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Illustration in Scientific Research

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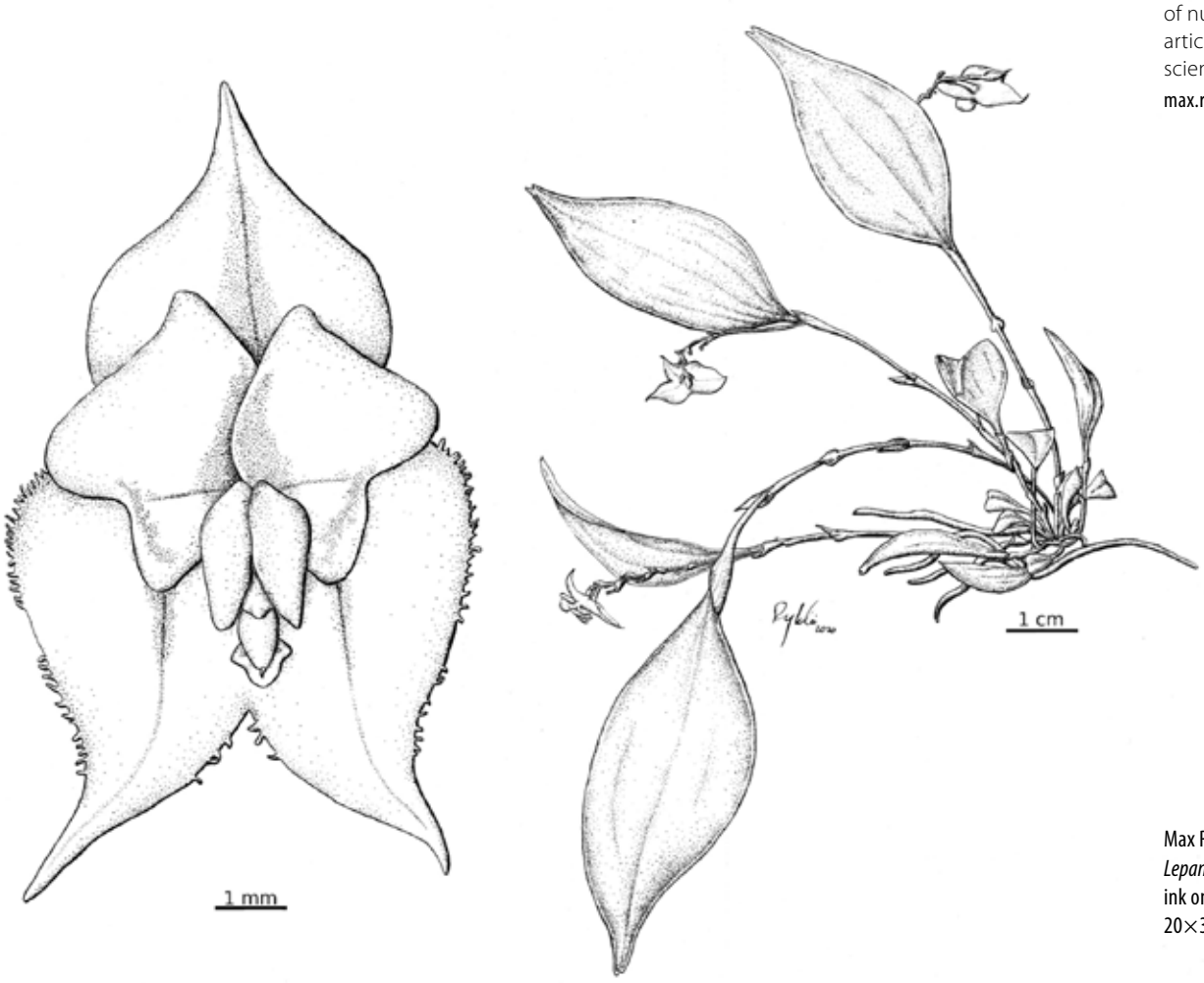

Max Rykaczewski, *Lepanthes andreasii*, ink on paper, 20×30 cm

The role of illustration in our studies of natural history has changed over the centuries, not just in how it depicts specimens or technologies but also as our interest in its different aspects has shifted.

