the earth from a distance, then it’s more obvious what’s
going on. We are on a rotating earth and the entire sky seems to be going around us
because that earth is rotating on an axis. This axis points toward what we call the North
Celestial Pole. Notice the North Pole of the earth is right there where that line meets the
earth. But the North Celestial Pole is out among the stars.

Now, there is actually a place up in the sky that we can point to as being very close
to the North Celestial Pole. There is a star up there that happens to be almost exactly up
that line and that star is called Polaris. So it’s named as the pole star, Polaris. It’s not
exactly at the pole. It’s quite close. So if you were just looking up in the sky and you saw
it, that would be pretty much the direction toward the North Celestial Pole.

Since the sky goes around the North Celestial Pole, that point in the sky never
shifts. So if you’re looking up at the sky during the night and you’re watching the North
Pole or Polaris, you would not see it moving. You would see other stars come up and go
down around it, but that particular place in the sky would seem to be fixed. And it’s
because the earth is rotating around that axis.

Now, the pole star is at a particular altitude up in the sky. In other words, if you look
at it, it’s not on the horizon; it’s partway up the sky. That angle up the sky is your latitude
on the earth. In other words, if you’re at a certain latitude on the earth here, this angle up
the sky is going to be the same number. So in Springfield here we’re about 37 degrees
latitude. And so if you were to look up at the sky at night, look toward Polaris, Polaris
would look about 37 degrees up in the sky all the time. It’s always at the same altitude.

And so down here near the South Celestial Pole, notice that is actually through the
earth. For you to see down here, you would have to be able to look through the earth.
You cannot see any of the stars or the sky that is down near the South Celestial Pole
because it’s always below your horizon. You cannot see that far down. Stars that are up
here around the North Celestial Pole seem to go around the pole but never set or rise.
They’re just going around the pole, showing you where the pole is. Sort of moving around
it. The stars that are from here down to there up in the sky seem to rise in the east, go
across your meridian, and set in the west. So the arrangement of the entire sky is based on the tilt of the earth’s axis, how it is rotating, and what you see as you look up in the sky during the night.

Now, what do you see when you look up in the sky at night? Well, if it’s not cloudy, hopefully you see some stars. And for thousands of years astronomers looked at those stars and decided that they were going to name them. If you’re looking at thousands of stars in the sky and you haven’t labeled them or named them, you can’t say to someone, “Hey, look over there at that part of the sky” because there are too many stars.

And so thousands of years ago, having nothing much else to do in the dark, astronomers and farmers and people tending their sheep would name various groups in the sky. Sometimes they named them for what they looked like. If you had three stars in a nice, equilateral triangle, you might just call it “The Triangle.” Or if you had four stars that looked like they were in a square, you might call it “The Square.” But sometimes there was just a bunch of stars up there that didn’t have a particular shape that you could figure out, and so maybe you decided to name it after an animal or a god or somebody famous from mythology.

And so some of those constellations, some of those groups of stars, are named for things that they don’t look like. And so you may look up in the sky and say, “Well, that doesn’t look like an archer.” Well, it was never really meant to; it was just named for that so people would be able to discuss it.

I have some slides to show you of these constellations so you’ll get an idea of what they look like.
This is a drawing of an ancient Egyptian constellation chart. You can’t see much on this chart. You can see some pictures but there are no dots for stars. Here are a few stars. There are a few stars over here, but they seem to be arranged in a strange pattern. That’s not the way the sky looks. Thousands of years ago people marked where all the constellations were but it didn’t necessarily make it any easier to find them.

Here’s an ancient Chinese constellation chart. Now, on this chart at least there are some stars marked and there are some lines between the stars to guide your eye to see what that constellation was supposed to be. Unfortunately, many of the names for these constellations are not the ones we use today. Different peoples gave different names to different groups of stars. There’s nothing unique about a particular group of stars. I might call it The Triangle, somebody else might call it Three Wisemen. You know, they might see three stars and give it a fancy name. I just called it The Triangle.

And so different groups gave different names to these constellations. And so there was no standard list for constellation names until the 20th century. That may surprise you. But until about 1925, there were many constellations in the sky that no longer exist officially. Because different groups had different names for them and nobody had really decided what is the official name for that group of stars.

