Jay Lenrow: Welcome to the second podcast of the Johns Hopkins University virtual alumni book club for the 2010-2011 academic year. I am your moderator, Jay Lenrow, alumnus of the class of 1973, and the vice president of Hopkins alumni council. We are here on a chilly late fall day in the Steven Muller building on the Homewood campus, the home of both the Space Telescope Science Institute and the famed Hubble Telescope.

It is a particular pleasure to introduce our faculty host, Dr. Mario Livio of the Institute. He will discuss this month’s selection, which is his own book, Is God a Mathematician. Dr. Mario Livio is a senior astrophysicist at the Space Telescope Science Institute and head of the institute’s office of public outreach. He joined the Institute in 1991 as head of the archive branch and also served as the head of the Institute’s science division. In addition to his scientific interests, Dr. Livio is a self-proclaimed art fanatic who owns hundreds of books. During the past few years he combined his passions for science and art in four popular books: The Accelerating Universe, which discusses the beauty of fundamental theories of the universe; The Golden Ratio, which tells the story of an astonishing number and discusses the beauty of symmetric simplicity of Phi and the equation that couldn’t be solved, which is the first extensive popular account of group theory language of symmetry and the theory of polynomials. But we are here to discuss his latest book, Is God A Mathematician?, which discusses the question of why mathematics is as powerful as it is in describing things ranging from the laws of nature to the properties of ordinary nuns. Dr. Livio weaves together science, history and philosophy, and he has made it his mission in life to explain the science of mathematics in a way that most people can understand and enjoy. Dr. Livio lectures very frequently to the public, including more than 20 full day seminars to the public at the Smithsonian institution in Washington DC. And he is also interviewed often in the media, which includes two appearances on the CBS program, “60 Minutes." Dr. Livio’s book, The Golden Ratio, won him the Peano Prize in 2003 and the International Pythagoras Prize in 2004 as the best popular book on mathematics. He is a master at discussing the relationship between mathematics, the cosmos and the human mind. Please join me in welcoming Dr. Livio.

Dr. Livio, if you could, please share two passages that you believe are representative of your writing and discuss why you chose them.

Dr. Livio: Okay, I’ll read three passages, one a little bit longer, two rather short, from the book Is God A Mathematician? So here is one:

“There are actually two sides to the success of mathematics in explaining the world around us (a success that Wigner dubbed “the unreasonable effectiveness of mathematics”), one more astonishing than the other. First, there is an aspect one might call ‘active’. When physicists wander through nature’s labyrinth, they light their way by mathematics--the tools they use and develop, the models they construct, and the explanations they conjure are all mathematical in nature. This, on the face of it, is a miracle in itself. Newton observed the falling apple, the Moon, and tides on the beaches (I’m not even sure if he ever saw those!), not mathematical equations. Yet he was somehow able to extract from all of these natural phenomena, clear, concise and unbelievably accurate mathematical laws of nature.”
“But there is also a ‘passive’ side to the mysterious effectiveness of mathematics, and it is so surprising that the ‘active’ aspect pales by comparison. Concepts and relations explored by mathematicians only for pure reasons-- with absolutely no application in mind-- turn out decades (or sometimes centuries) later to be the unexpected solutions to problems grounded in physical reality! How is that possible?”

That’s one passage. The second one is:

“The sign outside the barber shop in one village reads: ‘I shave all and only those men in the village who do not shave themselves.’ Sounds perfectly reasonable, right? Clearly, the men who shave themselves do not need the services of the barber, and it is only natural for the barber to shave everyone else. But, ask yourself, who shaves the barber? If he shaves himself, then according to the sign he should be one of those he does not shave. On the other hand, if he does not shave himself, then again according to the sign he should be one of those he does shave. So does he or doesn’t he? Much lesser questions have historically resulted in serious family feuds.”

And the latest, the last paragraph is:

“Philosophy is to be studied, not for the sake of any definite answers to its questions, since no definite answers can, as a rule, be known to be true, but rather for the sake of the questions themselves; because these questions enlarge are a conception of what is possible, enrich our intellectual imagination and diminish the dogmatic assurance which closes the mind against speculation; but above all because, through the greatness of the universe which philosophy contemplates, the mind is also rendered great, and becomes capable of that union with the universe which constitutes its highest good.”

