



THE STARDUST MYSTERY

The Solomon Family

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by

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PART 1

VIRTUAL REALITY

October to November



THE SCIENCE AND THE FUTURE CONTEST

(AS TOLD BY LIZZY)



Neddy came rushing into the house screaming, "Lizzy, Lizzy, Lizzy, we HAVE to enter this contest. If we win, we can take Grandpa to the moon, just like he's always dreamed of!!!! She's waving these pieces of paper and trying to catch her breath.

"Oh, zip it ," I yelled, shooting her my meanest look. "Can't you see I'm doing my homework."

"But, but..... but, Lizzy," she begged, "you've got to see this. There's this big contest, and we can enter with Milo and VC, and we can win, and we can go to the moon."

I dropped what I was doing. "Ok, I'm listening," I said. "Calm down and show me what you're yelling about! As I read through the announcement, and listened to Neddy frantically explaining how she thought we could win the contest, I had an image in my head. All of us were buckled into seats in the rocket ship, one on top of the other, with Grandpa on the top. But only Grandpa's head with his wizard cap could be seen through the window as we launched into space.

Her idea is either totally wacko or totally brilliant. I don't know which. I decided to write down what happened.

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This all started about three weeks ago. Neddy is my pain in the you-know-what little sister. She's eleven and in sixth grade, two years behind me. I only got to have a year and a half without her following me around. What were my mom and dad thinking, having a second kid?

There're really two Neddys, her usual self, 'Neddy the Nerd' and her sometime self, 'Neddy the Nice.' 'Nerd' drives me crazy, picks fights with me, steals my clothes, embarrasses me at school for being so spacey and pays no attention to the rules. 'Nice' is fun to play with, and we both love soccer, so we kick the ball around. Sometimes she has great ideas, sometimes she helps me with breaking the rules, which I almost never do, except for Mom's rules which I always break, and most times she is my ally against Mom and Dad. When she is not daydreaming, 'Nice' also is good with colors and loves fashions, so sometimes she helps me with shopping for new clothes, which I am not good at, and really don't like doing.

Anyways, Neddy is kind of a science nerd. She loves space and can tell you anything about the moon, like stuff brought back by the astronauts. These things are seriously boring to most of us kids, but Neddy loves it.

Most of the time in school, Neddy daydreams and stares off into space, and is lost in her own world. It's moments like these that I'm embarrassed to be her sister. She gets teased a lot by her classmates, and mostly by the class bully, Richie Ellis. Richie has come up with a bunch of mean names for Neddy, like Space Cadet, Spacey, Space Ship Challenged, Space Station, Looney Probe,.... The list goes on and on.

This one time, her science teacher had the class discussing space travel and she asked each of the kids, "if you could go to the moon, what is the one thing you would love most?"

"Floating in space", was Neddy's answer. She said that Richie whispered loud enough so that everyone would hear, "of course, that would be Spacey's favorite thing."

It didn't help her reputation when she came to school with toilet paper in her hair after un-mummifying the tree in our front yard the day after Halloween. Richie had the whole school calling her 'Hairy Potty.'

Usually Grandpa can cheer her up. When the kids teased Neddy about the toilet paper in her hair, he told Neddy, "you think Albert Einstein cared about how his hair looked?" Neddy loves anything about science, so Einstein goes a long way with her, as he is like the all time science genius. Grandpa showed her a picture of Einstein with his hair all wild and twisted like on a cave man. "You think Einstein cared what other people said about his hair? No,...because he had his mind on other things. BIG THINGS! Like the working of the universe...where we came from. Deep stuff. And you're like him, Neddy,...you are thinking of important stuff too."

Grandpa's pep talks usually work with Neddy, but two days after the toilet paper incident, I heard her crying in bed in the room we share. "Ok, spit it out!" I demanded.

Sniffling, Neddy admitted, "I'm tired of being 'Hairy Potty' and 'Looney Probe.' I don't want to go to school anymore. I do everything wrong, and I always get laughed at, so what's the point?"

Usually nothing really gets to Neddy. She just shrugs off all the laughing. But the teasing was finally getting to her. Richie and the other kids were killing her spirit. Nobody gets to bully my sister except me. "Look," I said, hugging her, "you're a great kid and you have great ideas. How about entering the Science Fair that they're having at school. You could show up the rest of those lame kids by winning. You could show them that being a nerd has advantages." Anyways, this idea seemed to interest her, and the Science Fair was just a week away.

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Nothing could wipe the smile off Neddy's face as she worked all week on the submission, showing it to me now and then for my approval. On the following Sunday, the day before it was due, she called me over to her desk and unveiled the project by removing a blanket. "Ta da," she announced with a huge grin and a bow as she revealed three incredible posters. "My project is called *'The Life of a Star.'* I made these posters of the birth, life and death of a star."



"I found lots of pictures to use on the NASA Picture of the Day web site," she said. "They put up pictures every day taken from the [Hubble Space Telescope](#) and other satellites and telescopes. I found two unusual pictures of a *'Star Factory.'* and a *'Supernova Star Explosion.'* And I have a picture of our *Sun* in the middle. Together, they tell about the life of a star. The *Star Factory* is a region of space where new stars like our sun are born by gathering up hydrogen gas. The middle poster of the *Sun* shows a star after it was born where the hydrogen is being burned to produce light and heat for the planets. And, the *Supernova Star Explosion* is how big stars die when they have used up all their hydrogen and explode in a blaze of glory. I hope that doesn't happen to the *Sun* any time soon."

"Wow," I said to give her confidence, "this looks really cool. I like it. I bet you'll win."

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And win she did! Neddy won for the entire school, and two weeks later entered the Connecticut-wide Science Fair at the Convention Center and won that too! Which, brings us to today. . .

. . . where she is screaming, "Lizzy, Lizzy, Lizzy, we're going to the moon with Grandpa." She's all worked up as she describes meeting the mysterious Dr. Chokey, Dr. Q for short. "He was one of the judges. He runs this big company, and his [company is going to take people to the moon](#). And they're having this big contest for kids all over the country, and if we win, we can go too."

I look back at the announcement. "His name is Quixote," I said with a laugh, "not Chokey. That would be more like Kwix-oat-he."

"Whatever," she says. "Anyway, Dr. Q said that only a team of family members can enter the contest, like sisters and brothers and cousins of up to four kids. And you can have one adult as coach. The kids have to be less than 13 by the end of this year. So there are you and me and VC and Milo. That would be the four. Milo is smart and VC is really good with computers. And Grandpa could be the coach. Grandpa is really smart, and I think that it would cheer him up. He has been kind of sad since he got fired. It is a perfect team."

"Neddy, it's not so perfect," I argued. "The only person I fight with as much as you, is Milo." Milo is our cousin. He is 13 like me, and we're in the 8th grade at King Philip Middle School. He looks a little like Justin Bieber, so the girls in our class think he's cute. But he thinks all girls are annoying, most of all me. "He is not going to want to cooperate with us," I said.

"But he cooperates with us when we go hiking and camping," replied Neddy.



October 1

SCIENCE & THE FUTURE CONTEST

Grand Prize:
A trip around the moon for your team and coach
aboard the Cosmic Voyager

WHO MAY ENTER:
Teams of up to 4 plus Coach
Must be members of the
Same Family (cousins or closer)
Team members must be no more than
13 years old on December 31 this year

1. REGIONAL QUALIFYING CHALLENGE:
Submit the best "*Invention For the Future*"
Submissions due March 31 next year
Regional Finalists announced in June

2. NATIONAL CHALLENGE FOR GRAND PRIZE:
Starts September next year
Entry Form Attached
Quentin Quixote, President

Time & Space, Inc, 33 Navaho Blvd, Palo Alto, CA 13456, 555 432 1234

"Yeah," I agreed, "he does cooperate sometimes. And he knows how to do research on the internet because of his sneaker obsession." He's got a collection of over 30 sneakers in all styles and has done lots of research about sneakers. "Well, even though he's not as smart as me, he's pretty smart, so we probably could use him on the team."

"And, you're right about VC," I said. "She would be a great team member. She's the only one I don't fight with." VC is also our cousin. Her name is Victoria Clair, but everyone calls her VC. She's 12 and in 7th grade. She's a great swimmer and wins lots of races against much bigger kids. And she has good manners, especially around grownups. She's not like Neddy and me and my brother who Grandpa calls the '*Barbarians*.' "Maybe VC's good manners will help us when we have to present our stuff to the judges."

"Yeah," added Neddy with a smirk. "But her good manners are just for show. Whenever we have a bad word contest, VC knows as many bad words as the rest of us put together."

"Actually more," I agreed, "because she knows them in French, too."

"I think VC could make a good spy," I said. "Remember when she organized that plot to embarrass Max Wildon." Max was one of the school bullies. VC organized a surveillance team of Neddy and me and some other kids who have been Max's victims. We kept track of him and took pictures and videos when we could.

"That was great," said Neddy between giggles. "We got a picture of him smoking under the bleachers at a school soccer game and a video of him stealing one of the sixth grader's lunches. VC left a copy of the picture in the Principal's mailbox and posted the video on YouTube. Everyone in school saw it and Max was pretty embarrassed."

I looked again at the stuff Neddy had brought home. "The contest is about *Science and the Future*," I summarized. "There are two parts. The first is the Regionals, where we compete against other teams in New England. We have to come up with an '*Invention for the Future*.' If we win the Regionals, we get to compete in the finals for the moon trip."

"And, you're right, Neddy," I agreed. "Grandpa, would be a great coach for the contest." Grandpa loves science and has a Ph.D. in physics. He once told me that the best job he ever had was working for NASA on the space program when he first got out of school. But he never would tell me about why he left. Grandma wouldn't say anything either. It's been kinda like a dark secret. Since NASA, Grandpa has been a middle school science teacher, and in his spare time, a computer programmer and inventor.

But, Grandpa is retired from teaching now. Everyone says he was actually fired. Until last year, he taught eighth grade science at my Middle School. All the kids said he was great and I was looking forward to having him as a teacher. Anyway, this one day, Grandpa was giving a lesson on [Galileo's Experiment](#) where you drop two objects that have different weights and show that they reach the ground at the same time. That shows that all objects have the same acceleration due to gravity. That's different from what people believed at that time.



Well, the class was doing the experiment using a watermelon and a tennis ball, which they were dropping out the window of our second floor classroom. The watermelon was supposed to land in this big box lined with soft pillows. The kids were doing repeat experiments and everything was going great. But this one boy had really bad aim with the watermelon. He missed the pillows and hit

the pavement. And that happened just as our principal, who we call Dr. Evil, was coming out of the building. Well, Dr. Evil got covered with watermelon pieces and that day it was decided that Grandpa would, like, 'retire'. He has been kind of sad since then.

"And you know what else," I added. "Grandpa would love the chance to go into space. And, it would definitely cheer him up."

"But let's keep this a secret from Grandpa for now," said Neddy. "Let's enter the Regionals, and if we are Regional finalists when they make the announcement in June, we surprise Grandpa then."

"Good idea," I agreed. "There's no need to get his hopes up on a long shot. So, we'll do it. It would be so cool to go for a space ride." Plus it wouldn't hurt Neddy to make good use of her nerdyness. Improving her image would help us both.

And picking up on my thought, Neddy added, "yeah, I'll show those kids what Spacey can do when I win. Plus, this will be the most amazing gift to Grandpa, ever."

I suggested, "why don't you talk to Milo, because he likes you better. I'll talk to VC."

"Ok", said Neddy smirking, "but he likes you a lot better since the .. ah..incident on the playground with Richie."

"Whoa," I said and punched her, "you had to bring that up again? Ok, I'll talk to Milo, you ask VC."

Neddy and I spent the next hour looking over all the rules for the contest. Our team would fit the contest objectives really well, since the contest required both inventing, doing science and making presentations. Milo and Neddy and I are really good at the science part. Neddy is also good at art and would help a lot with material for the presentations. VC is good with computers and would be really good at organizing the presentations.

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"Hi Milo," I called when I found him at school, "there's something I want to ask you."

"Hey Lizard," said Milo. He liked to call me Lizard or Dizzy to make me mad. But I wasn't taking the bait. "You can ask, but I probably won't do it."

I knew he was going to be trouble. Milo has been a royal pain in the butt since first grade. He argues with me about everything. Actually, he argues with anyone about everything, period. He just likes to argue and he gives everyone nicknames they hate. Like, he calls me Lizard or Dizzy. He's kind of stuck up and thinks he's the smartest kid in our grade, which is so totally not true. I'm the smartest, I get better grades and, also, I beat him all the time in races.

I decided to give it my best shot. "There's something really fantastic we can do together," I began. "We need you, and you and me need to cooperate." I told him about the contest and how we could make Grandpa's dream come true. "I know we are always competing, trying to be the smartest in the class. But think of what the two smartest kids could do if we worked together." I handed him the contest announcement and rules. "We really need you," I pleaded. "Please take a look at this. And if you agree to join, I will totally cooperate."

After looking over the stuff he changed his attitude. "Wow, this could be awesome," he said, smiling. "Designing the best *Invention for the Future* for the Regional contest is very interesting. And a trip to the moon would be awesome if we win the Finals. Ok, Lizzy, I am in, but remember, you have to cooperate."

I explained, "We've gotta come up with an idea that is new, and say how it would work and do some sort of demonstration of the concept. Wow, what would I like to see in the future?"



Hi Kids. I am Grandpa, or G-Pa as Milo likes to call me, or Papa as VC calls me. I hope you enjoyed reading Lizzy's chapter. You may not know about all the things that Lizzy talked about in her chapter, as well as things in the chapters to come. So, I decided to provide some extra information just in case there is something you would like to know more about. Throughout the book, I underlined and printed in blue some of those things. Just click on the blue topic and you are taken to the end of the book where I tell more about the topic.

Now, I have a question for you. *What would you pick for the most unusual things in space?*

December to March



THE INVENTION BOUNCE

(AS TOLD BY MILO)



My name is Milo, and I agreed to be the only boy working with 3 girls on this team. Did I make a mistake? I donno. We'll see. I also agreed to tell part of the story, so here goes. I am using a different type face, so you don't confuse what I say with what Lizzy says. Although, I don't think that can happen.

I wasn't so sure about joining the team when Lizzy asked me. Neddy and VC are ok, but Lizzy drives me nuts. Lizzy and I have been fighting with each other since first grade. She thinks she's so smart, but mostly she's a royal pain. Like, she always has her hand up to answer questions in school. I know the answers, and I have my hand up too. But Lizzy has that stupid dimple in the middle of her cheek when she smiles that makes the teachers think she's so sweet. So, they call on her. Well the teachers don't think she's so sweet since she got suspended for fighting in school. But that's another story that I'll tell you about later.

Lizzy's like Dr. Jekyll and Mr. Hyde in the old horror movie. One minute she's nice, and the next minute I think she's going to scratch my eyes out. She's so competitive. She wants to win at everything. I've got to stop letting her beat me in races.

But a trip to the moon would be totally awesome. And I've got to admit Lizzy is smart and creative, and will be good for the team. And she promised to be totally cooperative. Ha, Ha, we'll see about that. And I like the idea of doing it for G-Pa, which is what I call Grandpa. So, I agreed to join the team.

And here is how we came up with our great invention.

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During the winter holiday, we all got together for a meeting. I took charge. Lizzy didn't like that so much.

"Why should you take charge," said Lizzy with one of her angry stares?

"Because I'm the oldest," I said, staring right back.

"Whoa," said Lizzy. "But you're only 3 months older, and besides I get better grades." We continued staring at each other. Then she remembered her promise to be cooperative. "Oh, go ahead, be in charge," she grunted in defeat.

"OK," I said, "let's hear the invention ideas."

"We should invent a [Flying Car](#)," said VC, as she ran around the room with her arms out to demonstrate.

"I wanna do time travel. I wanna [Time Machine](#)," added Lizzy.

Neddy said, "I wanna Fashion Machine to design my own clothes and then it would manufacture them right then and there."

"How about a [Teletransporter](#) like on Star Trek," I suggested. "Beam me up Scotty. That would really be awesome."

"How about this for cool," said VC, "a [Brain Machine](#) that you wear on your head when you go to sleep, and when you wake up, you know a new language, like French."

"Or all your multiplication tables," added Neddy. "Or history and science facts."

We went back and forth for about an hour like this and made a list of all the best ideas. We included ideas for a [Medical Cure Scanner](#) and an [Anti Gravity Machine](#). "Let's show these to G-Pa and see what he thinks," I suggested.

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Lizzy and I met with G-Pa the next day. "Hi G-Pa," I said, as I handed him the list. "Lizzy and I are working on a school project, and we need to come up with ideas for inventions for the future. What do you think of this list of ideas? Pretty awesome, huh?" We didn't tell him about the contest, because we wanted to keep the trip around the moon a secret.

After reading our list, G-Pa says, "an invention is more than just an idea. You have to say how you are going to do it. And I don't know how to make a time machine or teletransporter. Do you? You need to invent something that can actually be made."

After leaving G-Pa, Lizzy and I were pretty bummed and we had a fight. "Well, your teletransporter idea was stupid," she growled. "And stop calling everything awesome. I hate it."

"No more stupid than your time machine," I shot back. "I really don't want to work with you, Lizard. And stop saying everything is 'cool'"

"Whoa," she yelled. "the feeling is mutual." And she stomped away.

Girls!!! They are useless and clueless!!!

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A week later, I got a brainstorm for an invention. I texted Lizzy saying I had an idea and she should look at a picture I posted on Facebook. She looked and texted back and we agreed to have a team meeting the following day to try and work together on the idea.

We met after school, and I explained my concept of a Teletransporter invention that would actually work. "What if we don't actually travel," I explained. "What if we do [virtual reality](#) travel. There are some neat virtual reality web sites. The picture I posted on Facebook for Second Life is just one of them." And I showed them the screen shot.



I continued, "the web sites create a virtual reality world that you can enter. You pick someone that you want to be, and pick a face and a body and clothes and a name for that person. It represents you in the virtual world, kinda like in a video game when you control the action of one of the characters. You enter that world as an [avatar](#). The *avatar* represents you, like in the picture. A girl could have a boy *avatar* or grown woman *avatar* if she wanted. You can talk to other *avatars* who represent other people that are on line at the same time and are in the same virtual space."

"G-Pa took me to see the movie 'Avatar'," I said. "These scientists enter the world on another planet as *avatars* and can mix with the native people, who were like 10 feet tall, and talk to them in their language. It was really awesome. That's what got me to thinking."

"Anyway, here's my idea," I said. Instead of entering an imaginary world as an *avatar*, you enter a virtual representation of a real place. Like, I want to travel to Pisa to see the Leaning Tower, so I type in the location where I wanna go and the web site creates that virtual world for the real place. Google has maps and street scenes from all around the world, so those could be used to create my virtual destination. So, I can virtual teletransport myself to any place I wanna go and walk around and see the sights. What do you think?"

That's a great Idea," said Lizzy. "Fantastic!!" And then this really awesome bouncing thing happened. The idea bounced from one of us to another getting better with each bounce. First Lizzy's bounce. "It doesn't have to be a place that exists today, Milo. I could have my Time Machine idea, too. I could also type in a date with the place, so I could visit Pisa in, like, 1600."

The next bounce was from VC. "And, instead of talking to other people who are on-line, we could talk to people that live there. The people could respond to our comments and questions like Siri does on my iPhone."

And then a bounce to Neddy added an awes... fantastic piece. "You could also talk to famous people that lived in Pisa," she said. "Remember about Galileo and his famous gravity experiment, dropping objects from the Leaning Tower. That was the same experiment that Grandpa was running when the watermelon exploded on Dr Evil. Galileo was smart enough not to use a watermelon. Well, we



could visit with Galileo, and the computer would allow him to answer our questions. What he says would be based on all the known historical and scientific facts. We could visit him by entering his name and let the program pick the date, or we could enter the date too."

"And we could have a Smartphone app," added VC. "It would allow people to talk to the historical person on the phone if you want a quick answer to a question."

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So, we had our idea, and we spent the next several months writing it up. We called it The **Beamer**® (Copyright © 2014 by TheBeamer, LLC) because it was like teletransporting in the Star-Trek movies where Mr. Spock says, 'beam me up Scotty.' We couldn't build the **Beamer**, but we knew what was needed to do it. We needed technology to create the screens with the *avatars*, like what is used for Second Life or game programs. We needed software that translates speech to text and an artificial intelligence program like Siri to respond to the text question with a spoken answer. We made pictures and diagrams to explain the **Beamer** using a visit with Galileo in Pisa, with the three girls as *avatars*, as the example. And that was our entry for the Regionals.

On March 31st, we got together and looked over our stuff for one last time and then emailed it to the contest people. "I really hope we make the finals," I said. "I want to go into space and it would be awesome to get the trip for G-Pa. Our invention rocks." And we did high fives.

Our invention is really awesome. And Lizzy and I managed to get along while we did the inventing. The important thing that I found out was that by cooperating, we came up with a better idea than any one of us could've come up with by ourselves. I came up with the original idea, but the team helped make something much better. An idea can bounce around from one person to another and get more awesome with each bounce. And that's how we came up with our invention. It worked, because for the first time Lizzy and I were actually cooperating. Together with the other kids we produced something really, really, spectacular awesome.

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I promised to tell you the story about how Lizzy got suspended from school. Some of it I saw, and some of it I learned from other kids. Here's how it happened.

Neddy was having trouble in school because of her daydreaming. She was in her 6th grade class doing just that when Mrs. Swift asked, "Neddy, please tell the class, what is Photosynthesis?" I had Mrs. Swift in 6th grade. She's the hottest teacher in school with long blond hair and a great smile. The kid in the next desk poked Neddy to bring her back to reality. Realizing she'd been asked a question, and remembering they'd been discussing how energy from the sun was produced, she said, "[nuclear fusion](#)." The class cracked up. Mrs. Swift rolled her eyes and went on to another kid.

At recess, Richie Ellis, who's the worst student in the class and has been Neddy's personal bully since first grade, started teasing Neddy. He loved to see someone besides him get into trouble. He taunted her by calling her "Space Cadet." Some of the other kids started chanting "Space Cadet, Space Cadet, Space Cadet." Neddy ran out of the playground in tears and headed for the library.

Lizzy and I saw what happened. Lizzy decided to do something. No one can bully Lizzy's sister except Lizzy. "Lay off Neddy, or else, you stupid idiot," she yelled at Richie.

"Oh yeah," said Richie. "What's a skinny girl like you gonna do about it?"

"I'll hurt you," said Lizzy, with her meanest stare.

"You're as stupid as your sister," snapped Richie. "I outweigh you by 20 lbs." And then he gave her a shove that pushed her back into all the other kids.



Oh man. He shouldn't a done that. Lizzy saw red. No sweet smile, no dimple. She backed up a few feet and then ran at Richie. It's hard to believe what she did. It really was awesome. She jumped in the air and planted a kick to Richie's chest, and before landing, she twisted her body and planted a second kick to Richie's head. I've seen a video of her doing that double flying kick in a Tae Kwon Do class. Wow! Richie ended up flat on his back where he started to cry. Oh man, what a scene. And the kids started screaming and cheering.

Then the playground teacher moved in. "People, People, this wild rumpus needs to stop immediately," she yelled. She grabbed Lizzy and helped Richie get to his feet and off they marched to the Principal's office.

I felt sorry for Lizzy. I knew she was in trouble. Our Principal, Dr. Cohen, was known as Dr. Evil. She had a Ph.D. that she said was in education, but all the kids said was in criminology. This was going to be bad news for Lizzy.

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Well, here is what happened.

1. Neddy promised to pay better attention in class.
2. Richie never bothered Neddy or Lizzy again.
3. Lizzy and Richie were suspended from school for a week.
4. Secret pleasure was enjoyed by the teachers who were happy to see a long time bully taken down.
5. Lizzy became a secret hero at Tae kwon Do, although she was officially told to use more restraint in the future.
6. I told Lizzy that she would never find a kid brave enough to be her boyfriend.

I visited Lizzy at home during her suspension. Oh boy, was she mad. "Besides suspension," she whined, "Dr. Evil has me writing a 10 page essay about how I shouldn't fight in school. I protested that I was quite sure that it qualifies as cruel and unusual punishment. That earned me 5 more pages...and this time I have to say why it is especially wrong to use martial arts on another student. She really is Dr. Evil. That's what I get for standing up for my dumb little sister. Neddy is like an anchor around my neck."

"I complained to Dr. Evil about Richie Ellis," said Lizzy. "That kid has been torturing Neddy at school for years. What does he get? Zip. Nada. Nothing. So, Dr. Evil says, 'a couple of hundred kids saw you attack Richie, so your punishment is quite appropriate. As for Richie, he did get suspended. As to additional punishments, I have investigated, and I am dealing with him appropriately.'"

I found out later that Richie also had to write a 10 page essay about not bullying any more, and he had to personally apologize to Neddy. I'll have to get Neddy to tell us about that. I would love to have been there.

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After the incident, and after working with Lizzy, I now have a lot more respect for her and we get along a lot better. And I try not to say 'awesome' so much.

Another thing. We had to pick a name for the group. I wanted us to be the 'All Stars,' but Neddy said it sounded too much like a sports team. The other girls agreed with her. A bunch of other suggestions got shot down, too.

Then Neddy said, "let's be the 'Space Cadets'. That is what the kids called me on the playground. But it would sure show them if I really was going into space."

Everyone agreed, and so we are the 'Space Cadets.'

One last thing. VC asked if it was ok if she started a blog about the Space Cadets. "Can a kid do a Blog?" asked Neddy.

"Sure," said VC, "it is just an on-line journal where I tell about what we're doing in the contest. Grandpa can help me set it up."

We didn't think anyone would be interested, but we said it was ok. "But you can't give away any secrets that would help other teams," I said.

What would you pick for the best invention for the future?

June



A BIG SURPRISE

(AS TOLD BY LIZZY)



The contest announcement said the finalists for the Regional contest would be announced in June. So, on June 1, Neddy and I raced to the mailbox the first thing off the school bus. "Nothing," I said and punched her. It was the same thing for the rest of the week.

"Maybe they forgot us," said Neddy. "Maybe they lost our address. Maybe they didn't get our email."

"Or, maybe we didn't win, and they only send the announcement to the winners," I suggested.

I started sleeping not so good. I was waking up in the middle of the night with dreams about Pisa and Galileo. I told Neddy, "he yelled at me to stop bothering him while he's doing such an important experiment. And then he was dropping watermelons and they splattered on me."

The second week in June, Neddy and I started fighting over who would get off the bus first and who would get to the mailbox first. Our dog Coco started barking every time we did this. Still nothing.

We gave up the third week. We figured if we got something, mom would let us know. Neddy and I were both bummed. Neddy moaned, "this was totally so not fun."

Then, on June 20th something finally appeared. "Wow," said Neddy, "we both got Fed Ex packages." We sat there looking at the packages, too scared and excited to find out whether we're in or out. Neddy broke the spell and opened the package. She was too stunned to speak.

I grabbed the stuff out of her hands. "Oh wow," I said. "The letter says that we're one of the top three teams in New England. We got past the first cut,cool. And we're going to get a trip to California." I was psyched. "This is way exciting," I said to Neddy as we high fived. "Now, we get to spring the surprise on Grandpa."

"Oh, Lizzy," Said Neddy, "he's going to be so surprised and excited. If we can get into the Finals and win, his lifelong dream of going into space would come true."

Neddy and I called Milo and VC and we decided to spring the surprise the next weekend when Grandpa was taking us on a tour of his 'dungeon.'

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"Be careful," said Grandpa, "if you fall, you'll die."

Grandpa and us kids were crossing over the canal that led to the 'dungeon' on a wooden plank. The 'dungeon' was the lowest floor in a 200 year old paper mill building on the Hockanum river. Grandpa had opened a lab there after Grandma had kicked his inventions out of the house some time ago. Outside the dungeon, water flowed through the canal to power the mill in the old days.

We kept our adventures a secret because Grandpa had gotten yelled at by Grandma and my mom too many times for returning us dirty and sometimes bloody.



"I wanna go home," whined VC, who definitely didn't like the idea of falling from the shaky plank and possibly dying.



"I was just kidding," laughed Grandpa. "Well, kind of...just be careful. I don't want to fish one of you out of the canal."

"Come on", I said to VC. "You can do it". I took VC's hand and helped her across the plank over the canal and into the building on the other side. We celebrated our success with a fist bump.

"You know," said Grandpa, who liked to play jokes on us, "there used to be something strange that lived down there. It was called the 'Canal Creature', but it hasn't been spotted in years, so it probably isn't there anymore."

"I don't believe you, Grandpa" said Neddy giving him her 'do you thing I am stupid look'. "But, I'm not going across on that plank. I'll go around the long way. I'm not going to get my new

boots wet and dirty." Even though Neddy was a nerd, she was trying to improve her image by wearing nice clothes. She sometimes changed outfits 5 times a day.

When we were all inside the building, I looked back at the canal through a window. "Look," I screamed, pointing into the canal at the ugly head poking out of the water, "is that the creature?"

Neddy and VC both shrieked and ran. But Milo looked carefully at the thing I was pointing at. "I know what that is," he said laughing. "It is a [hologram](#), like the ones they have on display in the Science Museum. See there at the neck, you can see through it." And we both punched Grandpa, because we knew he had set it up to scare us.

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After the tour, us dungeon explorers climbed upstairs to Grandpa's lab. Grandpa said he was going to show us some new computer software for doing physics simulations that he was developing.

But we planned on something else this afternoon. We'd brought the letter about our winning the trip to California and the contest announcement, and the stuff on our invention, and we showed them to Grandpa.

"Oh my," said Grandpa. "You kids did this all by yourselves?"

"And most of all, we did it to get you a trip into space," I said. "We want you to be our coach." I thought Grandpa was going to cry.

"Wow," said Grandpa. "I am amazed. To use Milo's favorite word, you kids are Awesome with a capital A. You did all this and you kept it a secret from me, too. I just can't believe it. And if we win the trip into space, that would be my



lifelong dream come true. It's something I've wanted to do since I was your age."

We told Grandpa about the trip to California and all about the **Beamer** and how we all contributed to the idea. Grandpa couldn't stop talking about how great our invention was and how wonderful we were. "He's right about that," I agreed.

He was actually more excited about the invention than the trip to California or the possible Grand Prize moon trip. He started thinking about how he could put up such a web site. "You know," said Grandpa. "IBM has technology that could power the **Beamer**. It is called Watson and it is [artificial intelligence](#) software."

Grandpa ran to his computer. "Yeah," he said showing us an article from the New York Times, "IBM showed Watson off in 2011 on a quiz show called *Jeopardy*, where it competed against two former human *Jeopardy* champions. Watson can answer questions put to it in natural language based on a huge file of history,



news and scientific data in its memory. IBM calls it a cognitive computer. On the show, the host gives an answer to a question and the winning contestant is the first one to come up with the question. Like the answer is 'the largest city in the United States' and the winner is the first one to say 'what is New York City?' See here on the picture, Watson is represented by the *avatar* in the middle between the two guys. And guess what? Watson beat the two humans at *Jeopardy*. Watson is just what you need for the **Beamer**."

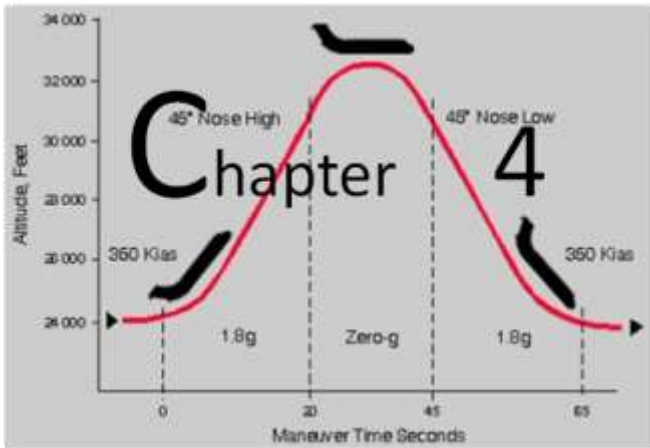
OK," said Grandpa showing his serious face, "let's get down to the practical stuff. What do you have to do in California to win the Regional competition? And how can I help?"

We told Grandpa about the Pisa visit with Galileo that we had submitted to explain the **Beamer** and how we had to do an oral presentation in California. "They'll pick the best of the three New England teams to go on to the Finals," Milo said. "You can help us improve our material and help us rehearse the presentation."

We talked some more about the presentation and finally Grandpa took us home. For once we were clean and there was no blood. We were all happy and so looking forward to our trip to California.

Where would you go and who would you talk to in the Beamer?

July



CALIFORNIA HERE I COME

(AS TOLD BY MILO)



This trip is going to be awesome. There, I said it again. But it's the right word. It'll be awesome.

We fly to California on Wednesday. We get to be in first class!! We can pick any movie we want to see on our own screen. We don't have to fight over what to watch. And we get a first class lunch.

When we get to California, we're gonna stay at the Time & Space, Inc. Mansion on the ocean where we meet the other teams. G-Pa promised to teach us body surfing in the huge Pacific ocean waves.

On Thursday, we fly in the company jet to Disney Land for the day. On Friday, we go up in a special plane ride called a [zero-G flight](#), where you float in space for a few minutes. It'll be like zero gravity on the trip to the moon. That's really awesome!! And Saturday is the big presentation where we tell about our invention. Awesome. Am I right?

There is some other great news. In June, Lizzy and I graduated from Middle School and we were number one and number two in the class. Guess who was numero uno. I was class Valedictorian and gave my speech on teamwork. Lizzy was class Salutatorian and she talked about pursuing your dreams. Dr. Evil talked about the Space Cadets and the **Beamer** invention and how it could be a wonderful way for kids to learn about history and science in the future. She said, "I am so proud of our school's four bright lights and what they have accomplished." And she wished us good luck in California.

Lizzy and I are both worried about high school. We're worrying about keeping up our grades and the bullying of freshmen. I wanna play football and Lizzy wants to play soccer. Well, we've got the summer off, and some exciting things to do.

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It was finally time to leave for the airport. Has Lizzy changed to totally nice and cooperative? Not so much. Lizzy raced to the car. "I call the front seat," she said with the dimple and sweet smile turned up to maximum for G-Pa. Oh, man!!! On the plane, it's "I call the window seat," and G-Pa gives in to her all the time. I gave my 'whatever look' and took the aisle seat. Well, at least you know what to expect from her.

On the plane ride, VC told us that since the announcement about the Space Cadets being one of the top three teams in New England, she had 450 followers on her Blog. She wrote about the contest and posted a picture of the team and the proposed **Beamer** screen with Galileo. She even started getting congratulations, including one from Dr. Evil.

When we got to California, we were picked up in a stretched limo that drove us to the Mansion. There, we met Dr. Quixote, the president of TSI. When he introduced himself, I found out his strange last name was pronounced key-ho-tee. Dr. Quixote was about the same age as G-Pa, but really tall like a basketball player. He had this white hair that stuck out like on Albert Einstein and a beard that looked kind of like the one on our picture of Galileo. He also had a big nose with lots of hair sticking out.

"Hi Q," said G-Pa with a big grin, "long time, no see." It turns out that G-Pa and Dr. Q, as he is called, were in graduate school together studying physics.

"I heard about your NASA astronaut adventures," said Dr. Q, smirking. "Too bad about the ah,... incident."

G-Pa turned bright red. I knew there was some secret about his NASA job. We have to get him to tell us.

"Well," said G-Pa, "you certainly have done well for yourself. But what about your grand concept of [frozen fusion](#) that you were working on. Did that ever pan out?" Dr. Q turned purple and walked away, saying, "see you later."

Neddy says to VC loud enough so that we all can hear, "that sounds just like Milo and Lizzy bickering. I guess it doesn't stop even when you get old."

G-Pa told us later that he knew all about the scandal over Dr. Q's fantastic claims about *frozen fusion*. He said, "all the energy on the sun comes from [nuclear fusion](#), where hydrogen combines to make helium at incredibly high temperatures, millions of degrees. The energy is predicted by Einstein's mass and energy relation, [\$E=mc^2\$](#) . That means that Energy, E is equal to Mass, m times the speed of light, times the speed of light again, that's c^2 . The helium has less mass than the hydrogens that combine to make it, so the extra mass is converted to the sun's energy that keeps us warm. Scientists have been trying for over 50 years to do controlled *nuclear fusion* for a power plant on earth, but without success."

"So, what did Dr. Q. do," asked Lizzy?

"Dr Q. claimed he had produced *nuclear fusion* at low temperatures in a simple experiment in his laboratory," replied G-Pa. "He made a big announcement about it. It was in all the newspapers. There was great excitement, because if it worked it would supply all the world's energy needs with cheap and clean power. There were lots of presentations at scientific meetings."

"And what happened," asked VC?

"The problem was no one could reproduce his results," said G-Pa. "He couldn't even reproduce his early results himself. Good science is built on a foundation of repeatable results. After a year, the idea finally died a shameful death. Dr. Q's scientific career was ruined, but as you can see his business career has been fantastic."

"Wow, that's some story," said Neddy.

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The mansion was awesome. It had 60 rooms and stood on a big hill overlooking the Pacific ocean, and you could hear the waves crashing on the beach. There were horses grazing on the field in front. Inside was super modern, with glass walls everywhere so you could see the ocean. They even had glass steps going to the second and third floors so you could look down to the lower floor. I don't like heights, so that's kinda scary for me.

The rooms were really bare. Everything was built in. You couldn't even see the doors to the closet or bathroom. I discovered the secret when I walked around the room and the bathroom door whooshed open when I walked in front of it. Wow, fantastic. "Whoa," I am thinking, "what if someone walks by while I'm sitting on the toilet?" VC helped me check it out, and the door doesn't open if there is someone inside until the inside person stands in front of the door.

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Before dinner, we met some of the other teams. "Hi" said this short African-American kid with big glasses. "I'm Jackson Graham. I'm in the West Coast Regional. Where are you guys from?"

"Hi, I'm Milo," I said. "And this is Lizzy and VC and Neddy. We all go to King Phillip Middle School in Connecticut. We are finalists in the New England Regional."

"Where are you from and where is the rest of your team," said VC?

"Oh," said Jackson, "it is just me. I'm from southern California. I go to Cal Tech."

My thought was that this little kid by himself would be easy to beat. Then G-Pa told us, "you know guys, Cal Tech is one of the best universities for technology in the country."

"This puny kid goes to college," I whispered to Lizzy? "I think we are in trouble. But he does seem nice." He told us his invention is a surround projection system for computers.

"Yo, Jack," said Lizzy, turning on the dimple, "you can hang with us if you want some company."

"Thanks Lizzy," replied Jackson. "Maybe I'll catch you later."

The team that was not so nice was the Brooklyn Babes. They were, 4 quadruplet sisters that looked alike. They were ok looking and tall with long dark hair. They looked more like 16 than the maximum of 13 that they had to be under the contest rules. They were originally from Russia and spoke with kind of an accent. They told anyone who would listen how they're already in the best high school in Brooklyn and how they had huge IQs. They're obnoxious and stuck up. But they looked like the sharpest team in the Mid Atlantic Region. I am glad we weren't competing with them.

Neddy overheard them talking about the other teams. She told us what they said, mimicking their accents, "thees ked Jickson, he ees, how you say, whimp. Es not priblim." Neddy does accents really well. "And Speece Cedets, they bunch of weirdies. But the Milo ked, he es cutie." VC and Lizzy looked at me and laughed and I turned red. We all agreed that we really need to crush the Russians if we both made the Finals.

There's another team that was interesting, the Wiz Kids from the South East Region. They're 12 year old boy cousins. They're kinda slobbey, with parts of their shirts sticking out of their jeans. They looked kind of nerdy and aren't very nice. One of the Brooklyn Babes said that they were suspended from school for hacking into their school administration computer to change test scores.

The team we had to worry most about was the Boston Terrors. Kinda like the dog breed. They're in the New England Region, so we gotta beat them to make the Finals. They're also three girls and a boy, like our team. Neddy did an imitation of them too, "we'aa heaa to be the winnaas." Then she added, "they'a weiaad."

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After dinner, Jackson caught up with us and we poked around the mansion together. Then we went back to my room to play games.

