Exploring the Unseen

Some explorers lift off into space. Others dive deep beneath the sea or trek through mountains or rain forests. Shirley Ann Jackson explores the universe too, but on a smaller scale and from a different perspective. She is a physicist who investigates the world on a submicroscopic level. She studies the tiniest elements of the universe, the particles that make up all matter.

Why is it so exciting to learn about things you can’t even see? Split one of those tiny particles and you could cause catastrophic destruction. Or you could harness its powerful force to improve the way we work and play and live our lives.

Because of Shirley’s scientific expertise and her willingness to take on new challenges, her career has moved in exciting directions. In industry, she worked on the cutting edge of technology, discovering ways for materials to be more useful in our everyday lives. When President Bill Clinton asked her to head the Nuclear Regulatory Commission in 1995, she made sweeping changes to ensure the public’s safety, in our own country and around the world. As president of Rensselaer Polytechnic Institute, she is creating unique opportunities for the next generation of scientists.

How did Shirley Ann Jackson achieve so much? She began with a curious mind and a passion for uncovering the secrets that lay hidden in the world around us.
To Shirley,  
the world was  
full of *mysteries*  

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that could help *solve* *them*. 
Shirley Ann Jackson stood in the hot summer sun, patiently staring at a large rosebush in her family's garden. It was still early morning, but already the heat was beginning to build. Shirley could feel a sneeze making its way through her nose. At 10 years old, Shirley was allergic to many things, including the pollen from the flowers she admired so much.

But this day, Shirley wasn't just admiring the garden of her family's home in Washington, D.C. She had important work to do. She was capturing bees.

As a large bumblebee headed for the rosebush, Shirley tensed in anticipation. The bee hovered over the bush, flitting here and there until it found just the right spot. It touched down and nestled itself into the center of a wide-open bloom. Shirley watched its fuzzy body vibrate as it slurped up the flower's nectar.

Carefully—very carefully—she reached down with one hand and closed the petals around the bee. She held her breath slightly, then gently plucked the bloom with her other hand. She could feel the bee's wings beating frantically inside the petals as it tried to escape. But that didn't worry Shirley. She had been capturing bees this way since she was eight years old. By now, she knew exactly what to do.
She dropped the bloom containing the bee into an empty mayonnaise jar. Quickly—before the bee even knew where it was—she screwed on the top, which already had tiny holes punched in it so the bee could breathe.

Shirley carried the jar with her new specimen to the wooden porch in the back of the house. She scooted under the porch where it was dark and cool, a perfect place for her bee collection. When her eyes adjusted to the dim light, Shirley picked out a spot on a ledge where she would put her newest addition. It would sit between two other jars. One held three yellow jackets and a wasp, and the other held a wasp and a bumblebee. The summer was only half over, but she had already collected dozens of bees in jars that her mother had cleaned out for her.

~ Bee Behavior

Some people thought it odd that a young girl would want to collect bees. After all, bees sting! And most of the other kids were afraid of them. Amazingly, Shirley had never been stung. But she wasn’t just collecting bees the way some people collect dolls or marbles. She had a purpose: to learn about bee behavior and in that way unlock one of the secrets of nature.

To Shirley, the world was full of mysteries, and living creatures provided the clues that could help solve them. She chose bees to study because they were always buzzing about and she would never run out of specimens. Plus, they were easy to keep in captivity.

Shirley had several questions about bees. For example, she wanted to know how they might behave if they were fed certain things. To find out, she had a different way of capturing them. She waited until the bee was at the edge of a flower petal. Then,
holding the jar on one side and the top on the other, she closed the bee into the jar without the flower. She added different foods, such as sugar, for the bees to eat. Then she observed their behavior after they ate the different foods.

At first, she kept the bees with their own kind. Then she wondered how they would behave with other species. She decided to mix them all up: bumblebees with yellow jackets, wasps with bumblebees, yellow jackets with wasps. The bumblebees seemed to be the most aggressive at first, but eventually all the species of bees got along pretty well with each other.

Shirley also wondered how the bees would act if they spent more or less time in the dark. In their spot under the eaves the bees were in the dark a lot of the time. Shirley would bring them out during the day to see if their behavior was different when they were in the light.

Like any good scientist, Shirley kept a detailed log of her observations. And when she analyzed her data she discovered some interesting things. For example, Shirley noticed that under normal circumstances, bees have a circadian-type rhythm—or a pattern of behavior that is repeated every 24 hours. Shirley found that she could change this rhythm by changing how long she kept the bees out of the light. If the bees stayed in the dark under the porch until the middle of the day, they tended to behave as though it were the middle of the night.
Lessons from the Bees

Surprisingly, the most important thing the bees taught Shirley was not so much a scientific lesson as a lesson about life itself. Shirley realized that no living thing likes to be in captivity. When the bees were first caught, they would bang against the side of the jar, trying to get out. Over time, they got more and more passive. That’s when Shirley knew it was time to let them go. But by then the bees had become so used to their new environment that sometimes they didn’t leave right away, even after Shirley opened the jar. It was as though they had given up. So Shirley would leave the jars open for as long as it took for the bees to fly away.

As Shirley got older, she saw the lesson of the bees repeat itself in the human world around her. Shirley realized that, just like the bees, people can easily become conditioned to having their space and their possibilities limited. And just like the bees in captivity, these people may simply stop trying.

