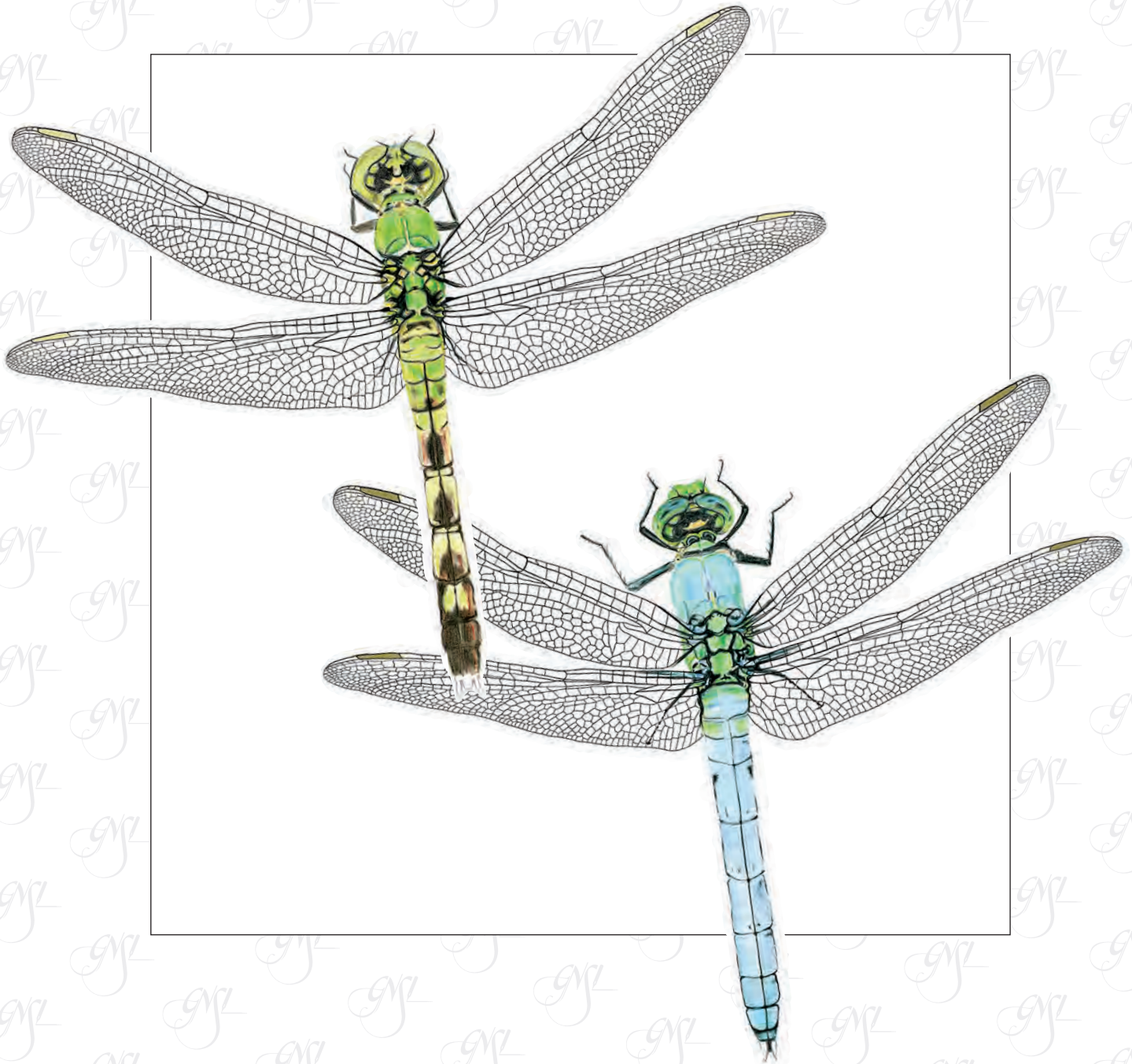


Journal of NATURAL SCIENCE ILLUSTRATION

GUILD OF NATURAL SCIENCE ILLUSTRATORS



VOLUME 55 • NUMBER 2 • 2023

A Note From...

Gail Guth, Managing Editor

As I write, another Michigan summer has come and gone, temperatures have moderated, and the trees are starting their Autumn show. Outdoor activity of any kind has been a challenge for many all over the globe this year between excessive heat, wildfire smoke, and extreme storms. I hope the changing seasons bring us all better weather. Take time to get outside, soak in the fresh air when you can, and make some art! This issue features a few articles to help us find inspiration and resources outside of our studios: using gouache for *plein air* journaling; and establishing a certified wildlife habitat in our own backyards for ecological benefits as well as sketching inspiration.

This issue also features more amazing and informative (and beautiful!) articles—including a review of Jen Christiansen's book *Building Science Graphics*, 3D printing, the annual CSUMB student exhibit works, a deep-dive into typographic elements of infographic design, combining traditional art with digital, and an introduction to GNSI's new Portfolio+ opportunity.

THE FUTURE JOURNAL

Everything changes and evolves, and the Journal is no exception: we are planning changes to how we present material to you, changes that will utilize both time and technology better, hopefully make life a bit easier for both our busy authors and the volunteer journal team, and save the GNSI a bit of money in the process. When these changes formalize, we'll let you know the details in the monthly digital newsletter. Rest assured the *Journal of Natural Science Illustration* is not going away!

As always, we hope you enjoy this issue and find useful information as well. And we always welcome ideas for articles, either ones you can write up for us or suggestions of topics you would like to see. You can contact us at journal@gnsi.org.

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Cover: Dragonflies have lived on Earth for over 300 million years. One of the world's most efficient hunters, they catch up to 95% of prey they pursue. Consuming their own body weight in bugs each half hour, dragonflies keep mosquito and fly populations in check. Illustration: (top left) female and (bottom right) male eastern pondhawk dragonflies drawn in ink and watercolor pencil on Strathmore bright white cardstock, with digital editing. © 2023 M. Genevieve Hitchings

NATURAL
SCIENCE
ILLUSTRATORS



The Guild of Natural Science Illustrators is a nonprofit organization devoted to providing information about and encouraging high standards of competence in the field of natural science illustration. The Guild offers membership to those employed or genuinely interested in natural scientific illustration.

GNSI GENERAL INFORMATION

MEMBERSHIP

USA Print: \$95/year (\$180 for two years)

Global: \$115/year (\$220 for two years)

Digital Delivery: \$75/year (\$145 for two years)

Portfolio+ gallery upgrade: add \$65/year to membership

Other membership options are available; see website. Secure credit card transactions can be made through www.gnsi.org. Or send checks made out to "GNSI" at the address below. Please include your mailing address, phone, and email.

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WEB & SOCIAL:

Stay up-to-date with all GNSI happenings at www.gnsi.org and through our monthly newsletter. Here you can update your member information, find announcements about members' accomplishments, information about our annual Visual Science Communication Conference, Education Series workshops, and more. You can also find GNSI on Twitter (@GNSIorg) and Facebook (@GNSIart).

GNSI JOURNAL

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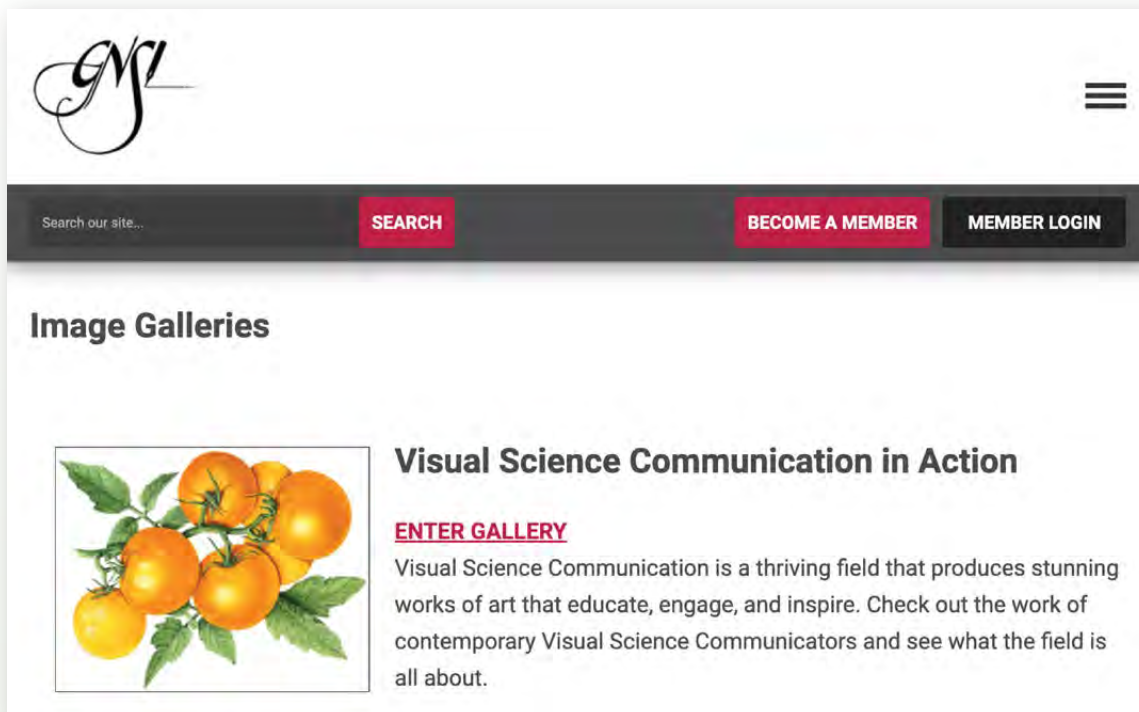
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Portfolio+ is listed at the top of GNSI's online *image galleries* and is titled "Visual Science Communication in Action." To search by category or artist, go to: <https://www.gnsi.org/science-art-today>.

GNSI's Vision for Portfolio+

—Kalliopi Monoyios

TWO DECADES+ OF SCIENCE-ART.COM

When GNSI made the decision to start *Science-Art.com* 25 years ago, building a personal website for your portfolio required knowledge of computer code. While some of us took the plunge and dove headlong into HTML, CSS, and Flash, many more were intimidated. For those who were deterred by the task of learning to code, GNSI created *Science-Art.com* with the intention that it would make showcasing your work easy. The resulting portfolio hub was a valuable one-stop resource for publishers, authors, researchers and art directors to find professional science illustrators for their projects. Over the years, hundreds of our members built their businesses and found work through the site.

Since its inception, the site was managed by GNSI Distinguished Service Member Britt Griswold. When Britt announced his intention to retire from managing it, we had the opportunity to rethink what we offered. We asked ourselves, what do our members need today? How has the landscape for freelancing and publishing changed? How do we make sure we are fulfilling our mission to provide career development and networking services for our members?

Today, reasonably priced website services are a dime a dozen and we no longer have to provide that service for our members. Every working artist should have an independent website where they showcase their best work, explain their services, and allow people to contact them. Services like Squarespace and Wix make it painless to keep these websites updated with your best and newest work and provide an air of legitimacy to an artist's business. So when evaluating what a replacement for *Science-Art.com* might look like, we knew we did not have to provide a website building service. *Phew*. But we were losing the portfolio hub that was a trusted go-to resource for art directors, publishers, and other would-be clients and collaborators.

Meanwhile, back at [gnsi.org](https://www.gnsi.org), our website was geared mainly toward providing information to members and aspiring illustrators. Yet GNSI is a natural hub for educating people about what we, as visual science communicators, do. Increasingly, I am convinced that though our field is needed more than ever before, fewer and fewer people understand what science illustrators are capable of. So it seemed a natural fit for us to bring our members' work onto our website, both to promote the excellent work of our members and

Screenshot of Portfolio+ gallery
searchable by category, artist,
or key words. URL: [https://
www.gnsi.org/science-art-today](https://www.gnsi.org/science-art-today)

to educate people about the breadth
and depth of the work we do.

ENTER PORTFOLIO+!

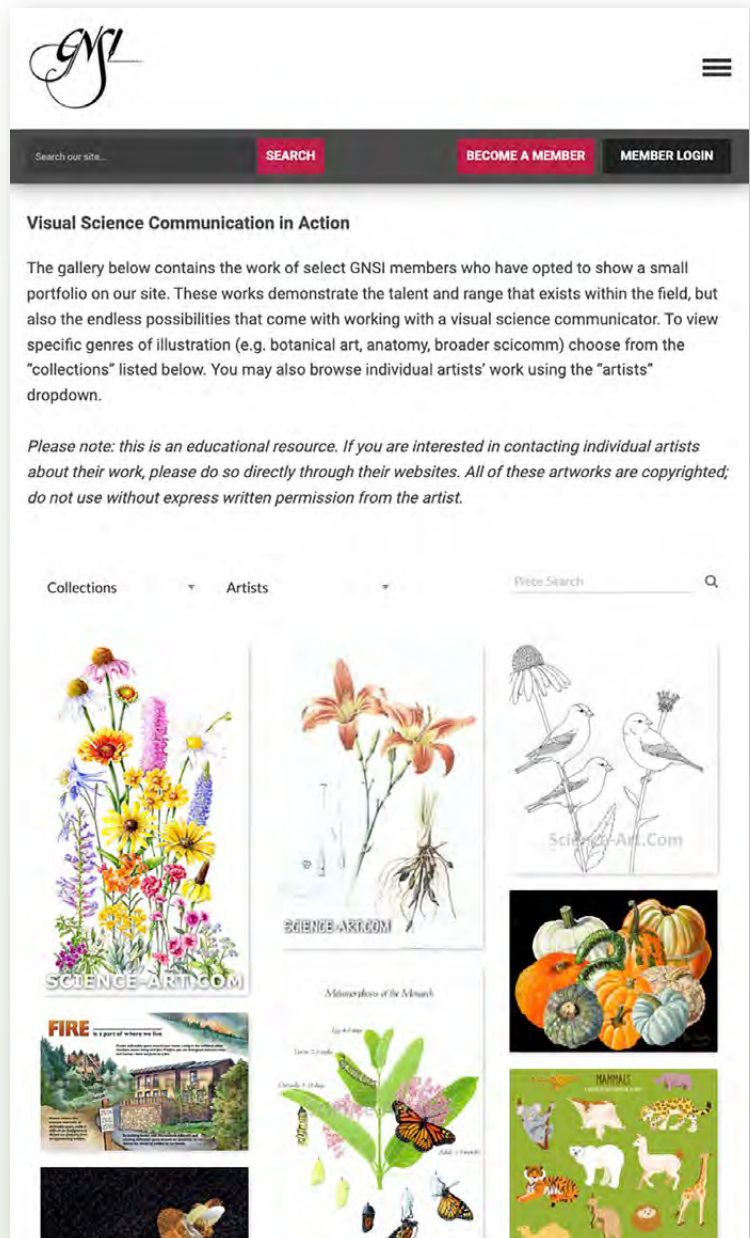
Through our explorations into software that would help us spread out the work of putting on an online exhibit, we discovered Artwork Archive. Artwork Archive is an art inventory tool that individuals and institutions can use to keep track of their work. As an individual, you can track each piece you make, organize them into series or bodies of work, track where they have been exhibited, and record vital information like pricing history, private notes, sales, contacts, collectors, expenses, and more. (GNSI members, take note, you can get a discount on an individual Artwork Archive account as a perk of being a member — just log into your profile on [GNSI.org](https://www.gnsi.org) and click on “Artwork Archive Discount”). But they also cater to institutions, and in 2022 we realized Artwork Archive could help us manage our exhibits and create a gallery that would replace the old [Science-Art.com](https://www.gnsi.org/science-art-today) site.

With our primary objective defined—to showcase the wide array of work being done by our members under the umbrella of visual science communication—and a platform partnership in sight, we got to work defining a new membership category. Portfolio+ was the result. For \$65 above the membership dues of our existing categories (Digital, US Print, and Global Print), you get a personalized upload URL that allows you to upload a portfolio of your best work to our gallery (<https://www.gnsi.org/science-art-today>). The gallery is searchable by keyword, artist, and subject and each image is accompanied by your bio and website link so that anyone sifting through the gallery may contact you directly about commissioning work. The service also can provide linking code that you can install on a website of your own to separately showcase just your art.

Our goal is ultimately to broaden people’s conception of the field of visual science communication. The work that you do spans from anatomical illustration to infographics to graphic novels to nature journaling. You are cutting edge animators, sculptors, skilled

painters and draftsmen. But you are more than that; you understand how people process information visually, you are adept at talking to very specific audiences, and you have the ability to understand and communicate complex scientific ideas. All of these skills make our members a vital resource in effective science communication. Help us educate the public and potential clients about what we contribute to science literacy. Contribute your work and then spread the word about our new Portfolio+ gallery!

To upgrade your membership or join the GNSI, please visit <https://www.gnsi.org/join-us>.



