

APPLICATION OF 2D AND 3D MODELS FOR TEACHING OF NATURAL SCIENCES

A. García Moreno, E. Moreno-Eiris, M.V. López-Acevedo Cornejo, J.C. Barriga Bernal, V. Buencuerpo Arcas, B. Cifuentes Cuencas, I. García Mas, M.A. Gómez Flechoso, M.T. González Jaen, J.M. Hernández de Miguel, V. Jiménez Ortega, R. Lahoz Beltrá, P. López González-Nieto, B. Muñoz Araujo, C. Ornos Gallego, R. Outere Domínguez, P. Refoyo Román, E. Ruiz Piña, A. Tormo Garrido, M.A. Vázquez Martínez

Universidad Complutense de Madrid (SPAIN)

agmoreno@bio.ucm.es, eiris@geo.ucm.es, vcornejo@geo.ucm.es, jbarriga@bio.ucm.es, vbuencar@bio.ucm.es, bcc@bio.ucm.es, igarmas@bio.ucm.es, magflechoso@gmail.com, tegonja@bio.ucm.es, hernandezdemiguel@gmail.com, jimenezv@med.ucm.es, lahozraf@bio.ucm.es, maplopez@bio.ucm.es, titomu@bio.ucm.es, paddy@bio.ucm.es, outere@bio.ucm.es, pa.refoyo@bio.ucm.es, edruiz@bio.ucm.es, decanobio@bio.ucm.es, chingel@bio.ucm.es

Abstract

A series of educational resources on 2D and 3D formats are described in this contribution, both applicable to the teaching of subjects related to biology and geology and for research in these areas.

The 3D models were generated by three systems: the use of a 3D scanner, 3D photography and digital video camera, plus 3D SketchUp and 3D MAX programs that produce images and videos in several formats. 3D Scanned Objects come from some collections of the Complutense University of Madrid (UCM), which may not be well known but have great educational value. Three-dimensional models can be seen at the institutional website as in a virtual museum. We have chosen objects in the Museum of Comparative Anatomy of Vertebrates (MACV), Faculty of Biological Sciences and the collection of ceramic crystallographic models Romé Jean Baptiste L'Isle (18th Century), composed of 312 pieces belonging to the Department of Crystallography and Mineralogy at the Faculty of Geological Sciences.

On the other hand, the collection of intaglio or chalcographies (1363 images, printed in sheets of zinc) used to illustrate various publications on geology has been scanned in 2D. The images were displayed using an application that lets you view images in high resolution. Biological and geological models have been developed by 3D design software and are freely accessible via the university's website, together with 3D digital image-based educational videos.

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1 INTRODUCTION

Learning natural sciences improves considerably if images are used: the anatomical differences between animals or between forms of crystallization of minerals (among many other examples) are. This way, more readily understood. Natural models are studied in three dimensions, both in biology and geology, which students must know how to interpret and manage.

The new generations of students using technology from an early age, provides the advantage of access to university education with a readiness for technology, but does not help them develop their capacity or space to handle and interpret the objects in three dimensions.

At the Complutense University of Madrid (UCM) there are a large number and variety of collections, in many cases unknown, with a great educational value, of considerable interest to the university community and the general public.

The Faculty of Biological Sciences has been working on creating a website (link) for the dissemination and exhibition of their collections. There currently include the Museum of Comparative Anatomy of

Vertebrates (MACV), the Museum of Entomology, MACB Herbarium, Ethnobotany UCM Museum, the Virtual Museum of Parasitology and UCM-MACB 2.0.

The Faculty of Geological Sciences also offers valuable material with potential to be disseminated through the network: the Museum of Geology (www.ucm.es/centers/webs/museogeo/index.php), the collection of ceramic crystallographic models of Jean Baptiste Romé de L'Isle (18th Century) and the collection of intaglio used to illustrate books of Paleontology and Geology.