Now why did I choose these passages? Well, the first passage really deals with one of the key questions that the book discusses, mainly what noble laureate Eugene Wigner termed the unreasonable effectiveness of mathematics.

Lenrow: And if you could just for the sake of our listeners, while you’re discussing these, just tell them what page in the book these passages are.

Dr. Livio: This was page 4 in the book. So the question is: How come mathematics is as powerful as it is in explaining nature. And I noted here that it is even effective in two ways. One is when you actually see the phenomena and then you try to find a mathematical theory to explain those phenomena. But second this is when mathematicians are, you know, doing something with absolutely no applications whatsoever in mind. In fact they are proud that they are no applications because that’s what mathematicians like to do. And yet somehow decades later those very precise mathematical branches are found to provide the answers to questions that are really explained phenomena that we observe.
The second paragraph that I read is on page 172 and it starts the chapter on logic and reasoning. And that is actually known as the barber’s paradox and it was designed originally by Bertrand Russell. And the idea was to demonstrate that our logic can be fallible, that things that look perfectly reasonable may result in paradoxes or contradictions.

And the last paragraph I read, which is actually the very last paragraph of the book on page 252, is actually a quote from Russell again in his book of Problems of Philosophy. And the reason I chose that is because it really in a way sums up the main reason why somebody should read this book. That the question is more important than the answer. People asked me often, “So what’s the answer to Is God A Mathematician?” And I say it’s not a simple yes or no. So that sort of describes very nicely, in my opinion, the general attitude that I have toward this book. It’s the question that matters.

Lenrow: What seemed important to me in reading your book is how you get people in popular culture, people who are not mathematicians, not scientists, to start thinking of math in a significantly different light. We have a problem probably in this country where mathematics is considered by many something too difficult to understand, to difficult to do. We see falling numbers of students in math, science and engineering in our schools. And what I think for our readers is going to be particularly interesting is the way you demystify mathematics. It’s interesting also to see how math has been treated in the last 10-15 years in some popular culture. And I know my children love watching a recent television series called ‘Numbers.’ It showed how a mathematician was using math to explain what seemed to be random events. So could you explore a little bit more of how you’ve approached that and what you see your research and writing doing to explain math and demystify popular culture.

Dr. Livio: So I think you touched on something that’s very important. You note that there is a great decrease in people going into what we call “stem’ disciplines” which is science, technology, engineering and mathematics. And this is actually a serious problem for this country. It has always been somewhat of a problem. But the problem has become more acute and, you know, the future is in these disciplines. I mean for countries to be successful in the future you need to have enough people that work in these disciplines. And this country used to depend, to some extent, on immigration to actually fill some of those gaps in the sense that you would have had, let’s say, students from China or from India coming here, doing here their PhD in these disciplines, the mathematics and sciences, and staying here. What has happened in recent years is, number one, the immigrations laws became more difficult. So it is more difficult for people to immigrate here. And [the] second is, those countries, you know, China, Korea, India, are actually developing themselves. What happens now very often is that people come here, they do their PhD here, and they go back. They no longer stay here. And since it has never been the case that working in the mathematics or the sciences … that’s the easiest way to become rich, then this is a problem. And this is definitely a developing problem. I see part of my task…. I mean I enjoy writing these books for many reasons…. but at least I hope that by demystifying mathematics and by making it a part of human culture as opposed to some, you know, obscure science, I hope that I encourage more people to actually get into these [fields] and see the beauty that is involved in studying sciences and mathematics. And you know, if I’ve managed to convince at least a few people to do this based on reading my books then I achieved a very big goal.
Lenrow: And I agree, pop culture has probably added to this sense of mystery behind science and math. Is there some way that the readers can extrapolate from your book in their own discussion ... during the discussions in their own wider community outside of this book club... in helping promote the teaching of science and math?