Book Review

Building Science Graphics: An illustrated guide to communicating science with diagrams and visualizations

BY JEN CHRISTIANSEN

— Review by Diogo Guerra, medical illustrator

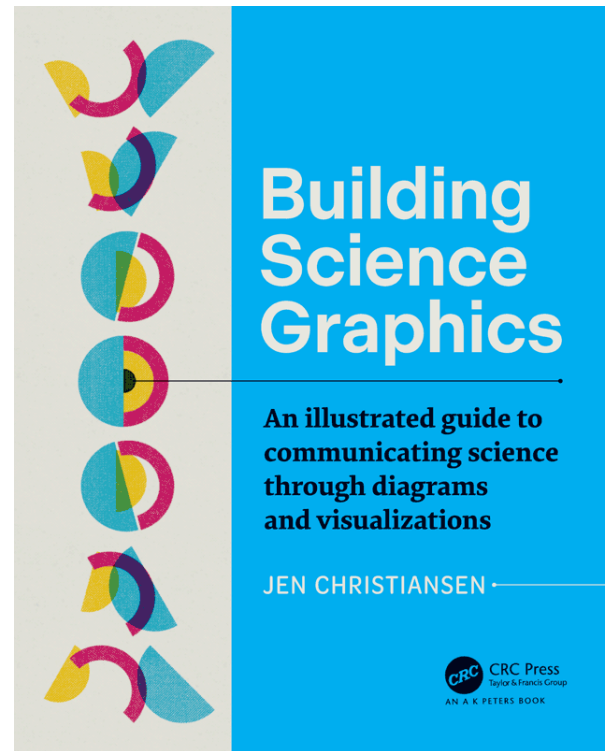
Building Science Graphics is a new practical guide written and designed by science communicator Jen Christiansen, Senior Graphics Editor at Scientific American, and published by CRC Press.

Contrary to what it may seem, this is not a book about charts or data visualization. As Jen clarifies in the early pages, the term "graphics" refers specifically to "illustrated explanatory diagrams."

I was thrilled to hear this, since these types of diagrams are among the most frequently used figures in scientific publications but rarely receive the same attention as other types of visuals, such as seemingly

more complex, purely figurative scientific illustrations (e.g. anatomical drawings) to more abstract data representations (e.g. data visualizations).

The book is extremely well-illustrated, featuring a variety of styles, topics, and showcased artists, demonstrating the book's relevance to any field or deliverable in science communication.



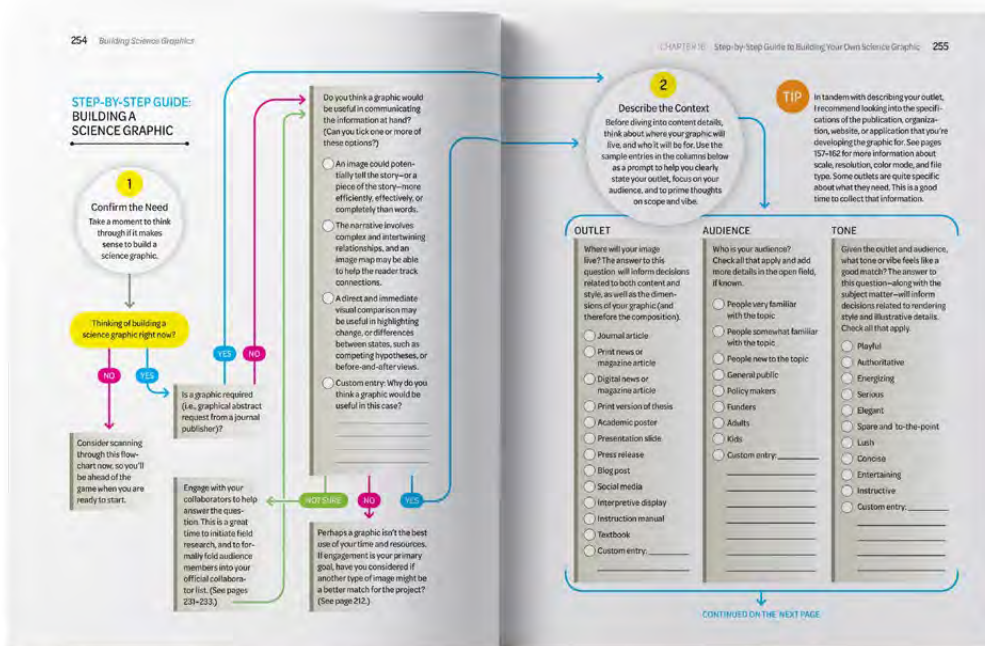
Above: Cover of *Building Science Graphics: An Illustrated Guide to Communicating Science with Diagrams and Visualizations* by Jen Christiansen.

A. K. Peters/CRC Press; 1st edition (December 20, 2022)

Paperback: 333 pages

ISBN-13: 978-1032106748

Left: Chapter 3 includes a couple of step-by-step guides on building and adapting science graphics.



REVIEWER

Diogo Guerra is a Lisbon-based medical illustrator and dataviz designer and consultant, with a background in Veterinary Medicine.

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Right: Sketch (left), and final artwork (right) by Cherie Sinnen in "The End of Orange Juice," written by Anne Kuchment, published in *Scientific American* (March 2013). Included with permission from the artist.



Above: Early sketches by Jen Christiansen for "The End of Orange Juice."



Image Credits: Cherie Sinnen, artist for "The End of Orange Juice," *Scientific American* (March 2013). Published here with permission from the artist.

the references that I had collected. She returned this tight sketch. Our expert consultant—Philip Anagnost Standy, an entomologist then at the University of Florida—did a thorough review, and returned a marked-up pdf. (For example, a note about the eggs included this guidance: "Eggs are usually laid on unexpanded leaves, i.e. much younger than these. They are often laid in a row down the middle of a leaf that is still tightly closed and are stalked so not randomly distributed or protrude as shown here. Also, hatches tend to have more eggs.") I went through the notes, clarified some points and overruled a few related to aesthetics, added some more visual references, and passed along the notes to Sinnen. Here's the final graphic.

Case Study: Dark Matter

Working with scientist authors really streamlines the process for me, since I have a direct line to a content expert, and they have a vested interest. For a magazine article by physicists Bogdan Dobrescu and Don Lincoln, I started with the unedited text manuscript, and a conversation with my text editing colleague, Clara Moskowitz. The authors study particle interactions and dark matter. This article would describe some recent ideas and experiments related to the idea that dark matter might, in fact, be a range of different particle and force types that just don't interact very much with what we think of as "normal matter."

Some *Scientific American* readers would be really comfortable with jumping straight into discussions of unconventional dark matter. But for the majority of our non-specialist readers, I wanted to provide more context. The formal goal of the graphic would be to introduce readers to a range of possible dark matter categories, as well as the evidence for and against some of the leading candidates.

I started by mapping out the different types of dark matter particles



Image Credits: Cherie Sinnen, as published in "The End of Orange Juice," by Anne Kuchment, *Scientific American* (March 2013). Published here with permission from the artist.

The content is organized into four main chapters:

- **Chapter 1**, the longest one, covers a wide range of introductory technical topics—from design principles and visual style to storytelling strategies; topics that I would argue are as important, if not more so, than pure illustration skills when it comes to creating effective explanatory diagrams.
- **Chapter 2** deals with some special considerations for science graphs. I want to give a shoutout to (a) the discussion about honoring complexity through clarification, rather than simplification, and (b) the several examples that illustrate the importance of and how to visually communicate *uncertainty* in science.
- **Chapter 3** walks the reader through the creation process, supplemented by several case studies with real-world examples. Additionally, the chapter includes two detailed flowcharts that guide newcomers through each step of the processes of creating/adapting visuals (*see previous page*).
- **Chapter 4** features interviews with professionals about their perspectives on sci-art collaborations.

There are a couple of topics in this book that are worth highlighting. The first is *perception science* and how its insights can help us make more informed decisions on how to create visuals that effectively convey information. While this section is not incredibly detailed, it is an excellent starting point that can hopefully inspire readers to explore this topic further.

The second theme I want to highlight is *knowing the audience* of a graphic. Throughout the book, Jen emphasizes the importance of designing visuals that cater to the needs and characteristics of the target audience, such as their level of expertise, age, or cultural background. Unfortunately, the field of visual science communication still lacks sufficient research on how audiences' preferences and understanding vary with different illustration styles. Nevertheless, I found the emphasis on this topic very pertinent and refreshing, and these factors should definitely be kept in mind and guide decisions about the level of detail, tone, and visual style of the final work. Finally, it's worth noting that, as Jen acknowledges at the beginning, her perspective is primarily from an American-centric viewpoint. Therefore, the presented style suggestions may not always translate well for international audiences.

This book feels like an excellent resource for scientific illustration students, scientists who want to improve their visual creation skills, and science communication enthusiasts. Although the content may be too simplistic for experienced scientific illustrators, the book still contains valuable nuggets of information and recommends further reading that may interest seasoned professionals. Therefore, I recommend this book, particularly for those who are new to the field. Alongside some theoretical sections, Jen's experience shines through her use of real-life case studies and practical tips. It would make an excellent introductory textbook for any visual science communication or illustration course/program, and it certainly belongs in the library of any sci-artist.

INTRODUCING

Tradigital Illustration

—By Scott Rawlins

When I mention “tradigital” illustration, people often laugh and ask me if it is something I’ve invented. Actually, the term has been around for approximately 30 years and is attributed to digital artist and educator Judith Moncrieff.

“Tradigital” is derived from **traditional** and **digital** and as the word implies, it results from combining traditional and computer-based (digital) approaches to create images. What constitutes these combinations varies and includes such pairings as computer-generated backgrounds with traditional hand-drawn cell foregrounds, digital templates used with traditional printmaking techniques and digitally fabricated models that are painted by hand.

How I interpret “tradigital” drawing is described later in this article. However, a broader interpretation is required to examine a couple of historical examples of what eventually evolved into contemporary tradigital art. It can be stated that this kind of art consists of a mix of mechanical and hand-rendered techniques. Let’s call this “tradimechanical”. Using this definition, it is clear that this kind of art has been around for a long time. Two examples are described below.

HAND-TINTED PHOTOGRAPHS

Photography was an exciting new way to capture and reproduce images when it was introduced in the early 19th century. However, these images were limited to black and white. One way to add color was to tint photographic prints by hand. “Hand-tinting” (also called “hand-coloring”) involved lightly painting over the photograph, usually using watercolors or “photo oil paint.” Most often the color on the resulting image was less saturated than a painting or color photograph—thus referring to the process as

“tinting” makes sense. The coupling of mechanical (the camera) with traditional (hand-tinting) is why I consider this an example of “tradimechanical” art.

HAND-COLORED LITHOGRAPHS

For reasons similar to the tinting of black and white photographs, prints of various sorts were also regularly hand-colored at one time. The example here is a lithograph (or a print of a lithograph) tinted with watercolor and/or gouache.

The book in which this illustration appears is William H. Edwards’ *Butterflies of North America* (in three volumes), published between 1874 and 1897. In his introduction, the author states that “at first there was difficulty in finding an artist who could faithfully portray the butterfly on stone, and two were tried, who were far from satisfactory.” Eventually, Mary Peart was hired and she is responsible for the majority of the illustrations. Edwards also credits two other women for their assistance with the illustrations: “I was fortunate from the start also in securing the cooperation of two such accomplished colorists as Mrs. Bowen and Mrs. Leslie, who had served their apprenticeship with Audubon.”

In this example, the “mechanical” process—using a printing press—is combined with traditional painting to produce “tradimechanical” illustrations. Regardless



Above: Tradimechanical art. Hand-painted lithograph, *Argynnis nokomis nitocris*.

All images © 2023
Scott Rawlins



Above: Hand-painted photo of the author's grandmother and father, Mary and Stokes Rawlins Jr., circa 1930.

of what constitutes the mixing of approaches, the reason for doing so has generally been to produce better or more interesting art—often saving the artist time and expense.

In my own case, the decision to mix traditional and digital techniques derived from having been exposed to art instruction in the 1970s when classical drawing was considered old-fashioned and abstraction was emphasized. I wanted to learn how to draw accurately and my teachers wanted me to throw paint around to produce nonrepresentational images that reflected the current political climate. Digital art seemed too far removed from the kind of art I believed “fine” artists should be making. I was aware, however, that digitally-generated images can be both more cost effective and more easily corrected than traditionally-generated images. Thus, it seemed to me that combining the approaches would allow me to take advantage of digital technology but also employ various traditional media and/or styles.

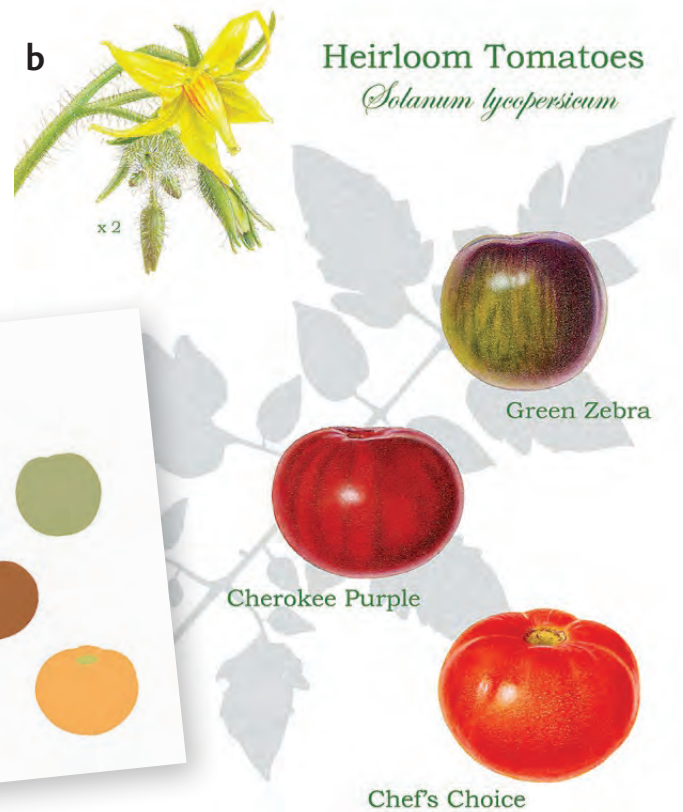
Reasons why I chose to explore a tradigital approach include the following:

- Some artists and illustrators are more comfortable with or prefer to use traditional media but recognize that producing illustrations digitally has many advantages.
- Some artists and illustrators find that a good percentage of digital work looks mechanical or lacks spontaneity.
- Some artists and illustrators find that there is value in making mistakes—and that when fixing these mistakes is as easy as typing “Command+Z” there are fewer opportunities to incorporate “mistakes” into the work, resulting in art that is more innovative, original or interesting.

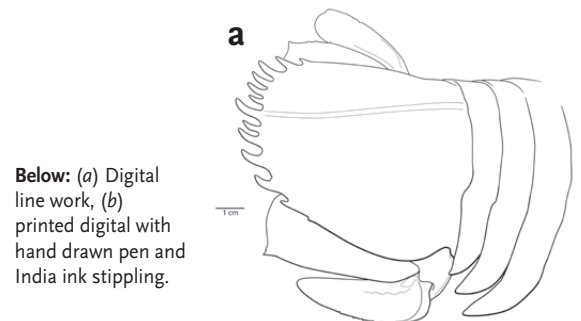
Tradigital art can take a number of forms, such as a composite consisting of a layer created digitally and a second one created traditionally, work begun traditionally and completed digitally (a single layer) or work begun digitally and completed traditionally (also a single layer). I will limit my discussion to the third type since I have used it most extensively.

I am both a slow artist and a procrastinator. Any approaches that will speed things up for me are worth investigating. For black and white illustrations, fairly simple, weighted line drawings are printed and “finished” with Micron pen stipples. Other details are added with India ink using a fine brush. In order to accelerate the multi-layering system I use with colored pencils, I decided to try creating “base coat” layers of color using Adobe Illustrator® before printing the results and finishing the drawings as I have done in the past. With some experimentation I discovered that a number of different papers could be used for the prints—vellum, Bristol® board and coquille board, among others. Since my printer is an inkjet, the digital prints intended for colored renderings accepted colored pencil beautifully. The completed drawings, sometimes using pastel dust (powdered pastel brushed onto the drawing surface) and white gouache for bright highlights, look like they were generated using only traditional media.

