CREATING EFFECTIVE SCIENTIFIC FIGURES FOR PUBLICATION

Learn how to create visually appealing and informative figures that will help tell the story of your research.

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FIGURE QUALITY IS A PAPER'S "SUIT AND TIE."

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WHY GOOD FIGURES MATTER

Figures are becoming increasingly important in academic publishing. Open Access has contributed to this by reducing limitations on the number of figures allowed in a paper and by eliminating color costs.

Within the last several years, PubMed and journal websites have begun to display thumbnails of figures alongside abstracts for all of their indexed publications. This means that from the initial search for your paper, your figures are already making an impression.

It is more important than ever that you make your first impression a good one. Unclear or unappealing graphics can often tarnish a reader's opinion of the work, even if the science is entirely sound.

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4 FRUSTRATIONS YOU CAN AVOID WITH GOOD FIGURES

1. JOURNAL EDITORS' CONCERNS ABOUT IMPROPER IMAGE MANIPULATION Without intending to, authors sometimes alter their figures in ways that are inconsistent with other aspects of the manuscript and/or journal guidelines. These inconsistencies can raise questions from journal editors, and if researchers have not kept their original files, this could result in being rejected by the journal.

2. REVIEWERS NOT UNDERSTANDING THE POINT OF YOUR FIGURES If you have not clearly determined the purpose of each of your figures before creating them, it is unlikely that reviewers will understand their purpose either. This confusion can create stress during the peer review process and could potentially add more work for you by having to explain or recreate your figures.

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3. READERS LOSING INTEREST IN YOUR PAPER Readers often assess the figures and images that go with a manuscript before reading through the entire paper. If the figures in a manuscript appear to be low-quality, readers will be less inclined to read past the abstract. Visuals can either elevate or detract from the success of a paper, depending on their quality. Of course, good visuals will have the former effect.

4. YOUR TIME BEING WASTED IN THE REVIEW OR PUBLICATION PROCESS If you do not invest the time to create effective visuals from the start, you will most likely have to spend extra time later to recreate, look for, or correct your figures to be able to publish your work.

SECTION 1 KEY TAKEAWAY:

Investing in good figures at the start of your research will save you time and frustration.

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STEP 1: IN THE LAB

Creating beautiful figures, especially ones involving images, begins at the bench. Images should not be an afterthought to your manuscript; they should be considered and planned from the start. Think of how you want to lay out your experiments, and strategize so that you can run them all at the same time and most efficiently. **Finally, before you begin, answer the question, what story do I want to tell with my figures?**

MASTER YOUR TECHNIQUE

To capture high-quality images, you must master the equipment. Practice or ask experienced labmates so that you can learn the settings most appropriate for your project.
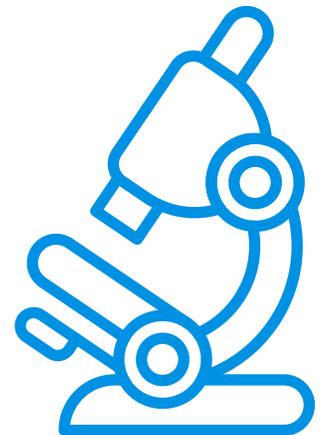
Also, note in your methods section any post-capture adjustments that you make to contrast, brightness, or gamma so that you can apply them exactly the same way to every set of images. This ensures transparency and consistency in your process, both of which can eliminate future frustrations and fulfill the best practice expectations of your journal.

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SAVE FIGURES AT HIGH RESOLUTION AND IN THE RIGHT FORMAT

Your pictures are your data, so it is imperative that they are both captured and saved at the highest quality possible. To achieve this, you should be mindful of the resolution and format that you are saving your images in.

When saving photographs directly from the equipment, they should be saved as a tiff, not as a jpeg or other low-quality formats. Tiff is the best format for saving scientific images because it is lossless, meaning that the number and color of pixels is preserved through mulitple saves or alterations of the image. (If you're curious why tiffs don't degrade, you can learn more about **Figures and File Types** on our Author Resource Center.) **It is important to note that later exporting a jpg image to a tiff doesn't undo the degradation that the jpg has already done.**

Most journals require that images with text be submitted at 600 dpi or higher. The typical requirement for line art submissions is 1200 dpi.

