SCIENTIFIC ILLUSTRATION

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Science and art are frequently mentioned in the same context for representing distinct ways of interpreting the world: from one point of view the laws of nature are investigated through unbiased observation and experimentation, to reach reason and objective understanding; from the other point of view skills and imagination are employed to create works that promote aesthetic feelings in the self and in the others (Eibl-Eibesfeldt, 1998). However the connections are much greater than usually considered (Reis, Guerra, & Braga, 2006) and at least one field of study is the overlapping outcome of the two.

Scientific illustration can be described as art at the service of science (Male, 2007). It is by definition accurate drawing (Wood, 1994) where informed observational, technical and aesthetic skills are used to portray a scientific subject (Hodges, 2003). Communication is at the base of all scientific illustrations (Jastrzębski, 1985) where each image is a visual explanation that renders scientific knowledge, studies and findings. Thus illustration performs a didactic function and also records and disseminates the state of human understanding since the presentation of scientific results is considered a fundamental part of science without it could not fruitfully evolve (Ford, 1993; Pyle, 2000).

By looking at the drawing the observer should be fully and correctly informed, be aware of and enlightened about the subject as if he was seeing it himself (Wood, 1994). Such images require meticulous and disciplined exactness but should also be artistically pleasing; nonetheless accuracy is primary since a beautiful but incorrect drawing is useless to science (Hodges, 1989) (FIG. 1).

It can be stated that a scientific illustration of a particular species is the next best thing to holding a specimen in the hand and examining it (Zweifel, 1988). No written description alone can suffice to present a clear understanding of the characteristics of a species, explain adequately its form and details; an illustration can relieve the burden to the writer and the reader of unnecessary descriptive material (Ridgway, 1938). In the words of the renowned paleontologist and science communicator Stephen Jay Gould, “Primates are, above all, visual animals from the very core and beginning of our evolutionary construction. The word is a latecomer. A good picture provides insights that words cannot convey at any length” (Gould, 1999). This so happens because scientific illustration can eliminate the ambiguities of language.

The use of illustration in a scientific context can compete with photography. Indeed, among pictorial media there is a general belief in the advantageous veracity of photographs. Yet the camera captures only a fleeting moment, anything that is on the surface whether pertinent or not, with inherent problems related to limited focal depth, lighting and reflections. A scientific

illustration is not limited to showing what actually exists. The illustrator has the ability to select specific aspects for special emphasis (Dalby & Dalby, 1980), he eliminates, adds or changes values and contrasts consciously when drawing, through a thinking and discerning process (Jastrzębski, 1985) (FIG. 2). He can reconstruct broken or missing parts, eliminate artifacts and show multiple layers of information in cutaway drawings, transparencies and exploded diagrams (Hodges, 2003). While the camera establishes and documents the existence of a subject, the illustrator illuminates its essence (Wood, 1994). Moreover, several subjects cannot be photographically depicted, from entire scenes of unreachable (e.g. outer space) or inexistent (e.g. extinct organisms and landscapes) situations, to the visualization of processes and concepts which are intrinsic to the advancement of scientific knowledge.

Nevertheless, the role of photography in scientific communication is not diminished by illustration. Both are different and equally indispensable approaches to supplying the distinct visual factor. Besides, photographs are one of the key information providers in the summation of the informed impressions that illustrators assemble, ranging from close consultation with scientists, to thorough literature search, examination of museum collections and direct observation when possible.

In the benefit of visual communication, conventions have been established through agreement between scientists for uniformity of presentation and mutual understanding. The direction of light, orientation of the subjects, display of anatomical parts and other perceptions are standardized and as such illustrators comply with the requirements when creating an image (FIG. 3) and take advantage of some generally accepted cues shared with the viewers (e.g. the presence of an outline for clarification even though there isn't a line around the actual subjects, or the absence of some anatomical parts for simplification despite no amputation occurred) (Jastrzębski, 1985; Wood, 1994). One generally accepted convention is to make the shading of the drawing be concurrent with an imaginary principal light source placed at the upper left corner (Ridgway, 1938). It became the customary light source used for examining and comparing specimens with the drawings, assisting in the visual perception and interpretation of unfamiliar structures.

Conventions are one of many guidelines covered in scientific illustration manuals. The beginning of the 20th century saw the publication of guidebooks such as John Ridgways' *Scientific Illustration* (1938) and Justus Mueller's *Manual of Drawing for Science Students* (1935); and the increase in the attention devoted to the publication of scientific results is patent in Noel Holmgren and Bobbi Angell's *Botanical Illustration: preparation for publication* (1986) and also in the release of *Illustrating Science: standards for publication* by the Scientific Illustration Committee of the Council of Biology Editors in 1988. A well known reference is *The Guild Handbook of Scientific Illustration* first published in 1989, with a second edition in 2003, edited by Elaine Hodges and with numerous contributions from professionals. "Guild"

refers to the Guild of Natural Science Illustrators, one of a few nonprofit organizations in existence today devoted to the promotion of scientific illustration.

Besides representational conventions, any of the referred manuals contains an array of the subject matters addressed and techniques used in scientific illustration. In fact, there are as many subject matters as scientific disciplines, and nearly as many techniques. More commonly connected with areas such as zoology, botany, geology and anthropology because of the images that frequently venture into public hands (Jastrzębski, 1985), scientific illustration really has a much broader range of coverage (FIG. 4). Environmental education, molecular biology, astronomy, paleontology, veterinary, medicine, ethnology, archeology, cartography are additional subjects, each with different communication requirements but all benefitting from the increased value of visual messages.