But since 1925 the International Astronomical Union, a group of astronomers, got together and said, “Okay. We’re gonna have one set of constellations that will cover the entire sky.” Turned out to be 88 of them and since then we have 88 official constellations. And I’ll show you a few of them.

This is one particular constellation. Let’s just see if I can turn this off. Okay. You
can see it better now. Anybody recognize this constellation right off? This is probably the oldest known constellation in the sky. This is the constellation of Ursa Major or The Big Bear, but you would recognize it more as The Big Dipper. Here’s the bowl of The Big Dipper and here’s the handle of The Big Dipper. But this constellation was named The Big Bear probably more than 10,000 years ago. As far back as we can follow it in history, it’s always had the same name — The Big Bear.

Now, we call it Ursa Major. That’s Latin for The Big Bear. I’m sure 10,000 years ago they weren’t using Latin. But they still referred to that group of stars in the sky as The Big Bear. So it’s the oldest, most ancient constellation and it is one of the easiest to find in the sky. If you know any constellations at all, you can probably find The Big Dipper. But it doesn’t look like a bear — at least not to me. It looks more like a dipper. And so most people when they identify it identify it as The Big Dipper rather than Ursa Major or The Big Bear.

Here’s a group of stars. Can anybody identify that one? Just looks like a bunch of stars, doesn’t it? Actually, this is The Big Dog. The ancients were fond of naming things after animals. We had The Big Bear and here we have The Big Dog. Now, you might say, “Well, where is this dog?” Well, I’ll guide you through the parts of the dog and so you’ll be able to see that there’s a dog there. Up here, this star is the brightest on that picture. That’s known as the Dog Star. Serious. The Dog Star. Think of that as the nose of the dog. From the nose, you have ears going up — so here are his ears. Here are his legs. Here’s his back and his back legs and his tail. So if you stare at those dots long enough, do you see a dog looking at you — with its tail sticking out? Maybe, maybe not. If you sat
outside in the dark for an hour or two, you might begin to see a dog. You never know.

Okay. Here’s a constellation that’s even worse than the dog. This is the constellation of Taurus the Bull. Anybody see a bull? Not particularly. Okay. This bright star right here is Aldebaran, the Eye of the Bull. That’s its name, The Eye of the Bull. So what you have is the face of the bull here sideways. You’re actually looking at the bull from above. So think of looking down at a bull, at a safe distance. This is its face, there’s its eye, and its horns go all the way up to there. Very long horned bull. I know you think I’m giving you some bull right now. Well, that’s the name of the constellation, Taurus the Bull.

Notice up here in the corner is a little group of stars. Some people think, if they don’t know the constellations, that that looks a little bit like The Little Dipper maybe. And they stare at it sometimes. Students ask me, “Is that The Little Dipper up there?” No, it’s not. That’s actually part of the constellation of Taurus the Bull. Because for astronomers it’s not just the stars and the face and the horns, it’s the entire area of sky is the name for that constellation. And so that little group of stars up in the corner actually is part of that group, that constellation, even though it doesn’t seem to be a part of the bull. Unless it’s a fly buzzing around the bull.

But in some cases this little group has gotten its own name. The Japanese name for that little group is Subaru. Recently they’ve actually named a car after it. But for thousands of years it was known as Subaru, a separate, small constellation. And if any of you own a Subaru, you may recognize that that little group of stars is actually a symbol on the car. So if you see a Subaru out in the parking lot, take a look. That symbol has those
stars in that pattern on it. So sometimes a part of a constellation or an ancient name of a constellation is still in use.

Okay. Here’s another group of stars. What are we looking at there? Well, hard to tell. You’re looking at another animal. You’re looking at Leo the Lion. Anybody see a lion? Not exactly, huh? Okay. Let’s find the lion. Up here is what looks like a backwards question mark. Everybody see the front end here with the backwards question mark? That’s the mane of the lion. So this is his head and that’s his mane, and these are his front paws down here and here’s his back and there’s his tail. Maybe this is his back leg. Everybody see that lion? Hmm, that’s kind of pushing it, isn’t it? When I want to look for this constellation in the sky I look for a backwards question mark with a triangle behind it. It’s easier for me to find it that way. But the official name is Leo the Lion. You have to be outside for at least two hours to find this one.

