Astronomy Cast Episode 183

History of Astronomy, Part 1 - The Ancient Astronomers

Fraser: Astronomy Cast Episode 183 for Monday March 29, 2010, History of Astronomy, Part 1 - The Ancient Astronomers. Welcome to Astronomy Cast, our weekly facts-based journey through the cosmos, where we help you understand not only what we know, but how we know what we know. My name is Fraser Cain, I'm the publisher of Universe Today, and with me is Dr. Pamela Gay, a professor at Southern Illinois University Edwardsville. Hi Pamela, how're you doing?
Pamela: I'm doing well, Fraser. How are you doing?
Fraser: I'm doing very well. I was mentioning to you... I just got a sailboat. It's an old, trailable sailboat. I went down to the states and picked it up and brought it back. Now it's sitting on the lawn.
Pamela: That will be wonderful for summer.
Fraser: Exactly. I've got about 100 things to do to fix it up, but, you know, other than that it should be fun. So, new hobby... like I really need a new hobby... but...
Pamela: And you live where you can see killer whales...
Fraser: That's true. Exactly. I live with whales and dolphins and lakes and oceans and yeah... exactly... so I can put it to use... is the plan. I'm not sure I can convince the wife to come out on the boat, but the kids want to. So I can trap them on the boat. And we're trying to think of a name... my wife suggested "Reason" which is actually a "Snow Crash" reference... you're not gonna get it.
Pamela: No...
Fraser: But it's also skepticism, science.... so I thought it was a good name. Anyway, we know you love a good series, and this time we're going to walk you through the history of astronomy... starting with the ancient astronomers and leading right up to the most recent discoveries. Today we're going to start at the beginning with the astronomers who first tried to understand the true nature of the earth, the planets, and our place in the cosmos. Alright Pamela.... so let's hit the Wayback machine... how far back would you like to go?
Pamela: Well, we can go all the way back to the first times that astronomy started cropping up in architecture because writing came later.
Fraser: So I guess, when you think about it, we don't know how early astronomy was actually happening and people might have made some very clever deductions about it, but it's only really right to the point where people started to record things, write them down. There aren't any cave paintings of astronomy, right?
Pamela: Well, there aren't any cave paintings that are older than when we started seeing astronomy in buildings. Out in Chaco canyon there's I guess cave carvings is a better term... but those are fairly modern in terms of Neanderthals drawing bison and buffalo and other things they were planning to eat side by side with astronomy references. That we don't have.
Fraser: That would've been nice. So, alright, so then when did they first start to build it into their architecture?
Pamela: Well, the earliest reference I've been able to find was from the Nabta Playa in Egypt. And I'm going to as always mispronounce many things in this episode.

Fraser: You know, you shouldn't even apologize... just do it. And then we can have the angry emails afterwards and then we can tell them that we know better.
Pamela: Ok, that works.
Fraser: So don't even apologize anymore... we're beyond that.
Pamela: But, back in 5000 BCE there was a large stone circle built in Egypt... and Egypt doesn't get enough play when it comes to stone circles... everyone only pays attention to the ones in northern Europe, mostly England. But the earliest one that I've been able to find references for was in Egypt. It was a stone calendar circle that, depending on where you were standing, could be used to help predict the differences in the seasons, which is in some ways the earliest thing you can start doing with astronomy.
Fraser: Right and I guess that would have practical implications. They would use that to know when to plant or when the Nile was going to flood...
Pamela: Knowing when they were going to get flooded was kind of the most important thing back then.
Fraser: Right. Right. And so you would be able to stand in the circle and sight the position of the sun and use that to know approximately where you were in the year and when the seasons were going to start.
Pamela: One of the things that they used more than the sun and the moon was they tracked the rising and setting of sets of stars. There were certain key days of the year where they knew two specific constellations would be rising and setting, and based on when those constellations rose right after sunset or rose right before sunrise they were able to keep track of the year. They were able to keep track of... well, Sirius is coming up.... that must mean... well, we're about to get flooded.
Fraser: And 5000 years BCE... that's 5000 years before the common era, so that's like 7000 years ago?
Pamela: Right.
Fraser: That's a long time.
Pamela: And it was so long ago that that part of Egypt, which is now one of the most arid deserts we have, it used to actually be lush and flood. So we're looking at things from so long ago that were necessary because the climate was radically different.
Fraser: Alright, well let's move forward then. What's next?
Pamela: Well, in the mid-3000s BCE again, the Sumerians developed cuneiform... this was a written language that was made basically by stabbing the moral equivalent of a putty knife into a clay tablet to form letters based on the shape of the stabbings. There's really no better way to describe it other than someone with a small delicate putty knife stabbing letters into a clay tablet. They were able to create language and they recorded numbers and astronomical records. They were the first ones to come up with a complex numerical system. They were the ones responsible for what's called sexagesimal which is base-60 numbers so when we look at circles, we have 360 degrees which is 6 times 60. Each one of those degrees is broken up into 60 minutes. Each one of those minutes is broken up into 60 seconds. That base-60 insanity that we all learned to hate when we were first trying to do mathematical manipulations of time recordings... that's all due to the Sumerians.
Fraser: So we can lay that firmly on their shoulders and blame them.
Pamela: Total blame... total blame goes to them.
Fraser: Right.

