TEDTALK ANNOTATED VIDEO TRANSCRIPTS

Unit 1 **BRIAN COX**

Why We Need the Explorers

Part 1

We live in difficult and challenging economic times, of course. And one of the first **victims**[1] of difficult economic times, I think, is public spending of any kind, but certainly **in the firing line**[2] at the moment is public spending for science, and particularly curiosity-led science and exploration. So I want to try and convince you in about 15 minutes that that's a ridiculous and ludicrous thing to do.

[. . .] The first thing I want to say, and this is straight from ***Wonders of the Solar System***[3]*,* is that our exploration of the solar system and the universe has shown us that it is indescribably beautiful. This is a picture that actually was sent back by the **Cassini space probe**[4] around Saturn, after we'd finished filming *Wonders of the Solar System.* So it isn't in the series. It's of the moon Enceladus. So that big sweeping, white sphere in the corner is Saturn, which is actually in the background of the picture. And that crescent there is the moon Enceladus, which is about as big as the British Isles. It's about 500 kilometers in diameter. So, tiny moon. What's fascinating and beautiful . . . this an unprocessed picture, by the way, I should say, it's black and white, straight from Saturnian orbit.

What's beautiful is, you can probably see on the limb there some faint, sort of, wisps of almost smoke rising up from the limb. This is how we **visualize**[5] that in *Wonders of the Solar System.* It's a beautiful graphic. What we found out were that those faint wisps are actually fountains of ice rising up from the surface of this tiny moon. That's fascinating and beautiful in itself, but we think that the mechanism for powering those fountains requires there to be lakes of liquid water beneath the surface of this moon. And what's important about that is that, on our planet, on Earth, wherever we find liquid water, we find life. So, to find strong evidence of liquid, pools of liquid, beneath the surface of a moon 750 million miles away from the Earth is really quite astounding. So what we're saying, essentially, is maybe that's a habitat for life in the solar system. Well, let me just say, that was a graphic. I just want to show this picture. That's one more picture of Enceladus. This is when Cassini flew beneath Enceladus. So it made a very low pass, just a few hundred kilometers above the surface. And so this, again, a real picture of the ice fountains rising up into space, absolutely beautiful.

[. . .] Our exploration of the solar system has taught us that the solar system is beautiful. It may also have pointed the way to answering one of the most profound questions that you can possibly ask, which is: **"Are we alone in the universe?"**[6] Is there any other use to exploration and science, other than just a sense of wonder? Well, there is. This is a very famous picture taken, actually, on my first

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[1] Cox uses "victims" here to talk about budget cuts during hard economic times.

[2] Something that is "in the firing line" is being criticized or likely to be gotten rid of. The expression refers to a prisoner being executed by a squad of soldiers firing their guns.

[3] *Wonders of the Solar System* is a TV series that Cox presented.

[4] The Cassini space probe was sent to Saturn in 2004.

[5] By "visualize," Cox is explaining that the image he is showing is a computer graphic made for his TV show.

[6] The question "Are we alone in the universe?" is referring to the existence of alien life forms.

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Christmas Eve, December 24th, 1968, when I was about eight months old. It was taken by **Apollo 8**[7] as it went around the back of the moon. **Earthrise**[8] from Apollo 8. A famous picture; many people have said that it's the picture that saved 1968, which was a turbulent year—the student riots in Paris, the height of the Vietnam War. The reason many people think that about this picture, and Al Gore has said it many times, actually, on the stage at TED, is that this picture, arguably, was the beginning of the environmental movement. Because, for the first time, we saw our world, not as a solid, immovable, kind of indestructible place, but as a very small, fragile-looking world just hanging against the blackness of space.

Part 2

What's also not often said about the space exploration, about the Apollo program, is the economic contribution it made. I mean, while you can make arguments that it was wonderful and a tremendous achievement and delivered pictures like this, it cost a lot, didn't it? Well, actually, many studies have been done about the economic effectiveness, the economic impact of Apollo. The biggest one was in 1975 by Chase Econometrics. And it showed that for every $1 spent on Apollo, 14 came back into the U.S. economy. So the Apollo program **paid for itself**[9] in inspiration, in engineering, achievement and, I think, in inspiring young scientists and engineers 14 times over. So exploration can pay for itself.