Okay. Here’s an important constellation. Anybody recognize it yet? No. This is Sagittarius the Archer. I mentioned a few minutes ago an archer doesn’t look like an archer to me. But actually you can push the point a bit. You see these three stars right here? That’s his bow. And that’s the arrow right there. So there’s the bow and the arrow, and the archer is back here somehow. I’m not quite sure how to put his head or his arms next to the bow, but he’s there. Most people do not find this constellation by looking for the arrow or the bow or anything else having to do with an archer. What they look for is what looks like an old-style teapot. So if you look at this group of stars here, that’s the bowl of the teapot. There’s the spout of the teapot and here’s the pyramidal top of the teapot, and over here is the handle of the teapot. Can you see the teapot? The handle on
the opposite side from the spout and the pyramid on the top. So if you were looking for this constellation, it would be easier to find the Sagittarius teapot than it would the archer. I can see you eyes are glazing over. You’ve seen too many stars.

Okay. Here’s the last group I’ll show you. What does this one look like? Now, so far it’s been mainly animals and an archer. We haven’t shown any constellations that were named for famous people. Well, this one is named Cassiope the Queen. Everybody see a queen? No, you don’t see a queen. This is one of those constellations that was named in honor of a mythological figure, Cassiope the Queen. But if you’re just looking at it, it kind of looks like a W that got sat on. It’s true. Cassiope sat on it. Or actually this is one of those circumpolar groups that goes around the pole. Sometimes during the year it looks upside-down so it looks like an M that was sat on. So it depends on when you see it whether it looks like a W or an M.

But actually many people find it by looking for what they call Cassiope’s chair. Do you see a chair? This is the back of the chair, here’s the seat, and here are the legs. So if you look at a chair — kind of an odd looking chair, but it is sometimes referred to as Cassiope’s chair. If you’re trying to find it, you can look for a W or you can look for a chair. But I wouldn’t try to look for Cassiope the Queen because it’s gonna be very hard to figure out what she looks like up there in the sky.

Okay. That’s all for the slides. Well, you still don’t know where any of those constellations are, right? I just showed you some pictures in the sky. In order to learn where they are, to be able to identify them, you’ll have to use the star charts that are in your book. The star charts are labeled according to the season so that we are now in
winter season but we could be in summer or spring or fall. And so you pick the particular chart that fits the season of the year and it will show you which constellations are above the horizon at night. And the reason you have to choose a particular chart — you can’t just take the same chart all year long — is that not all the stars are visible all year long. And the reason that they’re not I can demonstrate on this drawing.

Okay. What you have here is a representation. We’ve now actually backed off farther than we did a few minutes ago. You have the sun and you have the earth going around the sun. Now, this was not necessarily known to people thousands of years ago. They didn’t know why it was happening but I’ll give you the modern explanation just to make it a little simpler for you.

The earth goes around the sun in its orbit. In order for you to see constellations, you have to see them at night — which means the sun has to be on the other side of the earth. And so if you’re over here on January 1st, the sun is in that direction and so you would not be able to see that constellation Sagittarius the Archer or the Teapot because it’s directly on the other side of the sun. In order to see that, you would have to go all the way around to this point in the earth’s orbit so that you — it would be actually July. And then when you looked out in that direction, that would be the opposite direction from the sun and so you would see the constellation of Sagittarius at night in July but not in January. And the reason is, we’re going around the sun. And so if a particular constellation happens to be in the direction of the sun at a particular time of year, you can’t see it because it’s up during the day.

So if you’re looking for Sagittarius, the Teapot, you don’t want to look for it in
January. You want to look for it when the earth is over there in July. But there are constellations all the way around the sky. Notice the constellation of Leo that I mentioned a few minutes ago. The backwards question mark and the triangle at the back end. If you’re looking for Leo, best time to look would be in March. Because in March it’s in the opposite direction from the sun. Even in January you’d still be able to see it because it would still be up at night. So it’s a constellation that’s actually coming up during the night right now and will be easiest to see in March because it will be in the opposite direction from the sun. So you have to know during which season which constellations are visible.

