Okay, so you can see why there was an enormous amount of doubt at this time, and very good reason for it. The traditional world was crumbling in all sorts of ways. There were all sorts of horrible tensions leading to bloody wars, and at the center of those wars was an intractable dispute which seemed very pointedly to raise a fundamental philosophical problem: how can we know what's right?

Well, very soon things started happening in the realm of science, and let's just see how that came about. Aristotelian science was based on a very commonsensical idea, actually an idea Aristotle had got from the pre-Socratic philosopher Empedocles. There are four elements: fire, air, water, and earth. Everything we see is made up of mixtures of these basic four elements. Now, these things have natural motions. For example, if you take something that's made primarily of earth, it falls. We're used to that; earth has a natural motion of downwards. Fire has a natural motion upwards. Well, this all makes sense. Things made of earth are seeking their natural place. The natural place of earth material made of Earth is the center of the universe, the center of the Earth. So, it's entirely natural that things made of Earth move towards that. Likewise, fire, air, water - their natural position is with Earth, in a sphere at the center. Then water, then air, then fire. And the motions we see match with that. The heavier things are, the more they weigh; the faster they fall in proportion to their weight.

But what about the heavens? We look up at the heavens and we see bodies that do not fall towards the Earth. Instead, they move in circles around the Earth. How can that be? Well, they must be made of a different kind of stuff. Let's call it ether. So, there is this fifth element, this quintessence, this fifth essence of which all the heavenly bodies are composed. That explains why they move in circles - that is their natural motion. Why should circularity be their natural motion? Well, circularity is the closest they can get to the perfection of the eternal God. So, the explanation for why things work as they do in nature is all in terms of things striving to achieve a particular end. Bodies made of earth strive to reach the center of the universe. Bodies in the heavens strive to move in the perfection of circles.

Now, this came to be seen as a bit problematic. So suppose, for example, we take a siphon. Here we've got a siphon. I'm sure this is familiar to all of you. On the left, you've got a beaker with water in it, and the pipe is going into that, and the pipe itself is full of water. And as we know, what will happen is that the water will pass up the pipe and down on the right-hand side, and the beaker on the left will be emptied, and the beaker on the right will fill up correspondingly. Now, why does the water on the left rise up the pipe? It's easy to understand why the water on the right falls down. Okay, that's trying to reach its natural position, as in the rain. But you see, if it moved downwards on the right, that would leave a gap, a vacuum, a hole in the pipe. It would leave an emptiness. So why does water move up on the left-hand side? Well, it must be that nature abhors that emptiness. Nature abhors a vacuum. So the water on the left moves up in order to avoid there being a vacuum. It's striving to avoid this horrid situation of a vacuum. And it's actually a very natural way to think, isn't it? I mean, think of sucking water up a straw. You think of yourself as sucking it up, the water is coming up to fill the void. We know now that isn't what's going on. Rather, it's atmospheric pressure pushing. But that was the very natural explanation that they came to.

But compare this explanation, and this is actually from a parody, "The Imaginary Invalid," a play by Moliere in 1673. And he's making fun of this kind of supposed scientific explanation. So somebody asks a doctor, "Why does opium make one sleep?" And the answer comes, "Because it contains a dormative - a substance whose nature is to make the senses soporific." Now clearly, it's a parody. There's no explanation at all there. Why does it make you sleep? Oh, because it contains something that makes you sleep. And if you think about it, the same is true of the explanation with the vacuum. "Nature abhors a vacuum" doesn't explain anything. All it says is that vacuums won't naturally occur. It doesn't say why.

And now think about stones striving to reach the center of the Earth. Why do stones fall? Because they strive to reach the center of the Earth. That doesn't actually tell you anything about why it's happening. It's just re-describing the phenomenon. It's just saying, in effect, "Well, they do." Not only was Aristotelian science very unsatisfactory from this point of view - simply saying that something does X because it wants to do X doesn't actually give you any explanation at all - but there were specific problems with it.

Take the flight of a cannonball. How does a cannonball fly? Well, roughly, it's a parabola. The shape of the curve when it falls is almost the same as the shape of the curve when it's going up into the air - slight difference because of air resistance; it'll slow down a bit. But more or less, it's a parabola. But you go and look at pictures from the time before the early modern period. Look at pictures of cannonball flight, and you'll see they describe it as though, at the end of the flight, it's dropping almost vertically. And that's because their theory of motion would imply that while there's an initial impetus from the explosion, sure, the cannonball can keep going horizontally. But as soon as that impetus goes, it just restores its natural motion, which is downwards.

Well, take a sledge sliding on flat ice. Suppose you've got a lake of water that's frozen over, so very smooth, very flat ice. And you push a sledge on it, and then you let go. What happens? The sledge keeps going. How can that be? Once you've stopped pushing, how is it that the sledge keeps going? Well, Aristotelians came up with various explanations. They said, "Oh, well, as it goes through the air, it sets up vortices of air, and the vortices keep pushing it. That's why it keeps going." None of these explanations was very satisfactory.

What Galileo said was, no, actually, the sledge keeps going because the natural motion of things is to keep going in the same direction they're going, at the same speed unless acted upon by a force. What requires explanation is not why the sledge keeps going. What requires explanation is why it stops. And that's a fundamentally different view of things. No longer are you saying that things naturally move towards the center of the Earth. You're now saying that they simply stay where they are or keep going in a uniform direction at a uniform speed unless they are acted upon by a force. And that, of course, introduces forces like gravity.