Dr. Livio: Well one thing that everybody should realize ...and I hope that, you know, this book also makes clear as did some of my previous books ... is that mathematics is all around us. I mean even in areas that you don’t think about them as involving mathematics. Mathematics is heavily involved. Let me give you a very simple example. Everybody now uses a GPS, be it in their cars, in their wherever and so on. They have it in their phones and so on. This is a good global positioning system, yes? The global positioning system works in the following way. I mean basically there is a receiver which is the thing you have. And there are some satellites out there. And the system uses the time it take the signal to reach from those satellites to your receiver to actually locate where you are. And this is how it directs you to where you want to go.

Lenrow: Triangulation...

Dr. Livio: So it triangulates on several satellites. Now you may not know this. But actually in this system, both Einstein’s theory of special relativity and Einstein’s theory of general relativity are being used. Because the atomic clock onboard the satellite... they actually, because those satellites are moving, they tick a little bit more slowly by about 1 millionth, a few millionths of a second per day just because of special relativity. And they tick by a few tenths of millionths of a second faster everyday just because the satellites are farther away from the earth. And if those two corrections of special relativity and general relativity... both highly mathematical theories of physics, yes? ...were not used, the accumulated error could be as much as about 5 miles per day to where you are. Which means you would have never gotten to anywhere if they didn’t use these two mathematical theories. Now, people don’t think about this. And they shouldn’t, in a way. But, I mean, mathematics is in everything around you. And this book tries to deal with the nature of mathematics and how come it is as effective as it is, so on so forth. So I hope that people who read this will get this sense.

Lenrow: And I know there’s an attempt to show even young children some of the beauty of mathematics and science, as simple as looking at different patterns of snowflakes, or at the vein patterns in a leaf. I’m reminded of a funny story. When I was in my first year of law school I took a course on real property. And I, loving math, was very happy when I saw the chapter on Euclidian zoning. So I think this is some wonderful mathematical theory on how zoning was done, only to found out when I studied it that it was called that because it was the seminal case in the 1900’s came out of a town in Ohio called Euclidian. And so it became Euclidian zoning. So not everything that appears to be mathematics necessarily is. This actually leads us into some of the other discussion. As the readers are going through this, what ways do you think, what the issues that you raise in the book do you think would be particularly interesting for an online discussion?

Dr. Livio: I think that one of the things that readers may find most fascinating is the discussion of whether mathematics is an invention or a discovery. Namely, are mathematical truths out there
somewhere and we just discover those truths in the same way that astronomers discover a new galaxy? Or is mathematics entirely an invention of the human mind, and it has no existence outside the human mind?

Believe it or not practicing mathematicians are still debating this question. In fact there is a quote that I like to say that most working mathematicians are Platonists ...and I will explain that in a minute... during weekdays and formalists during weekends. And the idea here is the following: I mean, the Platonist feel of mathematics after Plato is that mathematics does exist in some abstract world of mathematical forms and we only discover a few things. So, the formalist view is no, no, no, no, no! This all just comes from the human mind. You just write down some set of axioms and you can derive mathematics from that. You can change the set of axioms and get a different mathematics from that in the same way that I can teach you how to play chess. I will tell you the rules and we will play chess. I change the rules, we play a different game. So there are these two views.

Now, the meaning of that quote is that, when mathematicians do their work they have this feeling that they are in contact with some existing reality. The mathematical truths are there and they just discover them. But when they are pushed on it, from a philosophical standpoint ...on weekends, they say “no, no, no, I don’t believe this... I am a formalist and this is only in the human mind.” So, I believe that this particular question is going to be an interesting question to discuss. And I discuss it in the book and come up with my own conclusions. And I know a good number of excellent mathematicians. .. in fact, there are better mathematicians than I am ....that will disagree with my conclusion. And they come in on both sides actually. So I think that this could be an interesting discussion.

Another thing that I think people would enjoy discussing is the relationship between logic and mathematics. And that Barber’s paradox which I read before, I mean, that just gives you an idea of how logic can sometimes fail you. But, there is a whole school that says that all of mathematics stems from logic. You start with a few axioms of logic and you can derive all of mathematics from that. I think that is also an interesting question to discuss.. you know, the relationship between logic and mathematics. Is mathematics all coming from some logical things? I mean just to give you an example of a logical axiom which I believe I mentioned in the book. If I tell you “either the butler murdered the millionaire or his daughter killed him.” And then I tell you “the daughter did not kill him.” Then you absolutely have to conclude that the butler did it. Your conclusion is not going to be based on how old is the butler, what is the length of the nose of the daughter, or any other details. There are some axioms of logic that you put down and they force you in a particular direction. Is mathematics stemming from something like that, or is this more complicated?

