



Professor Stephen Hawking

The third in a series of NASA lectures featuring prominent leaders who discuss the benefits provided by space exploration, scientific discovery, and aeronautics research to the economy, education, health, and the environment.



Why We Should Go Into Space

Including segment on Science Education by Lucy Hawking

April 21, 2008

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- Prof. Stephen Hawking



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- Lucy Hawking

Keynote Speakers

STEPHEN HAWKING, Professor, University of Cambridge

LUCY HAWKING, Journalist and Novelist

Monday April 21, 2008

at the

Morton Auditorium George

Washington University

Washington, D.C.

PROCEEDINGS

Moderated by

JOHN LOGSDON,

Director, Space Policy Institute, Elliott School of International Affairs, George Washington University

Also Present:

STEVEN KNAPP, President, George Washington University

RICHARD M. RUSSELL, Associate Director, Office of Science and Technology, Executive Office of the President

SHANA DALE, Deputy Administrator, NASA

MODERATOR: Good afternoon. Welcome to the campus of George Washington University in downtown Washington, D.C., for what promises to be a very remarkable afternoon. My name is John Logsdon. I am the director of the Space Policy Institute here at GW's Elliott School of International Affairs. We are a very happy co-host, along with Lockheed Martin and NASA, of this afternoon's lecture by Professor Stephen and Lucy Hawking, which promises to be something that will be special. Professor Hawking has prepared a brand-new lecture. This is his first showing or talking this afternoon, and I think that is remarkable. My job is to quickly get out of the way by introducing for a formal welcome, the sixteenth president of George Washington University, Dr. Steven Knapp. Dr. Knapp.

DR. KNAPP: Thank you very much, Professor Logsdon. On behalf of the Board of Trustees and the faculty of the George Washington University, it is a pleasure to welcome you all this afternoon to the third lecture in a series celebrating the 50th Anniversary of NASA. I would like to thank the event's sponsors, Lockheed Martin and NASA, for choosing George Washington University as a venue for this important event, and I would particularly like to acknowledge the presence here of Shana Dale who is the Deputy Administrator of NASA who is here with us today. It is a pleasure to be sitting here also with Lucy Hawking in the front of the theater. Time does not permit me to acknowledge all the distinguished members of today's audience, but you are all welcome for what I know will be a very exciting and stimulating lecture.

GW has worked closely with NASA for most of the agency's existence. NASA's second Administrator, in fact, James E. Webb, studied law at GW in the 1930s and was a member of the GS Board of Trustees from 1951 to 1963. As NASA Administrator, Webb in 1964 asked GW to turn its attention to the policy implications of the U.S. space program, and for the more than 40 years since then, GW has made space policy a focus of its research and its graduate education efforts. We established the Space Policy Institute in 1987 as part of the Elliot School of International Affairs, and that institute has become the leading center of

space policy studies in the world. Much of the institute's research and outreach activities has been supported by NASA grants and contracts, and we appreciate NASA's confidence in the quality of the Space Policy Institute's work. We also appreciate the continuing support that Lockheed Martin has provided to the Space Policy Institute from its very inception. The institute's focus on space policy is typical of the innovative character of GW's Elliott School of International Affairs, one of the nation's leading schools of international affairs. The Elliott School seeks to create knowledge, share wisdom, and inspire action to address global challenges.

My role is not to introduce Professor Hawking. That honor falls to Ambassador Richard M. Russell, Associate Director of the Office of Science and Technology Policy in the Executive Office of the President. I will note only that Professor Hawking's pioneering mind is one of the greatest of our era and that he has combined profound insights into the nature of the universe with an admiral commitment to making those insights available to the general public. It is a privilege, as well as an honor, to have him on our campus.

It is now my pleasure to introduce Ambassador Russell who serves both as Associate Director of the OSTP and as Deputy Director for Technology. Mr. Russell was nominated by the President and confirmed by the Senate in August 2002. He served as President Bush's Ambassador to the 2007 World Radio Communication Conference. He first joined OSTP as chief of staff in 2001, following a decade of service on Capitol Hill where he worked on science and technology issues in both houses of Congress. Ambassador Russell.