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Miniature from *Tacuinum Sanitatis*. Illustration to a text about anger by the physician Ibn Butlan, 14th century

The oldest known collection of plant sketches drawn for scientific purposes was found at the Amun-Re temple in Karnak. Commissioned by Thutmose III in 1450 B.C.E., the paintings depict medicinal plants of Ancient Egypt. In Europe, the tradition of creating atlases of plant drawings continued until the fall of Rome. The illustrations mainly depicted poisonous and medicinal plants and those used as dyes, and rarely also other plants. Although Greek and Roman drawings were stylized, they also comprised elements making accurate identification possible. The best known work from the period is the five-volume *De Materia Medica*, penned by Pedanius Dioscorides between 50 and 70 C.E. The botanist describes around 600 species of plants and animals, and notes over a thousand recipes for medical remedies. The work was widely used as an important source of medical knowledge until the late 17th century.

In Europe, from the 5th century and throughout most of the Middle Ages the art of illustration was replaced by simplified religious drawings commissioned by the Catholic Church. Many of the specimens illustrated would be impossible to identify without their captions; additionally, plants were widely anthropomorphized or given demonic attributes. Around the 13th century, scribes of prayer books started adding marginalia featuring realistic floral and animal motifs. A practice of creating illustrations realistic enough to identify the subject accurately finally returned to Europe in the second half of the 14th century with the publication of *Tacuinum Sanitatis*, a translation of the 11th-century Arabic manuscript *Taqwīm as-Siḥḥa bi al-Ashab al-Sitta* (Maintenance of Health).

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Viennese Dioscurides (Vienna, Österreichische Nationalbibliothek). Copy of *De Materia Medica*, early 6th century

The development of the printing press bolstered copperplate techniques used to reproduce illustrations in almost unlimited numbers. The method remained in use until the late 19th century to create fast copies of drawings for natural history books.

Scientific renaissance and the boon of scientific illustration

As interest in natural sciences saw a revival in the 16th century, illustrations created purely for scientific purposes became increasingly widespread. Animals entered the canon during the Renaissance, and drawing came to be adopted as an important element of geology. The best known/most prolific artists from the period are Albrecht Dürer and Leonardo da Vinci. Although Dürer made a huge contribution to the development of illustration techniques, he had no scientific background and his works were frequently inaccurate. His woodcut of a rhinoceros is an infamous example; the author had never seen the animal and his drawing was based on a written description.

The great polymath Leonardo da Vinci is perhaps best known for his detailed drawings, frequently anatomical, using distinctive thin lines of blue-grey or reddish hues. He favored a technique known as silverpoint, using a thin silver rod or wire on paper or parchment coated with gesso (animal glue mixed with chalk). The drawing is barely visible at first, and becomes increasingly clear as the exposed surface oxidizes. Since the wire can be made incredibly sharp, it is possible to draw details as fine as a human hair. However, despite this clear advantage, the method was of limited use in scientific sketches. The technique requires a lot of time and great focus, as it is impossible to make corrections – a trace left by the silver wire cannot be erased.

Watercolors vs. drawings

The 18th and 19th centuries marked the golden era of scientific illustration. Numerous scholars exploring new colonies collected vast numbers of specimens and created even greater numbers of drawings and watercolors. Watercolors were popular since specimens tend to lose color during conservation. Many illustrations survive until the present day and are shown at natural history museums all over the globe. However, despite many advantages, watercolors also have limitations, the main being their impermanence. The paint, comprising pigment suspended in honey which acts as an adhesive, is applied to paper made of plant fibers. The medium is absorbent cotton paper and the solvent is water; since watercolors were transported onboard ships, the illustrations frequently reached their destination in poor condition or never made it to the Old World. Another problem is the actual watercolor technique. Paint is applied in layers, usually starting from the palest to the darkest hues. The next layer can only be applied once the base is completely dry, otherwise the previous layer will lift from the paper, leaving a noticeable blurring of colors.