To respond to such variety of themes, a large number of techniques capable of precise, realistic rendering can be employed, a few of which have been developed or modified by illustrators to achieve the intended level of detail. Resourceful illustrators specialize in one technique or become proficient in several to take advantage of the media and obtain different styles to get across distinct ideas. Some examples of techniques with widespread use in other artistic fields are graphite, india ink, watercolors, gouache, acrylics, colored pencils; whereas carbon dust and surfaces like scratchboard, drafting film and coquille board have narrower uses in general but are repeatedly acquired by scientific illustrators. Also, during the last decade, digital technology has served illustrators who choose to use computers and graphic editing programs to produce images. They are a powerful and versatile addition to traditional techniques capable of improving effectiveness in the workflow (Flor, 2004). Regardless of the media, it is the illustrator's skills and mastery of the tools that dictates the visual result.

Considering the purpose, the number and variety of subject matters and techniques, an ubiquitous application for scientific illustration is expected, reaching numerous and diverse audiences. In fact, the end uses are even expanding since what was typically considered a natural setting – research papers, books and manuscripts, conference posters and presentations, all intrinsic to the interaction within the scientific community – has embraced the new dimensions of space and time and making use of internet, interactivity and animation. As such one can find scientific illustration regularly in printed and online newspapers and magazines, textbooks, popular and children's publications, field guides, museum and natural park displays and even postal stamps.

The visual message is shaped according to the audience since the scientific community is no longer the primary or exclusive target. There is a strategic approach led by the illustrator to effectively deliver the message, using different formats, sizes, compositions and media, to the viewer.

A good case study is the monthly publication of the Guild of Natural Science Illustrators, the GNSI newsletter. A glance through the last ten years of articles contributed by professional illustrators offers a privileged perception of the multiplicity of subject matters, techniques and applications that are involved. Highlighting some examples: space illustrator Lynette Cook writes about depicting the first planetary system ever found around a normal star outside our solar system (May 1999, no. 5) and Pedro Salgado describes the collaboration with the Portuguese Postal Services to draw a series of marine plankton images to become commemorative stamps (September 1999, no. 7). Australian illustrator Geoff Thompson shares his technique on drawing insects (November 2000, no. 9) as does Jennifer Fairman with birds (September 2003, no. 7). Peter Gaede explains the process of illustrating 3.3 mya dinosaur fossil remains (March 2001, no. 3) and Spanish illustrator Hannah Bonner (November 2004, no. 9) and Alan Male (October 2005, no. 8) walk through the development of scientific drawings to include in children books. Catherine Gaber writes about the challenge of illustrating minerals invisible to the naked eye (November 2005, no. 9) and Teresa McLaren about improving digital workflow (January 2007, no. 1).

Every scientific illustrator is interested in the fusion of art and science and might have formal training through a specific degree ("Careers in Scientific Illustration," 2010). It used to be true that an illustrator could focus on addressing one kind of audience, or work exclusively in one style or technique or even solely for an institution. That is rarely the case anymore. The rising importance of different trends in research, the ever more sophisticated image capturing systems, the proliferation of stock art and royalty-free image banks and above all the decrease in scientific funding have affected the institutions' ability to maintain full time employed illustrators. There is however an increasing need for illustrator's services. The scientific community demand coupled with a growing visual content demand for the media and the public have created opportunities for entrepreneurship and freelance illustrators. Yet there has been a consequent interference with their specialization in subject matter and techniques – the illustrator needs to be prepared to respond to a broader range of requests.

The role performed by scientific illustration will always be significant. Even more so in the light of the natural inflictions and scientific discoveries that we experience today and the future predicts. The advancement of science relies on the interaction within the scientific community and depends on public awareness for its influence on funding allocation. An ever growing general audience demands easy access to self explanatory and appealing information in all that concerns environmental, health and social welfare, areas where the contribution of accurate visual communication is fundamental.

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FIG. 1 - Embryo of coelacanth (*Latimeria chalumnae*) © Pedro Salgado, india ink on scratchboard

Scientific illustration for the identification of a species, suitable to be included in a research paper or species recognition poster. All the structures are clearly defined to facilitate the differentiation of spines and rays in the fins, counting of scales and taking of measurements. The coloration, the result of more or less density of black stipples, represents the volume and the areas of real color in the fish.

FIG. 2 - Seaweed (*Thalassodendron* sp.) © Ana Teresa Bigio, india ink on drafting film and digital

Photograph of a dried and pressed specimen and the scientific illustration of the same species drawn using the herbarium plate as reference. The illustration can convey the tridimensionality that the organism would have had in life and visually divides and selectively enlarges different parts for better understanding of anatomical details.

FIG. 3 - Rose chaffer (*Cetonia aurata*) © Diana Marques, acrylic on paper

Scientific illustration for the identification of a species that presents an impression of a truly typical example of the species as a whole, without any of the peculiarities or deviations exhibited by separate individuals. In accordance with the conventions for insect representation, it depicts a top left lit dorsal view with the legs evenly spread for clarification of segments and taking of measurements.

FIG. 4 - Paleoenvironment of the Cambelas delta (Portugal, 150-145 mya) © Nuno Farinha, digital

Paleontological illustration of a reconstruction of a past environment with extinct organisms that makes an informed prediction of what the setting would have looked like. A complex composition of numerous elements depicted in a lively and colorful fashion suitable for a wide and non-specialist audience.