"Thanks for being friends with me," said Jackson. "It really is kind of lonely being all by myself. I don't have any friends at school because I'm 13 and they are all at least 18. I miss kids my own age. Maybe I am too smart for my own good."

"Ok Jack," Lizzy challenged, "let's see who is smarter at gin rummy."

Lizzy smoked him. Maybe he let her.

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The visit to Disney was fun, but G-Pa was acting so not normal. On the plane ride down, G-Pa announced, "I am not going on the Zero-G ride tomorrow." Then while we're waiting on line for Space Mountain he says, "but I have to go or Q will really have the last laugh." And then while we're on the boat in 'Pirates of the Caribbean' he says, "no, not going to go." And every ride we took seemed to have another change of his plan. Going, not going, going, yes, no, yes, no. . . . It was crazy, period. Finally on the plane going home, it was, "I am not going and that is final."

When we got back to the room that night, we wanted to find out what was going on. Why was G-Pa acting so strange. And what about the exchange between G-Pa and Dr. Q over G-Pa's NASA career.

"Grinpa, vood you till us story about Nessa," said Neddy in her Russian accent, which she now seemed unable to get rid of.

G-Pa laughed, then got quiet, and then agreed to tell us his NASA story. "I was 26," he said, "and I had just gotten my Ph.D. in physics. It was 1965 and NASA was recruiting a second team of astronauts. And this time they were recruiting some scientists. I had this crazy idea to apply."

"I fit the profile for a scientist and I passed the physical, so I was in the program. I had a job at NASA. They had us doing all kinds of mental and physical tests. In one test, they wanted to see if we could stand the high gravitational forces that we would experience in takeoff and landing. They put us in this thing that was like a carnival ride. You know, the one where you stand with your back to the wall of a circular room. And then they spin the room so that you stick to the wall and don't fall when the floor moves away. I did fine with that one."

"But then came the test that got me tossed off the team. It was called the zero-G flight. This is the ride we are supposed to have on Friday. The NASA flight was in an airplane without seats, but with padded walls. The airplane went on a special flight path. You know what I mean, a special trajectory? First it went up real fast, and then it started an arc that ended with a fast drop. During the arc and drop we were flying off of the floor."

"The test was to see how we would do in zero gravity. Well, I get nauseous in a bumpy airplane, and this was the worst. My flying upchuck was not appreciated by my classmates. When the zero-G ride came to an end, my lunch was plastered all over the walls, the floor, and my classmates."

"NASA was nice. They gave me one more shot. I was all by myself in the back of the plane, since no one else wanted to go with me. I made sure not to have lunch and I had a barf bag. The result was the same. Only the mess was less. And that was the end of my astronaut career. There was kind of another issue too, but I am not going to go there."

"I am really worried about going tomorrow," said G-Pa. "I don't want to get sick again. I don't want a repeat of the NASA incident, especially not with Dr. Q around to see it."

"I don't wanna get barfed on," whined Neddy.

"Neddy, shut up," snapped Lizzy. "Grandpa, if you decide to go, we will sick....err, I mean stick with you."

G-Pa decided that he wasn't going to let Dr Q gloat over him wimping out on the ride. "Besides," he said, "if we win the trip around the moon, we will be in zero gravity for a long time. I better get used to it." And so it was decided, we were all going. G-Pa decided to skip dinner that night and breakfast the next morning. "I hope this works out", he said.

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We left at 10 for the airport and took off at 10:30. G-Pa looked a little nervous. We had to take our shoes off so we wouldn't hurt anyone. We roared down the runway and took off. Everything was ok on the way up. Then we started the zero-G portion of the trip. My body felt funny like it does on a roller coaster or when I jump off the high dive. We started floating. G-Pa looked a little green. We all kinda moved away from him. But then he started smiling and laughing and looking a lot better.

"I am going to be just fine," he said. And he gave me a fist bump which rocketed me towards the back of the plane. We started playing around, pushing one another or pushing off the side of the plane. Lizzy demonstrated in slow motion how she does her flying double kick. VC and Neddy were



doing summersaults. It was awesome. Yes, it really was awesome. Gravity came back after a couple of minutes, but it seemed much longer. Jackson, who was along on the ride, told us about how Einstein suggested the equivalence of acceleration and gravity. "We weren't really in zero gravity," he said. "It was just that the plane went down so fast that we were in free fall. We were accelerating downward toward the earth under the force of gravity. But it felt like zero gravity. Einstein said that if you can't tell the difference between accelerating or being in zero gravity, they must be equivalent. And he used that idea in developing General Relativity, which was all about gravity." I got the idea that accelerating felt like zero gravity, but I didn't understand how that led to General Relativity. But I'm not Einstein. Neddy whispered in my ear, "whoa boy, thit guy ess smert. Will be tough to bit."

"Ok," said Lizzy, "enough with the Russian accent."

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Saturday came so fast, it was hard to believe. We wanted to do the beach once, so we went down before breakfast. Jackson came with us. The sun was sparkling off the tops of the big waves and seagulls were calling to each other. It was really pretty.

"These are perfect waves for body surfing," said G-Pa. "They curl and break far enough from the shore to get a good ride. Now it is important to time it right. You have to start swimming hard when the wave starts to crest. Too early, and you will miss it. Too late and you get tossed around like in a washing machine. I'll show you how." And G-Pa swam out through the surf and then caught a wave back to the beach on his first try.

We all swam out to try it. After a bunch of misses and coaching from G-Pa, first Lizzy, then me followed by Jackson, VC and Neddy all caught our waves. It was awesome. We body surfed for about a half hour and then I caught a wave too late, went way up on the crest and got slammed down into the sand on my head. That was enough for me.

"I quit," I said, and went to sit on the beach to clear my head.

Then Jackson got tumbled like in a clothes dryer and almost lost his swim trunks. He came to sit with me. Then the girls came out of the water one by one. It was time to head back, so we shouted for G-Pa to take one last wave.

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After breakfast, we spent the rest of the morning practicing our presentation of the invention. We're doing a slide show with Power Point that VC put together. G-Pa helped to improve the graphics that we'd submitted in March. It really looked amazing. See, I really have more than a one word vocabulary.

Just before it was time to present, Neddy was nervous and had to go to the bathroom. When she came back, she had a tail of toilet paper hanging down her butt. We caught up to her and yanked it off. No wonder Lizzy is embarrassed to be her sister. This would have clinched her title of 'Hairy Potty.'



The time to present the **Beamer** came. We all went up on the stage. VC explained how to create a real place in our virtual world by using Google Satellite images, Google street views and historical photographs, and how you enter the world as an *avatar*. Neddy explained how to apply IBM's Watson cognitive computer software, to have people in the place talk to your *avatar* and answer questions that were consistent with the time, the place and the historical record. Lizzy explained how all the on-line historical records would be used to create a virtual place in the past. And I wrapped it up showing how it all came together in a visit to Pisa and a conversation with Galileo. G-Pa played the part of Galileo. We asked him whether a tennis ball and a heavy rock both accelerate at the same rate under the influence of gravity and would hit the ground at the same time. "What is a tennis ball," said Galileo?

We got a standing ovation for our presentation. We were told that the winners of the regional competition would be announced in September. We could hardly sleep that night, because we were so excited.

We traveled home on Sunday. We saw Jackson in the airport and Lizzy shouts out, "Hi Jack." All of a sudden, the whole airport gets quiet. Everyone is looking at us. Jackson is cracking up.

"Duuh, Lizzy," I teased. "Not the best choice of words." We started moving off towards our gate.

"Oops," she said.

No one followed us. And we were able to board the plane. I gave Lizzy a punch.

We sat in first class again. We were so high on excitement, we probably didn't need the airplane.

When we got home, VC said there were lots more comments on her blog. There were wishes for success from Mrs. Swift and Mrs. Ortiz, and even one from Richie Ellis. Are we going to win New England? I think we have a good shot.

What processes on earth are controlled by Einstein's mass/energy equation $E=mc^2$?

PART 2

STARDUST

September to November



ARE WE MADE OF STARDUST? (As Told By Neddy)



Guess What. The big shots, Lizzy and Milo, have finally agreed to let me tell part of the story. They're probably worried that I will say bad things about them. I'm going to fool them and say something good. They are both smart and hard working. But..... they're really bossy and their fighting with each other is slowing us down. I have taken Milo's Idea of using a different type face so you know who is telling the story.

"I'll race you to the mail box," I challenged Lizzy as we got off the school bus on September 1. Lizzy took off like a shot, and beat me.

"Nothing," She said. "I hate the suspense. They should've told us the exact day of the announcement. We could be going crazy for the whole month."

It was one week, then two weeks, and then three weeks. Grandpa told us to be patient. "Sometimes I had to wait for years," he said, "to find out if one of my patents was granted."

Mom and Dad kept telling us not to worry. They both said our invention was so great that we had to win. But waiting is hard, and every day, the room I shared with my sister seemed to be getting smaller. One wall had a slanted ceilings that kept bumping into my head. It never used to do that.

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Whoa!! They sure waited to the last second. It's the afternoon of September 30 and Lizzy and I just got Fed Ex letters from TSI. "Let's not open them," Lizzy whispered. "I am so way nervous. Let's get Grandpa and Milo and VC and open them together."

The rest of the team raced over to our house with their letters. We all opened them together. We were all stunned into silence for a moment, and then we all started jumping up and down and screaming. "Yes, Yes," I shouted, and gave everyone a high five.

"Oh, my." said Grandpa, "You won. I knew you would. Amazing!"

"This is totally cool, period," added Lizzy giving me a rare sisterly hug. "We could actually win a trip into space. There's, like, less than 100 people in the whole world that have ever done that. Wow. And 'Hairy Potty' will really get her wish to be floating in space." I broke out of the hug and punched her.

"Awesome," said Milo.

We opened all the letters and started reading everything in the package. The Space Cadet invention won for New England and we were eligible to compete with 6 other teams in the finals. We had the 5th highest score among the finalists. The highest score went to Jackson Graham. The second highest score went to the Brooklyn Babes. Yuck!!



September 30

Dear Team Space Cadet,

Congratulations on coming in first in the New England regional Science & The Future Contest. You are now eligible to compete against 6 other teams in the National Competition for the grand prize which is a trip around the moon for the team and coach aboard the Cosmic Voyager.

All the rules for the contest are enclosed.

I wish you the best of luck.

Sincerely,

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Quentin Quixote, President
Time and Space, Inc.

P.S. We may send you some presents from time to time.

But there's a huge surprise. While our presentation had some flaws, which lowered our score, the Space Cadet **Beamer** invention concept was judged to be the best.

"Look at this," said Grandpa all excited. "TSI liked your **Beamer** invention so much that they actually programmed it and created a web site for it. Maybe that is why they took so long to make the announcement. They have also implemented Jackson's surround projection system to show your virtual reality world. You and the other competing teams will be the first test users of the new combined system."

"And look at this," I added. "It'll be our only internet research tool. We can use any books or other material from the library, but if we are doing research on the internet, it has to be on the **Beamer**, no Google, no Wikipedia, no other sites. And they are going to monitor our computers and give us a lie detector test to make sure we don't cheat."

"OK" said Milo "here's the most important thing. For the Finals we have to solve this puzzle." And he showed everyone the STARDIST MYSTERY challenge.

*I was born in a place that is far, far away.
At a time long ago, but I am now here to stay.
George Washington's body was once my home.
I am now part of you, but I may roam.
Some call me Stardust because of my history
It will all be clear when you solve the mystery.
Who am I, and what is my story
Write me a rhyme to tell of my glory*

Milo said what he thought the riddle meant. "I think it means that we have to figure out what STARDUST is, how it got made, how it got into George Washington's body and how it got from his body to ours."

Lizzy added, "our final report is due on July 31 next year, and we may get to present our work in California on August 10."

"I am not that interested in the science," said VC, "but I really want to go on the moon ride, and win the trip for Papa."

"I want to win for G-Pa too," agreed Milo. "But I really think this mystery is interesting. Don't you want to know if you are made out of STARDUST, and if your STARDUST once belonged to George Washington? I do."

Lizzy and I supported Milo.

"Hey Milo," I teased, "is there another reason that you want to get back to California? I saw you go off walking with one of the cute Russian girls when we were there last June." Milo turned red.

We were asked to submit an official picture of our team. This is what we sent in. And that is how the STARDUST MYSTERY started. We were also asked for a message from the team for the contest web site which would go live on Nov. 1. We said, "we are winning it for Grandpa."



There was one other thing. In June there was going to be a cut based on the team standings at the end of May. Only the top 3 teams would go on to the final presentation in California. "That will be some extra pressure," I thought.

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Milo said that since I have a chance to tell part of the story, I should tell what happened with Richie in Dr. Evil's office. You remember, It was a result of the playground incident. So, here it is. We both showed up in Dr. Evil's office.

"Well, Richie, why are we here today," said Dr. Evil?

"I wanna apologize to Neddy," said Richie. "I'm really sorry, and I won't do it anymore. Neddy, I only teased you, because you are, like, the coolest girl in class and you never got upset when I teased you. So, I didn't realize it made you feel bad. I am really sorry."

"OK, Richie," I said, "apology accepted." And Dr. Evil said we could go.

Wow, 'coolest girl in class.' Yes!!!!

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On Nov. 1, I logged into the TSI contest web site. Wow, it was great. It had our picture with our message. Our picture was up because we had the best invention. It also had a leader board that would be updated every month.. On November 1, it showed that everyone had zero percent completion in solving the STARDUST MYSTERY. Each month, this percentage would be based on a report that we had to send at the end of each month, saying what we had accomplished. It also showed the percent of our hours left on the *Beamer*. We get to use 10 hours for each team member. Everybody had all their time left. There's also a section for 'CONTEST NEWS' that told about the *Beamer* and how we had to use it for doing all the on-line contest research.

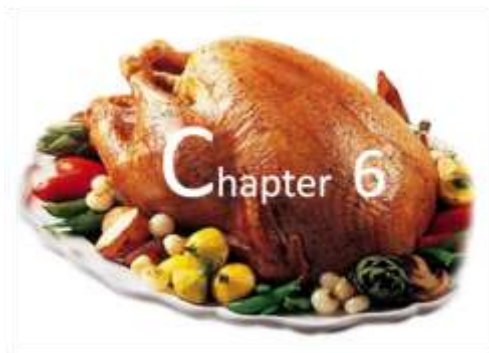
The screenshot shows a web browser window with the URL <http://www.tsi.com/Wiki.aspx?ID=1404>. The page features a header for 'Time & Space Inc.' with a logo of a rocket. Below the header, there is a section titled 'BEST INVENTION: THE SPACE CADETS' with a photo of four children. To the right, a table titled 'THE LEADER BOARD FOR NOVEMBER 1' lists teams and their progress. Below the table, a 'CONTEST NEWS' section states that the 'The Time and Space Machine' will be used for all internet research. A red speech bubble points to the children's photo with the text 'We are winning it for Grandpa'.

TEAM	% COMPLETED	T&S HOURS LEFT
Cal Tech	0%	100%
Brooklyn Babes	0%	100%
WIZ KIDS	0%	100%
THE SMASH	0%	100%
WOW	0%	100%
EINSTEIN'S GIRLS	0%	100%
SPACE CADETS	0%	100%

CONTEST NEWS: The Time and Space Machine, invented by the Space Cadets, will be used for all internet Research.

And that is how the finals got started.

Do you think that we are made of STARDUST? Do you think that you have STARDUST in your body that was once in the body of George Washington?



THANKSGIVING

AND THE FIRST CLUE

(As Told By Lizzy)



Milo and I settled into the routines of high school. The classes were okay, I made some new friends and the freshman teasing that we were so worried about wasn't bad. Milo had made the freshman football team and I made the JV (ha, ha) soccer team.

Thanksgiving was coming up, and we were going to use the 4 days off from school to plan our research for the contest. We'd be together at Grandma's big family dinner.

Grandma is a fantastic cook. She's fun because she's always teasing and playing tricks on us kids and on Grandpa. VC said, "I once asked Grandpa how people got to be here on earth. Grandpa told me about evolution, and how humans were the third evolution of the chimpanzee. So I asked Grandma and she told

me about Adam and Eve who had babies that grew up and had babies and that kept going until now, So I told Grandma that it sounded different from Grandpa's story of evolution from chimpanzees, and she said, "oh, the chimpanzees are on his side of the family."

For April Fool's day last year, Grandpa put clear plastic wrap over the toilet so Grandma wouldn't see it when she went to the bathroom. That made a huge mess. For revenge, Grandma put rubber bands on the spray handle at the kitchen sink so when Grandpa turned on the water he would get sprayed. Another huge mess.

Neddy told us this story. "The other day when I stayed overnight with Grandma and Grandpa, and Grandma packed my lunch for school, I got a weird note written on my banana skin. It said 'Help, I am being held prisoner on a banana boat.' I bet that was Grandma." We all laughed and agreed that Grandma plays jokes and she wrote the note. We'll get her back someday.

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On Thanksgiving day, lots of the family ran in the annual road race in Manchester, Connecticut. I was running the race for the first time. I was gonna run with Grandpa, but we made plans for what to do if I got too tired and had to walk. Half way through the race I decided that Grandpa was going too slow, so I waved goodbye and said "see you later, slowpoke." I took off for the finish line and beat Grandpa by 2 minutes. But I ended up crying after I couldn't find any of the family at the finish line. Grandpa was crushed that I beat him. Well he can still beat my little brother and he tortures him, calling him 'short and slow.' I bet he won't be beating **him** much longer either.

After the race, we got together at Grandma's for the turkey feast. It was delicious as usual.



After dinner we got into the 'do you remember' thing. Us cousins have shared a lot of experiences together and we love talking about them. On our last trip, Grandma and Grandpa took us sailing in the Caribbean. "Remember when we snorkeled in the caves and saw turtles and explored an old shipwreck," I said.

"Remember when the dolphin jumped out of the water at the shipwreck and I got so scared because I thought it was a shark," added Neddy.

"And remember when we did see a shark," said Milo with a grin. "I liked that."

"Oh yeah," I replied, "I never saw anyone swim as fast as Grandma, heading back to the boat."

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After gorging on turkey and stuffing, we had the first meeting about solving the STARDUST MYSTERY in the basement at Grandma's. The team was divided on whether they were made of STARDUST.

"How in the world could we be made of STARDUST, when the stars are so far away," asked VC? "I think that's just crazy."

"I don't think TSI would have made this challenge if it wasn't true," replied Milo.

"Winning the moon trip would be amazing," added Neddy.

"So, let's find out about STARDUST, and how it could be in the bodies of other people and now be in our bodies," I said.

We all agreed.

Grandpa had left a bunch of stuff for us in the basement that had come in the mail from TSI the day before. When we opened the first box, we found a set of dolls. Those are the dolls where each doll has a smaller doll inside it. I found out they are Russian nesting dolls and are called Matryoshka dolls.



"What are these for," I asked?

"I don't know," replied VC. "But I think it's a clue."

"And look," I said as I picked up each one, "the dolls look strangely like Grandpa and us."

"Wow, you're right," agreed Neddy. "Except we all look so fat, like we have eaten too many of Grandma's thanksgiving dinners. And look, they have pictures of my little brother and VC's little sister. Where did those came from? Strange."

"Yeah, strange," said Milo. "This is definitely some kinda clue."

"Remember the letter we got," I asked? "TSI said they're going to send us presents. Well, the presents must be clues."

We all agreed that we had to figure out what the clue meant.

The other boxes contained the computer projection system that Jackson had invented to get a complete surround picture of a scene on the walls of a room. TSI had designed the system to project the virtual reality world of the *Beamer*.

While VC was assembling the projection system, I suggested that we needed to plan the research.

Milo, as usual, was being bossy and took charge of the meeting. He is so totally uncool. But I must admit, he has been a really good organizer. "The first thing," said Milo, "is to identify the tasks we need to do. Then we can assign people to the tasks."

I went to the whiteboard and asked, "ok, what are the tasks? I'll write the list."

"First," said Milo, "we have to find out what human bodies are made of. I will take that task."

"Duh,.... thit ess essy," said Neddy slipping back into Brooklyn Babes speak. "Bois make of snikes n snils n pooppy dag tills, n gulls make of shuugr n speece n everything neece."

We all laughed. "Your imitation is great," I said. "But, what did you say?"

"Boys are made of snakes and snails and puppy dog tails, and girls are made of sugar and spice and everything nice," she replied in her normal voice.

"A little seriousness here," said Milo. "Next, I think we need to find out what is in our bodies that could be STARDUST."

"I'll do that one," I offered.

"And then we need to see how STARDUST could get from one person like George Washington to another person," added VC. "I'll work on that."

"And then we have to find out about where we live and how STARDUST got here," said Neddy. "I love everything about space, so I'll do that. But I may need some help from Lizzy."

Amazing, the '*Space Nerd*' wants help from me. "Sure sis," I said. And I gave her a fist bump.

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"Hey guys," said VC, "I finished the assembly of the projection system. Let's log on to the **Beamer** and take it for a test drive."

"Awesome idea," said Milo. "It was your idea, VC, so why don't you log on and show us what to do."

"Ok," said VC as she logged on. "Cool, I get to choose who my *avatar* will be. Fun, fun, fun. Ok, ready."

"Whoa," I said when the scene lit up, "this is fantastic." The scene was projected all around us on the walls of the basement. There were some paintings on the basement walls, so we took them down, and then moved the furniture to the center of the room. The walls were white, so the pictures were pretty clear.

"Wow," said Neddy looking at VC whose avatar appeared at the entrance to the Mystery Hall in the body of an older girl, "Hot."

"Yeah," said Milo the jerk, "that body is way better than yours."

I punched Milo on behalf of us girls, as I was sure that VC would want me to.



Then VC started exploring the Mystery Hall. There was this really neat Gallery of Experts. There was another *avatar* in the Gallery.

"Hey," asked VC, "what are you doing here? You look like me."

"My name is VC," replied the *avatar*. "I work here as a Guide. What is your name?"



"This is really strange," said VC. "My name is VC. Well, do your job and tell me about this place."

"Ok," said VC the Guide, "this is the Gallery of Experts. These are all famous scientists. If you want to visit any one of them, you just come to the Gallery and ask me. You can go to their home or where they work and ask their *avatar* questions and they will answer you. But you always have to start talking to an *avatar* by saying 'my name is' and saying your name."

"Cool," said VC. "I won't do that now, but I would like to see more of the Hall. What should I go see?"

"Well," said VC the Guide, "if I were you....." And all of us cracked up laughing because she was her."I would go visit the Time Machine. It is on the fourth floor of the Tower. A trip in the Time Machine is really cool."

"Thanks," said the *avatar* for the real VC. And off she went.

After wandering around several rooms and hallways VC found the entrance to the Time and Space tower. and climbed to the fourth floor.

And there was an *avatar* that looked like Milo standing next to a NASA space capsule.



"Hello, little guy," said VC. "My name is VC. Who are you?"

"Hello, VC," said the *avatar*. "My name is Milo. I will be your guide if you want to do time travel. You can visit previous times and places while you stay in the capsule, or you can go outside to visit. But the capsule in front of you is an antique. We don't use it any more. To get to the our modern Time Machine you have to use this teleporter over here." He was pointing to the teleporter

"How about if we all go," said the real Milo. "We could go visit George Washington, since he's part of the mystery."

We all decided to go, so we logged on and found the Time Machine room. Milo the guide explained that the Time Machine in the room was an old one just for display. To get into the real one, we each had to step into the transporter tube and that would take us to the real Time Machine. Milo the guide demonstrated, and we all followed.

The inside of the Time Machine was really cool with computers and switches and buttons. We agreed on a visit on December 25, 1776, because we knew exactly where GW would be. That Christmas night, he was crossing the Delaware River in a boat to attack the British army in Trenton, New Jersey in the middle of the Revolutionary War. We'd studied that in history earlier this semester. Neddy looked up the location of where he crossed, and, we entered the [Longitude and Latitude](#) because, that's how you tell the *Beamer* the location, like on a GPS.

Longitude is the east/west position and Latitude is the north/south position. Then, we entered the date and time, checked the option to make the visit outside the capsule, and pushed go.



I looked at the scene. It's dark. There's water all around us and its clogged with large chunks of ice. There are boats in front of us, which I think is north, and they are headed east to a shore line in the distance. I can just barely make it out. I turned around to look south and see more boats. "We're in the right place at the right time," I say. "There's George Washington's boat."

"But there's the four of us, and we're in the water," said Milo pointing to the image on the wall. "We're not in a boat. It's good that this is virtual reality or we'd be freezing."

"Ok," said VC, "let me try to fix this. I will change the Latitude to move us about 10 feet south into a boat." VC entered her password and changed the Latitude.

Then poof, VC landed in the boat and was now one of the oarsman. The rest of us were still in the water.



"OK," said Neddy, "I saw what she did, so I'll fix the rest of us." Neddy logged in for the three of us still in the water and adjusted the input numbers.

And then poof, poof, poof, we're still in the water, only now we're about 5 times smaller than when we started. "Something is wrong here," said Neddy.



"No, it's awesome," said Milo really excited. "They added a new feature to control the size of our *avatars*. It's just not working quite right."

"Ok, Great," I said, "but let's try to get back to our normal size and into the boat. I'll do it."

I fiddled with the inputs and hit go and poof, poof, poof, we are still in the water near the same chunk of ice. The boat and VC are gone. And whoa, now we're even smaller.



VC yelled at us like we were real far away, even though we were sitting right next to her, "I think there is a bug in the program. Let's log off and report it to TSI."

We logged off and discussed our first **Beamer** trip. "Awesome," was Milo's one word.

"They'll have to fix the software bug," said VC. "But otherwise, it's really great."

"I can't wait to try other trips," added Neddy.

.

A little later that day, we reviewed the tasks that we had decided on. "Is there anything else," I asked?

"I can't think of anything," Said Milo. "But, we'll be able to add tasks as we find out more stuff. Ok everyone, let's '*smartenup*' when we get home." That was Milo's stupid expression for doing research. Everyone found that expression silly and annoying. "But don't use more than half an hour of **Beamer** time, as we don't want to use it up too quickly. You won't have the complete surround system that we have at G-Pa's, but your computer screen will do. Also, think of what the nesting dolls might mean."

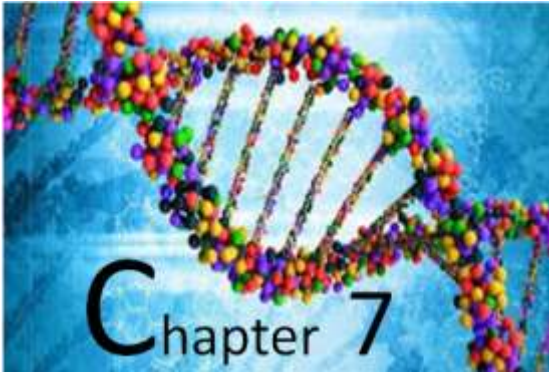
We agreed with Milo, and decided that the next meeting would be by Skype after the first task was completed.

We sent in our report for November to TSI.

DISCOVERED SO FAR	Research is Planned
NEXT QUESTION TO ANSWER	What could be STARDUST in our bodies?
ISSUES	Bug in entering the Beamer parameters. Changing the latitude made us smaller.
QUOTE OF THE MONTH	The Beamer is awesome.

What part of the body do you think might be STARDUST? What do you think the Russian Nesting dolls mean?

December



WHAT ARE OUR BODIES MADE OF?

(as told by Milo)



My football team is terrible with a record of 2 and 11. I hope my lacrosse team is better. School is ok, but the contest is really interesting. December first arrived. I logged on to the contest web site. Oh, wow, Jackson has already completed 20% of the mystery and we haven't even started. Even the crazy Russian girls are already started. We need to get going.

THE LEADER BOARD FOR DECEMBER 1

TEAM	% COMPLETED	T&S HOURS LEFT
Cal Tech	20%	90%
Brooklyn Babes	10%	90%
WIZ KIDS	0%	90%
THE SMASH	0%	100%
WOW	0%	100%
EINSTEIN'S GIRLS	0%	100%
SPACE CADETS	0%	100%

CONTEST NEWS: Jackson Graham of Cal Tech jumps out to a huge lead in the first month of the competition

California is going to show its stuff

I think my task is gonna be easy. Everyone knows what bodies are made of. I'd gone to the '*Bodies Exhibit*' at the Science Museum and had seen the bones and muscles and blood vessels and stuff. I just had to present what I knew to the team. The bodies exhibit brochure has a skeleton picture, and I could show that. And, we are mammals, and cows are mammals, so I went to the supermarket and took a picture of a steak to show that we also have fat and meat connected to our bones.

I set up a Skype call to show those pictures to the team.

.....

Lizzy and Neddy were excited. They said they'd gone over to G-Pa's and gotten another package that arrived from TSI. So, first, they opened the package. It was a Bart Simpson figure made out of Legos.

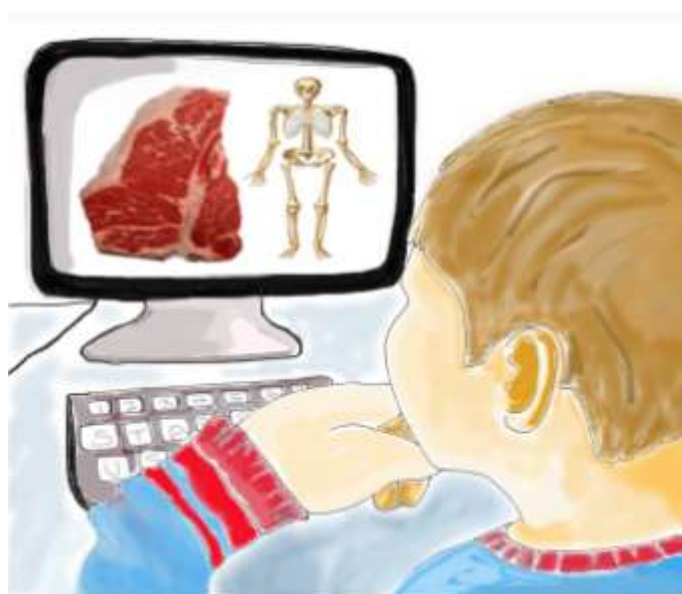
"This has to be another clue," I said.

"And we haven't even figured out the first clue, the nesting dolls," added Neddy. "We need to figure out what these clues mean."

"Well, let's get started." I said. And I made my presentation with the pictures of the skeleton and steak. I finished by saying, "of course we have skin, too."

"NO, NO, NO," shouted Lizzy, "skin and bones and meat are what we're made of, but that can't have anything to do with stars. They would burn up on a star." The other girls agreed.

"There're no cows on stars," added Neddy. "You should know that." Neddy had supported her sister, which she didn't usually do. She liked to fight with her sister. But here was a chance to show me up. It was an opportunity much too delicious for her to pass up. I made sure the steak picture covered my face on the computer screen so they couldn't see me turning red.



"You have to look smaller," demanded VC. "What are skin and bones and meat made of? Look smaller."

Then all of the girls started to chant, "smaller, smaller, smaller, smaller." And that ended the meeting.

Girls are really annoying. "OK," I thought, "I guess my task wasn't that easy. I'm gonna have to do some research."

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After school the next day, I went to see my science teacher, Mr. Olly, who was also the basketball coach at school. I asked to borrow a book that told about what the body is made of. He gave me a Life Science book. I also shot some baskets with him.

When I got home I looked through the Life Science book to find out what bones are made of. The answer was 'cells.' And what muscles and fat and blood are made of. Cells again. "OK," I said to myself, "I've got the answer, our bodies are made of cells."

And I read that cells were these little tiny building blocks with a cell wall and something in the center called the cell nucleus, and a bunch of other stuff inside.



I read that you could actually see cells, like from an onion, under a microscope. And, G-pa had a microscope. So I went to his lab and took pictures of onion cells through the microscope. I also took a picture of one of my own hairs that I put under the microscope to show how small the cells were by comparing them to the hair. The long dimension of the onion cells were about 5 times bigger than the hair. The Life Science book said that human cells are about the same size as the thickness of a hair, so human cells must be much smaller than the onion cells.



I decided that I needed some pictures of human cells, and I got this awesome idea. Yes, I am a genius. I remembered what happened in the Delaware river, how three of us got shrunk, like in *Alice and Wonderland*. I can use the **Beamer** to shrink myself and go into my body. I can just use my computer to do it. So I logged on to the **Beamer** and chose an *avatar* in a wet suite for touring the body. When I entered the Mystery Hall, I looked through the galleries to find the machine to change my size.

"Yeeees," I said, "the Size Changer. That should do it."



Neddy, the *avatar guide* showed me how to get into the capsule using the transporter tube. Suddenly, I was in the capsule sitting at the controls with Neddy beside me. I set the **Beamer** time and date for last night and the location in my room at home. I checked off the option for exploring outside the capsule.

"What about size" asked the Neddy *avatar guide*?

I want the thickness of my body to be about the same as the width of my hair. A hair is about the same width as a piece of paper and a package

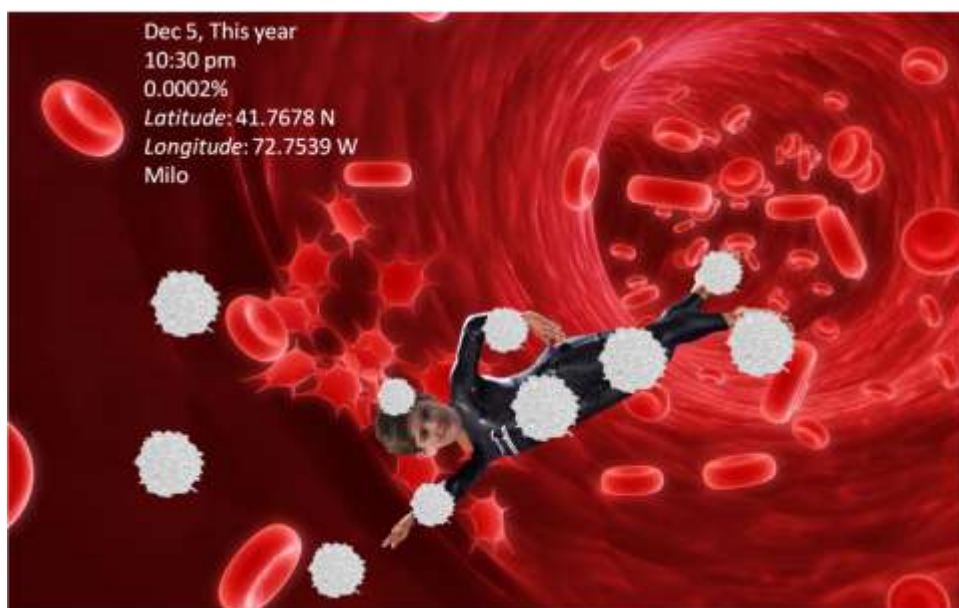
of 500 sheets is 50 mm thick, so a hair is about 0.1 mm. And I am about 4 packages of paper thick or about 200 mm. So I set the size control on the **Beamer** to make me 2,000 times smaller or 0.05% of my real size. And then I pressed go.

At first, I found myself in some gray goop so thick that I couldn't move. I wondered where I could be. But since I couldn't move, I changed the location a little on the

Beamer controls and found myself in one of my blood vessels. Awesome. I found out that if I used the position arrows on the key board, my *avatar* would swim in the direction I indicated. Awesome. I took a screen shot to show the team. I swam up stream until the blood was rushing by so fast, I couldn't move forward anymore.



And anyway, the way forward was blocked by some sort of moving door that kept opening and closing like in mini golf. I wondered what that was. I turned around and swam in the other direction.



Uh oh, something just stuck on my head. Oops, and another on my foot. All of a sudden, I was being attacked by these white prickly sponge things. There were a bunch stuck to me and more coming. I decided I had enough and was gonna end the session, but not before I took another screen shot of the attack.

Later, I compared the screen shot to the [parts of the blood](#) described in the Life Science book. I found out that I was swimming in the blood plasma. The red donut shaped things are red blood cells and the spiky things are called platelets. The white cell things that attacked me are killer T-cells. They're part of my immune system and are supposed to attack any foreign thing in the blood stream. I wasn't supposed to be there so they attacked me. Awesome. The experience was weird, but I now know what my blood stream looks like.

"Well," I thought, "this was really great, awesome stuff on the cells." I arranged for another Skype call with the girls.

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When we were all on the call, I showed my onion cells and explained about how the size was larger than my hair. And then I showed the screen shot from the **Beamer** and challenged, "I betcha don't know what this is."

Looks like you're swimming in a sewer pipe with a bunch of doughnuts and sea urchins," replied Lizzy.

"No way," I said.

"Ok," offered Neddy, "how about a new ride at Disney... Oh wait, I know, you're having a bad dream about a sore throat."

"Good guess," I replied, "but wrong."

"How about you are being sucked into a black hole, or you are in a stomach with a bunch of life savers," tried VC.

"Closer," I said. "It is a picture of me swimming in my own blood stream that I did on the **Beamer**. Remember, we found out that you could shrink yourself. Well, I made

myself 2,000 times smaller and entered the location and the time where I was in my room yesterday. At first I got into some gray goop and couldn't move. I didn't know where I was, so I changed the location and got into my blood vessel."

"Duhhh.....," said VC, "that gray goop was your brain, so you got the goop part right."

All three girls cracked up. Lizzy and Neddy and VC were fist bumping. "Ha, Ha, very funny," I said sarcastically, though it was pretty funny. I went on to tell them about the whole experience and they were pretty impressed. And they wanted to try it. But I said, "we have to save our time for the research."

Back to the research, they still didn't think that I had the right answer. "No, No, No," shouted Lizzy. "There must be something smaller. These cells can't have anything to do with STARDUST. A star would be way too hot for the cells to survive."

And Neddy, supporting her sister again, said, "she's right, you need to find something that could survive inside a star. Find the thing that is smaller."

And the girls took up the chant again, "smaller, smaller, smaller. Find something smaller." Oh, not again with the annoying girls. I was feeling like Bill Murray in that old movie, *Ground Hog Day* where every time he wakes up, he is living the same day all over again. They were having so much fun, but I wasn't. I logged off the call.

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I needed to get away from them and think about something else. So, I went up to my room to arrange my sneaker collection. I have about 30 pairs of sneakers. And I buy and sell them on-line and at sneaker conventions. I separated the ones that I was going to sell next time.

Then I noticed that my room was starting to smell bad. I live with my dad, and he isn't so particular about cleaning up. I think the pile of dirty clothes is getting way too big, so I took them down to the washing machine. Now the room smells better.



I was really thinking about quitting the team. But then I thought of the moon trip and letting G-Pa down. So, I decided to finish my job. I went back to the Life Science book. I found out that one of the most important parts of the cell is called the [cell nucleus](#). And in the nucleus are the [chromosomes](#) which are made up of [genes](#) and the chromosomes are the part of the

body where all the information about how to construct our body is stored. For example, that is where the information on our size and our hair color is stored. And the chromosomes and genes are made of [DNA](#) which is this huge molecule. And,

DNA which stands for [deoxyribonucleic acid](#) sounds soooo... awesome. Now, I have the answer I need. It must be the Stardust. This will shut up those girls. They won't even be able to say *deoxyribonucleic acid*.

And the girls were impressed when I showed the DNA picture. But Lizzy again said, "NO, NO, NO. You can see from the picture that DNA is made of something smaller. What are all those little colored balls?" And then Lizzy made the connection. "I got it," she said. "The Russian nesting dolls are a clue. We've got to keep opening each doll to find the smaller thing inside."

"She's right," said Neddy.

Now I knew that I was getting close to the answer. And I now knew how to get it. I just had to keep looking for what each thing is made of. "You just keep opening each doll to find out what is inside," I thought. So I went back to the Life Science book and looked up "what is DNA made of?" The answer was smaller [molecules](#). So I looked up "what are molecules made of?" And the answer was [atoms](#). DNA was made mostly of hydrogen, carbon, oxygen, nitrogen and phosphorus atoms. And then I looked for "what are atoms made of?" And the answer was [protons, electrons and neutrons](#). So I looked for "what are protons made of?" And, there was no answer in the Life Science book.

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.



