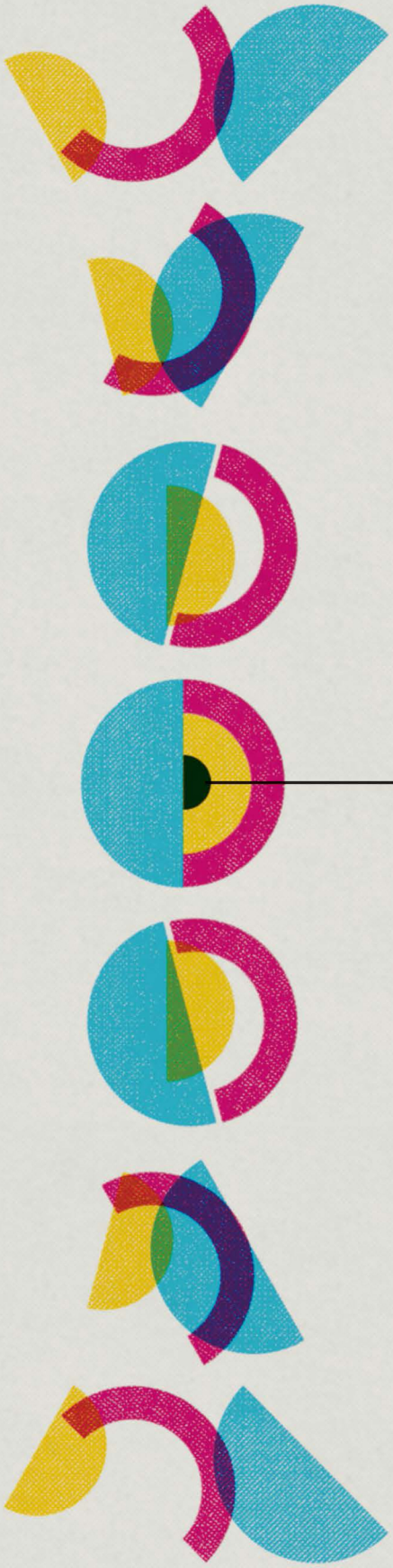

Building Science Graphics

An illustrated guide to communicating science through diagrams and visualizations

JEN CHRISTIANSEN

CRC Press
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AN A K PETERS BOOK

Building Science Graphics

"Jen Christiansen's book is a compelling resource with helpful visual strategies and suggestions to create effective scientific illustrated explanatory diagrams. The extended step-by-step visual worksheets are must-haves for both expert and non-specialist audiences interested in visually communicating science. Her clarity and level of detail to articulate each step combined with her specialized guidance on how to work with design principles make this book one of its kind."

—Sheila Pontis, Sense Information Design, and Massachusetts Institute of Technology

"This book will help readers and practitioners understand how to apply design principles during the process of developing and producing information graphics for diverse audiences, and offers perspectives about the design processes employed by graphics editors."

—Spencer Barnes, Associate Professor, Hussman School of Journalism and Media, University of North Carolina at Chapel Hill

"I love this approach—it's as methodical as good science. Breaking it down into manageable chunks is one thing; turning those chunks into an actual workflow is much more important, and that is in here. Trying to find resources that go through a methodical approach to designing information graphics is difficult. Trying to find ones that go beyond basic charts and into in-depth illustrations is even harder."

—Mark E. Johnson, Senior Lecturer, Grady College of Journalism and Mass Communication, University of Georgia

"Working with scientists and researchers myself, one of the many questions I get asked is where and how to start—this book will help to answer some of those questions and concerns. The fact that it is written by Jen Christiansen adds real value. The book is explained in a cohesive and logical way. This will allow the reader to follow the process, as you would for real, building an infographic from scratch—step-by-step."

—Nigel Hawtin, Information Design Consultant; Former Graphics Editor, *New Scientist*

"The book provides a practical guide targeted at individuals without an explicit art/design background and tailored towards the need of science communication. I consider this a very worthwhile endeavor and believe that many scientists (including my graduate students and myself) will draw considerable utility from this book."

—Stefan Bruckner, Professor of Visualization, Department of Informatics of the University of Bergen

Praise for *Building Science Graphics*

"Much like a successful science graphic, *Building Science Graphics* delivers compelling information on many different levels. From quick tips to deep dives, Christiansen shares well researched, clear examples, as well as actionable workflows and memorable anecdotes from her career. A great read and valuable resource for designers and researchers alike."

—Beth Rakouskas, Creative Director, *Science*

"This beautifully illustrated book is like a Swiss army knife—all the necessary tools of the trade are there and they fit together seamlessly. Communicating science visually has unique challenges and considerations, which makes this book a must-read for creators of science visuals. The step-by-step approach is accessible to all levels, from students to researchers to professional artists and designers."

—Kelly Krause, Creative Director, *Nature*

"Whenever Jen Christiansen was the art director for an article I was editing, I knew that no matter how imposing the illustrative challenge, she would find a visually stunning way to bring it to glorious, lucid life. In her hands, explanatory illustrations sing out a tale of discovery, one that inspires with the grace and elegance of its comprehension. With this marvelous book, Jen generously shares her approach to beautiful, informative design, and it does something I once wouldn't have imagined was possible: It makes me appreciate and love her work even more."

—John Rennie, Deputy Editor, *Quanta Magazine*;
Former Editor-in-Chief, *Scientific American*;
Adjunct Instructor, Arthur L. Carter Journalism Institute, New York University

"This book is a masterclass in the field of scientific visualization. Ms. Christiansen's approach is insightful, approachable, thorough, and inclusive. There is something here for everyone, from the true novice to those who have been practicing scientific visualization for years. Each page is bursting with useful and interesting content. As an unsurprising bonus, the book's design is a delight; it is a pleasure to read and peruse the images and layout. I strongly recommend this book for anyone interested in what it takes to create visuals that effectively and beautifully communicate science."