There are some constellations that you can see all year long if you think about constellations that are straight up from the earth. Not in the direction of the sun or in the opposite direction, but 90 degrees to them. Those are the constellations that are up near Polaris. And so as the earth goes around the sun, they’re always about 90 degrees from the sun and so you can see them all year long. The circumpolar constellations, the ones that are near Polaris, you can see all year long. They may be in slightly different positions in the sky but they are visible all year long.

But any constellation that is in the plane of the earth’s orbit is going to be blocked by the sun at certain parts of the year, and is going to be visible at night during other parts of the year. So we actually refer to the winter constellations, the spring constellations, the summer constellations, and the fall constellations. And those are the constellations you can see best during that particular season.

The big bear, Ursa Major, is a circumpolar constellation. It’s visible all year long. And that may be one of the reasons why it was the earliest one named. It’s the most
obvious of the circumpolar constellations. It’s the easiest one to find. And since it was visible all year long in the northern hemisphere, it was probably the first one recognized as a particular group.

Notice that all these constellations have names that may resemble names you’ve seen in astrology. I’m sure you might recognize quite a few of those. Here are a few more over here. Virgo, Libra, Scorpius. Why would these particular constellations have names that are used in astrology? The reason is that they are constellations specifically that are blocked by the sun. All around the sky there is a group of constellations that are along what we call the ecliptic. The ecliptic has several definitions. The one I like the best is it is the plane of the earth’s orbit. So if you think of the earth’s orbit here as a flat plane, a disk, those constellations are out along that disk.

But the ecliptic is also defined as the path of the sun around the sky during the year. The reason it’s called that is because if you’re looking at the sun from the earth, it is blocking some constellation along the ecliptic. And so if you think of the path of the sun as the mirror image of the orbit of the earth, you’re looking toward the sun, away from the earth, the path of the sun around the sky follows the ecliptic. Because we are going around the earth’s orbit and so any time we look at the sun, we are looking in the direction of those constellations that are directly behind the sun. So we call the earth’s orbit the ecliptic or the path of the sun the ecliptic.

But particular constellations that have those names around the ecliptic are also referred to as the Zodiac. The reason they’re called the Zodiac is that most of them are named for animals. And the word Zodiac has its root -- the same as zoology or a zoo is
having to do with animals, and so the Zodiac has Leo, Cancer the Crab, Taurus the Bull, Pisces the Fish. A few of ‘em aren’t. Capricornus is a goat person so it’s only part animal. Scorpius is a scorpion. Virgo is a virgin, that’s not an animal. Libra the Scales, that’s not an animal. But most of them are named for animals. Any questions on that?

Okay. What else did the ancients worry about other than constellations? They worried about the calendar. Now, you probably worry about the calendar but not in the same way they did. You worry when your Christmas break is over or when Spring break is over. You want to know when school is going to begin so maybe you check the calendar to find that out. You want to know what today’s date is so you can write a check. We take the calendar for granted. It’s always there. You get them free in the mail. Or you can buy one with fancy pictures attached to it, but it’s always available.

Well, thousands of years ago people didn’t know exactly when things were going to happen. If you were stuck on a desert island somewhere, how would you know what date it was? You might try to keep track of things. You might write down every day in the sand. Say, “Okay, this is day one. This is day two. And I started being here on a certain date.” And you would try to follow that. But after awhile you might forget. You might not mark things down. And so if you’re there for more than a year or two, you may not know what the date is. You may not even know what the season is.

Now, if you’re on an island that has seasons, that would be helpful. If you’re on a very northerly island or a very southerly island, you might get snow and so then you know it’s winter. It might get awfully hot sometimes and you kind of guess it’s summer. You might also notice that the sun is high in the sky when it’s hot and that’s a good indication
it's summer. You might notice it's low in the sky, the sun is always low in the sky during the day when it's cold out or when it's snowing. That's a good idea that it's probably winter.