Shirley’s parents already knew this reality all too well. George H. Jackson, a postal supervisor, and Beatrice Cosby Jackson, a social worker, were African Americans raising a family in the 1950s. They saw the limits placed on black children every day. At that time, segregation laws in the United States meant that blacks were not allowed to use the same facilities as whites. In addition to attending separate schools, African Americans drank from different water fountains, used separate restrooms, sat in the backs of buses, and were often barred from eating in the same restaurants as whites.
Though the Jacksons lived only a few blocks from the Barnard School, a public elementary school, they were forced to send their children to Parkview Elementary, an all-black school a couple of miles away. It was more than an inconvenience. The city did not provide school bus service, so families had to figure out on their own how their children would get to and from school each day.

The fathers on Shirley’s block banded together to work out a car-pooling system. One father would take the kids to school in the morning and another would pick them up in the afternoon. Each time, they drove right past the “whites only” school.

Segregation was a reality, but Shirley’s parents believed that their four children, Barbara, Shirley, Gloria, and George, should still strive to achieve their potential. Education, they knew, was essential for success. “Aim for the stars, so that you can reach the treetops, and at least you’ll get off the ground,” their father would urge.

Both parents encouraged any educational activities that interested their children. Beatrice had a lifelong love of literature and read to them every night. One of Shirley’s favorite books was a biography of Benjamin Banneker. Born in 1731, the African-American son of a former slave was a self-taught clockmaker, astronomer, and mathematician. When Shirley’s hometown of Washington, D.C., was being built, Banneker helped survey the land, plan the streets, and select building sites. Shirley drew inspiration from this man who refused to let the prejudices he suffered hinder his intellectual development.
While Shirley’s mother instilled in her a love of literature, her father shared his talent for mathematics and science. Though he had only a high school education, he had a great thirst for knowledge and a natural ability for math and mechanical things. He had put these gifts to work during World War II. During the Allied landing at Normandy in France, the vehicles that transported the soldiers from water to land lost their rudder mechanisms. This made them vulnerable to enemy fire. Shirley’s father fashioned a new steering mechanism for these vehicles from scrap metal, which ensured the safety of the soldiers. For this accomplishment he received a Bronze Star and a special citation.

Now a father, he amazed his children with the mathematical calculations he performed in his head. And after tackling tasks from rebuilding car engines to finishing the family basement, he seemed to have every tool imaginable in his workshop. He encouraged his children to learn to use them.

George Jackson also enjoyed showing his children how to use scientific principles to add some fun to their everyday lives. This included teaching Shirley and her younger sister, Gloria, how to build soapbox go-carts or “hot rods.” These wooden racing cars were built from spare parts. They rolled downhill just from the power of a big push.

To build their hot rod, Shirley and Gloria started with wooden planks for the body. Then they went scavenging through the neighborhood for various other parts, such as wheels, pipes, bolts, and pedals. The tricky part was the steering. Shirley tried all kinds of steering mechanisms, but ultimately settled on bicycle handles.
The finished result looked like a cross between a sled and a wagon.

Shirley, a born leader, organized go-cart races with some of the neighborhood kids. The neighborhood was built on hills, so the drivers could use gravity to propel the carts. They would line up their hot rods in the alleyways that ran between the houses and get ready to race.

Shirley soon figured out that the trick to winning a race was to build a cart that would naturally go faster than the others. This meant that the builder had to be clever in choosing axles and wheels, as well as the bearings around the wheels. Attention also had to be paid to the most important element of the design: the sleekness and shape of the cart's body.

Shirley found that if she made the front of the body narrower than the back, the air would flow around it more freely. This aerodynamic shape reduced air resistance and made the cart go faster. She did not know it at the time, but in designing her go-cart, Shirley was making the same kinds of decisions that car manufacturers make every day. These design decisions were based on physics, the science of matter and energy.
Shirley enjoyed winning the races. What she liked best, though, was figuring out what kinds of materials and design increased speed and efficiency. She also liked to consider where to position the cart before the race in order to get the maximum speed. By doing all this, Shirley was actually learning about applied physics. (See box.) She was also learning valuable lessons in leadership.

One particular race taught Shirley another kind of lesson. After Shirley won the race, one of the neighborhood kids became angry. In a jealous rage, he jumped up and down on the Jacksons’ cart and broke it in two. Gloria was devastated. Shirley was upset, too, and not just because all their hard work was ruined. She hated to see her family or friends hurt or treated unfairly.

Even as a young girl, Shirley had the ability to recover from hurt and to not let obstacles stand in her way.

**Bodies at Rest, Bodies in Motion**

Like everything else on Earth, Shirley’s go-carts obeyed the basic principles of physics called Newton’s Laws of Motion.

**Newton’s First Law of Motion** includes the idea that an object at rest will remain at rest unless an outside force acts upon it. In the case of the go-cart, Shirley knew her cart would sit at the starting line unless a force—such as gravity, someone giving the cart a push, or both—set it in motion.

**Newton’s Second Law of Motion** describes the relationship between mass and acceleration. This law states that the more mass something has, the more force is needed to change its motion. It also says that the stronger the force, the greater the acceleration.

So what did this mean to Shirley? She knew she couldn’t make her go-cart too big or it would be hard to push off the starting line. And she also knew that the starting push would be critical. The bigger the push, the faster the go-cart could move down the hill.

**Newton’s Third Law of Motion** states that for every action there is an equal and opposite reaction. This law would have come into play if Shirley’s cart had accidentally veered off course and hit another cart!
So Shirley considered what she should do. Although she didn't like to back down from a fight, Shirley was smart enough to know that the best revenge was not to get even, but to succeed.

Determined, she went back to her father and asked him to help rebuild the cart. The girls returned another day with the rebuilt cart and went on to race it again and again.

Even as a young girl, Shirley had the ability to recover from hurt and to not let obstacles stand in her way. She also had the power to persevere. This strong inner force and her dignified manner would carry Shirley through other challenges and obstacles in her life.