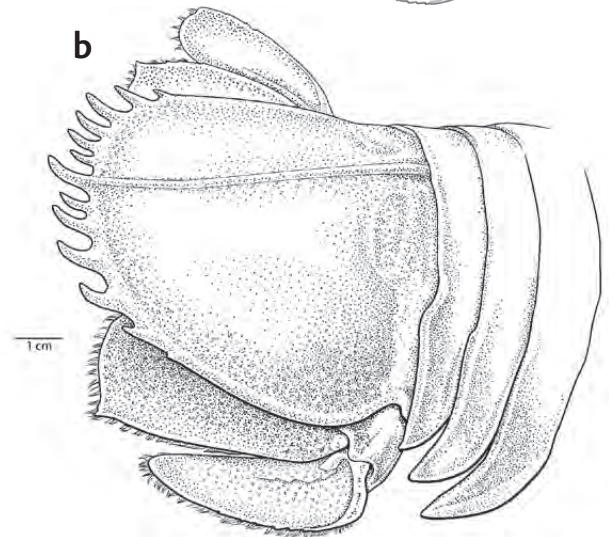
In terms of maximizing one’s time and effort, sometimes a tradigital approach might be the best option!



Above: (a) Example of a digital print with blocked color before (b) layering with traditional techniques.



Below: (a) Digital line work, (b) printed digital with hand drawn pen and India ink stippling.





Limited Gouache Palette

—by John Muir Laws

Figure 1 (left): Pine warbler painted with watercolor and light value gouache on toned paper—pop!

Here is a simple system that will help you take advantage of the upsides of using gouache paint in the field (buttery smooth color transitions, ability to rewet from a pan like watercolor, and opacity), while mitigating aspects of using gouache paint that many artists find frustrating (crumbling in the palette, drying shift with dark colors, and unintended reactivation of dried colors with subsequent washes). This system is great on white paper but rises to the next level of awesomeness on toned paper.

The light value gouache system is easy to use in the field or in the studio. You will create a mini gouache palette, which is comprised only of light values. This light value pallet will supplement your regular watercolor (comprised of both dark and light value paints). Here is a quick summary of how it works. First we will set up a mini palette with a few strategies to help prevent the paint from crumbling from the pan as it dries. Then we paint, starting with transparent watercolor for the darks and mid values, and end with light value opaque gouache. This approach is a

fast, effective, and fun way to paint and gives you the advantages of painting with gouache while avoiding many of the challenges.

MAKE YOUR OWN LIGHT VALUE GOUACHE PALETTE

This system does not require a wide palette of gouache paints. You will construct a small palette of pans of light valued gouache paints that will be left to dry and can be re-wetted as needed as is conventionally done with watercolor. Most gouache artists use wet paint from tubes. I find this inconvenient in the field. I like having a set of cakes that I can re-wet like watercolor. However, if you squeeze gouache paint into pans and let it dry, it will crack into pieces as the water evaporates. To minimize this cracking, we will carefully compress the paint as it dries, leaving solid cakes of color.

“A light value palette does not take up much room in your field kit and is a great adjunct to a watercolor palette. Consider it essential if you work on toned paper!”

—JOHN MUIR LAWS



Figure 2 (left): If you carry a watercolor kit, you do not need to bring a full range of gouache colors, only the light values.

Figure 3 (right): Preparing an Altoids® tin as a palette.

All images © 2023
John Muir Laws



Scratch the inside of the pans with a sharp knife for added texture and traction, then put a small dab of gouache in the bottom of the pan.

Press a piece of gauze into the dab of paint.

Fill the rest of the pan with gouache.

As the gouache begins to dry, it will contract and crack. Firmly press the drying gouache down into the pan.

The pressure will smash the paint back into a solid block. Repeat as necessary as the paint dries.

Figure 4 (above): How to prepare gouache pans (or “watching paint dry”).

Color Selection

My light value gouache kit has a selection of tints and light colors from a variety of manufacturers. If you already have a set of gouache paints, sort through your tubes and pick out the lightest colors. You will definitely need white and yellow. You can buy other colors or mix your own by adding white or other paints in your kit. Consider adding yellow to one of your greens to make a light yellow-green. The size of your palette will determine how many colors you can bring. I have included a list of the colors in my palette in order of priority. If you only have four spaces in your palette, I would suggest using the first four paints on this list. If you have eight spaces, use the first eight, and so on. New paints are constantly being produced; this is my selection at the time of this writing. There may be new paints and pigments available in the future and some of these paints may not be available in your area. Modify the list to suit your personal preferences and availability.

1. Permanent White, Holbein (PW6)
2. Lemon Yellow, Holbein (PY3)
3. Aqua Blue, Holbein (PB15, PW6)
4. Neutral Grey No. 3, Winsor & Newton (PW6, PBk7 PY42) Prioritize this paint if you are sketching in a Strathmore toned gray sketchbook. It is very close to the color of the paper and can be used as “white out” for the gray paper if you draw some ink lines you would like to make disappear. If you are not using gray paper, shift this paint to the bottom of the list.
5. Brilliant Pink, Holbein (PR209, PW6)
6. Leaf Green, Holbein (PY1.3, PG7)
7. Lilac, Holbein (PV23, PW6)
8. Cadmium Free Yellow Deep, (this is a light orange) Winsor & Newton
9. Pale Coral, Holbein (PO36, PW6)
10. Buff Titanium, Daniel Smith (PW6.1)
11. Naples Yellow Deep, (this is light yellow-tan) Winsor & Newton (PBr24)
12. Myosotis Blue, Holbein (PB 29, 60, PW6)
13. Moss Green, Holbein (PY42, PG8)

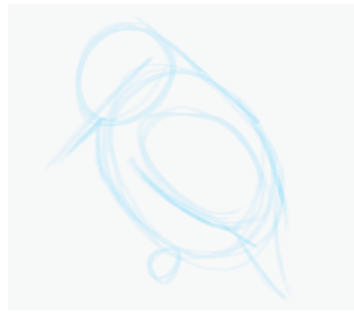
If you have an old compact watercolor kit that you no longer use, you can repurpose it as a new gouache palette. If you would like a fun do-it-yourself craft, you can create a new gouache palette from a metal breath mint tin. A typical Altoids® tin will hold thirteen half pans. Place watercolor half pans into the tin to see how many will fit and what orientation will allow you to have the most colors. Then prepare the mint tin. After you eat the mints, clean and dry the inside of the tin and spray the exposed inner metal surfaces with white rust resistant enamel (such as white Rust-Oleum® Gloss Protective Enamel).

The big trick is how to fill the pans with gouache paint so the paint will not crumble and fall out as it dries. The first step is to score the inside of each half pan with a sharp knife; make a grid pattern so that there is more texture on the bottom of the pan to help hold the paint. Then place a small drop of gouache into the bottom of the pan. While the drop of paint is still wet, cut a piece of medical gauze to fit inside the pan and press it into the drop of paint, then squeeze more paint into the pan to fill it to the top. This embeds the fabric in the pad of paint, helping it hold together. Set the pan aside to dry. Do the same with all of your colors. As the gouache paint dries, it will begin to

The Limited Value System

As an example of this process, let's walk through a painting of a kingfisher. This was not drawn in the field, but in the studio based on a photograph by Siegfried Poepperl.

1. Paint middle and dark values with transparent watercolor
2. Let the watercolor layers dry thoroughly
3. Paint the light values with opaque gouache.



Block in the basic shape: Begin each illustration by lightly constructing the basic shape with a light non-photo blue pencil. (If you draw on toned paper, try blocking the basic shape with an erasable light-purple pencil, which shows up better.) Pay particular attention to the negative shape on the back of the bird, the proportions of the head, and the negative shape below the bill and along the throat and upper chest. If you can get these shapes and proportions, you will have an effective base drawing.



Graphite drawing: Draw directly on top of the non-photo blue pencil under-drawing with a graphite pencil. If you look carefully at the head, you can see where I created a wireframe scaffold of curved lines that wrap around the head. This helps me visualize the head as a rounded form, particularly important in this three-quarter head view. Do not draw in every feather, but suggest feather masses.



Shadows: Try the grisaille technique, blocking in the shadows first with purple gray watercolor washes. Here I used Daniel Smith Shadow Violet watercolor. These shadows will show through subsequent transparent watercolor layers. In this illustration, I imagine that the light is coming from the upper left and a little behind the subject.



Local color: Once the shadow layer is dry, use watercolor again to paint blocks of local color (the body color of the bird as seen in neutral light). Note how the purple gray shadows show through the transparent watercolor, combining color and form.



Value range: Build up the watercolor painting from light to dark values. Fill the lightest areas with a middle value of the local color. This will be covered by gouache in the next step but provides a good undercoat in case any spots of paper might show through.



Gouache: Re-wet dried gouache in the pans to the texture of thick cream. Paint light value areas working from darker to lighter (opposite of what we did with the watercolor). Light value gouache appears more opaque when you first put it down, becoming more transparent and darker as it dries, especially if you add too much water. You may have to add more layers of gouache to build up your lightest lights. Let each layer dry between coats.



Final touches: Once the gouache has dried, add your finishing touches; add details to areas of focus, enhance contrast, and make the edges of the illustration more crisp and clean. I cleaned up my edges by erasing all the graphite along the perimeter of the illustration and redrawing it with a dark brown Prismacolor Verathin pencil. A brown edge adds subtle warmth to the drawing.

crack on its surface and pull away from the edges of the pan. When this happens, the top surface of the paint will develop a skin and take on a putty like texture. While the paint is in this putty stage, firmly press the mass of drying paint into the bottom of the pan. You will want to smash out all of the cracks and press the paint block up against the sides of the pan.

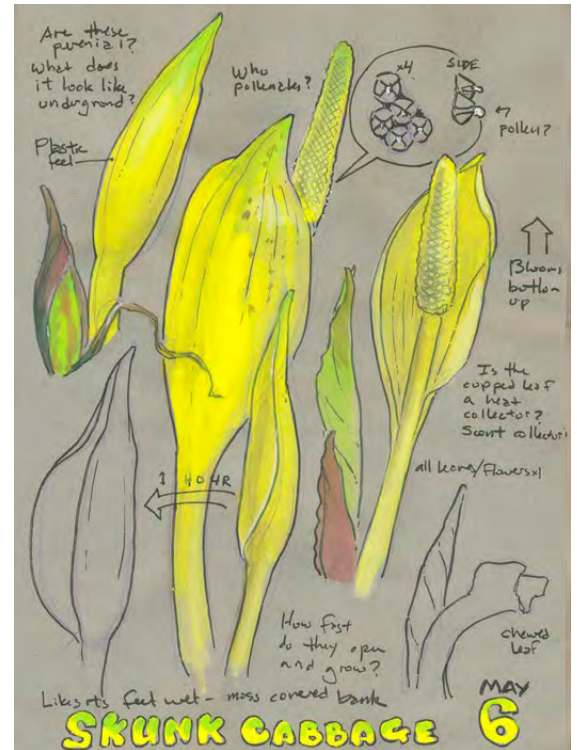
Continue this smash and press procedure several times as the paint dries over the next few days. If you press the paint too early, the paint will still be wet and squirt out all over your fingers. If you do it too late,

the paint will be truly dry and you will not be able to press and smash. The colors that dry first tend to crack the most.

Once your pans are dry, place them in the tin. The half pans will fall out of the tin if you do not secure them somehow. The easiest way to do this is with a few drops of superglue. Alternately, if you wish to be able to move and reorganize the half pans you can stick a strip of adhesive magnetic tape on the back of each half pan or place strips of double-sided adhesive mounting tape into the bottom of the tin.

Figure 5 (left): Finished gouache palettes. There has been some cracking as the paint has dried but the pads of paint remain intact and do not crumble. Note the dabs of white paint in the mixing areas. Add these paint dabs near the edges of the lids but far enough away from the lid wall that they will not block the lid from closing.

Figure 6 (right): Skunk cabbage.



Finally, squirt a few dabs of white paint around the edges of the lid (mixing area). You can use these dabs to tint colors without putting a dirty brush into your white paint pan. Should any of your cakes of paint fall out of their pan, add a few drops of water to the bottom of the pan and replace the cake, jiggling it back-and-forth with your finger to liquefy some of the paint on the bottom of the cake and re-adhere it to the pan.

THE LIMITED PALETTE SYSTEM

Painting with the limited palette system is fast and fun. We begin with a watercolor painting. Establish your shadows with a purple-gray mixture, then paint over the shadows with transparent watercolor layers, building from middle values to dark. Fill the highlights and light areas with mid-value colors as well. Once the watercolor layers have dried, paint the

light values with opaque gouache on top of the watercolor base, bringing out the lights and texture. Dry watercolor is much less likely to reactivate when it gets wet so it makes a good base below the gouache. If you had started with the gouache, it would reactivate when moistened by the watercolor layers on top of it. I often sketch and paint in a Strathmore brown or gray toned paper sketchbook. The light value gouache palette is wonderful for these studies. Adding white or other light values on the toned paper is so much fun. The opaque gouache “pops” on the dark paper, allowing you to have bright and clean lights. Every time your gouache touches the paper, you get a little squirt of dopamine. Mmmmm, more of that...

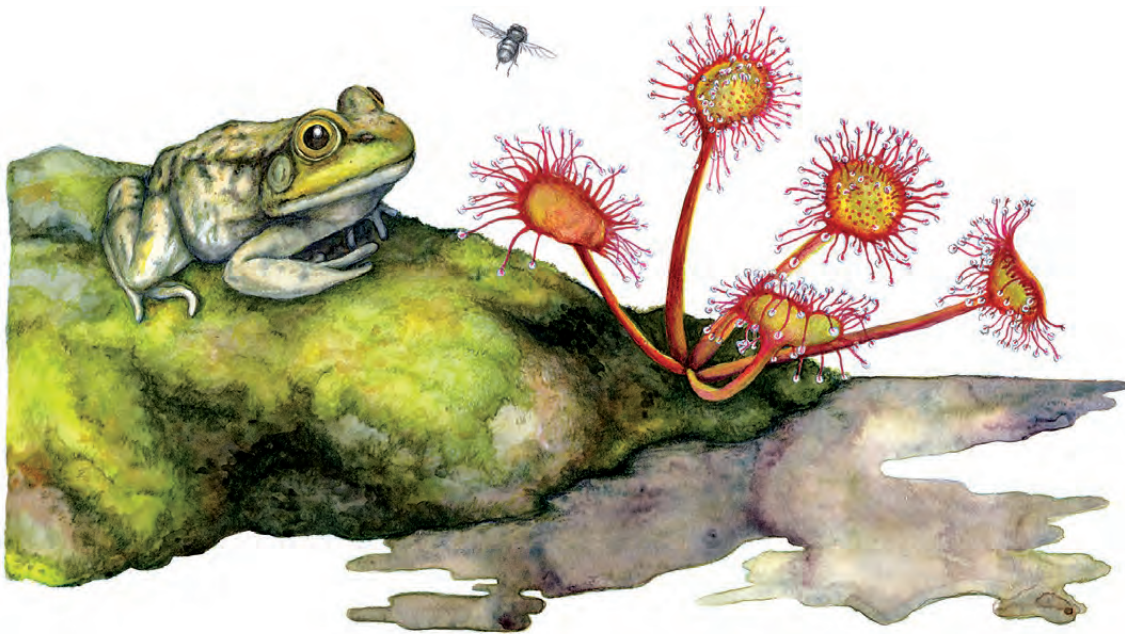
Being able to fill a portable palette with dried gouache is a game changer for me. I now can bring gouache everywhere. The addition of gouache to my process has changed the way I think about light and painting. I regularly find myself surprised and delighted by the results and I think you will too. By combining transparent watercolor with opaque gouache, you can take advantage of gouache’s opacity, and ease of mixing into smooth transitions while avoiding much of the frustration regularly associated with the medium. Have fun!



ABOUT THE ARTIST

John (Jack) Muir Laws is a principal leader and innovator of the worldwide nature journaling movement. Jack is a scientist, educator, and author, who helps people forge a deeper and more personal connection with nature through keeping illustrated nature journals and understanding science.

johnmuirlaws.com | [@johnmuirlaws](https://twitter.com/johnmuirlaws)



Above: Catching flies
(*Lithobates clamitans*
and *Drosera rotundifolia*).
Watercolor and colored
pencil. © 2023 Julia Kawai
@planet_earthstar
juliakawai.com

Illustrating Nature

CSUMB Science Illustration Graduate Program: Class of 2023

—by Emily Fries, Julia Kawai, and Nathan Michaelson

Illustrating Nature, the annual art exhibition showcasing the work of students from California State University, Monterey Bay's (CSUMB) Science Illustration certificate program, opened this year on May 19th at the Pacific Grove Museum of Natural History.

The artworks were beautifully presented within the museum's Room of Birds—a fitting location for such a dazzling display of uniqueness and precision. The curated selection of science and nature-inspired work—including field sketches, pen and ink drawings, digital and traditional paintings, and even one embroidered piece—were truly impressive.

The students of this year's cohort come from a broad range of backgrounds such as environmental science, art and design, neuroscience, marine biology, and education. And yet, they were united by their dedication to honing their craft, as well as their curiosity and care for the natural world. They became incredibly close in their year-long adventure in Monterey. From creating a band on the beach with seaweed collected during a macroalgae-focused field

trip, to going over the top for birthdays in the classroom, the vibes were always super chill.

