



Effective Figures and Captions for Technical Documents

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Conceptual drawing of the Macondo well, blowout preventer, and broken piping after the BP well exploded on April 20, 2010, and the Deepwater Horizon drilling rig sank. Rendering by Sabrina Fletcher. Courtesy Lawrence Livermore National Laboratory.

With thanks to S. Lance Cooper for the examples shown in Slides 13–15 and to Tony Liss for helpful suggestions.

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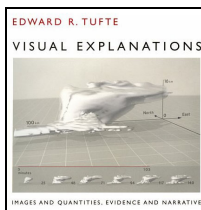


When feasible, put important points and conclusions in graphical form. Not everyone reads an entire article from beginning to end. When readers skim through an article, they are drawn to the figures. Try to make the figures and their captions

- (1) tell the story.
- (2) entice the reader to read the whole article.

Highly recommended:

If you're not acquainted with Edward Tufte's books, *Visual Explanations* should be required reading. He rules!



Edward R. Tufte, *Visual Explanations: Images and Quantities, Evidence and Narrative* (Cheshire, CT, Graphics Press, 1997).

Also highly recommended:

“Graphing Resources” (<http://www.ncsu.edu/labwrite/res/res-homepage.htm>), particularly their “Revising your Visuals” section.

Worst figure ever (the caption doesn't help either)...

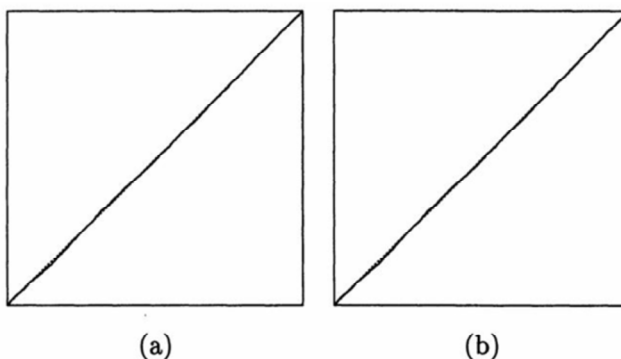


Figure 1. SRQ Plots of T_i/T_n (Vertical Axes) Against i/n (Horizontal Axes) for the Gibbs Sampler (a) and an Alternating Gibbs/Independence Sampler (b) for the Pump Failure Data Based on Runs of Length 5,000. Lines through the origin with unit slope are shown dashed; axis ranges are from 0 to 1 for all axes.

1. Per Mykland, Luke Tierney & Bin Yu (1995) Regeneration in Markov Chain Samplers, Journal of the American Statistical Association, 90:429, 233-241, DOI: 10.1080/01621459.1995.10476507.

So that it can be copy edited, the caption should not be embedded into the artwork



(Image courtesy U.S. Naval Research Laboratory)

20

Put figure captions (including the figure number) in separate text, not embedded into graphical files.

The caption embedded in the figure is inadequate, because it doesn't identify the important parts of the figure.

For photographs, crop out “background” to focus readers’ attention on important features

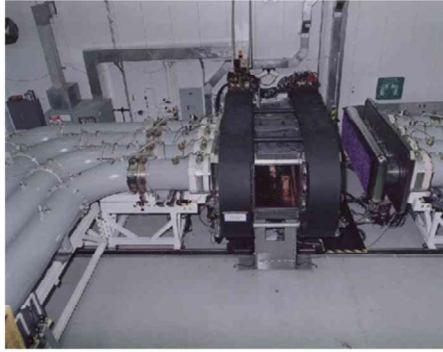


Figure 8. Final amplification stage of the Nike Laser: the 60-cm aperture E-beam-pumped amplifier.

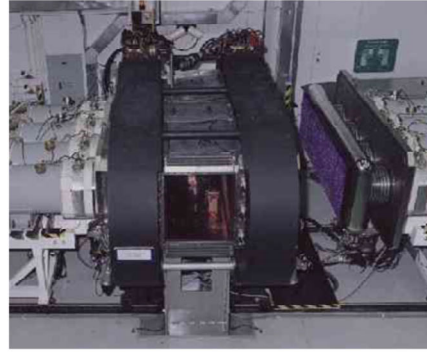
20

In the original photograph, the busy back wall and bare floor take up nearly 30% of the space occupied by the figure but add 0 information.

