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SYLVESTER JAMES GATES JR. BIOGRAPHY

At the Forefront of Science

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BY DAVID BAKER, ADAPTED BY NEWSELA

Sylvester James Gates Jr. is a distinguished professor, scientist, and member of the U.S. President's Council of Advisers on Science and Technology. His work is highly influential and stands at the forefront of some of the deepest mysteries about the Universe.

Born
December 15, 1950
Tampa, Florida, USA

EARLY LIFE

Sylvester James Gates Jr. has long considered himself a "simple country theoretical physicist" and prefers to go by Jim Gates. Jim's father, Sylvester James Gates Sr. (1925-2007), was in the army, and a veteran of the "Red Ball Express" during World War II. The oldest of four children, Jim's early years were spent moving from place to place. When he was 4 years old, his mother, Charlie Anglin Gates (1919-1962), took him to a movie called Spaceways, starring Howard Duff. It was the first movie Jim can remember seeing. Although he only figured out what movie it was many years later, the images stuck with him. He saw a rocket launch, he saw spacesuits, and even women venturing into space – a very progressive idea in the 1950s. This movie got Jim's imagination whirring. The imagery planted a seed in Jim's mind. That evening, 4-year-old Jim came home and tried to explain rockets to his father. But his mother possessed an artistic temperament and had no interest in science and technology, so why did she take him to see this movie? It turns out Howard Duff was married to Ida Lupino, one of his mother's two favorite actresses – the other being Loretta Young. In a way, Jim often jokes, Ida Lupino got him into theoretical physics.

Theatrical release poster for Spaceways, 1953.

Jim was a child brought up in the cultural atmosphere of the space race, where the idea of the U.S. competing with the Soviets as they both reached for the stars was often at the top of people's minds. It was certainly a rich atmosphere to continue to feed Jim's already considerable imagination. Jim's dad took care to foster this, and four years later, he brought Jim some books on space travel. The 8-year-old Jim had a revelation: the stars weren't just dots of light in the sky, they were places to where one might travel. And science was the way to get there. Like many kids, Jim decided he wanted to become an astronaut or else a scientist.

Jim's parents put a huge emphasis on education. His father had never graduated high school, though his mother had, so when his dad was studying math for his equivalence exams, Jim took a particular interest. Also, one day Jim's father brought home a set of volumes of the Encyclopaedia Britannica, the Google of that age. Jim was leafing through the many pages of information on everything from history to geography to literature. He came across something called "The Schrodinger Equation." And there he saw some very weird language, the most bizarre set of symbols. Jim was able to recognize it was math of some kind, because amid all the symbols there were equal signs and plus signs. He hoped that one day he would be able to understand this mysterious language. He would later describe the experience as like walking along the seashore, finding a beautiful seashell, picking it up, listening for a moment, and then moving on.

Jim's mother died when he was 11. It was a very painful experience for him. As a result, he retreated into a world of fantasy and imagination: reading science fiction, comic books, drawing, and making up his own characters. That only inspired him more on to the path of science and discovery. When he got older, he noticed a lot of his friends had ceased to use their imaginations as often. Jim continued to do so and it served him well. One of Jim's favorite scientific figures, Albert Einstein, once said, the best tool a physicist has – way more than just knowledge – is imagination.

When Jim was 14 he watched a TV show called Make Room for Daddy. The episode had a nephew visit, a character who was supposed to be a genius, and he went to a school called the Massachusetts Institute of Technology (MIT). Jim was excited to hear there was a school where you only studied what he considered "the good stuff," math, physics, and engineering, and decided he wanted to go there.