One of the most remarkable aspects of the exhibition was the students' ability to combine science and art seamlessly. The CSUMB Science Illustration program is one of the top programs of its kind, teaching students the skills and knowledge needed to create scientifically accurate illustrations. Under the leadership of Program Director Ann Caudle, instructors Justine Lee Hirten, Reid Psaltis, Andrea Dingeldein, and Amadeo Bachar have tirelessly shared their artistic expertise and appreciation for various science topics with students. Their dedication to their students was reflected in the caliber of the artwork on display.

Students:

Jonathan Broberg
Mica Carr
Julia Ditto
Erin Ellis
Emily Fries
Julia Kawai
Adara Koivula
Nathan Michaelson
Emily C. Mitchell
Lindsay Newey
Kaelin O'Hare
Charin Park
Andrea Pierre
Olivia Raster
Audrey Sauble
Mason Schratter
Rowan Weir

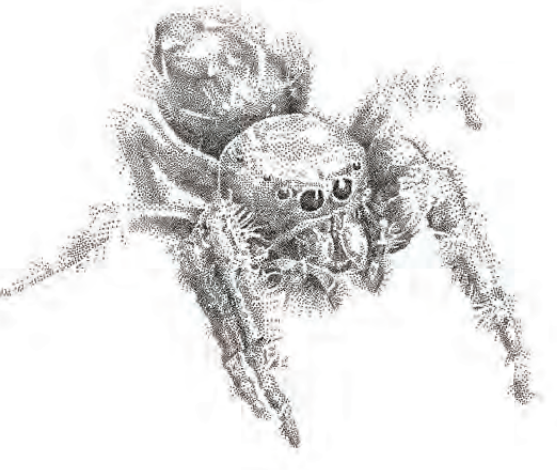
The *Illustrating Nature* exhibition was the culmination of the 2023 class's work; it provided students an opportunity to showcase their skills and for the public to appreciate the beauty and importance of science illustration. The exhibition remained open to the public from May 19th through June 18th, 2023 in Pacific Grove, California.

FOLLOW ALONG with the happenings of the program by checking out the CSUMB Science Illustration Program instagram page @scienceillustration.



Above: Abalone shell (*Haliotis rufescens*). Colored pencil. © 2023 Olivia Raster | @rastero_art

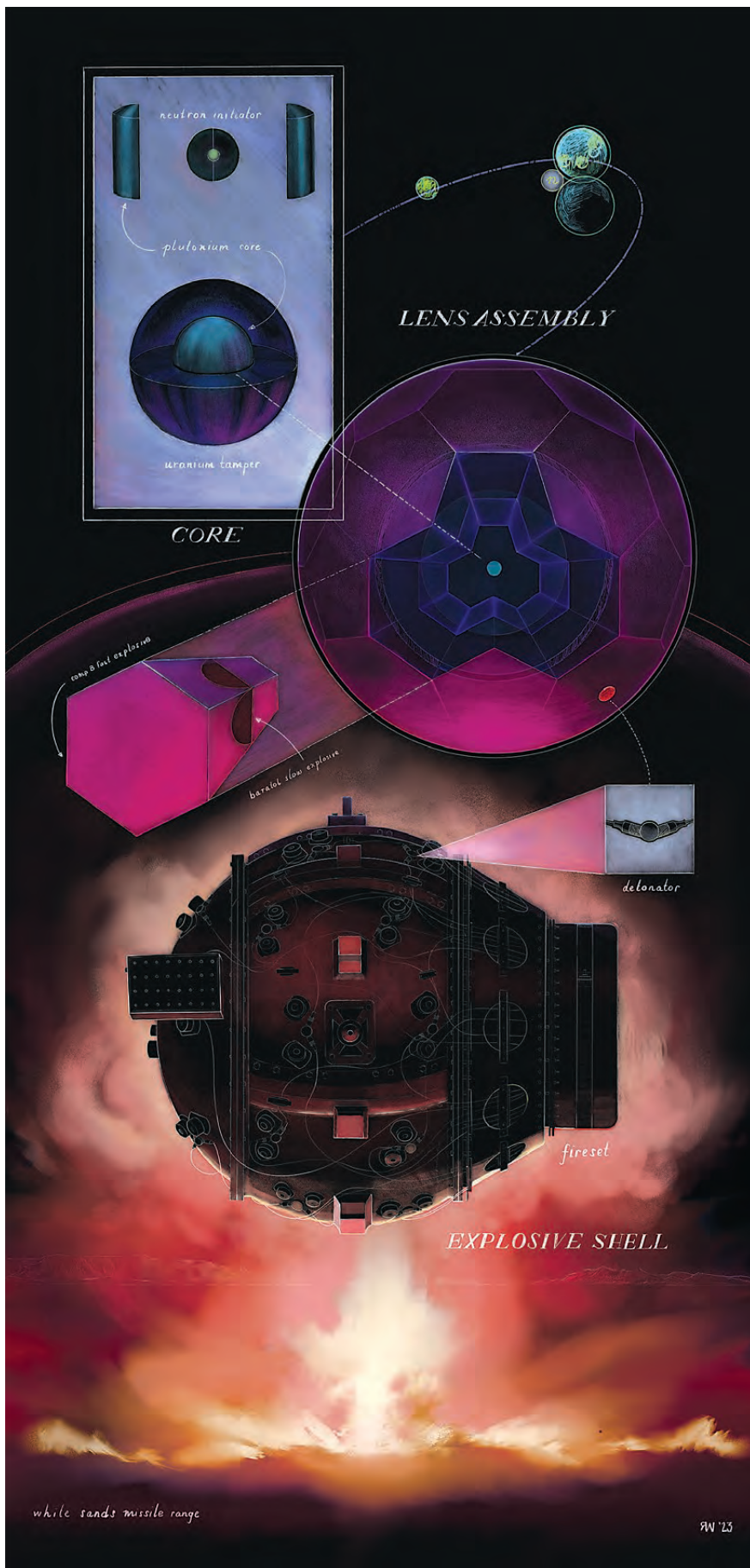
Below: Gosewinkler (*Phidippus audax*). Ink stipple. © 2023 Jonathan Broberg | @jonbro_art



Above: Peahen (*Pavo cristatus*). Scratchboard. © 2023 Mason Schratter @masonschratterart | masonschratterart.com



Above: Yukon sedimentary rock. Ink stipple. © 2023 Julia Ditto @julia_ditto_illustration | juliaditto.com



Left: The gadget: the first nuclear weapon test. Digital using Procreate®. © 2023 Rowan Weir
[@moromaru.art](https://www.instagram.com/moromaru.art)
[moromaru.art](https://www.moromaru.art)

CSUMB also offers summer classes in science illustration. These skills enrichment classes are open to all experience levels. Visit [csumb.edu/scienceillustration/summer-science-illustration](https://www.csumb.edu/scienceillustration/summer-science-illustration) to find out more!



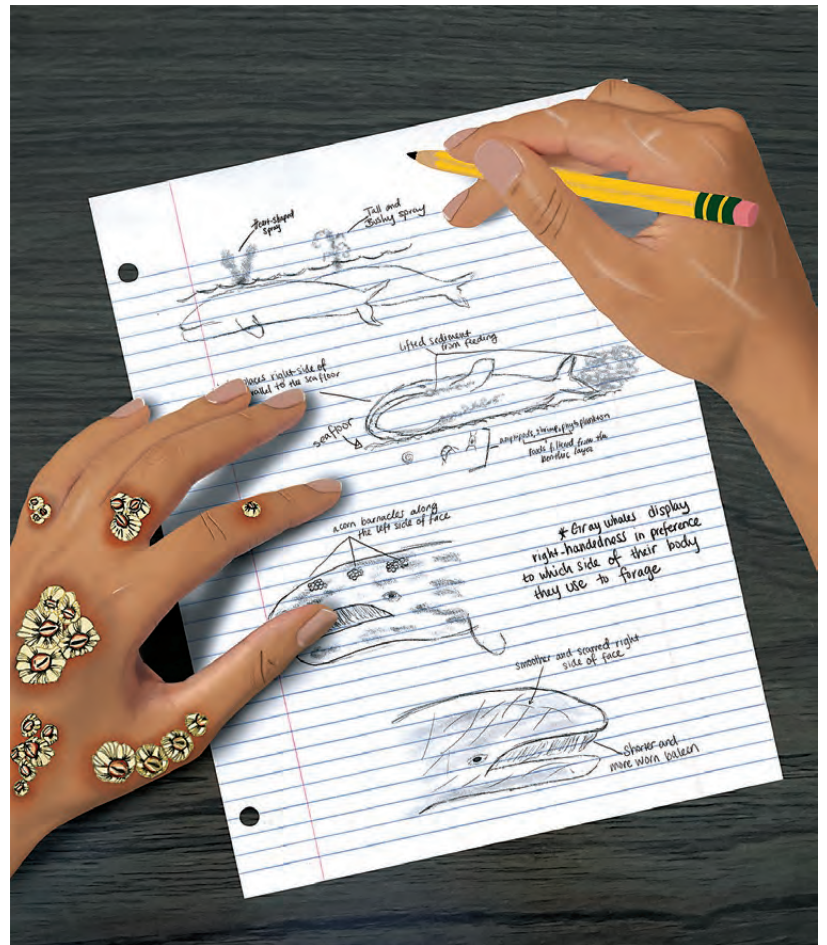
Above: Spotted hyena (*Crocuta crocuta*). Acrylic and colored pencil. © 2023 Nathan Michaelson
[nathanmichaelson.com](https://www.nathanmichaelson.com) | [@n.art.than](https://www.instagram.com/n.art.than)



Above: The abalone hunter (*Enhydra lutris*). Acrylic. © 2023 Audrey Sauble
[@audreysauble.illustrator](https://www.audreysauble.com) | [auresauble.com](https://www.audreysauble.com)

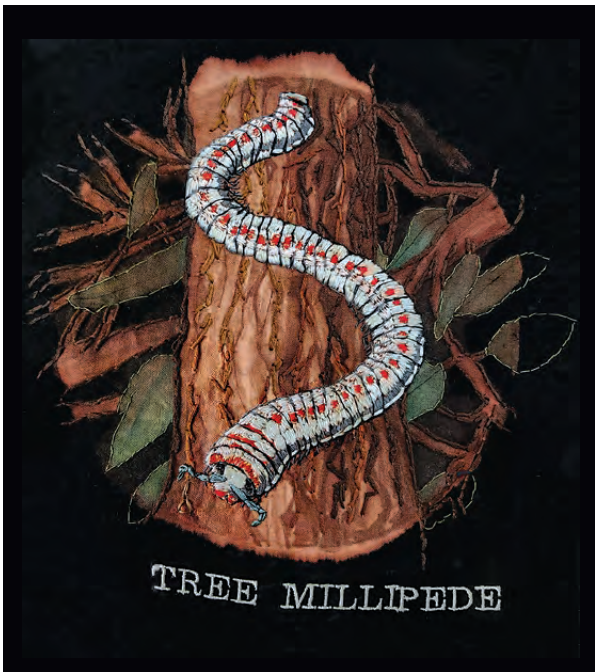


Above: Unlikely heroes (*Cricetomys ansorgei*).
Digital using Photoshop®. © 2023 Adara Koivula
[@koivulart](#) | [koivulart.com](#)



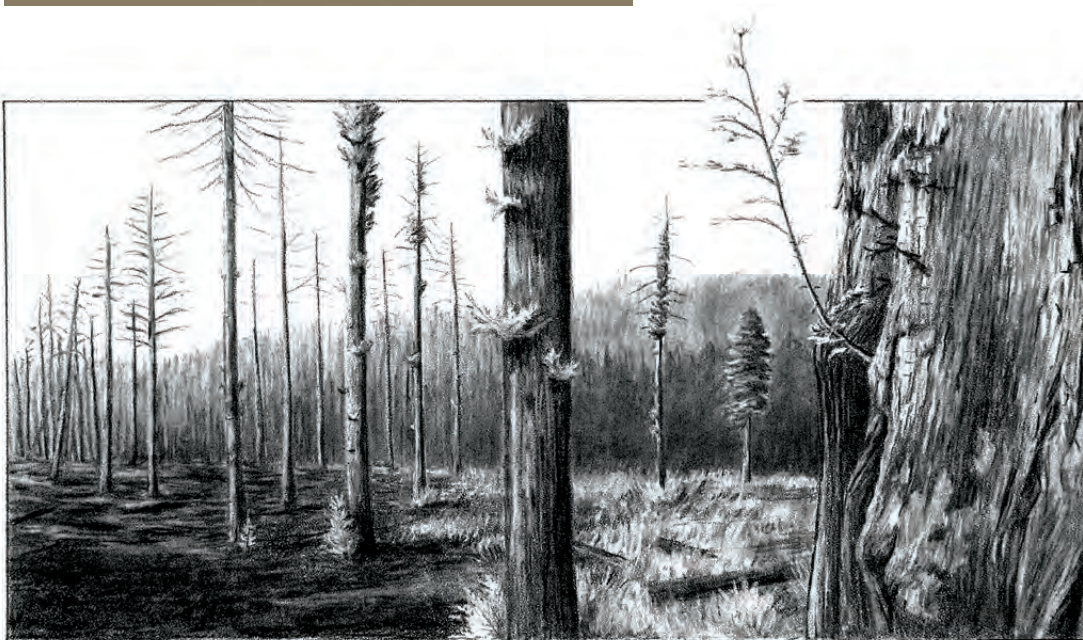
Above: The hands that feed you (*Eschrichtius robustus*). Graphite and digital using Photoshop and Procreate. © 2023 Andraeh Pierre
[@dre_illustrates](#)

Below: Tree millipede (*Anadenobolus arboreus*).
Embroidery on dyed fabric. © 2023 Lindsay Newey
[@covenriot](#) | [lnewey6105.myportfolio.com](#)



Below: Gorilla glowthrough (*Gorilla gorilla*). Graphic skull, digitally rendered face in Procreate. © 2023 Emily Fries
[@ringsofphilautia](#) | [emilyfries.com](#)





Top left: Intertidal landscape. Gouache.
© 2023 Mica Carr | [@liminaldesignlab](https://liminaldesignlab.com)
liminaldesignlab.com

Top right: Sisters (*Daphnia magna*). Ink,
watercolor, and gouache. © 2023 Charin
Park | [@Charin.Park](https://Charin.Park)

Middle left: See nothing, hear nothing,
speak nothing (*Rhinolophus ferrumequi-*
num, *Myotis lucifugus*, *Plecotusaustriacus*).
Digital using Photoshop. © 2023
Emily C. Mitchell | emilyc.mitchell.com
[@emily_c_mitchell](https://emilyc.mitchell.com)

Middle right: Winter's come and gone
(*Cardinalis cardinalis*). Watercolor
and gouache. © 2023 Erin Ellis
[@leavesandletterforms](https://leavesandletterforms.com) | erinellis.com

Bottom: Redwood regrowth after wildfire
(*Sequoia sempervirens*). © 2023 Kaelin
O'Hare | [@kaelinohare_illustration](https://kaelinohare-illustration.com)
[kaelinohare.com](https://kaelinohare-illustration.com)