So I logged on to the **Beamer**, went to the Hall of Experts, and asked the guide to see Stephen Hawking. There was a transporter tube in the Hall of Experts. The **Beamer** said that I would be going to University of Cambridge in Cambridge, England. I found myself in Professor Hawking's home in a room with 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 his hand to select words on his computer screen. **"HOW DO YOU DO, MILO? I AM STEPHEN."**

"I am working on a project to find out all of the things that our bodies are made of," I said. "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 stuff 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. AND QUARKS ARE EITHER MADE OF MORE QUARKS OR LITTLE TINY STRINGS ACCORDING TO STRING THEORY. WE ARE NOT SURE WHICH IT IS YET. STRING THEORY IS THE NEWEST PART OF THE THEORY OF EVERYTHING. BUT IT ISN'T YET PROVEN."**

Professor Hawking told me the names of the people that discovered quarks and are working on string theory, with the important dates of when these concepts were proposed. I took careful notes.

"ONE MORE THING," said Professor Hawking's voice, **"YOU MUST ESTABLISH COLONIES ON OTHER PLANETS."**

"Why," I asked?

"TO SAVE THE HUMAN RACE," answered the voice.

"That was strange," I thought, "about establishing colonies on other planets. And why me?"

I thanked Professor Hawking and logged off the *Beamer*.

"It was funny," I thought, "about the little tiny strings. Yeah. Girls aren't made of sugar and spice and everything nice. They're made of quarks and strings and other strange things."

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I called for another meeting of the Space Cadets, and we got together in G-ma's basement. This time, I was confident I had the answer and there would be no more chanting of 'smaller' because, according to Hawking, I was down to the smallest things known. So, I told the cousins 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 and electrons and neutrons, and those made of quarks, and quarks made of strings. "It's really like those Russian dolls," I said. "Every part of the body is made up of a still smaller part." And I laid out all the dolls and put labels for the body parts in front of them. But we didn't have enough dolls for the quarks and strings.



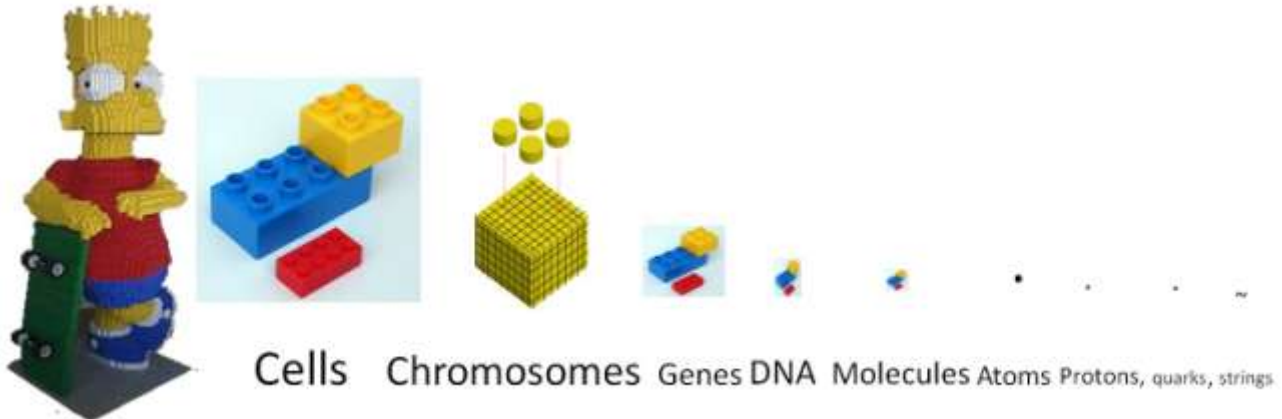
Cells Chromosomes Genes DNA Molecules Atoms Protons

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 Bart Simpson clue was. So I explained it this way. "Well, you know about Legos don't you? When you build a Bart Simpson like this one, you put lots of little Legos together, right?"

"Right," said VC.

"So, imagine your body is made of lots of really tiny little Lego pieces," I said. "They are so tiny that you can't see them individually, but you can see what they make, like a finger or piece of hair. Well, the Legos would be 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 mom assembled my Lego parts, which would be my cells."

"Right," I said with a fist bump to VC. "Now comes the hard part. You have to imagine that each tiny Lego piece is actually made of super tiny Legos. And the super

tiny Legos would be like the chromosomes, and other cell parts put together to make the cells."

"And then super duper tiny Legos, make up the chromosomes," I said. "And super duper teensy tiny Legos make up the genes, and these would be the DNA molecules. Well it keeps going on like this, like the Russian dolls, until you get to the smallest piece that scientists have so far found and these would be the quarks or strings. Does that make things clearer?"

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

So now we had the answer to what a body is made of. But we still had a mystery. Which one of the dolls, or the Legos, or the body parts was the STARDUST? Molecules, atoms, protons, quarks, or strings?

And since we were going to have to submit our mystery solutions in rhyme, I decided to put what I learned into a poem. Here it is.

Milo's Poem

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.
D N A 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.***

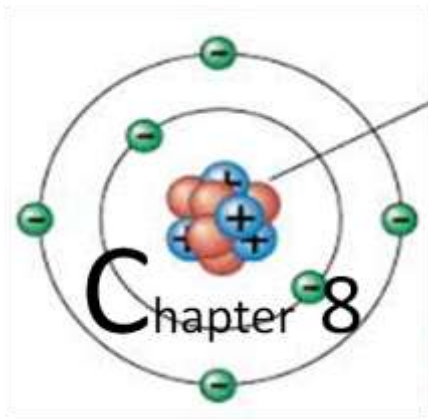
So that is Me

We submitted our report for December.

DISCOVERED SO FAR	Possibilities for STARDUST are atoms, protons, neutrons, electrons, quarks, and strings.
NEXT QUESTION TO ANSWER	Which one is it?
ISSUES	<i>The Beamer</i> worked great for swimming in the blood stream.
QUOTE OF THE MONTH	We got the meaning of the first two clues.

Can you guess which thing in our body is the STARDUST?

January



A

toms in Our Bodies

(AS TOLD BY LIZZY)



'Quarks and Strings and other strange things' is what Milo said girls are made of. He thinks he is soooo clever. But he is so totally not. He is sooo stuck up. I don't think he's handsome at all, and I don't like the way he sticks his hair up in the front like Justin Bieber, and I don't like the way he sticks out his chin and I don't like the way he thinks he knows everything, and I don't like the way he says 'awesome' all the time, period. If he ever tried my flying double kick that I used to take down Richie he would probably break his leg. But I have to admit, his *Beamer* trip through his own body was way cool.

Life is ok. I am doing well in school. But my sister still steals my clothes and drives me crazy. On the other hand, my flying double kick is the best at Tae Kwon Do.

I have to check the LEADER BOARD.... Oh, Pooh!!!!!!.....Not good. Jackson is still leading and we're still last.

Time & Space Inc.

LEADING TEAM: CAL TECH

This is like taking candy from babies

TEAM	% COMPLETED	T&S HOURS LEFT
Cal Tech	30%	85%
Brooklyn Babes	15%	85%
WIZ KIDS	10%	80%
THE SMASH	5%	90%
WOW	5%	80%
EINSTEIN'S GIRLS	5%	90%
SPACE CADETS	5%	95%

CONTEST NEWS: Jackson Graham of Cal Tech widens his lead in the second month of the competition

Seeing the Brooklyn Babes on the LEADER BOARD reminds me of something. During vacation, Milo went to Brooklyn to visit aunt Joanne. He's never visited her before. Was there some other reason for him going to Brooklyn? Russians, I wonder? Maybe he doesn't think all girls are annoying after all.

Well, I have to get started on my research on [atoms](#) to see if they could be the STARDUST. I chose atoms because I am studying them in school. I decided to get help on my research from Mrs. Ortiz, the school librarian. She pointed me to lots of good resource material. I learned that everything, like you and me and the dog and our house and the whole planet Earth is made up of tiny little building blocks called atoms and there're a whole bunch of different kinds of atoms. It was sorta like building everything out of Legos of different sizes and colors. The idea of atoms was proposed by this guy named Democritus a long, long time ago in ancient Greece. I also learned that our bodies are mostly made of four different kinds of atoms, Carbon, Hydrogen, Oxygen and Nitrogen, CHON for short. We also have calcium and phosphorus for our bones and iron for our blood and a bunch of other atoms in small amounts.



WAS YOUR STARDUST ONCE PART OF:

*George Washington,
Johannes Kepler,
Galileo,
Albert Einstein,
Edwin Hubble,
Elvis Presley,
Marilyn Monroe,
Henrietta Leavitt,
George Lemaître,
Ernesto Cardenal
Democritus,
J. Robert Oppenheimer,
Tyrannosaurus Rex,
Moby Dick
And Bill Clinton*

I needed to find out more about atoms. Could they be the STARDUST? What are atoms? How small are they? How many of them are there in our bodies? How do they get into our body? Also, the contest riddle said something about our STARDUST being previously in George Washington. If atoms are the STARDUST, were the atoms in my body once in George Washington's body?

And then there was the latest email from TSI. It had an attachment with a list of new people that could once have had some of my STARDUST. Are they for real? Could that possibly be true?

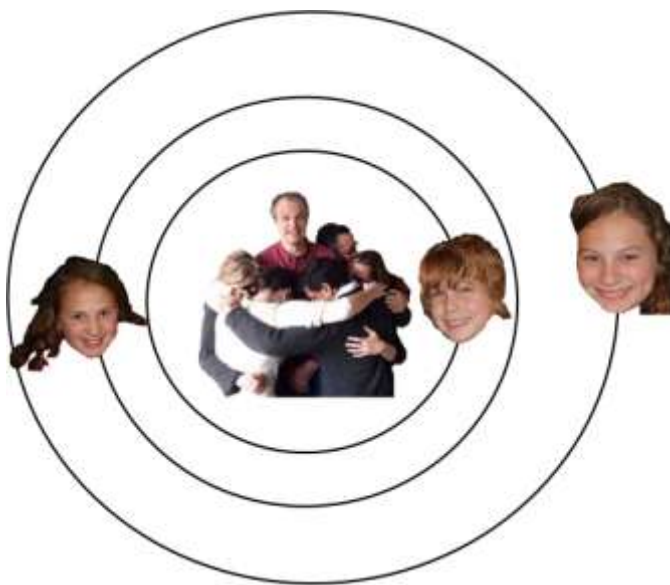
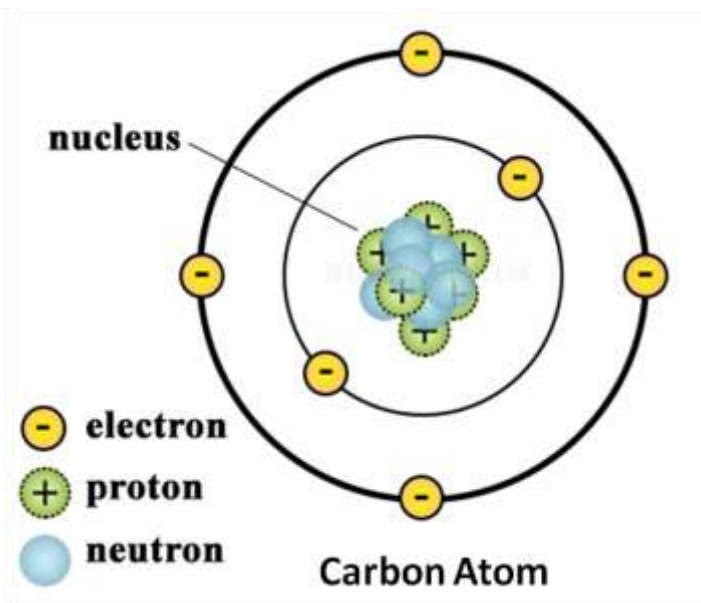
"Well", I thought, "I've got to do the research." Mrs. Ortiz had given me a book

with lots of diagrams of atoms. I will show the team a carbon atom, since there are lots of those atoms in our bodies. I found out that the carbon atom has 6 tiny particles called

electrons, racing in paths, called [orbits](#), around a bunch of bigger particles called [protons and neutrons](#). The protons and neutrons are stuck together in a group at the center called the [nucleus](#).

Different kinds of atoms have different numbers of protons and electrons. For example, hydrogen has only one of each, nitrogen has seven of each and oxygen has eight of each.

I showed the diagram of the carbon atom to Neddy and told her a story. "Atoms have electrons racing around the nucleus," I said. "An atom is like a family. The mom and dad, and maybe grandparents, uncles and aunts are the nucleus or center of the family. They are like the protons and neutrons. The kids are like the electrons. They are smaller, they need to stay near the parents, and they are always in motion, running around in circles."

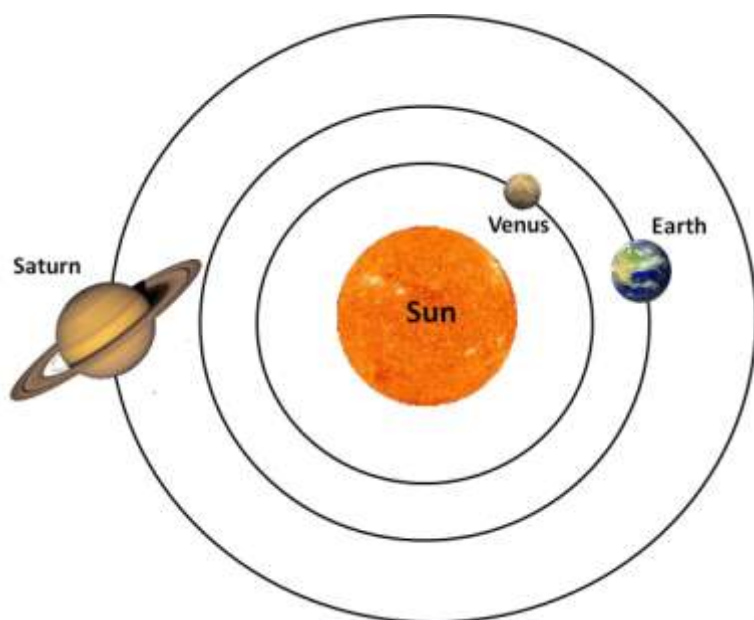


"Different kinds of atoms would be like different size families," I added. "Some families are small with a single mom and one kid and that'd be like the hydrogen atom. Some families are big with a mom and dad and 4 grandparents and 6 aunts and uncles and 6 kids. That'd be like the carbon atom. Does that make things clear?"

"Yeah," said Neddy, "I think so. Our family has 3 kids. What atom would that be?"

"That'd be the lithium atom," I said. "I think you got it."

"Yeah, and uranium with 92 protons and electrons," added Neddy showing off some of her science knowledge, "would be a really large family."



"You know," she continued, "the atom story is kinda like the story of planets racing around the sun. The planets make paths around the sun just like the electrons make paths around the nucleus."

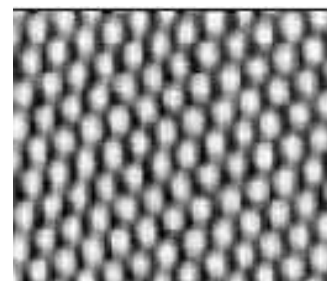
"But the two stories are different," I said. "The planets are really, really big. They just look small, like stars in the sky, because they are so far away. But atoms are really, really small, smaller than the eye can see."

I wondered if you could see atoms under a microscope. I wanted to show the team an actual picture of an atom, like Milo did with the cells, to make the story really good. So, I texted Milo to ask about the microscope.

Text from me to Milo - "Could I see an atom under Grandpa's microscope?"

Milo to me - "Duuh, no Dizzy, that is a really dumb idea. They're way too small."

"Whatever," I thought! There must be some way to see them. I went back to my books and found actual pictures of Carbon atoms. They were taken with a very complicated device called an [electron microscope](#). And the size of the carbon atoms was so small that they only showed up as fuzzy dots. They were so small, that a billion, billion of them could fit inside the little piece of hair that Milo had looked at under Grandpa's microscope.

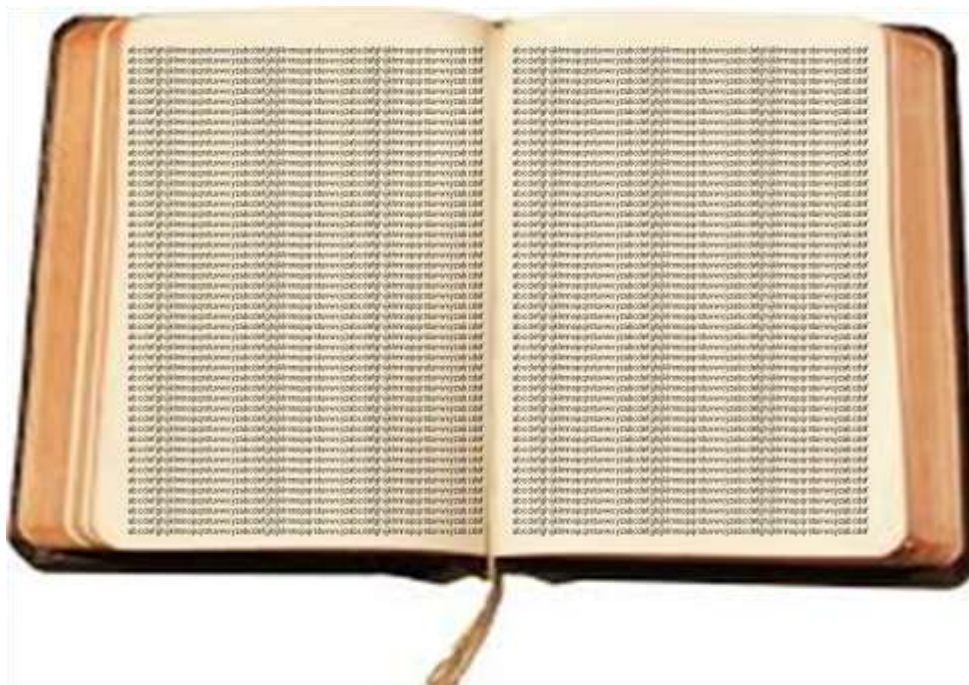


"Wow, 1 billion billion is such a large number," I thought. "How can I get an idea of such a large number, and how can I explain it to the team." I got this really spectacular idea and started typing a line of letters on my computer.

abcdefghijklmnopqrstuvwxyzabcdefghijklmnopqrstuvwxyzabcdefghijklmnopqrstuvwxyz

I got 84 letters on one line. "How many will I get if I type letters on a whole page," I thought? "I got 48 lines and so 48 times 84 equals 4032 letters. Wow, more than 4000 letters on one page!"

And I calculated that for one million letters, I would need a 248 page chapter book with each page filled with letters and no spaces between the letters. I wouldn't want to read that book.



And if I had 10,000 books, which is about the number of books in the average library, that would be 10 billion letters.



And if we had one million libraries, which is about all the libraries on earth, we'd have 10 million, billion letters which is still smaller than the number of atoms in the small piece of hair.

Imagine that, the number of atoms in one small piece of hair is 100 times larger than the number of letters on all the pages, in all the books, in all the libraries in all the world.

All of these numbers are making me dizzy. I decided to invent my own number because a million or billion is not big enough for counting atoms. I will call it the LIZZY. It will be the number of letters on every page in all the books, in all the libraries in all the world.

Then: 1 LIZZY = 10 million billion = 10,000 trillion = 10,000,000,000,000,000.

And 100 LIZZY atoms = the Number of Atoms in a small piece of hair.

To help compare all these big numbers, Grandpa put together a [Chart of Big Numbers](#) at the end of the book.

Well, if there are that many atoms in a little piece of hair, how many are there in my whole body? I need to figure out how many little pieces of hair would weigh the same as my body. And I got this great idea. I could do the shrinky thing that Milo did in the **Beamer** so that my size was the same as a hair. From the percent shrinkage value, I would know how many shrunk little Lizzys it would take to make a full size Lizzy. I decided I would go visit my dog Coco's hair to compare my size to his hair. I logged on and chose my *avatar*. I chose an *avatar* with a Tae Kwon Do outfit since that was what I was wearing. I entered the Mystery Hall and found the Size Changer that Milo had used. I entered the capsule through the transporter tube,



checked off an external visit and entered the present time and present location, on account of Coco was right there in the room with me. I put in 1.0 percent and hit go. I discovered that I was too big.

Then I remembered that Milo had shrunk himself by 2000 times to be the same size as a human cell, so I changed the size to 0.05 percent. That looked promising. Coco was lying in the corner of the room, which looked a mile away. My *avatar* hiked over to him and climbed onto his leg. Wow, I was in a forest. Coco's black hair looked like trees. The tree trunks were the same size as my waist so shrinking by 2000 was just right. I had my answer.

I was ready to log off when I heard this sound of heavy footsteps in back of me and this crunching sound, kind of like teeth grinding. I turned around and saw a huge Godzilla-like thingy coming towards me. Oh man, I should've been bigger. I am so outta here. And, I logged off the **Beamer**. That is a definite advantage to **virtual** reality compared to actual reality.

"Hey Mom," I called. "Guess what. Coco has fleas. Real bad ones."

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I now knew how to figure out the number of atoms in my body. I had to shrink by 2000 times to be the same size as the hair. So how many of these little Lizzys would I need to make one full size Lizzy? If I think of the big Lizzy as a box, I would need to pack 2000 little Lizzys across the width of the box by 2000 front to back for one layer. And then I would need 2000 of those Lizzy layers. So the total of little Lizzys in the box would be 2000 times 2000 times 2000, which is equal to 8 billion. So, I figured that the number of atoms in my body was 8 billion times 100 LIZZY atoms.

So, the number of atoms in my body = 800 billion LIZZY atoms.
or 8 billion, billion, billion atoms

.

I presented my research at the next team meeting. We were back in grandma's basement. I said, "Democritus proposed the idea that everything is made of small building blocks called atoms. And our body is made up mostly of 4 kinds of atoms, carbon, hydrogen, oxygen and nitrogen."

I said, "there are so many atoms in a small piece of hair, or in my whole body, that I invented a new number for counting, called the LIZZY. The LIZZY is equal to all the letters, in all the books, in all the libraries in all the world. A LIZZY equals 10 million, billion, and so my body has 800 billion LIZZY atoms."

"Wow, that's a lot of atoms," exclaimed VC, "all the letters in all the books, in all the libraries on almost a trillion planets like earth. And they are all in just one body."

"And I composed a poem to tell about the atoms in our bodies," I said. "Here it is." And I read the poem.

Lizzy's Poem

Atoms

*Atoms are nature's building blocks.
Used to build me, and even my socks,
and houses and cars and toys in a box,
and stars and planets and mountains and rocks,
are made of atoms of different kinds,
in different arrangements that chemistry binds.
Protons and neutrons in the center sit,
with tiny electrons in surrounding orbit.
Our bodies have plenty of oxy gen,
plus hydrogen, carbon and nitro gen.
And the number of atoms in one small hair
is a number that's so large, to be fair,
that to think of it was making me dizzy,
so, I invented a new number I call the LIZZY.
It's the number of letters in all books on earth.
One hair has one hundred LIZZY atom's worth.*

I got some polite applause.

Before we ended the meeting, I added, "we've got to figure out the list of people in the latest clue. Everyone give it your best thinking." And that ended the meeting.

Can you think of anything with a bigger number than the number of atoms in your body?



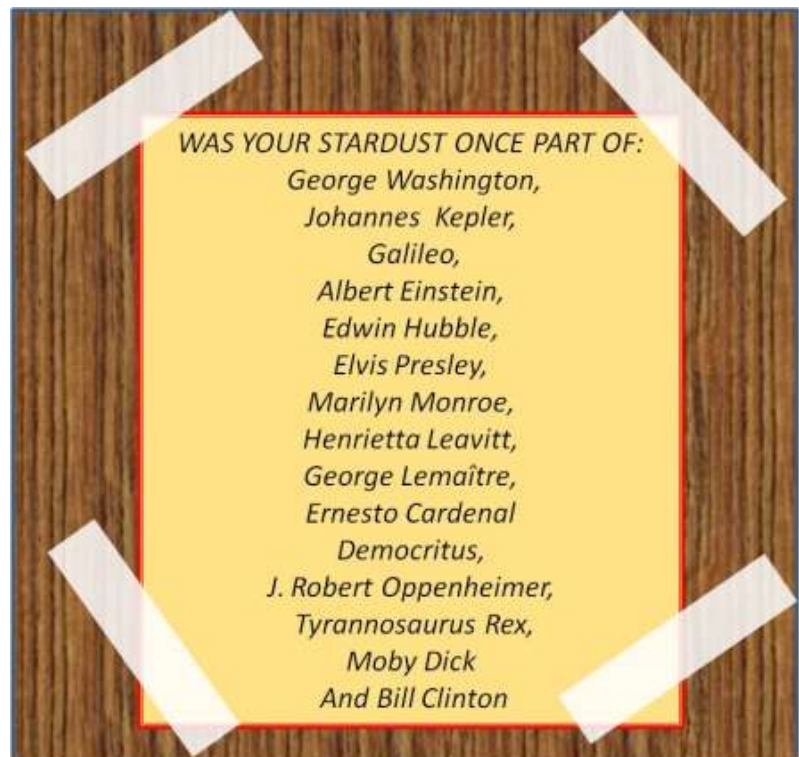
Neddy has a Brainstorm

(As Told by Neddy)



I'm baaack.

Before going on with the story, I want to confess that I really like driving my sister crazy. Here's the thing. She's bigger and faster and she sometimes hits me and she sometimes is very mean. I need a way to get even. Making her crazy is the way. Like I know if I wear something of hers, she goes ballistic. If she thinks I am getting a better deal from mom or dad or Grandpa or Grandma, she sees red. So I make sure she knows when it happens. Stuff like that.



There was one other mean trick I played. I had a friend call the house when she wasn't home and leave a message. He left the name and phone number of a boy in her class that she thinks is cute. She was all excited when she got the message and called back. Of course he didn't know what she was talking about and she was way embarrassed. Yes! ... Ok, confession over.

Now, about my brainstorm. I'm sitting in the Space Cadet meeting that Milo had called at his house, looking out the window at a jet plane making tracks in the sky, and thinking about our next trip to California. Milo was kind of going blah, blah, blah. Then I heard him say, "it is getting close to the end of January you guys, and we still haven't figured out the latest clue."

Milo was talking about the list of people that TSI sent us that once had our STARDUST in them. Milo had taped a copy of the list to the wall.

"George Washington, Elvis Presley, Tyrannosaurus Rex and Moby Dick," said VC? "That is some weird list."

"We've got to figure this out, and soon," Milo said. "Think guys, think." I shifted my attention from the birds outside that were chasing each other and making a racket to look at the wall. I started reading down the list, not seeing anything interesting until I got to the fifth name from the bottom, which I recognized.



Things in my head were going click, click, click and suddenly I screamed, "I have an idea." And I jumped up and down and danced around yelling, "this is so great. I'm a genius. I'm Sherlock Holmes. I'm Einstein. I cracked the code. I'm the best."

"Nerdy, oops I mean Neddy, won first place again in the Science Fair at school," my sister Lizzy told the group. "So, she's pretty impressed with herself"

"Thanks for nothing, Lizzy," I thought to myself.

VC was complimentary saying "Neddy is very observant. She always spots someone's new outfit or hair cut. Being very observant, she may have spotted an important clue in the list of former STARDUST owners. So quiet down. It could be important."

"OK Einstein," said Lizzy, "let's hear this genius idea. Spit it out"

"OK..., Ok..., Ok..." I said, out of breath. "The TSI people have been sending us stuff, and we're sure now that they're clues to the mystery. So what is the clue in this list of people and animals who had STARDUST in their bodies that are now in ours? I think that there are clues in the names on the list. I think the list is telling us that atoms are the STARDUST. Remember in her report on atoms, Lizzy told us that Democritus in ancient Greece came up with the idea that all things are made up of little tiny building blocks called atoms. Well, Democritus is on the list. I think that he is the clue that atoms are the STARDUST."

"Oh boy, maybe she's right," said Lizzy. "She'll be impossible to live with now."

"OK," agreed Milo, "let's think about this idea. Democritus is on the list, and atoms that he proposed seem to be important in the mystery. If Neddy is right about the clues, it means that atoms are the STARDUST. Is there anyone on the list that discovered protons, neutrons, quarks or strings, which are the other possibilities for STARDUST?"

"Whoa, ... wait a minute," Milo yelled. "I have the answer. It's in my notes from when I visited Professor Hawking. He told me all those names" He found his notes, and sure enough, none of the names of the discoverers of the other particles were on the list. "We have our answer," he announced. "Atoms are the STARDUST. And I just got a genius idea. If the atoms in our body are STARDUST, then all those atoms on earth must be STARDUST too." And now Milo did the jumping.

"And other names on the list may be clues," I suggested. "Some of them like Einstein are scientists and probably are clues, but some others like Elvis Presley, who was this singer, don't sound like they have anything to do with the STARDUST mystery."

"Maybe not everyone on the list is a clue," added VC, "because they didn't want to make it too easy."

So, we decided that there were three things that we had to do.

"First," said VC, "I have to figure out how atoms get from one body, like George Washington's, into another, like mine."

"Second," added Lizzy, "we had better look up all the people on the list to see who might be another clue to the STARDUST Mystery."

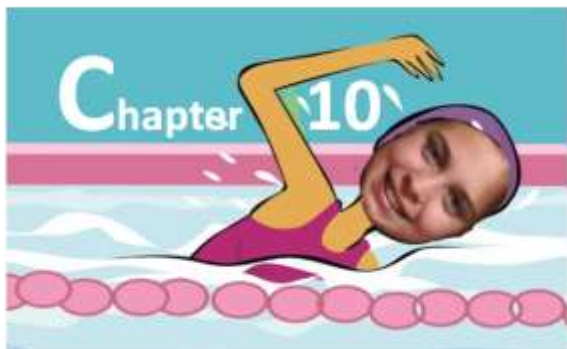
"And third," I finished, "I have to do research on the planet earth to see where it is, what it's made of and how it got its STARDUST."

We then submitted our report for January.

DISCOVERED SO FAR	STARDUST is atoms.
NEXT QUESTION TO ANSWER	How do George Washington's Atoms get into us?
ISSUES	We need to know more about the people on the list.
QUOTE OF THE MONTH	The Beamer worked great for finding fleas on Lizzy's and my dog.

Can you find any clues in the list of former STARDUST owners?

February



CARBON RECYCLING

(As Told by VC)



Bonjour everyone. What do you know? King Milo and Queen Lizzy are letting me tell some of the story, too. Lizzy isn't so bossy, at least not to me. We get along just fine. But, Milo is a know-it-all.

I had added the pictures of Milo swimming in his blood stream and Lizzy getting attacked by the 'fleazilla' to my blog. I didn't think they would give away any of our progress. I found that I had over 2000 followers. That's pretty impressive. Papa, which is the name I call Grandpa, thought it was great too.

I really like working on computers. Besides doing the blog, I made a web site for the team called <http://TheBeamer.net>. Of course, I got help from Papa. So far, it has pages for us kids, where they can ask questions and we give answers. I animated our pictures using this software that you can download and try for free. It makes the head and lips move when we speak. For some questions, I recorded my voice and my cousins voices for the answers. I also added some synthetic voices using text to speech software from the same company. It is not as good as TSI's *Beamer* web site, but this one has all the Space Cadet team as *avatars* and that's neat. Check it out.

It's my job to see about the possibility that some of the atoms that are in our bodies were once in the body of George Washington. Lizzy was helping me. "Could it really be true," I said? "Ces't ridecule," I said in French to Lizzy. "Il est mort depuis plus de 200 ans."

"English," snapped Lizzy a little annoyed. "I know you like showing off, but I don't speak French."

"Sorry," I replied. "What I said was 'That is ridiculous, he has been dead for over 200 years.'"

The plan was that Lizzy and I would work together during February on this question. And, we had received a new clue in the mail that might be important for our task. It was an empty crushed soda can.

Lizzy and I were together after school on the first day in February to work on the problem. We met in my bedroom. "Who is the guy on your wall," asked Lizzy?

"Michael Phelps," I replied, "the best butterfly swimmer in the world. That's my best swimming event, too."



The first thing we did was to check the contest web site. We'd moved up from last place to fifth. "Progress," I said. And we did a high five. "But we are not high enough to make the cut in June. Oh, look at this, the Wiz Kids were eliminated from the contest for computer hacking. So that puts us in fourth place. We only have to move up one more place. Yesssssss" And we did another high five.

THE LEADER BOARD FOR FEBRUARY 1

TEAM	% COMPLETED	T&S HOURS LEFT
Brooklyn Babes	40%	80%
Cal Tech	35%	70%
WIZ KIDS	20%	90%
THE SMASH	25%	80%
SPACE CADETS	20%	80%
EINSTEIN'S GIRLS	10%	90%
WOW	10%	80%

CONTEST NEWS: The Brooklyn Babes take over the lead. The Wiz Kids have been eliminated from the contest for hacking the email accounts of the other teams.

"I guess they really are keeping track of us, VC, so none of your computer funny stuff, please," warned Lizzy. "Oh, I almost missed it, the Obnoxious Babes are in first. What happened to Jackson?"

"I don't know," I said. "Ok, let's get started. We have to do a really good job, because Milo will want to get back at us for making fun of him and chanting smaller."

"Let's do it," replied Lizzy. "Where do we start?"

"Think about this month's clue," I replied. "Our problem is really about atom [recycling](#), so maybe the clue is about aluminum recycling. You know, when we put old aluminum cans in the recycle bin, and they melt them to make new aluminum cans. Can you think of a good way to explain aluminum recycling? And then, how do we relate that to the atom recycling problem?" We agreed to work with the recycling idea and meet the next day.

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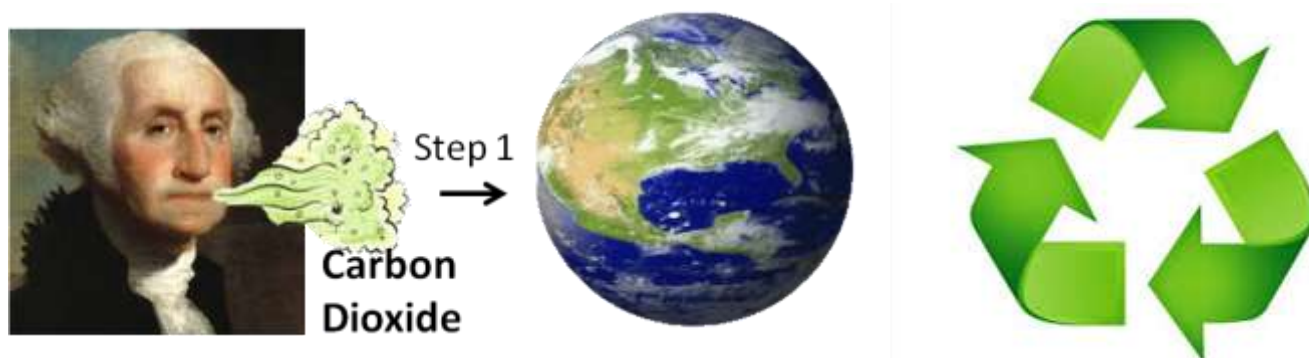
The next day, I began, "I think this will help explain recycling of aluminum cans." And I showed Lizzy this recycle poster that I had made. "There are 3 steps. **Step 1**, you put the used soda can into the recycle bin. **Step 2**, the old cans get changed into a useful form. For aluminum, they get melted down to make a new block of pure aluminum that is called an ingot. And **Step 3**, you use the aluminum ingot to make a new soda can."



"I think your mom took an old used VC, put it in the recycle bin, and got a new VC," Lizzy teased.

"Ha, Ha, very funny, you jerk," I replied.

"Sorry," Lizzy said. "But what about atoms? How do they get recycled? Let's think about George Washington. Let's call him GW for short. What happened to the atoms that were once in his body?"



"I got a book from Mrs. Ortiz at the library on the [carbon cycle](#) that I think is important for us," I said. "How about this. Every time GW breathed in, he took in oxygen and nitrogen. And when he breathed out, his breath had lots of carbon dioxide. That's because he [used the oxygen to burn his body's fats and sugars](#) for energy. And fats and sugars have carbon and hydrogen, so combining them with oxygen produces carbon dioxide and water. So **Step 1** would be his carbon, in the form of carbon dioxide molecules, going into the recycle bin. And for carbon recycling, that's all the air on earth."

"GW musta breathed out a lot of carbon dioxide during his lifetime," suggested Lizzy. "Could we have some of the carbon from his carbon dioxide in our bodies? I can think of one important question. Do carbon atoms last long enough? He died over 200 years ago. So if carbon atoms wear out quickly, then none of them could be in our bodies. But, Grandma says that diamonds are forever. And she got her diamond ring from her Grandma, so I guess it's pretty old. Anyway, diamonds are made of carbon, so carbon must be forever too. Ha, Ha, that's a Joke. Get it?"



"Whatever," I said. "Let's see if the book says anything about how long carbon atoms last." I looked, and found the answer. "Ok, it says the life for one kind of carbon is over 5000 years, but most carbon atoms live more than 20 billion years, way older than the earth."

"So, I guess diamonds really are forever," agreed Lizzy. "GW's carbon atoms would still be around. OK, then, here is another question. How could the carbon atoms from GW's carbon dioxide get into my body?"

"How about this," I offered. "Carbon dioxide that got put in the air in **Step 1** is used by plants like broccoli or apples to grow. That would be **Step 2**, the carbon dioxide in the recycle bin being converted to a more useful form. So those plants could have carbon atoms that were once breathed out by GW and lots of other people and animals. And then in **Step 3**, the apples are eaten by you, so now you have those carbon atoms in you."

"Eeee....uuu," whined Lizzy. "And you're so wrong. I never eat apples or any kind of fruits or vegetables and now I know there is a good reason. Now I can tell Mom and Grandma, when they try to get me to eat apples, that it's bad because it has carbon atoms that were in the bodies of other people, like Dracula and Frankenstein."

"Yeah," I replied, "but seeds and plants like grass are also eaten by turkeys. So, in that case, **Step 2** is putting the GW carbon atoms into the grass and then into the turkey. And then you eat turkey at Grandma's Thanksgiving dinner for **Step 3**. And so you get the GW carbon atoms anyway. Ha, Ha"

"Double Eee....uuu," said Lizzy.

"And so, as you grow," I said, ignoring her, "and add more carbon and oxygen atoms to your body, some of those atoms could be from GW and the TSI list of people, and lots of others."

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The two of us then worked on a poster of how GW's atoms get recycled into other people.



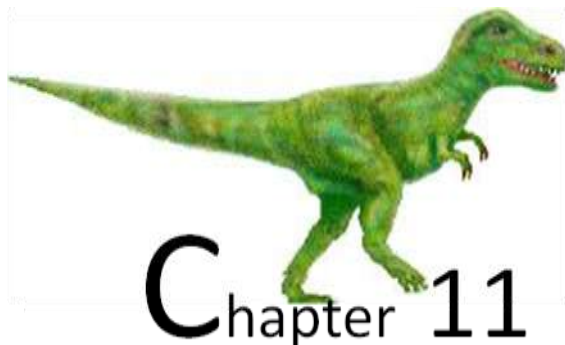
After we finished the poster, I added, "ok, here's another important question. Will GW's atoms be only around his house, or will they be all over the world?"

"Here is what I think," stated Lizzy, "A snow storm in Chicago can reach Hartford in one day. So, I'm willing to bet that carbon dioxide breathed out over 200 years ago would be all over the world by now."

"I agree," I said. "It looks like we really could have GW's carbon atoms in our bodies. Let's call a meeting of the Space Cadets and tell them that we have the answer. I have a great idea. Let's put on a play to explain recycling."

"OK," agreed Lizzy.

Whose atoms would you like to have in you?



MILO'S RECYCLE

CONTEST

(AS TOLD BY MILO)



"Ok, geniuses," I said when the meeting started in G-ma's basement, "did you find out whether we have atoms from the TSI list of people and animals in our bodies?"

"Yes, we did," replied Lizzy.

"We've got a definite answer, and it is YES," added VC. And VC and Lizzy high fived and started their stupid play to explain recycling.



