

Reflections:

Why drawings in the digital era?

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Abstract

Despite being an ancient technique, line drawing and pointillism are still applied to represent anatomical structures, even with the array of technological tools available today. This exploration delves into the advantages and disadvantages of these traditional techniques, revealing their enduring merits. Additionally, a discussion on the distinction between functional anatomy and taxonomic anatomy is presented. Functional anatomy focuses on understanding how the animal 'works,' while taxonomic anatomy examines how it is similar or different from others. These perspectives result in distinct types of drawings. Furthermore, a brief report on the process of creating taxonomic drawings is provided.

Keywords: anatomy, functional anatomy, taxonomic anatomy, scientific illustration.

Introduction

The technology has advanced remarkably, to the extent that Taxonomy now employs various tools, including digital photography, confocal photography, scanning and transmission electron microscopy, micro-tomography, magnetic resonance imaging, digital 3D composition of serial sections, etc. Despite all these technological advancements, I still prefer to use plesiomorphic (primitive) drawings for most illustrations in my publications.

Throughout the publication process, drawings have been subject to contestations, such as inquiries about why more modern imaging methods are not utilized. Questions arise, such as whether the drawing is a schema, and which specific specimen was depicted. Although these questions seem pertinent, they are, as explained below, either nonsensical or challenging to answer in the present context.

The focus of this paper is to elucidate the reasons for employing the ancient method of line drawings and pointillism to represent anatomical structures. Like any methodology, this approach has its advantages and disadvantages, which will also be explained. As can be observed, even with the current technology and the availability of advanced tools, line drawings and pointillism still offer more advantages.

Line drawings and pointillism emerged out of the necessity to produce images with shading, providing a sense of volume, especially in a pure black-and-white (BW) model. This type of illustration is much more cost-effective to publish than grayscale and colorful images, especially during the photolithographic era. Grayscale and colorful images require multiple inks and photoliths, making them more expensive. Although these dynamics have changed considerably with the development of computational processes, internet access, digital papers, etc., it partially justifies the colleagues' bewilderment at continuing to use this primitive drawing method to represent anatomical structures.

This is the second fascicle titled 'Reflections,' which addresses broader philosophical issues applicable beyond Malacology. The first fascicle (Simone, 2023) focused on the methodology for obtaining few or single cladograms.

Before delving into the reasons for using drawing in taxonomy, an additional explanation is necessary: the distinction between Functional Anatomy and Taxonomic Anatomy.

Functional Anatomy

Several authors commonly recognized as "anatomists" can more precisely be categorized as "functional anatomists." This distinction implies that the researcher is primarily focused on understanding how the animal functions, encompassing aspects such as digestion, waste elimination, feeding mechanisms, mating behaviors, protective strategies, movement, and respiration, among others. In these studies, illustrations tend to be schematic, didactic, and easily comprehensible even to laypeople. The researcher may not be particularly concerned with taxonomical distinctions, and the schematic illustrations are generally applicable to a broad range of closely related taxa, even if the author has studied a single species.