—Jill K. Gregory, MFA, CMI; President, Association of Medical Illustrators;
Associate Director of Instructional Technology,
Icahn School of Medicine at Mount Sinai

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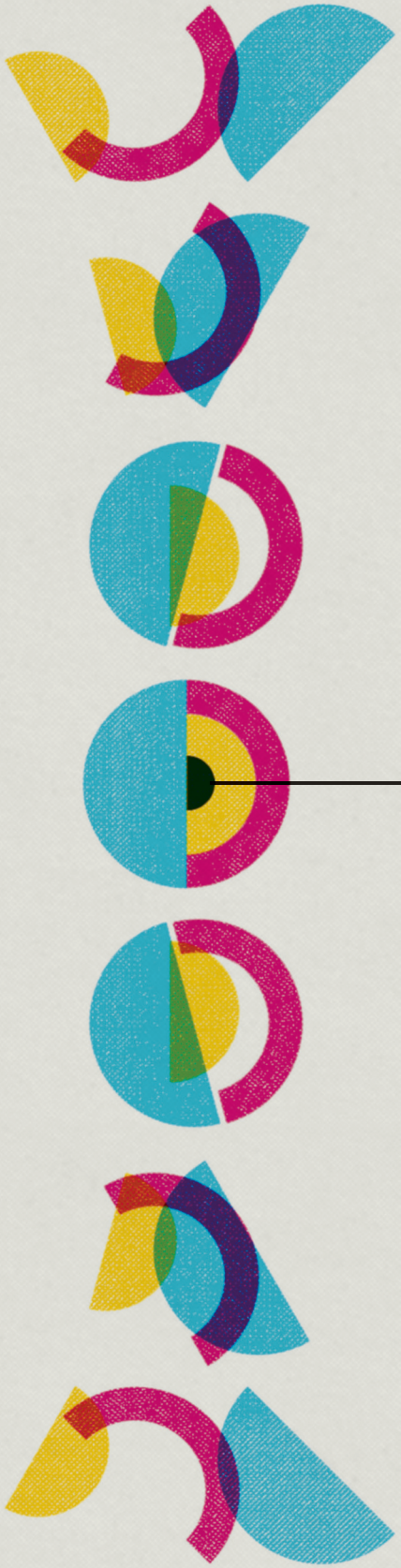

Building Science Graphics

An illustrated guide to communicating science through diagrams and visualizations

JEN CHRISTIANSEN

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Set in **Elena (Process Type Foundry),** Omnes (Darden Studio), and **Indivisible (Process Type Foundry)**

Design by Jen Christiansen

Dedicated to

George Christiansen and Marcia Christiansen
(my parents)

Joel Tolman
(my love)

Ed Bell
(my mentor)

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Series Foreword

JEN CHRISTIANSEN KNOWS A THING OR TWO about designing science graphics; by the end of this book we're sure you'll agree with that.

This book is the most in-depth guide to designing effective, clear, and beautiful science visualizations and explanations we know. In it, Jen offers gentle, thorough, and practical advice on everything from structuring a visual narrative to making reasonable choices on typography, color, composition, visual style, and much, much more.

Jen draws from her own extensive experience in science communication; many of the examples in *Building Science Graphics* are her own designs. Having a formal background in both the sciences and the visual arts, you'll soon notice that Jen's graphics achieve a rare balance between accuracy, depth, and clarity.

If you are a scientist interested in communicating your research to the general public, or a designer who helps researchers do that, or a graphics reporter at a news publication, or a teacher or student in need of a great textbook, you're in for a treat.

—Alberto Cairo and Tamara Munzner, Editors,
AK Peters Visualization Series

This book is part of the AK Peters Visualization series, which aims to capture what visualization is today in all its variety and diversity, giving voice to researchers, practitioners, designers, and enthusiasts. Visualization plays an ever-more prominent role in the world, as we communicate about and analyze data. The series encompasses books from all subfields of visualization, including visual analytics, information visualization, scientific visualization, data journalism, infographics, and their connection to adjacent areas such as text analysis, digital humanities, data art, or augmented and virtual reality.

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Preface

***BUILDING SCIENCE GRAPHICS* IS A PRACTICAL GUIDE** for anyone—regardless of previous design experience and preferred drawing tools—interested in creating illustrated science diagrams. Starting with a clear introduction to the concept of science graphics and their role in contemporary science communication, it then outlines a process for creating illustrated explanatory diagrams using design strategies informed by perception science research. The heart of this book is composed of two extended worksheets: one designed to guide you through the process of building a graphic from the ground up, and another that guides you through the process of adapting an existing graphic for a different audience. Both are designed to help jump-start any new project, starting with the question, "Would a graphic be useful in this context?" Although the focus is on illustrated explanatory diagrams, the lessons and examples within are also relevant to the full spectrum of information graphics, including classic figurative illustration—such as specimen drawings—and data visualization. This is both a textbook and a practical reference for anyone that needs to convey scientific information in an illustrated form for articles, poster presentations, slide shows, press releases, blog posts, social media posts, and beyond.

My Point of View

As a science communicator of the visual variety, I've been producing science graphics professionally since 1996. My double-interest in science and art started at a pretty young age. I loved to draw, but almost always needed some sort of project brief, a prompt from someone else for a specific thing to depict. Science classes in school offered up a plethora of topics. My high school biology notebooks were filled with

drawings. At Smith College, I double-majored in Geology and Studio Art. (Ask me about the trace fossil *Gyrolithes*, the star of my undergraduate honors thesis.[1]) I spent summers in the crustacea lab at the Natural History Museum of Los Angeles, sorting crustacea larvae and illustrating hydrothermal vent shrimp mouthparts.[2] Ultimately, I couldn't bear to follow one discipline at the expense of the other, and enrolled in the natural science illustration graduate program at the University of California, Santa Cruz. After a year of classroom training, I interned as an illustrator at *Scientific American* magazine. My education continued apprenticeship-style at the magazine under the tutelage of art director Ed Bell, and my internship led into an assistant art director position. I stayed with the magazine for a few years before heading south for a job at *National Geographic* magazine, first as an assistant art director/researcher hybrid, then a designer. Leaving *National Geographic* wasn't an easy decision, but the time was right to travel north again, and I started my own business. As a freelancer, I focused primarily on designing, art directing, and illustrating book and magazine projects for clients including McGraw Hill, The Cooking Lab, Intellectual Ventures, and The Rockefeller University. The pull of *Scientific American* was strong, however, and I returned to the magazine full time in 2007.