What about scientific discovery? What about driving innovation? Well, this looks like a picture of virtually nothing. What it is, is a picture of the spectrum of hydrogen. See, back in the 1880s, 1890s, many scientists, many observers, looked at the light given off from atoms. And they saw strange pictures like this. What you're seeing when you put it through a prism is that you heat hydrogen up and it doesn't just glow like a white light, it just emits light at particular colors, a red one, a light blue one, some dark blue ones. Now that led to an understanding of atomic structure because the way that's explained is atoms are a single nucleus with electrons going around them. And the electrons can only be in particular places. And when they jump up to the next place they can be, and fall back down again, they emit light at particular colors.

And so the fact that atoms, when you heat them up, only emit light at very specific colors, was one of the key drivers that led to the development of the **quantum theory**[10], the theory of the structure of atoms.

[. . .] Now, that sounds **esoteric**[11], and indeed it was an esoteric pursuit, but the quantum theory quickly led to an understanding of the behaviors of electrons in materials

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[7] Apollo 8 was a spacecraft that took three American astronauts into space in 1968. The craft orbited the moon and returned. It was the first to leave Earth's orbit with humans aboard.

[8] "Earthrise" is the name of a photograph taken by an astronaut aboard Apollo 8. The image, which students can see in the video, shows the Earth rising above the moon's horizon.

[9] Something that "pays for itself" creates either a direct or indirect income stream that helps reimburse its cost.

[10] The "quantum theory" explains how molecules move and behave.

[11] Something that is "esoteric" is considered intellectual and often specialized in something that the average person knows nothing about.

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like **silicon**[12], for example. The way that silicon behaves, the fact that you can build transistors, is a purely quantum phenomenon. So without that curiosity-driven understanding of the structure of atoms, which led to this rather esoteric theory, quantum mechanics, then we wouldn't have transistors, we wouldn't have silicon chips, we wouldn't have pretty much the basis of our modern economy.

[. . .] This is a beautiful quote that I found—we're talking about **serendipity**[13] there—from **Alexander Fleming**[14]: "When I woke up just after dawn on September 28, 1928, I certainly didn't plan to revolutionize all medicine by discovering the world's first antibiotic." Now, the explorers of the world of the atom did not intend to invent the transistor. And they certainly didn't intend to describe the mechanics of supernova explosions, which eventually told us where the building blocks of life were synthesized in the universe. So, I think science can be— serendipity is important. It can be beautiful. It can reveal quite astonishing things. It can also, I think, finally reveal the most profound ideas to us about our place in the universe and really the value of our home planet.

[. . .] The argument has always been made, and it will always be made, that we know enough about the universe. You could have made it in the 1920s; you wouldn't have had penicillin. You could have made it in the 1890s; you wouldn't have the transistor. And it's made today in these difficult economic times: *Surely, we know enough. We don't need to discover anything else about our universe*.

Let me leave the last words to someone who's rapidly becoming a hero of mine, **Humphrey Davy**[15], who did his science at the turn of the 19th century. He was clearly under assault all the time. "We know enough at the turn of the 19th century. Just exploit it; just build things." He said this, he said, "Nothing is more fatal to the progress of the human mind than to presume that our views of science are ultimate, that our triumphs are complete, that there are no mysteries in nature, and that there are no new worlds to conquer."

This is an edited version of Cox's 2010 TED Talk. To watch the full talk, visit TED.com.

[12] The material "silicon" is used in semi-conductors, which means that modern electronics would not be possible without it.

[13] "Serendipity" is the luck some people have in discovering something valuable by chance.

[14] Alexander Fleming, a scientist from Scotland, invented penicillin by accident. He had gone on an extended holiday and not cleaned up his research area in his laboratory. When he returned, the mold that had formed would lead to his discovery of the first antibiotic for medicine.

[15] Humphrey Davy was a well-known scientist and inventor in England in the 1700s. He was known for his work in electrolysis, as well as the discovery of elements, including calcium.

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