Pamela: But they were the first ones to start making recordings of what they saw in the sky. And so we can trace back the most ancient sunrise sunset knowledge, the most ancient information on the planets back to the Sumerians.
Fraser: Cool. Next?
Pamela: Well, continuing... still in the 3000s, we have the Egyptians started building pyramids. And they also developed the length of the year based on the sun. They were the ones that started figuring out the 365 and a quarter... that quarter was kinda hard to figure out. And they based a lot of what they did on needing to know the rising time of Sirius, the dog star. It was when Sirius rose right before the sun rose that they knew the time that the Nile was going to flood was coming quickly... this was called the inundation of the Nile. They based many of their buildings on specific stars. Aligning the pyramids with Thuban, which at the time was the northern pole star, aligning their buildings very precisely with mid-winter sun falling down certain temples, hallways, and making sure that they always knew when to track Sirius.
Fraser: This is like 5000 years ago... there was a different pole star?
Pamela: Yes.
Fraser: Wow.
Pamela: And so when we're trying to figure out these ancient buildings, we actually have to take into account that our planet isn't a solid object that is precisely aligned, but rather like a spinning top, its pole is constantly precessing. This precessing causes some buildings to align with the wrong object in modern days.
Fraser: Hmmm. I wonder, when you think about those situations like Indiana Jones where he goes into this temple and lines up the amulet with the sun...
Pamela: Yeah... it doesn't work...
Fraser: ...it wouldn't work, would it, because the earth's wobble would have it working in a different place or working on a different day, so it would have pointed to the wrong location.
Pamela: So we have the precession of the equinoxes to worry about with the sun and the precession of the pole to worry about when we're trying to line up stars.
Fraser: And the stars are moving...
Pamela: Yes.
Fraser: Not fast, but, you know... some of them are moving.
Pamela: All of these things go into play. Now the nice thing is in modern science, what we do is we take our computers and we precess everything in the computer to get back to what the sky used to look like and then you use laser pointers and GPS and you figure out what the alignments used to be. And it works.
Fraser: I think that should be some moment in some movie or TV show where they're like... "Things aren't lining up... wait a second! Precess the earth's... wait a second!" And there it is.
Pamela: That would be so much more interesting than some of the stuff they currently do, because then you get the laptops out and you do all the cool wires and laser pointers. Everyone likes a laser.
Fraser: And they're recalculating... "No, you stand over there. That's where the sun was..." And then get the angle... alright... ok, so we've talked about the Egyptians a lot, now what about... I know around that time... I've even been there... with Stonehenge?