High school was a very interesting time for Jim. In those days, U.S. schools were segregated as is often still the de-facto case today. The African-American teachers at Jim's school in Orlando were great. Due to segregation, they felt it was very important to put their all into the job. Jim's favorite teacher was a man named Freeman Coney, who taught Jim physics. It was in his class that Jim saw "the closest thing to magic" ever in his life. Coney showed how you could use math to figure out what objects in the real world do. Math was not just a bunch of numbers on a page or a game we perform in our heads, Jim realized. It tells us how the world works with stunning precision. After two weeks in the course, Jim realized he wanted to be a physicist, but was still thinking about becoming an astronaut.

It was in high school that Jim met a fellow student named Phillip Dunn, another very bright guy. They competed intellectually, seeing who could get to the end of a math problem the fastest, and testing the bounds of each other's knowledge in the same way athletes test the bounds of each other's strength and agility. Phillip introduced Jim to chess. For the first few months, Phillip beat Jim every time they played. This was the first time Jim was intellectually bested by anyone in his life. They kept with it, and soon Jim started to give Phillip a run for his money. Soon, fellow students started to watch their intense competitions, even their teachers took an interest. And, as a result, this segregated African-American high school formed a chess team. They were the only African-American team in the Orlando area, and they competed with predominantly European-American students. They beat everybody they ever played, much to the surprise of their opponents.

Jim grew up in a mid-twentieth-century world where not much was expected of him as an African-American simply because of prejudice. It was in this world that he developed a love for physics. His youth was a strange hybrid experience. Prior to his mother's death, the family lived on army posts which at that time were one of the few places in the U.S. where diverse environments existed. After his mother's death, he was in a world of racial segregation and a thousand modes of discrimination, some petty, some nasty. Yet Jim already knew he was smart from an early age. He had already developed a love for physics. He never let the biases of society discourage him from pursuing what he loved. It had not then influenced what he thought of himself or what he was determined to do with his life. As a result, Jim has ascended to the very peak of modern science, much to the profit of his fellow citizens in the United States, but also of all mankind; his work potentially being not only to the profit of those alive today, but to their children, grandchildren, and great-grandchildren. Albert Einstein is a source of great inspiration for Jim, first for his revolutionary scientific work and for his exceptional way of thinking through problems. It was to Jim's surprise that he learned about Einstein's comments on race, when a friend suggested a book to him in the early 1990s. In a short essay written in 1946, Einstein said:

> ***In the United States, everyone feels assured of his worth as an individual. No one humbles himself before another person or class. Even the great differences in wealth, the superior power of a few cannot undermine this healthy self-confidence and natural respect for the dignity of one's fellow man. There is, however, a somber point in the social outlook of Americans. Their sense of equality and human dignity is mainly limited to men of white skins… The more I feel American, the more this situation pains me. I can escape a feeling of complicity only by speaking out.***

For Jim, Einstein was one of the first Nobel Laureates to speak so forcefully for the rights of African-Americans prior to Martin Luther King Jr. Jim suspects that it was Einstein's scientific method that always had him asking "what if?" questions that gave Einstein a great deal of empathy, and after going through his early career as a German Jew, he was also very aware of how racial discrimination caused people to treat one another in the most appalling and oppressive ways. The story given to us by the scientific method further adds empathy to fellow humans. Jim feels it is important that the story of how we are all descended from a small population in Africa about 64,000 years ago (a blink of an eye in evolutionary time), and how closely related we are in terms of our DNA, is a story that should be shared more broadly throughout society. Jim says:

> ***When you look at that fellow over there who may be darker, or perhaps his eyes are shaped differently from yours, or perhaps his hair texture's different from yours, you really are looking at a distant relative… Yes, family conflicts can be severe, but most of the time that familial bond asserts itself and that's actually what we need as a species… Think about that: when you abuse someone because they don't look like you, that's abusing a relative. That's a really difficult thing to do… And ultimately you are abusing yourself.***

Jim graduated high school in 1969. He spent that summer in a program where even later he met Ron McNair, a future astronaut who would later lose his life in the Challenger tragedy. The cash-strapped students pooled together their funds with a group of others to buy food, so they trekked off to the market to buy fresh meat and vegetables. Jim went to MIT and Ron went to a traditionally African-American college, North Carolina A&T State University, to study their bachelor's degrees. They would meet again.