For photographs, crop out “background” to focus readers’ attention on important features



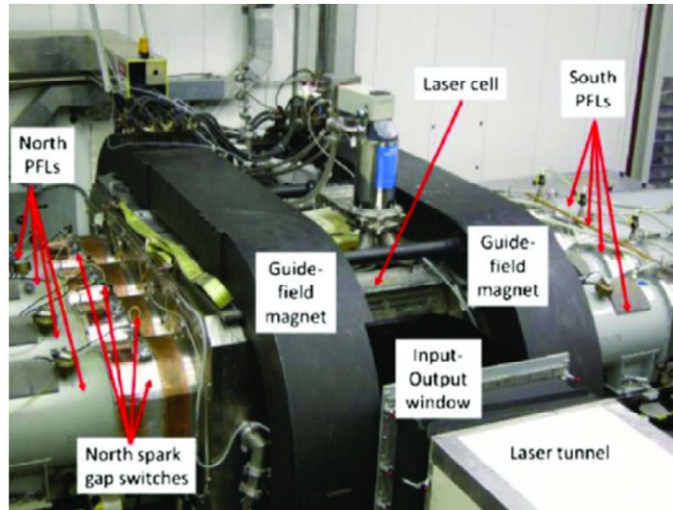
Before



After

20

Label each element of the figure so readers know what's important and where to look



Stephen Obenschain et al., "High-energy krypton fluoride lasers for inertial fusion," *Applied Optics* **54**, F103 (2015).

20

Point out each important element in the figure by labeling it, so that readers know what they're looking at.

Figure captions are placed *below* the figure and aligned according to the journal's style

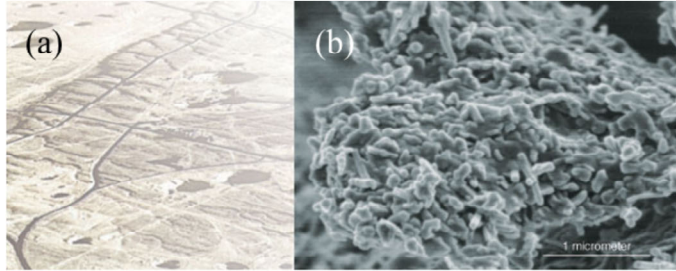


Figure 1. Field studies and microscopic experiments are being conducted to determine how plutonium is transported in ground water. (a) Aerial view of the Nevada National Security Site; (b) transmission electron microscope image of Pu-contaminated ground-water. Colloids have been shown to play a significant role in transporting Pu at contaminated sites worldwide. [1]

1. A. Heller, "Plutonium Hitches a Ride on Subsurface Particles," Science & Technology Review, October/November 2011, <https://str.llnl.gov/OctNov11/kersting.html>.

2

Always begin the caption with the word "Figure" and the number assigned to that figure.

Use Arabic numerals and the word *figure* to denote figures and captions, e.g., Figure 1, Fig. 23.

Figure should be capitalized when combined with a numeral to form the title of a specific figure.

"Temperature variation is shown in Fig. 3."

"The figure clearly shows the temperature variation with elapsed time."

Don't abbreviate *figure* (or anything else) if you use it to begin a sentence—or a caption.

You can use the "caption" feature in Word (and the equivalent utility in LaTeX) to assign consecutive numbers to your figures and to automatically update the numbers in the captions and the text if you move figures around, such that what used to be Fig. 9 is now Fig. 4.

Describe all elements of the figure without referring to material in the text

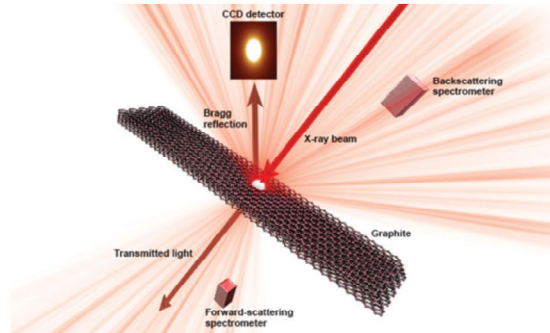


Figure 2. Experimental setup to measure breakdown of solid-crystal graphite. A charge-coupled device (CCD) detector simultaneously collects Bragg-reflected x-ray laser light as crystal x-ray spectrometers collect light from inelastically scattered photons, enabling observation of extremely fast changes in graphite “melting.” [1]

1. “Graphite, a Quick-Change Artist,” *Science & Technology Review*, Jan-Feb 2023, Lawrence Livermore National Laboratory. Published online at <https://str.llnl.gov/january-2023/hau-riege>.