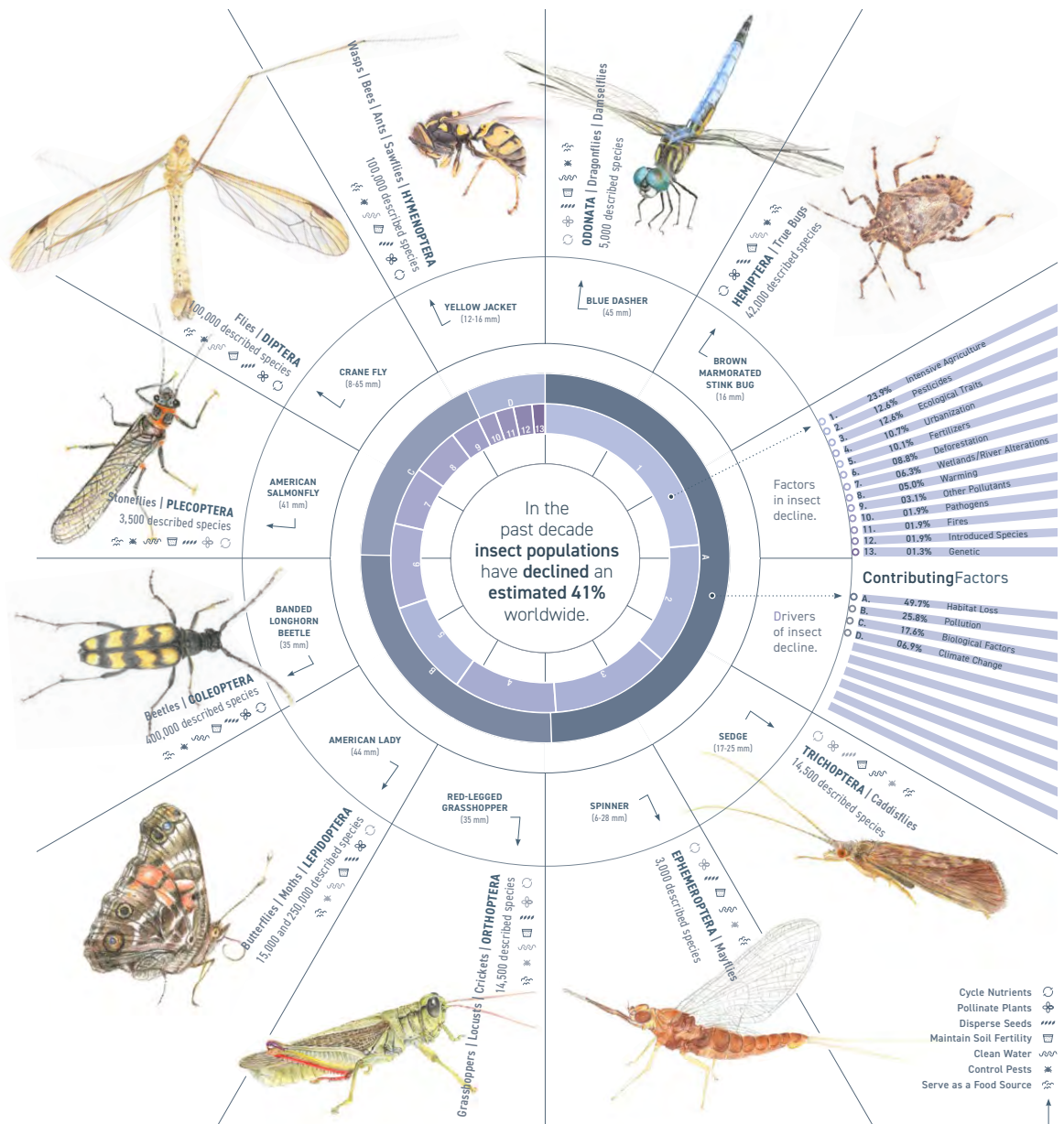
Dissecting Typographic Components in Effective Science Visualization

—by M. Genevieve Hitchings

In this article I explore the process of planning and developing illustrated visualizations with emphasis on information design and the supportive role typography can play in communicating complicated ideas to broader audiences. Successful information design is a marriage between type and image.

Right: Sample typography and layout from the infographic, Insects are the Building Blocks of the Planet's Ecosystem.

All images © 2023
M. Genevieve Hitchings



Insects are the Building Blocks of the Planet's Ecosystem

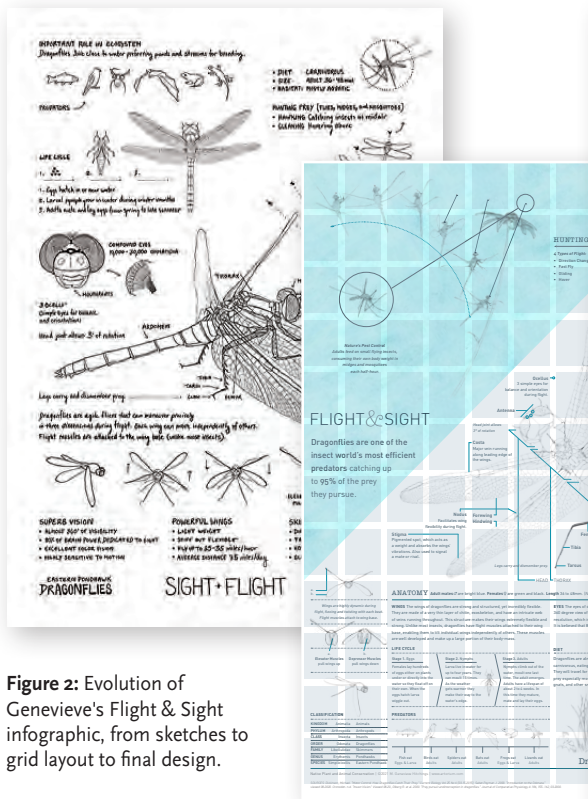


Figure 2: Evolution of Genevieve's Flight & Sight infographic, from sketches to grid layout to final design.

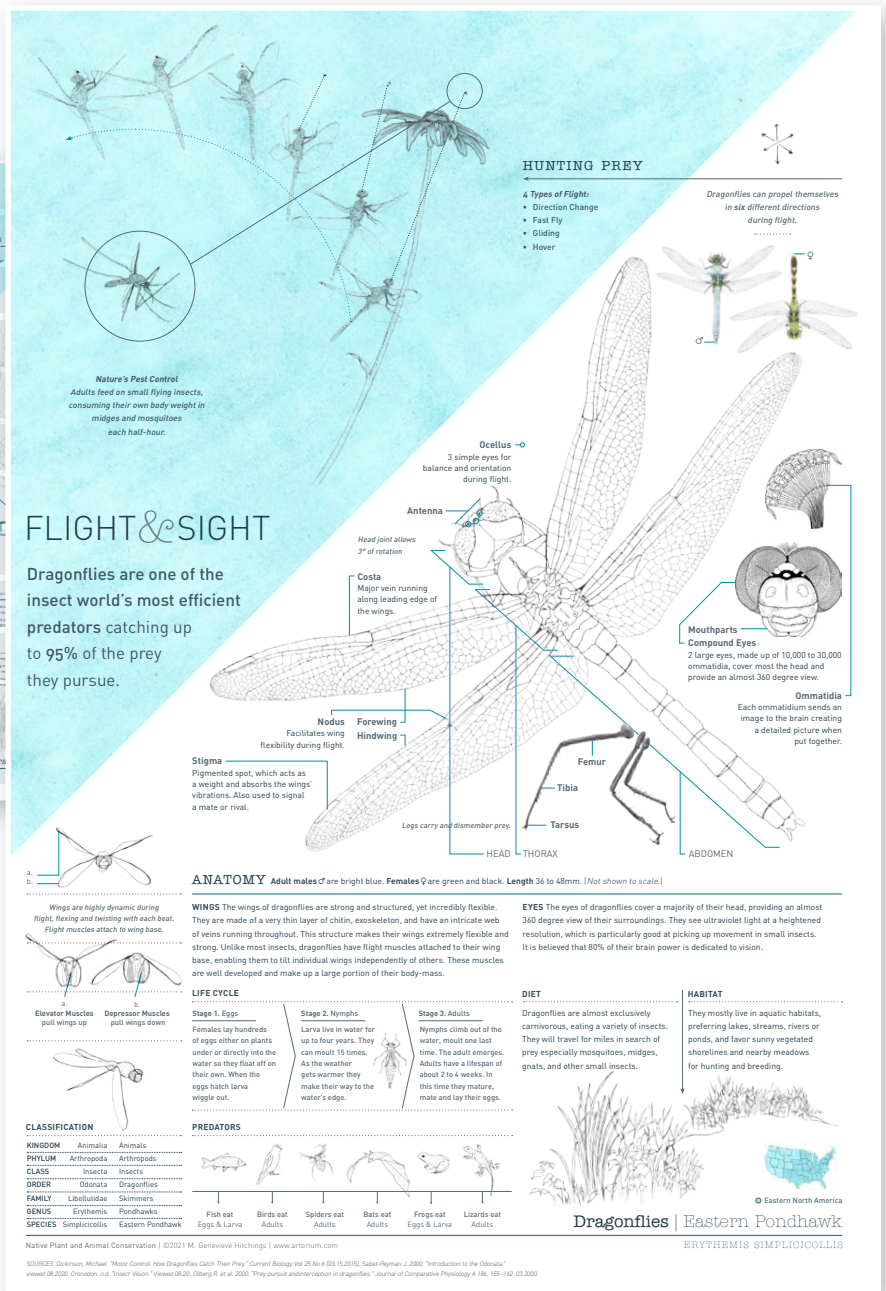
Type and image play different but equally important roles in an infographic. For this to be successful they must support each other. More on type in a moment. To understand this marriage it helps to define the role of designer and illustrator, tasked to consider three interconnected threads:

1. **The problem** or the assignment being communicated. This might include any number of topics but can loosely be categorized into the following four areas: process, procedure, phenomenon, or object.
2. **The audience** being communicated to.
3. **The client** who is requesting the communication.

Visual communicators are beholden to each of these threads. The decisions made in finding successful solutions must be informed by each. And ultimately the client has the final say regardless of how pleased or displeased the designer is with the solution.

At its best, information design, especially in the service of science, is a story-driven experience that educates and makes scientific concepts visible, understandable and usable. This form of visualizing science can facilitate ideas that are difficult for broader audiences to understand.

Science is full of captivating and complex ideas that are often out of reach to non-expert audiences.

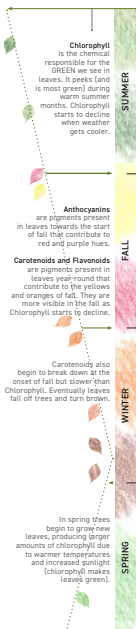


"I am really trained as a designer, but I work as a translator. I am actively trying to take scientific papers and I'm really trying to break that chain of communication from one researcher to another researcher. I might want to intercept that idea and find a visual way to communicate it to someone who does not have this terminology. Can I find a visual explanation for it?"

—JONATHAN CORUM, NEW YORK TIMES SCIENCE GRAPHICS EDITOR



Trees Drop Leaves to Conserve Energy



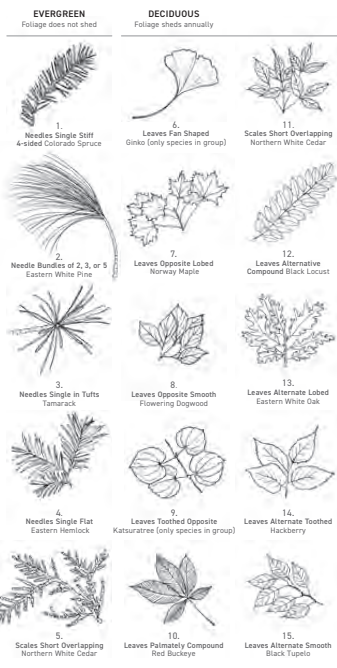
In all but the warmest climates, many insects depend on leaf litter for surviving winters.

Plants generate energy from sunlight through a process called photosynthesis. Trees produce chlorophyll, a green pigment that absorbs light. That light is then turned to energy that feeds the trees. During the summer growing season, trees produce chlorophyll as fast as they use it.

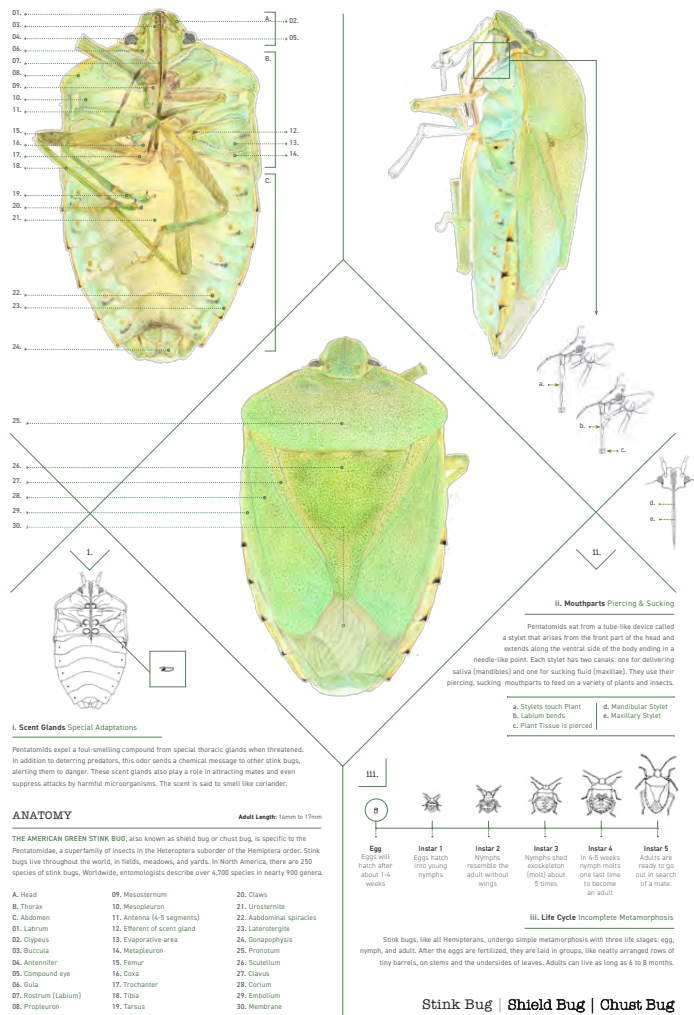
As summer comes to an end, days start to shorten, nights become cooler, and plants go to seed. This causes trees to produce less and less chlorophyll. The green pigment starts to fade and other pigments hidden underneath emerge. These include vibrant yellows, oranges, reds, purples, and even pinks. All these pigments (chemicals) are always present in leaves, but in the summer, they are subdued by the out sized amount of chlorophyll.

During the winter months the axis of the Earth tilts toward the northern hemisphere, away from the sun, reducing both the amount and the intensity of sunlight. Trees slow down their metabolism in order to conserve energy for the winter. As less chlorophyll is produced, underlying pigments in the leaves become visible and eventually cause them to fall off the tree branches and turn brown. The tree's trunk and branches go into a sort of hibernation for the winter.

Nothing goes to waste. A thick layer of fallen leaves provides additional insulation against cold weather and can protect newly planted perennials when frost-heave may expose tender roots. Fallen leaves support an important community of organisms allowing them to overwinter during the cold winter months. Leaf litter also creates an annual influx of organic matter, ensuring the soil is rich with nutrients to support new life in the spring.



Leaves are the primary way plants interact with the atmosphere and take care of their basic needs. Trees can be categorized into 15 groups identified by the shape and arrangement of their SCALES, NEEDLES or LEAVES.



There are approximately 100 native trees species growing in the wild across New York State.

LEAVE the LEAVES

Native Plant and Animal Conservation | ©2023 M. Genevieve Hitchings | www.artorium.com

Sources: NYC Trees Parks & Recreation (2005), NAWF (2019), Arves Society (2017), Fine Gardening (2007)

ANATOMY

THE AMERICAN GREEN STINK BUG, also known as shield bug or chust bug, is specific to the Pentatomidae, a superfamily of insects in the Heteroptera suborder of the Hemiptera order. Stink bugs live throughout the world, in fields, meadows, and yards. In North America, there are 290 species of stink bugs. Worldwide, entomologists describe over 4,200 species in nearly 100 genera.

- | | | |
|----------------------|-----------------------------|-------------------------|
| A. Head | 09. Mesosternum | 20. Claws |
| B. Thorax | 10. Mesopleuron | 21. Unispiracles |
| C. Abdomen | 11. Antenna (4-5 segments) | 22. Abdominal spiracles |
| 01. Labrum | 12. Effluent of scent gland | 23. Laterotergite |
| 02. Clypeus | 13. Evaporative area | 24. Gonapophysis |
| 03. Buccula | 14. Metapleuron | 25. Pronotum |
| 04. Antennifer | 15. Femur | 26. Scutellum |
| 05. Compound eye | 16. Compound eye | 27. Clavus |
| 06. Gula | 17. Trochanter | 28. Corium |
| 07. Rostrum (Labium) | 18. Tibia | 29. Embolus |
| 08. Propodeum | 19. Tarsus | 30. Membrane |

Life Cycle

- | | | | | | |
|---|---|--|---|--|---|
| Egg
Eggs will hatch after about 1-4 weeks | Instar 1
Eggs hatch into young nymphs | Instar 2
Nymphs resemble the adult without wings | Instar 3
Nymphs shed exoskeleton (molt) about 5 times | Instar 4
In 4-5 weeks nymphs molt one last time to become an adult | Instar 5
Adults are ready to go out to search for a mate. |
|---|---|--|---|--|---|

Stink bugs, like all Hemipterans, undergo simple metamorphosis with three life stages: egg, nymph, and adult. After the eggs are fertilized, they are laid in groups, like neatly arranged rows of tiny barrels, on stems and the undersides of leaves. Adults can live as long as 6 to 8 months.

Stink Bug | Shield Bug | Chust Bug

Native Plant and Animal Conservation | ©2023 M. Genevieve Hitchings | www.artorium.com

Above: (Left) Leave the Leaves. (Right) Stink Bug.