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KEEP YOUR ORIGINAL IMAGE AND FIGURE FILES

After you have saved your images in the appropriate format, you should keep the original files. Even if you adjust, alter, or crop the image in any way at a later time, always keep your originals, as they were captured from the machine. Saving the originals can be extremely beneficial if you ever receive questions from journal editors or reviewers about your images.

TIP: Save the originals and the adjusted images in two separate and clearly labeled folders on your computer so that there is no

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SECTION 2 KEY TAKEAWAY:

Save imags as tiffs (not jpgs or other low-quality formats), and keep all of your original files.

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STEP 2: BEFORE YOU CREATE

Before you begin incorporating your images and creating figures for your paper, there are a few decisions to be made. These decisions will help determine the types of graphs and software you should use and will help lay the foundation for creating your figures. You should take time to think through each of these items, and always ask your colleague for help if you have questions.

CHOOSE THE TYPES OF GRAPHS YOU WILL USE

One issue that authors are sometimes confused or uncertain about is the type of graphs they should use to report their data. There are usually several different standard visuals to choose from, depending on what you would like to communicate. **(See the chart on pg. 10.)**

SECTION 3

GRAPH OPTIONS:

COMPARISONS

DISTRIBUTION

PARTS OF A WHOLE

TREND OVER TIME

DEVIATIONS

RELATIONSHIPS

If you are comparing one set of values with another, you could display this information with a bar graph, scatter plot, pie chart, line graph, or a data table. If you want to show the distribution of a set of values to communicate the outliers, normal ranges, etc., you could use a bar graph, scatter plot, line graph, or a box-and-whisker plot.

You also have several options to demonstrate parts of a whole, trends over time, deviations, and relationships in data. Remember, before you begin creating your figures, consider what you would like to communicate, and then choose the most appropriate graph.

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CHOOSE THE SOFTWARE YOU WANT TO USE

IMAGES

Although the goal is to make few changes to your images after they are taken since they are considered primary data, the reality is that you will probably need to make some adjustments. To do this, you will need good photo-editing software.

Two programs that can be used to edit images are Adobe Photoshop and GIMP. Adobe Photoshop is a popular software that can be purchased and has extensive options and features for altering images. GIMP is also a useful software for editing images and is free to download.

Again, when you make changes to an image, remember to save your originals, save the updated image as a tiff, and record all changes. Also, if you are comparing a group of images, such as florescence images of the same cell, and you edit one of the images (contrast, etc.), the edit must be applied to all of the images in the group. It is not ethical or accurate to change only a single image in a group comparison.

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SECTION 3

FIGURES

Creating figures also requires good software. Fortunately, there are many options available to researchers. Paid options include Corel Draw, Microsoft Expression Design, and Adobe Illustrator. These programs have a steep learning curve, but offer the tools needed to create excellent figures.

There are highly useful free software programs available to researchers as well. These programs include Dia, Inkscape, and Microsoft Excel. Excel is one of the most popular options used. Within Excel, you can set the size of your figure, remove graph lines, choose colors, and more.

Whatever software you choose to use to create your figures, you will likely be able to find tips, tricks, and answers to many questions online and from labmates.

SECTION 3 KEY TAKEAWAY:

After you have considered the purpose of your figure, choose the right graph to represent it.

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STEP 3: WHEN YOU CREATE

When you are ready to begin creating your figures, there are required and best practices to keep in mind. Required practices will be set in the guidelines of the journal you are submitting to. Following a journal's specific guidelines can help you avoid desk rejection based on simple items that can easily be addressed before submitting. Therefore, it is helpful if you know your journal choice when you are creating your figure. If you haven't already chosen the journal when you start creating your figures, there are general guidelines that you can use.

WHAT TO LOOK FOR IN JOURNAL GUIDELINES

Many journals have guidelines about figures. This helps them maintain consistency and ensure visually appealing images in their publications. We have put together a list of items to check for when referencing a journal's specifications. **(See the checklist on pg. 14.)**

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CHECKLIST:

☐ Figure width

☐ File type (tiff or EPS) and resolution

☐ Does the journal allow or encourage you to use color?

☐ If the use of color is encouraged, is the color space RGB or CYMK?