Lenrow: To what extent when readers are applying mathematics.... just to think about your example... is that understanding of mathematics come just as much from eliminating possibilities that don’t fit as discovering facts that do fit? In your example, you started with a basic fact and by process of elimination the answer could be “A” or “B.” And then you discovered that the answer can’t be “B.” You don’t have to go further to understand that it is “A.” In mathematics, to what extent in theoretical math .. or mathematicians eliminating things that don’t work as opposed to approaching it form the other side?
Dr. Livio: So, in mathematical logic that is what happens almost all the time. This is how exactly it operates. But there are other areas of mathematics. Mathematicians sometimes formulate an entire new branch of mathematics that didn’t exist before. When Newton wanted to describe motion, for example, he did not have a good mathematical tool to describe motion. So being Newton, he formulated a whole new branch of mathematics, which is what we now call calculus. And, you know, kids study it at school. Calculus was found to be a fantastic tool for describing motion. So in that case it was not an elimination of something. It was the creation of an entirely new branch of mathematics that did not exist before.

Lenrow: It was interesting that one of our astronauts had an opportunity to do an experiment while on the surface of the moon… one of Newton’s theories.

Dr. Livio: Yeah, well, according to legend Galileo did this experiment from the Tower of Pisa, but as far as I could tell from my research Galileo never did this experiment.

Lenrow: The tower wasn’t leaning quite as much back then [laughs].

Dr. Livio: [laughs] It doesn’t matter that the tower is leaning. But somebody did do this but much later. I did this experiment of dropping two things in a vacuum and seeing that if you drop a feather and a hammer they will fall at the same time to the surface when there is a vacuum. On earth this is of course not going to happen because there is air resistance which slows down the feather. But you could make it in a vacuum tube on earth and you will see that they fall exactly the same way. So one of the astronauts did that just to show that the moon has very little atmosphere, which is practically a vacuum.

Lenrow: But I think that it is also an example of how someone can make that aspect of mathematics entertaining for the general public.

Dr. Livio: Of course, yes. There are many entertaining aspect of mathematics, yes? And people don’t realize this. I think that. I think that the Barber example I gave you is entertaining at some level. So definitely, there are many entertaining aspects. I mean, popular culture as you mentioned before often does not do a service to mathematics because mathematicians and scientists in general in popular culture are often described as crazy people. They are real weirdoes that do all kinds of strange things. I know some people that are weirdoes … but they are not necessarily mathematicians. Some of them may be. But certainly not all mathematicians are weirdoes. One example that I gave in a previous book was this famous mathematician Evariste Galois. He died at age 20 in a duel. So he was, I mean, the romantic, the romantic’s romantic. There are all kinds of mathematicians like there are all kinds of people.

Lenrow: I am reminded of a discussion when my daughter came here to Hopkins. She was trying to decide whether to go into the applied mathematics program in the School of Engineering or the Arts and Sciences mathematics program. So she asked what was the difference? The department chair in Engineering said, well, the mathematics department in arts and sciences tackles a very difficult math problem and they spend the next three years trying to solve it. They come up with a solution and they all go out and celebrate. And the next morning they come into work and say where is the next problem.
And then he said, we here in Engineering say that you just got hired by a company that has 18 trucks that they have to make 94 deliveries in the next 72 hours to 54 different cities. How do you route the trucks for the greatest efficiency?

Dr. Livio: That is actually a famous problem you know. The traveling salesman and so on.

Lenrow: So in a nutshell, I think that really showed two aspects in math that are both necessary. Are there any other issues that you see that would be interesting for discussion?

Dr. Livio: You see I think that these are... plus the main theme of the book, which is how come mathematics is as effective as it is, and does it work in all occasions? What about biology? Do you apply mathematics to biology? Can you apply mathematics to economics? Could we have predicted the latest collapse of the entire economic system? Or, did mathematics in fact cause the latest collapse of the economic system? I'm sure people will discuss some of these questions, and some of them are discussed in the book. Not all of them. But people can create their own subjects based on the reading.