Galileo is famously reported to have performed another experiment (scholars doubt actually whether he really did, but it's a nice story). Go to the top of the Leaning Tower of Pisa, take a cannonball and a marble - a large one and a small one - drop them and see how fast they fall.

What you will find is that they fall at almost the same speed - not exactly the same speed because of air resistance, but so maybe you have seen on the web or whatever. I remember vividly from when I was a lad when David Scott, the Apollo astronaut, I think it was Apollo 17, or something, went to the moon, took out his hammer, took out a feather, dropped them on the moon where, of course, there is no atmosphere, and they fall at the same - a very nice illustration that Aristotle is wrong. On Aristotle's theory, the larger object should fall much, much faster than the smaller object. So, Aristotle's physics is looking in serious trouble for a range of reasons.

But that's not the worst that was to happen. The telescope was invented in 1608. Its initial uses were things like military - you can see when the enemy is advancing, you can see how many there are and so on. Or if you're a merchant and you want to know whether your ship is arriving in port, you can take a look and see things at much greater distance than before. Well, what Galileo did - as well as perfecting the telescope; he made a much better one than anyone had before - he had the bright idea of turning it upwards, looking at the sky. Well, what did he find? He found mountains and valleys on the moon. He even found, by looking at them at particular times of day, he could see the shadows cast by these by the sun and even estimate their height. He found four moons orbiting around Jupiter. Of course, we now know there are far more, but before that, he saw with his telescope very famous… It shows not everything is centering around the earth. Innumerable stars - I mean, when you look through a telescope, you see the Milky Way. And of course, the Milky Way was much more visible for him than it is for us today with all the street lighting that we get. Look at the Milky Way through a telescope, and you find that behind, as it were, all the stars that we can see, there are zillions more. The idea that the stars are on some fixed crystalline sphere that rotates around the world, once you look at that, that kind of death becomes less plausible. And he saw that Venus has phases. Now, we're used to the Moon having phases. Sometimes it appears as a crescent, sometimes it doesn't appear at all, it's just black, sometimes we see a full Moon. Well, the same is true of Venus.

Now, the Aristotelian theory, as I said, was based on the idea that all heavenly bodies basically move in circles. Now, that's a bit of a simplification. If you look at the motion of the planets in the sky, you will find that they don't simply go around the Earth in a continuous circle. Sometimes they seem to move backwards for a time and then move forwards again. Now, we understand that, of course, because we think of the Earth as orbiting around the Sun, and say Mars also orbits around the Sun, and so we've got a complication of two different motions added together, which means that in general, Mars will move in a consistent direction around the Earth, but sometimes, as it were, the Earth overtakes it, so Mars seems to go backwards. So, how did the Aristotelians deal with that? I mean, how did they explain the fact that the motion of the planets visibly was not just a straight… Well, they explained it in terms of planets moving on circles around circles. So, instead of simply having a circle like that, you might have an arrangement like this, where a planet is moving on one circle. And by doing that, they were able to give an account of the position of the planets in the sky that worked out - pretty well, of the order of five degrees plus or minus. So, not great, but enough to keep them relatively content.

Now, in order to explain the motion of Venus in the sky, there's a bit more of a problem. You see, Venus, as we know now, is closer to the Sun than the Earth is. Its orbit is within the Earth's orbit. So, that means that Venus never gets more than a certain angle away from the angle of the Sun, which is why Venus is the morning star and the evening star. Okay, it only appears in hours fairly close to when the Sun is appearing. So, how do you explain that within an Aristotelian model? Well, the way it was done, developed by an Alexandrian called Ptolemy, famous - he had the Sun moving around the Earth, and Venus orbiting around a point on the line between the Earth and the Sun. Okay, so Venus went like that. Here's the Earth; the Sun is going around, and Venus is going around like this, always roughly between the Earth and the Sun.

Here's the problem: imagine what you see from the Earth when you look at Venus illuminated by the Sun like that. What you see is a crescent. Agreed, you never see a full Venus. You cannot see a fully illuminated Venus. You can only see a fully illuminated Venus if Venus is sometimes on the other side of the Sun. Even then, of course, you never see it fully illuminated because the Sun would be in the way, right? The Sun is far too bright. But the point is that what we do see is Venus nearly full when the Sun has just gone down, there's nearly… So, these precise Aristotelian astronomical observations really caused immense problems for the Aristotelian worldview. They blow it apart.

Okay, so that helps to explain why Galileo was such an important figure, had a great influence on Descartes as well. And as I've said, it's not just the detailed astronomy that is the problem, it's the whole conception of science. Aristotelian science was based on purposes, what's called final causation - things striving to reach a particular final state. Whereas Galileo preferred a model based on efficient causation - one thing bashing into another, making it move. Matter doesn't strive. It's not that material things have some sort of desire to reach a particular state. Instead, things, because one thing acts on another, push it - as in billiard balls banging into another or as in water in a pipe pushing it along. So the outcome doesn't depend on some foreseen final state. It depends on where the causal sequence happens to lead. And so, you get the ideal of the mechanical philosophy, the paradigm. Those are the standard thoughts about efficient causation - is mechanical contact, that is intelligible. The Aristotelians had said that things move because they're striving to reach a particular situation. They thought that was intelligible. They thought that made the world comprehensible because it made physical things act in the same sort of way as we do. But the advocates of the mechanical philosophy in the early modern period wanted to say, no, that isn't the right kind of intelligibility that we should be looking for. We should understand causation in terms of one thing bashing into another, the familiar contact of billiard balls or as I said pressure of water in a pipe. That seems both genuinely explanatory and genuinely intelligible.