In my current role as a senior graphics editor at *Scientific American*, my goal with every project is to develop images that engage, inform, and inspire both specialist and non-specialist readers. Sometimes I create the final renderings myself. I also hire and collaborate with freelance illustrators, data designers, and researchers on a project-by-project basis, acting as a project manager of sorts.

I have been incredibly fortunate over the years to learn directly from a wide range of artists, designers, art directors, science journalists, scientists, researchers, and educators. That said, I cannot—and don't aim to—speak for all science graphic designers. My viewpoint is informed by research, but is rooted in a career of practice, not theory. The text that follows draws upon the work of many, and I hope that it provides a

1 Jennifer Christiansen, *The Trace Fossil* Gyrolithes*: Unwinding the Spiral Enigma in the St. Marys Formation (Miocene) of Maryland (*Smith College Department of Geology, 1995)

2 Joel Martin and Jennifer Christiansen, "A new species of the shrimp genus *Chorocaris* Martin & Hessler, 1990 (Crustacea: Decapoda: Bresiliidae) from hydrothermal vent fields along the Mid-Atlantic Ridge," *Proceedings of the Biological Society of Washington*, Vol. 108 (June 22, 1995)

sufficiently broad view of the topic. That said, I also present ideas, opinions, and frameworks that are my own. My thoughts do not necessarily reflect a consensus view within the science graphics community.

I should acknowledge that much of my personal experience is rooted in an era that is well described by Faith Kearns in *Getting to the Heart of Science Communication*:

> *Until recently, science communication advice was seemingly agnostic as to who the practitioner was, although the implicit assumption has been largely white, male, with tenure at an elite institution. Simultaneously, many science communicators spoke to a mythological 'general public,' in which everyone was lumped together. It was assumed the same strategies would work for all—practitioners and communities alike—and that factors such as race, gender, sexuality, age, ability, and class did not affect the communication and engagement process, much less power and authority.*[3]

I'm a cisgendered middle-class white woman born and raised in the United States who was in a position to take the unpaid internship that initiated my career in the mid-1990s. I certainly benefited from—and learned within—that era of science communication. My hope with this book is to share what I've learned about building science graphics as the field—and I—have grown over time. I am still learning. And the practices of science communication and information design are certainly still evolving. Throughout, I share references that are currently shaping my viewpoint and are challenging me to continue growing. This book is meant to be a benchmark. Not an endpoint.

Motivation

I wrote this book so that I'd finally have a singular and reasonably comprehensive reference to recommend to students and scientists who ask me how to create more considered diagrams for their scientific papers, articles, and presentations. I also wrote this book for designers, illustrators, and visual journalists who are struggling with how to approach content rooted in science; and to science communicators of all types looking to bolster their knowledge of the practice of creating graphics.

3 Faith Kearns, *Getting to the Heart of Science Communication: A Guide to Effective Engagement* (Island Press, 2021); © 2021 by Faith Kearns; Quote used by permission of Island Press, Washington, D.C.

Interest in science communication training is going up,[4] as have expectations for scientists and others to effectively communicate research findings to both broader and more well-defined audiences.[5] But most training materials focus on writing and oral presentations. There is a need for comprehensive, clear, and practical guides to communicating science through imagery.[6] Data visualization authors have been stepping up to the task in recent years, with books that run the gamut from chart-choosing guides, to design primers and data storytelling workbooks. This book aims to expand that corpus to include a different portion of the information graphics spectrum; illustrated explanatory diagrams. Scientists are expected to be able to create diagrams and figures for their papers. But they are not routinely trained in how to do so, and "visual material is typically treated as an add-on instead of being an integrated part of the whole."[7] That's not to say that webinars, guides, and references on the topic don't exist. Indeed, I'll nod to many of them in the pages that follow. But I am not aware of any other practical step-by-step guides to creating scientific illustrated explanatory graphics in book form. This text will help fill that gap on the bookshelf for not only scientists, but also journalists, authors, artists, and science communicators of all types.

Audience

The primary audience for *Building Science Graphics* is scientists and science communicators—students and researchers alike. The book presumes no previous formal design training. Familiarity with specific design or illustration computer programs is not required. The principles within can be applied to your drawing tools of choice. Designers, illustrators, visual journalists, and writers looking to become more

4 Toss Gascoigne et al., eds., *Communicating Science: A Global Perspective* (ANU Press, 2020)

5 Ilda Mannino et al., "Supporting Quality in Science Communication: Insights from the QUEST Project," *Journal of Science Communication*, Vol. 20 (May 10, 2021)

6 This topic is thoroughly cited by Karen J. Murchie and Dylan Diomede in "Fundamentals of Graphic Design—Essential Tools for Effective Visual Science Communication," *FACETS* (June 11, 2020).

7 Fabiola Cristina Rodríguez Estrada and Lloyd Spencer Davis, "Improving Visual Communication of Science Through the Incorporation of Graphic Design Theories and Practices Into Science Communication," *Science Communication,* Vol. 37 (February 1, 2015)

adept at conveying scientific content with graphics will also find the content useful, although a few chapters may cover familiar ground. This book is a natural fit for undergraduate and graduate-level science communication and journalism classes, and as a practical reference guide for anyone who needs to convey scientific information in an illustrated form.

What's in This Book

In this book, I use "graphics" as shorthand for the portion of the information graphics continuum that encompasses illustrated explanatory diagrams. Part 1 defines those terms, submits why they are useful for science communication, and explores concepts and principles that guide information design. I should point out that many of the fundamentals within this book lean quite heavily on design principles that come out of a very specific Western European and North American design tradition, destined for European and American audiences. Broader critiques of defaulting to those design systems are included. But the fact remains that this section leans heavily on a specific design canon.

Part 2 focuses more sharply on science graphics. It establishes a classification system of static science graphics types, and addresses topics that are particularly relevant to this sub-genre, including sections on complexity, uncertainty, and misinformation.