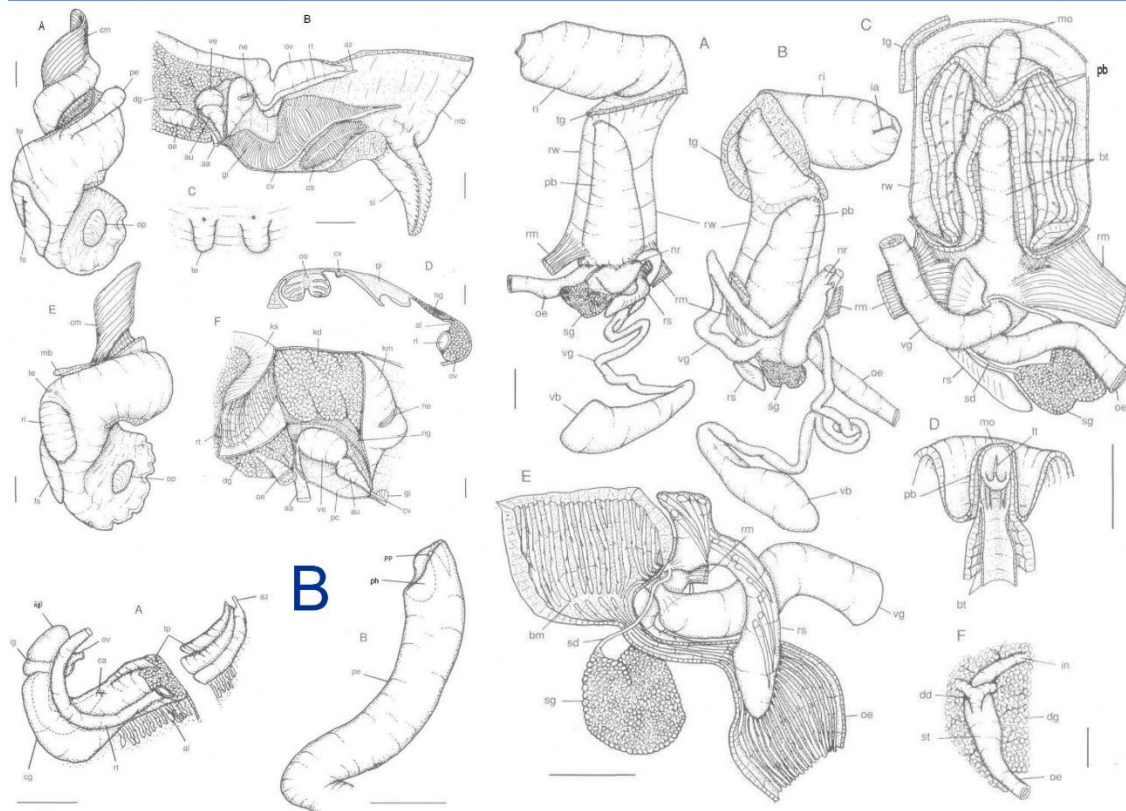
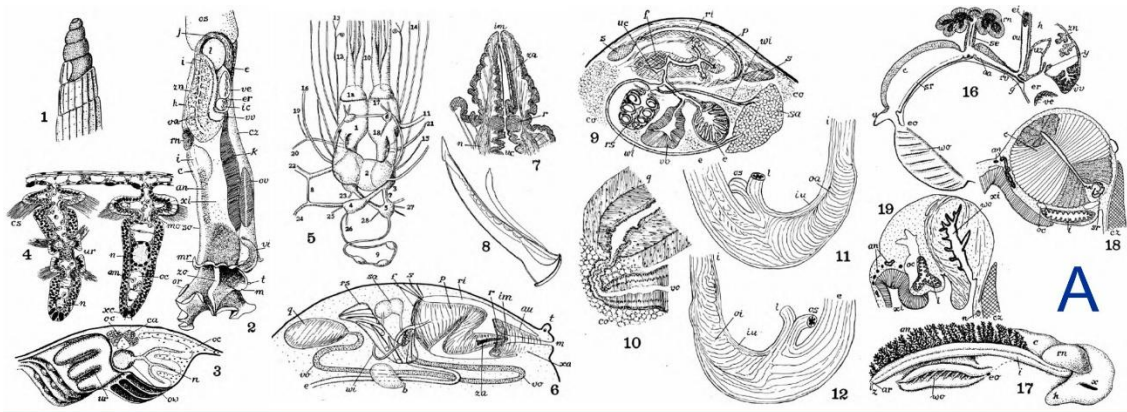
Despite its significant importance, studies conducted by functional anatomists have limited applicability in taxonomy for this reason. While serving as a valuable script and starting point, they contribute minimally to the work of a taxonomist who is examining the same species addressed by the functional anatomist.

An exemplary case of functional taxonomists is the Marcus couple. They have authored numerous outstanding papers with an anatomical approach. Their freehand drawings (Fig. 1A) serve as excellent schemas with easy interpretation, undoubtedly serving as models for the target species and a broader range of allied taxa.

Taxonomic Anatomy

Despite also falling under the umbrella of "Anatomy," Taxonomic Anatomy adopts a different approach. A taxonomic anatomical study is not concerned with understanding how the animal "works." Instead, the primary focus lies in determining how a given taxon differs or resembles others, employing a fundamentally comparative approach. Consequently, illustrations in taxonomic studies should not be schematic. On the contrary, they should be precise, adhering to

proportions, rich in details, and showcasing somatic and organic interactions—each serving as direct or potential sources of taxonomic information (Fig. 1B).



1: Drawings differences between Functional Anatomy and Taxonomic Anatomy, paper studying a same species: *Hatula cinerea* from SE Brazil. A, replication of drawing by Marcus & Marcus (1960), functional anatomists; B, replication of drawings by Simone (1999), a taxonomic anatomist. More details on text.

Due to this approach, taxonomic illustrations may lack the didactic and charismatic qualities of those in functional anatomy. They are not designed to be schematic or easily understood by non-experts; in fact, they may appear intimidating and nonsensical to amateurs. The primary goal is to present details that facilitate differentiation from allied species, both those already known and those that will be studied in the future.