But knowing the calendar down to the day takes some work. Thousands of years ago one of astronomers’ major projects was to know the calendar, to know when things were going to be happening. And there were several reasons for this. One, you have to know when to plant crops. If you plant too early, you might get a late frost — or what isn't even a late frost, just a regular frost — and that ruins your crops. If you plant too late, you won't be able to get the plants completely grown before you run out of summer. And so you have to know what time of year it is in order to plant your crops correctly.

There are also many religious holidays and those religious holidays were specifically at certain times of the year when certain things were supposed to be happening. And so astronomers were charged with knowing when they were coming up. So they had to know the calendar. It's not easy to tell exactly how long the year is. You can look at the stars, you can look at the sun, you can feel the seasons. But knowing that the year is exactly 365-1/4 days is not easy. And so thousands of years ago different groups of people had different concepts of how long the year was.

The Egyptians thought it was about 360 days. That's close. They liked that number. 360 was almost a magic number for them because it’s a nice, round number. It's divisible by many, many other numbers. And so they actually decided that the year should have 360 days. And they noticed that as the sun moved around in the sky, as the constellations shifted from night to night and week to week, month to month, during the
year, that everything seemed to shift about 1 degree per day. And so that’s how they came up with 360 degrees in a circle. 360 days in a year, 360 degrees in a circle. It just seemed to work so nicely. Well, it turns out it’s not exactly 360 days in a year; it’s 365-1/4. It’s not even an even number.

And it took a while, but other people — the Babylonians figured out that it wasn’t 360. It was more like 365. But not all peoples were using a 365 day calendar. Some were using the 360, some were using the 340 or the 320. Some weren’t even using a solar calendar. We based the year on repetition of the positions of the sun. We go around the sun once, we say that’s a year. Some peoples didn’t even use the sun. They used the moon. The moon was an easier thing to keep track of.

Let’s start out with full moon. You look up in the sky and you see a full, round moon on a particular date. About 30 days later, you will see another full moon. So you will notice month after month that about every 30 days you have a full moon. You can actually keep a calendar with the moon. Now, it turns out it’s not exactly 30 days. It’s more like 29-1/2. These things just don’t quite work out equally. But it’s close to 30 days. And so our actual word for month is actually a moonth. Thirty days is a moonth. It is one repetition of the phases of the moon. So our calendar today is still based on lunar happenings. We don’t exactly use 29-1/2 days for our month, but it’s based on that old 30-day or 29-day calendar.

Now, when did our present calendar come up? Well, it actually goes back to Julius Caesar. The Roman calendar in the time of Julius Caesar was very bad. It didn’t have 365 days in it. I think it had 340-some or 350-some. And it was always getting off. Every
few years they had to make adjustments to figure out where they were. And so Julius
Caesar decided to reform the calendar. To put the empire on a strong footing he wanted
to
have a good calendar. And Julius Caesar was not an astronomer. And so if you think the
Julian calendar was named because Julius Caesar worked it all out, you’re wrong. He
found himself a good astronomer who happened to be an astronomer named Sosigenes
and that astronomer happened to be Cleopatra’s personal astronomer. And so when
Julius Caesar visited Cleopatra, he talked to Sosigenes about calendar reform. And
Sosigenes suggested setting up a calendar and Julius Caesar followed his requests and
ideas to the letter.

Sosigenes suggested having 12 months, each with 30 or 31 days. And you had to
vary the 30 or 31 so you came out with 365 at the end of a year. He then suggested that
the year begin on January 1st. Kind of an odd time. It’s not a particular holiday. It is now
but back then it wasn’t a particular holiday. But Julius Caesar thought, “Well, okay. We’ll
follow that.” And so the entire Julian calendar was set up by Sosigenes based on his best
measurements that the year was 365-1/4 days.

Now, how are you gonna handle a quarter day? The way you handle a quarter day,
Sosigenes said, was every fourth year add an extra day to the calendar. So you get an
extra quarter every year and after four years you put an extra day into the calendar, and
we refer to that as Leap Year. So we just stick an extra day in to make the calendar work.
Julius Caesar set up those reforms and that calendar became the standard calendar for
about 1500 years.
We'll continue this next time.