AMBASSADOR RUSSELL: Thank you, Dr. Knapp. It is truly an honor and a pleasure to introduce the speakers for the third in the series of NASA lectures that celebrates NASA's 50th Anniversary year. These lectures are a unique opportunity for prominent leaders to address matters of global interest in the areas of space, exploration, scientific discovery, aeronautics, research to audiences of key policy-makers, corporate leaders, academics, and the public sector. I would also like to acknowledge Shana Dale, the Deputy Administrator of NASA, for establishing this series, and it really is going to be a treat this

afternoon to listen to Professor Hawking and Lucy Hawking.

Today, we have a unique father-daughter pair with us. Not much needs to be said about Professor Stephen Hawking who is one of the world's foremost cosmologists and astrophysicists. Since 1979, he has been the Lucasian Professor of Mathematics at Cambridge University, a seat once held by Sir Isaac Newton. I am actually a stand-in for the President's Science Advisor, Dr. John Marburger, who unfortunately has the flu today, but he wanted me to recount a story to you about how important Professor Hawking's work is in terms of being able to translate science into something that is understandable for the public.

Dr. Marburger used to be the head of the Brookhaven National Laboratory, and while he was there, he attempted to start up the Relativistic Heavy Ion Collider, also known as RHIC. That caused a lawsuit. There was a claim that if RHIC was turned on, we would create a black hole and it would eat the world. Now, that may sound funny, but unfortunately, the public actually believed that a black hole might be created, and Professor and, at that point director of the National Laboratory, Marburger turned to Professor Hawking and asked for advice and asked for him to give advice to the press. And it is because of his advice that we should not worry about being consumed by a black hole if the collider was turned on, that it allowed Brookhaven to move forward with the collider.

So Dr. Marburger wanted to both express his sadness at not being here today but also his pleasure and thanks for the wonderful work that Professor Hawking has done not only in terms of an understanding of physics but also in terms of being able to relate to the general public directly and move science forward. Professor Hawking's lecture, which is titled "Why We Should Go Into Space," was written especially for this event, and he considers it a 50th birthday present for NASA, and quite a birthday present I am sure it will be.

His daughter Lucy is a journalist and author. Lucy and her father have co-authored a book for children called "George's Secret Key to the Universe," which was published in October, and there is a second book on the way. Professor Hawking will initially speak for a few minutes, followed by Lucy, and then Professor Hawking will complete his lecture. With that, I would like to introduce and welcome Professor Hawking and Lucy. Thank you all so much.

DR. HAWKING: Why we should go into space. What is that justification for spending all that effort and money on getting a few lumps of moon rock? Aren't there better causes here on Earth?

In a way, the situation was like that in Europe

before 1492. People might well have argued that it was a waste of money to send Columbus on a wild goose chase. Yet, the discovery of the new world made a profound difference to the old. Just think, we wouldn't have had a Big Mac or a KFC.

Spreading out into space will have an even greater effect. It will completely change the future of the human race and maybe determine whether we have any future at all. It won't solve any of our immediate problems on Planet Earth, but it will give us a new perspective on them and cause us to look outwards and inwards. Hopefully, it would unite us to face a common challenge.

This would be a long-term strategy, and by long term, I mean hundreds or even thousands of years. We could have a base on the Moon within 30 years or reach Mars in 50 years and explore the moons of the outer planets in 200 years. By "reach," I mean with man or, should I say, person space flight. We have already driven Rover and landed a probe on Titan, a moon of Saturn, but if one is considering the future of the human race, we have to go there ourselves.

Going into space won't be cheap, but it will take only a small proportion of world resources. NASA's budget has remained roughly constant in real terms since the time of the Apollo landings, but it has decreased from .3 percent of U.S. GDP in 1970 to .12 percent now. Even if we were to increase the international budget 20 times to make a serious effort to go into space, it would only be a small fraction of world GDP.