Part 3 is the crux. It outlines the process that I use to develop static science graphics, illustrated with real-world examples, including images of notes, concept sketches, tight sketches, and final products. This section includes two worksheets that I've designed to walk you through the process of building your own graphics. Although the guides describe specific *strategies*, they don't dictate specific solutions. Recommendations—rooted in fundamentals described in Parts 1 and 2—provide enough flexibility for you to directly address the needs of your specific audience.

Teams are often better suited to the task than individuals. Part 4 acknowledges that the project you have in mind may exceed your current skill level or schedule, and it provides tips on how to effectively collaborate with others.

In short, Part 1 explains the necessary underpinnings and frameworks. Parts 2, 3, and 4 focus on science graphics themselves and how to build them. This book is rooted in my experiences, and therefore leans heavily on what I've learned from collaborating with scientists

and artists while creating science graphics for magazines and textbooks for over 25 years. Footnotes throughout nod to the work of others that have informed the text directly.

What's Not in This Book

Although many of the design principles and recommendations within are relevant across platforms and genres, this book is very much rooted in my experiences building static explanatory graphics. It does not directly address interactive explanatory graphics or animated graphics, topics that could easily fill entire books of their own.

This book also excludes tool-specific instructional guides. In case you're wondering, I usually start with a pencil and paper, and use Adobe Illustrator, Photoshop, and/or InDesign for my final graphics. Many other digital drawing programs exist, at a wide range of price points.

This book does not aim to teach you how to draw. It aims to get you thinking critically about how to organize and edit information within a set space. You may find that you're distracted by the task or challenge of drawing shapes, and unable to shift focus to the task of organizing those shapes into an explanatory diagram. If that's the case—and depending upon your needs—you may prefer to start with *Drawing on the Right Side of the Brain* by Betty Edwards.[8] Or you may prefer to make use of the extensive library of over 20,000 editable natural science icons available for use by BioRender,[9] organism silhouettes from PhyloPic,[10] or icons available for download by the Noun Project[11] (although the Noun Project isn't science-specific and some icons may include scientific inaccuracies).

I should admit that field research—the act of gathering evidence "from real people about how they think, feel, and behave in order to inform the design of effective solutions"[12]—is not a part of my regular practice. As a journalist working on tight deadlines, it sadly has not been practical or possible for me to step back and engage with my

8 Betty Edwards, *Drawing on the Right Side of the Brain*, The Deluxe Edition (TarcherPerigee, 2012)

9 *https://biorender.com/*

10 *http://phylopic.org/*

11 *https://thenounproject.com/*

12 Sheila Pontis, *Making Sense of Field Research: A Practical Guide for Information Designers* (Routledge, 2018)

intended audience during the design process for every graphic. My design decisions are informed by what I know about the magazine's subscribers as well as data on how readers interact with content on the magazine's website, and feedback in the form of letters from readers, communications with scientists and colleagues, and conversations within the design community. I always define my audience as a step in the design process. But it's important to note that this book does not include information based on my first-hand experience of how to collaborate with the intended audience as a part of the design process. For that reason, I largely rely on the expertise of others when addressing the topic in the pages that follow. Similarly, I still have much to learn on the accessibility front. The section that addresses this topic head-on in Chapter 12 is based on the expertise of others, and is limited in scope. These are both areas in which I'm committed to learn more. Many resources that I've found useful as I embark on that journey are cited within.

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PART 1

Underpinning

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CHAPTER 1

Introduction

AS A STUDENT, I was torn. Was I a scientist or an artist? I loved the clarity and order inherent to the scientific process: ask questions, set up methodologies, collect data, analyze. Research projects and papers I co-authored on the topics of trace fossils and hydrothermal vent species were immensely satisfying. No matter the result of the study, it gave me the chance to contribute a rigorously produced bit of knowledge to the world.

I also loved the idea of communicating through visuals rather than words. My studio arts classes encouraged me to question and morph methodologies. I couldn't stop making images. Nor could I imagine choosing one discipline at the expense of the other. Scientific illustration allowed me to merge those two identities. Finding the similarities between art and science, I honed in on observation and interpretation.

In college, I mimicked the style of vintage works rooted in direct observation.[1] Think Maria Sibylla Merian's botanical and entomological illustrations. I spent hours looking through a microscope, with a rapidograph

Image Credit: Maria Sibylla Merian; Metamorphosis of a Small Emperor Moth on a Damson Plum (plate 13 of the Caterpillar Book, 1679); Digital image courtesy of the Getty's Open Content Program.

1 It's important to acknowledge that colonization went hand-in-hand with expeditions that resulted in many classic scientific illustrations that are still lauded by lots of people today. I recommend reading "The Beauty and Violence of Ernst Haeckel's Illustrations," by John Kazior, *AIGA Eye on Design* (April 8, 2021).

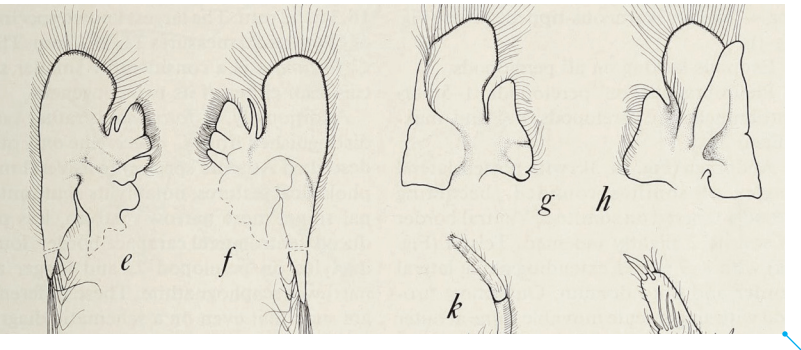


Image Credit: Jen Christiansen. Detail from "A new species of the shrimp genus *Chorocaris* Martin & Hessler, 1990 (Crustacea: Decapoda: Bresiliidae) from hydrothermal vent fields along the Mid-Atlantic Ridge," by Joel Martin and Jennifer Christiansen, *Proceedings of the Biological Society of Washington*, Vol. 108 (June 22, 1995).

pen in-hand, counting hairs on mandibles and faithfully documenting crustaceans for species description papers.

