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A Book Report: Charles Townes
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On July 21, 1969, astronauts Neil Armstrong and Buzz Aldrin set up a series of small reflectors on the surface of the moon and faced them toward the earth. A few days later two teams of astrophysicists on earth – 240,000 miles away – sent a narrow beam of extraordinarily pure red light, from a crystal of synthetic ruby through two large telescopes, to bounce off those tiny reflectors on the moon and return to earth. The interval between the launch of that pulse of light and its return permitted calculation of the distance to the moon within less than one inch. This pulse of pure light was a laser and its application, since that time, in our daily life has become almost commonplace. Lasers are used in almost every conceivable field from medicine to surveying to communications to monitoring air pollution. The smallest lasers are so tiny one cannot see them without a microscope – thousands can be built on semiconductor chips like those that form the hearts of computers. The largest lasers, like those at the Lawrence Livermore National Laboratory, are more than 400 feet long and can focus a beam of light on a spot the size of a pinhead – generating temperatures of many millions of degrees. All of these amazing instruments, that have significantly improved our quality of life, owe their existence to one remarkable and fascinating man – Dr. Charles Hard Townes.

"How the Laser Happened" is a personal, engaging story of the life and discoveries of one of the twentieth century's greatest scientists. It is a human study of how focused research and openness to new ideas can result in life-changing discoveries, dwelling less on the technical specifics of scientific research and more on the personal influences that guided and motivated Dr. Townes throughout his professional career. That career as a physicist, engineer, astronomer, and humanitarian has led to more than 30 patents and a Nobel Prize in Physics for the development of the maser and laser. In addition to his fundamental research in microwave spectroscopy, he has served the governmental and scientific communities in many different capacities. He has been a personal advisor to six presidents and was the founder of the President's Scientific Advisory Committee in 1958. He helped develop the atomic clock. He was a founding member and chairman of the controversial "Jasons", an influential group of scientists that independently advises the government on defense policy. He served as chairman of The Science and Technology Advisory Committee for the Apollo space program and was responsible later for leading the discovery of a giant black hole at the center of our galaxy. He currently serves as Chairman of the Pontifical Academy, a group that advises the Pope on all scientific matters.

It all started on a 20-acre farm that his father Henry Keith Townes owned on the edge of Greenville – on the site of today's St. Francis Hospital. Charles Townes grew up working on the farm helping the family grow cotton, corn, and sweet potatoes and fell in love with the natural world as he played in the fields and streams with his older brother. He doesn't remember deciding to be a scientist but instinctively knew, from a young age, that he would either be a scientist or a teacher of science. He was an eager student and his parents allowed him to skip the seventh grade. He enrolled in the local college – Furman University – at the age of 16. He earned money to help with tuition by tutoring, taking care of the Furman Museum and selling apples from the family's farm. He satisfied all of the requirements for his B.S. degree in Physics in only three years but his parents felt he was too young to go off on his own so he put in a fourth year and graduated with a second degree, a B.A. in Modern Languages. He was one of only two Furman physics graduates in 1935, which did not help much getting a scholarship or fellowship to any of the major graduate schools.

Luckily he was offered an assistantship at Duke University and was assigned the job of setting up and operating the new Van de Graaff generators the University had purchased to get a nuclear physics program started. He developed new ways that the Van de Graaff might be used as early accelerators using static electricity to give proton beams energy and wrote his thesis by the spring of 1936, which qualified him for a master's degree. His faculty advisor felt that because they had never had anyone finish in just one year, it might not look too good and advised him to wait a year. Townes asked if he could leave and they could mail him his degree later - which is why his degree is dated 1937. Once again, he had finished school so quickly that he had some difficulty getting financial help to attend preferred schools like MIT, Cornell, Chicago and Princeton. So, he saved up $500 and headed off to Caltech.

It had been a good idea. At Caltech, he was invigorated by new ideas and influenced by many memorable characters. Here he learned that experimental physics and research was his calling and began to focus on molecular spectroscopy. He wrote a paper for the America Physical Society on the nuclear spin of Carbon 13 which ended up as the core of his thesis for his Ph.D. in 1939.

