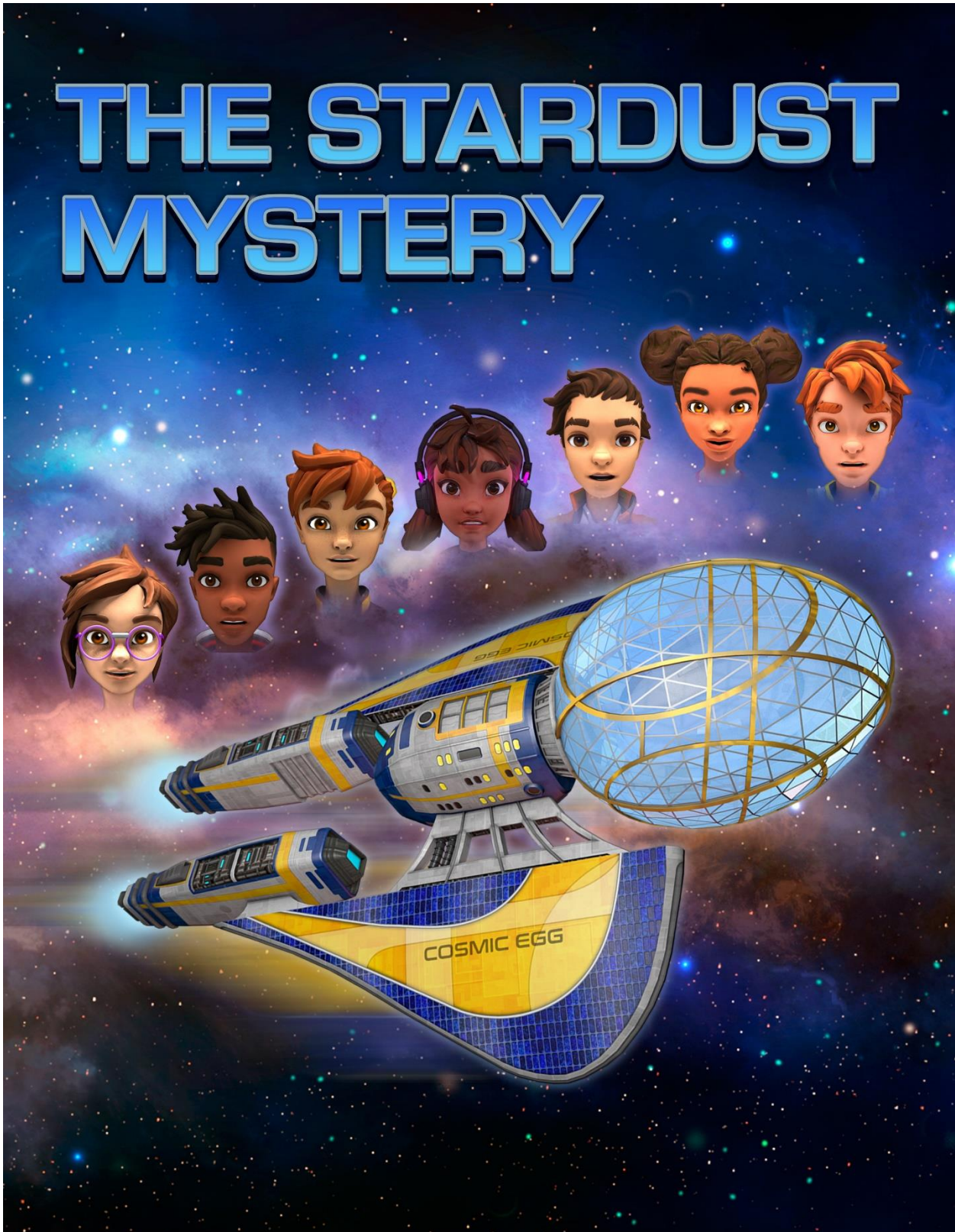
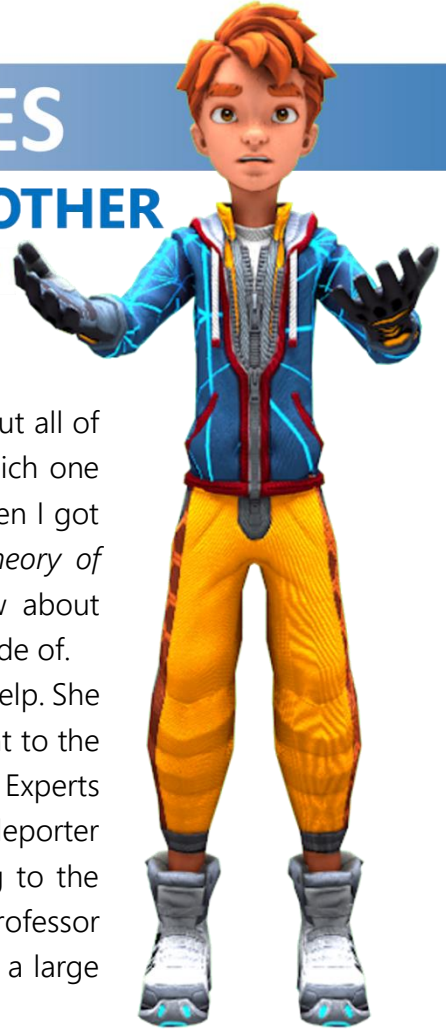


