Art and Science

Looking in the Same Direction

*Drawing by **Isabel Seruca***

by Maria Clara F. Magalhães and Rosa Maria Oliveira

The present cultural convergence of art, science, and technology provides ample opportunity for artists and scientists to examine how these various areas of knowledge influence one another. We live in a time characterized by cross-disciplinary interaction, and those in the arts and sciences must develop new approaches to face the challenge of working together. If successful in meeting this challenge, innovators in these fields will be able to create exciting new art forms and achieve creative and useful technological innovations.

Relationship Between Art and Science

From prehistoric times to the Renaissance, there was little distinction drawn between art and science—both were viewed as important aspects of culture, driven by creativity. The Renaissance, however, initiated an era of specialization during which art and science began to move in different directions, intersecting only occasionally. Until recently it has been taken for granted that art and science have followed different paths, characterized by different languages and world views, making communication between participants in these two human pursuits nearly impossible.

In today's world, however, some artists have begun to study and employ the concepts, tools, and contexts of scientific and technological research, and advances in technology increasingly allow the artist to operate outside the conventions of traditional practice. We believe that during the 21st century, this trend will continue to evolve and become more widespread, leading to new techniques and materials and new aesthetic perspectives that will be used to convey artists' unique conceptual experiences of the world.[1]

Chemistry's Role in Art

Even as far back as the stone age, the ancient relationship between art and chemistry can be perceived in early humans' recognition and exploitation of differences in the properties of natural dyes and pigments in terms of color, transparency, and texture, and in the use of water and fire in the transformation of these materials. Throughout history, the discovery of new minerals and other materials has led to new aesthetic possibilities. In modern times, chemistry—as the science of the properties of materials, and of their transformations—has continued to serve as a source of inspiration for art. And artistic pursuits in turn influence work in chemistry. Jewelry-making and sculpture lead to the development of new alloys, and the visual arts and architecture motivate research into new materials with unique chemical compositions, structures, particle sizes and shapes, and stability in reaction to light and weather.

Science also enables us to deepen our knowledge of artistic masterpieces by using a plethora of analytical techniques to investigate the composition of the materials used, their origins, and the artist's technique, as well as ultimately helping to determine the authenticity of the pieces themselves.

Our reflections concerning the links between chemistry and art arose from the exhibition *Solubility: Art and Science*, presented at the 11th International Symposium on Solubility Phenomena Including Related Equilibrium Processes, held in Aveiro, Portugal, in July 2004. This discussion touches on several different connections between chemistry and art, including art and chemistry as mutual sources of inspiration, the properties (specifically solubility) of materials, and some of the associated techniques used in creating works of art.

Art and Chemistry as Mutual Sources of Inspiration

Pursuits in both the arts and sciences are strongly influenced by the emotions of the individuals who undertake them, as well as by numerous social and aesthetic influences. Creativity is one of the common drives of all human beings, and we must not forget its importance in scientific work and in the evolution of modern society in general. For example, Nobel Prize winners Roald Hoffman[2] and Jean-Marie Lehn[3] call attention to the importance of creativity in chemistry, particularly in the synthesis of new molecules and materials, with wholly new properties, that have not previously existed on earth, as a most obvious expression of the similarity of approaches to chemistry and art. Like artists, chemists combine existing elements in previously unknown ways to create something entirely new. And like art, science seeks to bridge previously disparate areas of knowledge, allowing scientists to look at materials in new and different ways, and to make unexpected associations that lead to new discoveries. In science, as in art, it is necessary to tap into imagination and creativity in order to rise above accepted knowledge and practice to create new mod-

els and theories that can stimulate or accommodate new knowledge.

Scientists work within their own epoch, and sometimes it takes an outside influence to allow mental barriers to be broken down. One example is the discovery of a whole family of carbon allotropes named fullerenes, in which the carbon atoms are arranged in spherical or ellipsoidal structures. Harold Kroto made this discovery after recognizing the structural significance of the geodesic domes built by twentieth-century architect R. Buckminster Fuller.

Science in general, and chemistry in particular, can also be a source of inspiration for artists. In literature, the beautiful passages on the subject of water in James Joyce's *Ulysses* merit particular attention. The confluence of science and art can also be enjoyed in the books *Chemistry Imagined, Reflections on Science* (Smithsonian Institution Press, Washington and London, 1993), by Roald Hoffman and Vivian Torrence, and *Crossing Over, Where Art and Science Meet* (Three Rivers Press, New York, 2000), by Stephen Jay Gould and Rosamond Wolff Purcell. These two very different works were produced by very different scientific and artistic personalities who nevertheless share a passion for their work and an ability to make science clear, stimulating, and highly enjoyable to the general public.