My interest eventually shifted from illustrating objects toward trying to represent things that can't always be directly observed, like concepts and processes. Think Abū al-Rayḥān Muḥammad ibn Aḥmad al-Bīrūnī's moon phase diagram.

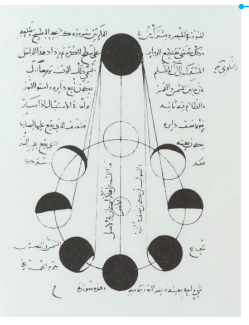


Image Credit: Abū al-Rayḥān Muḥammad ibn Aḥmad al-Bīrūnī; In *The Book of Instruction in the Elements of the Art of Astrology*, From The New York Public Library Digital Collections (Retrieved from *https://digitalcollections.nypl.org/items/b5b8f0ad-2287-4be2-e040-e00a18065bdd*)

At the time, I thought of it as a natural extension of scientific illustration. In retrospect, I can see that I was simply striding toward the worlds of information design and data visualization. But I was lacking a clear guide.

Perhaps that's why in 1996 I was so taken by a required reading in graduate school: Edward R. Tufte's book, *The Visual Display of Quantitative Information*.[2] Not having had read much about information design up until that point, I devoured the pages, and moved on to other books by the same author. (I'm not alone. Tufte's writings were quite influential as the practice of data visualization and information design became more widespread in the late 1990s and early 2000s.) One of his classic and compelling "Principles of Graphical Excellence" stuck with me. It states concisely that, "Graphical excellence is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space."[3]

Soon after, I was swept into the publishing world, working for magazines that enthusiastically embraced extravagant, colorful, and remarkably detailed three-dimensional (3D) renderings. We were using a heck of a lot of printers' ink in as much space as we could carve out between columns of text. It made a lot of sense at the time.

2 Edward R. Tufte, *The Visual Display of Quantitative Information* (Graphics Press, 1983)

3 I should note that this is just one of five principles, and they appear in a book that is centered on visualizing quantitative, not qualitative, information.

Computer rendering programs were becoming more accessible to artists and designers, and digital 3D illustrations were elbowing out analog airbrush paintings and ink drawings. And the Web was starting to compete seriously for attention. The era called for lush, dynamic, and bold visuals in print media, and we delivered them. The trend influenced college-level science textbooks too, as imagery broke out of confined boxes and spilled into text columns, magazine-style. The work I was doing for *Scientific American*, *National Geographic*, and the science textbook market wasn't quite maximalism. But it certainly wasn't Tufte-esque minimalism.

But then the prevailing aesthetics began to shift in a minimalist direction again, and I was excited. The time felt right to consciously apply Tufte's principles. A 2011 *Scientific American* article on the topic of cosmic inflation by physicist Paul J. Steinhardt provided a great opportunity to see how far I could push it.

The original plan was to use simple and spare imagery. I hoped to introduce a visual vocabulary with shape and color, then use that visual vocabulary to explain several concepts related to the expansion of our universe. Although the content still needed to be vetted, I imagined the style of the final illustrations to be very similar to the concept sketches below; flat shapes and limited color. Every color, shape, and line would be imbued with meaning. Nothing extraneous. Cyan for the classic hypothesis, magenta for new ideas, and yellow zones to define the period of inflation.

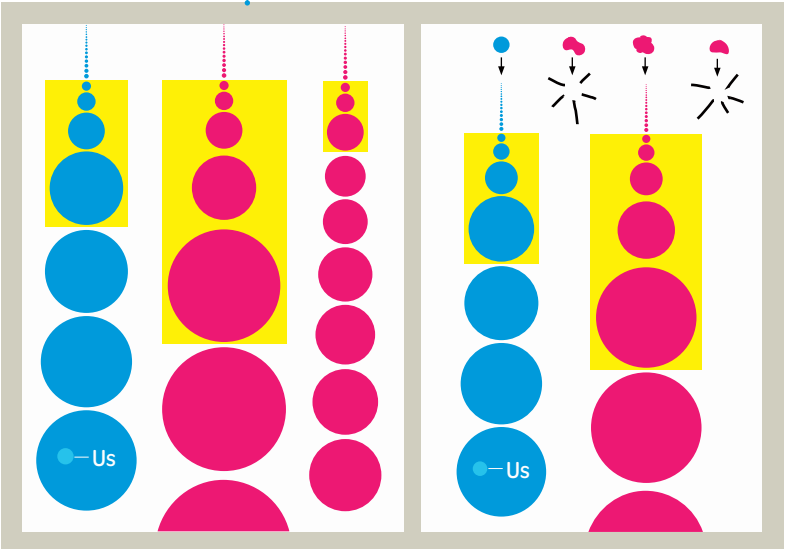


Image Credit: Concept sketches by Jen Christiansen

I was so caught up in developing a spare and efficient language to explain the science, that I was taken aback when editor-in-chief Mariette DiChristina asked for something richer and more engaging. I had completely lost sight of the context for the graphics. The illustrations were intended for an existing audience who loves articles about space. And a potential audience who might benefit from a familiar and comfortable visual hook as a welcoming counterpoint to the abstract concepts in the article. By stripping out figurative details, I had lost all visual references to space. And I may have pushed an already abstract concept further out of reach of a non-specialist audience.

So I pivoted, starting with color. Pure magenta, cyan, and yellow gave way to a color palette that evoked space—dark purples with bright white details, and warm globes that would eventually glow.