☐ Font size and type

☐ Line weight

Usually, you will find preferences for file type and resolution. Sometimes journals will have have specifics for color space and figure width. Occassionally, you will see preferences for font size and type, as well as line weights.

If the journal doesn't specify some or any of these items for figures, it is best to use general guidelines. **(See general guidelines on pg. 15.)**

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GENERAL GUIDELINES:

☐   Single Column: 85 mm

☐   1.5 Column: 135 mm

☐   Double Column: 175 mm

☐   Font: 8 point Arial

☐   Avoid Bolding and Italics

HOW TO LABEL YOUR PRIMARY DATA

When you label your primary data, balance conciseness with adding enough information in your figure so readers don't have to reference the legend to understand labels. Ideally, the legend will consist of "supplemental material." Below is an example of a well-labeled image.

TIP: Learn best practices for using abbreviations in your figures without frustrating readers.

(Plank et al., 2006)

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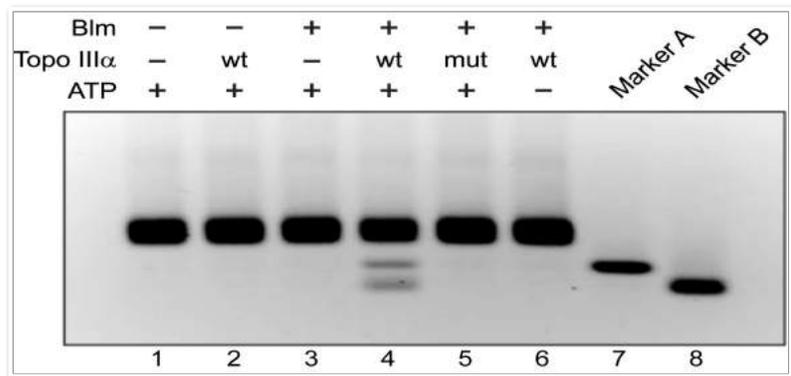
HOW TO CREATE EFFECTIVE GRAPHS FOR YOUR SECONDARY DATA

Creating clear graphs doesn't have to be hard, and it can have immense benefits for researchers. For instance, when you begin to create a poster or presentation to talk about your work, it will be simple to add in your figures if you are purposeful in the design from the very start.

REMOVE UNNECESSARY ELEMENTS

As mentioned previously, software programs like Excel are excellent options for creating graphs. However, **the default output of graphs from such programs often will not meet the guidelines of your target journal.**

These default graphs usually contain text that is too small, and an unneccessary title and legend. They will likely have superfluous gridlines, tick marks, and labels.

With a little bit of intentionality and adjustment, you can send a clearer message by removing extraneous things from your graph. You should be able to easily remove these in the software you are using to create it. **(See graph comparisons on pg. 17.)**
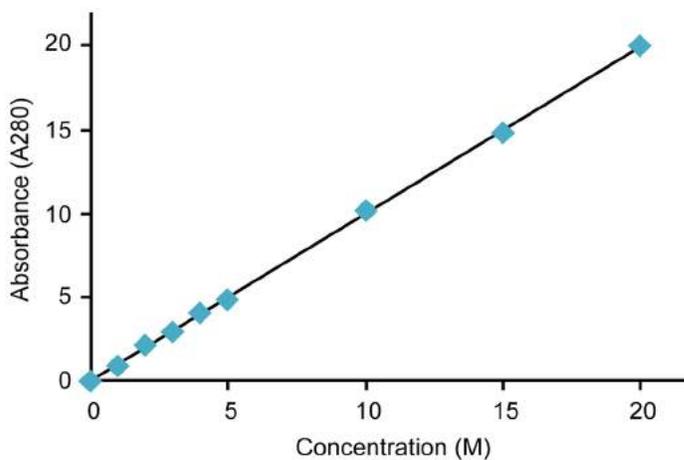
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BEFORE (DEFAULT GRAPH):

AFTER (EDITED GRAPH):