"The girl in the funny hat is an atom," said VC. "Her name is Al and she is a metal. What atom is she?"

"She's plutonium," I replied, "because she looks like she came from the dwarf planet, Pluto."

"Don't pay attention to him," said VC rolling her eyes. "He's just trying to ruin our theatrical production."

"I know, I know," shouted Neddy, "she's aluminum."

"Correct," said VC.

"I like that," said Neddy. "Her first name is Al which is the symbol for aluminum, so she is Miss Uminum. Get it? Al Uminum."

"I'm millions of years old," continued Miss Uminum. "Recently, me and a bunch of atoms just like me, joined together to make this little tank that was filled with a fizzy brownish, sugary liquid that people drink, especially when they are hot. What is the little tank?"

"That sounds gross," said Neddy making a disgusted face. "I wouldn't want to drink any of that."

"Yes you would," argued Milo. "I think it is a soda can and the drink is cola."

"Correct," said VC. "Give that guy a can of soda."

"Well," continued Miss Uminum, "soon, someone popped open the can top and drank the contents. Then, he threw the empty can into a green box. What is the box?"





VC showed a funny cartoon with me throwing a soda can. "Great body, Milo," commented Neddy, which got everyone but me laughing. "The box is a recycle bin."

"Right," said Miss Uminum. "This is recycling **Step 1**. "Now comes the part of my life that I like the best. My can gets tossed together with other cans into a big hot cauldron. The temperature is so hot that I get separated from my old friends in the can. But I find new aluminum friends. We get cleaned up so there are no other atoms but us aluminums, and we form a new thing called an ingot. We are pure aluminum. And that is recycling **Step 2**."

"Guess what happens to the aluminum ingot," said VC.

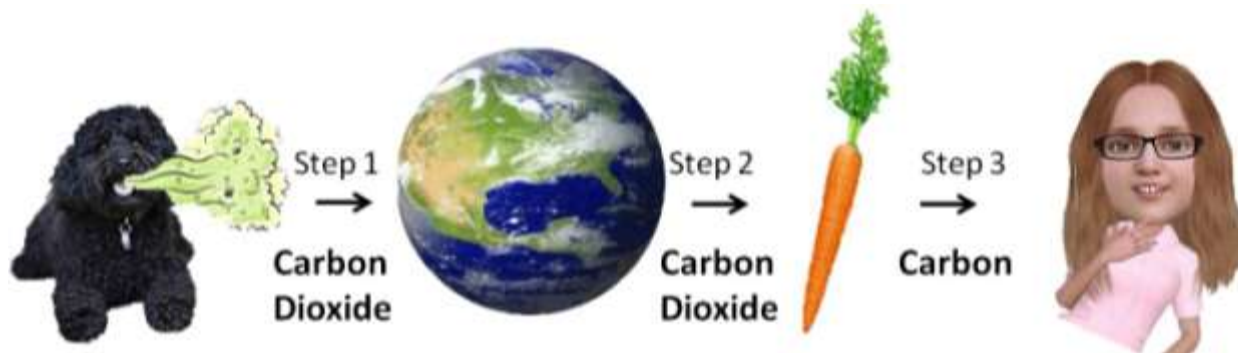
"I can see from your poster," replied Neddy. "It gets made into a a new soda can."

"Right," said Miss Uminum. "I get to start a whole new life as part of a new soda can, and that is recycling **Step 3**. And that's how I get recycled from one aluminum product to another. An interesting life, huh."

"Now that everyone understands how aluminum atoms recycle, let's talk about carbon recycling," said VC. "You see, Mother Nature invented recycling before we did."

"I know about carbon recycling," said Neddy. "We discussed it in school when we were studying [global warming](#)."

Lizzy, who took off her aluminum hat, presented a poster showing the recycling of carbon atoms from her dog Coco into her sister Neddy. "**Step 1** is collecting Coco's old breathed out carbon atoms in the form of carbon dioxide into the recycle bin, which for carbon recycling is the earth's atmosphere. Then, **Step 2** is converting the carbon dioxide into a usable form like carrots. Then in **Step 3**, Neddy eats the carrots and gets some of Coco's carbon."



"So," concluded Lizzy, "carbon from all people and animals gets recycled into fruits and vegetables and other plants and then into people and animals that eat them."
"Ha, Ha," I thought, "now, I've got them."

"No, No, No," I shouted. "You haven't proved that. You haven't finished the job. You showed that it is possible that Neddy might have some of Coco's carbon atoms. But you haven't shown that she absolutely, for sure, has Coco's carbon atoms. You have to show that there is a really **high probability** that Neddy will have Coco atoms." And with the chance to get revenge for what the girls had done to me at an earlier team meeting, I started chanting, "you have to prove it, prove it, prove it," And Neddy joined me in the chant.

Before the meeting ended, I was going to propose a contest, but I made a small noise which I thought no one heard.

"Who dealt it," asked VC?

"Eeeuuu," choked Lizzy, "that is awful."

"Yuck, Milo," added Neddy.

"Sorry," I said.

But this inspired Neddy to tell a joke. "What person **never** does **that** in public," she says while laughing?

"Certainly Grandma and Grandpa aren't the answer," replied Lizzy.

"Neither is my Dad," added VC. "My mom said he has been that way since he turned 'forty'. I don't know whether that is spelled with an 'o' or an 'a'."

That got a laugh, but no one had a good answer, so Neddy tells us, "It is a private tutor." Everyone groaned.

"Ok, back to the meeting," I said. "Let's see who can come up with the best carbon atom recycling story. E-mail your entries to me and we'll judge them at the next meeting."

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Neddy and Lizzy's little brother loved dinosaurs, and he convinced her to do something about him and dinosaurs. This is what she submitted. "The tyrannosaurus rex died and got buried and turned into oil, which got burned in my Dad's car to make carbon dioxide, which got used by Grandpa's carrots, which my brother ate. So he has T-rex atoms. He says he can feel them."



VC wrote, "The Queen of England has perfect manners. She's very old, so she breathed out a lot of carbon dioxide, and there has been a lot of time for it to blow all over the world. I eat lots of vegetables that must have her carbon, which explains why I have such perfect manners, too."

"Maria Sharapova gets my vote," wrote Lizzy. "She traveled all over the world to play tennis, so her carbon dioxide is well mixed into the earth recycle bin. I ate Grandma's turkey, that ate vegetables, that got Sharapova carbon. That is why my backhand is so good."

But when Neddy heard about Lizzy's choice, she objected, "Wait a minute. Sharapova is mine because she is a fashion designer and fashion is my thing. And I eat vegetables, so I don't have to wait for the turkey to get her carbon."

Lizzy rolled her eyes and responded, "don't worry, she probably breathed out billions of carbon atoms so there is enough for everyone."

VC submitted a second one about her sister, Megan. "My dad was grilling steak last summer and he burned half of it. So the carbon dioxide from the steak got in the air and then into the snap peas in our garden, and Megan loves the snap peas. So she has cow carbon atoms."



"She doesn't look like a cow," objected Lizzy.

"Whatever," said VC.

"I pick Michael Jordan," I wrote. "Jordan was a great basketball star and has lots of sneakers named after him. His carbon is also all over the world and got into wheat, which got into bread, which I love to eat. Check out my jump shot."

When we showed G-pa the stuff that we had written, he made sure to tell each one of us that our ideas on carbon atom recycling from one thing to another were super, but that the great backhand or jump shot probably didn't go along with the carbon atoms.

Who do you think should be the winner?



Do I HAVE A GEORGE WASHINGTON ATOM?

(As Told By Neddy)



Well, I guess I did a good job on writing the earlier chapters, because they agreed to give me a third turn. So, here's what happened next. Lizzy and VC went back to work and they invited me to join them. We met at our house. Lizzy took charge.

"Ok," she started, "Milo said that we have to show there is a high probability that we have atoms from other people or animals, like *Coco* or *George Washington*. How can we find out about probabilities?"

"I know, I know," I replied getting this super idea. "Let's use the *Beamer* to go to Las Vegas. Gambling games are all about probabilities, so people there must know all about them."

VC loved the idea. "Let's go," she said. "Vegas here I come."

"Ok," agreed Lizzy, "I'm not sure this is a good idea, but I'm in."

We logged on to the *Beamer* and went to the Time Machine Gallery. We climbed in, checked the option for exploring outside the capsule, entered Las Vegas for today's date, and pushed go. We landed on a busy street with lots of people hurrying by.

"Well genius," said my sister, "we're here. Now how do we find out about probabilities? Do we just go ask someone on the street?"

"Well," I answered, "I guess that's what we'll have to do." So I said to this man walking by, "excuse me sir, could you help us with a school project. We need to know about probabilities."

The guy looked at me like I was some kind of weirdo and snapped, "are you nuts, kid? I ain't no professor." And he walked away. Suddenly, my idea of going to Vegas didn't seem so great.

Then we saw this really pretty lady dressed in a costume. I figured she worked at one of the hotels, so she must know about probabilities. I ran over to her and asked if she could help us. She stopped and looked at us with pity and said, "shuua, wadda yas need?"



We got to talking.

"We are from Connecticut," I said. "We are working on a school project about probabilities and we were thinking that you would know about that, since you work in Las Vegas."

The lady said, "my name is Shoily and Oi'm from Brooklyn. Oi've been in Vegas for 6 months and Oi'm woiking at the Sands Hotel. Oi'm in one of doze shows. I'd like ta help yuz goils, but I don't know nutten bout probabilities."

But then she changed her mind and said, "I do know something because Oi used to play da lottery. Hea's what I know. If tha's one winnin ticket out of a million tickets and ya get to buy only one, then ya don't have a good chance of gettin the winna. Youa chances are 1 in a million, see, cuz ya could pick 1 million loosas. But what if tha's 100,000 winnin tickets? Then one out of every 10 tickets is a winna. If you buy one, then youa chances are 1 out of 10 of gettin a winna, or 10%. But if ya buy 100 tickets, the chances are ya'd get 10 winnas, or 1000%. Get it?"

"Yeah," we said. "Thanks a lot Shoily." And we logged off the *Beamer*.

"You and your dumb ideas," said Lizzy to me. "We sure didn't learn that much."

We did kind of get it about lottery tickets but we needed much more. So Lizzy decided to get a book on probabilities from the library. Lizzy and VC worked on understanding the probabilities in carbon recycling and a week later, they were ready to make another presentation to the team. We got everyone on a Skype call and Lizzy announced, "this time we have the answer for sure."

VC continued, "we all have George Washington carbon atoms in our bodies, as well as carbon atoms from everyone on the TSI list of people and animals."

"And almost every other person and animal that ever lived on our planet," added Lizzy.

"Whoa," exclaimed Milo, "I can hardly wait to hear this."

We arranged a face-to-face Space Cadet meeting at Lizzy's and my house on Saturday.

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It snowed Friday night so everyone was cold and wet when they got there. Milo hit me with a snow ball when I opened the door. I'll so get him back for that.

At the team meeting, VC announced, "Lizzy and I worked really hard on understanding the probabilities for carbon recycling and we did a report. The report is a little hard to understand, so we won't present everything. We'll just summarize, but I made copies of our [Probabilities Report](#) for anyone that is interested."

"So here's the situation," said Lizzy. "We showed you last time how a carbon atom could get from George Washington to one of us. I'll call him GW again. GW breathed out carbon dioxide into the air, an apple that grew 200 years later could have used his carbon dioxide to grow, and VC could have eaten the apple. So now VC could have GW carbon atoms."

"What we need to know," continued VC, "is the probability that if I ate any apple, it would have some of GW's carbon atoms. Lizzy and I made up a diagram to explain the concept for the probability of me getting a GW carbon atom."



"Let's think of the carbon atoms in the atmosphere recycle bin as being a pile of white sand," said Lizzy. "And let's think of GW's old recycled carbon atoms as a teaspoon full of little grains of blue sand. When the blue sand gets recycled into the pile in **Step 1** and gets mixed all around over 200 years, there are little grains of blue sand everywhere. When the apple gets carbon from the air in **Step 2**, it will probably get some blue grains. And then VC will get them when she eats the apple in **Step 3**."

"I get it," I said. "The larger the number of grains in GW's spoonful, and the smaller the pile, and the larger the apple's spoonful, the higher the probability that the apple will get some of GW's grains in its spoonful, and the more likely VC will get them when she eats the apple."

"Right, agreed VC. "Now that we know the concept, we have to figure the actual chances that I'll get a GW carbon. Let's take the sand pile as our example. If we mix 1000 blue grains from GW's spoonful into 100,000 white grains in the pile, then 1 out of every 100 grains will be a blue GW grain. If we take 1000 grains for the apple, then the probability is that we'll get 10 GW grains since 1 out of every 100 that we take is a blue GW grain."

"This lady that we met in Las Vegas told us the same thing, but her example was lottery tickets," added Lizzy. "Say that there are 100,000 tickets sold and there are 1000 winners. If you buy one ticket your chances of winning are 1 in 100 or 1%. But if you buy 1000 tickets you're likely to get 10 winners."

"And here are two other examples," I said. "If you're trying to get on a sports team that has only one open spot and there are 10 equally qualified kids who have tried out, your chances of getting picked are 1 out of 10 or 10%. if you flip a coin there are only two equal possibilities, heads or tails, so the probability is that half the time it will be heads and half the time tails. So your chance of getting tails on any flip is 50%."

"What if it lands on the edge," asked VC with a smirk? We ignored her.

"We had to figure out the carbon problem like it was a lottery," said VC. "It was a lot of work and we put all the calculations in our report. Here is a summary of what we did."

"First," said Lizzy, "we need to know the number of winning tickets. That is [the total number of carbon atoms that GW breathed out in his lifetime](#). I had Grandpa breathe out into a plastic bag for a minute, which was about 12 breaths and he filled a total volume of 6 large soda bottles or about 6 liters. From the book that Lizzy got from the library on the Carbon Cycle it says that about 4% your breath is carbon dioxide."

If you multiply that all out, like we did in the report, you get 268,000 trillion trillion carbon atoms for a 60 year lifetime. That is:"

"268,000 trillion, trillion = 268,000,000,000,000,000,000,000,000
carbon dioxide molecules."

"My head is so totally starting to hurt," I complained.

"Shut up and listen," snapped Lizzy. "Next is the total number of tickets sold which is the total carbon in the earth's recycle bin, plus in the more useful forms. VC's book says that [all the carbon atoms in the atmosphere](#), which is the recycle bin, plus all the carbon atoms in [plants and animals](#), which are the more useful forms is 77,000 trillion, trillion, trillion carbons." That is:

77,000 trillion, trillion, trillion =
77,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000
Carbon atoms

"Now my head hurts," said Milo.

"So," concluded VC, "if GW's carbons are evenly spread throughout the total, you divide 268,000 trillion, trillion by 77,000 trillion, trillion, trillion you get 3.5/(1 trillion). That means there are 3.5 GW carbons for every trillion carbons in the atmosphere or plants."

"Only 3.5 winners in every trillion," asked Milo? "It doesn't seem likely I'll get any."

"Not true," replied VC. "It depends on how many lottery tickets you get to buy, which is the number of carbon atoms you are going to get with each apple. [An apple will have a huge number of carbon atoms](#). It will give you lots of chances to win the GW lottery. Every apple you eat will have 2 trillion, trillion carbon atoms."

"Here is how we figured that out," said Lizzy. "Remember that I figured that there were 8 billion, billion, billion atoms in my body. It would take 500 apples to equal my weight. Then each apple will have 16 million, billion, billion atoms or 16 trillion, trillion atoms. One out of every 8 atoms is carbon so there are 2 trillion, trillion carbon atoms."

"So," said VC to finish our story, "if there are 3.5 GW carbon atoms in every trillion you multiply 2 trillion, trillion x 3.5/(1 trillion), you get 7 trillion GW atoms in every apple. You won the lottery 7 trillion times. 7 trillion is your lucky number."

"Wow," exclaimed Milo, "7 trillion GW carbon atoms in each apple. That is so hard to believe."

And you know what," said VC? "If I ate enough apples to equal the weight of my body, I would have to eat 500 apples and I would probably get more than 3500 trillion GW atoms."

"The only thing you would get by eating 500 apples," teased Lizzy, "is sick, sick, sick."

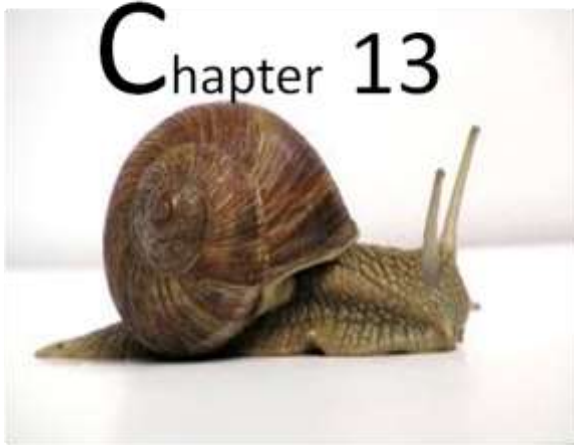
"Ha, Ha, very funny," replied VC. "I wouldn't eat them all at once, you jerk. And I could get the carbon from other foods, like milk or turkey."

"What it means," Lizzy summarized, "is there are probably trillions of atoms from GW, and every other person and every other animal in you and me. TSI's question about whether our atoms were previously in other people and other living things is not crazy after all. Because this is a probability, it is not a certain thing. But since you have so many lottery tickets, it would be almost impossible not to have some winners."

"And you know what that means," added VC? "Boys really are made of snakes and snails and puppy dog tails."

"That's kinda weird," I said.

"Do you really believe this is true?"



GIRLS HAVE A CONTEST (As Told By VC)



Bonjour everyone. It's my turn again. And, I get to tell about the next thing that happened, which was lots of fun. I whispered to Lizzy, "hey Lizzy, I have a wicked idea, We know that we all have atoms in our bodies that once were in the bodies of other people and things, And the other things include lots of creepy bugs and grody mold, and even poop. So, let's have a contest to see which one of us girls can make up the best saying about the gross things boys are made of." I showed Lizzy a drawing of what cousin Milo was made of. "It has to be a rhyme like boys are made of *Snakes and Snails and Puppy Dog Tails*," I said.



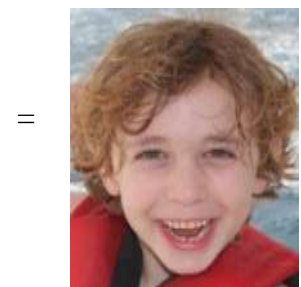
"Which turns out to be true," said Lizzy. "I so totally love it."

So we called Neddy and told her about our idea.

"Yeah, fantastic," exclaimed Neddy. And she ran over to my house.

"How about, Rats and Bats and Siamese Cats," suggested Neddy.

"And, *Beatles and Slugs and all kinds of Bugs*," added Lizzy. And she drew a picture to show the girls what her little brother NoNo was made of.



"And, Junk and old clothes and Frankenstein's Nose," I continued.

"You know," said Lizzy, "half of the atoms that the boys are made of once belonged to girls."

"Ok, how about, Taylor swift, the Queen of Jordan, and Lizzy Borden," I said.

"I got the best one," exclaimed Lizzy. Boys are made of "*boogers and slimy goop and monkey poop.*"

And that got all of us laughing so hard, we had tears in their eyes. We voted Lizzy the winner and that would have been the end of the meeting except that Milo happened to come to my house and heard some of what we were doing.

"Ok," he said. "Pretty funny, and in line with the science we are learning. But to be fair, we need to do a 'what are girls made of.'"

And Lizzy came up with, "Girls are made of ice cream and candy and everything dandy."

And Milo finished things off with, "Girls are made of slimy sludge and wormy creepers and smelly sneakers."

And that ended the meeting.

We filed our report for February which showed really good progress in solving the mystery.

DISCOVERED SO FAR	Each of us probably has 1750 Trillion carbon atoms (STARDUST) from George Washington and from almost every other person or animal.
NEXT QUESTIONS TO ANSWER	How did STARDUST get formed and then get to earth?
ISSUES	Are there more clues in the TSI list of names?
QUOTE OF THE MONTH	Probabilities make us dizzy!!!

Can you think of a good list of what girls or boys are made of?

March



Where Do We Live?

(As Told by Lizzy)



"You sneaky little creep," I shouted. "Take it off right now. I swear, if you keep stealing my clothes I'm going to strangle you." She's always taking my best stuff. This time it's my favorite shorts which she tried to cover up with a long top. "This isn't a good way to start off our working together. And I saw your confession on how you do this on purpose just to make me angry. You'd better quit it"

"Ok, sorry," said Neddy. And she takes off the shorts and I see my polka dot underwear on her big butt.

"I'm going so going to kill you," I screamed. "What I did to Richie is nothing compared to what I'm gonna do to you." She ran to her room, locked the door and slid my underwear under the door. I think she has more than her fair share of atoms from thieves and other criminals.

TEAM	% COMPLETED	T&S HOURS LEFT
Cal Tech	50%	65%
Brooklyn Babes	45%	75%
THE SMASH	40%	75%
SPACE CADETS	38%	75%
WOW	10%	75%
EINSTEIN'S GIRLS	10%	75%

CONTEST NEWS: Jackson Graham of Cal Tech Takes back the lead. The Space Cadets move up.

While I waited for her to show herself, I logged on to the TSI web site to check the leader board. She snuck up behind me and started reading over my shoulder.

"Ho kay, thit ess goot," she said. "Ruskies, not feerst thees time."

I laughed and agreed, "yeah, and we're closing in on the leaders. We only have to move up a few percent to make the cut. And look what Grandpa got in the mail from TSI," and I showed her the telescope that he brought over and I assembled. "So, what we're studying is right on target. Let's get started."

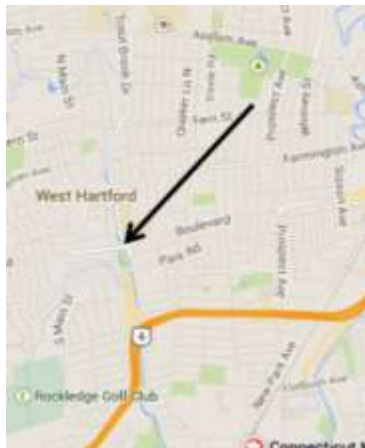


"I already did a bunch of the work for a school project," said Neddy. "It's on where we live in the universe. First I found mom's photo album and copied a picture of our house and drew an arrow on the picture to show where my room is. Then, for the next part of the report, I went to the computer and typed in our house address in



Google Maps. I zoomed in on our house and printed the satellite image. Then I drew an arrow to show where our house was on the street. Here's our house at 33 West Hill drive."

"And where's West Hill Drive," I asked?



"That's so easy," answered Neddy as she showed me the next picture in her report. "We live in West Hartford."

"You can guess what's next," I said. "Where's West Hartford?"

And Neddy was ready with a map that showed that West Hartford was in Connecticut, and Connecticut was in the United States of America.

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"Ok, your report is pretty complete so far, but what's the biggest place that you can think of to describe where we live," I asked?



"Now you're getting to the stuff that I so love the most," exclaimed Neddy. "Here's a night photograph of the earth from space. It shows the United States with the lights on, and you can even pick out where Connecticut is."

"And you know what," I added. "The size of the earth is almost a million times larger than the size of our house."

Then I got this really cool idea. "Neddy, if the **Beamer** could shrink us maybe it could expand us too, so we could look at where we live as we get bigger and bigger."

"I so love it," agreed Neddy with a high five.

So we both logged on to the **Beamer**. We chose space suits for our *avatars*, since we were going to do space travel in the Size Changer capsule. We clicked go and found our *avatars* at the entrance to the Mystery Hall. We quickly found the right gallery with the Size Changer. "Uh, oh," I said. It has lightening coming out the top."

"Wow", exclaimed Neddy, "that thing is fantastic."

"I am so not getting into that," I objected. "I think that machine could microwave us."



"Stop being such a chicken, 'Miss almost Black Belt in Tae Kwan Do,'" she replied. And she climbed into the machine.

I had no choice but to follow her. Inside seemed pretty safe. There was a big window where we could look outside and a computer screen with an *avatar* wearing a hat that said **Beamer Guide**. So we asked the **Beamer Guide** how to make the thing work. Neddy listened carefully and when the guide finished she said, "Ok, I got it. Let's do it." And she set the size scale for a 1 million times expansion so we would be the same size as the Earth. She clicked go, The screen broke into pixels and then reassembled and there was the Earth, out the window.



You can see North America," I exclaimed. "This is really cool."

"Yeah," agreed Neddy. "Milo would say it was awesome."

"OK, I said, "you know what to do next. Where's the earth?"

And Neddy expanded us again and said, "The planet Earth is racing around the Sun in the solar system. It is the third planet from the sun." And She pointed out the window to the Earth.

"And you know what," she stated, the size of the Solar System is almost a million times larger than the size of Earth."

"And where's the Solar System," I asked?

I didn't know the answer to that one, but the space Nerd did. And she expanded us some more so we could see the Milky Way which was kinda flat like a pancake. She pointed out where our solar system would be. She explained, "the Solar system is revolving around the center of the pancake like the earth revolves around the sun. But the time it takes to make one revolution (that's one Galactic year) is 200 million times our solar year."

Then we asked the *Beamer Guide* about the location and she replied, "*Our solar system is located an estimated 28,000 [light-years](#) from the center of the Milky Way galaxy and 20 light-years above the galaxy's equatorial plane. We're just one star system in the galaxy's Orion spiral arm, and our sun is just one of roughly hundreds of billions of stars in the entire Milky Way.*"



"TMI," I said, which was short for *Too Much Information*. "I understand the part about our sun being only one of hundreds of billions of stars in the Milky Way. But what are light-years? How big is the Milky Way? Can I see the Milky Way?"

Neddy answered, "you can see the Milky Way, and that would be a really good thing for us to do. Most of the time, when we look at the sky we don't see the Milky Way. That's because there's too much light around us from the house and the street lights, so our eyes can't see the fainter stars. So let's go out in the back yard tonight after we turn off all the house lights, and let some time pass so that our eyes adjust to the dark, and maybe we can see the Milky Way."

"Good Idea," I agreed. "Now what about Light-years? Do you know what those are?" But Neddy didn't know. So we asked the *Beamer Guide*, who answered, "*because the distances in space are so large, they made up a new unit called a light-year. A light year is the distance that light travels in one year. The distance is 5,794 billion miles, because light travels at 670 million miles per hour.*"

"That's sorta like what I did with the LIZZY," I said.

"Wow," exclaimed Neddy. "Mom gets speeding tickets and she only goes 75 miles an hour. The police car couldn't even catch us if we were going that fast."

"And 28,000 light years to the center of our galaxy means 160 million billion miles away," I added. "And think of this, the starlight that we see from the center the Milky Way started out towards us 28,000 years ago."

"And," said Neddy, "how many times would we ask '*are we there yet?*' if we were going there by space ship? And you know what, the size of the Milky Way is more than 100 million times larger than the size of our Solar System."

"OK," said Neddy, "let's do another expansion by 1 million and see what comes next." And out the window, we saw lot's of galaxies.

"I bet there are a million of them," I guessed.

"No," Neddy said, "according to NASA, there are 100 to 200 billion galaxies like our Milky Way surrounding us in the universe."



"Wow," I added. "If each galaxy has 100 billion stars, and there are 100 billion galaxies, there would be 10 trillion billion stars in the universe."



That would be one million LIZZY STARS," observed Neddy. "Many fewer than the number of atoms in our bodies."

We did one more expansion of our size by 1 million and the view out the window was totally blank. So we finished our trip by logging off.

"Hey," suggested Neddy, "it's dark outside. Let's go out and find out if we can see the Milky Way."

"Wow," I exclaimed, "it was there all the time, and I never saw it."

And we took a picture to show the team. The Milky Way looked like a stripe of stars across the sky. But it was really a flat pancake of stars and we were looking across the diameter of the pancake from near an edge.

"Hey," said Neddy, "let's get that telescope and see if we can see anything cool."



We set it up and pointed it at the brightest star that we could see. But it wasn't a star at all, it was the planet Saturn. It was a big shiny ball like the moon, but striped, and around it was a disk like in the NASA pictures.

"Wow, it's beautiful," cried Neddy. "I can even see one of its moons."

We pointed at another bright area of the sky and we saw thousands of stars in a cluster. "I think that is the center of the Milky Way," said Neddy. After an hour of star gazing, we finished with a view of our next nearest neighbor, a giant spiral galaxy called Andromeda. "It looks like pictures of the Milky way," observed



Neddy. "You know, like a twin."

"And speaking of our Andromeda twin," I said. "Look at this picture from NASA. NASA predicts that the Andromeda Galaxy is gonna smash into the Milky way. See here, the swirly thing on the left is going to hit our Milky Way."

Neddy turned pale and looked frightened. "Oh, wow," she cried. "Are we in trouble? Are we gonna die?"

I pretended to look scared myself and said. "NASA said It's definitely going to happen."

And Neddy looked like she was going to cry. "In about 4 billion years," I added. "And the picture isn't real. It's only a simulation."

And Neddy punched me. "You are so totally mean," She yelled. "I am so never gonna talk to you again."

"Then stop stealing my clothes," I replied. "and I'll stop being mean."

"You know," observed Neddy, "this whole thing kinda reminds me of the Russian nesting dolls. The biggest doll is the universe, and inside that is the galaxy cluster, and then the Milky Way and then the solar system, and then the earth, all the way down to our state, Connecticut."



Universe Galaxy Cluster Milky Way Solar System Earth USA Connecticut

.

Neddy and I got all the pictures for our '*Where Do We Live?*' project ready for the next team meeting. We got together at our house for the meeting the next day. We made our presentation with all the pictures and Neddy read a poem she wrote.

Where do we live?

*We live in a house with a dog that's brown.
On a lot, on a street, in a nice part of town.
And the town's in a state in the US of A.
And it is all just perfect for school and for play.
All of it sits on our pretty blue planet,
that is made out of water, and air and granite.
Earth circles our Sun that's really a star,
if you were to see it from super way far.
And our star is one speck in a Galaxy,
that has hundreds of billions of stars to see.
The Milky Way Galaxy is our home.
One end to the other is too far to roam.
One hundred thousand years for a one way trip,
on a super duper speed-of- light space ship.
One galaxy of billions is our Milky Way.
Is that the whole universe? Is there more to say?
Another Universe could still be out there,
we can't see it, so we don't know where.*

"Neddy," I objected, "our dog is black not brown."

"**That**," she said, "is called poetic license. You see, 'brown' rhymes with 'town.'"

And that ended the meeting. We filed our report for March.

DISCOVERED SO FAR	We found out where we live in the universe.
NEXT QUESTION TO ANSWER	How, when and where in the universe did STARDUST form?
ISSUES	Are there more clues in the TSI list of names?
QUOTE OF THE MONTH	We are closing in on the leaders.

What is the farthest place to which you have travelled?

April



DUMPLINGS AND A VISIT TO GERMANY

(As told by Milo)



During April vacation, G-ma is gonna make a big family dinner. It's gonna be a Chinese banquet on April 1. Everyone loves the Chinese dishes that G-ma and G-Pa cook. When we got there, G-ma gave everyone hugs and kisses. Oh, boy, you can't get out of G-ma's hugs and kisses. And G-ma says to Neddy, "what about that boy Richie, is he.....?" And Neddy is shaking her head furiously no, no.

"What's this about Richie," asks Lizzy? And Neddy turns red.

"Nobody was invited and nobody is coming," answers Neddy. "So, let's drop it."

Lizzy smiles, and pokes her in the gut. "Oooo kaaay," she says.

Our favorite dish is jao tse, or dumplings. G-ma formed an assembly line of all the grandkids. Lizzy's little brother who is called NoNo, because I gave him that nickname, made little round balls from the big pile of dough that G-ma had prepared. I rolled the balls into flat pancakes. Neddy filled each pancake with G-ma's mixture of meat and soy sauce and scallions. VC's little sister, Megan, pinched the edges to make dumplings. VC and Lizzy did the frying and steaming. The crew made 150 dumplings, and they were delicious. Neddy ate 19 and couldn't eat any of the other dishes.



During dinner, G-Pa told the kids about something he had read in the newspaper. "I have some news. We may all be Martians, not native Earthlings. Some scientists think that the Earth was too hot for a long time after it was formed for life to start. But Mars was a Goldilocks planet then. It was not too hot, and not too cold, but just right. So, they think that little bitty one celled creatures got started on Mars and then much later they got transferred by meteors to earth, when it was cooler. So, we may really be immigrant Martians. What do you think of that?"

The only response to G-Pa's startling revelation came from NoNo, who said, "is that good news or bad news?"

Everyone laughed and G-Pa shut up.

After dinner, we went down to the basement for a team meeting. "Ok, guys," I started, "we now know that the earth and everything on it, including us, is made of STARDUST. And we know that the carbon atom STARDUST goes all around the world and is recycled from person to person. What we don't know, is where the STARDUST comes from, when it was made, and what makes it STARDUST. We know that since the Earth is made of STARDUST it must have been present in the universe 4.5 billion years ago when our Earth was formed. We need to find out how long ago STARDUST first appeared, and how it got formed? The goal of this meeting is to figure out how to go forward. And we may have to do it without any new clues."

"First, let's check the leader board," said Lizzy.

Time & Space Inc.

THE LEADER BOARD FOR APRIL 1

TEAM	% COMPLETED	T&S HOURS LEFT
Brooklyn Babes	60%	50%
Cal Tech	55%	60%
SPACE CADETS	50%	55%
THE SMASH	45%	65%
WOW	20%	60%
EINSTEIN'S GIRLS	20%	65%

LEADING TEAM: THE BROOKLYN BABES

CONTEST NEWS: The Brooklyn Babes take back the lead. The Space Cadets edge out The Smash for third.

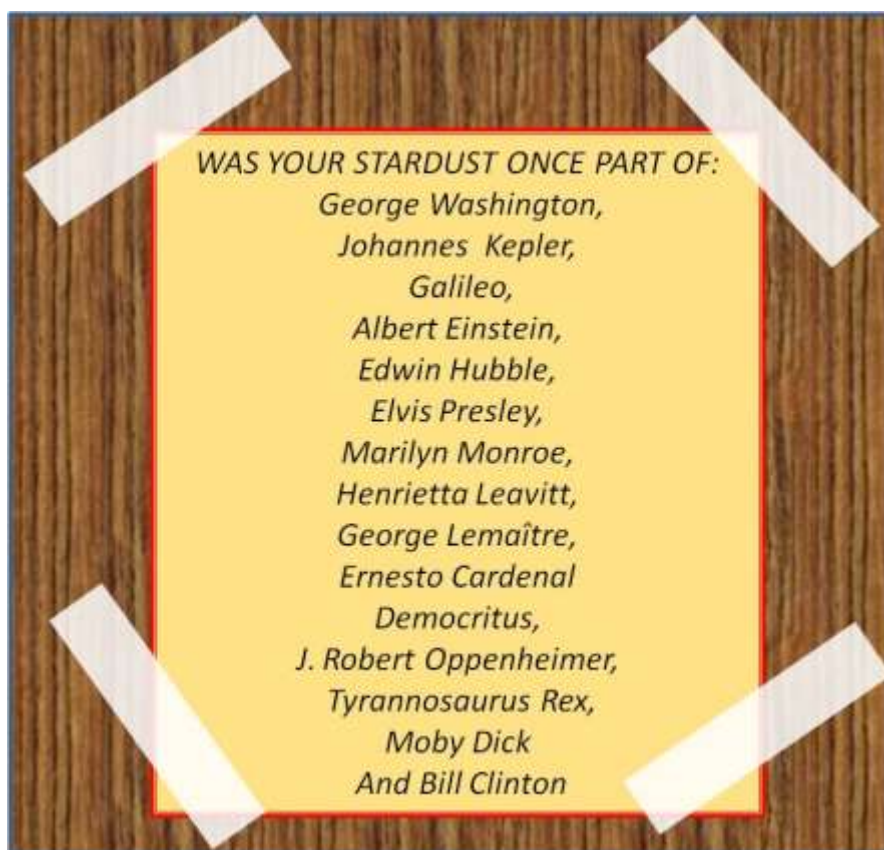
We're Back

"Oh, pooh," cried Neddy, "the Brooklyn Babes are back in the lead."

"Yeah," added VC, "but, we are now in third place. We're only 10% behind the Brooklyn Babes and 5% behind Jackson. We've so got to stay in third for two more months. I don't know if my nerves can stand this."

"I have an idea to make progress," said Neddy. "We only identified one clue on the TSI list of people and animals and that was Democritus. There's gotta be more names that are clues."

Neddy is right," I agreed. "Let's study it again." So we got out the list and taped it to the wall again.



"Well," I suggested, "let's take a look at Johannes Kepler. He's the next one on the list after Washington. I'd like to visit him."

"And after that, I would so like to visit Henrietta Leavitt," added Lizzy. "There're only two women on the list and Marilyn Monroe, the movie star, is probably not a clue. But Henrietta might be. I think me and the other girls should use the **Beamer** to pay her a visit tomorrow."

Neddy supported my Kepler visit saying, "I think that he must be a clue, because when I

studied him for my school report, I found out that he was a cosmologist who studied the planets and stars and stuff. He was born on Mars and came to earth in 1575 when he was 4 years old. He graduated with a Ph.D. in physics from the University of California and invented the internet, the telescope and space rockets. We could ask cousin Maryanne for more information, because she went to school to be a cosmologist.

"No, you idiot," I yelled, "that is so lame. Maryanne went to school to be a cosmetician, that's someone that does makeup, not studies stars. And none of what you told us could possibly be true. No one came here from Mars except maybe G-Pa's one cell creatures. And the internet started just 25 years ago."

"And he didn't invent the telescope," added Lizzy. "I think Galileo did."

"You are obviously dreaming," said VC.

"April Fool," said Neddy. And everyone started laughing again.

But Kepler was really an astronomer, so, we all agreed that I should make the visit. I logged on, went to the Gallery of Experts and asked the *Beamer Guide* to let me visit Johannes Kepler.

"Ok," said the guide, "just step into the transporter tube." I made my *avatar* step into the tube and there was a high pitched screeching sound and my *avatar* disappeared. The **Beamer** generated a picture of Kepler, and indicated that I was going to visit him in Graz, Germany in the year 1596.



"He looks like he's eating with chopsticks," cried Neddy, "just like we just did." Everyone started laughing so much that it looked like the meeting would be over. Neddy was laughing so hard and choking that it looked like she was ready to barf up the 19 dumplings.

Finally, the projection showed my *avatar* which I dressed nicely for the visit. I am in a laboratory kinda room, with lots of junk on the tables and charts on the walls. And there is this formally dressed man in the laboratory doing a little dance. "Oh, man" I exclaimed, "either this guy is a little nutsy or the **Beamer** has a serious bug."

"Hi," I said following the *Beamer Guide's* instructions to introduce myself first, "my name is Milo."



"Guten Tag!, Milo" he answered, and continued dancing.

Uh oh, we may have a language problem too, I am not sure this is gonna work. "Hi," I responded.

"Mein name ist Johannes," he said.

"Do you speak English," I asked?

"Ach, ich spreche English a little." he answered.

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A little is right, but better than my German. Anyway, this is what I found out. Professor Kepler was a mathematician and astronomer. He had just published a paper called the *Cosmographic Mystery* that supported the concept that [the Earth revolves in paths, called orbits, around the Sun.](#) At that time in history, most people believed that the Sun revolved around the Earth. "Wow, that was revolutionary," I said to Professor Kepler. "That's funny, *revolutionary... revolves*. Get it Professor Kepler?"

I guess he didn't get it, because he didn't laugh. He just kept on dancing.

Anyway, the device in back of me and the diagram on the wall were made by Professor Kepler to show the orbits of the planets. Professor Kepler explained that his orbits all had an interesting property. "For each planet," he explained, "the acceleration towards the sun is always a constant for that planet divided by the distance to the Sun squared."

"Wow, you discovered the ['1 over distance squared' part of the 'law of gravity.'](#) I didn't know that," I said.

I asked Professor Kepler if he had made any other new discoveries and he said, "nine."

"Wow", I exclaimed, "nine new discoveries. That's awesome. What were they?"