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Title page of *Flora Graeca*, Ferdinand Bauer, 1806

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Albrecht Dürer, Rhinoceros, 1515

Max Rykaczewski, Cowslip (*Primula veris*), watercolor on paper, 26×32 cm

Many plant and animal specimens collected around that time came from equatorial regions, frequently tropical rainforests where the high humidity made it impossible for paint to dry at all. Additionally, the practical difficulties involved with expeditions – hostile terrain, the party being constantly on the move and so on – meant that only essential equipment could be carried. On expeditions to collect specimens, carrying paint and other materials and protecting finished watercolors was extremely difficult, therefore most of the rare watercolors that were commissioned by scientific institutions and wealthy individuals were dizzyingly expensive.

Most of these problems were solved in the 18th century by the Austrian botanical illustrator Ferdinand Bauer, who developed a technique known as painting by numbers. He created meticulous field sketches and would use numbers to mark individual parts of the illustration to designate colors. Once he was somewhere with better conditions for painting, he would complete the illustration. He initially coded 140 colors and hues, expanding them to around a 1000 over the years. Bauer's works made using the technique were immediately recognized in Europe for their high quality and realistic color depiction. Several variants of the method became popular among European illustrators working in tropical regions. Bauer was highly acclaimed for his illustrations for *Flora Graeca* made using his method. The ten-volume publication describing the entirety of Greek flora known at the time was the most expensive book of the 19th century.