Think about how scientists “read” a journal article—they read the abstract, scan the “introduction” and “conclusions” sections, and glance at the figures and tables. Thus, figures must “stand alone”; a reader should be able to understand the main message in a figure without having to read the text.

What's wrong with this caption?



Figure 4. An image sequence from a dDAC experiment shows the growth of a dendritic ice-VI crystal in response to increasing compression. [1]

- **dDAC not defined (caption must “stand alone”)**
- **sample material not specified**
- **pressure range and the elapsed time not specified**
- **black “spots” in each image not identified**
- **label pointing out the “crystal” would be helpful**
- **“micrometers” should be “ μm ”**

1. Kristen Light, “Diamonds Put the Pressure on Materials,” Science & Technology Review, June 2010, Lawrence Livermore National Laboratory. Published online at <https://str.llnl.gov/June10/evans.html>.

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This caption is insufficient. It should probably define the dDAC acronym (dynamic diamond-anvil cell), tell what the sample material is (liquid water being cooled under high pressure to below the freezing point), and specify both the pressure range and the elapsed time shown in the series of images. The black “spots” in each image should also be identified (ruby chips used to calibrate the pressure).

Ms. Particular quibble: the scale should be written as 45 μm . Units are always abbreviated when they are used with exact numbers that have been measured or calculated.

**If a figure is taken from another source,
it should be referenced in the caption**

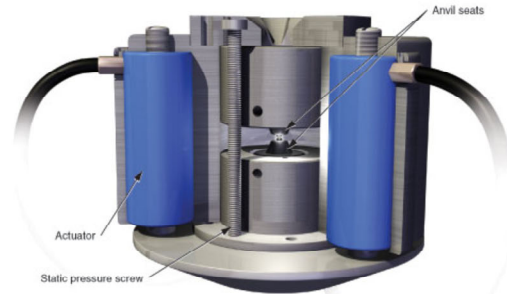


Figure 3. Drawing of a dynamic diamond-anvil cell (dDAC). As diamond anvils compress micrometer-size samples, the piezoelectric actuator varies the static pressure, allowing researchers to examine how compression rates affect materials' behavior. [Taken from Ref. 1]

1. Kristen Light, "Diamonds Put the Pressure on Materials," Science & Technology Review, June 2010, Lawrence Livermore National Laboratory. Published online at <https://str.llnl.gov/June10/evans.html>.

5

Written permission must be obtained from the publisher—not the author—to **reprint** a figure in another publication. We'll talk more about this issue when we discuss copyrights later in the semester.

For purposes of this class, simply provide credit for figures you use. For a talk, identify the source of a figure on the slide on which the figure appears.

**If a figure is taken from another source,
it should be referenced in the caption**

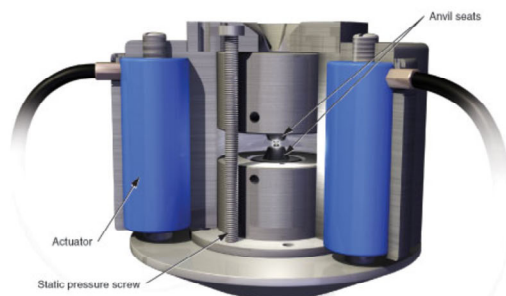
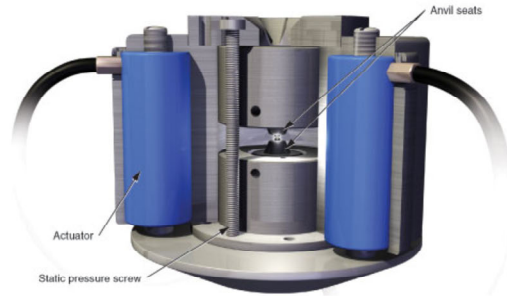


Figure 3. Drawing of a dynamic diamond-anvil cell (dDAC). As diamond anvils compress micrometer-size samples, the piezoelectric actuator varies the static pressure, allowing researchers to examine how compression rates affect materials' behavior. [Taken from Ref. 1]



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Make sure the labels are big enough to be read

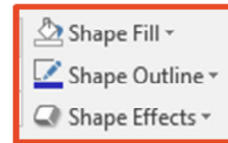


These aren't.