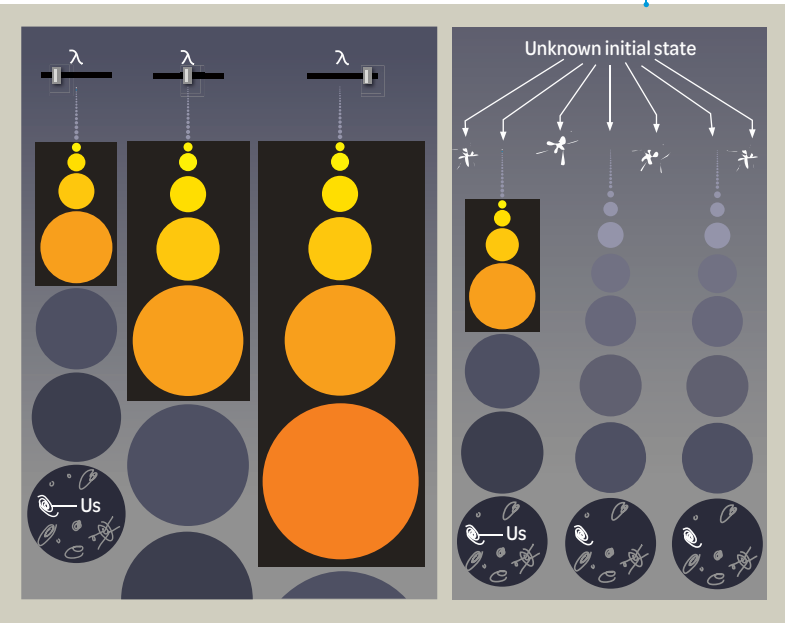


Image Credit: Revised concept sketches by Jen Christiansen

The final graphics remained more or less faithful to the original sketches in terms of content, but the spare iconography shifted toward a more figurative vibe. Ulitmately, artist Malcolm Godwin of Moonrunner Design brought the shapes to life. Intellectually, I resisted the shift in style at first. But in time I realized that the galaxy details and marble-like spheres provided a welcoming counterpoint to the abstract concepts in the article. I now like to think of those fanciful details as a

Image Credit: Photograph of magazine by Jen Christiansen. Detail of final illustrations by Malcolm Godwin (Moonrunner Design), as published in "The Inflation Debate," by Paul J. Steinhardt, *Scientific American* (April 2011).

welcoming gesture before blowing the reader's mind with counter-intuitive concepts. Sort of like a glass of wine alongside a challenging plate of tripe. The final lush imagery signals "space!" more directly than flat shapes for a casual reader flipping through the magazine.

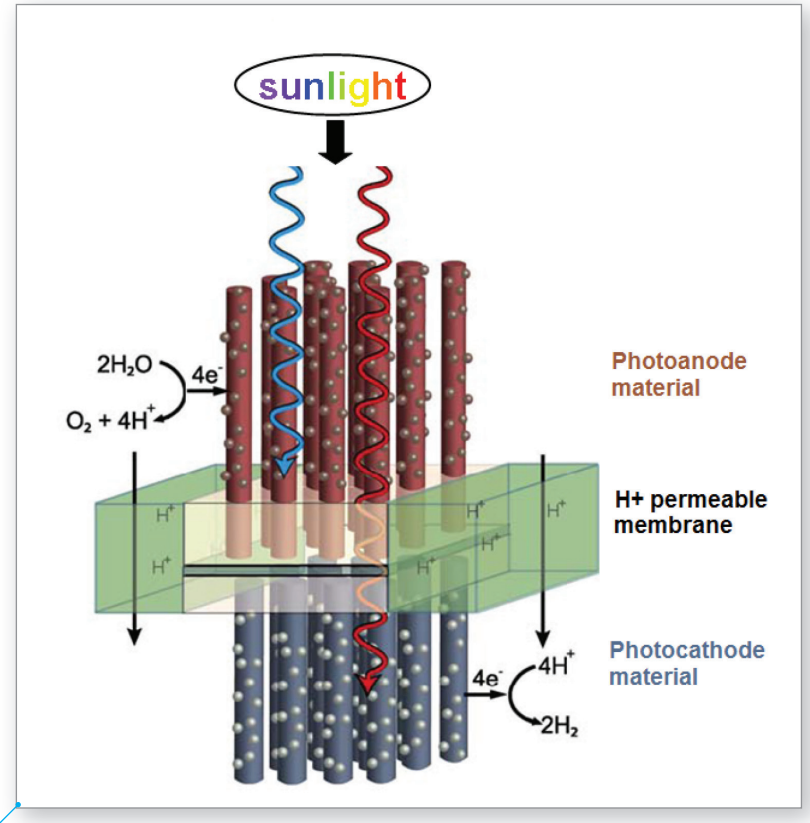
I learned a few important things while working on that article. Those lessons continue to inform my graphics philosophy today:

- **Be wary of applying "principles of graphical excellence" without consideration of your particular project's ultimate audience and use;**
- **Nonetheless, there's still great value in critically considering the principles and ideas from folks who have come before.**

Although the final aesthetics of these cosmic inflation images don't reflect the spare concept I started with, approaching the project with a minimalist mindset forced me to prioritize how the information should be organized on the page. I wasn't leaning on visual style from the start, and I think the series of graphics is better for it.

I aim to honor those two lessons in this book. I will not offer my own "principles of excellence," as that depends upon who you're designing your images for, and how they'll be used. Those combined possibilities are endless. But I will present research findings and often-cited principles and ideas from others, as well as strategies for designing graphics that I have developed over time. My goal is to provide you with a solid foundation of knowledge about science communication and information design (Part 1), and a framework for thinking about—and building—science graphics of your own (Parts 2, 3, and 4).

As you'll see in Chapter 15, I start projects by establishing the goal of



Original Caption: "Schematic of the proposed solar powered water-splitting device incorporating two separate semiconductor rodarray photoelectrodes that sandwich an electronically and ionically membrane." Image Credit: As published in "Silicon and Tungsten Oxide Nanostructures for Water Splitting," by Karla R. Reyes Gil, Joshua M. Spurgeon, and Nathan S. Lewis, *Solar Hydrogen and Nanotechnology IV*, *SPIE Proceedings*, Vol. 7408, edited by Frank E. Osterloh (2009)

the graphic. That goal reflects both the project's ultimate audience, and the use to which it will be put. In my work for magazines, the context remains more or less consistent across a broad range of topics, so I don't always articulate it outright. But that context shapes every decision from content and composition to style. The following example shows how.

