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# ACCESSIBLE ASTRONOMY: ASTRONOMY FOR EVERYONE

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**Abstract.** In this chapter, Noreen Grice, an astronomy educator, describes her expertise in making astronomy accessible to people with disabilities.

## 1. Disability Statistics

According to the United States Census, 54 million Americans or about one out of every five citizens are living with a disability. Worldwide, the United Nations and various international organizations estimate that more than 500 million people are disabled. People who do not have a disability and are "temporarily able" may require assistance later in life due to age-related health conditions.

Although there are different interpretations of the word disability, it is often associated with a limitation of physical or mental abilities, including mobility, vision, hearing, communication and learning. People living with a severe disability may require augmentation and assistive technology to fulfill basic life needs, while others may only need limited assistance to participate in school, work or other events.

## 2. My Involvement with Accessibility

In 1984, I was an astronomy major in my senior year of college, working part time in the planetarium at the Boston Museum of Science. One afternoon, a group of blind students came to my planetarium show. A manager told me to help the students to their seats.

This was a pre-recorded program, so I welcomed everyone to the planetarium and pressed a button on the computer to start the show. At the

end of the show, I wondered what these blind students thought of the planetarium, so I asked them. They said, "It stunk." That was the first time I realized that astronomy and the planetarium were not very accessible.

I began work immediately to create accessible resources, starting with tactile images. After a few meetings with people from the Perkins School for the Blind and the Massachusetts Association of the Blind, I used hand tools to etch tactile images from plastic pages. After a month of continuous effort, I had created a spiral bound book of tactile images to accompany all of the planetarium shows at the Museum. At least, blind visitors would have a resource that they could borrow during the planetarium shows.

Next, I began writing the text for a new astronomy book that would be specifically designed for blind readers. I called the book *Touch the Stars*. As I composed the text, I imagined that many tactile images would accompany it including constellations, phases of the moon, eclipses, nebulae and galaxies. However, in the mid 1980s, technology to mass-produce tactile images did not exist. Primitive methods, such as gluing string to cardboard, were used to individually make touchable pictures. So, I graduated from college, put the book away in a box, and headed to California for graduate school.

## 3. Creating Resources to Make the Universe More Accessible

Two years later, I returned to the Boston Museum of Science with an M.S. in astronomy. Through a small grant, I purchased a state-of-the-art Braille embosser. I began designing artwork with an Apple IIE computer and mass-producing tactile astronomy images to go along with all of the planetarium shows. Because the Braille paper was so inexpensive, visitors could keep the images after the planetarium show. Many visitors told me after the programs that they never knew what these space-related objects looked like before. The tactile images provided a great conversation starter and helped me understand how to simplify and improve my designs.

With the Braille embosser, I was finally able to design the tactile images for my book. The Museum of Science supported my work and published *Touch the Stars* in 1990. The book was such a success that it was expanded into second and third editions in 1994 and 1998.

In 1999, I was contacted by a NASA educator who had seen a copy of *Touch the Stars* in a bookstore in Chicago. He said that it was too bad something like that didn't exist for the Hubble Space Telescope images. And that began my work on *Touch the Universe: A NASA Braille Book of Astronomy*!

I collaborated with the NASA educator and a teacher of the blind in Colorado. As I designed prototype tactile images, students at the Colorado School for the Blind reviewed them. The students were surprised that I

*Figure 1.* An amateur astronomer shows a child how a telescope works by providing a tactile tour of the telescope. (Photo credit: Andrew Cheng, Texas Astronomical Society of Dallas)

wanted their opinion of my tactile images and the teacher observed that, at first, their comments were neutral because they didn't want to be critical. However, the teacher explained that I was asking them to be very critical so the tactile pictures would be very useful. Then, they expressed what they really liked and disliked.

The students asked me to reduce some of the "tactile clutter" that I designed into the images. I learned from these students that "less is more." That is, when you simplify a tactile image, it is easier for the tactile reader (especially a person who has limited experience with tactile images) to imagine the picture in their mind. When a sighted person examines a picture, they look at the whole image and then examine the details. A tactile reader must examine the details and piece it together in their mind. This was a powerful concept for me. Based on student and teacher comments and suggestions, I continued to make changes in the tactile images until they were deemed "accepted."

I organized *Touch the Universe* as a voyage of discovery, starting from Earth orbit, traveling through the solar system, our galaxy and outward to the most distant image taken by HST at the time, the Hubble Northern Deep Field. Tactile codes were assigned to distinguish different components

of the images. On the facing page was a caption for each image. For example, the caption for The Ring Nebula image includes, "The true colors in this image indicate different layers of gases: helium (blue), oxygen (green), and nitrogen (red). The outline of the outer layer of cool nitrogen is represented by a dotted texture, the middle hot layer with oxygen has a texture of parallel lines, and the very hot center area of helium, with a star, has no texture."

Originally, I had planned to duplicate the images one by one at home on plastic sheets; however, the project received a lot of media attention and Joseph Henry Press became the publisher. The final images were printed in color on paper and embossed with metal plates like a greeting card, with text pages in print and Braille. The book was published in 2002, the same year the $4^{th}$ edition of *Touch the Stars* was available.