Pamela: Yeah... We're still trying to figure out how Stonehenge was built and the orderings of the building... It's a hard-to-date system because people didn't live there. There were huge artists' villages, huge workers' villages associated with the buildings of the pyramids... and that means that we have trash to carbon date. Stonehenge... there's a lot less trash to carbon date, and it's thus somewhat more of a debate. Somewhere between 3000 BCE and 2000 BCE construction started on Stonehenge. We're still trying to sort out all the things you can do with this amazing set of rocks. But, it was clear that they knew how to track the moon cycles, track the sun cycles, track the seasons. Thus, midsummer still lines up. The date of midsummer is always shifting slightly... but midsummer still lines up--you can still watch the sun rise between the stars. With the computer you can figure out which stars line up with different days. And then there's different stone holes that you can use to track... well, here are how the lunar cycle and the solar cycle line up across enough years. If you wait long enough you can get a full moon and the sun lining up on the same day again in the future. It doesn't happen all the time, but if you wait long enough... and there's ways to calculate that waiting long enough using the Aubrey holes at Stonehenge. It's an amazing calculator that we're still working to figure out. And it's just one of many stone circles built during that period. It's just the biggest and most famous.
Fraser: But it's amazing that they... I guess they built such an enormous structure... I don't know if you've ever seen it... We visited it about ten years ago and it is mind-bogglingly large. I mean these stones are gigantic. And imagine how far they had to move them and how they lifted them up... you know it must have been aliens that did it... but anyway...
Pamela: Well, what's amazing is that it's in a fork in the highway and there's a sheep farm. So you're standing at Stonehenge watching these giant lorries go by and surrounded by sheep, which is just the most amusing thing I've ever seen. No one knows quite how they moved these stones, because they were many-ton rocks and very precisely carved given the point in history when they were being moved. It's a huge, huge mystery that we're still trying to sort out. And there's other examples of tens of ton stones lifted up as much as eight feet off the ground and balanced on other stones and other different stone things that were built throughout that period.
Fraser: But wasn't a lot of work being done in China at the same time, too?
Pamela: And the Chinese weren't so busy moving rocks. That's the neat thing. Now you do actually have to wait about 1000 years to get to the Chinese. So, about 1300 BCE, the Chinese started writing astronomy down. The Chinese had an amazing language dating back thousands of years. It was during the Wu Ding empire, that bronze age of China, that they actually started writing down catalogs of stars, writing down the constellations, writing down the sun's position in the different houses of the constellations. So this is where we start getting our first written records from another culture. We started getting some written records from the Sumerians, and then the Chinese start writing things down in the 1300s as well.
Fraser: But that wasn't really the highlight of the Chinese astronomy, I know they did a lot more work more recently, but I'm sure we'll get to that in a little bit.
Pamela: We have a few more thousand years to creep through first.
Fraser: Yeah, so where to next then?