"Ach, sorry," he corrected. "In German, nine means no."

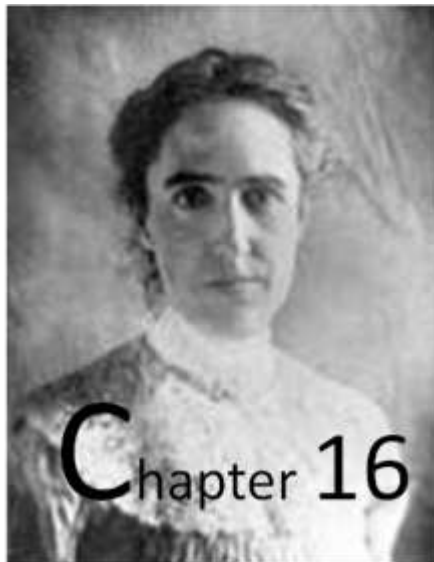
"Oh," I said. "Well, do you know anything about STARDUST? Like where does it come from?"

"STARDUST," he asked? "No, I don't know about STARDUST. I have lots of dust in the laboratory, but I don't think it is STARDUST. I don't think stars make dust."

I said to the others in the room, "I don't think we're learning anything that we don't already know." They all agreed. I looked around Kepler's lab to make sure there wasn't some clue that I was missing. I said "Auf Wiedersehen," to Professor Kepler, which means goodbye in German.

He said "Auf Wiedersehen," back to me and was still dancing when I logged off. "Why was he on the list," I wondered?

Do you know of anything that Kepler discovered that would put him on the list?



THE WOMAN WHO OPENED THE UNIVERSE

(As Told By Lizzy)



After school, I saw Neddy and Richie having this quiet chat for two in the park today. Things have so turned around there. I yelled, "come on Neddy, we have a trip to make on the *Beamer*." She look startled and embarrassed at the same time.

"Ok, be there in a sec," she yelled.

After I got home, VC arrived and then Neddy, so we could all use the *Beamer* to visit Henrietta Leavitt, as we'd promised at the team meeting. We logged on, went to the Gallery of Experts and asked to see her. Her picture appeared and then the *Beamer* indicated that it was taking us to Harvard University in Cambridge, Massachusetts in 1912. We took a screen shot of our arrival on the Harvard campus to Show Milo. "Ok, now how do we find Henrietta", I asked?



We wandered around until we found this bulletin board with announcements about stuff happening at Harvard. "We are so lucky," cried VC. "There's an announcement about a lecture by Henrietta Leavitt of the Harvard College Observatory. She's going to talk about her. . . ." and she read the title, "*Discovery of a Method to Measure the Distance to Stars.*"

"Oh, look," added Neddy, "there's a lecture to follow by Edwin Hubble. Isn't he one of the people on the TSI list? And he's going to talk about '*Some Observations Based on the Leavitt Method.*' These things have got to be important to the STARDUST mystery."

"So right," I agreed. We all did high fives. Now we knew where Henrietta worked, so I asked a college student, "how do we get to the Harvard College Observatory?" He gave us directions. On the way there, we couldn't cross the street because there was a parade of women going by.

"What is going on," asked VC of a man in the crowd.

"Oh," replied the man, "these women are Suffragettes. They are trying to get the right to vote for the president of the United States and for Senators and Congressmen. Isn't that ridiculous? Women are much too emotional and are not educated enough to vote."



"Wow," said Neddy, "I'm sure glad that I didn't live back then. And those dresses are so ugly. Hey, what is that thing on the side of the street? It looks like the giant flea from Lizzy's trip into Coco's hair." When we went closer, the flea ran away. "That's weird."

"Ok," I said when the parade passed, "let's cross the street and get to the Observatory." We arrived just in time to see a bunch of people, mostly ladies, having their picture taken in front



of the building. One of them was Henrietta Leavitt, as we recognized her from the picture we saw when we logged on.



After the photograph was taken, we followed her to her desk.

"Hi." greeted Neddy, "my name is Neddy, and this is Lizzy and VC."

"Hello," replied Henrietta, "I am pleased to meet you Neddy and Lizzy and VC."

"We are working on a science project, and we heard that you made a fantastic discovery. Could you tell us about it," I asked?

"I am so happy that you girls are interested in science," said Henrietta. "I can tell you about my work and about measuring the distance to stars. What would you like to know? By the way, were did you get those outfits? I have never seen anything quite like them."

"Oh," I said, thinking fast, "there is a store in Boston that sells clothes designed for the future. We like to shop there." I made a mental note to dress more in keeping with the time period on our next time travel.

"I would be happy to help," said Henrietta. "What can I tell you?"

"What did you discover," I asked, "and why is it important?"

"Good questions," said Henrietta. "Let's take a walk up to one of the telescopes. It's easier if I show you what I did." So we all climbed up to the top floor of the building, to the biggest telescope. "This is where we take the star photographs."

"Well," said Henrietta, "you know that this is the Harvard College Observatory and we look at stars and take their photographs using a telescope. The telescope makes things much bigger and sharper than what we can see with the naked eye. We ladies are called the 'computers.' What we do is identify each star and compute how bright it is in the photograph and write all the data in a big book."

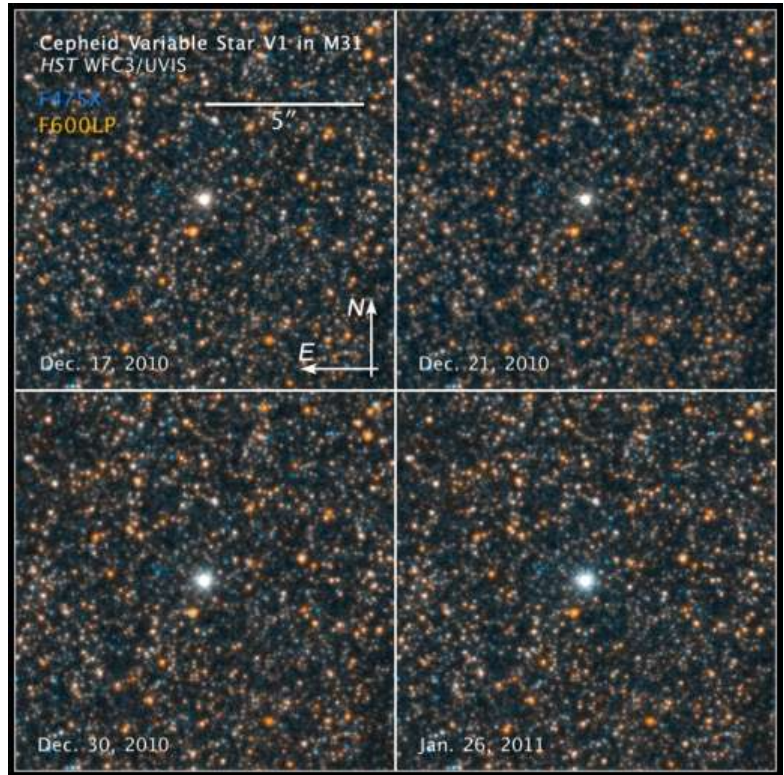


"That is funny," I thought. "In those days a computer was a person, not an electronic device."

Henrietta continued, "one problem that astronomers have, is that if we see a very bright star, we don't know if it is bright because it is a very big star, or it is bright because it is a smaller star that is much closer to earth. So, astronomers don't know how big the universe is. They don't know which stars are close and which are far away."

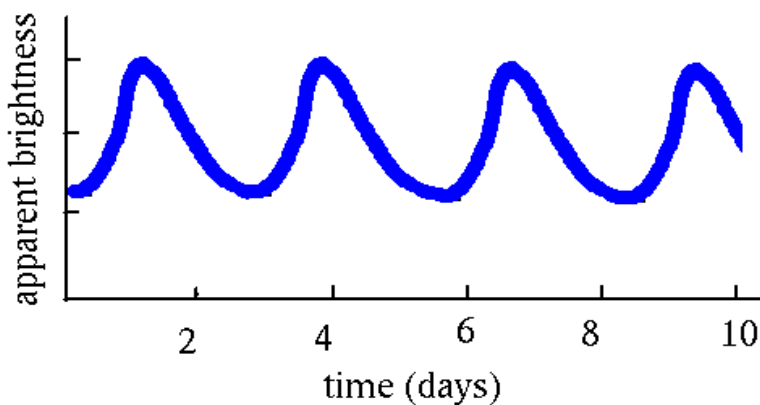
"Ok," VC responded, "I understand that. How did you fix the problem?"

Ms. Leavitt pulled out some photos and said, "here are some pictures that we took between Dec 12, 1910 and Jan 26, 1911. You see the star in the center. Look what happens to it during that time. In December, which are the top two photos, it seemed to get dimmer and then at the end of December and in January, it got very bright. I would measure how bright the star was every day and make a plot of brightness over time.



She continued, "here is one of those plots for a star that changed from faint to bright over just two days. What I discovered from making these

plots for lots of these 'variable stars' in a cluster was that the brightest stars took the longest time to go from faint to bright and back to faint. It seemed that the speed of change was a clue to how big the star was. Big stars took a month, while small stars took only two days. If that was always true, we had a way to determine how big a 'variable star' was. We just measure the



time it takes to go from bright to faint, and that would tell us whether it was big or small. And for the first time since people started studying stars, we would know how big the 'variable star' was. My observation then allows us to use its peak brightness to tell us how far away the star is. I think that could be very important for astronomy."

"Thank you," said Neddy. "You made it very easy to understand."

"Can you help answer a question about our science project," asked VC? "We think that our bodies are made of STARDUST, and we think that the STARDUST is atoms. Could atoms be made by stars?"

"I don't know," replied Henrietta. "That is an interesting idea, but I don't have an answer. Maybe there will be some new discoveries, now that we can measure the distance to the stars. I know that Dr. Edwin Hubble has been using my method, and he is going to talk about his observations later today. There is also a physicist in Belgium named Georges Lemaître that is also interested. He has written me to ask about my discovery. You will have to wait and see. By the way, Professor Lemaître is also a Catholic priest. Isn't that interesting?"

"I have a question," added Neddy. "Do you think that you will win a Nobel Prize for your discovery?"

"Oh my, no" replied Henrietta. "Thank you, but that will never happen. Only one woman, Marie Curie has ever won a Nobel Prize in physics and I don't think that my work is that important."

VC asked, "why are the 'computers' all women?"

"That is easy," said Henrietta. "We work for much less money than men, and we do a better job. I only get paid 25 cents an hour. Wouldn't you hire just women?"

I had one last question, "are you 'computer' ladies respected for your work?"

"Oh my," replied Henrietta, "that is kind of a touchy subject. I will let you be the judge. We work for Professor Edward Pickering and everyone calls us Pickering's Girls or Pickering's Harem. Do you think that sounds respectful?"

"What is a Harem," asked Neddy?

Henrietta didn't know what answer she should give to a little kid, so I said, "well it's sort of a club of pretty young girls that you can...er....you can play with. Yeah playmates."

"Oh," said Neddy, not totally satisfied with the answer.

With that, we thanked Ms. Leavitt, left the Observatory Building and logged off of the *Beamer*.

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The next day, we had a team meeting. Milo asked, "how about Henrietta Leavitt? What did you find out about her?"

"Some interesting stuff," I replied. "We found out about her important discovery, and we also got information on two other people on the TSI list that we have to visit. They're Edwin Hubble and Georges Lemaître. We think they're important to our mystery."

"Now, about Henrietta Leavitt," I said. "She's my new hero. This is what we found out with our trip to Harvard. Henrietta Leavitt was an astronomer who graduated from Radcliff, which is a really good woman's college. She took a job at Harvard looking at stars in telescope photographs and writing stuff down in a catalog."

"She made an amazing discovery that certain stars had a special feature that allow astronomers to calculate how far away they are from Earth," I continued. "That was something that they could never do before. Before then, everyone believed that all stars were part of our Milky Way galaxy. Her discovery may show that there's lots more in the universe"

"I added, "what Henrietta Leavitt discovered was a way to tell how big certain stars were. These stars were called [Cepheid variable stars](#). So her discovery allowed astronomers to tell whether a star's brightness was from being big or from being close to Earth. And that was fantastic because her discovery had opened up a whole new universe to study."

We filed our report for April.

DISCOVERED SO FAR	A major discovery by Henrietta Leavitt allowed scientists to determine how far away a star is.
NEXT QUESTION TO ANSWER	What do Edwin Hubble and Georges Lemaître have to do with the STARDUST Mystery?
ISSUES	Is the dancing Kepler a bug in the Beamer software? And a large real bug appeared in the parade at Harvard. It looked like the flea from Lizzy's previous Beamer trip.
QUOTE OF THE MONTH	We are making our move.

P.S. I was really curious about whether Henrietta ever got any credit for the important work she'd done. So after the meeting, I logged on to the **Beamer** for Harvard University in 1930. I asked around about Ms. Leavitt and didn't like what I found out. Not one bit.

Can you think of anyone in science that has shown us anything as big as Henrietta Leavitt?

May



THE EXPANDING UNIVERSE

(AS TOLD BY MILO)



Oh man, it's May already. And that means we're running out of time to solve the mystery. But, we've made good progress. I looked at the Leader Board. The Russians held on to the lead. But, the Space Cadets are now tied for second place. One more month in this position and we make the cut!!!

THE LEADER BOARD FOR MAY 1

TEAM	% COMPLETED	T&S HOURS LEFT
Brooklyn Babes	65%	30%
Cal Tech	60%	50%
SPACE CADETS	60%	45%
THE SMASH	50%	50%
WOW	40%	50%
EINSTEIN'S GIRLS	35%	40%

LEADING TEAM: THE BROOKLYN BABES

Still on top

CONTEST NEWS: The Brooklyn Babes keep the lead. The SPACE CADETS tie for second .

We all met at G-Ma's for a meeting and to use the **Beamer**. Lizzy and I were going to visit Edwin Hubble. He's the guy that the space telescope is named for, and the guy that Henrietta Leavitt suggested we talk to.

I was gonna talk about the visit, but Lizzy interrupted, "I have something new to report based on my follow-up visit to Harvard in 1930. I found out that Leavitt's discovery led to some great things. Edwin Hubble used her method to discover lots of new galaxies. So our Milky way is only a small part of the universe. He also used her discovery to show that all the stars are moving away from Earth and from each other and the further away they are the faster they are moving. That means that the universe is expanding. And Georges Lemaître, who is also on our list, actually predicted an expanding universe two years earlier, based on solving Einstein's General Relativity

equations. He also suggested that the expansion all started with something called the BIG BANG."

As she talked, Lizzy was getting madder and louder, "but, here is an example of how you men don't give us women any credit. Ten years after her discovery, the men of science finally realized what a great discovery she'd made and were considering giving her the 1924 Nobel Prize in Physics. But they found out that she had died 3 years earlier. Men! Here's a woman who did such great work that they were going to award her a Nobel Prize and they didn't know that she had already died."

"Men can be so inconsiderate," said VC. Which sounded pretty funny coming from a 12 year old.

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Before using the **Beamer**, we talked about the questions we need to ask Hubble. "Ok, Lizzy," I asked, "ready to go back in time?"

"Let's do it," she replied.

So we each logged on, chose our *avatars*, went to the Gallery of Experts and asked to see Edwin Hubble. The **Beamer** showed us a picture of this old guy with a pipe in his mouth, and informed us that we were going to the Mount Palomar Observatory in California in the year 1950. After a minute or so, we found ourselves outside a large domed white building, which I guessed was the observatory.

"What the. . ." shouts Lizzy. "I think I discovered another bug in the **Beamer** software. I dressed my *avatar* nicely for this visit, but I am dressed in the same Tae Kwon Do uniform that I used to visit Coco's hair forest. That's weird."

"You're right," I agreed, first the flea in Coco's hair, then the dancing Kepler, then the flea appears at the Suffragette march near Harvard, and now, the wrong clothes on your *avatar*. What doing with the **Beamer**? What's gonna happen next?"

Well, it was a really nice day and we found Professor Hubble outside on a path near the observatory.

"Hi Professor Hubble," I called as we walked over to him, "my name is Milo and this is my cousin Lizzy. Could we ask you some questions about your work?"

"Sure," he said, "what do you want to know?"



"I spoke to Henrietta Leavitt," started Lizzy, "and she said that you were doing some amazing work based on her method of measuring the distance to stars."

"Hey, are you kids trying to pull a fast one on me," demanded Hubble? "Henrietta Leavitt died over 25 years ago. You kids are way too young to have talked to her."

"Oops," said Lizzy with a nervous little laugh, "what I meant to say was that I had read something that she had written. I kind of imagined I was talking to her." She flashed the smile with the dimple.

"Oh, ok, let's start again," said Hubble. "What would you kids like to know?"

"Well," I said, "what did you discover using her star distance measuring technique?"

"I discovered two things using her wonderful idea," he said as he held up his fingers to count. "One, there were many more galaxies out there besides our Milky Way. We had previously thought it was the only cluster of stars in the universe. And two, the universe is expanding. All the stars and galaxies appear to be moving away from us and from each other. The further away they are, the faster they are moving."

"Were these two discoveries important," I asked?

"Oh, yes," replied Hubble. "I can tell you a story about my work and Albert Einstein. When Albert heard about my work on the expanding universe, he said that he had made the 'biggest blunder of his life.'"

"Can you tell us about the blunder," I asked?

"Sorry," said Hubble. "I don't really have time, and I don't think you kids would understand it anyway."

"Ok," agreed Lizzy, "but I have one last question. Do you know anything about STARDUST?"

"No," said Hubble.

I asked whether he knew how atoms like carbon were formed. He said, "they are formed by nuclear fusion. You should talk to Professor Fred Hoyle about it. He has been working on how atoms form in stars."

We were ready to go when something terrible happened. We heard some heavy footsteps, like from the dinosaurs in the Jurassic Park movie and some crunching sound. We looked back towards the observatory where the sound was coming from to see what was going on.

"Oh, no," screamed Lizzy, "there's the flea that chased me through Coco's hair. What is it doing here? The **Beamer** software really has bugs, real ones. First it puts on the outfit that I wore on my visit to Coco's leg, and now it adds the flea that chased me

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there. I think it must have been after me at Harvard too, cause we saw it at the Suffragette parade. It's still after me. Help."

Lizzy was sure the flea, who was now giant size, was after her. So, she started to run. She took off around the observatory. And she was right, the flea went after her. When she appeared on the other side, she was in the lead, but the flea was gaining. She put on a burst of speed and started around again and the flea followed. This time, when she came around, she headed for us yelling for help. But the flea caught her, picked her up in its claws and bit off her head.



"Oh man, that was gross," I moaned. "I think it's time to log off." I waved goodbye and signed out for both of us.

Lizzy was in a state of shock. It's not often that you see yourself get killed. Even if it is virtual reality. She was freaked out and talking nonsense. "I am so never leaving Grandma's house," she cried. Neddy and VC tried telling her it wasn't real and she was safe. They were laughing and telling her it was pretty funny. "Thanks for the support," she growled as she punched them both.

"Come on," I said, "I'll walk you and Neddy home." And she finally agreed.

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The first thing next morning, Lizzy showed up at my house. She was still freaked out. She said she had a horrible dream about being chased by the huge flea. And she started asking crazy questions, "what if the **Beamer** virtual reality transfers over to the real world? Could that happen? Can the flea come after me in real life? I'm so not happy. I don't like this. I'm not going on another **Beamer** trip."

"Can't happen, Lizzy," I assured her. "You are safe. It is only a software bug." And Lizzy started to calm down.

"But if it does happen," I teased, "you can just use that double flying karate kick to take it down." And Lizzy gave me a really hard punch.

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One more thing. Neddy arranged for a Skype call to tell us some news. "Guess what," she asked? "I went to the library to check on the other names on the TSI list to see whether we missed a clue. When I got to Ernesto Cardenal I found out he was a Nicaraguan poet and priest, so I was going to skip him. But then I saw the name of one of his poems that was interesting. It was *'The Saga of the Third Chimpanzee.'* I wanted to find out who the Third Chimpanzee was, so I got his book. Look what I found in the poem. I think this is a clue for us."

***"The third chimpanzee has dominated earth
the one that made Chartres and the Sistine Chapel
and now begins to explore space
he is speaking to the stars
that have yet to respond
has seen the birth of the Big Bang
from which everything was born and he was born."***

***What do you think the clue means?
What was Hubble's most important discovery?***



The BIG BANG

(As Told By Neddy)



Привет!! ... That's hi in Russian and it's pronounced '*privet*'. I am getting ready for the Brooklyn Babes if we make the cut. We are getting closer to understanding our universe, but we still didn't understand how STARDUST was made. Maybe the clue I found will help. So we got together at Grandma's for a meeting. We taped the important lines from Ernesto Cardinal's poem to the basement wall.

"OK, peasants", announced Milo taking charge as usual, "let's get to work." We all rolled our eyes. Like, he is the king, and we are his lowly subjects. Ha!!!

"Does the poem that Neddy found have anything to do with our mystery," he asked? "I think I know one thing about the poem. The Third Chimpanzee is us. It's humans, like in the theory of evolution. But what about the rest of the poem?"

"I know about the Sistine Chapel," offered Lizzy. "It's in the Vatican in Rome, Italy. That is where the Pope lives. And the ceiling of the chapel was painted by Michelangelo. It shows the hand of God reaching out to touch the hand of man."

"And I know about Chartres," added VC. "It is a beautiful cathedral in France."

"So," I concluded, "the priest got some religion into his poem. But the rest of it is all science and it is about our mystery. Here's why. First, it says everything was born in the BIG BANG, so that has to do with what we are made of. Second, Henrietta Leavitt said that we should talk to this Belgian physicist by the name of Georges Lemaître. And Lizzy found out later that he came up with the idea of the BIG BANG which is in the poem. And third, Professor Lemaître is also a priest and the poem was written by a priest. So I think the clue is telling us to visit Georges Lemaître and find out about what the poem calls, '*the Big Bang from which everything was born.*'"

They all agreed. I suggested, "since we were all together in Grandma's basement, we should do the *Beamer* visit to Professor Lemaître right away." We also decided it would be just the girls and that VC would be the leader for the visit, since she speaks French and that was one of the languages spoken in Belgium.

"Lizzy," I asked, "have you calmed down from the flea incident? Are you going to go?"

"Yeah," she replied, "I'm not going to be scared off by a software bug."

So, we all logged on, went to the Gallery of Experts and asked to see Georges Lemaître. The **Beamer** informed us that we would be going to the Catholic University of Leuven, Belgium, where Dr. Lemaître was a Professor of physics. The year was 1932.

A big surprise came when we were plunked down on the campus by the teleporter.

"Wow, look," I exclaimed, "those two men talking over there. One of them is Albert Einstein."

"You're right," said Lizzy. "And the priest that he's talking to must be Professor Lemaître. He must be really important if Einstein is visiting him."



The second thing that was interesting was that Professor Lemaître was really a Catholic priest like Henrietta Leavitt said. Based on the story of how Galileo got in such trouble with the Catholic church for saying that the earth revolved around the sun, I didn't think that religion and science mixed so well. But, then there was the poem by the priest Ernesto Cardinal that sure mixed science and religion.

We didn't want to interrupt such an important meeting, so we waited until they were done talking. Professor Lemaître went into the building, but Professor Einstein stayed to walk on the path outside.

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"Hey guys, we can't waste this opportunity to talk to the greatest genius of the last century," I suggested. Let's go ask him some questions." And I rushed over and introduced myself, "Professor Einstein, my name is Neddy, and this is VC and Lizzy. We're working on a science project. Can you tell us about your most important discoveries."

"Vell," he said with a heavy accent, "it is nice to meet you, Neddy and VC and Lizzy. I would be happy to tell you about my verk. There are a few important tings. I'm very proud of my equation, $E = mc^2$. That says that mass vich is 'm' can be converted into energy, 'E'. The term c is the velocity of light in vacuum."

I knew that it was how nuclear fusion worked because that is what happens on the sun. That is why the sun is hot and bright. When you fuse hydrogen atoms to make helium, the helium has less mass than the hydrogen atoms you used to make it, and so lots of energy must be released in the form of heat and light.

"And den," he added, "I like my cosmic speed limit, c, for the velocity of light. The speed of light in a vacuum is always the same and nothing can go faster. Ven tings dat haf mass approach the speed of light they get more mass, and time for those tings slows down."

"So if I put my sister Lizzy on a rocket ship and made her go almost the speed of light, when she came back could I be older than her," I asked?

"Ya," said Einstein. "Dat is called da '*Twin Paradox*.'"

"Professor Einstein," I said, "This really smart kid told us that you figured out that acceleration and the force of gravity were the same thing. Is that true?"

"Ya," said Einstein. "I had this idea in my head that if a person falls, he will not feel his own weight. Dat vas the '*happiest thought in my life*.' I had this experiment in my head that if I vas riding in an elevator, and it vas going down zo fast that I started to float. It vud feel like der vas no gravity. But that vas not correct. Dare vas gravity, but I vas accelerating. If I couldn't tell the difference between accelerating because of gravity and being in no gravity, then they must be the same thing. Dat vas one of the important observations in developing my General Relativity Theory."

Milo, who was in the room, whispered, "I just read about Einstein's '*happiest thought*' in Scientific American. It was a special issue for the 100 year anniversary of General Relativity. It said that there was a story that Einstein saw a painter fall from the roof of a neighboring building. But they didn't think that after seeing a man fall, Einstein would have called what popped into his head, '*the happiest thought of my life*.'"

Lizzy asked, "Professor Einstein, we talked to Professor Hubble, and he said that when you found out that the universe was expanding, you said that you made, '*the biggest blunder of your life.*' Can you tell us about that?"

"Ya," said Einstein. "Ven I finished General Relativity, it predicted that because of gravity, the universe must be expanding or contracting. It couldn't be static. That means it couldn't stand still. It is like a ball ven you throw it up in a gravitational field, like on earth. It can be going up, or it can be going down, but it can't stand still. And everyone at that time thought the universe was standing still. So I added a new term to my equation to make the universe stand still. I called it the Cosmological Constant. It was my anti-gravity term. It would be like adding a term to Galileo's law of gravity so that the ball could stay floating in the air."

"But den," he added, "I found out from Professor Lemaître and Professor Hubble that the universe was expanding. So adding the Cosmological Constant was, '*the biggest blunder of my life.*'"

When we told Grandpa about our visit with Einstein the next day, he said that now scientists think Relativity Theory needs the cosmological constant. He said we recently discovered that the universe was expanding faster and faster because of something we call Dark Energy and that requires Einstein's added cosmological constant term in his equation.

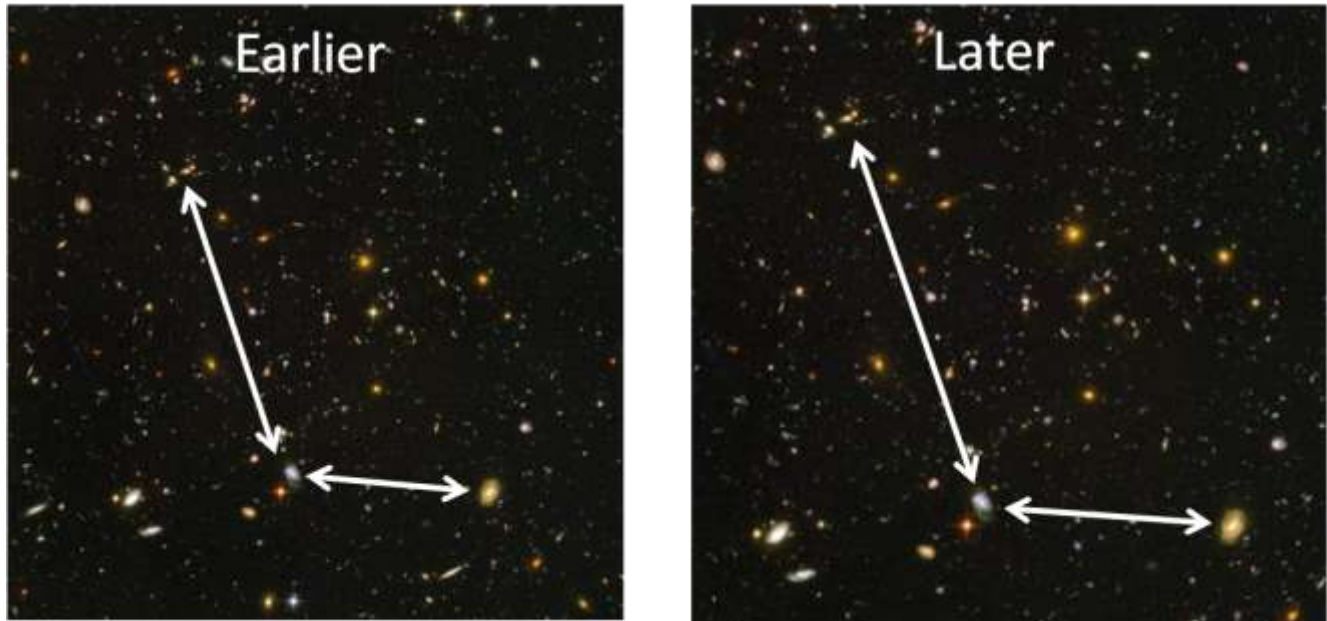
Back to the visit. We thanked professor Einstein and went into the building to find Professor Lemaître. He was in his classroom working at the blackboard.



"Bonjour," greeted VC, introducing us, "Je m'appelle VC, et elles sont Neddy et Lizzy. Comment allez vous," said VC, asking how he was?.

Well the rest of the conversation was in French so VC give a summary. She said, "Professor Lemaître was a mathematician and astronomer, so he was very interested in Einstein's General Relativity Theory and especially in the Cosmological Constant. He started solving the General Relativity equations without the Cosmological Constant. What he discovered was amazing. He could get a solution for the universe, but just as Einstein said, the universe had to be expanding. He showed us star photographs as an illustration. He said all the stars had to be moving away from us and from each other."

VC said, "here is a translation of what Lemaître explained about the photographs, 'if we think about the distance between stars, at some time in the past, they were a certain distance apart, like what is shown by the arrows in the Earlier diagram. But General Relativity predicted that at some later time, the distances apart would be bigger, like in the Later diagram.'"



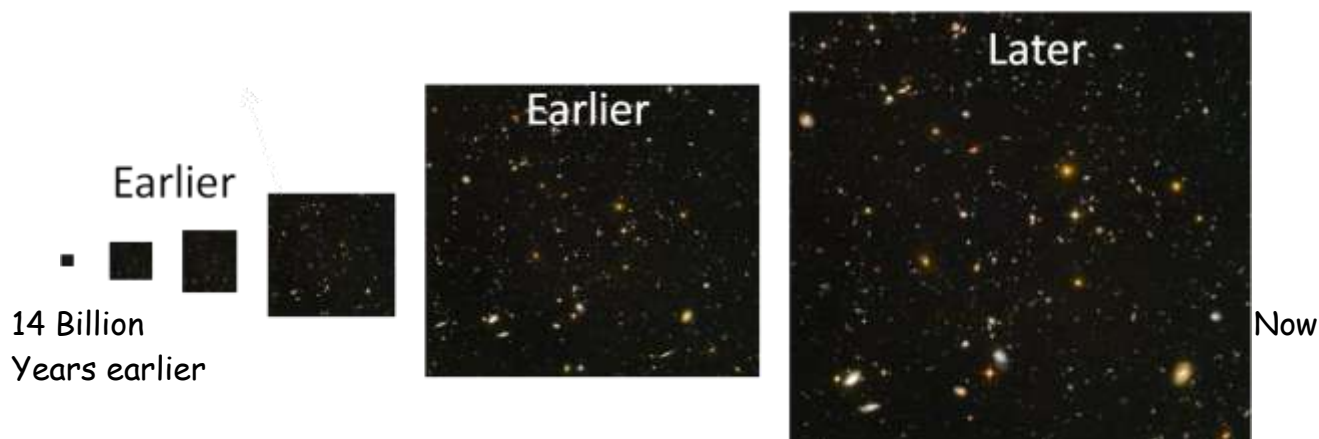
"Wow, what an amazing prediction," exclaimed Lizzy.

"Wait a minute," I said, "I thought that Edwin Hubble discovered the expansion of the universe."

So VC asked Professor Lemaître about that. She translated his answer, "well, that depends on how you look at it. I made the prediction from a theory. I published in a scientific journal that is not so well known, so few people had read about my prediction. When Dr. Hubble published two years later, it was about measurements using a star's color to show that all stars were moving away from us. Distant stars were moving away faster than closer ones. That confirmed my prediction. Everyone read his article and gave him all the credit for the idea of the expanding universe."

"Oh, wow," I said. "That is awful."

VC asked him about this and translated his answer, "I was a little upset, but I did get credit for something much more important based on the idea that the universe was expanding. I thought about what the expansion meant. I wondered about what would have come earlier if the universe were expanding." And he showed us some diagrams to illustrate his idea.



VC translated, "if all the stars are moving away from each other, then at some earlier time, they were closer. And even earlier, they were closer still. I calculated that going back 14 billion years in time, all the material in the universe had to be crunched together in one tiny mass. I called this my hypothesis of the 'Cosmic Egg.' But other scientists have called the explosion that set all the mass flying out in all directions the BIG BANG."

VC asked him if atoms like Carbon were formed in the BIG BANG, and he didn't know the answer. She asked him if he knew anything about STARDUST and he didn't know about that either. So we thanked him and said, "au revoir" which is goodbye in French. Then we logged off the *Beamer*.

Just before the log off screen came on, something strange appeared. It was an email from Milo to someone named Svetlana. It had a picture of Milo making a muscle pose. It was a request from Milo that he visit her in Brooklyn. Another bug in the *Beamer* software has given us the answer to the Aunt Joanne mystery visit. This is a really bad software bug.

Milo was there when we did our visit and heard my translations and saw all the diagrams and saw the email. We gave him a look that said 'ah ha,' and the girls started laughing. He turned red. We controlled our giggles and decided not to tease him.

Then we got down to serious business. "Was that how our atoms were formed, in the BIG BANG?" said Milo. "If so, we would be made of BIG BANG dust, not STARDUST. "What we need to do, is make a visit back to the BIG BANG and find out. I'll do it in the *Beamer* from home tonight, and tell you what I found out tomorrow."

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The next day Milo told us about his *Beamer* visit on a Skype call. He said, "oh man, the Time Machine is really awesome. You guys have to go on a trip or at least be in the room for the next trip. It was fantastic. I logged on and found the Time Machine departure station. I used the transporter to get to the Time Machine and got a tour from the

Beamer Guide avatar. I set the time to minus 14 billion years and pressed *GO*. Back came the message '**error 86.... there is no data for that time period.**'"

"I think I asked to go to a time before the universe started," he explained. "So I tried minus 13.7 billion years and the *Beamer* showed a white cloud outside the capsule windows. I measured the composition outside and found mostly hydrogen (one proton and one electron) and helium (two protons and two electrons plus one or two neutrons). There were also tiny amounts of lithium (three protons, some neutrons and three electrons) and beryllium (four protons, some neutrons and four electrons), but no heavier atoms like carbon with six protons and electrons or oxygen with eight. I had the answer, no heavy atoms were formed in the BIG BANG or shortly after."



"I took a screenshot of the BIG BANG at minus 13.7 billion years," he continued, "and added the names of major atoms. We will need it for our contest report and final presentation. I logged off. The Time Machine was really awesome."

"So, we're not BIG BANG dust," said Lizzy. "This is real important. There's no STARDUST from the BIG BANG. None of the heavier atoms that we're made of were formed in the BIG BANG. Our hydrogen coulda been from the BIG BANG, but not carbon, oxygen and nitrogen. We still have a missing piece of the STARDUST MYSTERY to solve. Where did the heavier atoms come from?"

"Lizzy is right, we still have a mystery to solve," said Milo. "Let's think hard, and meet again when someone has an idea." And that ended the call. We filed our report for May. We made a lot of progress. I hope it is enough to stay in third place and make the cut.

DISCOVERED SO FAR	The universe was born in the BIG BANG about 14 billion years ago. Hydrogen and helium were formed from the BIG BANG but none of the carbon, oxygen and nitrogen that is the STARDUST.
NEXT QUESTION TO ANSWER	How, where and when did the STARDUST get formed and how did it get to earth?
ISSUES	The flea that came to Mount Palomar and attacked Lizzy is definitely a bug in the <i>Beamer</i> . A second bug is the email from Milo that flashed on the screen before <i>Beamer</i> log off.
QUOTE OF THE MONTH	We are almost there.

Can you figure out where the STARDUST comes from? How would you find out?

June



Mount Washington

(As Told By VC)



Bonjour. I had this really great idea for TheBeamer.net web site that I started in February. I added some pages for the scientists that we have visited, which so far is Johannes Kepler, Henrietta Leavitt, Edwin Hubble, Albert Einstein and Georges Lemaître. I have pictures of them that are animated and talk to answer questions from a list. Some of them have really bad accents and are hard to understand, so I added some voices without accents. I will add other scientists after we have visited them.

Now to the Space Cadets and the STARDUST MYSTERY. Here is what happened next. On June first everyone got on a Skype call, so we could be together when we got the news on whether or not we made the cut. I counted to 3 and we all logged on to the contest web site to see the Leader Board. "Wow, I yelled, "we made the cut." Everyone cheered and shouted and jumped around wildly!!! Even Papa was jumping and cheering!!!!

The screenshot shows a web browser window with the URL <http://www.tsi.com/104.aspx?104&url=http://www.tsi.com/>. The page features a header with "Time & Space Inc." and a logo of a rocket. Below the header, there is a section titled "THE LEADER BOARD FOR JUNE 1" with a table showing the progress of various teams. The table has three columns: TEAM, % COMPLETED, and T&S HOURS LEFT. The teams listed are Cal Tech, Brooklyn Babes, SPACE CADETS, THE SMASH, WOW, and EINSTEIN'S GIRLS. The bottom three teams (THE SMASH, WOW, and EINSTEIN'S GIRLS) are crossed out with red lines. To the left of the table, there is a section titled "LEADING TEAM: CAL TECH" with a photo of a young boy and a speech bubble that says "Back where I am supposed to be". Below the table, there is a section titled "CONTEST NEWS: Jackson Graham of Cal Tech Takes back the lead. This is a tight race for the three top teams. The last three teams did not make the cut and have been eliminated from the contest".

TEAM	% COMPLETED	T&S HOURS LEFT
Cal Tech	95%	20%
Brooklyn Babes	85%	20%
SPACE CADETS	85%	25%
THE SMASH	70%	30%
WOW	65%	30%
EINSTEIN'S GIRLS	60%	30%

LEADING TEAM: CAL TECH

Back where I am supposed to be

CONTEST NEWS: Jackson Graham of Cal Tech Takes back the lead. This is a tight race for the three top teams. The last three teams did not make the cut and have been eliminated from the contest

"Jackson has taken back the lead," Said Milo. "And, we are were right behind him, tied with the Brooklyn Babes for second."

"Winning the contest is going to be close," added Lizzy. "I am so nervous."

"Me too," agreed Neddy. "We need to work really hard to win." We all agreed to work hard and logged off the call.

We had to make more progress. But June isn't a good month to get work done. I am graduating from middle school, and Lizzy and Milo are both freshmen in High School, and have lots of finals.

And then, there's the trip with Papa. Papa was taking all the cousins for an adventure on Mount Washington. The plan was to hike to the *Lake of the Clouds* hut to spend the night, and have a team meeting at the hut to plan our final attack on the MYSTERY. The next day we would hike to the top of Mt. Washington, and then down.

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The day of the climb arrived. On the hike up, Lizzy challenged Milo, "I bet I can beat you to the hut."

"Give it your best shot," he responded. And Milo and Lizzy took off, followed by Neddy and I.

About twenty minutes later, Papa, with my sister Megan and Neddy's brother NoNo, found all four of us exhausted, lying on the side of the trail. So much for a race up more than 2000 feet in elevation.



We continued the hike to the hut. Grandma was going to call us to arrange where to pick us up. Papa put his cell phone in his back zippered pocket and told us kids to listen for the phone, since his hearing was not so great. Well, with Papa leading the way, there is this loud noise from his butt. He obviously is not a private tutor. I shouted out, "hey Papa, your phone is ringing." Everyone, including Papa cracked up.

