

Messages from Modern Inventors to the Next Generation

7. Development of the Electron Microscope and Discovery of Carbon Nanotubes

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Carbon nanotubes are nanometer-size tubular shaped materials made of carbon atoms that can only be seen with an electron microscope. They are attracting the attention of researchers all over the world because they are much lighter and dozens of times stronger than iron. Dr. Iijima, who conducts research on new materials using electron microscopes, succeeded in observing individual rows of atoms of various substances for the first time in the world. Carbon nanotubes were discovered while conducting such research.

What inspired you to become an inventor/researcher?

Although I am now conducting research on new materials using electron microscopes, it isn't that I wanted to become a scientist when I was a child.

As I went to elementary and junior high school in the years right after the end of World War II, I used to play in a natural environment and would play in rivers or collect insects and plants. I also tended to do things on my own such as make model ships, airplanes, and trains or build kites and radios. So I might have had an aptitude for science from the time that I was in elementary school. Furthermore, as I had good physics, chemistry, and biology teachers in high school, my interest in science was somewhat roused, but I still could not decide my future course in life.

I majored in electrical communication in university but devoted myself to club activities and didn't study very hard. However, when I became a senior and was assigned to a laboratory, I encountered a

theoretical chemistry professor who showed me the fascination of pursuing one's studies. I made up my mind to go to graduate school in the summer of my senior year and started preparations. I decided to specialize in basic science and chose the Department of Physics in the Faculty of Science. It was there that I first came into contact with an electron microscope. It turned out that this field of study suited me best, and at last, I was able to find a career that I wanted to pursue for the rest of my life.

What specific ideas and difficulties have you faced as an inventor/researcher?

An "invention" is defined as a new creation based on knowledge and methods that are already known, while a "discovery" is defined as the finding of something new despite one's initial intentions. Since carbon nanotubes were found by chance in an attempt to find other carbon materials, they are considered to be a discovery. Such a discovery is called "serendipity". Looking only at the results, it may seem that the discovery of carbon nanotubes was accidental. However, we cannot ignore the various factors that led to the discovery including the research conducted over the years and the knowledge accumulated through the examination of materials using electron microscopes, experimental technology, profound insight, research environment, etc. Although many great discoveries in the history of science were made by accident, it is not possible to continue one's research with the goal of making an accidental discovery. I believe that it is important to keep in mind at all times when conducting research toward a specific goal that something interesting other than the goal may be happening. The famous French scientist Dr. Pasteur once said, "Chance favors the prepared mind."

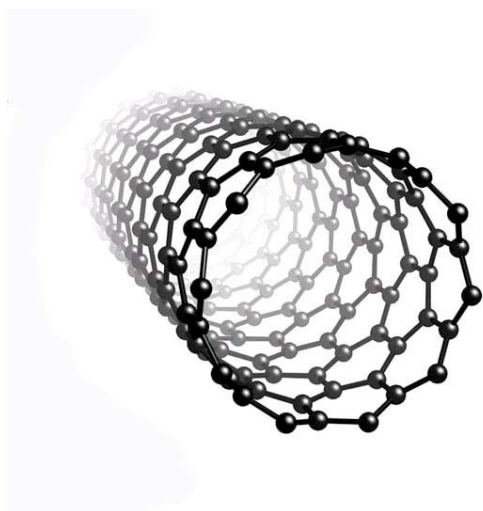


Diagram of a single-wall carbon nanotube model

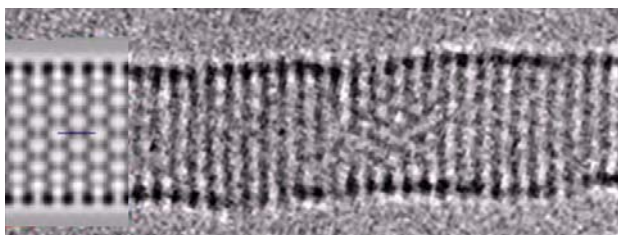
What gives you joy as an inventor/researcher?

I feel a great pleasure as a researcher when I succeed in revealing a small part of the unknown. This may be a small discovery or a discovery that will go down in history. In my case, I have made three discoveries.

My first achievement was when I succeeded in taking sharp images of atoms in crystals using an electron microscope for the first time in the world, soon after starting research in the US after receiving a PhD degree from a Japanese university. It was the first excitement that I felt as a young researcher who was very anxious about his future. At that time, the laboratory to which I belonged was leading the world in the field of electron microscopy, and researchers from all over the world came there to conduct research, and these days, it is enjoyable to be able to meet with those researchers from time to time.

Upon returning to Japan after finishing my research in the US, I participated in a government research program. In that program, I developed a method of observing extremely fine particles using videos for which I received the Nishina Memorial Prize. When the data for this discovery were obtained, I remember walking home late at night alone savoring the excitement.

My third excitement was the discovery of carbon nanotubes. When I discovered this new material using an electron microscope, I felt intuitively that it was a promising material. I experienced the greatest joy as a researcher when the discovery immediately attracted the attention of researchers all over the world, resulting in high appraisal and a number of prizes.



This is an electron microscope image of single-wall nanotubes. Individual carbon atoms are captured in the photo. The diagram inserted on the left is a computer simulation of the atom arrangement.

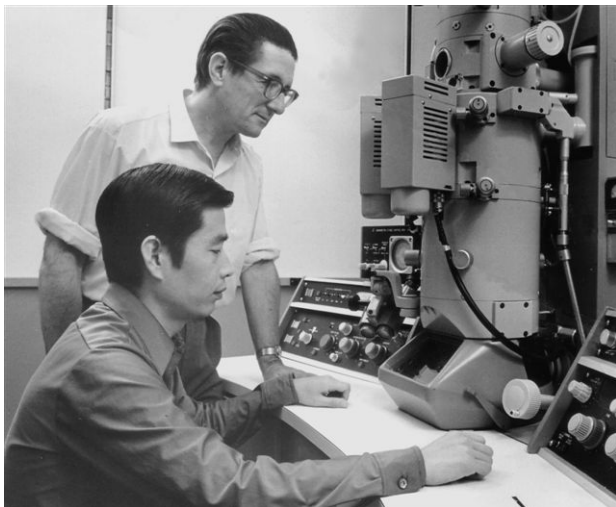
What message would you like to give to the Next generation?

As my profession is looking at the world through electron microscopes, I am always expressing the importance of “observing” things. The importance of carefully observing things applies not only to

natural phenomena but to human society as well. We need to carefully observe the cause of things happening in the world. In the same way that we carefully observe our surroundings before taking actions in our lives, in scientific research, we should first carefully observe an object, analyze it, create simulations if necessary and finally make judgments. Understanding the essence of things in this way is the basics of science.

We all have our strong and weak points. When choosing one's future course in life, one needs to choose something at which one naturally excels. For example, let's say a person wants to become a scientist. Although it is natural for the person to make efforts to realize this desire, there are cases where dreams cannot be realized by desire alone. Through effort, one may achieve results to some extent in an area in which one does not naturally excel. However, in the world of science, one has to aim for the top of the world. It is difficult to judge whether you are good enough at something to aim for the top, but you must consciously make this decision.

Lastly, I'd like to briefly address the issue of globalization. There is only one truth in science, and this applies to the whole world. Therefore, the ability to communicate in English is requisite for competing with scientists in the world on equal terms. I suggest that you start training yourself to be able to speak up for yourself in English at a young age.



This is a photo taken in front of an electron microscope with my teacher Dr. John Cowley while doing research at Arizona State University.