For an article on artificial photosynthesis, preliminary research uncovered a great reference figure published by Karla Reyes-Gil, Joshua Spurgeon, and Nathan Lewis. It's a schematic of a material their lab developed to mimic photosynthesis. This image is well suited to the context of a conference proceedings paper. The goal is clear: Show the components of the nanostructure and provide a basic sense of how it works. Color is used intentionally to represent different material types, labels are legible, and the schematic isn't overwhelming. It's not trying to accomplish too much in the space allotted, and it would also translate well into a slide deck or academic poster. It's a great example of a solid figure designed for the authors' peers in a book connected to a scientific conference.

When you change the audience and the outlet, you also shift the goal of the graphic. When presenting this same basic content to a non-specialist audience, I needed to not only engage non-specialist readers, but also help them more immediately see the parallels between this technology and natural photosynthesis. In an effort to make the parallels as explicit as possible, I started by drawing out the steps using the same composition for each approach—natural photosynthesis at the top, and artificial at the bottom. Then I used color to help highlight which parts correspond.

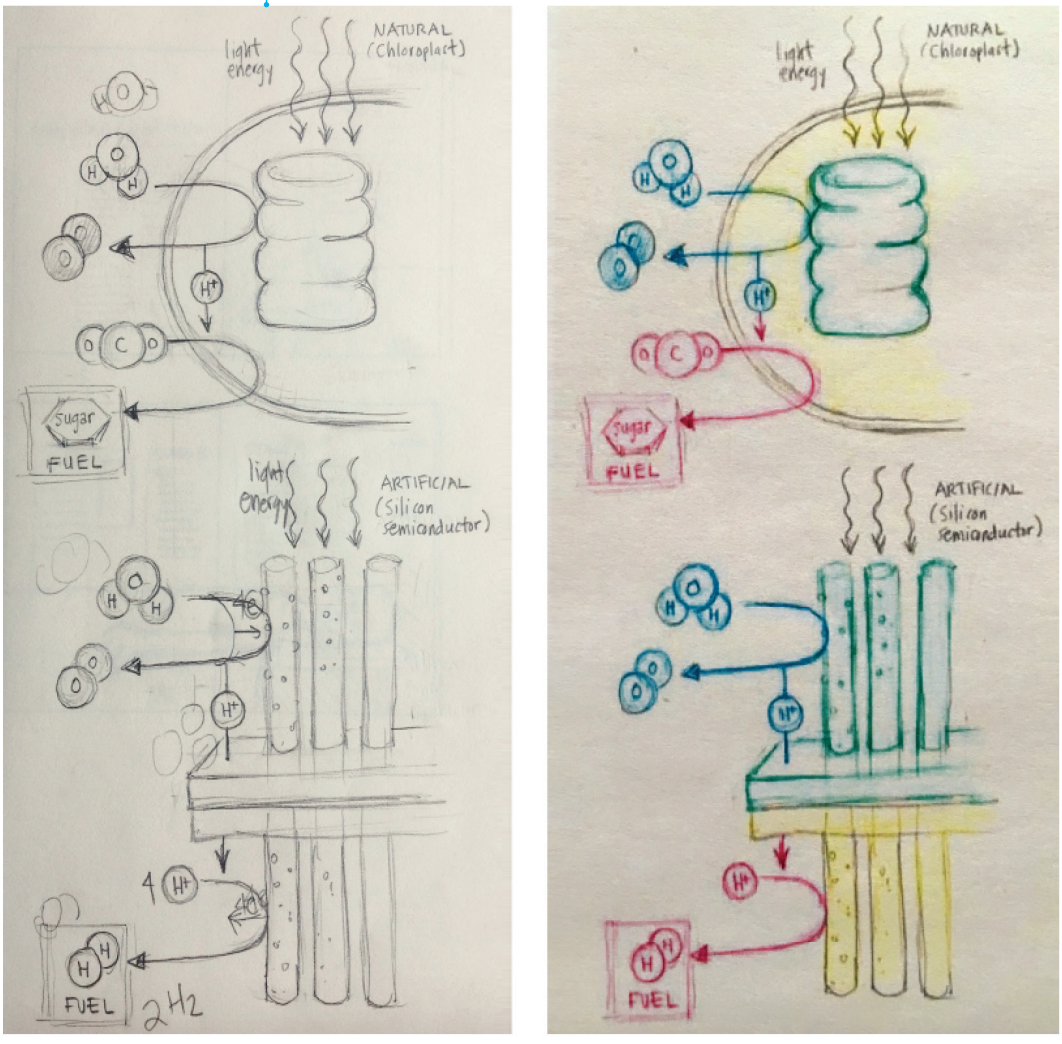


Image Credit: Jen Christiansen, sketches for "Reinventing the Leaf: Artificial Photosynthesis to Create Clean Fuel," by Antonio Regalado, *Scientific American* (October 2010)

But stacking things on top of each other meant that the reader's gaze would have to bounce from top to bottom and back again, searching for the corresponding steps. So I pulled the two approaches apart, and put them next to each other, leaving room for explanatory text between the two scenarios.