What is familiar and intuitive to scientists with specialized knowledge is often unintelligible to the average reader. Presenting science through information design can play an important role in facilitating comprehension, thus fostering public awareness. Successful visualizations provide a unique and powerful means to see what lies within, find relationships, call attention to things that might not be visible in other forms, and even help determine the answers to questions.

The concept of storytelling entails a beginning, middle and end. Good information design is storytelling that allows you to enter the story in your own time and at your own pace. The

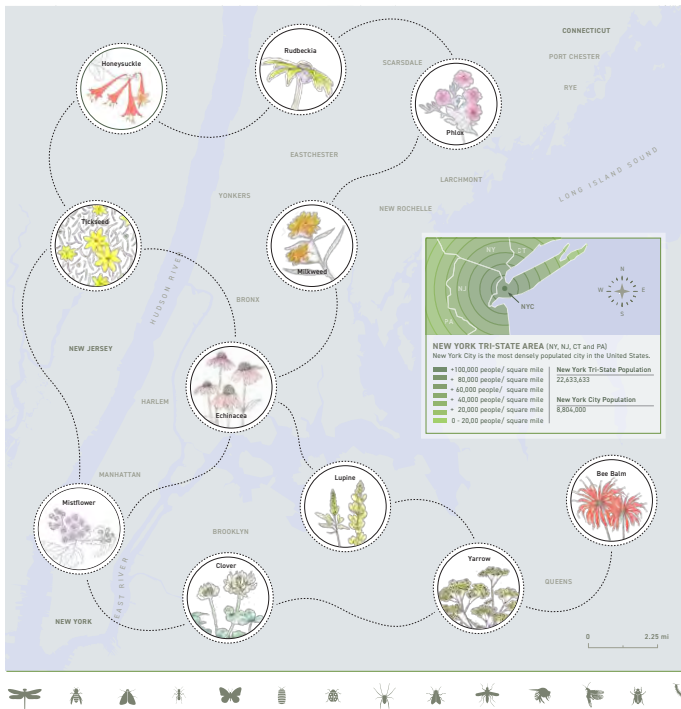
visual hierarchy of things, i.e. color, line, shape, type, image, margins, borders, etc., all work collectively to communicate a story. Their logical sequence directs the eye and engages viewers to make sense of a story. When you break that logical sequence you obscure meaning. In the West we read from left to right, top to bottom. We are subject to the realities of gravity

and perceive the world from our horizon line. The act of reading (left/right/up/down) should influence but not dictate our decisions, especially our typographic decisions.

In science visualizations, typography generally plays a supportive but essential role. Excellent typographic design in this environment is type that does not call attention to itself. Type is the foundation of good design. Yet because type is so subtle and so nuanced it is also one of the harder components of design.

In my opinion the telltale difference between professional and amateur design is in the use of typography. I am convinced there are a minimum of four type truths that information designers must be aware of:

- Type has an intrinsic relationship with information design, especially in science visualizations. With some exceptions, one does not exist without the other.



GREENPATCHES

Parks, gardens, and other green spaces can serve as a matrix of interconnected webs influencing the natural community. In general insects and arthropods do well if small plots of land are made available to them for foraging and nesting.

INSECTS AND ARTHROPODS Power the Ecosystem

- Cycle Nutrients
- Pollinate Plants
- Disperse Seeds
- Maintain Soil Fertility
- Clean Water
- Control Pests
- Food Source

Pollination in Flowering Plants

- 1. INVERTEBRATES**
Invertebrates include insects and arthropods. They are the most diverse group of organisms on the planet. Not only do they keep nutrients cycling, soil healthy, plants growing and ecosystems running, they are also an essential food source for many mammals and birds. Additionally, roughly 90% of all pollination that occurs in flowering plants is taken care of by insects.
- 2. ALARMING DECLINE**
Invertebrate populations are believed to be in serious decline worldwide because:
 - Natural areas are growing smaller and more isolated from each other.
 - Chemical residues from artificial fertilizers, insecticides and herbicides.
 - Expansion of urban and suburban land.
 - Intensified industrial agriculture.
- 3. SUSTAINABLE HABITATS**
Sustainable habitats are formed by plants and wildlife native to a region that have developed symbiotic relationships over thousands of years. Minor adjustments to even the most densely populated urban and suburban environments could have a dramatic impact on the ability for insects to survive.



Window pots with pollinator friendly flowers sustain foragers in fragmented urban landscapes.

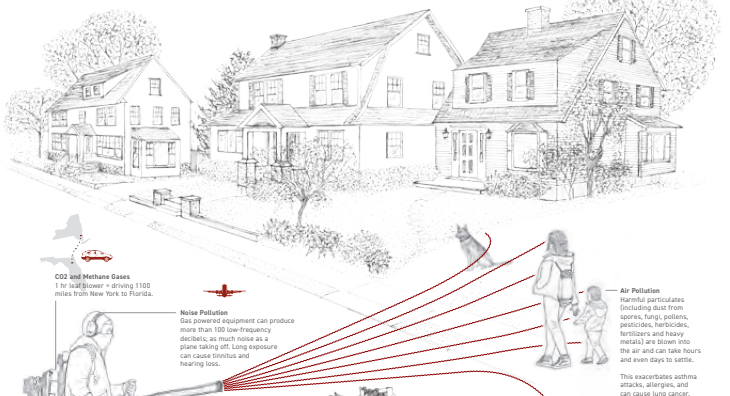
Native Plant and Animal Conservation | ©2023 M. Geronimo Hirsch | www.artium.com

Sources: U.S. Census Bureau (2020), NHP (2019), Pollinos (2022), NHP Society (2017), NYTimes Times to Blow (2014), ANHP (2010)

HEALTHYLAND

The ENVIRONMENTAL IMPACT of keeping lawns green, weedless, and pest free is significant. Currently residential lawns produce more greenhouse gases than they absorb because of harmful land management practices. Small changes to our urban and suburban landscaping practices could have major implications for restoring lost biomes across the United States.

- 1. MOW HIGH AND WATER LESS**
Mowing grass to about 4" helps shade out weeds and encourages roots to grow longer. This helps the lawn tolerate heat better and require less watering.
- 2. USE A RAKE OR GO ELECTRIC**
Rake leaves or switch to electric or battery powered yard equipment. It's cleaner, less polluting, quieter and it is better for your health as well as the planet's.
- 3. NO PESTICIDES OR HERBICIDES**
Save the natural ecology of the soil and the quality of our drinking water by using only natural amendments. For the safest protection against ticks, use tick bait boxes and check your self.
- 4. NO ARTIFICIAL FERTILIZERS**
Runoff from chemical fertilizers causes great harm to our streams and ponds. Native plants, shrubs and trees don't need fertilizers, water runoff.
- 5. MULCH GRASS AND LEAVES**
Leave grass clippings on the lawn and attach a leaf mulching blade to your existing mower in the fall to mulch leaves into the lawn.
- 6. CHOOSE SUSTAINABLE PLANTS**
Pollinators and birds rely on native plants to raise their young. Plant native perennials also for better drainage, erosion control and their beauty.
- 7. AMEND SOIL NATURALLY**
Try to plant densely to decrease the need for water and weeding. Compost and fallen leaves improve the soil structure and add nutrients for your plants.
- 8. REDUCE THE SIZE OF THE LAWN**
Turf grass provides very few benefits to the ecosystem. For a more sustainable yard, reduce the size of the lawn and add beds for native plants.
- 9. KEEP IT DARK**
If you place light fixtures in your landscape make sure they direct downwards, so they don't distract wildlife. Don't use blue light and turn the lights off when you leave the outdoor.
- 10. REMOVE INVASIVES**
Familiarize yourself with the invasive plants in your area and remove them from your property.



- CO2 and Methane Gases**
1 hr of lawnmower = driving 1100 miles from New York to Florida.
- Noise Pollution**
Gas powered equipment can produce more than 100 low-frequency decibels, as much noise as a plane taking off. Long exposure can cause tinnitus and hearing loss.
- Air Pollution**
Harmful particulates (including dust from spores, fungi, pollen, pesticides, herbicides, fertilizers and heavy metals) are blown into the air and can take hours and even days to settle. This exacerbates asthma attacks, allergies, and can cause lung cancer.
- Pesticides**
Pesticides contribute to a concerning decline in beneficial insects needed to pollinate roughly 90% of all flowering plants.
- 7% Yard Debris**
Total Solid Waste: 14.1 Million Tons Per US Household, Yearly
- Bring back the night.**
- 30% Watering Lawns**
Total Drinking Water: 38,040 Gallons Per US Household, Yearly

- GAS-POWERED EQUIPMENT**
A two-stroke engine is found in most consumer gas powered leaf blowers and combines oil and gas in a single chamber, which gives the machine serious power while remaining small and light to carry. This design means as much as a third of the fuel is spewed into the air as unburned aerosol.
- PESTICIDES**
Exposure to pesticides can alter a range of organisms' behavior. Many deformations have been found after exposure to hormone-mimicking pesticides classified as endocrine disruptors. For smaller creatures, this impacts their ability to survive, for larger including pests and humans, exposure is linked to cancer and infertility.
- LANDFILLS**
Leaves and other garden clippings account for more than 13% of the nation's solid waste—33 million tons a year in the United States. Besides wasting valuable nutrients, transporting yard debris to landfills generates air pollution, and huge amounts of grass decomposing anaerobically generates methane, a powerful greenhouse gas.
- LIGHT POLLUTION**
Natural light signals an escape from danger for many insects. Artificial lighting confuses that signal and also disrupts the mating patterns of many nocturnal animals including fireflies. Night and security lights should be motion activated only, or as not to disrupt nocturnal creatures.
- WATER WASTE**
Turf grass is the single largest irrigated crop in the US. The average American household uses 200 gallons of drinking water a day, 35,000 gallons annually, of which about 30% is used for watering lawns and gardens. Of that 30%, as much as 50% is wasted due to overwatering, wind, or runoff.

Native Plant and Animal Conservation | ©2023 M. Geronimo Hirsch | www.artium.com

Sources: Healthy Yards (2022), EPA (2018) Fact and Figures, NYTimes (2021) Leafblowers, University of Maryland (2009), Scientific American (2009)

- Most classic typefaces are beautiful and varied individual forms that have been refined and perfected over many years by accomplished and experienced designers. Respect the letterform! Do not distort.
- In a science visualization, type generally plays a supportive role. It needs to be clear, consistent, accurate, accessible, legible and readable. It also serves as a directional guide to the information and the hierarchy of the content.
- Type itself is an element of design. Although it serves to communicate meaning through text, it takes up space within a composition and influences the overall balance and visual perception. Designers need to 'see' type as an element of proportional balance within a composition, not only as something to be read.

In this article I focus on the static representation of (two-dimensional) composition but would like to point out that on screen, where so much of our designs are created, proportion in composition is

more fluid—sizes are easily scalable, you can zoom way in or out. This has the unintended consequence of making type size hard to discern. In the print world type is one-to-one. 11pt type is 11pt type. On screen, however, proportion is relative to a scalable environment. This requires an extra degree of awareness.

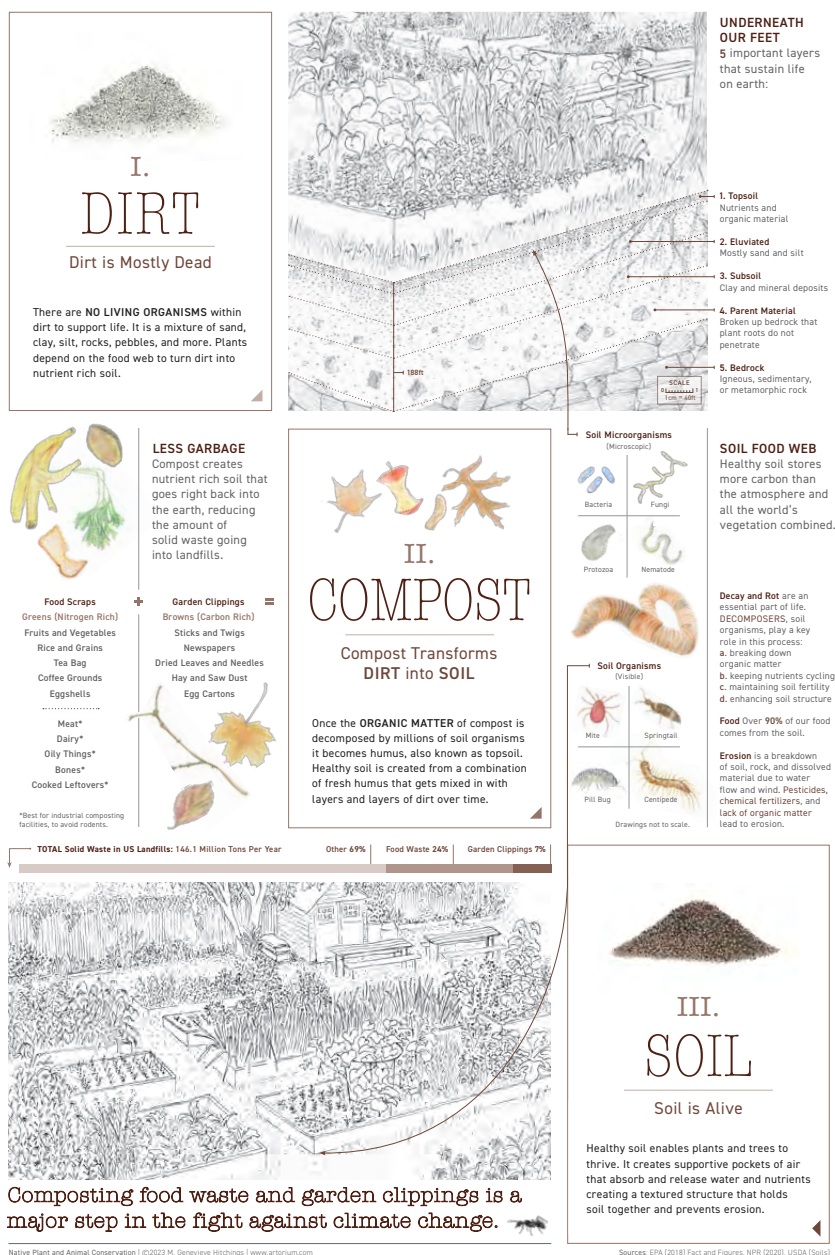
STRATEGIES FOR WHERE TO BEGIN

Since communication design is not an exact science, and there is no single solution to any given problem, our goal as visual communicators is to come up with a unique solution that satisfies all three threads of an assignment. The design process, referred to as the design thinking methodology (also known as the 4Ds) is a logical series of four stages, designed to ensure that the final solution includes the right narrative and tells the right story:

1. Discover: Research and Narrative Development

Science visualizations should be built on research. You need to understand and clarify the subject matter for yourself—so you can explain it for others. Take notes. If you are lucky, you have access to experts.

Above: (Left) Green Patches. (Right) Healthy Land.



phase will help you define a visual style and direction. Note: this stage can be time consuming; being aware of this can help determine a realistic project timeline and budget.

3. Develop: Design Development

Revisit the thesis of your project. Create an outline that supports this thesis. Edit. Chunk your outline into sections. Organize this content so that it supports your thesis. These can become subsections, building blocks with consistent structure and detail. Think of them as content containers that can easily scale up or down. They may hold the various assets that you are simultaneously developing.

The dimensions of your project—your format—will inform your layout and its structure. It is essential to establish a logical order of things. This is dictated by two distinct goals: the information at hand as it relates to the assignment (the story); and elements of visual perception known as the principles of design, which influence how the eye is directed within a layout.

Working within a clearly defined grid can be very helpful in creating a basic structure: a skeleton for your design. This consists of invisible lines upon which your design elements can be placed. Doing so helps tie supporting content into an overall system and define a focal point, which clarifies your thesis. A grid can also encourage experimentation and help you to discover a more surprising layout.

A clear visual hierarchy with an intentional focal point will direct the eye and help your viewer decipher meaning. Define a visual focal point—dominant elements supported by secondary elements. Both color and type play an important role here. Choose a color palette that provides both consistency and contrast—color can be used as a layer of directional information and navigation.

Above: Infographic describing the difference between dirt, compost, and soil, and how composting can support healthy soils and plants.

Take the time to research, gather references, keep track of sources. In this stage, define and understand your audience—meet them where they are at. What do they know and what do you want them to know?

Once you have a good understanding of the story you are trying to tell, pinpoint your communication goal. What is the main purpose of the project? What is the intended take away? Define the thesis of your project.

2. Define: Analysis and Documentation

Begin to define the assets you will need to tell the story. These might include illustrations, charts, graphs, etc. Begin to create these assets. Start sketching, brainstorming and experimenting. Allow yourself time to interpret and iterate. Continue to refine. This

In the Roman (Latin) alphabet there are essentially three logical paths when we read: horizontal, vertical or diagonal. Compositions designed with these reading paths intuitively direct viewers. All copy should be clear, concise, supportive of graphics, and of course well-edited and organized. Good typographic choices will establish and reinforce hierarchy.