We finally arrived at the hut and got our bunk assignments. That night after dinner, we went out to see the sunset and to tell ghost stories.

But first, Papa wanted to know about our visit with Georges Lemaître and what we learned about the BIG BANG. "What do you think of the concept of the BIG BANG," he asked?

"Well, it is a really cool idea," replied Lizzy. "But how did it start?"

"Yeah," asked Milo, "what was there before the BIG BANG? Why did it happen?"

"OK," replied Papa, "scientists really don't have an answer to those questions. But here is what I think may be a possibility. I need to tell you about Goldilocks."

We all looked at him in puzzlement. "Goldilocks," I asked? "You're kidding, right?"

Papa explained, "No, I am not kidding. We call Earth a [*Goldilocks Planet*](#), because everything is just right for us to live here. It is not too hot. It is not too cold. It is *just right*. *Goldilocks*, get it? It also has water and oxygen and lots of land to grow food. So, how did we get so lucky?"

"The answer," Papa continued, "is that there are many trillions of planets in the universe and there are probably billions of them that are *just right*. Astronomers call them *Goldilocks Planets*. And if living things are going to appear, they would appear on one of them. So it isn't luck. Probability says there will be lots of *Goldilocks Planets*. And, if we exist, it has to be on one of them."

"I get it," said Neddy. "We don't have to be lucky to be on a planet that's just right. There were lots of *Goldilocks Planets* that we could be on."

"Right," continued Papa. "Now think about our universe. It is a *Goldilocks Universe* because all of the laws of physics and chemistry, and other composition parameters like the amounts of [dark matter](#) and [dark energy](#) are *just right* for us to exist. So how did we get so lucky? One possibility is just like *Goldilocks Planets*, our *Goldilocks Universe* may be just one out of millions of other universes in a [multiverse](#). And, there may be lots of them where the laws of physics and chemistry, and composition parameters might not allow us to exist. So we are on a *Goldilocks Universe* because we couldn't exist on one of the other universes. And just like our universe started in the BIG BANG, lots of other universes had their BIG BANGS. After all, if a BIG BANG could happen once, why wouldn't it happen lots of times. So, BIG BANGS could be regular events, like rain storms, or lightning strikes. But we still don't know what causes them."

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"Ok," said Milo. "So just like there are *Goldilocks Planets*, because there a billions of chances to get some that are *just right*, there may be billions of universes with different laws of physics and chemistry, and different compositions, so that the probability is that some are *just right*."

"Right, Milo," replied Papa. "There are lots of BIG BANGS creating millions of different universes. And of course, because we exist, our universe is a *Goldilocks Universe*. It is *just right*. Of course this is just a hypothesis and it is one that we really can't test. But it does make good sense."

Everyone got kind of silent, thinking about the idea of millions of universes like ours.

"I like the multiverse idea with the probability of at least one that is *just right*," said Neddy. "It seems very logical."

Milo left the group for a minute and came back laughing. "Peeing downwind in, like, a hurricane is awesome," he exclaimed. "It goes a hundred miles." Papa and NoNo went off to try it. We girls were not amused.

Then, Papa told one story about the hermit that roamed the mountains at night and kidnapped and tortured little kids. Neddy and I decided it was time to go inside.

"Let's start our meeting," Milo said. "I think that we have most of the mystery solved. We're sure that the atoms in our body are the STARDUST. We proved that atoms in our body have also been in the bodies of the people and animals on TSI's list. So we have three questions left. How did STARDUST get made, when did it get made, and how did it get to Earth, so it could get into our bodies?"

"Well," asked Lizzy, "have we missed any clues?"

"I don't think so," I answered. "We got the nesting doll clue, we got the Lego Bart Simpson clue, we got the telescope clue and we got most of the names on the clue list including the Ernesto Cardinal clue. We didn't visit Galileo who was on the list, but Neddy knows most of what he did, and she doesn't think we are missing clues from him. Did we miss any other names on the list that could be clues?"

"Maybe we should look again," replied Milo, "especially after Neddy did her library search and found a new clue."

Lizzy volunteered, "I will review the list again when I get home."

"OK," I added, "and I think that we should use the *Beamer* to go back in time to find out when the heavier atoms were formed."

Everyone agreed, and that was the plan for when we got home. We spent the rest of the time talking about some of the other things that we had learned during our investigations.

"I want to show everyone a picture of the Pinwheel Galaxy taken by the Hubble Space Telescope," said Lizzy. "I got it from the NASA *Picture of the Day* collection in the library. The reason I love it, is that it is so beautiful and it is exactly 1 LIZZY miles across."

"It is 25 million light-years away," she continued. "When light from the Pinwheel, started toward us 25 million years ago, there were no humans on earth, but there were some of the first monkeys and other mammals. And one of the ices age on earth was starting. And 25 million light years is 14,500 LIZZY miles. So the distance in miles is way less than the number of atoms in our bodies. By the way, the LIZZY is over a billion times bigger than the number of miles in the light year."



Papa also wanted to say something about the Pinwheel Galaxy. "You know kids, the this is a good example of why we have proposed the existence of [Dark Matter](#). The picture looks like a pinwheel that is spinning. And it is. And you know from riding the merry-go-round at the playground that if you stand at the edge of the merry-go-round and it is going fast, you will fly off if you don't hold on. Well, why doesn't the Pinwheel Galaxy fly apart? The answer is Gravity. Gravity is the force that holds on to the outer stars. But when cosmologists calculated whether gravity was big enough the answer was no. So to explain why galaxies stay together, they have invented some additional matter that adds to normal gravity. We can't see it, so they called it Dark Matter.

Not wanting to be outdone by Lizzy, Milo chimed in with his own facts. "Think about this. Light from our sun takes about 8 minutes to travel here. But light from stars on the other side of the Milky Way take 100,000 years to get here. So when that light started out, the first human beings were just starting to appear outside of Africa. And Neanderthals, you know cave men, were still on earth. And by the way, I have invented my own unit called the MILO. It is the number of miles light travels in one year. 1 MILO is exactly 5,794 billion miles."

"Duuh," heckled Lizzy. "That is a great idea, but someone else thought of it first. The MILO is the same as the light year."

"Oops," said Milo.

"Oh man, there goes Milo and Lizzy again," I thought as Neddy and I both rolled our eyes.

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When we got home, we filed our report for June.

DISCOVERED SO FAR	We think that we have figured out all the clues given so far.
NEXT QUESTION TO ANSWER	How, where, how, and when did the STARDUST get formed and how did it get to earth. We plan to use the Beamer Time Machine to travel in time between the BIG BANG and the formation of the Earth to find out.
ISSUES	No New Issues.
QUOTE OF THE MONTH	We had to take a break after finals at school.

How would you find out how STARDUST got formed?

July



FINDING THE MISSING PIECE

(As Told By Lizzy)



The first thing I did on the first day of July was check the Leader Board. The result was disappointing, but not unexpected. We were still in third place. Well, we didn't accomplish anything in June. But I got good grades on my finals. Wow!!! I just noticed, Jackson is at 100%. He's finished.

TEAM	% COMPLETED	T&S HOURS LEFT
Cal Tech	100%	10%
Brooklyn Babes	90%	10%
SPACE CADETS	85%	15%

LEADING TEAM: CAL TECH

I am done and waiting for the rest of you

CONTEST NEWS: Jackson Graham of Cal Tech holds the lead. This is still anyone's race.

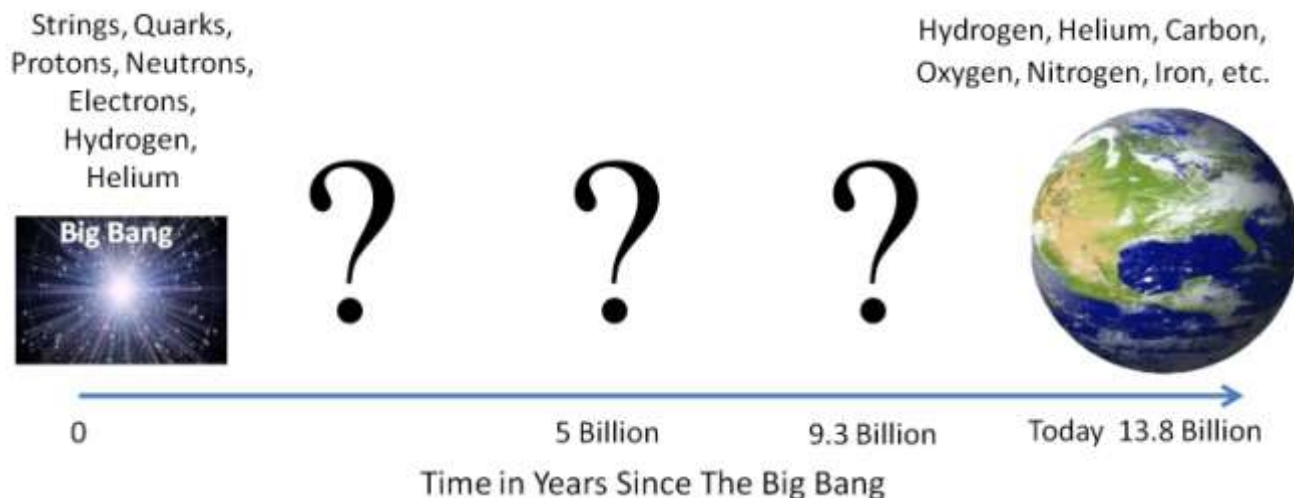
Milo organized our meeting for the next afternoon at Grandma's.

.....

"Well," he announced when we all settled down, "we're going on an adventure. We're going in the **Beamer** Time Machine to find the missing piece of our puzzle. And we better find it by the end of the month, or we won't be going on the moon trip."

"And," I added, "Milo and I decided that we can get much more done if we work together. I've agreed to be nice to him and stop starting those chants that drive him crazy, and he's agreed to stop calling me Dizzy and Lizard. So we worked together on a poster to show what we know and to plan the time travel trip." And I brought out the poster. "The poster shows what we know is happening at different times during the evolution of the universe."

"It starts with the BIG BANG, which is 13.8 billion years ago, and goes right up to today," continued Milo. "At the beginning, we found out from my last time travel trip that there is hydrogen and helium that was formed right after the BIG BANG, but no heavy atoms. And today, we know that there are heavier atoms like carbon and iron, and all the rest of the atoms on earth. And we believe that these heavy atoms are STARDUST. So what happened between the BIG BANG and 13.8 billion years later? That is our mystery. We're gonna use the Time Machine to find out. We're gonna step back through time and measure the concentrations of hydrogen, helium, carbon, oxygen, and nitrogen and find out when things changed. Then we have to figure out why they changed. How did STARDUST form?"



"Can I invite Richie for our trip," asked Neddy?

"I thought you hated him," I teased.

"Well, since the playground ah. . . incident and his apology in Dr. Evil's office, things have been much better," answered Neddy. "And since we won the New England Regional competition, he has been extra nice. He even brought me some candy at lunch. He said that he likes me better than all the other girls because I do my own thing, I don't follow the crowd."

"I am ok with it," I offered. "What do you guys think?" No one objected, so I said, "ok, text him and get him here fast, because we are going to start the trip as soon as we plan the data taking."

.

Richie showed up and we were ready to go. He cringed a little when he saw me, and sat as far away from me as possible. I wonder why, ha, ha.

We decided that we would all use the *Beamer* as *avatars* since this was probably our last trip. All the girls wanted to see the Time Machine because Milo said it was awesome. So we all logged on and chose our avatars and outfits. I chose first, and picked shorts and a pink tank top. Milo chose next, and he went with a space suit. Neddy and VC followed his lead. We finished the log on and pressed go and we all appeared in the Mystery Hall.

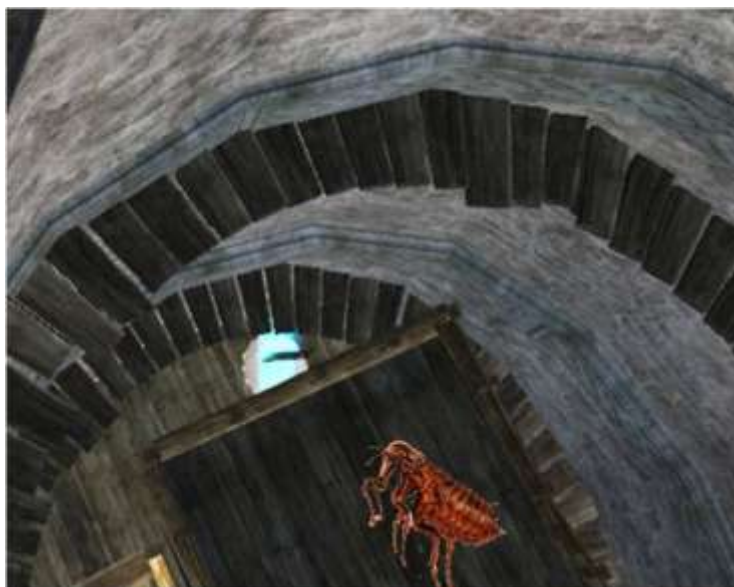
We explored a little and eventually went to the Time and Space Tower and started a long climb up the rickety stairs to the fourth floor, which was the departure station for the Time Machine. Milo led the way because he had been there before and I was last. We were almost to the fourth floor when I heard scratching and thumping behind us. I looked down.

"Oh no," I screamed. "It's that miserable giant flea again."



The other kids started running up the stairs. I started after them. But then I stopped. What good are all those years of martial arts if I am gonna run away every time. And I remembered that last time my running away didn't work out so well. I am not losing my head again.

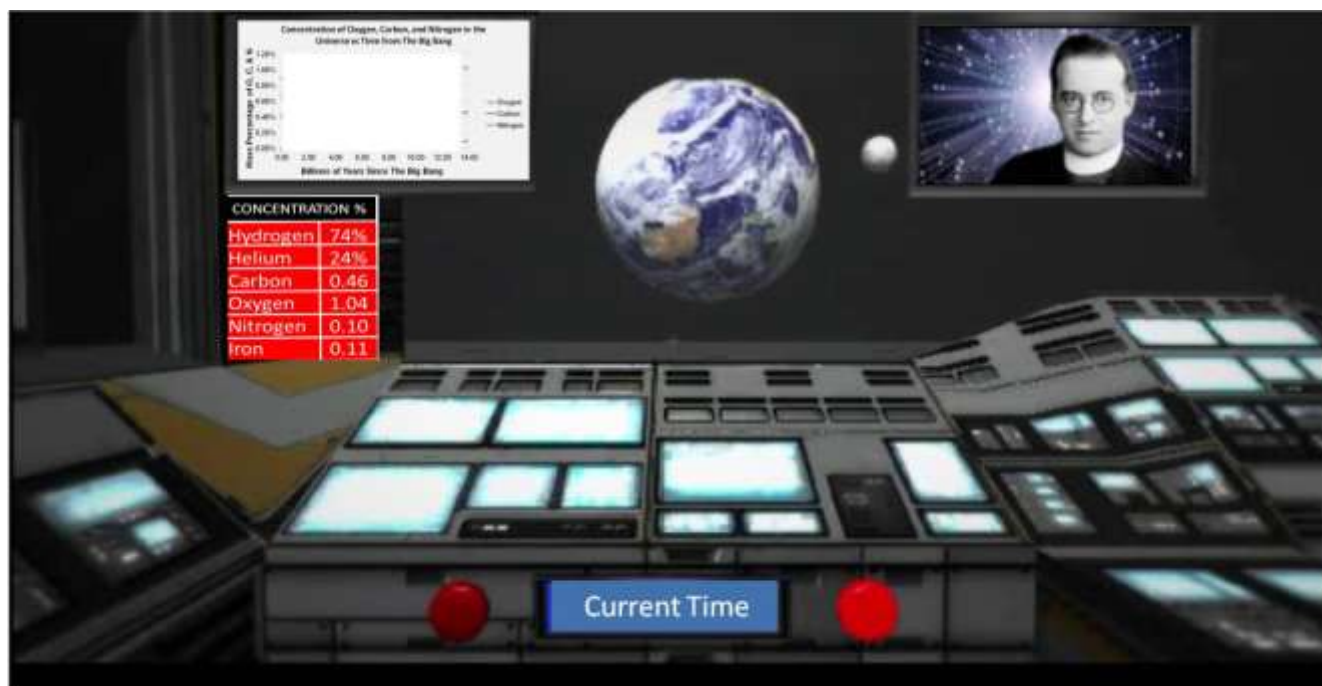
I yelled up to the other kids, "go up and lock the door. I'm gonna take care of that stupid thing." I had my plan. I started running down the stairs. Fleazilla was running up. "I hope this works," I am thinking. "I never did the kick this way before." At five feet away, I gave my fiercest battle cry, "aaaaahhhhhhhhhhh" and leaped into the air. My first kick was onto the wall on the side of the flea. I rotated and planted the second kick to its head, pushing it towards the edge of the stairs. It made a high pitched sound, "eeeeeeeeeeeeeee," as it lost its balance. It was fighting gravity as it desperately tried to stay on the stairs. I landed between it and the wall, and bracing myself on the wall, I gave it another kick, and gravity won. Fleazilla continued screeching all the way down. He landed on the bottom with a thud, and didn't move.



The other kids who didn't do what I told them, and stayed to watch, cheered. "Way to go," yelled Milo who came down the stairs to get me, seeing that I was pretty shaky.

When I calmed down, we continued up the stars to the Time Machine. "Let's go," said Milo, and we all used the teletransporter to enter the time machine.

"Wow, Milo was right, this is awesome," said VC when they we inside. It was awesome. The *Beamer Guide* avatar gave us the tour. When our *avatars* were facing front, there was a rectangular window where we could see the present day earth and moon. We will be able to look out and see things as we go back in time. Around the window were instruments and computers, and below the instruments were the buttons we would use for time travel. The left button would send us backwards in time and the right button would sent us forward. Between the buttons was the time indicator, which was now showing '*current time*.' On either side of the window were computer screens. The one on the right allowed us to select and see *Expert Avatars* to consult with. It currently showed Professor Lemaître, the most recently visited *Expert Avatar*. The screen on the left was to graph the data on the elemental composition of the universe measured at each time. The gauge below showed the current values. In the back of the time machine was an even bigger round window.



With the tour finished, VC said, "we are ready to go." First we recorded the temperature and concentrations for the present time. The data showed up on the graph. The *Beamer Guide* said that the temperature was of the surface of the object we were looking at. But, we could choose between concentrations of atoms on the surface of the object or an average over the universe. Since we wanted to know when the heavier elements appeared, we selected the average over the universe and recorded the concentrations shown on the gauge. Hydrogen was 74% of the mass in the universe. The reading was in percent. Helium was 24%, carbon only about half a

percent, oxygen about 1%, and nitrogen and iron only one tenth of a percent. Then, Milo set the location to our current location and pushed the left button to go back in time. We went back 50 thousand years and looked out the large window in back.

"OMG," said VC, "our planet is all covered in snow."

"That's Ice," said Milo. "This must be the Ice Age. The Earth is almost completely covered in ice."

We spent some time looking at the view out the window and then we set to work recording the data. We recorded the concentrations of the elements and the temperature. The concentrations were the same as when we started.



We took the next step back in time to 65 Mya (million years ago). "Oh, man," exclaimed Milo, "something really bad is happening." Out the front window, the earth was being struck with a huge asteroid from outer space. "Wow," said Milo, "I'll bet that caused some serious damage."



The *Beamer Guide* said, "you can find out more about the impact from Dr. Luis Alvarez. You can summon him on the computer screen." So, we asked to see Dr. Alvarez, and the first thing we learned was that this was the event that wiped out the dinosaurs. The impact was so huge that its dust covered the whole planet, blocking out the sun for years. That caused all the

vegetation to die and eventually the dinosaurs all starved to death. It took a million years for the earth to recover from that disaster.

Dr. Alvarez said that his theory of what happened was based on a sample of rock layer that his son had collected in Gubbio, Italy, and sent him to analyze. He was puzzled, because the composition of the rock was what he would have expected from a meteor. Geologists subsequently found the same layer all over the earth. The formation of the layer was dated at 65 million years ago. Dr. Alvarez suggested that a cloud of dust from a huge meteor, which spread out to cover the whole earth, eventually settled to form that layer, which is now called the *Gubbio Layer*. The date when the layer formed also marked the time that the terrestrial or land-based dinosaurs disappeared. There are no land-based dinosaur fossils above the *Gubbio Layer*. Dr. Alvarez proposed that the extinction event could be explained by an asteroid impact. An impact crater fitting the same date was discovered in Chicxulub, México in 1978.

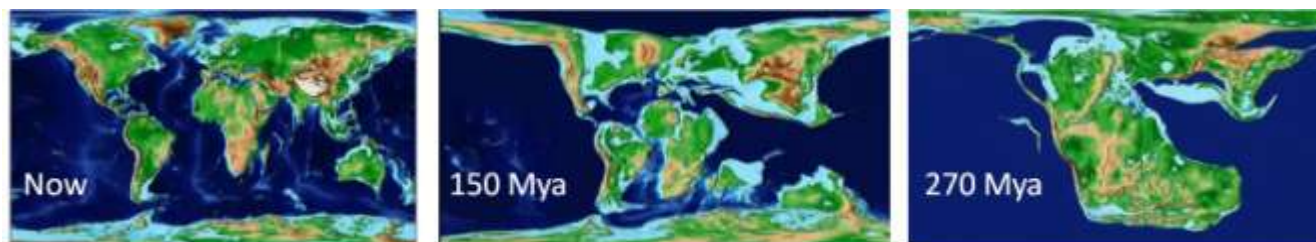
After we said goodbye to Dr. Alvarez, the *Beamer Guide* told us about some recent discoveries that were discussed on a PBS science broadcast called [RadioLab](#). First, the asteroid was about the size of Mount Everest. Second, it was traveling at ABOUT 20,000 miles per hour. And third, and most important, the dust which was mostly molten rock crystals was ejected out of the atmosphere, some of it reaching the moon. Then that stuff spread out and started raining back onto the atmosphere like tiny meteors because of the pull of gravity. That dust rain created so much heat that the earth's surface reached 1200 degrees Fahrenheit. And that killed off most of the land based animals soon after the original impact. Only sea creatures and animals that lived underground were what survived. The *Beamer Guide* also told us that Dr. Lisa Randall, who is a Harvard physics professor, proposed that the gravitational force from a disk of [Dark Matter](#) may have knocked the asteroid out of orbit.

"Maybe this is one of the reasons that Stephen Hawking said we need to colonize other planets," said Milo. "It makes good sense if this kind of catastrophe can happen again. Or, maybe with today's technology, we could destroy an incoming asteroid, or send it off course."

The *Beamer Guide* also told us to look at the computer screen on the left that had a picture of the continents. "They don't look right," said Neddy. Neddy was right.

The *Guide* said, "*look at the continents during the next step back in time. The continents are going to move because of plate tectonics, which results in [continental drift](#).*"

Sure enough, on the next step back in time to 270 Mya, we found the Earth was now warmer by about 10 degrees centigrade, and North America and the other continents had merged into one big continent. The *Beamer Guide* told us that the new super continent was called Pangea. "Wow," said Milo. "Things sure moved around."



"That's right," said the *Beamer Guide*. "Continental drift is only an inch a year, but if you do that for many millions of years, a continent can move all the way around the Earth."

We kept stepping back in time and looking at the changes in the Earth. It looked the same, except for the shape and position of the continents. But then the land started disappearing, leaving one large ocean covering the planet at 3300 Mya.



At 4000 Mya, everyone gasped as the scene outside our capsule changed from dark to bright orange. It was a huge change in the Earth. It was big and round and very, very hot.

"What happened to the Earth," asked VC?
 "This thing looks more like the sun. But it isn't the sun because, I can see the sun out the front window."

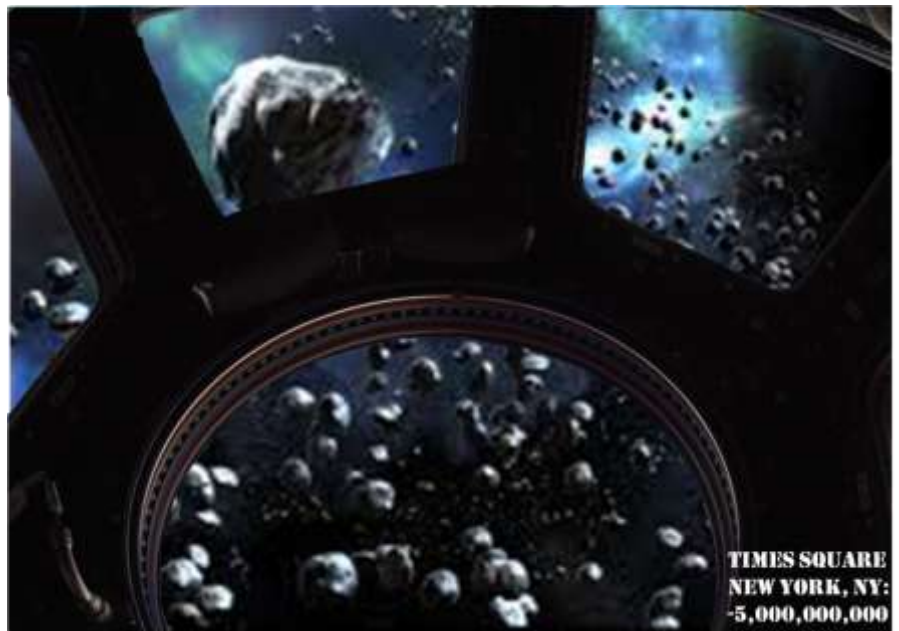
"I know from my '*Science Fair*' project," said Neddy. "That is baby Earth. When the Earth was first being formed, it was because gravity pulled lots of gas and space rocks together. As pieces crashed into one another it created lots of heat. And so the Earth was hot when it first formed. That is what we are seeing, because we are nearing the time when it started. Let's go back to 4500 Mya and you will see it happening"

At 4500 Mya, we did see it happening. All kinds of space junk was accumulating in a hot ball. VC recorded the temperature which was 1000 degrees centigrade and the element concentrations which were pretty much the same.



Then we went back 5.25 billion years. "This scene is pretty awesome," exclaimed Milo. "There is no Earth. There is just a collection of space rocks and gas clouds. Maybe this stuff is made of STARDUST. We needed to find out. I'll go outside and make measurements."

Milo checked the temperature and atmosphere outside and found he would need to use a space suite to go out of the Time Machine capsule. So Milo's *avatar* got dressed in a suite and entered an airlock and then went out into space. He used the jet pack he was wearing to move about by using the keyboard arrows.



As Milo did the measurements on the rocks he said, "they are made of lots of the same atoms that are on Earth. There are lots of atoms heavier than helium. The gases contained hydrogen, helium, carbon, oxygen and nitrogen. The rocks contained iron, silicon, oxygen, gold, lead and lots of other stuff. So all the stuff outside has the same atoms that are on the Earth, and has all the atoms that were in our bodies. So this stuff has to be STARDUST."

We did the measurements for the elements in the universe, and again they were pretty much the same as when we started our trip.

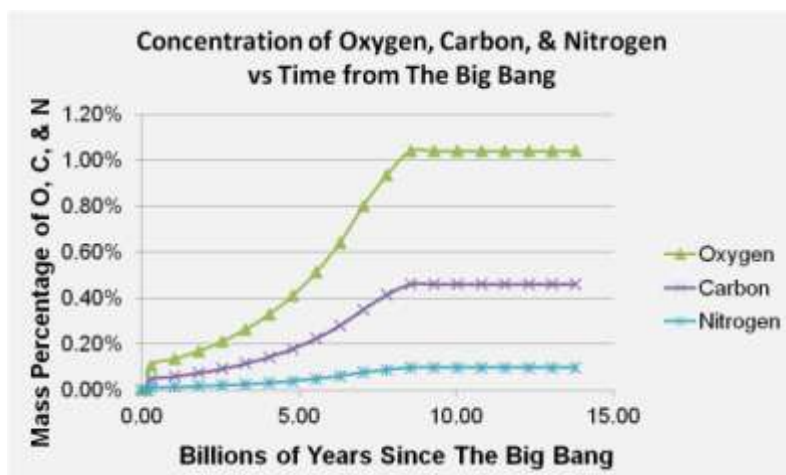
"Wow," said Milo after he came back in, "that was awesome. It really was. And now we know that the Earth was formed from STARDUST, and that STARDUST became us!!! Now, we need to keep going back in time to see when the STARDUST first appeared." Everyone agreed.

At 6 billion years ago the Sun was gone, but there were lots of other stars around. We measured the concentrations of the elements and found they were still the same.

"We're not learning anything new," complained Milo.

"Stop griping," said VC. "This is how research is done. It's not always exciting. Let's keep going."

As Milo changed the date and the scene outside changed, VC screamed, "look at the concentration gauge. The concentrations of heavier elements are dropping."



We continued back in time and the concentrations of oxygen, carbon and nitrogen continued to drop. We stopped at 13.6 billion years ago, which was 200 million years after the BIG BANG. The hydrogen and helium were a little higher at 75% and 25%, but, the heavier elements were all zero.



"Hey guys," yelled Milo looking at the *Beamer* data screen. "we found when the STARDUST first formed, sometime later than 200 million years after the BIG BANG. Yesssss!!!" We all did high fives.

"OK, you guys," said Neddy looking at the scene outside the window, "I know what is going on from my 'Science Fair' project. That is 'the star factory' where stars

are being formed out of the hydrogen and helium from the BIG BANG as gravity pulls the gases together. So STARDUST formed sometime after the first stars appeared."

"Great," I said. "We can add this screen shot to our poster."

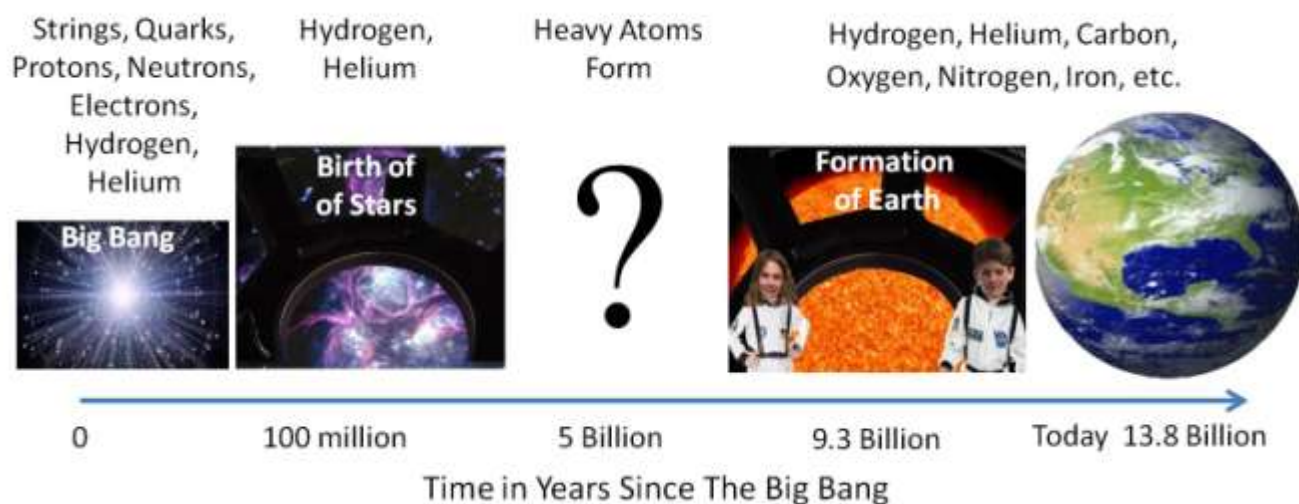
As we got closer to the BIG BANG, the stars all disappeared. So, between the BIG BANG and 100 million years later, there was just a hot gas of hydrogen and helium, and no stars at all. And as we got closer to the BIG BANG, the concentration of hydrogen and helium started dropping, so that just after the BIG BANG, there weren't any atoms at all.

"I am homesick for our old Earth," complained Milo. He changed the setting to the 'Current Time' and pressed GO. "Now I am happy," he said. "We have our beautiful blue planet back. North America is where it should be. Everything is cool." And we all logged off the *Beamer*.

Richie who was watching us the whole time said, "that was so cool. I even learned something about how the earth was formed and how the dinosaurs died." And he was looking at Neddy with an expression of pure worship.

"So," I said, "we saw how the earth was made of STARDUST, and STARDUST has all the atoms that we are made of. And we learned when STARDUST was formed. Now we just have to figure out how the STARDUST was formed.

We added two more pieces to our poster.



Do you know what the missing piece is?



Nucleosynthesis

(As told by VC)



"Anyone have any new ideas," groaned Milo when we got together in Grandma's basement for a meeting?

Neddy whispers, "oh, I forgot to tell you guys. Another package arrived yesterday from TSI." We were all ready to kill her for not telling us, because it was now July, and every minute counted. But we calmed down while Neddy went to get the package.

"What the" I exclaimed when we opened the box. "It is just a pair of Chopsticks."

No one had any idea of what the chopsticks might be a clue to, or how to fill in the missing piece of our poster, and of course solve the mystery.

"Think, guys, think," pleaded Milo.



After a few minutes, an idea percolated in my brain. "I have the brainstorm this time," I announced. "Remember when we saw the picture of Johannes Kepler, it looked like he was holding chopsticks. And remember when Milo visited him, he didn't learn anything. Well, I think we missed something on the Kepler visit. I think the chopstick clue is for Kepler. And maybe we missed the clue because we visited Kepler too early. Maybe he didn't make the important discovery until later."

"Wow," agreed Neddy, "that was really smart." We all decided that we needed to visit Kepler again. And we decided, that even though it was my idea, Neddy would be the one to make the visit to ask the questions because, as we all agreed, Neddy was really observant. "Maybe if she was not so busy observing everything, she would do better in school," I thought to myself.

We picked the year 1605 as the date, 10 years after our first visit. Neddy logged on, went to the Gallery of Experts and asked the *Beamer Guide* if she could visit Kepler. This time the *Beamer* took her to Prague where Kepler was now working. This time, he wasn't dancing. We watched as Neddy asked him all kinds of questions and finally he told her about observing a supernova starting in 1604 and lasting right up to her visit.

"Oh, I know about the supernova from my '*Science Fair*' project," Neddy responded, "It's when a star explodes."

"Yes," agreed Kepler, "It looks like a star has exploded."

Kepler said that he would show it to her that night. So she waited till dark and saw this super bright star in the sky. Then she asked Kepler a few more questions about the supernova, said goodbye, and logged off.

"That must be it," said Milo. "The supernova must be the missing piece. We need to use the Time Machine again to see if there are supernovas when the heavy atoms appear."

So Milo and I started logging on to the *Beamer*. "Wait," I said, "I want Lizzy the flea slayer to come too." So she logged on too and we all went to the Time and Space Tower. We climbed the stairs cautiously *because the flea's body was no longer dead on the ground*. But, we got to the fourth floor safely and used the Time Machine to go back to 250 million years after the BIG BANG. Then we started searching the sky for something really bright. We found a supernova, and sure enough, where the supernova appeared, we measured heavy atoms.



"The supernova has gotta be the missing piece of the puzzle," I said. "The heavy atoms must be made when the star explodes. That's why they call it STARDUST." We took a picture of a supernova to put in our poster.

We decided that we needed to find out [how the heavy atoms form in a supernova](#). "We need an expert on atom formation that we can visit," I said. "Anyone have any ideas?"

"How about Fred Hoyle," suggested Milo. "Remember, Professor Hubble said that he was working on how atoms form in stars."

"Perfect," I agreed, "let's ask Hoyle. We can summon him from the Time Machine computer. What year shall we choose?"

"I suggest 1960," said Milo. "That is after both the atomic and hydrogen bombs were developed. So the scientists must have known a lot about atomic reactions by then." Milo entered 1960 and pressed go. The beamer told us we were going to Columbia University where Hoyle was giving a lecture. Hoyle appeared on the computer screen above the front window replacing Professor Alvarez. He was back stage, getting ready to speak. "Hello," he greeted. "My name is Fred Hoyle. What is your name?"

"My name is Milo," answered Milo. "And these two are my cousins VC and Lizzy."

"It is nice to meet you, Milo and VC and Lizzy," said Hoyle. "What can I do for you?"

"Thank you, It is nice to meet you too," I replied. "We want to ask you some questions about how heavy atoms form. We think it has something to do with Supernova star explosions. Can you tell us about that?"

"Yes," responded Hoyle, "the subject is called [Nucleosynthesis](#). I published a paper on it in 1946 and another one in 1954. Basically, the heavy atoms are formed by nuclear fusion. Nuclear fusion is what happens when two

atoms come together and form a new larger atom. On our Sun, hydrogen atoms that are very hot fuse into helium atoms, and release lots of energy according to Einstein's equation, $E = mc^2$. All that energy is what keeps the sun burning bright."

"And fusion also happens in an H-bomb," added Milo, who knows lots about weapons in addition to sneakers, "and in the BIG BANG. But none of the heavier atoms that are in our bodies were formed in the BIG BANG. So, where did they come from?"

"You are right, Milo," agreed Hoyle. "The temperature just after the BIG BANG when atomic nuclei could form was only 100 million degrees centigrade. That is sufficient to form helium and lithium, but it isn't high enough to form big atoms. But stars can form bigger atoms like carbon and oxygen in their core where the temperature is really hot, billions of degrees. The hotter the star, the bigger the atoms that form by fusion. But, when a star uses all its hydrogen, it either forms a white dwarf like our Sun would do, or if it is a really big star like the first ones to form after the BIG BANG, it collapses and then explodes to form a supernova. And in that supernova, conditions are really, really hot, like 100 billion degrees. And that is hot enough to form all the big atoms, even up to uranium which has 92 protons. And the explosion blows all those new atoms out into space where they can condense to form new stars and planets, like Earth."

"We did it!!!! We solved the Mystery," I screamed. And we all high fived.

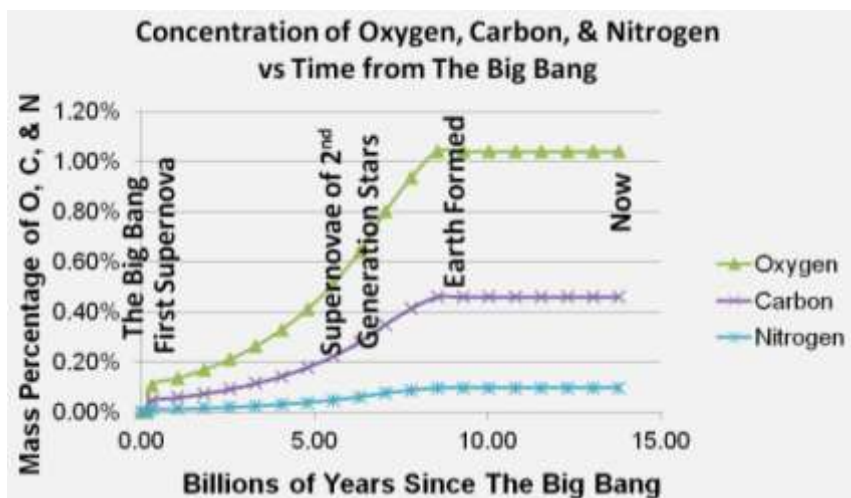
We thanked Professor Hoyle, and then took a quick look out at the audience that was gathering for the lecture." After we logged off. I asked, "didn't that young guy in the first row look a little like Papa?"

"Way too young," answered Milo.

"No," I objected, "that is the age he would have been in 1960 and I think he went to graduate school at Columbia so he must have been in the audience. And Dr. Q was probably there too. We missed a good opportunity. But, we can't go back. We have work to do."

Neddy made a copy of the data screen from the Time Machine and put on labels for the important events.

Milo summarized what we knew. "First, the BIG BANG happened 13.8 billion years ago and that produced the BIG BANG DUST of hydrogen and helium. Over time, gravity causes the BIG BANG DUST to start coming together, and eventually after a hundred million years, formed the first stars and later, galaxies. And the stars burned the hydrogen by nuclear fusion to produce light and heat."