The group that presented this proposal has, for many years, produced educational resources based on the potential of the images. The experience began with the development of an educational server for the interpretation of architectural models in Zoology (link) based only on photographs, which included all the specimens studied in the Zoology practicals (Fig. 1). It includes more than 2,000 pages in PDF and is available in an open and free form from the UCM website. From this work we set up a Virtual Campus course, available from the UCM Open Project (link), and an interactive educational server based on flash format (<http://inedu.bio.ucm.es/serviflash/index.php>).

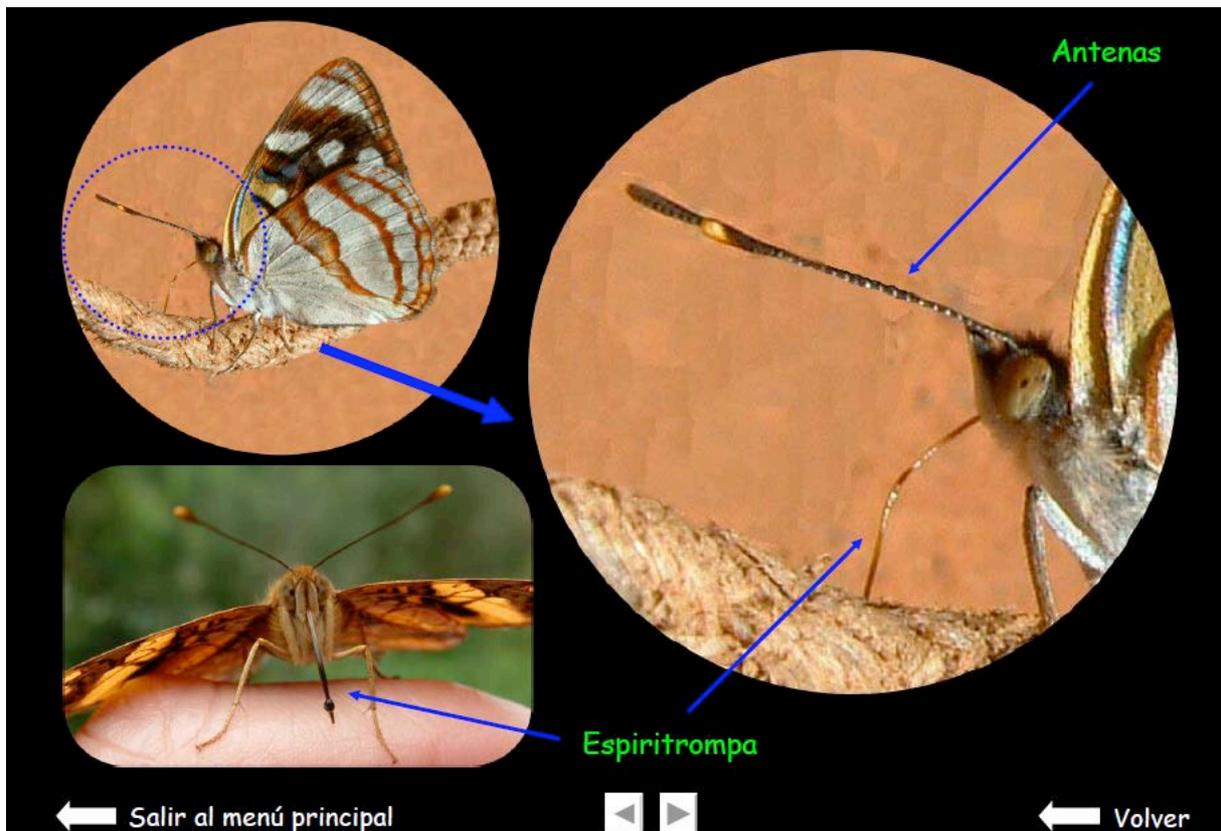


Figure 1. Image from the educational server for the interpretation of architectural models in Zoology.

Following this model and, in parallel, we proceeded to computerize the subject of Parasitology. The results included the edition of an interactive manual of Animal Parasitology, the development of the course in the Virtual Campus, the creation of the Virtual Museum of Parasitology (Parasitology Museum) and participation in the image bank "Bio.Imágenes" (www.bioimagenes.com), with a gallery theme on this topic, both available from the website of the Faculty of Biological Sciences (Fig. 2).