At MIT, Jim declared himself a mathematics major but did many physics courses simply out of his love for the subject. Jim and a friend then looked into seeing whether his coursework could get him both degrees. The Physics Department said he needed to do some laboratory work and an undergraduate thesis, but otherwise his transcript looked very much like that of a physics major. And so in 1973, he received both a

Bachelor of Mathematics and a Bachelor of Physics.

Jim then embarked on graduate work in physics at MIT. Ron McNair came to MIT to do the same. They took classes together. In order to do a Ph.D. at MIT, they needed to pass a grueling exam process. The first time Jim and Ron tried, both failed. So in January 1975, Jim and Ron studied together. This was the first time in Jim's life when he studied with someone else. Through the experience, Jim learned that having more than one mind attack a problem was a powerful thing. A problem usually has more than one possible solution, so having people with different points of view approach a difficult challenge was a great way to learn collectively.

Jim and Ron both passed their exams and went on to write their Ph.D. theses. Jim was looking around for a topic. Jim started off with something called "weak interaction physics." It soon became clear that this topic could be mastered and that he already had done so. Jim realized if he was going to distinguish himself in his career, he was going to have to tackle some trickier questions that nobody had really explored before. In 1976, Jim surveyed the literature of questions at the forefront of physics. He came across a couple of papers on "superspace" and "supersymmetry," which used the strangest mathematics he had ever seen to describe physics. It was new and nobody essentially knew much about it. Jim wrote the first doctoral thesis at MIT on supersymmetry. By the time Jim got his Ph.D. in 1977, he became a world expert on the subject at a fairly young age. At the conclusion of Jim's defense of his thesis, Professor Ernest Moniz, who much later would become the secretary of the U.S. Department of Energy, commented that it was the best Ph.D. defense he had ever witnessed.

WORK AT THE FOREFRONT OF SCIENCE

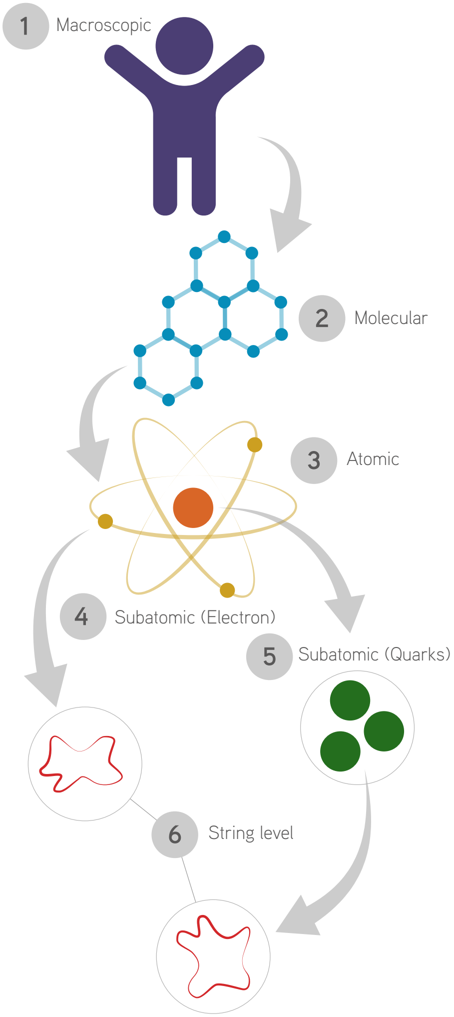
Jim's work is of profound importance to how we understand the Universe. But what does a physicist do? When Jim was growing up, he was intrigued by the mysterious language, the set of symbols, he had seen in Encyclopaedia Britannica. Math happens to be the only known human language that is accurately constructed enough to describe nature in all its complexity.