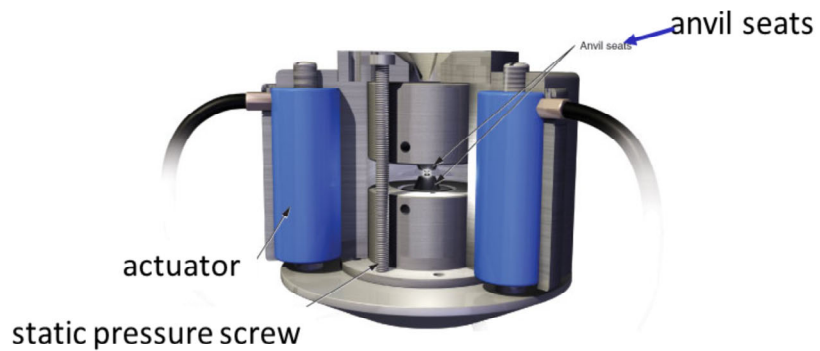
7

For talks, superimpose a new label

Insert a text box, type the label, no outline, fill to match the background color

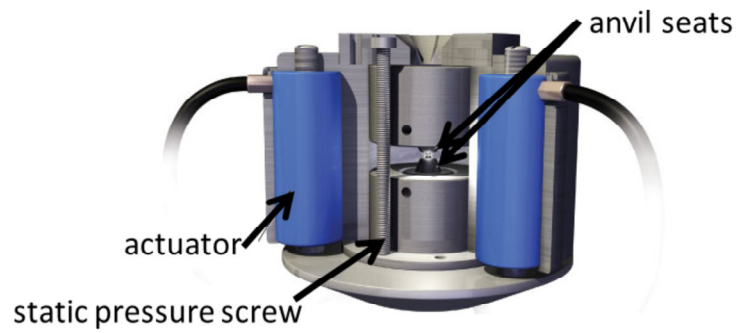


Slide the new label over the original label



8

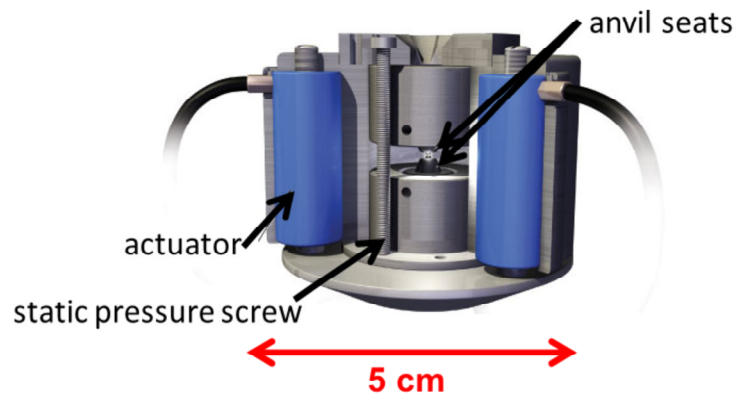
**Make the arrows big enough to see, too,
by superimposing new arrows**



9

Make the arrows big enough to be seen, too, by superimposing new arrows

And always provide a scale!



9

State what the figure is showing before launching into an explanation of what it means

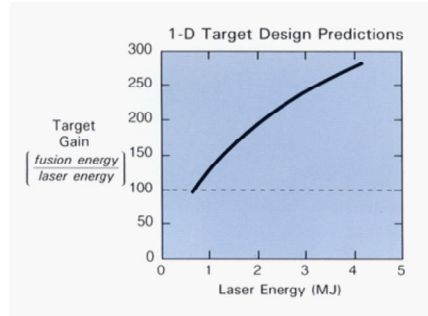


Figure 3. The 1-D spherical target designs at NRL predict target gains of 100–300 for a few-MJ laser. This gain curve is an upper bound on possible target performance. A gain of at least 100 is required for fusion-reactor applications. (Courtesy U.S. Naval Research Laboratory)

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Always give the “title” of the figure first. Tell readers what they’re looking at before you start explaining the details.