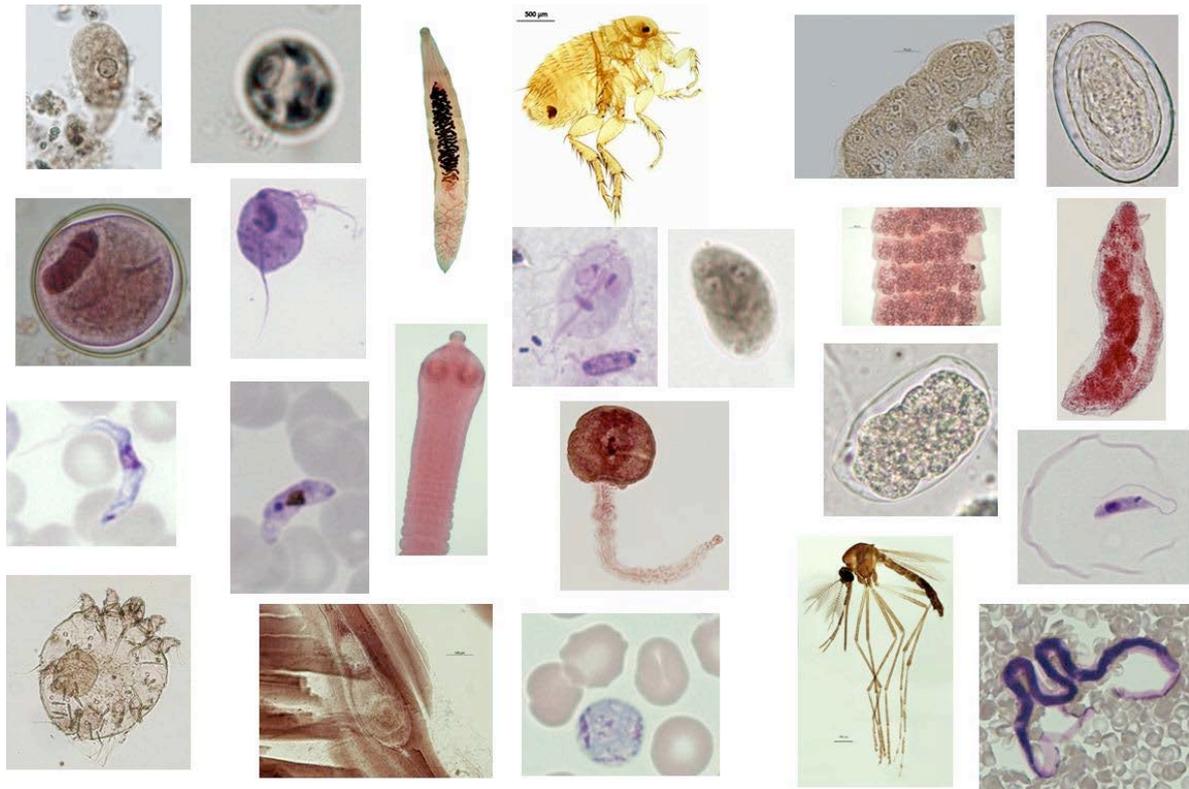


Figura 2. Images from the educational servers in Parasitology.

The papers on the clinical anatomy of exotic animals are the result of interdisciplinary projects that have involved veterinarians and biologists [1] [2] [3]. Projects dedicated to the creation of a virtual herbarium (UCM-MACB 2.0) (link) and a Moodle Seminar on Human Food (link) have also been based on interdisciplinary work, whose main objective has been the editing of virtual spaces in which images play a major role.

In all cases the images were digital photographs and diagrams in two dimensions. The development of 3D computing possibilities with digital imaging, use of paint programs, video editing, flash animation production, use of the Virtual Campus platform, images and sound banks, network dictionary, etc., enabled the release of new graphics.