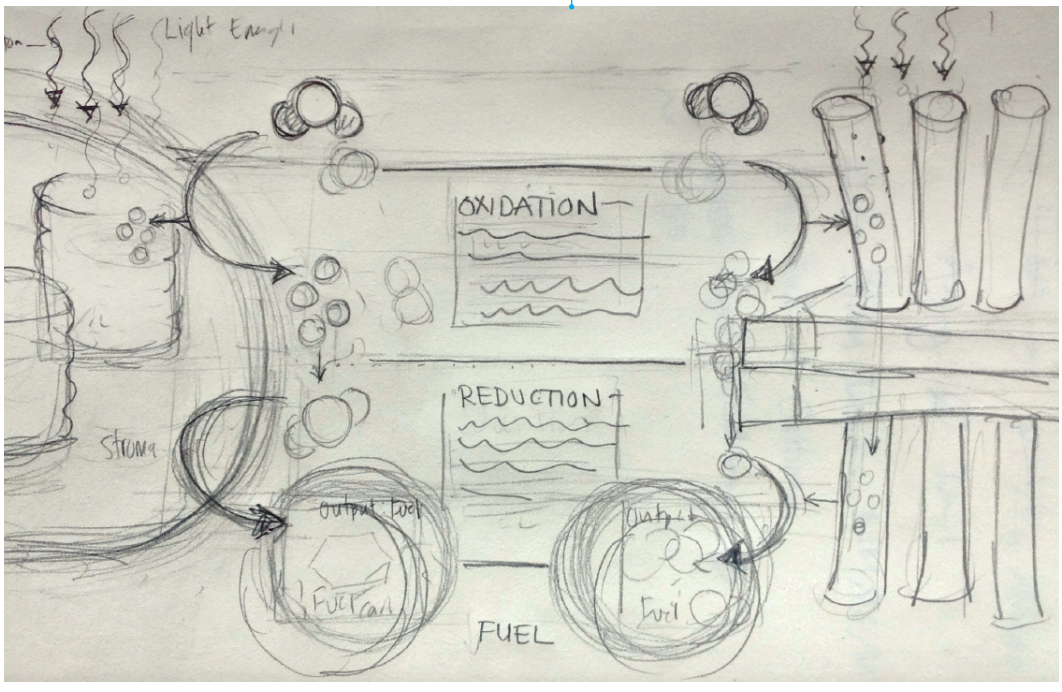
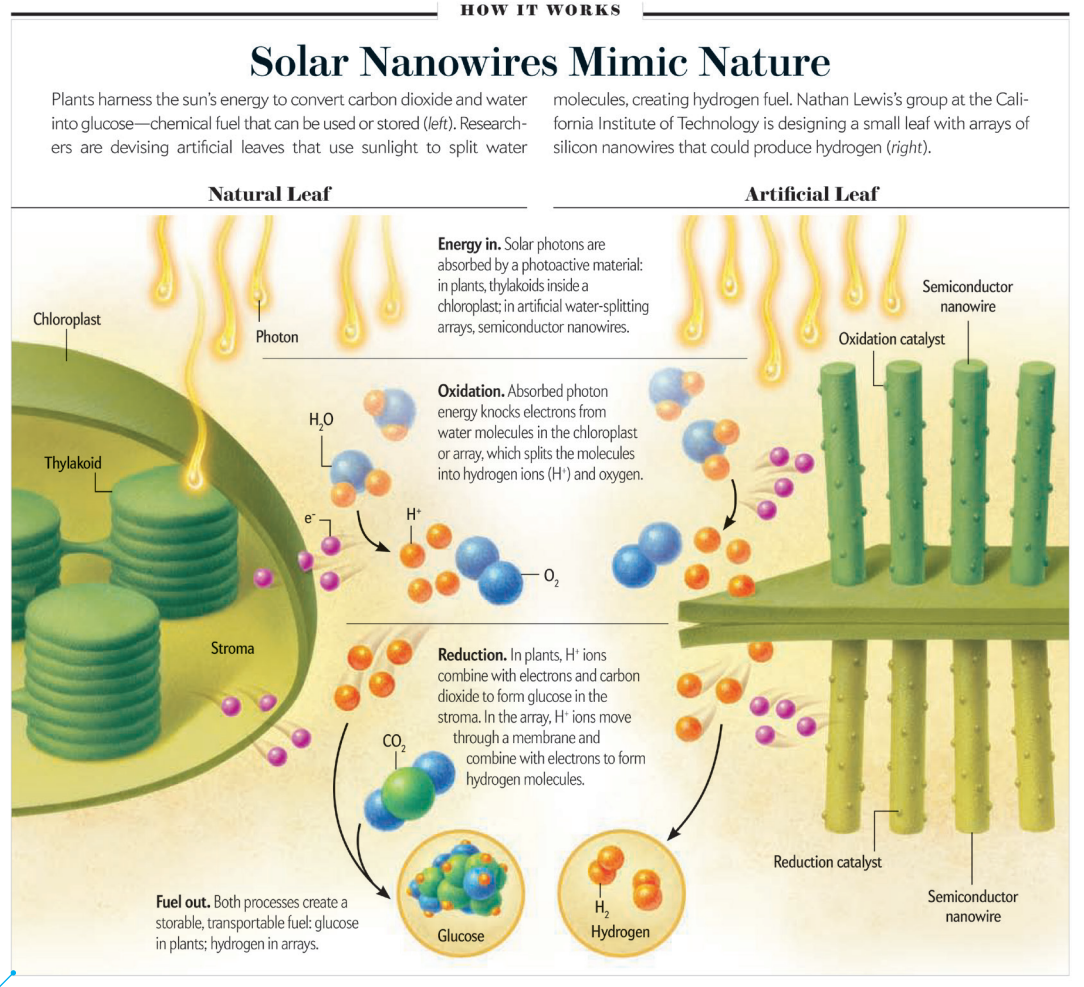


Image Credit: Jen Christiansen, sketch for "Reinventing the Leaf: Artificial Photosynthesis to Create Clean Fuel," by Antonio Regalado, *Scientific American* (October 2010)

Here's the final art box, as rendered by botanical artist Cherie Sinnen. As discussed in Chapter 10 on visual style (see page 127), the goal was to invite the reader in with a warm and welcoming aesthetic, keep them engaged with some basic primer information about photosynthesis that would likely feel a bit familiar, then have the reader build on that more familiar content by showing how the new technology works.

As demonstrated in this example, my initial solution was just that. An initial solution. I needed to draw it out to see what worked, and what didn't work. Once I realized that the composition—or position of objects on the page—didn't allow for a seamless comparison between scenarios, I was free to iterate. Knowledge of basic design concepts about composition, color, and visual style informed every decision along the way. But trial and error is a powerful teacher.

Image Credit: Cherie Sinnen, as published in "Reinventing the Leaf: Artificial Photosynthesis to Create Clean Fuel," by Antonio Regalado, *Scientific American* (October 2010). Reproduced with permission from the artist.



The next two chapters take a step back, and provide a foundation for thinking about science graphics and science communication. Then you'll dive into basic concepts in design, lots of real-life examples, guides that aim to help you start—or continue—on your graphics-building journey, and tips on how to collaborate with others.