Pamela: So now we skip over to Babylonia. In 1200 BCE the Babylonians started creating star charts that we think were probably actually passed down from Sumerian astronomy, but many fewer tablets survived from the Sumerians. From the Babylonians, we have tablets that are called the "Three Stars Each." These tablets divided up the sky into a northern section, an equatorial section, and a southern section such that the sun spent equal parts of the year in each of these three regions of the sky. They divided the sky up even further into sets of three bright stars, each defined their own constellations. This was all working towards building up major sets of constellations. So it starts with the 3 stars each, because 3 was an important number to them, and the dividing of the sky up into 3 sections. And they also in this period started making careful records of the sun rising positions on the horizon over time.
Fraser: And a lot of the names that we know today have Babylonian origins, right?
Pamela: Right, and thus, in turn, probably have some Sumerian origins as well. And in some cases, the constellations that they came up with, not necessarily in 1200 but a few 100 years later in about 1000 BCE, these particular names got retranslated. The Babylonians had the constellation of the Lion, and the Greeks just renamed it into Leo. They had Scorpius, and they just called it the Scorpion, except in Babylonian. So we have many constellation names as well date back to the Babylonians and Sumerians and then just got stolen and translated into Greek and then we kept the Greek names.
Fraser: The Babylonians got a pretty good handle on the planets, too, didn't they, at that point.
Pamela: It was actually more about 1000 that they started getting a better record of the planets. So about 1000, you had the Mul.Apin which detailed all sorts of new zodiacal stations is what they called them...
Fraser: What? What? New...
Pamela: They called the zodiacal stations. They didn't quite have "constellation."
Fraser: Right, ok...
Pamela: So these zodiacal stations... these were places where the sun passed through sets of stars. And just as you might talk about having stations in a church, they had stations in the sky. The sun passed through one set of stars, one zodiacal station, before it passed on to the next.
Fraser: Right, and they were pretty big into astrology as well so they had a lot of meaning and lore associated with the different times that the sun was going through these stations.
Pamela: And what's interesting looking at these is because the earth was aligned somewhat differently back then, they actually had the sun at vernal equinox close to the Pleiades, and that's not something we would consider part of the zodiacal constellations nowadays. But the sky was just a little bit differently aligned, and that made a difference. They also didn't have Ares yet, so back then it was very much the age of Taurus with the sun passing through Taurus. It was a very different way of looking at things. So they looked at Taurus marking the vernal equinox with the sun close to the Pleiades. They had Leo marking the summer solstice, the Lion. They had the Scorpion, Scorpius, marking out the autumnal equinox. The goatfish, Capricorn, marking out the winter solstice. All together they had 71 stars involved in the constellations of the three ways, of the 3 stars each, and then they built on that, building out all these zodiacal stations as well. They looked to mark time by seeing which constellations rose and set simultaneously. So if

you have a specific pair doing something, and you know what night of the year it is, you know what time it is. So they had tables to allow them to tell what time it was even at night just by knowing the date of the year. They were very careful about transcribing the path of the moon and the planets. This was the first data that was of high enough quality that you could start using it mathematically. They paid attention to when the planets were at solar conjunction, and how long they stayed there... this was when the planets disappeared into the day. All of these things... they recorded things very carefully using gnomon sticks to mark the shadows and check the angle of the sun and very carefully transcribing the length of night during the year.

Fraser: So did they have any kind of concept, like modern... what did they think was the nature of this... did they think the earth was flat or the center of the universe, you know, that kind of old model? Did they still have that?

Pamela: They actually didn't record a lot of their cosmology. But, one of the things that does date back to them is the idea that our earth is just one of many planets orbiting in one of many different heavens. They didn't have orbits, but just one of many planets in many heavens. To them, the center of the universe was where the deity was, which is separate from the idea of the earth or the sun being the center of anything.

Fraser: That's interesting that they had all of that data and they didn't make the conceptual leap of the earth going around the sun. Even though they were ok with the earth not being the center of the universe.

Pamela: Well, what's interesting is that they didn't actually look for geometric solutions. What they did instead was they looked for mathematical solutions. We know that Venus appears in the sky every X days as an evening star and here is its mathematical pattern of behaviors. Take that frequency, predict forward based on those numbers. And as soon as you don't try to instill geometry on planetary positions, things become much easier to deal with actually. And so they looked at the ratios. They looked at the periods that things recurred over and over in the sky. So it was just a very different way of looking at things. It was the "what are the ratios" vs. "what is the geometry."

Fraser: So was there any of this work being done in the Americas? There were civilizations and great buildings built in the Americas as well.

Pamela: So around 1000 BCE we also had in Chaco Canyon... they didn't yet have a written language among the Anasazi people of the United States, but they did have the ability to carve and there are many different pictographs left in rocks all over the American southwest and in the Rocky Mountain area. So, in these pictographs, what they're able to find are places where they align stones such that shadows were cast on symbols in the rocks on special days of the year. There's a particular one sun dagger in Chaco Canyon where on the equinoxes you have a dagger of sunlight appearing on this swirling pattern that appears one way for solstice, one way for equinoxes, and another way for the other solstice of the year. So you can see it bounce from summer solstice to winter solstice, passing through an intermediate step for the equinoxes. These alignments only occur at local noon on these specific days. It was a way of marking the year just by looking at the sun's shadow.