So when Jim's wife, Dr. Dianna Elizabeth Abney, gets asked the question, "What does he do?" she likes to say, "He makes stuff up for a living." And like a novelist who strings nouns and verbs together to tell stories, Jim uses math to tell stories. But the real test for a physicist is to tell stories that accurately reflect the natural world.

Another way to think of it is that a physicist is like a composer. But instead of using musical notation and a series of sounds to express something beautiful, a physicist uses equations. The people in a composer's audience judge the quality of the music for its expression and its ability to stir deep feelings. A physicist's audience is nature, and it is the "audience of nature" that provides the judgment.

So when Jim's wife says, "He makes up stuff for a living," it is not too far off. Jim must use math to tell stories, or, rather, to construct theories. When new facts arrive that current theories don't account for, you need to make up a new theory. There are things about the Universe that classical physics don't quite explain. Jim's work with string theory and supersymmetry suggests that if we want to understand our reality, we have to craft a new story. While at graduate school, Jim discovered that supersymmetry equations might tell us more about the Universe than anything else. If true, the new story that we write about nature could show us amazing things. It could even result in a simple piece of mathematics that describes our entire reality in one elegant story. And that is the essence of the goal of science – finding the most accurate way to describe the Universe in which we live.

But what does Jim study? He studies the fabric of the Universe, tiny vibrating "strings" or "filaments" that physicists believe exist at the smallest



Different levels of magnification of matter:

1. Macroscopic level: Matter
2. Molecular level
3. Atomic level: Protons, neutrons, and electrons
4. Subatomic level: Electron
5. Subatomic level: Quarks
6. String level

scales. How small? Take a child that is about a meter tall and shrink them down to a tenth of their size. Now they are about the size of a small rodent. Shrink them down again to another tenth and they are about the size of a coffee bean. Shrink them by another tenth, and then another, and they are smaller than a grain of sand and about as tall as the width of a single human hair. Shrink them by another tenth, and they are about the size of a white blood cell. They are no longer visible to the naked eye.

Shrink them down this way two more times, and even the microscopes you use in science class probably won't see them. Shrink them by another tenth, and they are tinier than some of the smallest viruses known to humankind. Shrink them down this way three more times, and they are smaller than a hydrogen atom. Shrink them by a tenth four more times and they will be about the size of a single proton in the nucleus of that atom. Keep reducing by 10 another for six or seven times, and they will be the size of the quarks that are the ingredients for protons and neutrons. Jim spends a lot of time studying the nature of particles around this size. Keep going, shrinking into a tenth, again and again, for another 13 times. You have now arrived at the rough size of the strings which Jim studies. This is thought to be the fabric of the Universe. To a person the same size as one of those strings, the original child would be bigger than the entire known Universe is to us.

In order to study tiny vibrating filaments this small, we need mathematics. As Jim says, "For a theoretical physicist, mathematics is like an extrasensory perception organ that we use to see the universe." It is through mathematics that Jim explores the Universe on scales that were once not thought possible. He looks at the tiny particles that make up matter: quarks that are the ingredients for protons and neutrons, and leptons, the most well-known being electrons. He also looks at "force carrying" particles like photons, gluons, and W and Z bosons, that are responsible for the "fundamental forces" that determine the physics of our Universe: electromagnetism, the strong force, and the weak force. Gravity is much trickier to understand, because it is so different from the other forces.

MATTER	"FORCE"
Quarks (ingredients for protons/neutrons)	Photons (electromagnetism)
Leptons (such as electrons)	Gluons (strong force)
	W, Z bosons (weak force)

Jim's calculations on supersymmetry showed an exciting new idea. The math indicated that there may be a new world of hidden particles that no one had previously suspected. Every matter particle could have a force partner. These twins are called "super-partner particles" or "sparticles." An electron partner would be a "selectron," a quark partner would be a "squark," a Z boson would have a "Zeno," and a W boson would have a "Wino."