In this paper we describe the resources generated by three alternatives: 3D scanning, the use of a 3D digital camera and video and editing three-dimensional objects with SketchUp and 3D MAX programs.

We have chosen four alternatives for resource development in 3D: the zoological material in the Department of Zoology and Physical Anthropology and the Museum of Comparative Anatomy of Vertebrates (MACV), both from the Faculty of Biological Sciences, the collection of ceramic crystallographic models and the collection of oak-wood crystallographic models of the Department of Crystallography and Mineralogy, and the collection of chalcographies of the Department of Paleontology.

3D scanning was done on a 3D Picza (Roland) Laser Scanner at the Multimedia Workshop, Complutense University of Madrid. Tridimensional objects are generated from Google SketchUp and 3D MAX programs. To obtain 3D pictures and videos we used a digital camera FinePix Real 3D W3 Fuji.

To promote the use of these resources, teachers co-authoring this paper have organized courses to show the use of these technologies to other teachers, so that they can be able to generate their own materials.

2 ZOOLOGICAL MATERIAL

The Department of Zoology and Physical Anthropology has been collecting, for more than thirty years, a considerable number of specimens and anatomical preparations of most animal phyla, for the training of students. The continuous incorporation of samples over several decades has meant that, today it is one of the most important of European universities.

The dissemination of these collections in 2D through web pages began several years ago, including the possibility of guided tours. The presentation in 3D of the specimens of the new developed material will facilitate three-dimensional viewing over the Internet, extended access to the collections and virtual tours through the network.

At the moment, scanned 3D models of skeletons of Vertebrates, Molluscs and Echinoderms (Fig. 3) are already available, and models for Arthropods and Annelids are being made.

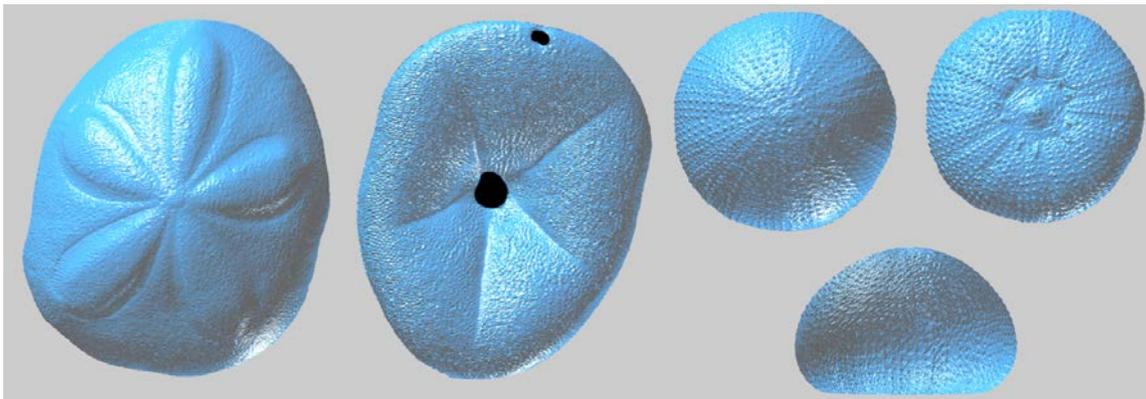


Figura 3. 3D models of skeletons of Echinoderms.

3 CRYSTALLOGRAPHIC MODELS

The fine polyhedral shapes shown by minerals, together with other qualities such as transparency or bright colors, might be the historic cause behind human interest in them and started their study, giving rise to crystallography. The main objective of those scientists was to find explanations for such regular and symmetrical morphologies. This required an exhaustive description of as many forms as possible. However, well-crystallized, complete natural specimens, of an acceptable size are relatively rare, so they turned to artificial models, large and idealized, to facilitate the measurements and tests necessary to establish the first crystallographic laws, and find the explanations they sought.