It seemed absolutely clear that the ideal next move was to a faculty position at a good university where he could teach and do research. Unfortunately, during the Great Depression of the 1930's the research-oriented universities were hiring almost no new physicists. The new Dr. Townes needed a paycheck. One of his friends talked him into filling out an application for a job with AT&T's Bell Laboratories. They offered him a job and with very little enthusiasm, he accepted. It turned out to be the smartest move of his career. He was assigned to work first in the field of magnetics, then in microwave generation and then in electron emission from surfaces. But the war in Europe was growing hotter and it looked as if the U.S. would have to become involved. Bell labs was becoming involved in the development of electronically guided anti-aircraft guns and put Townes to work designing a radar bombing system by adapting the technology used for anti-aircraft guns. He spent the next five years working on new radar systems and became fascinated with radio waves and magnetic fields.

He became more and more convinced that microwave spectroscopy or the study of those frequencies of the microwave spectrum from 1,000 megahertz to 300,000 megahertz that are selectively absorbed by certain materials, was the direction he needed to move in with his research and he received an offer to continue that research at Columbia University. By this time the armed services had become more interested in microwave research because of the opportunities for more efficient radar systems and offered block grants to Columbia for continued research. After the lessons of World War II, the military had learned to listen to the scientists and wanted to be sure that no fruitful avenues for practical technologies were missed. Unfortunately, after some months the idea of studying short wavelength microwaves began to lose some of its appeal and Townes was in danger of losing the military's support and money. Charles Townes was convinced that it was possible to amplify and transmit an intense, highly focused beam of high-frequency radio waves which could be of tremendous benefit to communications and precision measuring. He assembled a scientific committee, for the Navy, to study the problem but after months of work, even his committee members were a bit skeptical.

While in Washington, in 1954, he shared a room at the Franklin Park Hotel with Dr. Arthur Schawlow and one morning he awoke shortly after dawn wrestling with the amplification problem. Not wanting to wake Schawlow, he went for a walk in Franklin Park. In the fresh Spring morning air of the park he could smell the azaleas in full bloom and became absorbed in the beauty of nature. As he enjoyed the fresh air he began to mull over why they had not been able to make any progress and then suddenly the solution came to him. This is the part of the book where he gets very technical and to describe his solution, involving an oscillator in which the basic frequency control arises from an atomic resonance, would take much longer than my allotted time. Anyway, he pulled out an envelope and wrote the formula for the MASER on the back. He named his creation a MASER, which is an acronym for Microwave Amplification by Stimulated Emission of Radiation.

Dr. Townes continued his research into wave amplification and soon was able to apply his theory of atomic resonance to the areas of visible light waves. His new brainchild was named the LASER which is an acronym for, Light Amplification by Stimulated Emission of Radiation and the rest, as we say, is history.

Charles Townes writing his MASER formula on an envelope in the S. Main St. sculpture by artist Zan Wells. *(Photo courtesy of John M. Nolan.)*

In 1964 Dr. Charles Hard Townes received the Nobel Prize in Physics for "Fundamental work in quantum electronics which led to production of oscillators and amplifiers according to the maser-laser principal," or as was more simply stated by physicist Bengt Edlén who introduced him at the Nobel Ceremony, for "invention of the maser and laser".

This intriguing story of the laser doesn't stop there, however. Dr. Townes goes on to describe his continued exploration using the laser and maser, including his discovery of natural masers in outer space. He helped develop the Hydrogen Maser which emits a very sharp, constant oscillating signal, thus serving as a time standard for an Atomic Clock. His work in astrophysics using the laser to measure the size and mass of stars has provided scientists with new and exciting data about our solar system. His continuous exploration in the field of microwave spectroscopy has produced a wealth of new information on molecules and even on the masses of atoms and the structure of their nuclei. He is truly a fascinating man and his book is one that you will find difficult to put down.

He closes his book with this statement:
"I myself feel very fortunate to be able to spend my life exploring and to be a part of the scientific community, enjoying science and the intimate, powerful connections that it turns up. Scientific principals are so general and pervasive that they continually show up as familiar friends in new territory – or with exploration in any direction. I am both thrilled and intrigued by nature's beauty. Somehow, essentially every aspect of nature can be inspiring and beautiful. A calm sea and a stormy sea are both strikingly esthetic and beautiful. So is the structure of an atom, a field fresh with flowers, a desert, an insect, bird, fish, star, galaxy, or the mysteries of a black hole. As I have had a chance to explore and try to understand, I feel enriched – not just by the usefulness of science, but by its awesomeness, connectedness, and the beauty of all its dimensions. Scientific exploration is indeed fun, and thinking over the experiences or the pathways that my colleagues and I have excitedly enjoyed is an occasion to be thankful."