Finding the right typeface is crucial. The many options available can easily feel overwhelming. A general rule of thumb is to limit any given design to a maximum of two typefaces. Choosing typefaces from styles that are distinctly different, for example a serif and a sans serif, tend to create contrast and complement each other. But when you have a layout with powerful illustrations meant to draw

attention, a wise choice can be to find only one typeface, a classic typeface that comes with a range of different weights (type family) i.e. regular, bold, light, condensed, extended, etc. This will ensure a level of consistency within your design but also provide options for a great deal of variation. Typefaces with large families allow you to establish a clear hierarchy in your headers, subheads, captions, callouts, paragraphs, etc.

Lastly, white space, also known as negative space, is the area between elements in a design composition. If white space is not balanced the layout will feel crowded and the copy will be hard to read. Negative space matters as much as, if not more than, all the other elements. The edge of your layout should have plenty of negative space. Be generous with your margins.

“A clear visual hierarchy with an intentional focal point will direct the eye and help your viewer decipher meaning.”

— M. GENEVIEVE HITCHINGS

4. Deliver: Selecting appropriate visual presentation and explanation

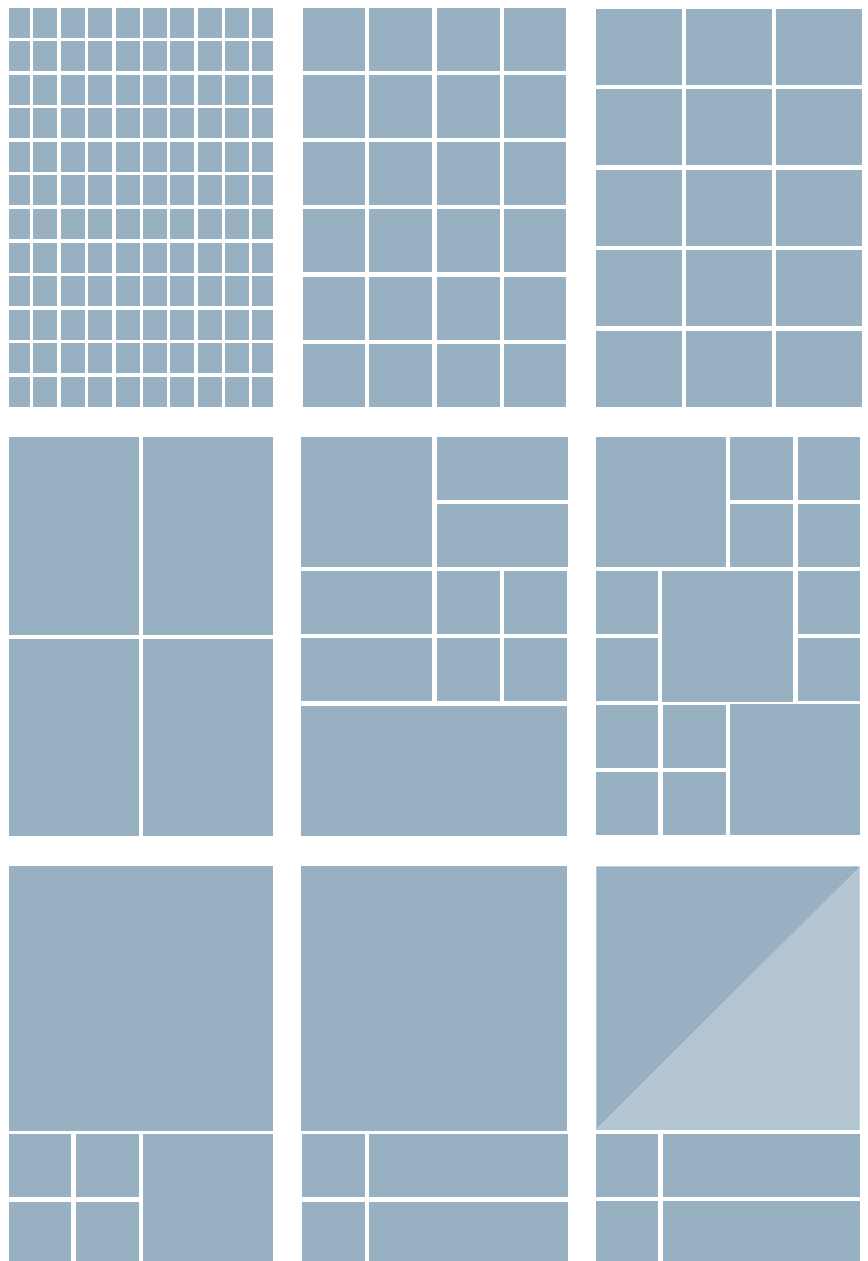
If the final is going to be printed, then you must print a proof. Everything looks different once on paper: scale, margins, bleeds, color, type, negative space, etc. Flip your printed proof upside down, blur it with your eyes. This will enable you to see the proportional balance of all your design elements including type and determine what needs more negative space.

As you approach the final revisions, continue to revisit your thesis. Keep supporting points connected and meaningful. Try to avoid information overload. When in doubt leave it out.

“If it does not cause loss of meaning, get rid of it.”

— EDWARD TUFTE

And don't be afraid or discouraged if you need to start over. Experimentation and iteration are what make good design GREAT.



Above: Examples of grids used to place design elements.

Below: Examples of grids used to establish reading paths: horizontal, vertical, or diagonal.

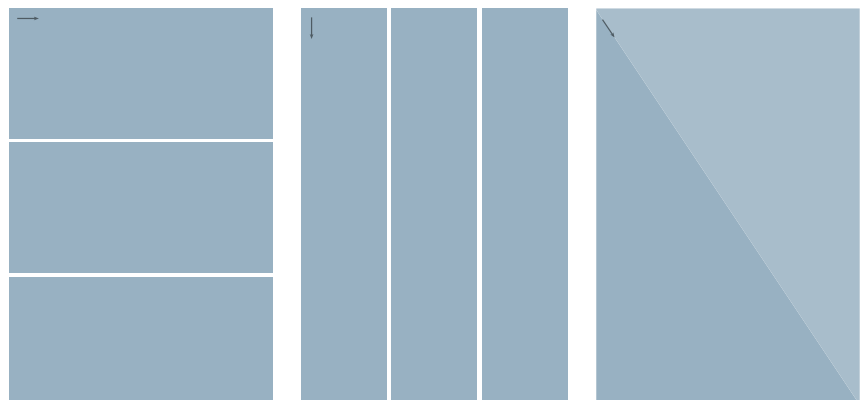


Figure 1: 3D printed snail

All images © 2023
Mieke Roth



Three-Dimensional Design

HOW TO PREPARE MODELS

—By Mieke Roth

In this article, I'm going to tell you a bit about how to optimize your models to get the most out of three-dimensional (3D) printing. I am not going to tell you about all the different printers out there or all the different techniques there are, because those things you can look up in abundance on the Internet. What I will do, however, is give you some insights into best practices with the actual printing of the models and how I look at 3D printing compared to illustration and 3D modeling.

There are two main types of 3D printing: resin printing and filament printing. Most of my experience is in resin printing. This is because the details in resin are crisp and layer lines are almost invisible, contrary to filament printing. A model printed with resin also feels more “real,” something I find important.

In the example shown above—my right-handed (by now, almost famous) anatomical snail—you can see that I didn't 3D-print everything in the model (Fig. 1). Only the stuff that makes the model insightful. I removed half the shell and a lung to give people an understanding that they are still looking at a snail. Both the shell and lung are suggested by the shape of

the rest of the structures—the organs follow the shell, and the veins follow the lining of the lung.

Filament printing has its advantages: it's a lot cheaper, although that is changing rapidly. You can buy a 3D printer for as little as \$100 (U.S. dollars) or as expensive as \$40,000. The printers I am talking about are between \$400 and \$1,500. For most purposes, you don't need to get more expensive than that.

Of course, if you print detailed structures, the model is more prone to damage. This is one of the reasons the current anatomy models are comparatively simple. But because you can 3D-print it yourself, you can always print a new one. So basically anything you

can think of—plants, fossils, anatomy, or skeletons—can be 3D-printed. As with illustration, you can not only 3D-print an object as it is in natural life, but you can also show or hide structures for clarity.

The biggest advantage of 3D printing is, in my opinion, the fact that you can make stuff look realistic for people. It invites them to touch it, take it into their hands, turn it, and start investigating.

I have been 3D-printing since 2013 and have several printers. At this moment, only the Anycubic® resin printers are “live,” the rest are collecting dust. These Anycubic printers are affordable workhorses, and after an initial learning period, I only get perfect prints (Fig. 2). The bigger the printer gets, the more prone they are to users’ mistakes.

In the coming months, I will add two additional printers: a Rocket® 1 Pro, which uses a different technique than most 3D printers: instead of pulling the print out of the resin after exposing the bottom of the resin vat (Fig. 3), it prints by exposing the resin surface and sinking the print layer for layer down into the resin. It was a Kickstarter, so it’s going to be a gamble if the printer does what they claim, but if it does, it enables even more possibilities. Gravity is always an issue with 3D printing, especially resin printing.

The other printer is a Bambu® Lab X1 Carbon. This is my first filament printer in years, and it also came out of a Kickstarter. But this one is different: instead of using the Kickstarter campaign to develop a product, Bambu used it to market theirs.

There are already loads of Lab X1 printers in the field, and as a result there are a lot of people with experience using them. This printer is “plug-and-play” and is extremely fast for a filament printer. I will use this printer to experiment with detailed prints also, but I especially bought it because I can print in different colors with it. As with resin printing, I will experiment with it and stretch the limits of this printer too.

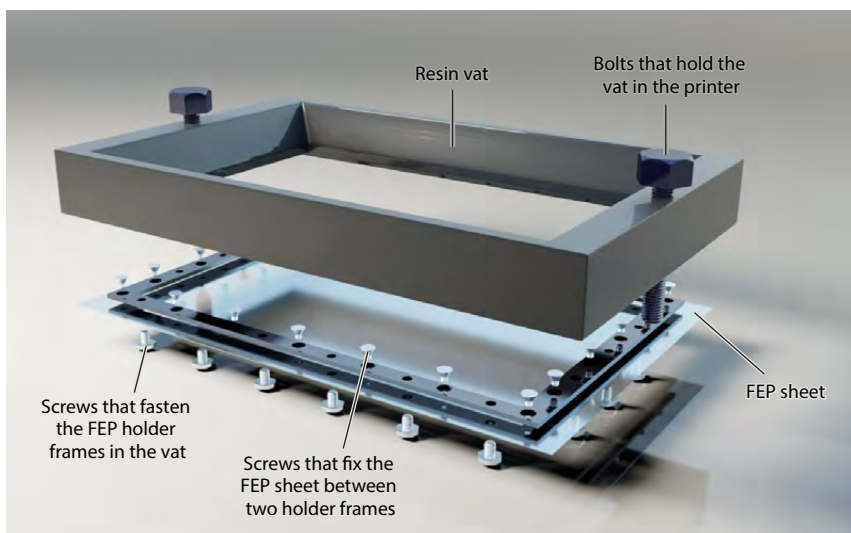
To be able to 3D-print a model, you need special software to prepare it. These are called “slicing applications.” What they do is cut your model into very thin slices. With filament printing, those slices are then interpreted and made into “walls” of a certain thickness—basically the outside of the model and an infill. The infill is there to make the finished model firm.

With resin printing, you can choose to hollow out the model or not. I only hollow out when a model is very big and would use up a lot of resin. Hollowing out with resin printing has its own challenges because you are basically pulling a suction cup off the FEP (Fig. 3), which is the transparent sheet that forms



Figure 2: Printers and prototypes in the studio.

Figure 3: Example of standard vat construction where the resin-based 3D model is built from the bottom up using an FEP (fluorinated ethylene propylene) film as “table” where each layer of the model is printed. This is one of the common failure points in 3D resin printing.



the bottom of the vat the resin is in. It lets the light through that is used to solidify the resin. So, if you are hollowing out the model, make sure you make holes as close to the build plate as possible, so the model doesn't pull a vacuum as the model rises out of the vat. Another issue with hollowing out using resin printing is the fact that you risk leaving uncured resin inside the model. There are ways of solving that, such as by using thin UV LED strips inside the model, but your model still can crack over time.

Before your model is ready for the slicer app, you first need to prepare it in your preferred 3D modeling application. The application that I use is ZBrush®, especially for complex models. Make sure you bake all the details into your model instead of keeping the subdivisions. Also, make sure all the surfaces are without any non-manifold issues (holes in your model, funky polygons, and so on). Sometimes a slicer application can repair a non-manifold issue, but it's better to solve these issues beforehand to avoid surprises when printing.

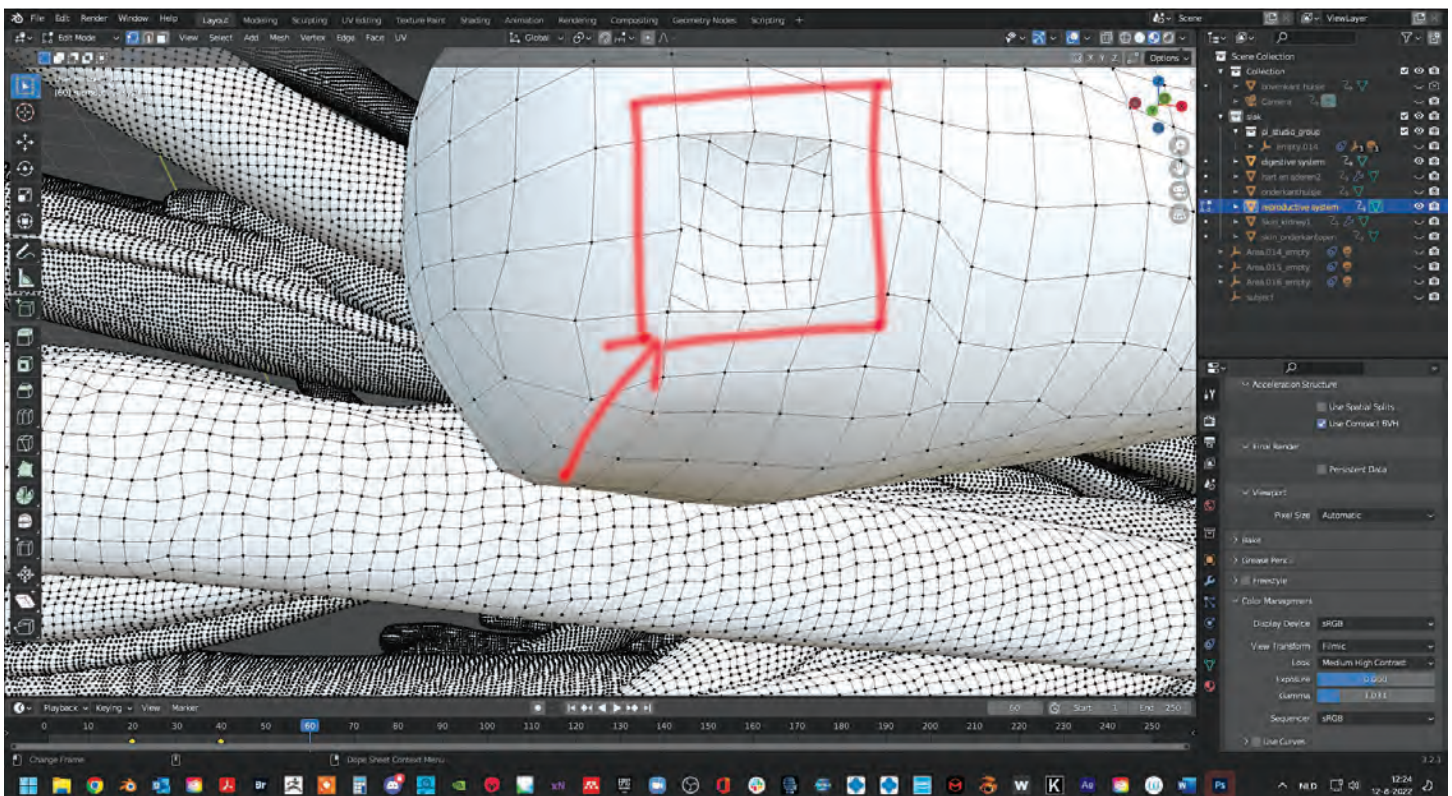
The reason for this is that the slicer app makes black-and-white images of each layer. (The white is what is getting printed.) If there's a hole in your model like I show you below (Fig. 4), the slicer doesn't know what to make white. So, make sure your model is clean and solid. Digital 3D models are 2D surfaces shaped in a 3D form. There is no actual way to do it differently than this. To be able to distinguish the inside from the

outside, your model needs to be one complete surface without any intersections or holes. So, if, for example, you want to print a model that is made up out of different objects in one go, you need to make sure that the objects don't intersect or are fused to form one object. This is easily done in ZBrush. For example, use Dynamesh® and set the resolution high enough for the objects to fuse and the details to still show. ZBrush also has a function where you can check the mesh volume. This is a very handy function because it makes sure the model is completely solid.