In this sense, noteworthy collections of ceramic models designed by the great eighteenth century French mineralogist, Jean Baptiste de L'Isle Romé is considered one of the founders of crystallography. He started out as an amateur collector of minerals and came to be consecrated as an expert in the field. Born in Gray (France) in 1736, he studied Humanities in Paris. While serving as an officer of the French Navy, he increased his mineral collections by gathering new species in the various places he visited. He returned to Paris in 1764, where he found work as a curator of some private mineralogical collections, classifying and publishing their respective catalogs.

He was very interested in explaining the various morphologies of well-known minerals and, because of his incessant research in this area, understood the importance of good replicas to work with. His first models, made of metal sheets, were difficult to manufacture and were not very accurate, so he had to devise something else. He came up with molding with clay and then baking the models in an oven, possibly assisted by a friend who had access to Sèvres Porcelain Royal Factory, Françoise Louis Swebach Desfontaines. He and his staff put so much effort into the project that in a few years had produced hundreds of crystal models, about 3 cm in size, with very consistent and accurate shapes and angles.

These models represent idealized minerals, deduced from their natural counterparts. The method is based on choosing a form, as simple as possible, "primitive", which was later modified and complicated, based on truncation of its vertices and beveling of its edges. He never considered the

presence or action of symmetry elements, nor did he recognize the obtained polyhedrons with the Crystal System, as this was 30 years before the latter were defined by Weiss (1815).

In 1783 he published the most important book of his life, "Cristallographie", containing hundreds of drawings and descriptions of minerals. This book was very expensive, so with a view to improving and activate sales, he decided to offer every buyer a collection of 448 ceramic models that represent all the minerals described in the book. The success was overwhelming and in a few years many of these collections were sold throughout Europe. These small models are considered as valuable objects and were never used for teaching purposes. As a result, many copies have been preserved, which currently can be seen in numerous European museums and centers.

One such center is the Department of Crystallography and Mineralogy at the Complutense University of Madrid, which has a collection of 318 pieces (Fig. 4). There is no document of its purchase, or copies of the acquired inventory, so the number of original parts is unknown. Search results for "Cristallographie" in Spain demonstrate the existence of a complete specimen, with two repeated volumes in the library of the National Museum of Natural Sciences-Madrid. Considering that this institution was closely linked to the faculties of Natural Sciences (Biology and Geology), and Department of Crystallography and Mineralogy in the early days, the possibility that the collection of the Department may be related to the acquisition of these Museum books cannot be ruled out.

At the end of his life, Romé de L'Isle disappeared from the scientific scene and saw, not without some frustration, as one of his contemporaries, the crystallographer René Haüy, took his place. Romé called him a "crystaloclast" (glass breaker), while Haüy despised him for his amateur status as a "mineral collector." Haüy did not know how to make these models with ceramic, so he made them of wood, more durable and easy to work with. From this point on, a real model business took off, specially by the German company "Krantz", which in the late nineteenth century designed 928 prototypes that spread around the world for the teaching of morphological crystallography.

In the Department of Crystallography and Mineralogy at the Complutense University of Madrid there is also an extensive collection of these models (2,211 registered pieces) made with wood of different qualities (pear, walnut, oak and beech, while the simplest are made of pine-wood) and various sizes (supersized, large, medium and small).

To date, our resources have generated 3D crystallographic models of the oak-wood models and the ceramic pieces of Jean Baptiste Romé, which are accessible from a web site devoted to crystallography (www.inedupro.com). On one side, they have scanned the original parts, and on the other, virtual models have been developed using the above-mentioned programs.



Figure 4. Ceramic models designed by Jean Baptiste de L'Isle Romé.

4 CHALCOGRAPHY

The collection of intaglio from the Department of Paleontology at the Faculty of Geological Sciences, (Fig. 5), were used to illustrate the papers and paleontology books by D. Bermudo Meléndez, and various editions of the Manual of Geology by Meléndez & Fúster, and an unspecified number of volumes of the publication COL-PA (Colloquia of Paleontology).

The iconography of these books were developed manufacturing zinc plates which were treated by photomechanical methods (most commonly used in the first half of the Twentieth Century) to translate the original drawings. The reason they were drawn, instead of using photographic techniques, is that this way, reality was reconstructed eliminating unnecessary details, while representing morphological features which due to their nature or size, would have been invisible otherwise.