Fig. 1 Oil on Canvas by ***Susana Távora***

It should also be noted that although scientific papers are not normally an arena for presenting original works of art, popular articles on science often rely on artistic renderings to introduce concepts and make them understandable to the reader.

Artistic Materials and Their Properties

As well as serving as mutual sources of inspiration, chemistry and art also influence each other in the realm of the physical. Progress in the study of chemistry, for example, brings new techniques and materials to the art world. Research on artistic mediums and materials is relevant to a whole host of artistic fields, including painting, sculpture, photography, holography, cinema, engraving, stained glass, architecture, jewelry-making, perfumery, and textiles. And detailed analysis of the materials and construction of certain paintings and other works of art can afford us insight into the scientific ideas of the artist's own epoch, and of the artist him or herself. The mutual influence between DaVinci's pursuits in the fine arts and his studies in anatomy, mechanics, and optics are perhaps the best example.

Among the large range of properties of materials that influence artistic expression, solubility was chosen as the particular subject of the exhibition *Solubility: Art and Science.* Solubility is important in differentiating pigments from dyes. Both types of materials are natural or synthetic substances used to impart color to another substance, but pigments are powdered substances used in suspension—they are practically insoluble in solvents and binders—whereas dyes are applied in solution. The study of chemistry has been indispensable in the development of both types of materials, from the prehistoric use of natural pigments to the development of modern synthetic dyes. And throughout history, the new colors and techniques made possible by chemistry have had a great influence on the development of art.

Artistic Techniques Presented at the Exhibition

The works of art presented in the *Solubility: Art and Science* exhibition were created using many different technologies and materials, and they represent various forms of artistic expression. Each work of art is unique, even among those produced by the same artist. However, every great artist is aware that he or she must take into consideration the specific properties and limitations of the technology or materials used to produce a work.

Painting:

The paintings presented in the exhibition included *oil on canvas* (Figure 1 and 2), in which the materials used are colorants, both organic and synthetic, mixed with linseed oil and white spirit, allowing the artist to apply successive layers to achieve the desired colors and to give the illusion of shape and volume. This technique has been in wide use since the 15th century. Other paintings in the exhibition were created with *watercolors* (Figure 3), in which transparency is fundamental. The colorants used are soluble in water. The stroke of the paintbrush must be secure and firm—hesitation leads to failure, and corrections are not possible. The use of *acrylics* (Figure 4) is a relatively recent development. Acrylics are soluble in water, but still allow the artist to work in successive layers and to achieve various textures. They dry very quickly, however. In each of these cases, the specific characteristics of the materials used have a profound influence on the technique employed by the artist, and thus on the emotion conveyed by the final work.

Drawing:

The drawings presented in the exhibition were created using ink and graphite, which have traditionally been used to achieve different tonalities of light and shadow, and thus give the illusion of depth and volume (Figure 5 and on page 4).

Serigraphy:

Serigraphy (Figure 6) is used to produce multiple copies of a work. The artist applies beeswax to a fine net of silk or nylon to create a kind of stencil for each color used. This stencil is then placed over a sheet of

*Fig. 2 - Oil on canvas by **Isabel Azevedo***

*Fig. 3 - Watercolor by **Manuela Oliveira***

*Fig. 4 - Acrylics by **Chuva Vasco***

*Fig. 5 - Drawing by **Isabel Seruca***

*Fig. 6 - Serigraphy by **Isabel Maria Dos***

*Fig. 7 - Holography by **Rosa Maria Oliveira***

paper, and colorants are mixed with white spirit and spread out over the netting, transferring to the paper through those areas to which beeswax has not been applied. This process is repeated for each color used in the work.

Holography:

This technique (Figure 7) represents a close relationship between art and science. Holography is based on the principles of physics, using coherent light. A recording of the image is made on a plate of film or glass coated with a light-sensitive emulsion. After imaging, the plate or film is developed in various chemical developers and bleachers in order to develop and fix the recorded image. The holograms presented in the exhibition were also preswollen in different solutions of triethanolamine to achieve multicolored final images. The colors attained are determined by controlling the preswelling of the emulsion.

As can clearly be seen from the illustrations, the specific characteristics of the materials used have a profound influence on the technique employed by the artist, and on the emotion conveyed by the final work of art.

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References

1. Stephen Wilson, Information Arts, *Intersection of Art, Science and Technology*, The MIT Press, 2002.
2. Roald Hoffman, "Por trás do artigo de química," *Química, Boletim da Sociedade Portuguesa de Química*, 1993, Série II, **50**, 44, and "In praise of Synthesis," *American Scientist*, 1991, **79**, 11.
3. Jean-Marie Lehn, text for the exhibition "Art of Chemistry—Alchemy of Art," conceived by the Centre National de la Recherche Scientifique (CNRS) for FAUST 1990—Forum des Arts de l'Univers Scientifique et Technique, France.