**History of Stained Glass**

**Stained glass** or **colored glass** has been made by artisans since ancient times. Although the exact origins are unknown, ancient Egyptians were likely the first people to discover the process of making colored glass. In fact, the oldest known examples of colored glass are Egyptian glass beads from about 2700 BC. The *Kitab al-Durra al-Maknuna* (The Book of the Hidden Pearl), attributed to 8th century Persian alchemist Jabir ibn Hayyan, describes the production of colored glass in ancient Egypt and contains 46 original recipes for producing colored glass.

Windows with colored glass decorated the homes of wealthy Romans in the first century AD, and early examples of stained glass windows can be found in cathedrals and mosques throughout Europe and the Middle East.

One of the oldest known examples of a window containing multiple pieces of colored glass can be found at St. Paul’s Monastery in Jarrow, England and is dated from 686 AD. However, the elaborate stained glass windows that many people are familiar with did not emerge until later. Depictions of religious stories began to appear around the 10th century with the spread of Christianity, and the intricate geometric designs of the windows within the Blue Mosque (Istanbul, Turkey) and the Nasir al-Mulk Mosque (Shiraz, Iran) are from the 17th and 19th centuries, respectively.

The aesthetics of stained glass have generally followed the art trends of the times, moving from a largely architectural element to adopting more painting-like qualities to even abstract designs in the 20th century. Although innovations in glass production have also influenced these designs, as evident in the works of 19th century glass artists La Farge and Tiffany, who created opalescent stained class, for example.

While the ability to produce colored glass has existed for centuries, the understanding of what gives rise to the different colors is more recent. This understanding is providing artists with new materials to create with, and scientists are using this understanding to provide platforms for harnessing solar energy, targeted cancer treatment, and more!

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**Science of Stained Glass**

What gives stained glass its colors? Glass obtains its color during its production, not by applying a color afterwards. Clear glass is made by heating sand until it becomes a liquid. Once molten, the liquid sand can be poured into molds to create objects like bottles or casted to create flat sheets for use as windows. Colored glass is obtained by creating very tiny pieces of metal oxides or metals within the liquid glass, which become trapped within the glass as it cools. For example, trapped iron oxide gives many bottles their blue-green colors.

Particularly vibrant examples of colored glass come from the inclusion of gold and silver particles that have dimensions approximately 100,000 times smaller than the width of a piece of human hair. These particles have nanoscale sizes and unexpected colors because of how they scatter and absorb light. For example, while gold is commonly thought to have a yellow luster, spherical gold particles with nanoscale sizes will appear red and produce *cranberry glass* or “*gold ruby”* glass. Spherical silver particles with nanoscale sizes give glass a yellow color. These properties of very tiny metal particles embedded into glass account for many of the beautiful colors in stained glass windows. They also account for why the 4th century Roman Lycurgus Cup appears red when lit from behind and green when lit from in front.

Remarkably, the color of metal particles depends on particle size, particle shape, their composition, and their surrounding environment. This allows very tiny gold and silver particles to be nearly any color of the rainbow. Please explore these properties by “coloring” a virtual stained glass image. In general, the properties of many materials depend on their particle size and new properties can arise at the nanoscale. Scientists and engineers are studying these properties to find new materials that address needs related to solar energy, medicine, national security, and more.

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**Meet the Scientists**

Video still to be made.

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