The Rainbow Analysed

Aristotle's theory

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For centuries, the rainbow has been an object of wonder for scientists and mathematicians - it's taken more than two thousand years to discover many of its secrets. You may be quite familiar with it's bow-like shape and multicoloured bands.

And you probably know that in order to see a rainbow, you need both sunlight and water droplets. But how do these result in the formation of a rainbow?

In about 300BC, the Greek philosopher Aristotle proposed a theory to explain this phenomenon. Today's models about why the rainbow has a specific shape are very similar to Aristotle's theory which involves a cloud of rain illuminated by the sun's rays.

Aristotle's main idea was that when rays of sunlight hit points in the rain cloud they are all deflected back at a fixed angle.

Since rays from the sun are parallel to each other, they will be deflected at the same angle from points all over the cloud.

Imagine the sun is behind you and there's a rain cloud in front of you.

There will be a point - from which deflected rays hit your eye. That point in the sky then appears brighter. There are *other* points which deflect light back to your eye in a similar way.

In fact, the set of points, which you the observer see as bright, form a circular arc.

Aristotle didn't really understand why there was this fixed angle. But he did understand the geometry.

If light is deflected back at an angle *Y* to the sun's rays, then *this* angle will be the same as this other angle. This means that the position of the rainbow is fixed in relation to the line from *your* head to the top of your shadow. Think about the implications of that.

In fact the fixed angle idea means that if the ground were not in the way, you would see a full rainbow circle; with that 'shadow line' between your eyes and the tip of your shadow directed towards the centre of the circle.

The circular bow shape arises from a fixed angle of deflection from points all over the cloud. In fact, the colours arise because the different colours that make up the sunlight each have a slightly different angle of deflection and hence a slightly different circle of bright points. But this concept was something beyond Aristotle's experience. We'll come back to it later.

You might have heard that there's supposed to be a pot of gold at the end of the rainbow. But suppose you were to move *towards* the end of the rainbow in order to find the treasure.

Because the angle Y is fixed to your shadow line, the rainbow, along with its end point, actually moves as you move. Every observation position gives a unique rainbow. There's no way of reaching the pot of gold, however hard you try, because your shadow line is always at the centre of the rainbow circle. Aristotle's model explains another feature of the rainbow - the change in its position as the sun changes position in the sky.

If the sun is low down – early in the morning or in the evening – when the rays are nearly horizontal - you can see much more of the rainbow's circle.

When the sun is high in the sky, less of the circular bow is visible above the ground.