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# MILO'S STORIES

## QUARKS, AND STRINGS, AND OTHER STRANGE THINGS (AS TOLD BY MILO)



I thought that it was really important to the mystery that we find out all of the things that our bodies were made of, so we could identify which one was stardust. So, I had to think of who would know about that. Then I got this brilliant idea. G-Pa had taken me to see the movie *The Theory of Everything* about the physicist Stephen Hawking. He must know about everything, including what protons, electrons, and neutrons are made of.

The next morning, Neddy went home. I thanked her for her help. She was growing on me, that kid. I definitely owed her one. Then I went to the G-parents and I logged on to the *Beamer*. I went to the Gallery of Experts and asked Milo the Guide to see Stephen Hawking. There was a teleporter in the Hall of Experts. Milo the Guide said that I would be going to the University of Cambridge in Cambridge, England. I found myself in Professor Hawking's office. He was sitting in a motorized wheelchair next to a large telescope.

I introduced myself as I was instructed.

"Hi, Professor Hawking," I said, "my name is Milo."

Professor Hawking introduced himself, but he didn't talk. Instead, a deep loud voice came from his computer, as he used a sensor connected to his cheek to type words. "HOW DO YOU DO, MILO? I AM STEPHEN."

His voice sounded strange and metallic. But I remembered from the movie that Professor Hawking had a nerve disease—a disease where the neurons in his brain no longer worked like they were supposed to. That's why he was in a wheelchair and used a computer to simulate his voice.

"I'm working on a project to find out all of the things that our bodies are made of," I explained. "I found out about cells and DNA, and that DNA is made of molecules, and molecules are made of atoms, and atoms are made of protons and electrons and neutrons. But what comes next? What are the protons and neutrons made of?"

"THAT IS EASY," said the voice after a long pause during which Professor Hawking composed his answer. "PROTONS AND NEUTRONS ARE MADE OF [Quarks](#)."

"Quarks! That's great news."

## QUARKS, AND STRINGS, AND OTHER STRANGE THINGS

Then the voice went on to tell me more—he said that quarks might be made out of tiny strings according to something called [String Theory](#). “WE ARE NOT SURE YET. STRING THEORY IS THE NEWEST PART OF THE THEORY OF EVERYTHING, BUT IT ISN’T YET PROVEN.”

So, I told him thank you, but let’s stick to quarks. There’s enough confusing stuff to think about without adding unproven things to the mix. I took careful notes as I learned what we thought we knew.

“ONE MORE THING,” said Professor Hawking, “YOU MUST ESTABLISH COLONIES ON OTHER PLANETS.”

“Why?” I asked.

“TO SAVE THE HUMAN RACE,” answered the voice.

I said thank you and left the office. *First let me win this contest and go to the moon*, I thought shaking my head and smiling. *Then maybe I can colonize Mars.*

• • • • •

At our next Cosmic Kids meeting, I told my team what I had learned. “Girls aren’t made of sugar and spice, and everything nice,” I said grinning. “They’re made of quarks, and strings, and other strange things.”

So, I thought about bones made of cells, and cells made of chromosomes, and chromosomes made of genes, and genes made of DNA, and DNA made of molecules, and molecules made of atoms, and atoms made of protons, electrons, and neutrons, and protons and neutrons made of quarks, and quarks maybe made of strings.

“Lizzy, you were right. It really is like those Russian dolls,” I said. “Every part of the body is made up of a still smaller part.”

I laid out all the dolls and put labels for the body parts in front of them.



Cells

DNA

Molecules

Atoms

Protons

Quarks

Strings

## THE STARDUST MYSTERY

But VC looked puzzled. "I don't understand cells and DNA and molecules and atoms" she said. "And I definitely don't understand protons and electrons and quarks and strings."

I finally realized what the blobby figure made up of plastic building blocks—the second clue—was.

"So," I said as I took that out and started disconnecting the pieces, "See these plastic building blocks?" Everyone nodded. "When you build something like this character, you put lots of little blocks together, right?"