Fraser: Right, right. So it was that same tool. You can see that the first real practical use of astronomy was to be able to plot when to harvest, when to plant, when are the rivers going to flood, and when do we need to be on the ball for all that. So it's quite... so it's

always that same tool around the world. Ok, well let's keep rolling. What's your next stage and innovation in ancient astronomy?
Pamela: Well the most important records actually started coming in about 700 BCE. This was during the reign of Nabonassar, another Babylonian-area ruler. He ruled from 747-734 BCE, and he drove his astrologers... astronomers... call them what you will... to very carefully make recordings, make measurements. Looking through the records that the Babylonians already had, it was during his reign that people figured out the Saros cycle, the way that eclipses returned to almost the same place every 18 and a bit years, allowing us to watch the eclipses move across the planet over time. It was during his reign that the Venus tablet was created. It was a copy of 2000 BCE records that allowed people to very precisely know when Venus would be appearing and disappearing from the night sky. He made science and math, and it was records from during his reign that Ptolemy said started the modern mathematical age of astronomy. These were the first accurate records that could be used by Ptolemy and others to sort out well how do we mathematically figure out all the planets. Ptolemy was trying to use these records to come up with geometrical solutions that just didn't quite work, but it was a good start. And it was because of Nebonassar that we have those records spanning thousands of years.
Fraser: So thanks to the Babylonians...
Pamela: Yeah, they did a lot of amazing work.
Fraser: Unlike the ancient Sumerians... alright, well I think we're nearing the end here, because I think we're going to save all of the Greek stuff for the next show. Were there any more significant developments in astronomy before we get to the Greeks?
Pamela: The only last thing I point out is 400 BCE we had from the Chinese two competing astronomers who each worked to develop star charts. We had Shi Shen who had a star chart of 212 and he was the first person to start recording sun spots. Now he thought that these were eclipses that were starting to spread out and just never succeeded, but he did record sunspots... he just didn't understand them. But back then, the Chinese also were concerned that solar eclipses were caused by dragons eating the sun, so when you're looking for the wrong reasons for eclipses, it's easy to make that mistake.
Fraser: I still worry about that today... but that's kind of a neat idea, right? You look at the sun, and then you see a black spot on the sun, and you can imagine that that is what causes an eclipse. But they must have started to figure out that eclipses were caused by the moon passing in front.
Pamela: Well, they just weren't recording that excuse yet.
Fraser: Right.
Pamela: It's much more interesting to have a dragon consuming it. And this was still 400 BCE. But in competition with Shi Shen we had Gan De and he was one of the first ones to start doing detailed observations of Jupiter. And one of the coolest things about what he did was Jupiter's moons... the moons are actually naked-eye viewable, but we normally don't see them because the glare of Jupiter itself blocks them out. It's said that Gan De blocked out the light of Jupiter with a tree branch so he could observe the moons.
Fraser: Whoa...
Pamela: Isn't that kinda cool?
Fraser: Yeah, if the records are true... that's pretty amazing.
Pamela: So it's just a bit of history that somehow got lost from our modern records.

Fraser: Because I have a shot... I've tried to spot them with binoculars, and I still haven't been able to do it. So maybe I need to line up a tree in front of my binoculars so that I just cover up the moon, right?
Pamela: So what you want to do is actually get Jupiter just off the very edge of your binocular field of view.
Fraser: Right and then you'll be able to see any moons on that side.
Pamela: Yeah, get it just off your field of view and then circle it, so it stays just off your field of view going all the way around it.
Fraser: Ok. Alright, well I think we're done with the ancient folk. But the next step, I think one of the most exciting ones, is when we get to the Greeks and around that period because it's quite amazing how many of the things that we now know were uncovered by the Greeks and then later forgotten. But they were first discovered and written down and recorded... and it's amazing that 2000 years ago people were that modern... they thought about things in that very careful way and had the math to back it up. I'm looking forward to that. Well, thanks a lot Pamela. And we'll talk to you for the next show.
Pamela: Ok, sounds great.