There will be those who argue that it would be better to spend our money solving the problems of this planet, like climate change and pollution, rather than wasting it on a possibly fruitless search for a new planet. I am not denying the importance of fighting climate change and global warming, but we can do that and still spare a quarter of a percent of world GDP for space. Isn't our future worth a quarter of percent?

We thought space was worth a big effort in the '60s. In 1962, President Kennedy committed the U.S. to landing a man on the Moon by the end of the decade. This was achieved just in time by the Apollo 11 mission in 1969. The space race helped to create a fascination with science and led to great advances in technology, including the first large-scale integrated circuits which are the basis of all modern computers. However, after the last Moon landing in 1972, with no future plans for further manned space flight, public interest in space declined.

This went along with a general dissention with science in the West because, although it had brought great benefits, it had not solved the social problems that increasingly occupied public

attention. A new manned space flight program would do a lot to restore public enthusiasm for space and for science generally. Robotic missions are much cheaper and may provide more scientific information, but they don't catch the public imagination in the same way, and they don't spread the human race into space which I am arguing should be our long-term strategy.

A goal of a base on the Moon by 2020 and of a man landing on Mars by 2025 would reignite a space program and give it a sense of purpose in the same way that President Kennedy's Moon target did in the 1960s. A new interest in space would also increase the public standing of science generally.

The low esteem in which science and scientists are held is having serious consequences. We live in a society that is increasingly governed by science and technology, yet fewer and fewer young people long to go into science.

As a small step towards hearing this, my daughter Lucy and I have written a children's book. I will now let Lucy talk about how to encourage the next generation to take an interest in space and in science generally.

MS. HAWKING: Hello, and good afternoon. I am very, very honored to be here at the NASA 50th Birthday Lecture Series. It is a great honor to be here talking to you. You have heard my father telling you about why we need to travel into space. Well, I would like to take just a few minutes to tell you why we think we need to have a next generation who wants to travel into space as well.

As my father said, at the moment, we face a paradox. Never before has science and technology played such a big part in our lives, and yet at the same time, it seems that children are turning away from science. They are losing interest in science, and they are not studying it. So I would like to talk a bit about what we learned from children, what we learned about children in science education, and how NASA makes a great contribution to ensuring that the next generation does engage with science.

Last year, my dad and I published a book for kids. It is an adventure story in which all the adventures are based on real science. It is about a little boy who lives next door to a scientist, and this scientist has an amazing computer called Cosmos. Cosmos is so powerful and so intelligent, he can draw a doorway to which you can walk to any part of the whole universe that you want to visit. Now, when I talked to people at NASA about Cosmos, the fictional computer, they said, "Oh, I wish we had one of them because that would help our budget enormously."

Now my father wants to work on this project because of his high level of concern about children

and science education. That is not saying that we set out to persuade every child to be a scientist because our world needs people with a wide variety of skills, but science affects all of us, and it matters to all of us. And it will do even more so in the future. The children of today are the adults of tomorrow, and they need to have a basic understanding of science if they are going to make the kind of decisions that will affect us all, and we are going to need scientists as well, not just to work on space travel but to work on issues that face us all, like climate change or fuel sources of food production.

Now, some recent research has highlighted the fears about children and science education. In the United Kingdom, a recent survey found that a third of U.K. school children believe that wartime Prime Minister Winston Churchill was the first man to walk on the Moon. I'm sorry about that, NASA and Neil Armstrong. And the statistics that came with this survey are not very heartening either. They found that 40 percent of children thought Mars was a chocolate bar, 35 percent of children said the Earth was not an official planet, and extraordinarily, 72 percent could not identify the Moon from pictures.

Now, just in case you are sitting there feeling smug, I am afraid the results in the USA are really not looking much better. Only 4 percent of U.S. adults when asked could name a living scientist who they would nominate as a science role model, although at the same time, 96 percent, a stunning 96 percent of U.S. adults think that it is important for the U.S. to be a leader in science education.