In my case, anatomical structure illustrations in taxonomical papers fall into the category of Taxonomic Anatomy. Conversely, the explanatory schemes in Malacopedia typically adhere to the Functional Anatomy model.

Interestingly, the distinctions between drawings of functional and taxonomic anatomists can be exemplified by Fig. 1, which features illustrations from two papers that studied the same

species – *Hastula cinerea* (Neogastropoda, Terebridae) – predominantly from the same region, the SE Brazilian coast. The top images (Fig. 1A) are drawings by the Marcus couple (Marcus & Marcus, 1960), representing typical functional anatomists. In these illustrations, a schema (their fig. 6) is discernible, resulting from the reconstruction of several surrounding detailed structures obtained from serial sections. In the bottom part (Fig. 1B), there is drawings by Simone (1999), exemplifying a typical taxonomic anatomist. This illustration displays portions of the species that hold taxonomic importance and are compared, both within the same paper and across others, to different species. Each drawing stems from the study of numerous specimens and highlights significant similarities and differences. Notably, the image replication in Simone (1999) is exclusively focused on drawings, excluding photos and SEM images.

Disadvantages and advantages of scientific drawings

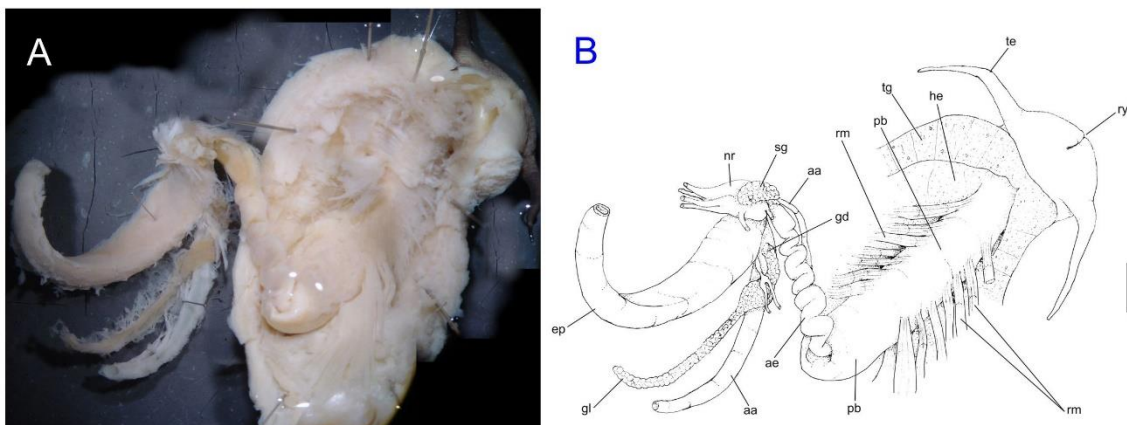
Every scientist must evaluate the pros and cons of each technique and incorporate it into their routine. Line drawings and pointillism, as mentioned earlier, are still better than any other techniques I have tested. However, they are not without their challenges.

Main Disadvantages of Drawings:

1. Time-consuming: Depending on the level of detail in your image, a drawing can demand hours or even days of labor and dedication to complete.
2. Necessity of Special Drawing Tools: Instruments such as ink pens, rulers, tracing paper, erasers, etc., are necessary. While not particularly expensive, these tools need to be of good quality.
3. Need for Talent: While not an absolute requirement, having artistic talent is beneficial. However, even individuals without exceptional talent can produce excellent drawings, as drawing is a technical procedure that can be learned and developed.

Advantages of Drawings:

1. Clarity: Drawings precisely convey the intended information. A well-prepared mind leads to better drawings. In contrast, other imaging methods, such as photos, may display imperfections or details that obscure the intended message. The differences between a photo and a drawing of the same piece can be seen in Fig. 2. The drawing, jointed to the interpretation of the anatomist, is much clearer and clean.