Here's the same figure and caption, but an explanation has been added to immediately orient the reader

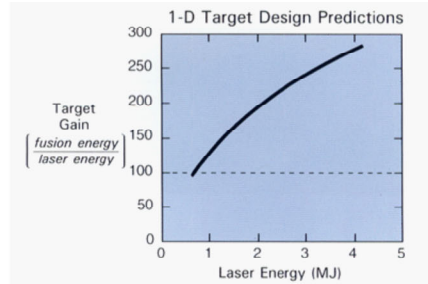


Figure 3. Plot of target gain as a function of input laser energy; the dotted line indicates the minimum gain required for fusion reactor applications.
1-D spherical target designs at NRL predict target gains of 100–300 for a few-MJ laser. This gain curve is an upper bound on possible target performance. (Courtesy U.S. Naval Research Laboratory)

Here's another example—what's wrong?

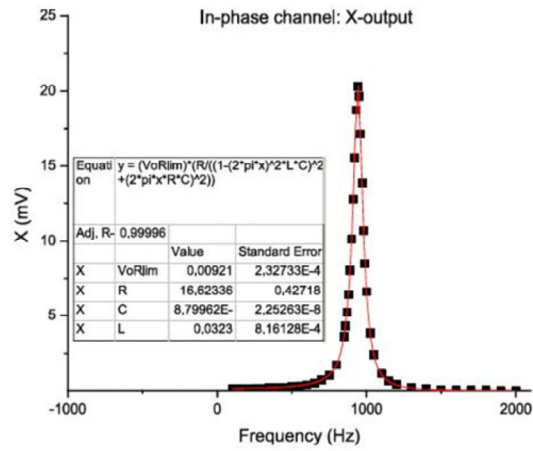
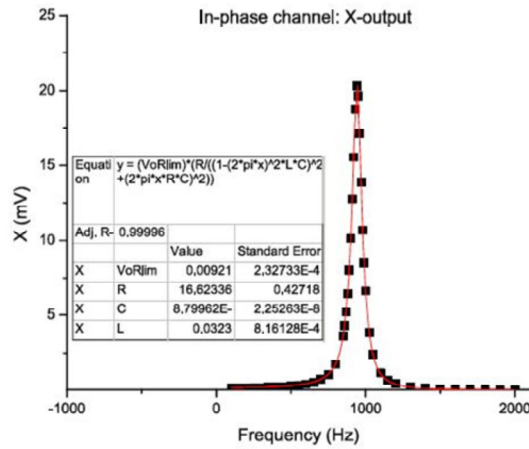


Figure 4. The in-phase output voltage amplitude of an RLC circuit shows a clear resonant response frequency at a peak around 980 Hz.

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Here's another example of an inadequate caption.

Avoid inset tables if possible



Too small to read
Too complex to process easily
Authors moved intersection of x and y axes to accommodate table so they don't intersect at 0 for the plot

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If you absolutely must show the table, move it to the right of the plot so the axes intersect at 0.

First, state what the plot is depicting

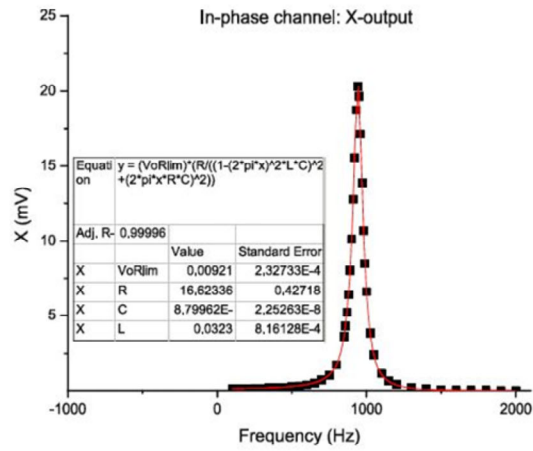


Figure 4. Plot of the in-phase output voltage X (mV) vs. frequency (Hz). The in-phase output voltage amplitude of an RLC circuit shows a clear resonant response frequency at a peak around 980 Hz.

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First, tell the reader what the figure represents.