It could be that, right now, we can only see one partner from each pair. If this were proven, it would revolutionize our understanding of physics. It could shed light on what dark matter is. It could help us understand what the "fabric of the Universe" is, and how it can be more accurately defined. It could also explain why existing particles of matter and energy have the properties that they have, or why they seem to exist in such great numbers. It could help us understand better how gravity fits with all the other forces, resulting in a Grand Unified Theory.

Finally, it could increase our understanding of what happened at the Big Bang. In current physics, there is no single clear point in time where all the fundamental forces were joined together a split second after the Big Bang. Supersymmetry demonstrates such a point where every single force was united far back in time, before they split off and became distinct, determining the physical laws that govern our Universe.

Starting in the middle 2000s, Jim pursued a route where calculations can be represented as pictures that can be examined by other mathematicians. They seem to have "codes" in them, as if the Universe were a big computer generating a world like that in the *Matrix* films. Jim thought about whether there are other codes considered in nature and found suggestions of them in DNA and evolution. An exciting possibility is that evolution played a role in the laws of nature for the entire physical Universe, just like in biology. He finds this interpretation of his work as the most profound accomplishment of his career.

Jim's theories have many different models. The Large Hadron Collider at CERN can only test for a few at a time. The hunt for these "sparticles" could take quite a while. But the end result of these experiments might revolutionize our understanding of what the Universe is made of and how it works. It is in this sense that Jim's work stands at the forefront of science.

Theoretical physics takes time to become clearer and clearer in its value. It is like putting a message in a bottle and sending it out to sea, in the hopes that someone finds it someday and reads its message. A theory can have amazing results when harnessed by future generations. Sort of like how the discoveries that made cellphones possible were made all the way back in 1876. In a similar way, Jim's theories might be useful to build amazing technologies in the next 150 to 200 years, perhaps even something like the transporters and warp drives we see in Star Trek. Many times in history, physics has provided us with the "DNA" for advanced technology.

JIM'S CAREER

After graduation, Jim did postdoctoral work at Harvard. From 1979-1980, Ron McNair encouraged Jim to apply to NASA and become an astronaut. For a time, Jim pursued his other childhood dream. Eventually, NASA informed Jim that he didn't have the "right stuff" and he went off to do a postdoc at Caltech from 1980-1982 with some of the giants of modern physics: Richard Feynman, Murray Gell-Mann, and John Henry Schwarz. Jim re-embarked on a career concerning his other passion – physics. From 1982-1984, Jim taught mathematics at MIT. In 1983, Jim co-wrote a book called *Superspace or 1001 Lessons in Supersymmetry*. The book contained one of the only advanced treatments of supersymmetry for over a decade and remains a staple for students of physics today. In 1984, Jim began teaching physics at the University of Maryland where he continues to teach today, and from 1990-1992 also did some teaching at Howard University.

In 1986, Jim lost a friend. Ron McNair was aboard the space shuttle Challenger when it broke apart shortly after launch. Jim remembers exactly where he was when heard the news. He was in a bank on campus at the University of Maryland, and a woman came running into the room shouting "the shuttle exploded!" Some people thought she was referring to the campus bus system called "the shuttle" which was always breaking down. A look of horror came over her face, and she said, "No, the real shuttle has exploded." In that moment, Jim knew what had happened to Ron. He had seen Ron six months before at a roast in his honor, where they joked about the old days. When the tragedy happened, Jim dealt with his grief by telling stories about his old friend. Since then, Jim has watched his old friend become a historic figure, which Jim says is a pretty frightening process.

Today, Jim Gates is Regents Professor, John S. Toll Professor of Physics, and Center for String & Particle Theory Director at the University of Maryland. He was the first African-American to hold an endowed chair in physics at a major research university in the U.S. In 2006, Jim published another book called *L'arte della Fiscia* (The Art of Physics). In 2009, Jim was appointed to the Maryland State Board of Education and almost simultaneously to the President's Council of Advisers on Science and Technol-

The crew of Space Shuttle mission STS-51-L pose for their official portrait on November 15, 1985. Ron McNair is in the front row, far right.