Lenrow: If one of the readers was going out on a walk with their child, and they have just read this book. Is there a nugget that they can keep in mind, just walking through nature, to try and spark an interest in mathematics for their future?

Dr. Livio: Well there are lots actually. They will look up in the sky and maybe the sky will be blue that day. But the reason the sky is blue has to do with the way light scatters through the atmosphere. And it just so happens that our atmosphere scatters light in a way that the somewhat bluer light, shorter wavelengths scatters more than the other parts of the light. And this is what gives the sky its blue color.

They will look around them and see lots of symmetric things. And by that I mean both bilateral symmetry, like the symmetry of our face and that of animals. But they [also] will see other symmetries, like the symmetry of a snowflake, which you can rotate in certain ways and it remains unchanged. And all of those are described by mathematical theories.

They can look at phyllotaxis which is an arrangement of leaves on a stem. And it turns out that the way that leaves are organized, believe it or not, are such that they are organized in an optimal way that they will fill up all space without overlapping. Because if leaves were overlapping then it means that not all leaves would get the same amount of sunshine and rain and so on. So almost everything around you has some sort of a mathematical explanation at some level. I mean that there are things that are not explained in all details. But the theories that we have, they are generally mathematical.

Lenrow: So is there something else that you think the readers should focus on and would be interested in knowing about this particular book. And perhaps even discuss how all four of your books explore different aspects of mathematics?

Dr. Livio: One thing I think people will hopefully enjoy while reading this, I mean I go through the history of great ideas about mathematics through history. So I go through some extraordinarily clever individuals and through their histories. When I write books I do an incredible amount of research. And
also I very often like to travel to the places where these people worked. Some of that you will not know it from just reading the book. But I can tell you some things.

So, for example, I write about Plato. I was very disappointed to discover that Plato’s academy, which was this incredible school where Aristotle was a student and so on, archeologists were unable to find any remains from the academy. But then, while in Greece, I did find that Plato mentioned several places where he liked to walk. And I did find that in Athens. It was an incredibly hot day, close to 130 degrees that day. And I still walked there. Kind of back and forth, thinking ah-ha, this is exactly where Plato used to walk.

Then when I wrote about René Descartes, this famous philosopher, mathematician, biologist, everything, there are all kinds of interesting stories about where he was buried, how his bones were removed from Sweden and sent to France. And I thought, well I have to see his grave. Some of his remains, I mean not the skull, are buried in the church at the Abbey of Saint-Germain-des-Pres. And believe it or not, you come to that church and you enter and I asked “Where is Descartes’ grave?” And they didn’t know. How disappointing? This is one of the most famous philosophers. And then I started looking, and eventually, in one of those small chapels you have alongside of churches on the right I found that there was one of these small chapels where there were three people buried and one of them was Descartes. And there is not even a sculpture there of him. It is of one of these other people, priests or whatever they were. Which I thought was really just unbelievable. It was so unbelievable to me that I actually told somebody about that there in the church. And actually last December I was again in Paris at the church and went in and that part is closed to the people. They have actually put a sign that this is where Descartes’ grave is. So there are all kinds of little things like this.

I wrote about Archimedes. Well Baltimore actually is very lucky in that a very famous piece of Archimedes was donated to the Walters Art Museum. And actually the deciphering work on it was done here at the Walters. Because I knew some of the people there I got to see it. I saw them doing the work. So to me this is very beautiful to be able to get to see this piece with Archimedes’ writing on it and so on. I really enjoy this part of the writing and I hope that it shows in some ways even if I don’t describe it in some detail in the book.

Lenrow: That’s wonderful. Well Dr. Livio, I can’t thank you enough for taking time to do this with us. And I know our listeners will enjoy hearing this discussion and reading the book. And I understand that sometime during the month of January and February you will be posting some six questions on the website and participating in an online discussion of the book. I know the listeners will be looking forward to that. For those of you listening we wish you a very happy holiday season and we thank you again doctor for your time.

Dr. Livio: My pleasure.

END