Next, describe all key elements

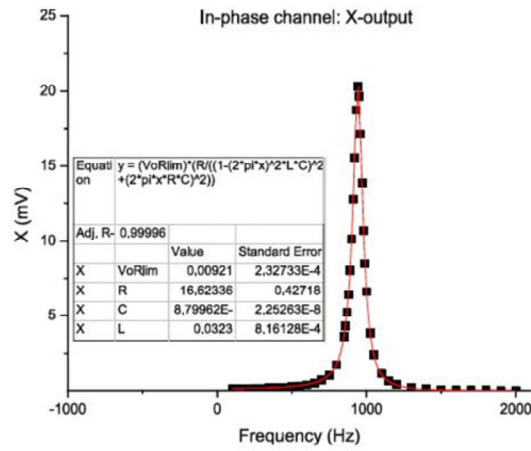


Figure 4. Plot of the in-phase output voltage X vs. frequency. Filled squares represent measured points, and the red line is a fit to the data using a Lorentzian lineshape. The inset table gives the fit parameters associated with the Lorentzian fit. The in-phase output voltage amplitude of an RLC circuit shows a clear resonant response frequency at a peak around 980 Hz.

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The caption must describe every element of the figure. The original caption is insufficient, because it doesn't explain the significance of the filled squares on the plot, and it doesn't say what the inset table is for.

Finally, what have you concluded?

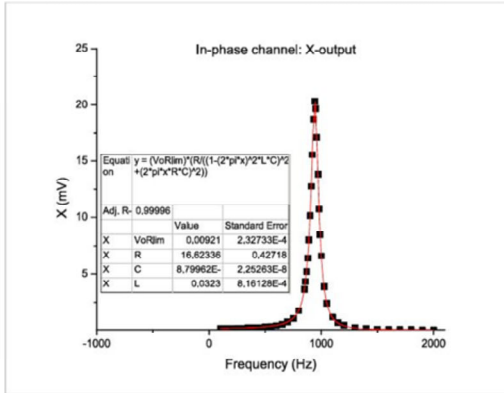


Figure 4. Plot of the in-phase output voltage X vs. frequency. Filled squares represent measured points, and the red line is a fit to the data using a Lorentzian lineshape. The inset table gives the fit parameters associated with the Lorentzian fit. **The in-phase output voltage amplitude of an RLC circuit shows a clear resonant response frequency at a peak around 980 Hz.**

15

The caption should explicitly state what the point of the figure is. What should the reader learn or conclude from the figure?

What's wrong with this figure caption?



Microphotographic images of pressure-induced dendritic crystals (top row) are remarkably similar to the patterns produced in computer simulations of temperature-driven dendritic crystal growth (bottom row). [1]

1. Kristen Light, "Diamonds Put the Pressure on Materials," Science & Technology Review, June 2010, Lawrence Livermore National Laboratory. Published online at <https://str.llnl.gov/June10/evans.html>.

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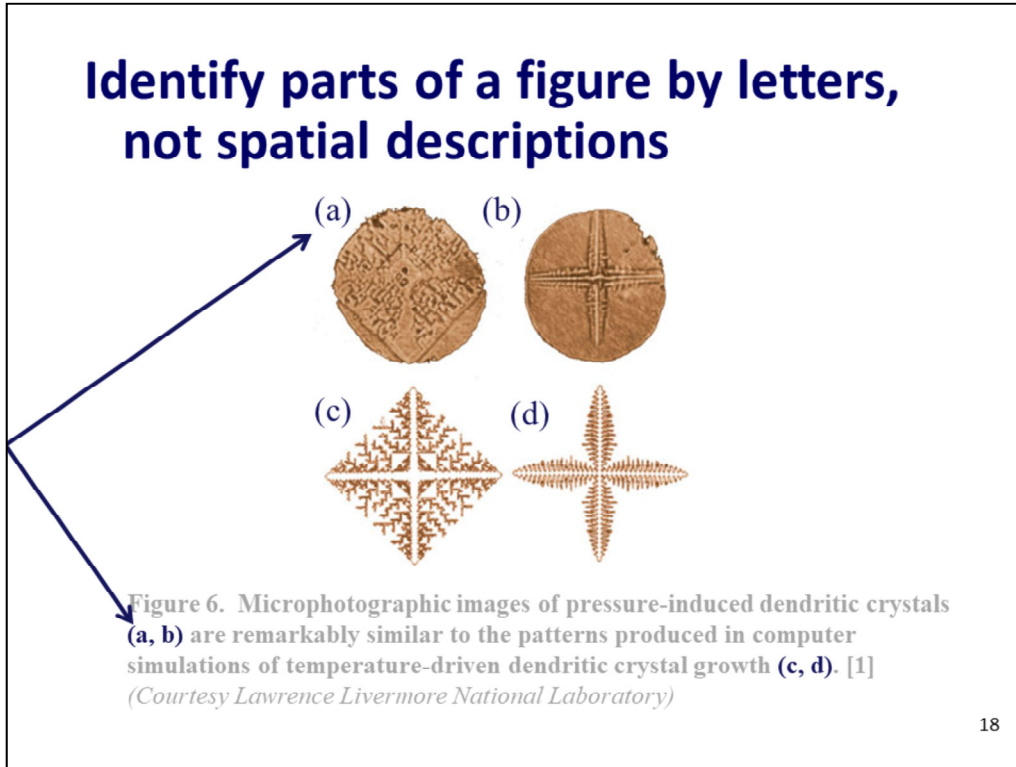
Number figures consecutively and “call them out” in the text