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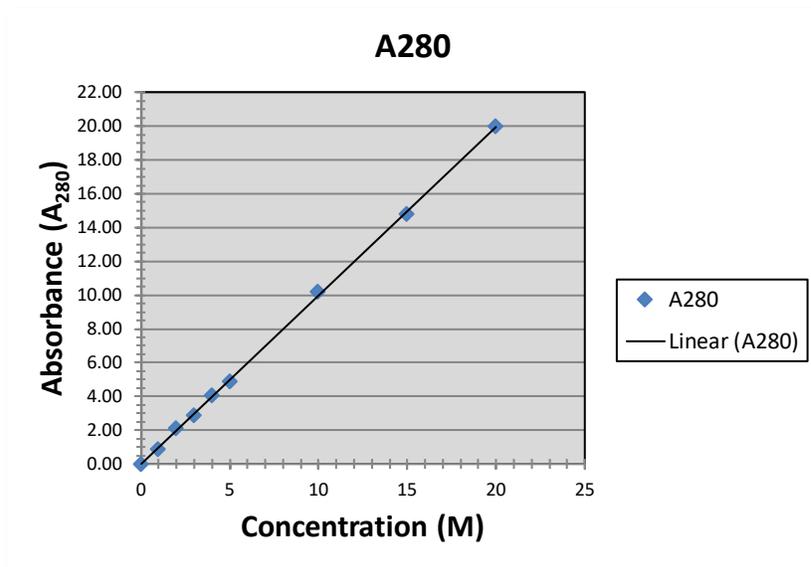
SECTION 4

USE COLOR EFFECTIVELY

In addition, the colors, shading, and patterns that are automatically chosen within these programs usually do not look good, especially on a printed page. Patterns, in fact, should be avoided altogether when creating a graph, as they tend to obscure data, not reveal it. Instead, use shades of gray that are at least 20% divergent, or use color if you have a larger number of categories.

TIP: Watch our video to learn the types of colors that work best when creating figures for your research.
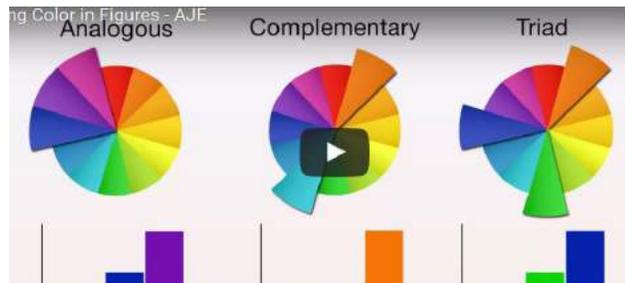

USE ELEMENTS TO SIMPLIFY FIGURE LEGENDS

Do not crowd your figure legends with too much information. Just like with figure legends for primary data, it is preferable that figure legends for secondary data be treated as "supplemental" information. This effort can be supported by carefully including color and good labels with your graphs.