So it all sounds rather gloomy, but there is hope, as I found out when I went on a worldwide school's lecture tour with a talk, surfing the solar system. It is about the sort of concepts of astronomy and theoretical physics that we set out to cover in our book. I have probably spoken, and we estimate, to about 20,000 kids worldwide, and what I discovered was an enormous appetite and enthusiasm for science, and there are so many questions that we have to write another book in order to be able to answer them. And they are great questions like can you skateboard on Jupiter, and my personal favorite is what does happen if you get to the edge of the universe.

Now, you could say that we are just lucky, that we have got the science at our disposal, and without a doubt, I can tell you that black holes presented by Stephen Hawking explained simply for kids is a winner. We have them. We had them with us all the way. But more seriously, some research at universities in the U.K. shows that a significant percentage of students studying sciences -- and I mean across the board, this isn't just physics -- report that their interest in science was sparked by

exactly these topics. They went on to become scientists because of an early interest in astronomy and the exotic phenomena of theoretical physics, but space has the power to capture children's imagination and engage their curiosity. There seems absolutely no doubt, and we have never needed to do this more urgently. Of course, it is not just what we say to kids. It is what we show them.

The images sent back by NASA's Hubble play such a huge part in capturing kids' attention in an ever increasingly crowded world with many, many demands on them. This means we can show kids something of the cosmic environment that surrounds them, from Saturn's rings to getting them to think about what would it be like to see a sunset on Mars.

Now, manned space flight is a topic which kids never tire of, and because of NASA, they can read about it, they can hear about it, watch documentaries, look at photographs, and visit space centers. NASA runs a huge number of educational programs both in and outside schools. This means that kids' space dreams aren't limited to science fiction, and with exciting new missions planned back to the Moon and onwards to Mars, it means that there may be kids now who will grow up wanting to be astronauts, as excited about it as a whole generation of astronauts today are, the ones who watched the Apollo Moon landings in their pajamas with their parents and decided they were going to grow up to be an astronaut, and that is certainly an awful lot more aspirational than wanting to grow up to appear on a reality TV show or become a pop star.

Because of NASA, we can also show kids what our planet, what the Earth looks like from space. They can see what a beautiful planet we live on, but how vulnerable it is, how fragile it is, and we can really make it clear to them that they need to look after it. When we look around us in space, we see all sorts of other fascinating, extraordinary, exciting worlds, but we don't see another planet nearby exactly like the Earth, and that is a very strong message to kids to say, "You live on a beautiful planet after. You need to look after it."

So we are not saying that all children need to grow up and go into space, but we are saying that the work done by NASA has a profound and lasting impact on the way that children view their life on Earth, their cosmic environment. It can influence the choices they make in the future and their careers.

I would like to close with a fan letter we had from Ben, age 6. His mother had told us he wasn't a confident child, but that he loved reading about space so much that it has changed his life. He wrote to us to say, "Now that I know I am good at space, I have decided to become a scientist when I grow

up."

Thank you. Thank you for listening.

DR. HAWKING: What will we find when we go into space? Is there alien life out there, or are we alone in the universe? We believe that life arose spontaneously on the Earth. So it must be possible for life to appear on other suitable planets, of which there seem to be a large number in the galaxy.

But we don't know how life first appeared. The probability of something as complicated as a DNA molecule being formed by random collisions of atoms in ocean is incredibly small. However, there might have been some simpler macro molecule which can build up the DNA or some other macro molecule capable of reproducing itself. Still, even if the probability of life appearing on a suitable planet is very small, since the universe is infinite, life would have appeared somewhere. If the probability is very low, the distance between two independent occurrences of life would be very large.

However, there is a possibility known as panspermia that life could spread from planet to planet or from stellar system to stellar system carried on meteors. We know that Earth has been hit by meteors that came from Mars, and others may have come from further afield. We have no evidence that any meteors carried life, but it remains a possibility. An important feature of life spread by panspermia is that it would have the same basis which would be DNA for life in the neighborhood of the Earth. On the other hand, an independent occurrence of life would be extremely unlikely to be DNA based. So watch out if you meet an alien. You could be infected with a disease against which you have no resistance.