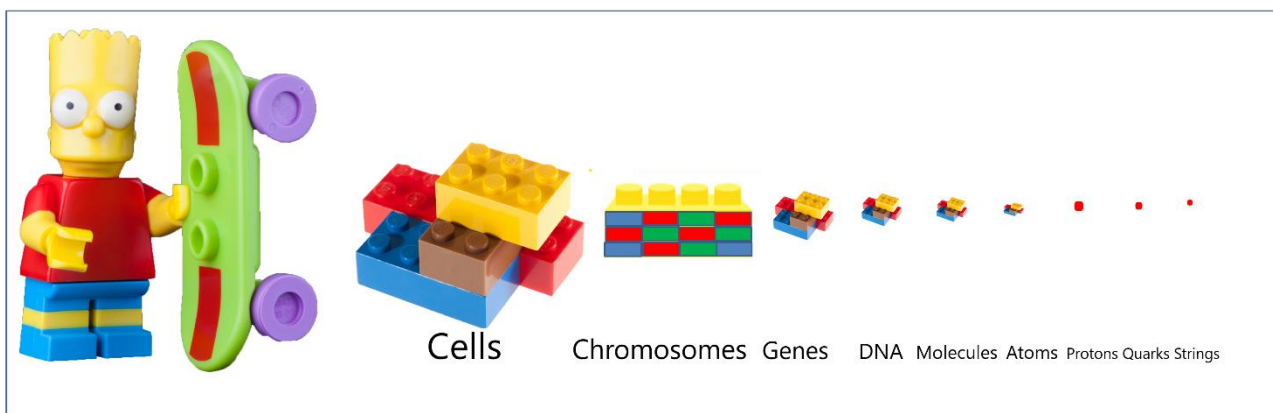
"Right," said VC.

"Squint at it so you can't see the blocks, just the shape of the figure."

Everyone squinted at the figure.

"Now it's just one big blobby figure," VC said.

"So, imagine your body is made of lots of really tiny little blocks," I said. "They are so tiny that you can't see them individually, but you can see what they make when you put them together, like a finger or piece of hair. Well, the blocks are like the cells in your body. You assemble the cells into the different parts like bones and fat to make a body."



"I get it," said VC. "My building blocks are my cells."

"Right," I said with a fist bump to VC. "Now comes the hard part. You have to imagine that each tiny block is actually made out of even tinier blocks. And the super tiny blocks are things like chromosomes, and other cell parts that build a cell."

"And then super-duper tiny blocks make up the chromosomes," I went on. "And super-duper teensy-tiny blocks make up the genes. Those are called DNA molecules. Well, it keeps going on like this, like the Russian dolls, until you get to the smallest piece that scientists have found so far, and these are the quarks. Does that make things clearer?"

"Maybe a little," said VC. "I do understand how the big blocks are like our cells."

"And as far as the stardust goes," I added, "it seems like atoms has got to be the answer."

## QUARKS, AND STRINGS, AND OTHER STRANGE THINGS

I decided to put what I learned into a poem. I wrote:

### WHO AM I

*I am skin and bone and muscle and fat.  
With legs to walk and a head for a hat.  
With eyes to see and a nose for smells,  
and each of these is made of cells.  
And my cells contain my DNA,  
I have millions of billions of these, they say.  
DNA is chains of mol-e-cules,  
with atoms all joined by chemical rules.  
Protons and neutrons and electrons too,  
make all the atoms that make me and you.  
Even smaller quarks create these particles,  
I learned about them from science articles.  
And quarks may be made of tiny strings,  
That's all there is, there are no more things.  
So that is me.*

*Can you guess which thing in our body is the stardust?*

# GRANDPA'S GLOSSARY

Quarks: Scientists discovered that besides the well-known building components for atoms (protons, neutrons, and electrons), there are over 200 other fundamental particles (photons, W bosons, Z bosons, gluons, Higgs bosons, gravitons, muons, and neutrinos). In 1969, Murray Gell-Mann and George Zweig independently proposed that just as atoms are composed of smaller particles, most elementary particles were actually composed of a smaller set of particles too. These are called quarks. There are six types, or flavors, of quarks: up, down, strange, charm, bottom, and top. Protons are made of two up quarks and one down quark. Neutrons are made of two down quarks and one up quark.

String Theory: There are two theories that are the foundation of modern physics: General Relativity (that describes gravity), and quantum field theory (that describes the behavior of the basic fundamental particles). String theory is being developed to bring both theories together. If we think of a guitar string, different notes can be played on the string. The string vibrates in ripples or waves like you see on water. In string theory, the elementary particles are thought of as the "musical notes"—or excitation modes—of elementary strings. In string theory, quarks are different excitations of the more fundamental strings.

QUARKS, AND STRINGS, AND OTHER STRANGE THINGS

# THE STARDUST MYSTERY PROJECT

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