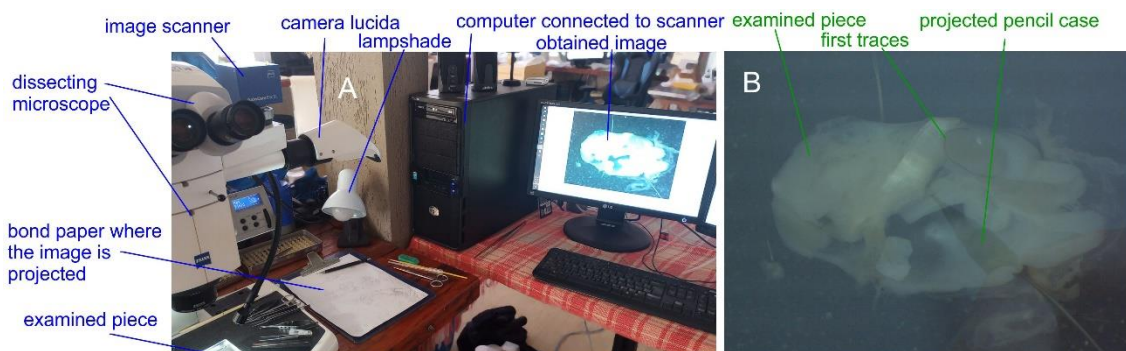
2: Example of clarity of a drawing if compared to a photo in anatomical illustration. Foregut of *Buccinanops cochlidium* ventral view; **A**, dissected specimen; **B**, drawing based on it, interpreted by the anatomist (from Pastorino & Simone, 2021), Scale= 5 mm. Lettering: aa, anterior aorta; ae, anterior esophagus; ep, posterior esophagus; gd, gland of Leiblein duct; gl, gland of Leiblein; he, haemocoel; nr, nerve ring; pb, proboscis;

2. **Modeling:** A drawing can represent an average of several specimens. Instead of drawing each specimen individually, a single drawing can be created based on the first specimen, utilizing the remaining specimens to complete the picture. Completing the picture involves checking the average proportions of structures, filling gaps from damaged or incomplete specimens, and incorporating information from other techniques, such as serial sections.
3. **Standardization:** Drawings can be standardized, allowing the use of the same basic images across all taxa. This standardization is particularly challenging in other techniques, such as photographing anatomy. In arthropod studies, where morphology and its implications in taxonomy are more advanced than in mollusks, this standardization is widely applied.
4. **Routine:** Linked to the factors mentioned above, every study is conducted to examine all standardized structures with potential taxonomic value. This approach eliminates the need to conform strictly to traditional taxonomy and removes the necessity of searching for a key taxonomic structure. A holistic approach is consistently applied.
5. **Easy comparison:** Clear, averaged, and standardized drawings facilitate easy comparison among taxa. To enhance comparability, drawings in research papers are typically presented in similar views, and the same abbreviations are used to indicate same structures. This practice greatly facilitates species comparison and the application of comparative biology among the papers, such as taxonomy and phylogeny.

A brief description of a line-drawings and pointillism taxonomic drawing

Contrary to the earlier explanation regarding the primitive nature of drawing techniques, only the initial stages adhere to traditional methods. Once certain steps in line drawings and pointillism on the tracing paper are completed, all subsequent steps are carried out digitally. This is further explained below.

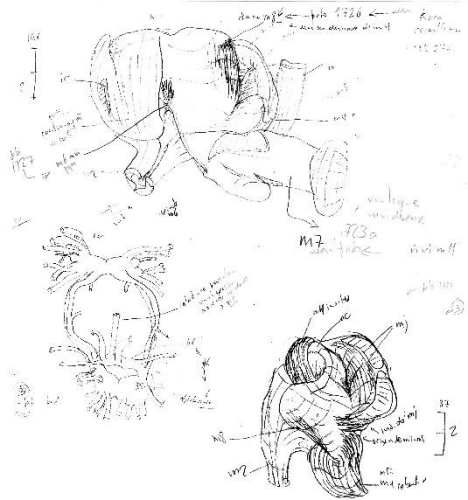
Obtention of the first drawing directly from the specimen via camera lucida:



3: How the drawings are obtained – first steps. A, workstation composed of a dissecting microscope, connected camera lucida and image scanner; B, detail of an image (*Hiatella* sp) seen in microscope when the camera lucida is on, the images of the examined piece and of the paper are mixed, the anatomist can draw it obeying the proportions. More details in text.

Any taxonomical drawing must accurately depict the proportions among the structures illustrated. Even a skillful freehand drawing is rarely executed with precise proportions. Therefore, the assistance of a camera lucida becomes essential. While single-camera lucida devices exist and are useful for larger specimens, we primarily utilize one connected to the dissecting microscope (Fig. 3A), given that most studied animals require this optical tool for accurate examination. The

camera lucida employs a prism and lens arrangement that blends two images into one (Fig. 3B): the image of the specimen being examined is merged with that of the blank drawing paper. This technique allows for more precise and accurate drawings.