Shortly after *Touch the Universe* was published, a solar scientist at NASA was interested in creating a tactile book about the Sun. This started me working on a new tactile book entitled *Touch the Sun: A NASA Braille Book*. The vivid tactile images for this book were silkscreened and vacuum-formed (thermoform) onto plastic pages. Joseph Henry Press published *Touch the Sun* in 2005.

Also in 2005, I wrote a book about learning the Moon's phases. Entitled *The Little Moon Phase Book* (with its Spanish counterpart *El Pequeño Libro de las Fases de la Luna*), this features tactile naked eye and glow-in-the-dark tactile telescopic views of the moon during the different lunar phases. The *Little Moon Phase Book* also includes a text description of why the phases of the moon occur that corresponds to the tactile images in the book. The motivation behind this book was a simple resource that sighted or blind people could use to look at the moon, turning the pages until the tactile image matched what they saw. People who could not see the moon visually could still observe it by touch and read about the phases. *The Little Moon Phase Book* was produced (in English and Spanish) by Ozone Publishing using a tactile silkscreen technology.

My third NASA book dealt with observing the universe through different wavelengths. As co-author on *Touch the Invisible Sky: A Multi-Wavelength Braille Book Featuring Tactile NASA Images*, I wrote sections of the text and designed the tactile images in sets, comparing color/tactile views of an object at four different wavelengths.

One of the focus groups that reviewed the text and tactile images from this book included students and adults who were blind or had low vision, at the National Federation of the Blind's Youth Slam. As we discussed the images, one student who had low vision commented about the bright colors in a galaxy image. Immediately, one of the adult mentors said, "The pictures are in color? You mean sighted people can use our book too?" I found

*Figure 2.* An amateur astronomer verbally describes an image as a visitor examines the image by touch. (Photo credit: Andrew Cheng, Texas Astronomical Society of Dallas)

this to be incredibly profound because my goal had been to create books with accessible text (in print and Braille) and accessible images (in color and touchable) that students could use together. Rather than reproducing books for students who were blind, I had been designing books that could be used by everyone from the start. Another strength of this book was that since no human can see beyond visible light, all readers were blind to other wavelengths. Everyone would be learning and experiencing the images together. Ozone Publishing released *Touch the Invisible Sky* in 2007.

## 4. A Guide to Accessible Astronomy Places

Although my books have been focused on providing tactile access to the cosmos, I have also received training in assistive technology for people with a variety of disabilities. For my latest book, I decided to write a guide for making astronomy available to people through mobility access, non-visual access, non-hearing access, and non-verbal communication access.

*Everyone's Universe: A Guide to Accessible Astronomy Places* is really two books in one. The first half of the book is an educator's guide to making astronomy accessible at star parties and observatories. In the past, it was assumed that if you wanted to look through an observatory telescope, you had to walk up a steep spiral staircase. Or, you had to have enough vision to see the object in the eyepiece or be able to speak with the tele-

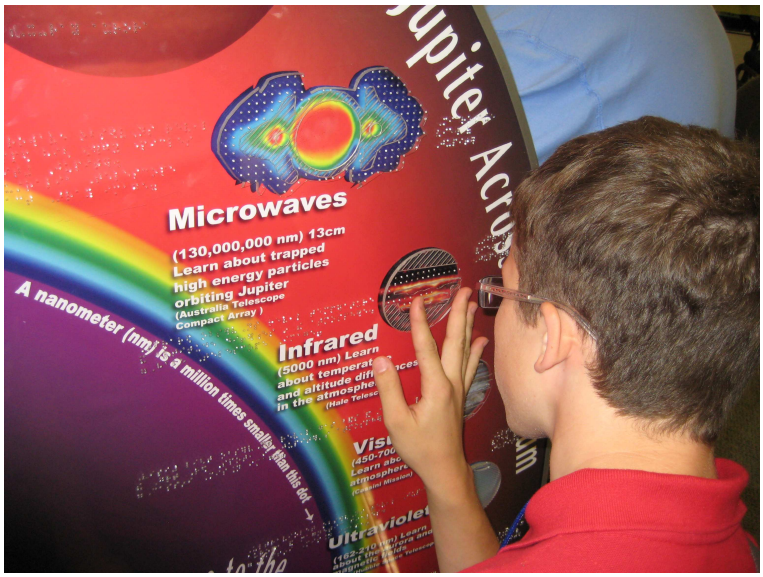


*Figure 3.* A visitor explores tactile graphics on a NASA exhibit designed by Noreen Grice. (Photo credit: Noreen Grice)

scope attendant. Not anymore! This book describes strategies and resources that make observing not only accessible for a person with a mobility, a visual, a hearing or a communication disability, but also more convenient for everyone else.

The second part of the book is a friendly travel guide within the United States (plus the Thinktank Museum in England) that highlights observatories and planetariums that offer accessible features. These might include an extended eyepiece for people in wheelchairs, tactile images for visually impaired, assistive listening systems or captioning for people with hearing impairments and communication boards for people who communicate non-verbally.

*Everyone's Universe* was published in 2011 and has the potential to change the way people perceive disabilities and enhance the access and participation of this underserved population. Then, it really will be everyone's universe.

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