"Ok," I continued, "and a few million years later after those first really big stars formed, they started to run out of hydrogen fuel. They collapsed and exploded in events that astronomers call supernovas to make carbon, oxygen, nitrogen and heavier elements. And that is STARDUST."

"And as time went by," added Lizzy, "stars continued to form and die, increasing the concentrations of oxygen, carbon, nitrogen and heavier elements in the universe."

"And then about 4.6 billion years ago, gravity pulled the BIG BANG DUST and STARDUST into the Sun and Earth and the rest of the planets in the solar system," continued Milo.

"So, bottom line," I concluded, "almost all of the elements that are heavier than helium come from nuclear fusion in stars that explode in supernovas. The earth and everything on it is made of STARDUST and BIG BANG DUST."

"And finally," added Neddy, "the carbon, oxygen and nitrogen (CON) from STARDUST and hydrogen (H) from BIG BANG DUST that was on the Earth, got made into us. And since those atoms last almost forever, they get recycled from person to person and plant to plant as new people and plants populate the earth."



"So we really are made of STARDUST that was once in the body of George Washington," we all yelled together!!!

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So we all worked for the rest of July on getting the story together and then on July 31 we sent it out and hoped for the best.

We filed our report for July.

DISCOVERED SO FAR	STARDUST is made up of the atoms that are heavier than Helium that form in Supernovas. The earth and everything on it is made of STARDUST.
NEXT QUESTION TO ANSWER	Did we Win?
ISSUES	No New Issues.
QUOTE OF THE MONTH	It was a great mystery to solve. We learned a lot.

What do you think of the idea that you are made of STARDUST that got created over 13 billion years ago?

August



The Final Presentation

(As Told By Milo)



Well, here we are back in California. G-Pa took the Space Cadets body surfing and Jackson went too. And then, we all went for a walk along the ocean to talk about the MYSTERY. "Actually, I knew all about nuclear fusion, the BIG BANG and supernovas before the contest started," said Jack. "But I was very impressed with the **Beamer**. I thought it was great."

Of course, The Brooklyn Babes were full of complaints about the bugs in the software. "Thit pragrim not so hot," said Neddy doing a great imitation of them. But I like Svetlana and we went together for another walk on the beach. Maybe all girls are not so annoying.

When I got back, we went over our presentation with G-Pa and he made some good suggestions for improvements. We did a rehearsal. "No, you idiot," I yelled at Neddy, "it's 'quarks' not quacks."

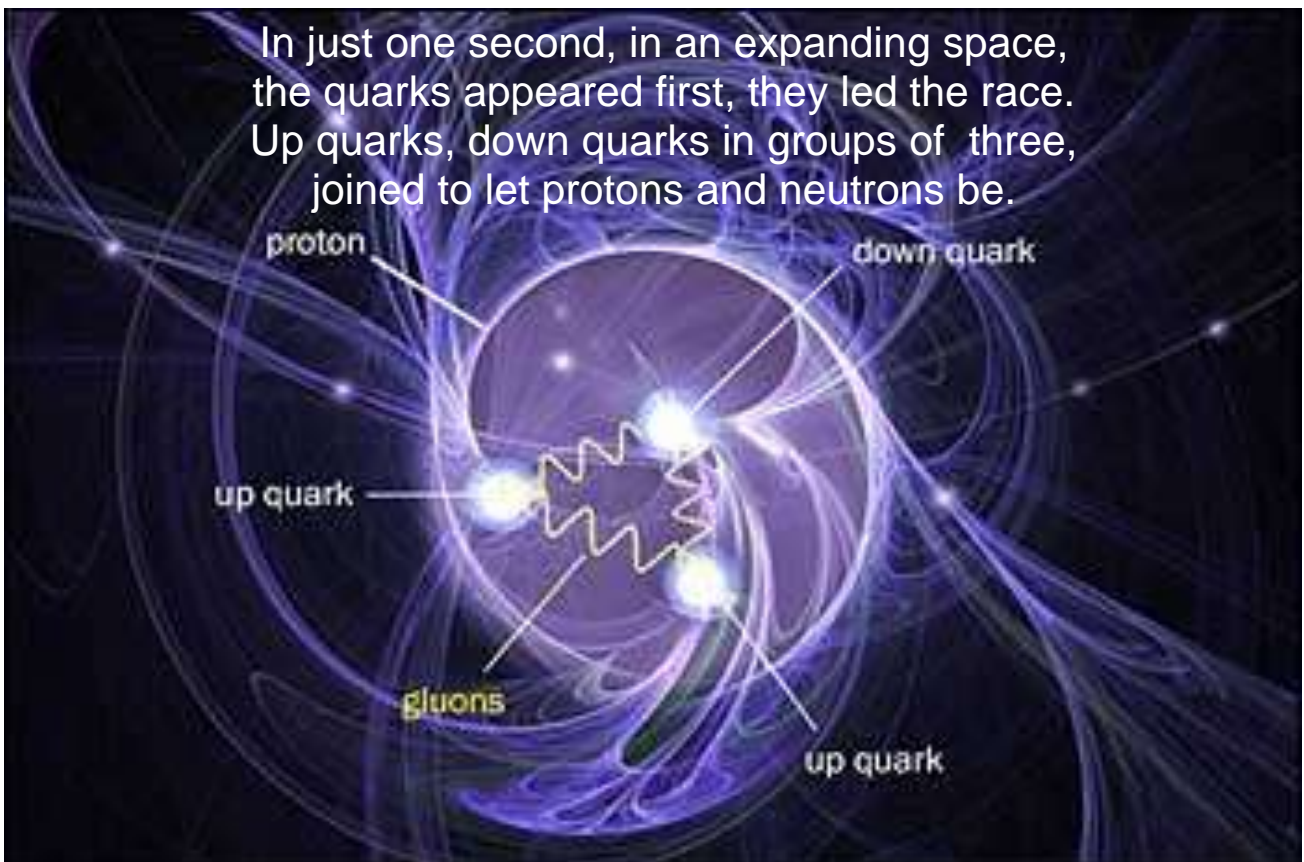
We were all nervous. We sat in the audience while the first two teams presented and then we were next. Our presentation was in three parts. It went like this.



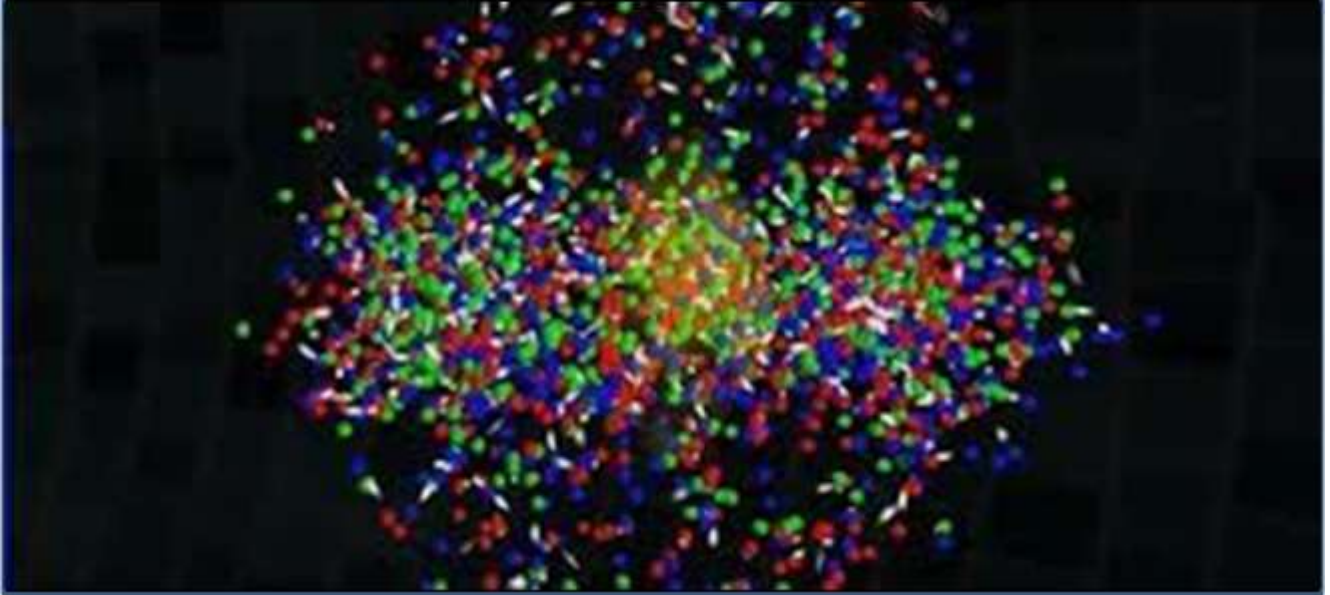
The key to solving the STARDUST mystery,
was the BIG BANG that began our history.
The BIG BANG was how the universe started
14 billion years ago, when space-time parted.



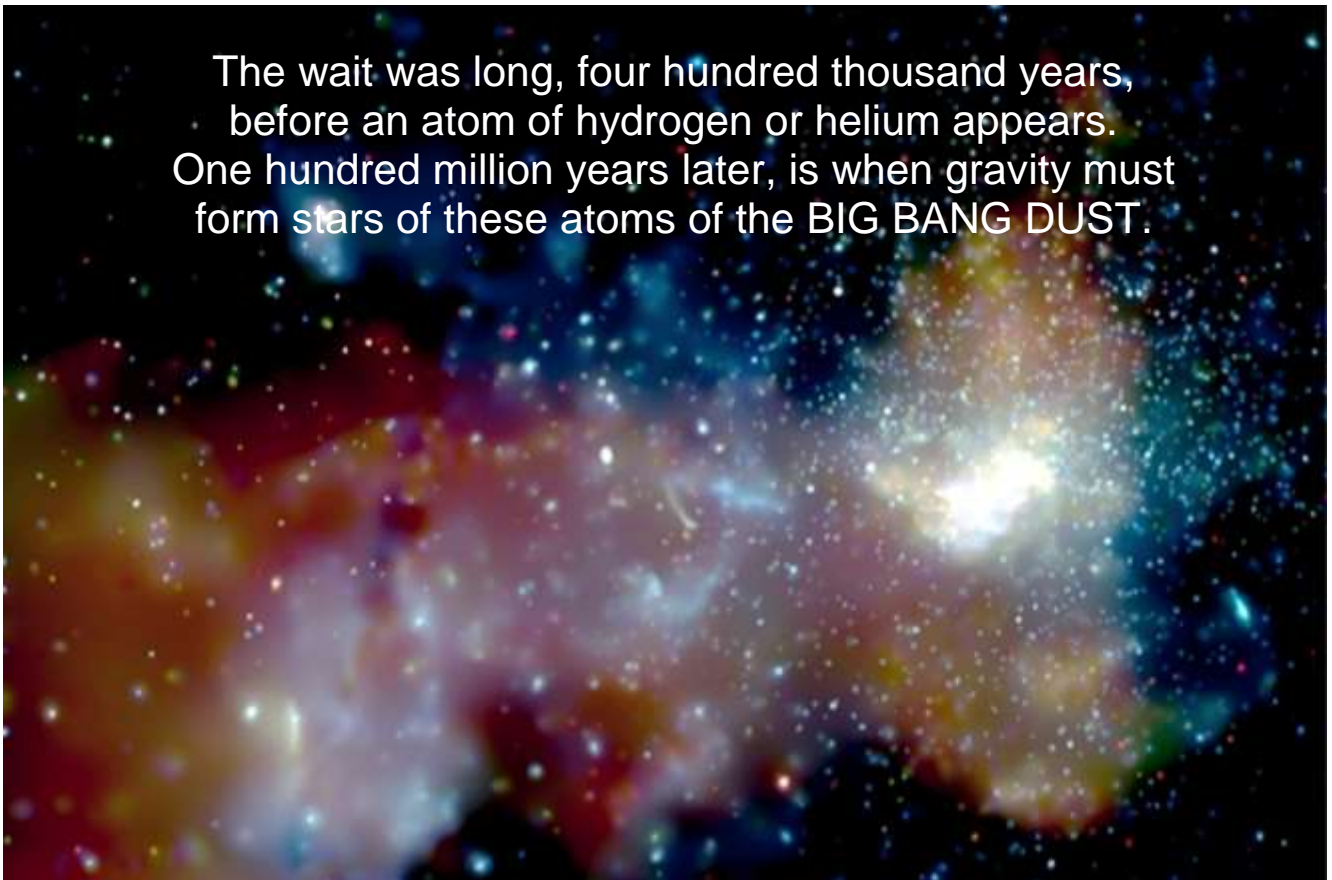
In just one second, in an expanding space,
the quarks appeared first, they led the race.
Up quarks, down quarks in groups of three,
joined to let protons and neutrons be.



At a billion degrees, with much kinetic confusion,
hydrogen nuclei made helium by nuclear fusion.
But for electrons to join nuclei, they had to wait,
until the universe expanded to a cooler state.

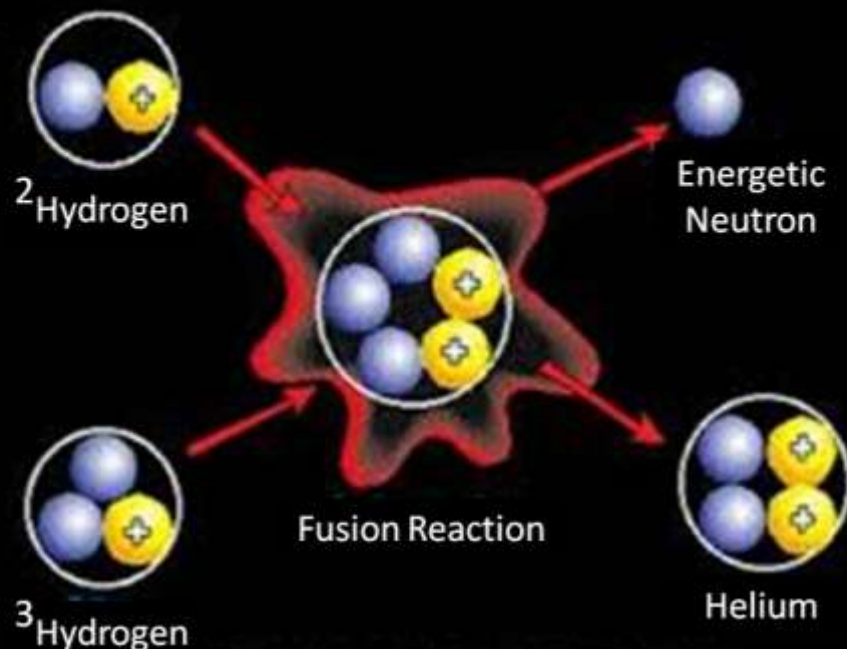


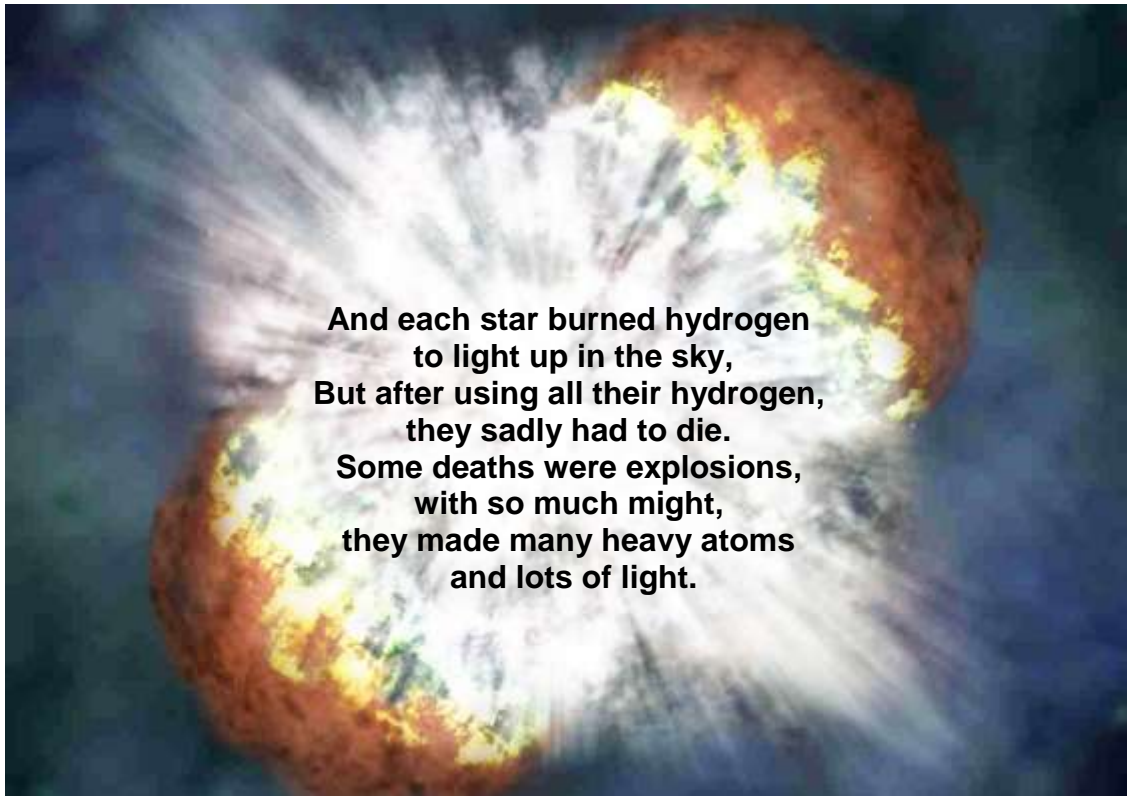
The wait was long, four hundred thousand years,
before an atom of hydrogen or helium appears.
One hundred million years later, is when gravity must
form stars of these atoms of the BIG BANG DUST.



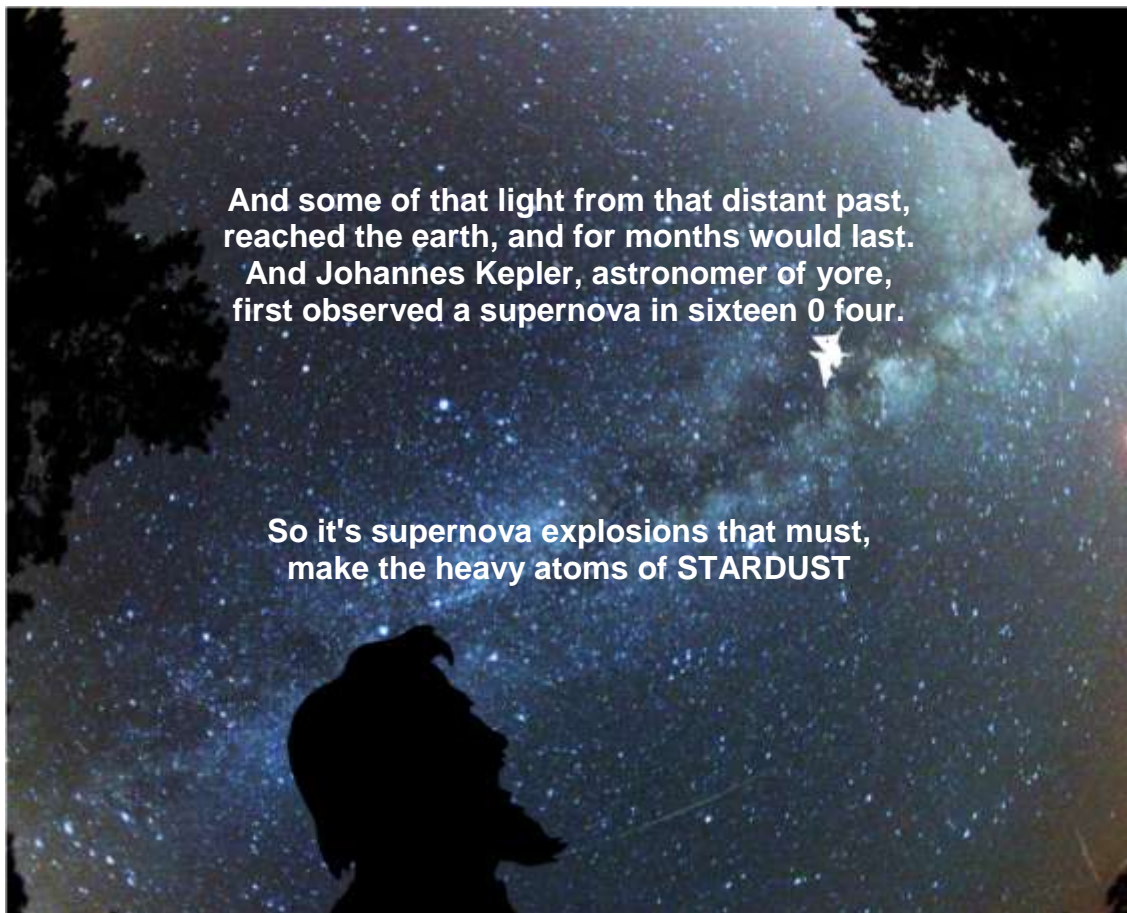


Over the many billion years, stars formed in the Quadrillions, organized into galaxies that numbered in the billions. The scientists that studied stars, came to the conclusion, energy to keep them bright comes from nuclear fusion.





And each star burned hydrogen
to light up in the sky,
But after using all their hydrogen,
they sadly had to die.
Some deaths were explosions,
with so much might,
they made many heavy atoms
and lots of light.

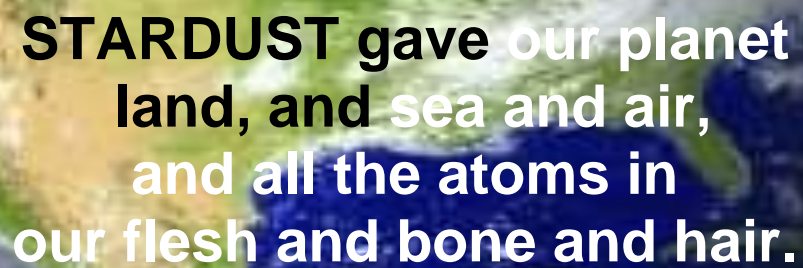


And some of that light from that distant past,
reached the earth, and for months would last.
And Johannes Kepler, astronomer of yore,
first observed a supernova in sixteen 0 four.

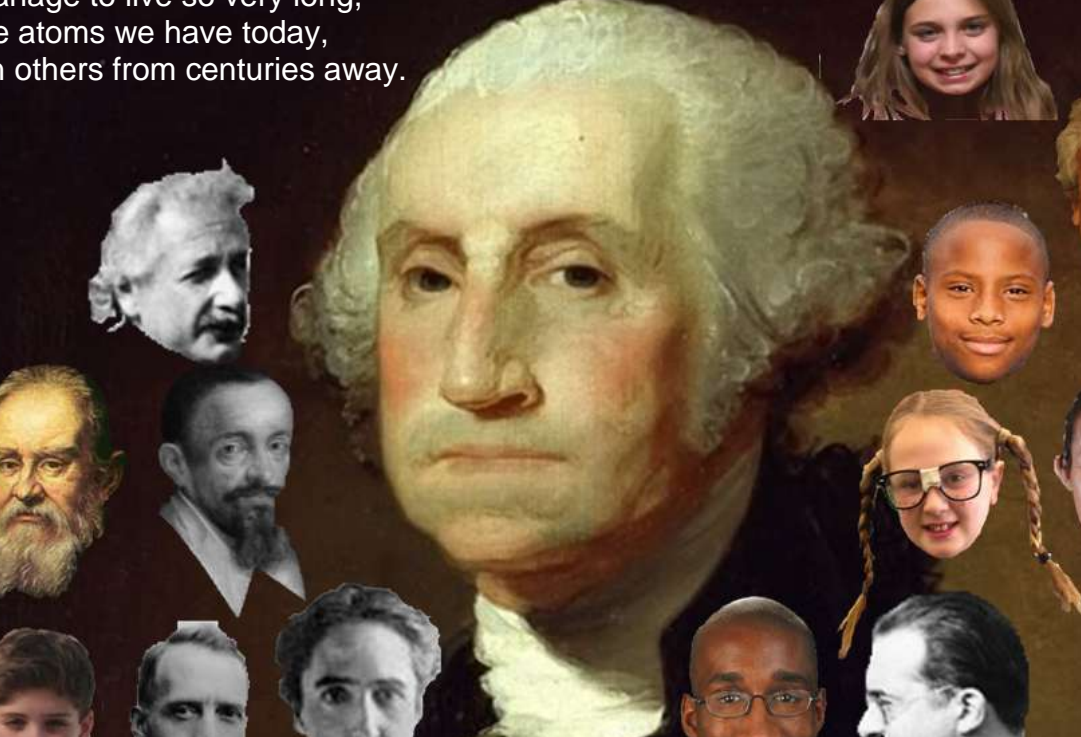
So it's supernova explosions that must,
make the heavy atoms of STARDUST



9 billion years later, STARDUST did condense,
into a swirling disk, that was really quite immense.
In the center of the disk gravity formed our Sun,
and eight planets on the outside, when gravity's work was done.



And those atoms are so very strong,
and manage to live so very long,
that the atoms we have today,
were in others from centuries away.







AND THE WINNER IS. . .

(As Told By Lizzy)



Well, I started this story almost two years ago and I get to finish it.

The winner is be announced at 6:00 pm today, before dinner. The announcement will be streaming live so everyone back home will hear at the same time. We Space Cadets are nervous. We think we've got a shot at winning. To fill the time, we went for a another walk on the beach. The huge Pacific coast waves crashing on the beach and the cries of seagulls were soothing to our state of super anxiety.

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We're back in the auditorium at 10 minutes to 6. The place is packed, with standing room only. But the teams have seats up front. At precisely 6 pm, Dr. Q walks on stage.

"Ladies and gentlemen, boys and girls, future scientists and inventors," he started, "this has been a wonderful competition. I was so pleased to see the effort, the creativeness, the cleverness, the artfulness and the genius of each one of you in solving the STARDUST MYSTERY."

Dr. Q. went on, "I am also pleased to see how well members of the same family were able to work together to create something really special. I have a confession to make. I have a sister, and we don't talk to one another, and we haven't done so in years. I am happy to see that other brothers and sisters and cousins can get along and work together. It inspires me to try again with my sister. But this is not what you are here for. You want to know who won. As you know, there were three teams that have been leading for the last 3 months, Cal Tech, the Brooklyn Babes and the Space Cadets. Judging the winner was very difficult. But the Judges have reached their decision. I don't even know what it is." He pulled out an envelope which he proceeded to open way too slowly.

My heart was thumping in my chest. I wanted so much to win for Grandpa and me and the other kids. Time stood still for an awfully long time. I looked at Grandpa and he looked very nervous and serious, too. Milo and VC and Neddy were all on the edge of their seats.

And then Dr Q said. "Cal Tech, Mr. Jackson Graham. Second place goes to the Space Cadets and Third place goes to the Brooklyn Babes."

Oh, no, we had lost and I started to cry. We came in second and we would win a one year scholarship to college. That's something. But it's no trip to the moon. I was kind of out of it as we and the other two teams were called on stage to get certificates and congratulations.

And VC reported that over a thousand Tweets had come in congratulating us on coming in second. We were all pretty sad. But we hugged each other and were happy that we beat the Brooklyn Babes.



One Last Thing

(As Told By Milo)



We were back in our rooms, feeling down, when G-Pa called us to come to his room. Dr Q was there.

"There is some good news," said G-Pa. "But I am going to let Dr. Q. tell you."

And so, Dr. Q told us. "Congratulations to all of you. You were great. Unfortunately, you were competing against this seriously genius kid that is already in one of the country's best colleges studying physics. But, you almost beat him."

"But here is the news," he said. "My company loves your **Beamer** invention. I know there were some bugs,.....ha, ha, ha..... in our software. Lizzy, I am sorry about the flea attack. We are still trying to figure that one out. But, I see you finally beat him. And Milo, I apologize for the breach of your email account. I really laughed at the dancing Kepler. But, bugs aside, the concept is great. And here is the thing. We want to buy the idea."

"Awesome", I said.

Dr. Q. went on, "first, we would like you to take the ride to the moon. The Cal Tech team is only Jackson and we had planned for a team of 4 plus coach, so you can go with him. And second, we will pay you for the **Beamer** idea. We even like the name. If it is ok with all of you, I will negotiate the deal with your Grandfather."

We all agreed. There were high fives all around and fist bumps. And even G-Pa and Dr. Q. joined in.

And that is really the end of the story, except of course that we are all excited about our trip to the moon, which is coming up in two months.

Oh, Yeah. There is one more thing. G-Pa finally confessed the final part of the NASA Zero-G catastrophe. It seems that G-Ma was in the airplane hangar before takeoff to give G-Pa moral support. Apparently, he convinced her to go with him on the flight and snuck her aboard the plane. G-ma was fine in zero G, except that G-pa ended up puking on her. NASA was furious with G-Pa for breaking the rules by taking G-ma. That was the main reason for why he got fired.

Anyway, G-Ma did fine on the Zero-G flight, so maybe she should go on the moon flight with us.

AUGUST, THREE YEARS LATER



The Moon Trip

(AS TOLD BY VC
AND NEDDY)



Bonjour. It has been 3 years since the end of THE STARDUST MYSTERY contest. Milo and Lizzy have graduated high school, are getting ready for college and resigned from the Space Cadet Team. That leaves Neddy and I in charge. We decided to add one final chapter to the story. Of course, the most exciting thing that happened in the last 3 years was our ride into space. Neddy will tell you about that.

The ride was awesome, super cool, fantastic, stupendous. . . . you get what I mean. We left from California in October, two months after the end of the contest. Grandpa finished the negotiations with Dr. Q for the rights to the *Beamer* and as part of the deal, Grandma got to go with us for our space ride. And, Jackson, remember, the winner from Cal Tech, was going too. We did a photo opp for the whole gang in front of the space craft.



The takeoff was scary, with lots of noise and lots of g-force that were pulling my cheeks to the back of my head. But it became beautiful when we left earth's strong pull of gravity. The rocket shut off and we were coasting towards the moon. It was quiet and we became weightless. I finally got my wish from 6th grade to be floating in space. And, we could see our beautiful planet out the window getting smaller and smaller.

It was going to take 2 days to reach the moon, so we settled in to a routine of reading, playing games, and taking pictures of each other and out the windows. Eating was a challenge. Because of zero gravity, we had to suck food out of, like, a toothpaste tube. But, guess what Grandma did? She made Chinese dumplings and smuggled them aboard. We had to eat them without the sauce, but it was a treat compared to the toothpaste food.

It got noisy again when we reached the moon and had to fire the rockets to slow us down. The scene out the window from moon orbit was fantastic. The best picture was of the surface of the moon with the earth rising in the background. It was earthrise time on the moon. Wow!!!! After four times around the moon, we fired up the rockets again, and headed for home.



On the ride home, we had another two days of quiet cruising and weightless fun. I was the gin rummy champ. It was scary again when we entered earth's atmosphere and the skin of our space craft got super way hot. But the landing

was smooth. The trip was wonderful, but, we were all glad to be home again. . . . And now more news from VC.

Well, Neddy got to tell the best stuff, because she is still the *'Space Nerd'*. But lots of other interesting stuff happened during the three years. First, about Lizzy and Milo. Just like in middle school, they were first and second in their high school graduating class. But guess what, this time Lizzy was first as Valedictorian and Milo was Salutatorian. They both got into the colleges that they wanted. Lizzy got into Tufts and will major in biology to prepare for a career as a veterinarian. Milo is going to UCONN on a lacrosse scholarship majoring in sneakers. Ha, Ha, just kidding. But his sneaker trading made him interested in working on Wall Street, trading stocks, so he is majoring in finance.

On the social side of things Milo was wrong. Lizzy did finally find a jerk brave enough to be her boyfriend. He was the only one that could take her down in Tae Kwon Do, so he is not afraid of her. And guess what. Neddy and Richie are a thing. He has become a good student and loves science. Milo is playing the field. He has finally come to the conclusion that girls are awesome, not "useless and clueless" anymore. I guess us girls have improved over the last five years. As for me, I hang with a group of guys and girls, no one special.

Here is the news of the Space Cadet Team. We did one more project. We were contacted by this really cool video game genius. He is actually Dr. Q's nephew. He had this idea to develop educational games using the *Beamer*, and Dr. Q was all for it. The *Beamer* wasn't yet released to the public, but he knew the Space Cadets and other finalist teams were able to use it and had lots of experience. So he asked us and Jackson and the Brooklyn Babes to work for him on the development. The first game was based on an idea from the Space Cadets called THE EVOLUTION GAME, where players have to manage their evolution from a one cell creature to a human. They get to make choices about the environment to stay on the right evolution path. It was a really cool project. But sadly that was the last project for the four of us with Milo and Lizzy leaving the team when they go to college. But, we have two new recruits, my brother NoNo who is now 12, and VC's sister Megan who is 13. There are two more younger cousins that want to join too named Leo and Griffin.

Oh Yeah, I almost forgot. Jackson graduated from Cal Tech, Summa cum Laude, that means with the highest honors. And, he came to Connecticut for a summer internship before he goes on to graduate school. He is staying with Grandma and Grandpa so we see lots of him. It has been a lot of fun remembering THE STARDUST MYSTERY contest.

Here is one final thing. TheBeamer.Net web site is being used by the public now. New scientist *avatars* are being added every year. We will talk to you later about our next adventure.

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The End

ADDITIONAL INFORMATION

Grandpa's Extra Information Only If You Want It

Chapter 1

[Hubble Space Telescope](#) The Hubble space telescope is a satellite developed and launched by the National Aeronautics and Space Agency (NASA) in 1990. Because it is circling the earth at 347 miles above the surface, it can take pictures free of distortions due to the earth's atmosphere. The Hubble has been able to collect light that started traveling towards earth over 13 billion years ago.



[Star Factory](#) The star factory known as Messier 17 lies some 5,500 light-years away in the constellation Sagittarius. This is a place in the universe where stars are formed from cosmic gas and dust. The collection of material by stars when they form has led to the unusual undulating shapes of the leftover gas and dust seen in the photograph in Chapter 1.

[Supernova Star Explosion](#) Stars are bright because they are very hot due to nuclear fusion in which hydrogens combine to form helium. After billions of years, all of the hydrogen is consumed and the star starts to cool and collapse toward the center. In big stars, the collapse leads to an explosion called a Supernova in which huge amounts of light and material are released. Supernovas are bright enough to be seen on earth with the naked eye and can last for more than a year.

[Company is going to take people to the moon.](#) There is a real company called Virgin Galactic that is developing a space craft to take people into earth orbit. They are now selling tickets for \$250,000 per ride.

[Galileo's Experiment](#) There is a popular story that may or may not be true that in 1589, the Italian scientist Galileo Galilei had dropped two balls of different masses from the Leaning Tower of Pisa to demonstrate that their fall time was the same. This showed that the objects had the same acceleration due to gravity. This observation disproved Aristotle's theory of gravity which states that objects fall at speeds that depend on their masses.

Chapter 2

[Flying Car](#) Flying cars already exist. They have wings that fold up when they drive on the road like a car and unfold when they fly like a plane.

[Time Machine](#) Time machines do not exist except in science fiction books and movies. With today's science a time machine is not possible.

[Teletransporter](#) Teletransporters are also part of science fiction. They were used in the movie and television series Star Trek, where the person to be transported from the surface of a planet to the space ship said "beam me up Scotty." The idea is that the atoms of one's body are disassembled on the planet and reassembled on the space ship (using atoms available locally). Today's science does not indicate that this is impossible, but the technology for assembling the billion billion billion atoms in a body in exactly the correct places and amounts does not exist and will not exist anytime in the foreseeable future.

[Brain Machine](#) Like the Time Machine and the Teletransporter, the Brain Machine (learning by listening while you sleep) has been part of science fiction. Homer Simpson tried to reduce his appetite by listening to a tape recording while sleeping, but somehow increased his vocabulary instead. Research indicates that learning a language by playing information during sleep doesn't work. But some improvement in game skills or remembering vocabulary of a new language have been reported.

[Medical Cure Scanner](#) Such a machine was in the science fiction movie Elysium. It scanned the body to determine what was wrong and then fixed it. Modern Cat Scanners and Magnetic Resonance Imagers (MRIs) can often diagnose problems by looking at the body's physical state (broken bone, muscle tears, intestinal problems) but do not fix the problem. This invention is in the same category as the teletransporter of being theoretically possible, but not practical with today's technology.

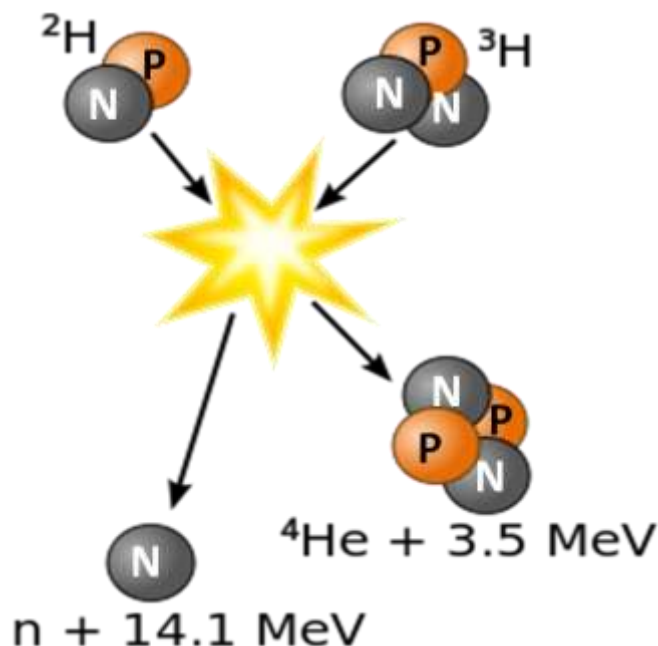
[Anti Gravity Machine](#) Science fiction again, like the flying car in the movie "Back to the Future." There is no theory in science on which a machine can be built to turn off gravity. However, scientists believe there is something called Dark Energy that is pushing the stars and galaxies away from each other, working against the force of gravity (an anti-gravity force).

[Virtual reality](#) Virtual reality, also known as virtual environment refers to the use of computer technology to create a simulated world that a user can explore and interact with, while feeling as if he were in that world. The representation of the user in that world is called an [avatar](#).

[Nuclear fusion](#) Nuclear fusion is what happens when two atoms come together and form a new larger atom. We can exist because nuclear fusion on our Sun provides light and energy to our planet. On the Sun, the main nuclear fusion reaction takes place when one hydrogen atom that has one proton and one neutron (^2H , called deuterium or heavy hydrogen) bangs into another hydrogen atom (^3H , called tritium) that has one proton and 2 neutrons. In order to fuse, they must bang into each other really hard, and that requires a high temperature, like 15 million

degrees C. They fuse into a helium atom that has 2 protons and 2 neutrons (^4He) and the extra neutron comes shooting out with lots of energy. The energy is in units of million electron volts or MeVs. All that energy is what keeps the Sun burning bright.

Fusion of bigger atoms on our Sun can form atoms like lithium with 3 protons and beryllium with 4 protons and small amounts of bigger atoms. But really big stars can form big atoms in their core where the temperature is really hot. When a star uses all its hydrogen it either becomes a white dwarf the size of earth like our Sun would do, or if it is a big star, it collapses and forms a supernova. And in that supernova, conditions are hot enough (100 billion degrees) to form atoms like like Iron that has 26 protons and even uranium that has 92 protons."



Chapter 3

Hologram. Using a hologram plate (film) and a laser, a three dimensional object can be made to appear to a viewer. The hologram plate is a photographic record produced by illuminating an object with a laser so that light reflected from the object plus light from the laser fall on a photographic plate. Later, when the plate is illumined with the same laser light, a viewer seeing the light reflected from the plate will see what appears to be the original object on the other side of the plate. The window through which the kids saw the creature was a hologram illuminated by laser light.