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Like in the example below, you can use color to differentiate data. Additionally, if space allows, you should consider including labels directly within the graph.
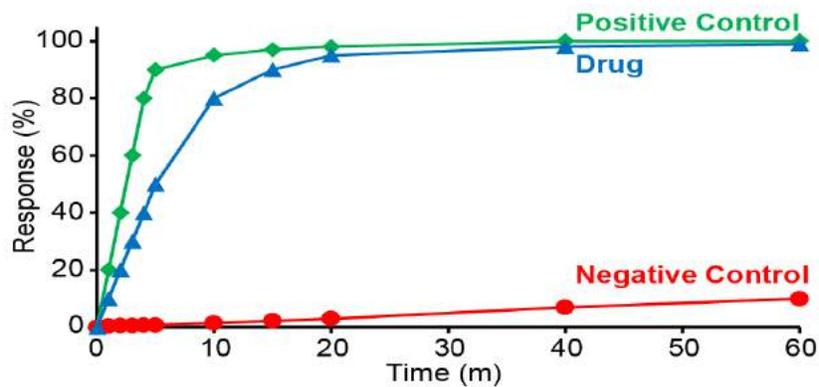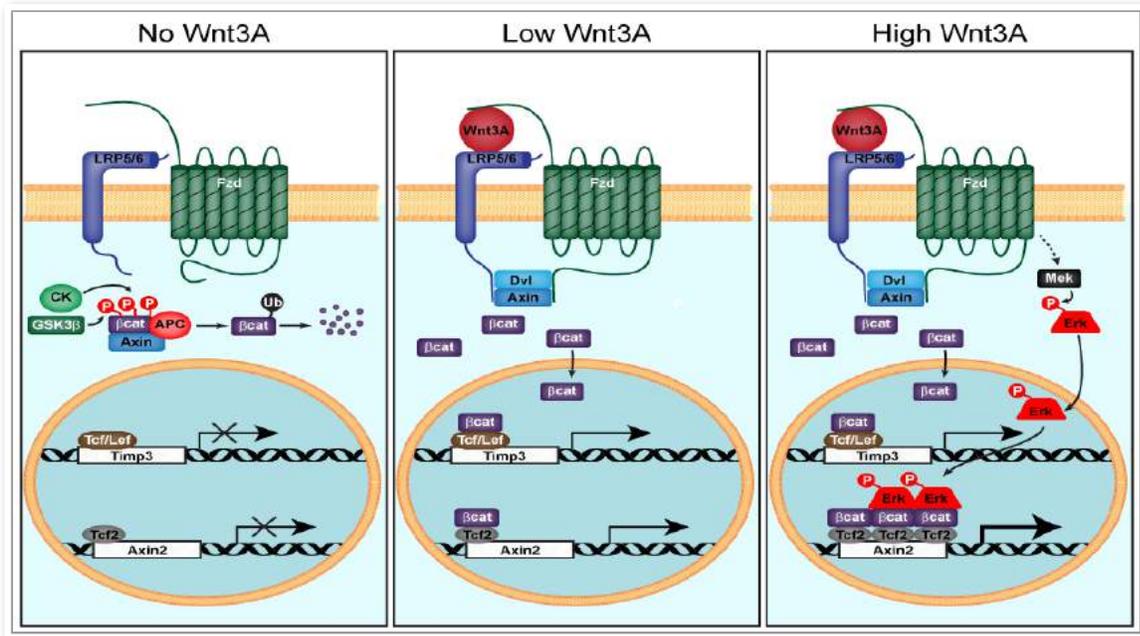

CONSIDER USING ILLUSTRATIVE DIAGRAMS

Illustrative diagrams are useful in displaying complicated information, and if designed correctly, they can help readers understand data and concepts more easily. In addition to the clarity that they bring, illustrative diagrams are like a work of art.

They can be created using design programs like Adobe Illustrator, and although making them will require more time than creating graphs, they are worth the investment. A diagram that is both visually engaging and easy to understand is an effective tool to promote your research and your lab. **(See example on pg. 20.)**

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(Your Name et al., 2017)

SECTION 4 KEY TAKEAWAY:

Check journal guidelines before you build your figure to save yourself time. Also, evaluate the necessity of every aspect of your figures, and eliminate any unnecessary clutter.

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4 KEY TAKEAWAYS

1. INVESTING IN GOOD FIGURES AT THE START OF YOUR RESEARCH WILL SAVE YOU TIME AND FRUSTRATION
By being diligent in creating your figures, you can avoid questions or accusations from journals and confusion and disinterest from readers. Your figures are a visual representation of your research, so make sure they are just as well thought out.

2. SAVE IMAGES AS TIFFS (NOT JPGS OR OTHER LOW-QUALITY FORMATS), AND KEEP ALL OF YOUR ORIGINAL FILES
When you create your figures, the first step is saving them in a proper format and at a high-quality resolution so that your data is not compromised. The second step is to ensure that you have a good organization system for filing and keeping the originals because you will likely need to retrieve the originals later during the publication process.

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3. AFTER YOU HAVE CONSIDERED THE PURPOSE OF YOUR FIGURE, CHOOSE THE RIGHT GRAPH TO REPRESENT IT

The purpose of a figure should be to highlight and draw attention to an aspect of your research. What does that set of data show? After you have established this, you should then carefully select the type of graph that will best display your findings.

4. CHECK JOURNAL GUIDELINES BEFORE YOU BUILD YOUR FIGURE TO SAVE YOURSELF TIME. ALSO, EVALUATE THE NECESSITY OF EVERY ASPECT OF YOUR FIGURES AND ELIMINATE ANY UNNECESSARY CLUTTER

Some journals have guidelines that researchers must follow when creating figures for their research, so it will save you time if you know which journal you will be submitting to before you create your figures. You can make your figures more impacting by removing extra elements like grid lines and tick marks and by using color effectively.

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