One piece of observational evidence on the probability of life appearing is that we have fossils from 3.5 billion years ago. The Earth was formed 4.6 billion years ago and was probably too hot for about the first half billion years. So life appeared on Earth within half-a-billion years of it being possible, which is short compared to the 10-billion-year lifetime of an Earth-like planet. This would suggest either panspermia or that the probability of life appearing independently is reasonably high. If it was very low, one would have expected it to take most of the 10 billion years available. If it is panspermia, any life in the solar system or in nearby stellar systems will also be DNA based.

While there may be primitive life in another region of the galaxy, there don't seem to be any advanced intelligent beings. We don't appear to have been visited by aliens. I am discounting reports of UFOs. Why would they appear only to cranks and weirdos? If there is a government conspiracy to suppress the reports and keep for itself the

scientific knowledge the aliens bring, it seems to have been a singularly ineffective policy so far. Furthermore, despite an extensive search by the SETI project, we haven't heard any alien television quiz shows. This probably indicates that there are no alien civilizations at our stage of development within the radius of a few hundred light years. Issuing an insurance policy against abduction by aliens seems a pretty safe bet.

Why haven't we heard from anyone out there? One view is expressed in this Calvin cartoon. The caption reads: "Sometimes I think that the surest sign that intelligent life exists elsewhere in the universe is that none of it has tried to contact us." More seriously, there could be three possible explanations of why we haven't heard from aliens.

First, it may be that the probability of primitive life appearing on a suitable planet is very low.

Second, the probability of primitive life appearing may be reasonably high, but the probability of that life developing intelligence like ours may be very low. Just because evolution led to intelligence in our case, we shouldn't assume that intelligence is an inevitable consequence of Darwinian natural selection. It is not clear that intelligence confers a long-term survival advantage. Bacteria and insects will survive quite happily even if our so-called intelligence leads us to destroy ourselves.

This is the third possibility. Life appears and in some cases develops into intelligent beings, but when it reaches a stage of sending radio signals, it will also have the technology to make nuclear bombs and other weapons of mass destruction. It will, therefore, be in danger of destroying itself before long. Let's hope this is not the reason we have not heard from anyone.

Personally, I favor the second possibility that primitive life is relatively common, but that intelligent life is very rare. Some would say it has yet to occur on Earth.

Can we exist for a long time away from the Earth? Our experience with the ISS, the International Space Station, shows that it is possible for human beings to survive for many months away from Planet Earth. However, the zero gravity aboard it causes a number of undesirable physiological changes and weakening of the bones, as well as creating practical problems with liquids, et cetera. One would, therefore, want any long-term base for human beings to be on a planet or moon. By digging into the surface, one would get thermal insulation and protection from meteors and cosmic rays. The planet or moon could also serve as a source of the raw materials that would be needed if the extraterrestrial community was to be self-sustaining independently of Earth.

What are the possible sites of a human colony in

the solar system? The most obvious is the Moon. It is close by and relatively easy to reach. We have already landed on it and driven across it in a buggy. On the other hand, the Moon is small and without atmosphere or a magnetic field to deflect the solar radiation particles, like on Earth. There is no liquid water, but there may be ice in the craters at the north and south poles. A colony on the Moon could use this as a source of oxygen with power provided by nuclear energy or solar panels. The Moon could be a base for travel to the rest of the solar system.

Mars is the obvious next target. It is half as far, again, as the Earth from the Sun and so receives half the warmth. It once had a magnetic field, but it decayed 4 billion years ago, leaving Mars without protection from solar radiation. It stripped Mars of most of its atmosphere, leaving it with only 1 percent of the pressure of the Earth's atmosphere. However, the pressure must have been higher in the past because we see what appear to be runoff channels and dried-up lakes. Liquid water cannot exist on Mars now. It would vaporize in the near-vacuum. This suggests that Mars had a warm wet period during which life might have appeared either spontaneously or through panspermia. There is no sign of life on Mars now, but if we found evidence that life had once existed, it would indicate that the probability of life developing on a suitable planet was fairly high.