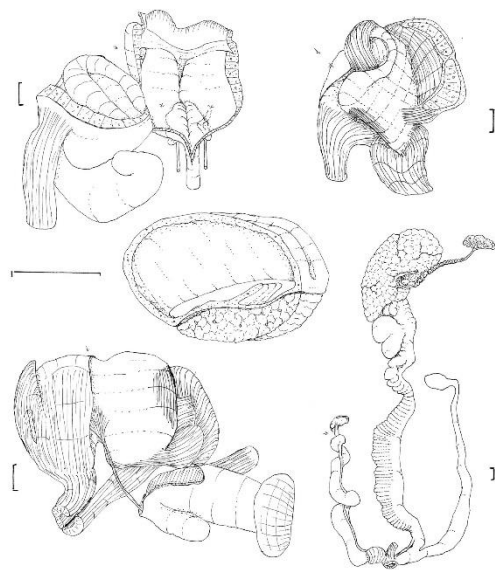
4: Example of first step of drawings. Drawings made with pencil with the aid of a camera lucida, containing notes and observations. Each picture is incremented and completed with the examination of remaining specimens. In this phase, the drawings only concern to researcher.

If the microscope is equipped with a digital camera or scanner capable of capturing digital images of the examined specimens and transmitting them to a computer (Fig. 3A), it becomes possible not only to draw but also to photograph all pieces and document every step of the dissection process for each specimen. While the drawing may represent a unique, carefully selected position that encapsulates the average characteristics of all examined specimens, the photographs serve as a comprehensive record. These photos can be stored for future reference, consulted in case of any uncertainties, or even used to illustrate specific structures, thereby complementing the drawn representations.

The outcome of this phase in the anatomical study is illustrated in Fig. 4, featuring pencil-drawn images directly obtained from the camera lucida. In addition to the drawings themselves, the identification of specific structures and annotations is undertaken. These aids are instrumental in organizing thoughts and facilitating the subsequent phase when the drawings are refined to achieve their final form. They also serve to document species characteristics for inclusion in the paper's description and discussion. Scales are always essential at this stage, with the pencil drawings primarily serving the anatomist; only those familiar with the research design need to interpret them.

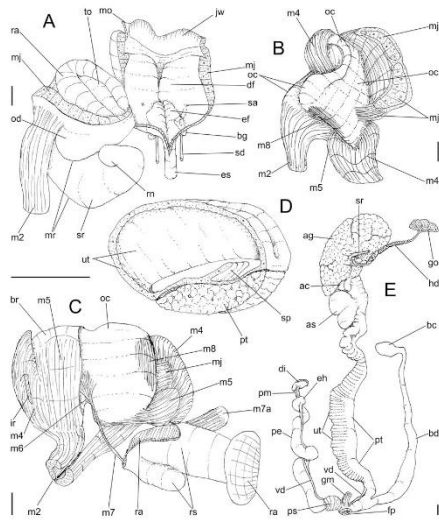
The next step in the drawing process involves transforming the researcher-exclusive pencil drawings into a more professional image that can be interpreted by anyone knowledgeable about the anatomy of that taxon — what is commonly referred to as the 'final art.' In my case, I use an ink pen on tracing paper, resulting in something exemplified in Fig. 5.

During this phase, multiple drawings are assembled on a plate, proportionate to the journal's size and considering space for the legend. Some errors in the drawing process are retained, to be digitally corrected in the subsequent step, as indicated by small arrows. The scale bars are provisional and will be replaced by digital bars. The advantage of producing the image as a plate at this



5: Example of second step of drawings. The selected pictures are arranged in a plate. The drawings are made with ink pen on tracing paper, making them as done as possible for scanning and posterior digital processing.

stage is that the journal will treat it as a single figure. This is particularly beneficial for journals that charge for published figures.



6: Example of third step of drawings. Done via computer program, the pictures are clean, corrected, sometimes completed, and the letters-indications are added. Everything obeying the margins of the plate. In this phase, the drawings concern to the other people.

This marks the final analogical step; all subsequent procedures are digital, conducted on a computer using image editing software (I personally use Corel Photo-Paint, while many colleagues prefer Photoshop). To initiate the digital phase, the plate containing the drawings must be scanned to convert them into a digital format.

Within the image editing software, the possibilities are vast. In the case of anatomical drawings, the plate undergoes a thorough refinement process: imperfections are removed, certain details are enhanced, scales are replaced, and abbreviations of structures—accompanied by corresponding arrows—are incorporated, all while adhering to the plate's margins (Fig. 6). This underscores the advantage of initially producing the drawing in a plate format, as opposed to submitting separate figures for the editor to arrange throughout the paper.

The concluding step involves submitting this refined phase to the journal, attached to the manuscript. Typically, I submit a lighter JPG version initially, suitable for analysis. After the paper's final acceptance, a high-resolution TIFF version is sent, albeit separately, as it tends to be too heavy for an initial submission.

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