Firms that are recognized in many of the plates correspond to the Benito sisters: Asunción and María del Carmen, and to Ana Maria Somoza. Also are some signed by A. Masvidal, of the Paleontological Institute Miguel Crusafont from Sabadell.

The complete collection consists of 1363 pieces. We have selected 120 of these plates for their scientific significance and aesthetic value to be displayed in the Museum of Geology, Faculty of Geological Sciences of the UCM.

The plates represent a large variety of fossil groups: Amphibians, Arthropods, Birds, Brachiopods, Cnidarians, Echinoderms, Fish, Mammals, Mollusks, Porifera and Reptiles. Some plates show characteristic fossils of different geological periods, which were published in different editions of the Manual of Geology by Meléndez & Fúster. Other plates shown are considered "fossil humor", in the form of sketches and cartoons, and were published in different volumes of Col-Pa.

These pieces have been scanned and are displayed at the pyramid tiff image bank developed by the group authoring this paper (<http://inedu.bio.ucm.es/biotiff/>).

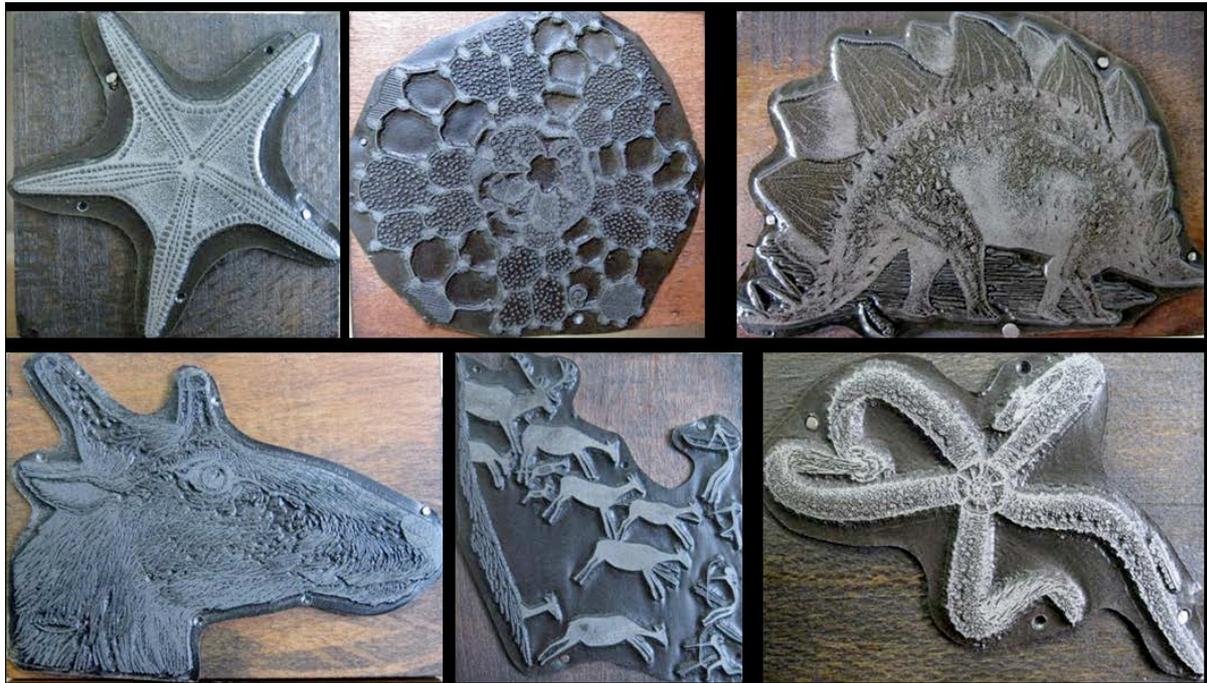


Figure 5. Some specimens of the collection of intaglio from the Department of Paleontology at the Faculty of Geological Sciences.

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