Watson: Watson is a computer program developed by IBM. Watson can read and understand natural language. When asked a question, Watson generates possible answers, based on a very large data base, and selects and scores the best answers. A speech recognition layer could be added, so that questions could be asked as speech. In 2011, Watson competed on the quiz program Jeopardy against former winners. Watson received the first prize of \$1 million. IBM calls Watson a cognitive computer. These kinds of software programs are also called Artificial Intelligence.

Chapter 4

[Equivalence of acceleration and gravity](#) In the zero-g airplane, Jackson and the other kids could not tell the difference between being in free fall in a gravitational field, or being in a place with no gravity. The equivalence of acceleration and gravity was something that Albert Einstein realized and it guided him in the development of General Relativity. He called it the *weak equivalence principal*. This is how it is stated: "uniform gravitational fields are equivalent to frames that accelerate uniformly relative to inertial frames." General Relativity was one of the two great physics laws of the 20th century. The other one was Quantum Mechanics. General Relativity applies to very large masses, like stars, and high velocities near the speed of light. Quantum Mechanics applies to very small things like electrons and protons. I must confess, that I do not understand relativity, so my friend for over 50 years and physicist, Tom Lucatorto helps me with the Relativity stuff.

Einstein's thoughts on the equivalence principal started with the concept of mass. There is gravitational mass (that determines how large the force of gravity will be) and inertial mass (which determines how much force is required to start a body moving or to slow it down. (Changing speed is called acceleration). Why should these two properties be the same? Ever since Newton, the importance in the observation that the two are identical was not recognized. When Einstein became aware that this was not just a simple coincidence, that being weightless in the absence of gravity or freely accelerating because of it were equivalent and something extremely fundamental, he called it the '*happiest thought of his life*.' This connection between the two types of masses led to the weak equivalence principle. Einstein came to the conclusion that no experiment can tell us whether we are in free space or in a gravitational field. These equivalences helped Einstein develop General Relativity. For more information, you can go to:

http://www.einstein-online.info/spotlights/equivalence_principle

[Zero-G flight](#) The idea behind the zero-G ride is simple. If you throw a ball in the air on earth it will follow a trajectory, like the ball in the picture following the dashed blue line. You start the ball out with the throw and then gravity starts accelerating the ball towards the earth.



If you are riding in an airplane going up rapidly, and the plane suddenly disappeared, you would follow a similar trajectory. That would be a zero-G ride that would end badly. But the plane doesn't have to disappear to put you on the trajectory. All it has to do is fly slightly below your free fall trajectory, like on the black line. Now you are following the free fall trajectory, but you are doing it inside the plane.

[Frozen Fusion.](#) This processes was called Cold Fusion when it was announced to the world in 1989. As you have learned, fusion of hydrogen to form helium takes place on the sun at a temperature of 15 million degrees. Fusion to form heavier atoms like iron or uranium requires

temperatures of 100 billion degrees. The high temperatures required for hydrogen fusion on earth have been accomplished in a Hydrogen Bomb, but no practical fusion energy power source has yet been developed. So the announcement in 1989 that fusion had been achieved in room temperature experiments that could be performed in a laboratory were very exciting. Unfortunately, other laboratories were unable to reproduce the results and Cold Fusion was eventually called 'Junk Science' and 'Crackpot science.'

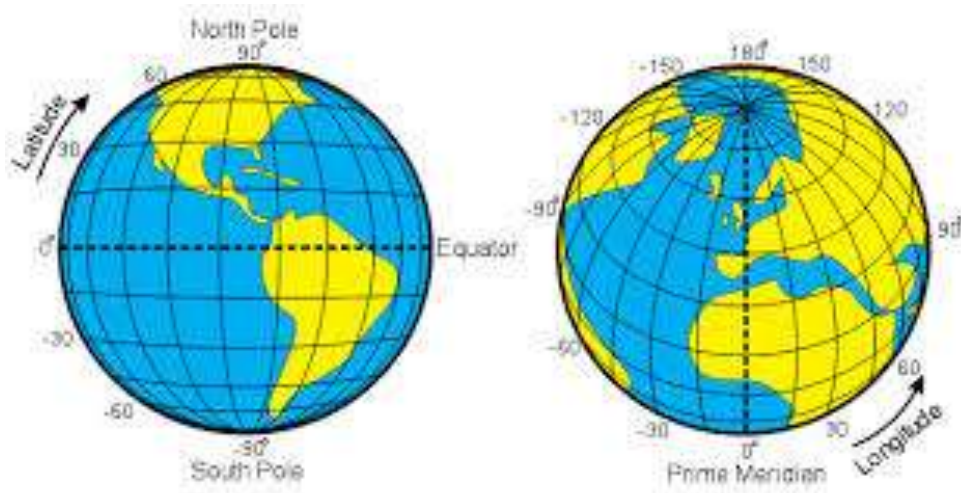
But the idea of Cold Fusion didn't go away. If it could actually be developed, it would solve all of the world's energy needs with cheap abundant power. So many laboratories continued to do experiments. In 2009, Sixty Minutes did a piece on the current status of what is now called a 'Nuclear Effect' rather than Cold Fusion. Many laboratories have now seen excess energy produced in an experimental apparatus similar to what was used in 1989. But many scientists still doubt the results. We will have to wait and see.

[nuclear fusion](#) See Grandpa's Extra Information for Chapter 2

[E=Mc²](#) Einstein's famous equation was published in 1905 as part of his Special Theory of Relativity in a paper called, "Does the Inertia of a Body Depend Upon Its Energy Content?" The meaning of the equation is that, mass can be changed into energy, and energy can be changed into mass. So, to a stationary observer, an object that is moving very fast appears to have more mass than when it was at rest. This concept is related to Einstein's cosmic speed limit which says that no object can go faster than the speed of light, because as it approaches the speed of light, its mass would become infinite. At the beginning of World War II, physicists proposed that $E=mc^2$ could be the basis for a new weapon, the Atomic Bomb. They reasoned that if a heavy atom were split into two lighter ones, there would be energy released if the sum of masses of the lighter atoms were less than that of the heavy one. That situation was the case for very heavy atoms like uranium and plutonium. The huge Manhattan project, authorized by President Franklin Roosevelt developed the Atomic bomb before the end of the war. Practical use of the same energy generation led to the building of nuclear power plants.

Chapter 6

Latitude and Longitude When people started to travel around the world, they needed some way to indicate their location. So they assigned a number to the north/south position on the earth and that was the Latitude. Lines of constant Latitude are the horizontal lines in the left figure with the equator being zero. The value of the Latitude is the number of degrees from zero so that the north pole is plus 90 degrees and the south pole is minus 90 degrees. Lines of constant Longitude are drawn from the north pole to the south pole. They go from zero on a line which passes through Greenwich, England to plus 180 degrees going east and minus 180 degrees going west. The location of West Hartford, Connecticut is Longitude = 72.7539 degrees West and Latitude = 41.7678 degrees North



Chapter 7

Cells: The cell is the basic building block for all living things. The cell was discovered by Robert Hooke in 1665 from studies of living material in which he observed very small repeating structures using a microscope. He called the structures 'cells' because they resembled cells of a honeycomb. The word cells comes from the Latin meaning small room, like in a prison or monastery. The first living things on earth were single celled organisms. Each cell was able to perform all the functions necessary for life. They could feed themselves and reproduce. Multi-cell creatures like humans have highly specialized cells that perform specific functions such as nerve cells which are long and can transmit signals, muscle cells which contract to move arms and legs, and killer T-cells which can attack foreign objects to protect the body. Most cells are between 1 micron (1/1,000,000 of a meter) and 100 microns in size. The human body contains about 100 trillion cells whose size is like the thickness of a hair. An interesting web site with interactive diagrams of cells is at: http://www.cellsalive.com/cells/cell_model.htm

Parts of the blood If you look at the back of the supermarket, you will see loading docks for trucks. Trucks bring the products for the supermarket and carry away the empty boxes and other waste. Your blood, carried in your veins and arteries (circulatory system) is the trucking system for your body. It is pumped around the body by the heart. Blood is composed of a liquid called

plasma and blood solids transported by the plasma. The blood solids consist of three types of cells, red blood cells, white blood cells and platelets. Also found in the plasma are dissolved substances such as vitamins, minerals and digested food molecules from the small intestine. Plasma also carries hormones and brings wastes from the cells to the kidneys or lungs to be removed from the body. Each type of blood cell has a different function. Red cells (that look like donuts in Milo's picture) carry oxygen from the lungs to your body's cells and takes carbon dioxide back to your lungs to be exhaled. Platelets are small colorless cell fragments whose function is to promote blood clotting to prevent bleeding. White cells come in many shapes and sizes. Their function is to fight infection. The killer T-Cells shown attacking Milo are one kind of white cell.

[Cell Nucleus](#) The cell nucleus is a highly specialized structure of every cell that serves as the information processing and administrative center of the cell. This structure has two major functions: it stores the cell's hereditary material (the information your body's characteristics) in the genes, and it coordinates the cell's activities, which include growth, intermediary metabolism, protein synthesis, and reproduction (cell division).

[Chromosomes](#) threadlike bodies in the cell nucleus that carry the genes in a linear order: the human species has 23 pairs, designated 1 to 22 in order of decreasing size and X and Y for the female and male sex chromosomes respectively.

[Genes](#) The basic arrangement of DNA molecules in the chromosomes of the cell nucleus that determines the bodies characteristics like hair color, eye color and height; a linear sequence of nucleotide molecules along a segment of DNA that provides the coded instructions for hereditary characteristics.

[DNA, deoxyribonucleic acid](#) Let's say you wanted to build a robot. You look on line and find a set of instructions. It would have to contain lots of things: a list of parts; specifications and drawings for each part (for size, shape, color, function, etc.); and instructions for how the parts are connected. If your friend is going to build one too, you need to copy the instructions. If you are building a complicated robot, the list could be very long, requiring a whole book full of instructions. The instructions for building you and all living things is contained in the DNA which is reproduced in every cell.

The double helix structure of DNA was identified by James Watson, Francis Crick, Maurice Wilkins, and Rosalind Franklin in separate papers in the journal Nature in 1953. Watson, Crick and Wilson (but not Franklin who died in 1958) received the 1962 Nobel Prize in Physiology or Medicine. You can see a picture of the double helix in this chapter. It is two long chains of molecules that are twisted around each other, like a long rope. The molecules are built of mainly 5 atoms: carbon, hydrogen, oxygen, nitrogen (CHON) and phosphorus. The building instructions are determined by the order or sequence in which the atoms of the elements are arranged, just as the 26 letters of the English alphabet can be rearranged to spell out thousands of different words

Each cell in your body contains a complete DNA twisted pair of chains. When you started life as a single cell, one of your DNA chains came from your mother and the other from your father.

As your cells multiplied, the DNA was copied so that each cell had an identical copy of your first DNA molecule. The instructions on whether you are a girl or boy, the color of your eyes and hair, how tall you will be and every other physical thing about you is coded in your DNA.

Atoms. Every solid, liquid, or gas in our world is made of atoms. Most things like water or people or trees or houses or cars are made of combinations of different kinds of atoms. But some substances like silver or gold or oxygen or carbon are made of only one kind of atom and these are called chemical elements. The atom is the smallest unit that defines the chemical elements. Anything made of atoms has mass, meaning that a force is necessary to make it go faster or slower. Atoms are very small. A single strand of human hair is about one million carbon atoms wide. Atoms can be attached to one another in small units called molecules, in large crystals like diamond and salt, in mixtures of crystals or in random arrangements in solids or liquids.

Some things in our world are not made of atoms. The most common is light, which consists of tiny particles called photons. Photons always move fast and have no mass. Some things are parts of atoms like a beam of electrons in an electron microscope or an old television tube. And then there is dark energy and dark matter that we think is out there in the universe, but are not made of atoms. We are pretty sure they're there, but we don't yet know what they're made of.

Protons, electrons and neutrons All atoms are made of the same three particles: electrons, protons and neutrons. Electrons are tiny particles that have very little mass and a negative electrical charge. Protons have almost 2000 times the mass of an electron and are positively charged. Neutrons have almost the same mass as the proton, but have no charge. In an atom, the protons and neutrons are tightly bound together in the nucleus, attracted by the nuclear force. The electrons circle around the nucleus and are bound to it because of the electrical force of attraction between the positive and negative charge of the particles. Different kinds of atoms have different numbers of electrons, protons and neutrons. Hydrogen, the lightest element has only one electron and one proton. The heaviest elements like uranium have almost 100 electrons, 100 protons and a similar number of neutrons.

Molecules. Atoms can be attached to other atoms to form a new unit called a molecule. Simple molecules can be made of the same kind of atom, like hydrogen, nitrogen, or oxygen molecules which have only two atoms each. Or, different atoms can attach like two hydrogens and one oxygen to form a water molecule. An example of bigger molecules are found in oil which consist of strings or rings of a few to more than 20 carbons with attached hydrogens. Then, there are very large molecules like DNA that have hundreds of millions of atoms of many different kinds.

Milo's Notes - What are protons and neutrons made of?

Quarks Scientists discovered that besides the well known building blocks of 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, all the know elementary particles were actually composed of a smaller set of particles too. These are called quarks. There are six types of quarks, known as flavors: up, down, strange,

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charm, bottom, and top. George Zweig, despite his contributions to a theory central to modern physics, was not awarded a Nobel prize. A Nobel prize award to Zweig would have required a second Nobel Prize for Gell-Mann (he already won one in 1969 for his work on the theory of elementary particles) and some have speculated that this is the reason that Zweig did not received an award.

[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 fundamental particles. String theory is being developed to bring both theories together. If we think of a guitar string, different notes can be excited in the string. These musical notes are the excitation modes of the string. 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.

Chapter 8

[Atoms](#) See the Extra Information for Chapter 7 for more information on atoms.

[Orbits](#) The paths followed by electrons around the nucleus in an atom, planets around the sun, or the moon or satellites around the earth are called orbits. The objects that are trapped in orbits stay there because of the forces of attraction between the object in orbit and the object it travels around. In the case of atom, the force is the electrical attraction between the electron and the nucleus. In the other examples given, it is the force of gravity. The exact path is controlled by how the force depends on the distance between the objects. Both the electrical force and the gravitational force get smaller as the distance between the objects gets bigger according to a $1/r^2$ dependence. The diagrams of the carbon atom and the solar system show the orbits as circles for simplicity, but in general the orbits are elliptical.

[Protons and neutrons](#) See the Extra Information for Chapter 7 for more information on protons, neutrons and electrons.











[Nucleus](#) At the center of every atom is the nucleus which has almost all of the atom's mass. The nucleus is made up of protons and neutrons, and so, has the positive charge of the protons. The protons and neutrons are held together by the strong nuclear force. Electrons orbit the nucleus like the earth orbits the sun, but not exactly, because the electron orbits are fuzzy clouds described by quantum mechanics. The size of the nucleus for hydrogen with one proton is almost one trillion times smaller than the onion cells that Milo showed in chapter 7. The nucleus of uranium with 92 protons and between 143 and 146 neutrons is 10 times bigger than the nucleus of hydrogen. The size of the atom is more than 10,000 to 100,000 times bigger than the nucleus.

Electron microscope For over 100 years scientists believed that there was a limit to how small an object could be seen with an optical microscope. That was because light was in little bundles called photons, whose size was the wavelength of the light. If you bounced light off of an object that was large compared to the photon, you could see its detail, but if the object was smaller than the photon, you couldn't see detail. Imagine that you are throwing tennis balls at a wall with a door. When you hit the wall you get one sound and when you hit the door, another sound. Or if the door is open the balls don't come back. You get detail because the ball is smaller than the object. But if you used huge beach balls the same size as the door, little detail could be learned.

This problem of the size of the light photon prompted the invention of the electron microscope. Instead of using photons, you bounce electrons off of the object. Because the electron is much smaller than the photon, you could see much smaller details.

But scientists are continuing to think of new ways of doing things. In 2014, the Nobel Prize in chemistry was awarded to three scientists that invented new ways of doing optical microscopy. Their methods can get detail 100 times smaller than previously possible. For more information see: http://www.nobelprize.org/nobel_prizes/chemistry/laureates/2014/press.html

[Chart of Big Numbers](#) I know that all the huge numbers for how many atoms there are in the body, how many stars there are in the universe and the distances to the furthest galaxies is confusing. So I made a chart that compares the numbers in different ways, using names, zeros and special units.

The big Number	Picture	Number	LIZZYS or Light Years	Scientific Notation
Number of Carbon Atoms in a piece of hair		1,000,000,000,000,000,000 18 zeros 1 million, trillion Carbons	100 LIZZY Carbons	1×10^{18} Carbons
Number of Molecules in the air in average house		10,000,000,000,000,000,000,000,000,000 28 zeros 10 thousand, trillion, trillion Molecules	1 trillion LIZZY Molecules	1×10^{28} Molecules
The number of Carbon Atoms in a human body		8,000,000,000,000,000,000,000,000,000 27 zeros 8 thousand, trillion, trillion Carbons	0.8 trillion LIZZY Carbons	8×10^{27} Carbons
The number of Carbon Atoms breathed in 60 years		268,000,000,000,000,000,000,000,000,000 29 zeros 268 thousand, trillion, trillion Carbons	26.8 trillion LIZZY Carbons	2.68×10^{29} Carbons
The number of Carbon Atoms in the atmosphere and plants		77,000,000,000,000,000,000,000,000,000,000,000,000,000 40 zeros 77,000 trillion, trillion, trillion Carbons	7.7 trillion, trillion LIZZY Carbons	7.7×10^{40} Carbons
Number of Stars in the Milky Way		100,000,000,000 11 Zeros 100 billion Stars	0.00001 LIZZY Stars	1×10^{11} Stars
Number of Stars in the Universe		10,000,000,000,000,000,000,000,000,000 22 Zeros 10 trillion, billion Stars	1 Million LIZZY Stars	1×10^{22} Stars
The distance across the Milky Way		580,000,000,000,000,000 17 zeros 580 million, billion miles	100,000 Light Years	5.8×10^{17} Miles
The distance from earth to the pinwheel		145,000,000,000,000,000,000,000,000 20 zeros 145 billion, billion miles	25,000,000 Light Years	1.45×10^{20} Miles
The distance from earth to the most distant Galaxies		75,000,000,000,000,000,000,000,000,000 22 zeros 75 billion, trillion miles	13 billion Light Years	7.5×10^{22} Miles

Chapter 10

[Recycling](#) When I was a kid, our school used to have paper drives. We kids collected old newspapers from the neighbors, tied them in bundles and our moms carted them to school. There was a huge pile of bundles at school that got taken away and used to make new paper and cardboard. We were recycling paper, turning the old paper into new. Today, most towns collect (right at your house) all kinds of recyclable materials including: paper, glass, metal and plastic. So, there are many more things being recycled, but the paper drive is dead. Why should we recycle things? The answer is that by reusing useful materials, we reduce the consumption of new raw materials, reduce processing energy, reduce air and water pollution, and reduce greenhouse gas emissions. So recycling is a win for everyone.

[Carbon Cycle](#) There is lots of carbon in the oceans, and soil and fossil fuels. But, that carbon is stuck there for long periods of time, like thousands of years. The places that George Washington's carbon is likely to go and the places where our carbon is likely to come from would be the atmosphere and plants, because that is the carbon that circulates the most. There is an estimated 800 billion tons of carbon in the atmosphere and 550 billion tons of carbon in plants. And these get mixed back and forth and circulate all over the world. So there is a total of 1350 billion tons of carbon which is 1.35 trillion tons.

[Used the oxygen to burn his body's fats and sugars](#) For your cells to function, they must have energy. That energy comes from the food you eat. The foods are digested and stored as fats and sugars. When energy is needed, the blood carries sugar and fat molecules to the cells, where they pass through the cell membrane into the cell. The blood also delivers oxygen. The chemistry is complicated, but eventually the oxygen is combined with the fats and sugars to produce energy for the cell, plus carbon dioxide and water, which are removed by the blood.

[Life for one kind of carbon is over 5000 years](#) The half life of Carbon-14, (6 protons and 8 neutrons in the nucleus), is 5730 years. If you have a block made of Carbon 12 and 14, that is the time for half of the carbon 14 atoms to decay to Nitrogen 14. In that decay one of its 8 neutrons decays to a proton (and an electron which flies off the atom) leaving 7 protons and 7 neutrons in the nucleus.

The half life of carbon 12 is 20 billion years (it is stable), so the ratio of Carbon 14 to Carbon 12 will decrease as the block get older. That ratio in an old fossil can be used to tell how old it is. That is called [carbon dating](#). Here is how it works. That natural ratio of carbon 14 to carbon 12 in the atmosphere is 1 part in one trillion and is constant in time. This is because new carbon 14 atoms are continuously being formed in the upper atmosphere (due to cosmic rays) to replace those that decay. When an organism is formed it has the natural ratio of carbon 14 to carbon 12. When the organism dies, it no longer gets carbons from the atmosphere and its carbon 14 decays. The change from the natural ratio when the organism was living to the ratio in the fossil determines how long ago the organism was formed.

Chapter 11

Global warming The earth's temperature is controlled by two things: 1. the energy radiated from the sun to the earth, sunlight in the form of photons of visible light, lower frequency infrared light, and higher frequency ultraviolet light that reaches the earth's surface; and 2. the energy radiated from the earth's surface that reaches outer space. Now, very hot things like the sun radiate mostly high frequency photons (visible and ultraviolet) while cooler things like the earth radiate lower frequency photons (infrared). You can see this effect on an electric stove where the heating coils look white when they are on high heat but dark red or no color at all when they are on low heat.

You need one more piece of information to understand Global warming. Infra red light is absorbed by molecules like carbon dioxide and other 'greenhouse gases' like methane. So, those molecules, if they are in the atmosphere, will absorb the energy radiated by the earth. When they release the energy as radiation, half will go into space and half back to the earth's surface. This trapping of infrared energy can make the earth warmer. There is no similar effect for the sun's energy coming in because the higher frequency energy of the sun is not absorbed by these molecules.

The same infrared energy trapping effect occurs in a greenhouse. Sunlight passes through the glass without absorption, while infrared light from inside the greenhouse is absorbed by the glass. The half of the absorbed light is returned to the inside and keeps the greenhouse warm.

So here is the problem. Carbon dioxide (a strong infrared absorber) has been increasing steadily for the last 100 years because of the increase in burning fossil fuels like coal and oil to produce electricity or run cars and trucks. There is no controversy about this observed increase. The increased carbon dioxide absorbs more of the radiation leaving the earth and returns more back to the earth. The higher the concentration of carbon dioxide, the more radiation that gets returned to Earth, and the warmer the Earth will get. The existence of this effect is also not controversial.

The debate is over how big the affect is. Has the man made increase in carbon dioxide led to the observed recent increase of a degree or so in the earth's temperature, or is the increase a normal part of the earth's temperature swings? It is important to know which is happening, because if it is a manmade increase in temperature it will get worse as more carbon dioxide is added to the atmosphere. Most climate scientists believe that the human contribution is the cause of the increased temperature. To control it, we must reduce our carbon dioxide emissions.

The Probabilities report for Chapter 12

The problem is to figure out: 1. the number of carbon atoms that George Washington (GW) added to the atmosphere and plants; 2. the number of carbons in the atmosphere and plants; and 3. your chances of getting one of GW's carbons when you take carbon from the atmosphere by growing and then eating an apple.

1. [the total number of carbon atoms that GW breathed out in his lifetime](#) We want to figure out the number of Carbon Dioxide molecules George Washington breathed out in his lifetime. He took 12 breaths a minute for 60 years so he took $12 \text{ Breaths/min} \times 60 \text{ min/hour} \times 24 \text{ hours/day} = 17280 \text{ breaths/day}$. In his lifetime he took $17280 \text{ breaths/day} \times 365 \text{ days/year} \times 60 \text{ years/lifetime} = 378,432,000 \text{ Breaths/lifetime}$.

Now we have to figure out the number of carbon dioxide molecules in each breath. We start with the knowledge from chemistry that every 22.7 liters of gas at standard pressure and temperature will contain 602 billion trillion molecules (Avogadro's number). If that was pure carbon dioxide, that would be one mole and would have a mass of 50 grams (where 50 is the atomic weight of the molecule). But only 4% of the gas is carbon dioxide and we have 2 about $2/3$ (0.667) of a liter in each breath. So $0.667 \text{ liter}/22.7 \text{ liter} \times 4\%/100\% \times 602 \text{ billion trillion} = 0.71 \text{ billion trillion carbon dioxide molecules per breath}$.

So the total number of carbon dioxides breathed out in GW's lifetime is $378 \text{ million breaths/lifetime} \times 0.71 \text{ billion trillion carbon dioxide molecules per breath} = 268,000 \text{ trillion trillion carbon dioxide molecules per lifetime}$.

2. [all the carbon atoms in the atmosphere, plants and animals](#). We start with Avogadro's number again, 602 billion trillion molecules in each 22.7 liters of gas. So, how many liters of gas are there on Earth? The surface of the earth is 510 trillion square meters and the height of the troposphere which contains $4/5$ of our air is 17,000 meters. So there are 8.67 million trillion cubic meters of air. There are 1000 liters in each cubic meter so there are about 40 times Avogadro's number per cubic meter at the surface of the earth. If we assume the average pressure is half of that, on the surface, then there are 20 times Avogadro's number per cubic meter in the atmosphere. The concentration of carbon dioxide is .04% or 400 for every 1 million molecules. So the total number of carbon dioxides in the atmosphere is $602 \text{ billion trillion}/22.7 \text{ liter} \times 8.67 \text{ million trillion cubic meters} \times 1000 \text{ liters per cubic meter} \times 400/1,000,000 \times 0.5 \text{ atmospheres which equals } 46,000 \text{ trillion, trillion, trillion molecules of carbon dioxide}$. But there are an additional 31 trillion, trillion, trillion carbons in the [plants and trees](#). So 3.5 of every trillion carbons in the atmosphere and plants came from GW

3. [An apple will have a huge number of carbon atoms](#) Start with the weight of an apple as 100 grams of which 42% is carbon, so an apple contains 42 grams of carbon. That would be $42/12$ times Avogadro's number or 2 trillion, trillion carbon atoms. So an apple will contain 7 trillion carbon atoms that came from GW.

Chapter 14

[Light year](#) The distances to other places in space are huge. For example, the distance from the earth to the sun is 93 million miles, the distance to the closest star, Proxima Centauri, is 24 trillion miles and the distance to the nearest galaxy, Andromeda, is 14 million trillion miles (14,000,000,000,000,000,000 miles). Astronomers decided that giving distances in such large numbers of miles or kilometers was not very efficient or easy for comparing different distances.

So they decided to invent a new unit of distance called the light year. (Lizzy used the same idea in chapter 8 to describe the large number of atoms in a piece of hair.) The light year is the distance that light travels in one year. Since the speed of light is 186,282 miles per second, it travels 5.79 trillion miles per year. Since light takes only a little over 8 minutes to come from the sun, it is not a good unit to use for the distance to the sun. But Proxima Centauri is 4.22 light years away, and Andromeda is 2.5 million light years away.

When looking at an object in a telescope, the light year tells us something interesting besides distance. It is the time it took for the light we now are seeing to get here. So we are really seeing how the object looked at some time in the past. So when we see Andromeda in a telescope, we see how it looked 2.5 million years ago. When the Hubble telescope takes pictures of the furthest objects away from us, it is actually seeing what they looked like 13 billion years ago, not that long after the BIG BANG. So looking at objects that are further and further away, lets us look at earlier and earlier times in the history of the universe. So, when you see the Andromeda Galaxy, you see it as it was 2.5 million years ago. It is called "looking back in time." The further away an object is, the younger you are seeing it.

Grandpa's Extra Information For Chapter 15

The earth revolves in paths, called orbits, around the sun. In the solar system, the earth travels in a path around the sun, called an orbit. To understand an orbit, take an object attached to a string (such as a yo-yo) and twirl it around. The path it travels is a circle. A force is required to change the direction of an object to keep it in the circle. For the yo-yo, that force is supplied by the string, and since the string has a fixed length, the orbit is a circle. For the earth, the force of attraction to the sun is gravity, and that force depends on the distance between the earth and the sun and the mass of each object. The force of attraction = (G x Mass of earth x Mass of sun) divided by the distance r, squared). G is a constant. So the force varies as $1/r^2$. The general orbit for such a distance dependent force is an ellipse where the circle is just one special case of an ellipse.

1 over distance squared part of the law of gravity. Sir Isaac Newton's law of gravity proposed in 1687 is

$$F = G \frac{m_1 m_2}{r^2}$$

where **F** is the force, **m₁** and **m₂** are the masses of the objects interacting, **r** is the distance between the centers of the masses and **G** is the gravitational constant. So the force varies as 1 over r^2 . This is called the inverse-squared law. Newton also discovered that the acceleration of a body was proportional to the force exerted on it,

$$F = ma$$

where \mathbf{F} is the force, \mathbf{m} is the mass of the object and \mathbf{a} is the acceleration. So Kepler's observation that the acceleration of the planets in his orbits was always a constant times $1/r^2$ was an important contribution to the law of gravity.

Chapter 16

Cepheid variable stars Cepheid variable stars are special stars whose appearance cycles from large and bright to smaller and dimmer. Henrietta Leavitt had a hunch that the time (period) it took to go from bright to dim might depend on the size of the star. To test her idea, she reasoned that stars in the Small Magellanic Cloud (a distant star cluster) would be about the same distance away from earth, so their brightness would indicate their size. She found 25 variable stars in the cluster and determined that the period varied with the size. Bigger stars took longer to change than smaller stars. Knowing how the change period varied with a star's size allowed astronomers, for the first time, to determine the size of any Cepheid variable star in the universe. By knowing the size, the astronomers could use the peak brightness to determine the distance from earth.

Chapter 18

Cosmological Constant The solutions to Einstein's General Relativity equations predicted that the universe would be expanding or contracting. At that time everyone believed that the universe was static. So Einstein added a term to his equations called the Cosmological Constant to 'hold back gravity' and achieve a static universe. But Edwin Hubble's measurements showed that the universe was expanding, so now the Cosmological Constant could be removed. But wait a minute, cosmologists have discovered that there is something called dark energy that is acting like anti-gravity material in accelerating the expansion of the universe. So now the Cosmological Constant is back in the equations of General Relativity.

Dark Energy Dark Energy is another fudge factor. It is actually the same fudge factor that Einstein called the Cosmological Constant. So what is the problem this time. Lets consider an experiment. Through a ball in the air. What happens? Force of gravity pulls on the ball, causing it to accelerate in the direction of the force, which is toward the earth. So as you know, the ball will slow down, turn around and accelerate back towards you. But what if it didn't behave that way. What if it started accelerating away from the earth. We would have to assume that there was a stronger force pulling the ball up, or some other force pushing it up. Well, that is the problem with the universe. It is expanding and our normal physics would suggest that the expansion should be slowing down as gravity exerted its force to pull the galaxies back. But the galaxies are accelerating away, not back. Ok, new fudge factor. All of space is filled with Dark Energy and that is what exerts the push against gravity. Calculations show that Dark Energy constitutes 73 percent of all the matter and energy in the universe. So if Dark Energy is 73% then matter is 27%. And Dark Matter is 85% of that 27% or 23%. That leaves only 4% of the energy and matter in the universe as the stuff, the visible matter, we really know about.

The BIG BANG The planet Earth that we live on is a Goldilocks planet. It is not too hot. It is not too cold. It is just right as a home to support the lives of beings such as our own species and millions of others. And our species has been constantly fascinated with the questions of where we live and how we got here.

More than two thousand years ago, humans looked at all the things in the sky and decided that the universe consisted of the Earth at the center with the Sun, Moon and stars all revolving around the Earth. In the 15th and 16th centuries, Copernicus and then Kepler and Galileo said that the universe has the Sun as the center and everything revolves around the Sun. Then, in the 19th century the picture changed to the Sun and planets revolving around the center of the Milky Way galaxy. In the early 20th century, the work of Henrietta Leavitt, and Edwin Hubble showed that the Milky Way galaxy was only a small part of the universe, which has billions more galaxies like the Milky Way. What's more, Hubble's measurements, and Alexander Friedmann's and Georges Lemaitre's predictions, showed that the universe is expanding, with the most distant stars moving away from us the fastest.

Based on the expansion of the universe, Lemaitre made a bold prediction. He reasoned that if you follow the universe back in time, it gets smaller, the further back in time you look. So if the evolution of the universe were a movie showing its expansion, and you played it backwards it would be contracting. The contraction of the universe would put the universe in one tiny super dense point about 14 billion years ago. Lemaitre pictured the expansion of the universe from that point as the hatching of the *'Cosmic Egg exploding at the moment of the creation.'* Other scientists call this the BIG BANG theory. Lemaitre gave lectures explaining his theory, including at Princeton University, where Albert Einstein was in attendance. It was reported that Einstein said, *"This is the most beautiful and satisfactory explanation of creation to which I have ever listened."*

How do we know that the BIG BANG theory is correct? Well, scientists can calculate what occurred as the universe expanded from that first point. They can make predictions about the concentrations of elements in the universe and about the leftover radiation from the earliest times, which can still be seen as the cosmic microwave background. They can predict the size of stars, galaxies and galaxy clusters, and the rate of the universe's expansion. Compared with these observations, the BIG BANG theory is very accurate.

When we look at all the things that have to be just right for the universe to evolve as it has, and for us to be here on our Goldilocks planet, it seems that we live in a Goldilocks universe, too. But we understand our Goldilocks planet as being the one that is just right in the millions of other planets that aren't just right. Of course, living things may be on the ones that are just right and not on the others that aren't. So is our Goldilocks universe just the one that is right out of the millions of other universes that aren't just right? Are there millions of other universes out there that aren't just right? So, just like we found the Earth, and then the Sun, and then the Milky Way galaxy were only a small part of the universe, maybe the universe that evolved from our BIG BANG is only a small part of the multi-verse. Or was there a creator of the Goldilocks universe that chose the conditions to be just right?

Chapter 19

[Goldilocks Planet](#) We live on a Goldilocks Planet. It is not too hot, it is not too cold, it is just right. Well most of the time. It also has water and all the other atoms need for life as we know it. So if life as we know it exists out there on some other star system, it will be on a planet that is also just right. So astronomers call such planets the Goldilocks Planets. Astronomers believe that there could be billions of such planets out there.

[Dark Matter](#) Dark matter is what we scientists call a fudge factor. We put it into our theories when the physics we know doesn't work. So, why do we need Dark Matter? Where does our physics not work? The answer is the structure of the universe. Normal Physics says it shouldn't look like it does. Take a galaxy like our Milky Way. It is rotating like a pizza dough when the pizza guy tosses it in the air to make it bigger because of centrifugal force which wants to push the dough away from the center. You feel that force when you stand at the edge of the playground merry-go-round. If you don't hold on, you fall off. Well gravity is holding on to the stars at the edge of the Milky Way disk as it rotates. But, gravity from the visible matter isn't enough to do the job. Our Milky Way would fly apart if the only gravity was from visible matter. Hence, the fudge factor. Let's assume there is enough matter to do the job of keeping the stars from flying off the galaxy. But we can't see it, hence the name Dark Matter. Calculations show that Dark Matter makes up more than 85% of the total matter in the universe.

[Dark Energy](#) See Dark Energy in Chapter 18.

[Multiverse](#) The idea that we live in a Goldilocks universe implies that there are many other universes (millions or billions) that have the range of possible constants and physical laws that exist. We live in the one that has the right set of constants and physical laws that support our existence. All of these universes make up everything that exists including all of space, time, matter and energy. The other universes are called parallel or alternate universes.

Chapter 20

[Radiolab](#) Broadcast at <http://www.radiolab.org/story/dinopocalypse/> This PBS radio broadcast explores new findings about how the terrestrial or land dwelling dinosaurs became extinct. It had been believed that the dust from the impact of a Mount Everest sized asteroid or comet covered the earth for long enough to block the sun, so that all vegetation died and consequently the dinosaurs died of starvation. But new evidence suggests that the dust was ejected out of the atmosphere, spreading out, with some of it reaching the moon. When gravity started to pull it back into the atmosphere, the dust behaved like tiny meteors and burned up during their descent to earth. This rain of burning particles was sufficient to heat the earth's surface to 1200 degrees Fahrenheit, a temperature high enough to kill anything on the surface. Only sea dwelling and burrowing creatures survived.

Dark Matter and the Dinosaurs In her book. Dark Matter and The Dinosaurs, <http://www.amazon.com/Dark-Matter-Dinosaurs-Astounding->

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terconnectedness/dp/0062328476#reader_0062328476 particle physicist Professor Lisa Randall of Harvard makes a case that Dark Matter had something to do with killing off the dinosaurs. Her proposal goes like this. When geologists and paleontologists look at the fossil records, there appears to be evidence that a major species extinction occurs every 30 to 33 million years. So she asks, is there a physical reason to explain that. There is a physical event that has such a period. It is the oscillations of our solar system up and down above through and below the plane of the Milky way disk as it makes it way around the galaxy during its 225 million year orbit. Each such orbit makes a galactic year. The idea is that the passage through the plane which its higher gravitational field might knock comets and asteroids out of their normal orbits around the sun, and some of these unhinged bodies might hit out planet. But calculations of this affect suggest gravity from normal matter is not sufficient to dislodge these objects from their orbit. Hence, she proposes that there is some extra gravity exerted by a disk of dark matter which lies within the disk of the visible Milky Way. The combined gravity from the normal matter disk and the dark matter disk might be enough to do the job. But Processor Randall proposes that only a small fraction of Dark Matter can make such disks by radiating energy to allow the cloud to flatten. Most Dark matter doesn't radiate energy. That is why it is dark. But just like regular matter has different particles like quarks and Higgs bosons, Dark Matter may have some diversity too.

[Continental Drift](#) Continental drift was a theory proposed in 1912 by Alfred Wegener, a geophysicist and meteorologist, that explained how continents shift position on Earth's surface. The theory proposed that the present continents were once joined, forming a supercontinent. It explained why look-alike animal and plant fossils, and similar rock formations, are found on different continents. While details of how the continents moved were incorrect, the general ideas were important. Today, the theory of continental drift has been replaced by the science of plate tectonics that provides the explanation for how the contents move.

Chapter 21

[How the heavy atoms form in a supernova](#) For Chapter 2, I added some extra information on nuclear fusion. There is a picture of two heavy forms of hydrogen atoms, deuterium and tritium, banging into one another to form Helium and a neutron. The requirement for fusion to take place is that the banging has to be done with lots of energy. The two hydrogens have to be going very fast to make the fusion happen. In this case, where helium is formed, a temperature of 15 million degrees C is required. That temperature was available during the BIG BANG, and is available at the center (the core which is the hottest part) of our Sun. The temperature in the BIG BANG and on the Sun is also hot enough to form some smaller amounts of lithium (3 protons) and beryllium (4 protons), and in the core of the sun, small amounts of carbon, oxygen, nitrogen and other elements.

The formation of larger atoms requires much higher temperatures. Where can we find higher temperatures? Stars that are bigger than the Sun have more gravity crushing the atoms together, and so the temperatures in their core is hotter than on our Sun. The biggest stars can form big

atoms in their cores. Another place for higher temperatures is in a Supernova. When big stars have used up all their hydrogen (about 5 billion years after they formed) they start to cool. Then gravity starts to crush all the atoms into the center. This creates fusion reactions of bigger atoms and much higher temperatures. The core gets so hot, 100 billion degrees, that fusion runs away, producing atoms up to uranium with 92 protons and the star explodes in what is called a supernova. The explosions are so spectacular, that they can be seen with the naked eye from earth. They can last for up to 2 years.

Supernovas do three things that are important for us to exist: 1. they created the heavy atoms we needed to form a solid earth to live on and the atoms required to make living things; 2. the explosion rocketed those atoms out into the universe where eventually they could condense to form the earth and us. Those atoms that formed in the supernovas are the STARDUST; and 3. supernovas produce gamma rays which may help to drive mutations, important in the evolution of species

[Nucleosynthesis](#) The term used to describe the formation of new atomic nuclei by nuclear reactions. Nucleosynthesis occurred shortly after the BIG BANG to form hydrogen, helium and some other light atoms. It occurs in the interiors of stars and during supernovae to form the heavier atoms in the periodic table.