Once you have optimized your model, you can export it. Most people export it as an STL file, but a lot of slicers can also handle OBJs, which are the preferred file format for 3D color printing. What you choose all depends on your preference. What I have encountered is that ZBrush doesn't give a clear size to models. Often, I need to go through Blender® 3D modeler to give a model a proper size and even then, the slicer application still can have a problem with that. Even though that does not always happen, it's something to consider. I solve that by noting the size I make it in the slicer and noting the amount I scale it. This way I'm sure everything fits if I print a model with separate parts, or if I want to redo the model for some reason.

Now that you are in the slicer application, you need to be aware of how a resin printer works. It fuses very thin layers of solidified resin. While printing, the

Figure 4: Hole in model shown in vector drawing in ZBrush.



resin will stick to parts of the model that are faced toward the build plate. This resin will partly solidify, making the details on that part of the model blur or even disappear. There will always be parts of the model that are faced to the build plate, so one of the most important things in getting a great print is how you position the model on the build plate.

To make matters more complicated, the larger the surface area that needs to be exposed per layer, the bigger the forces are on the model, making it prone to failure. Luckily, those two restrictions mostly have the same solution: which is to angle the model in such a way that the surface per layer is as small as possible, best accomplished by angling flat surfaces to the build plate. This enables the resin to slide off the model as much as possible. If you also want to minimize the visibility of the layers, most of the time an angle of 45° is somewhat okay for a layer height of 50 µm, which is the layer height mostly used in 3D printing. If very smooth surfaces are an issue, you need to calculate the Arctan for your specific printer. A video at the following link will explain how you do that: <https://youtu.be/Qs2Rb0ExnIM>.

Next, you can add supports to your model. The supports make sure your model is printed as you want it to print without distortion. The slicer app will calculate overhangs and most of the time the default settings are good enough to start with. Make sure you use the right thickness for the right model: tiny models need thin supports, and of course, larger models need thicker supports. If you use the default settings to add supports, make sure they aren't too close together. Remove the ones that are too close, so you get a nice and even support "forest" (Fig. 5).

Having done all that, you need to make sure you have the right exposure time for your resin. The best way to figure that out is to use a calibration model. The best one I have found so far is the Ameralabs® Town (Fig. 6), which can be found on this blog: <https://ameralabs.com/blog/3d-printer-calibration-part/>. The blog gives you everything you need to know on how to interpret the model once you print it. You will probably need to do this several times with different exposure times. The best way is to start with the recommended exposure time for the resin you are using, and then go up or down in time depending on what you see when you print the calibration model.

Now you are ready to put this value into your slicer application for that resin. Here are my recommended slicer settings for the Anycubic Mono X with Esun® plant-based white resin. First I make sure the speeds aren't too high. Most of the time a slicer has a lot higher default settings, but those are prone to failure.

Second, it is better to start with a low exposure and work your way up. This video, <https://youtu.be/zO5DxVGWxXs> gives good insight into what slicer settings do and why.

For me, 3D prints make science education much more interactive and a lot more accessible. It is relatively simple to get models out there and let students print them themselves. You don't have to worry that a model breaks because you can print it again and again. It enables you to show stuff that isn't easily explained in text or illustrations. Having said that, I approach 3D printing in a similar way to illustration. Because I can choose what to show and how to show it, I can make models both insightful and beautiful.

Even though 3D printing is a technique that has existed for decades, the evolution of the techniques is going at an astonishing rate. There are now 3D printers that can print objects in the same number of colors as you do with printing illustrations in magazines and such.

The prices of those printers are still in the tens of thousands of dollars and the time it takes to print a relatively small object is insane, but affordable full-color 3D printers should become a reality in a matter of years.

In conclusion, I hope you can see that recent advances in 3D printing enable a new path for many illustrators to explore science education by enhancing interactivity and accessibility. 3D printing presents an intriguing opportunity for students, the general public, and even science colleagues to communicate complex concepts that are challenging to explain through text or a single image. The rapidly evolving nature of 3D printing techniques, with the promise of affordable full-color printers in the near future, suggest an exciting future for anyone ready to explore 3D art.



Figure 5: Model C1 C2 with supports.

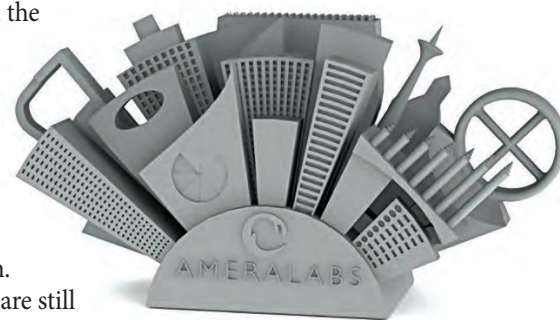


Figure 6: Ameralabs calibration model. Image by [Ameralabs.com](https://ameralabs.com)





The Certified Wildlife Habitat

EXPERIENCING BOTH NATURE AND ART

—By Gail Selfridge

For me, visiting botanical gardens, arboreta, wildlife sanctuaries, and natural history museums has always been a source of enjoyment. Often I discover additional ways to incorporate plants into my own landscape and garden.

Above: Certified Wildlife Habitat sign from the National Wildlife Federation.

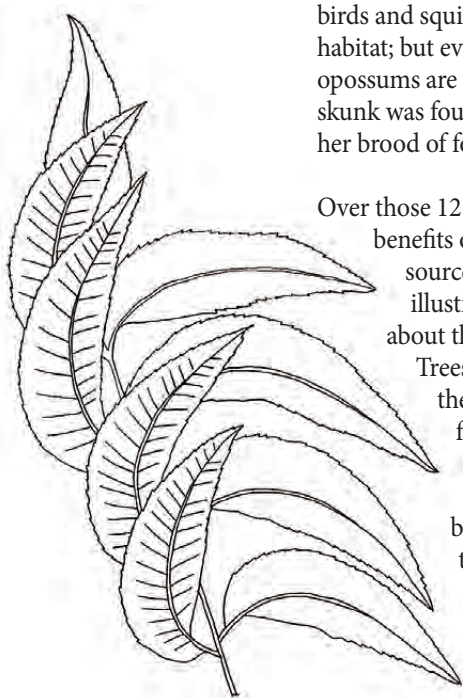
Below: Pecan leaf line drawing

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Gail Selfridge, unless
otherwise noted

Twelve years ago, I established a Certified Wildlife Habitat with the National Wildlife Federation and started implementing some of those ideas into the 50' by 150' city lot where my home is located. Now, having a CWH doesn't mean you just put up a bird feeder and water bowl then go out and take care of it whenever you feel like it. It involves the entire yard; and while food and water are necessary, shelter and places to raise young are also important. Many birds and squirrels make their homes within my habitat; but even though I live in town, raccoons and opossums are frequent visitors, and once a mother skunk was found sitting on the back porch along with her brood of four babies.

Over those 12 years there have been many gardening benefits of my CWH, but it has also been a source of inspiration for various art and illustration projects, plus ideas for writing about the plants and animals that live here.

Trees are a very important component of the habitat as they provide homes and food for birds and squirrels, but for me they have also provided a rich supply of free and readily available leaf/branch specimens that have been used to teach both children and adults about the enjoyment of drawing from nature.



FROM HABITAT TO ART

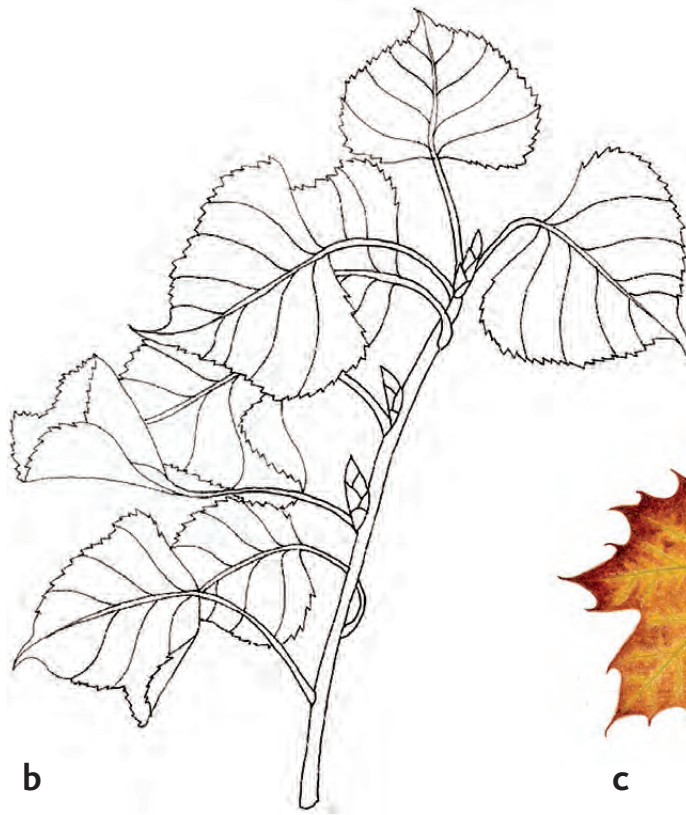
As a local botanical artist, I have often received requests for educational outreach programs. Instead of just talking about art and illustration, I developed a hands-on presentation that included a leaf rubbing demonstration, followed by audience participation, ending with examples of my own work showing how to use the rubbings to create scientifically accurate drawings. Having experienced leaf rubbing in grade school, I erroneously thought all adults were acquainted with the process, but surprisingly many of them were not.

Requests for presentations eventually exceeded my capacity for giving them. I needed a way to recruit others and teach them how to also give the programs. This was the starting point for a project that eventually became the *Colorful Leaves* publication and program of instruction that was funded by the American Society of Botanical Artists through their Anne Ophelia Dowden Award. The grant gave me total control over the project, including not only the text but also the selection of leaves and how they were rendered either in color or as black and white line drawings.

All of the specimens used in *Colorful Leaves* came from trees and/or shrubs that reside either in my CWH or close by. Support of the publication allowed me time to get up close and personal with these trees and shrubs, and because of their location, I was



a



b



c

able to study their development year-round from dormancy through emergence of buds, then flowers, then leaves, and eventually leaf coloration and the production of seed/seed pods.

THE DIGITAL HERBARIUM

Traditional herbarium specimens are dry and fragile, must be stored away from dust, insects, and humidity, and the colors have long ago disappeared. For me, when working with plant material, it was important to maintain a record of not only the shapes of the leaves, blossoms, seeds, and fruits, but also the colors because, once removed from the source, plant material soon loses its shape as well as its color. A digital record then becomes an available reference for color information that can be accessed later when rendering line drawings in various techniques (colored pencils, watercolor, crayons, markers). Digital records can include both photos and scanned images—my digital herbarium was born.

SELECTION OF LEAVES

The final publication was directed not only to individuals but also to teachers and a decision had to be made regarding which trees and shrubs to include. Those chosen were ones that were rather common and ranged beyond my area. Users were encouraged to find leaf specimens in their own locale, then render the line drawings following those colors. In addition, users were encouraged to find leaves in their own area, use them to make rubbings, and then to create

their own scientifically accurate line drawings. Here are some of the specimens that were selected:

- Flowering crabapple (*Malus 'Robinson'*)
- American elm (*Ulmus americana*)
- Eastern cottonwood (*Populus deltoides*)
- Sycamore (*Platanus occidentalis*)
- Pecan (*Carya illinoensis*)
- Burning bush (*Euonymus alatus*)
- Red mulberry (*Morus rubra*)

THE GARDEN

Having a Certified Wildlife Habitat also includes practicing sustainable gardening techniques such as eliminating pesticides, conserving water, and planting native species. Out here on the prairie where I live it is hot in the summer, cold in the winter, windy and dry all year. Many plants have a hard time surviving in these conditions. It can get to 100 degrees in the summer or 20 degrees below zero in the winter, meteorologists describe any wind speed under 40 mph as “breezy,” and when floods are occurring around the country, we feel fortunate if there is one inch of rain in a month.

The garden is also an important part of the habitat that provides us with delicious fruits and vegetables but also insects—not all of which are beneficial.

Above: (a) American elm leaves from the digital herbarium. (b) Eastern cottonwood line drawing. (c) Sycamore leaf in colored pencils.



a



b



c

Above: (a) Eastern cottonwood, colored pencil. (b) Burning bush, colored pencil. (c) Morning Glories and Butterflies, intaglio print.

Caterpillars, butterflies, bees, and ladybugs are some of the most interesting and beautiful, often preferring native *Echinacea* or herbs including parsley and dill. And there are wildflowers and plants that can survive here, including cacti and succulents, because they can withstand the heat and require less water.

In addition to scientifically accurate plant illustration, the habitat has inspired me to explore other art styles. Many insects, particularly butterflies, are attracted to trumpet-shaped flowers. Morning Glories are one of my favorites and I chose to create a personal logo for the registered name of my own Certified Wildlife Habitat with images that are not accurate representations but convey the spirit of both the butterflies and the flowers. I have continued to create works using the “Morning Glories and Butterflies” theme/style both in drawings and in fiber construction and am currently working on a large fabric wall hanging version.

THE FELINE AGRICULTURE RESEARCH STATION

The habitat also attracts domesticated animals, particularly cats. It is sad and amazing to me how pets can be just thrown out or left to manage on their own, but word has spread through the neighborhood that there is an “easy touch” at 1509, so over the years many have found their way here. My habitat is after all a “wild place” and the cats that do find their way here also find shelter and protection perhaps for the first time in their lives. Some have been relocated to good homes, but others have lived on after being vaccinated, neutered, and/or spayed.

The cats enjoy the garden, but they do have to work for their keep, so they are required to provide

companionship and entertain me with their antics. In return for that, I have rewarded them with 10 different varieties of catnip i.e. *Nepeta*.

Years of working and illustrating for scientists has left its mark; thus the Feline Agriculture Research Station was created to conduct my own research projects, including one to identify the variety of *Nepeta* preferred by cats. Much unscientific testing determined that 9 out of the 10 cats surveyed preferred *Nepeta cataria* over *Nepeta mussinii*. I wrote and illustrated an article about that project for *The Herbarist*, the annual publication of the Herb Society of America.

THE TALLGRASS PRAIRIE

Last year, our sewer had to be dug up from the house to the alley, leaving the habitat with piles of soil and completely disrupting the small back yard. That soil had to be redistributed and when replanting the grass, I decided to just let it grow without mowing this year. After all, this is Kansas, home of the Tallgrass Prairie National Preserve that is only 70 miles from where I live, so I decided to create a micro-Tallgrass Prairie. The cats truly love it, but when a cat is moving through the grass it is visible only by a tail that is sticking up. Because it is in the backyard, the tall grass does not interfere with the city ordinance.

WATER AND ADDITIONAL FOOD

All animals need water to survive, and some need it for bathing or breeding as well. Blue Lake, as we call it, provides water for squirrels. Then there is a large ceramic plant saucer that is a shallow drinking and bathing place for birds. For our enjoyment as well as for the animals, these are located in the courtyard

NOTE: The *Colorful Leaves* publication is still online at the official ASBA website along with two downloads featuring workshops that used the materials. All three are free to everyone and can be seen at <https://asba-art.org/merchandise>.



along with seed and suet feeders. They can be seen from both the kitchen and living room, thus making it possible to observe year-round the many different birds and animals that live in this area and visit the stations.

CREATING A HABITAT

During the pandemic when we were all staying at home, wearing our masks, six feet of room, sanitized hands, parties on Zoom, the Certified Wildlife Habitat was an available retreat that continued to provide not only enjoyment and entertainment, but was also a source of art, illustration and writing material.

Any site can be recognized as a Certified Wildlife Habitat regardless of size. To explore possibilities for creating one of your own, the requirements for the designation can be found at:

https://www.nwf.org/~media/PDFs/Garden-for-Wildlife/Certified-Wildlife-Habitat/CWH-application_0810.pdf

Observing and becoming involved with nature, both plants and animals, is educational and inspirational. When I tell people about my experiences with the habitat, many will say to me, "Yes, the animals are a lot like us." But after watching it all up close and over time, I have concluded for myself that it is not how much they resemble us, but rather how much we are like them.



Above: (a) Flowering crabapple (*Malus 'Robinson'*) in bloom, Tallgrass Prairie. (b) Blue Lake, water for both birds and squirrels. (c) Swallowtail caterpillars feasting on parsley.



Left: *Nepeta cataria*, colored pencil.

Above: Cats and Feline Agriculture Research Station sign.

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