U.S. President Barack Obama presents the National Medal of Science to Dr. Sylvester James Gates.

ogy. Even today, Jim is not enamored of titles. That is just as well, because his many achievements and honors speak for themselves. He holds many positions, holds many awards and several honorary degrees, and has appeared in a large number of documentaries for science outreach.

In 2011, President Barack Obama awarded Jim the National Medal of Science for his considerable contributions to modern physics and scientific outreach. The ceremony took place in 2013. This was a major scientific award. He was nominated by the former president of the University of Maryland, then a set of experts were asked to provide input on what Jim had done with his scientific career, then another group of people evaluated that input, then still another group decided if he deserved the award. Like the Medal of Honor for bravery and the Medal of Art for beautiful expression, the Medal of Science is an important recognition of a person's contribution to science, with a long list of brilliant people going all the way back to 1962 – the days when Jim was nurturing his imagination with science fiction, comic books, and a thirst to explore the Universe.

In 2013, Jim became the first African-American physicist to be elected to the U.S. National Academy of Sciences in its 150-year history. At the time, a friend pointed out to Jim that "he had finally made it into the history books alongside of Ron."

Jim has written or co-written more than 200 papers and articles. Jim has been teaching for 43 consecutive years, researching for 39 consecutive years, doing media outreach on behalf of science for 20 consecutive years, and advising on public policy at national and state levels for five consecutive years. Jim thus has four careers. In fact, he's got a budding fifth career by lending his charismatic "narrator's voice" as a spokesman for the "Potential of Us" campaign, where he stresses how connecting minds through technology is vital to the collective learning of humanity. Because of connectivity, it doesn't matter where you are in the world, you can constantly talk to your friends and colleagues and form a creative network, the power of which has never before been seen in human history. For 200,000 years, humans have collaborated generation after generation to invent everything from stone tools to skyscrapers. Now, the immense amount of connectivity between us means that innovations may be radically accelerating.

THE IMPORTANCE OF SCIENCE

Jim's wife is a chief health officer for one of the counties in Maryland. Their twin children, Delilah Elizabeth Abney Gates and Sylvester James Gates III, completed their Bachelor of Science degrees at the University of Maryland. Their son studied biology and their daughter, like Jim, studied both mathematics and physics. Their twins, as of 2015, have been both admitted to do graduate research, to continue to push the frontiers of human knowledge. Jim has urged them to ''Think Different'' if they are to make innovative contributions to science. It is also a surprise to Jim, who says, ''I never thought I would become the father of a scientist and certainly not two.''

To Jim, science is important. We must strive to increase the storehouse of human knowledge which is ultimately used to improve the quality of human life. In this sense, scientists are working not just on behalf of us, but our children, grandchildren, great-grandchildren, and great-great-great-great grandchildren. Science is a commitment to humanity. For most of human existence, we've lived in a global environment that has been very gentle and congenial for us. In the next century, millennium, or tens of thousands of years, if the environment becomes more hostile, only technology will prolong our survival as a species. And for that technology, we need to rely on science.

In that sense, Jim feels it is important to be a lifelong learner. Most people disengage from science after they leave school because it is not strictly relevant to their daily lives. But science is constantly putting us in the position of redefining what it is to be human. Even those people who don't pursue science with their daily lives need to engage with these ideas, in order to discuss what it is we want for our future. This will not happen if people disengage from science. In that sense, the grand narrative that science tells us about humanity and the Universe is important to everyone.

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Image of U.S. President Barack Obama presenting the National Medal of Science to Dr. Sylvester James Gates, University of Maryland, during a ceremony in the East Room of the White House in Washington, February 1, 2013. © Jason Reed/Reuters/Corbis.