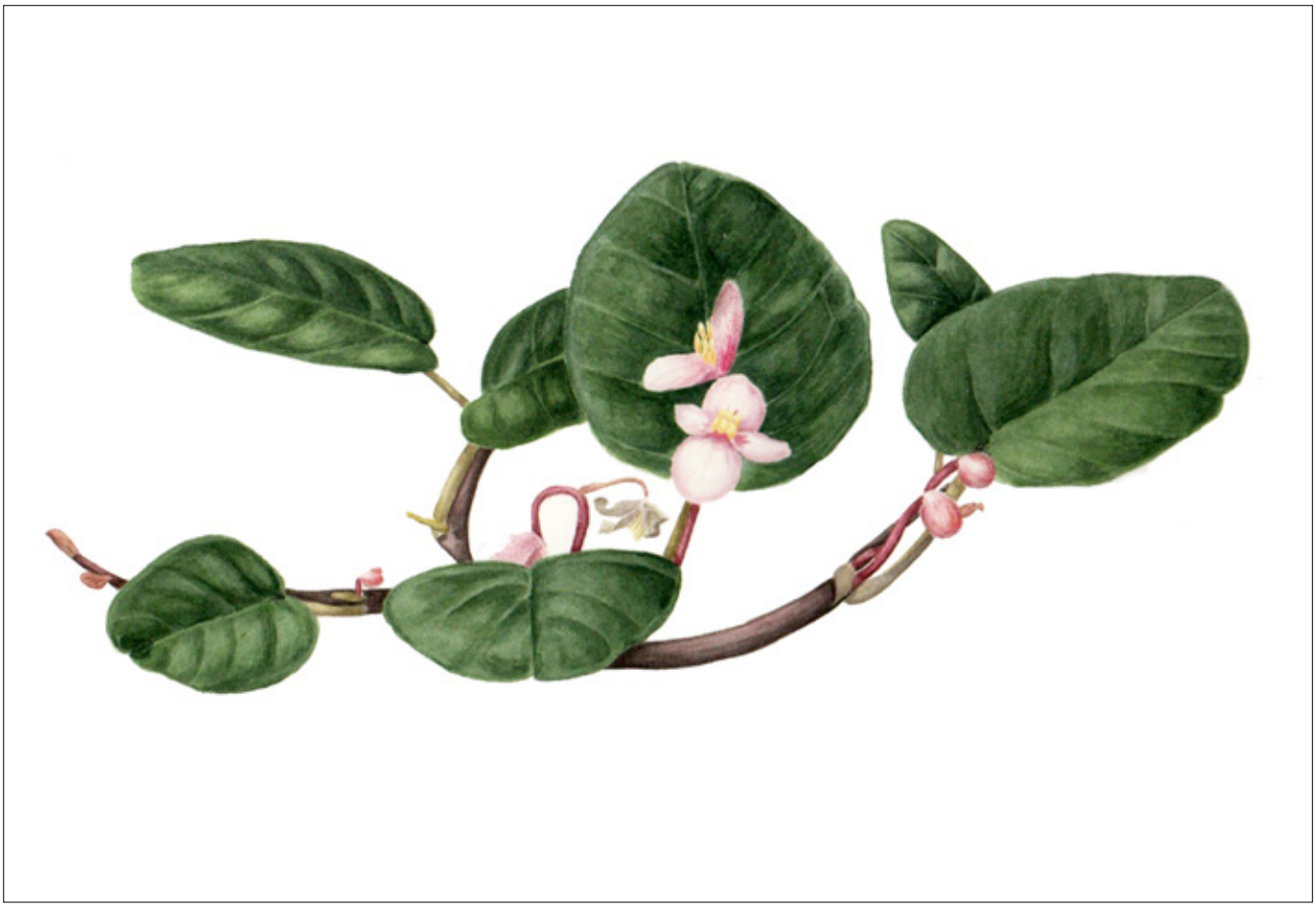
Between new technologies and traditions

In the 20th century, photography became the dominant medium in the scientific world. Illustrations were replaced by photos, and their reproductions appeared in monographs and accompanied descriptions of new species. Herbariums embraced collections of slides for projectors. The initial delight with the technology lasted throughout the second half of the 20th century, until the point when it became clear that photos depict one particular specimen, which may not actually represent typical characteristics of the given species. Photos frequently described growing numbers of new colors and morphologies within the same species, raising questions as to their accuracy. Museums also noted that photographic material is not stable in the long term: negatives are prone to color change, while images on photographic paper fade and do not stand up well to repeated conservation work. The 21st century, therefore, is seeing a gradual return to traditional methods of illustrating scientific specimens.

Contemporary scientific illustration

The current consensus is that the role of scientific illustration is to meticulously depict the given specimen, including any detail which may turn out important in current and future research. While the aesthetic aspect is important, it is secondary. Scientific illustration is generally divided by field into medical illustration and natural history illustration. The latter covers plants, fungi, animals and geological specimens. Of the myriad techniques available, the dominant two are ink drawings and watercolors. We are seeing attempts at using multimedia tools to create natural history illustrations, although this is not widely accepted by the majority of illustrators' associations. The main argument against is the issue of storing the images, since the systems are constantly being upgraded and replaced. This could make it impossible to use electronic illustrations in future research, which is not the case with traditional techniques.

The most popular method used today is ink drawing, since it is low-cost and easily reproducible. Since it is essential that illustrations should be highly durable, they are made on acid-free paper which is resistant to



Max Rykaczewski, Begonia schulzei (*Begonia elaeagnifolia*), watercolor on paper 20×20 cm

degradation, has high grammage and high mechanical resistance; the medium is Chinese ink made of soot, which is highly resistant to light damage.

Drawing specimens

The main aim of scientific illustration is documenting specimens for future application in research. This means that they are created in a structured way making it possible to make direct comparisons between works by different artists. Additionally, by removing any elements which could cast doubt as to shape and form, they are significantly different from drawings with no scientific applications. Some of the elements common in scientific illustration are the source of light (always coming from the top left corner) and the three-dimensional structure of the specimen which casts no shadow or, at most, only such as to make surfaces clear. It is also important to present natural poses and shapes and non-stylized forms, since their arrangement could prove important in future research by other scholars. The drawn item must represent averaged features of typical specimens from the given population. These standards mean that documenting natural specimens through illustration allows for broad and full description of the subject under investigation. This makes it possible to analyze all stages of development and phenotypical variants, as well as comparing illustrations from different parts of the world to reflect morphological variation in a geographical context.

Preparing the drawing board representing the given specimen is a demanding, time-consuming process. It usually starts by finding the species in its natural environment, observing at least a few specimens and making quick field sketches, followed by more precise drawings including details making it possible to correctly identify the species. If possible, the artist collects samples, ideally a single specimen with typical features to be used for reference. Illustrators frequently create their own private herbariums or collections of animal specimens. This means they can return to them as and when they need to record any changes and include them in their latest depiction of the species.

Today's science poses major challenges for illustrators. Meeting all the requirements while maintaining traditions and techniques enables other researchers to perform their studies using the best sources available and by state-of-the-art methods. There is no doubt that illustration has played a key role in our studies of the natural world in the past, and it remains an important tool in biological sciences, in particular its classical fields such as botany and, to a lesser degree, zoology. ■