NASA has sent a large number of spacecraft to Mars, starting with Mariner 4 in 1964. It has surveyed the planet with a number of orbiters, the latest being the Mars Reconnaissance Orbiter. These orbiters have revealed deep gullies and the highest mountains in the solar system. NASA has also landed a number of probes on the surface of Mars, most recently the two Mars Rovers. These have sent back pictures of a dry desert landscape. However, there is a large quantity of water in the form of ice in the polar regions. A colony on Mars could use this as a source of oxygen. There has been volcanic activity on Mars. This would have brought minerals and metals to the surface which a colony could use.

The Moon and Mars are the most suitable sites for space colonies in the solar system. Mercury and Venus are too hot, while Jupiter and Saturn are gas giants with no solid surface. The moons of Mars are very small and have no advantages over Mars itself. Some of the moons of Jupiter and Saturn might be possible. In particular, Titan, a moon of Saturn, is larger and more massive than other moons and has a dense atmosphere. The Cassini-Huygens Mission of NASA and ESA has landed a probe on Titan which has sent back pictures of the surface. However, it is very cold, being so far from the sun, and I wouldn't fancy living next to a lake of liquid methane. What about beyond the solar system?

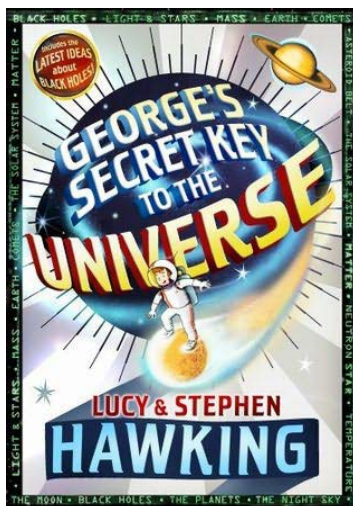
Our observations indicate that a significant fraction of stars have planets around them. So far, we can detect only giant planets like Jupiter and Saturn, but it is reasonable to assume that they will be accompanied by smaller Earth-like planets. Some of these will lay in the [inaudible] zone where the distance from the stars is the right range for liquid water to exist on their surface. There are around a thousand stars within 30 light years of Earth. If 1 percent of each had Earth-size planets in the [inaudible] zone, we would have 10 candidate new worlds. We can revisit it with current technology, but we should make interstellar a long-term aim. By long term, I mean over the next 200 to 500 years.

The human race has existed as a separate species for about 2 million years. Civilization began about 10,000 years ago, and the rate of development has been steadily increasing. If the human race is to continue for another million years, we will have to boldly go where no one has gone before. Thank you for listening.

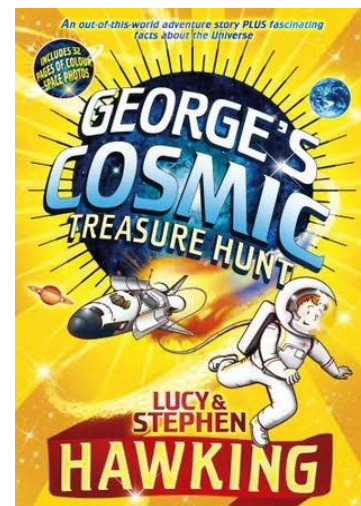
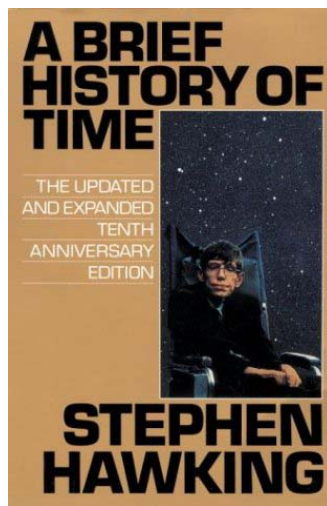
MODERATOR: Thank you, Professor Hawking, for that series of insights and a challenge to us all. I believe now for those of you who wanted to do flash photography, it would be okay for a few moments, and I invite you all to head upstairs for a very nice reception, courtesy of our sponsor, Lockheed Martin. Thank you all.



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