→ **Figure 6.** Microphotographic images of pressure-induced dendritic crystals (top row) are remarkably similar to the patterns produced in computer simulations of temperature-driven dendritic crystal growth (bottom row). [1] *(Courtesy Lawrence Livermore National Laboratory)*

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The caption must begin with the number assigned to it in the narrative text.



When you submit “camera-ready” copy, you control where the figures are located in relation to the text and how multiple figures are presented.

Designate sub-figures using letters, in alphabetical order. Arrange them left to right, top to bottom (the way English is read).

What happens when the compositor decides to rearrange your images?



Microphotographic images of pressure-induced dendritic crystals (top row) are remarkably similar to the patterns produced in computer simulations of temperature-driven dendritic crystal growth (bottom row). [1]

Now which is the “top” row and which is the “bottom” row of your caption?

1. Kristen Light, “Diamonds Put the Pressure on Materials,” Science & Technology Review, June 2010, Lawrence Livermore National Laboratory. Published online at <https://str.llnl.gov/June10/evans.html>.

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When you submit a paper to a journal that still typesets manuscripts, you don’t control how or where on the page figures are displayed. The compositor may decide that to save space and better fill up the page, he’s going to present your four photographs as shown on this slide.

Now what’s “top” and what’s “bottom”?

Never refer to spatial directions in the text of an article or in a figure caption.

Don Ranly's Rules for Captions*

"Every picture ^{requires} ~~needs~~ a caption."

"Captions are read five times more than the text."

"Complement the image; say what it does not say."

"Give useful information."

"Connect the figures to the text. A good caption says 'see story' without saying it."

"Write complete sentences."

"Use active verbs in the present tense."

Ranly → The plot shows that a phase transition occurs at 77 K.

cme → A phase transition was observed at 77 K, as shown.

"Scale the caption to the size of the image; captions should be at least two lines, optimum three lines, maximum four lines."

*<http://www.ranly.com> 21

Don Ranly, "Ranly on *Heads*," University Research Magazine Association Annual Conference, Florida State University, May 16–19, 2006.

Don Ranly is professor emeritus of the Missouri School of Journalism.
<http://www.ranly.com>

His remarks were intended for newspaper reporters and editors, but they're good advice for scientists, too.

Ms P quibbles:

I would rewrite Professor Ranly's Rule #1 to "Every picture **MUST HAVE** a caption," but that's a rant for another day. (Refer to Ms. Particular on "need.")

I would also say that the passive-voice construction is just fine, too, but I have enough trouble convincing physicists of the superiority of the passive voice for science writing. I'm not about to take on journalists. (Never argue with someone who buys ink by the barrel and paper by the ton.)

To recap:

Place the caption below the figure

Number figures consecutively and call them out in the text before displaying them

Identify what is being shown at the beginning of the caption

Describe all elements of the figure in the caption

Make labels big enough to be legible

Always provide a scale



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<http://physics.illinois.edu/people/Celia/>

NOTES: