



DESIGN STRATEGIES FOR SCIENTIFIC FIGURES



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design to communicate

INTRO

Scientists occasionally reach out to request help with improving the design of figures in their paper before submitting it to a journal. When they do, the question is usually something along the lines of, “How can I make this look better?” While design can and should improve the aesthetic quality of figures, it is not primarily a solution to an aesthetic issue; it is a solution to a communication issue. Good design can be a powerful tool for communicating your ideas clearly and effectively. If scientific figures are too convoluted in their presentation, significant data may be overlooked or misunderstood.

Visuals are powerful because we are able to comprehend images much faster than words. A concept that might have taken pages to explain in words can be communicated in seconds with the right graphic representation. For this reason, the accompanying visuals in your paper have the potential to amplify the reaction your audience has to the research, but the opportunity is often lost when the visuals are treated as an afterthought.

Learning and utilizing design strategies can feel daunting if you’ve previously thought of it as a form of art. But design is more like a skill that can be learned than a fine art that relies on talent. Understanding the basics of visual communication can be an asset that helps you break through the noise and allows your work to have a greater reach.

As you prepare figures for publication, this guide will help you:

- clarify the message
- restructure the composition
- simplify the components
- create intentional color palettes
- refine the text style

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← NOTE: This is an interactive PDF, so you can use the side panel as a navigation bar to move through the different sections.

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define the message

What is the purpose of the figure you are trying to create? If you don't have a clear idea of what conclusion you want your audience to draw, they're not going to know either. The first step in any design is defining the message that the design is going to support. Here's a few ideas:

To compare and contrast

To show a pattern in

To demonstrate the process of

To show the relationship/connection between

To show the change in

To show the variability of

If you are trying to say more than one thing in the same space, consider separating your figure into two figures, even if some elements are repeated with just a different types of data. Clarity is more important than using space efficiently.

reconsider the approach

It's worth considering in the early stages whether you are presenting the data in the most impactful format. Sometimes clarifying your message will prompt you to take an entirely new approach to visualizing information.

MESSAGE

See this example of a pie chart vs. a bar graph of the same information. The pie chart is presenting the data accurately, but it is hard for the viewer to see the differences from one group to another and draw conclusions about the most prevalent groups. Rather than spending effort trying to improve the design of the pie chart, taking a different visualization approach, namely representing data in a bar graph, is what's needed to get across the message.

The [Data Visualization Catalogue](#) is a great resource that can help you discover the best way to represent your data visually.

before

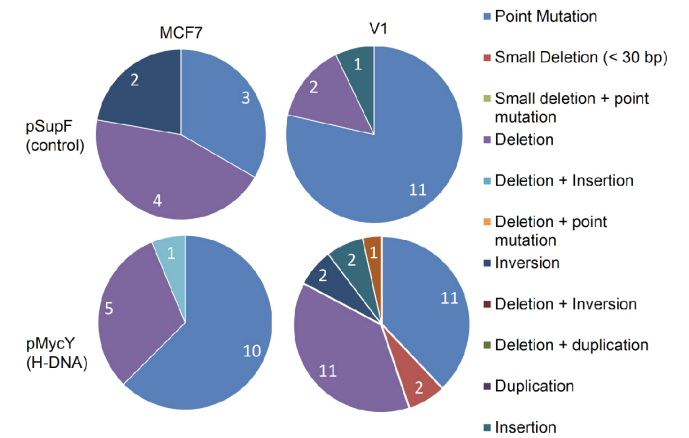


Figure 4. H-DNA generates point mutations and deletions. Control plasmids generated point mutations and deletions (30 – 2200 bp). H-DNA plasmids also generated primarily point mutations and deletions, but generated an increase in the type of mutations in V1.

after

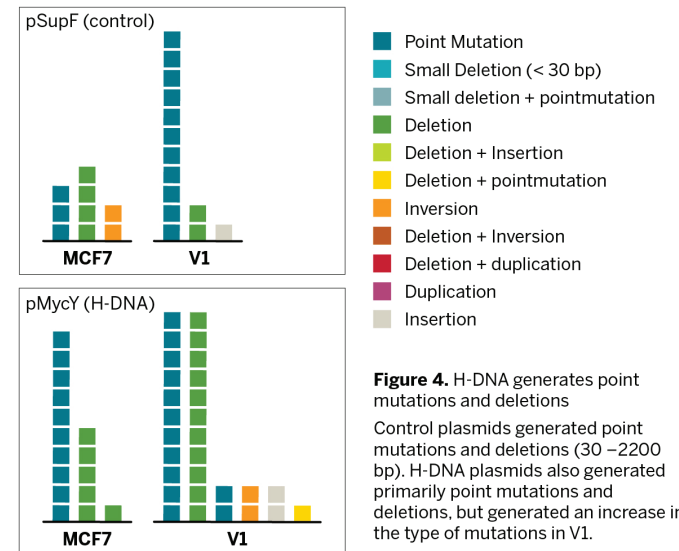


Figure 4. H-DNA generates point mutations and deletions. Control plasmids generated point mutations and deletions (30 – 2200 bp). H-DNA plasmids also generated primarily point mutations and deletions, but generated an increase in the type of mutations in V1.

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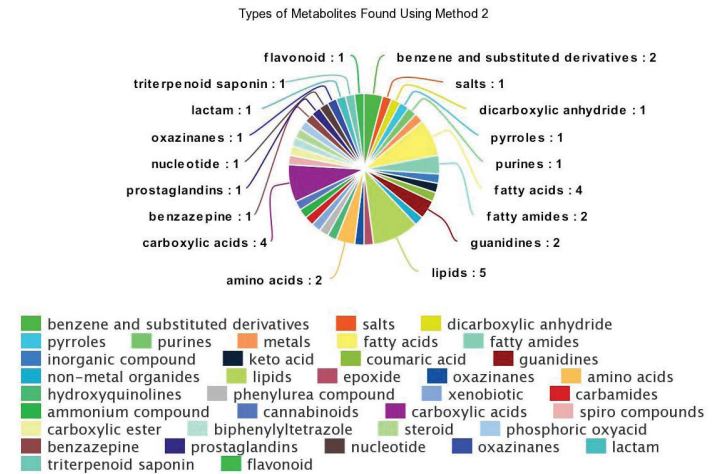
TEXT

RESOURCES

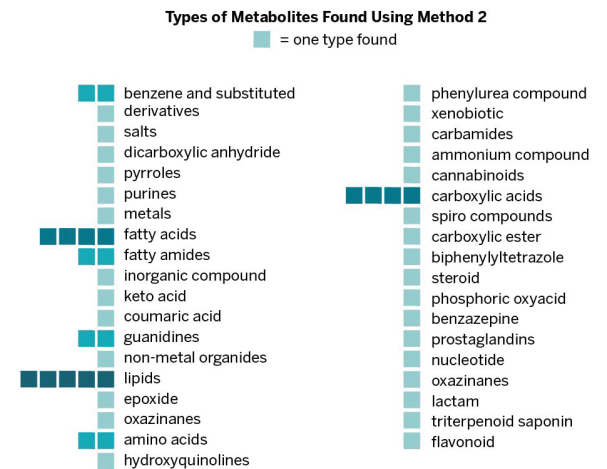
This pie chart is even more complex, containing 37 different slices, all with unique colors assigned to them and defined in a legend below. The legend is hardly useful, since some colors are so similar that it's difficult to identify where the corresponding slice is.

Since the numerical values in the pie chart are so small (1-5), and so many of them are exactly the same (value of 1), the redesigned figure simply lists all 37 labels, with boxes representing 1 unit. This makes it much easier for the viewer to read the labels and see the corresponding data.

before



after



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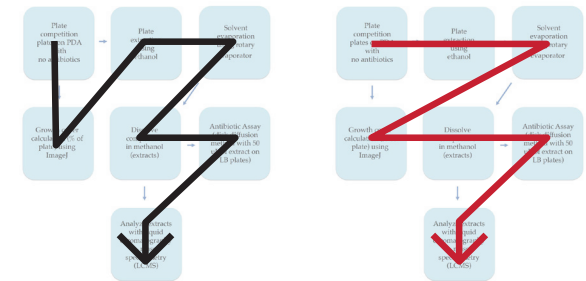
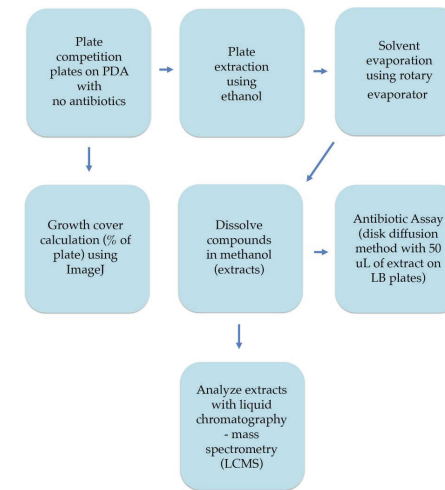
examine the composition

The proper layout of elements is essential to guiding the viewer through the content in the sequence you intend. Imagine if you were to draw a line through your figure, tracing where you want the viewer's eyes to start and end. Is it a straight line, or more of a zig zag? We're used to reading left to right or top to bottom, even if what we are "reading" is composed of shapes and symbols instead of lines of text. If the line you drew is something other than a straight line in one of these directions, the viewer is probably seeing a block of information that they don't know how to digest, or they read it in the wrong order initially. Try tweaking the composition where the information you want to be read first and last is going left to right or top to bottom.

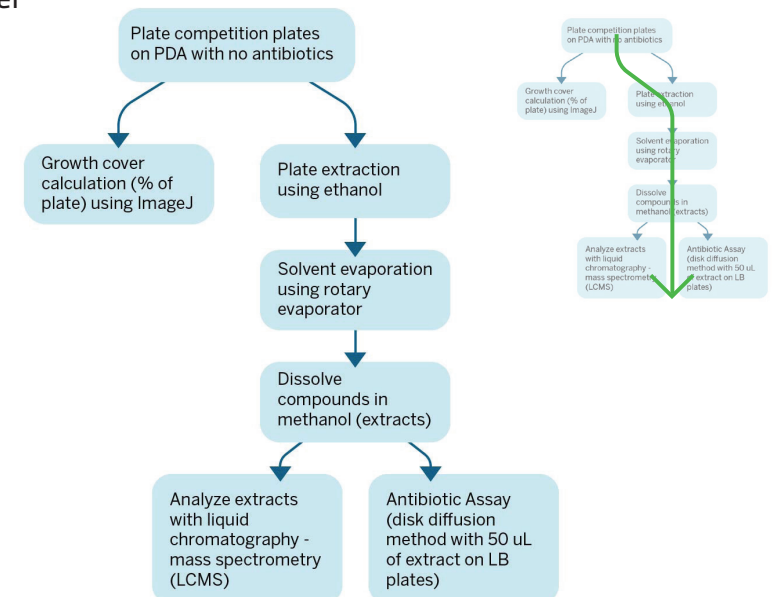
Modular flow charts like this are often set up in a grid as a default, with arrows being added last. The information is all there, but a different composition would allow readers to absorb the text more efficiently, aided by a structure that flows in a more obvious sequential order. In the original version of this figure, it's more natural to assume that the alignment indicates reading row by row, and the viewer will likely start reading the rows from left to right before noticing the small arrows. The overlaid black line represents the path that the researcher probably intends for the viewer to follow, but it's more likely that they will initially read through the information in the (incorrect) order that the red line traces.

The redesigned figure clarifies the flow of information by organizing the modules to read from top to bottom. It also makes the connecting arrows more prominent, and scales down the space between related elements, instead of universal margins.

before



after



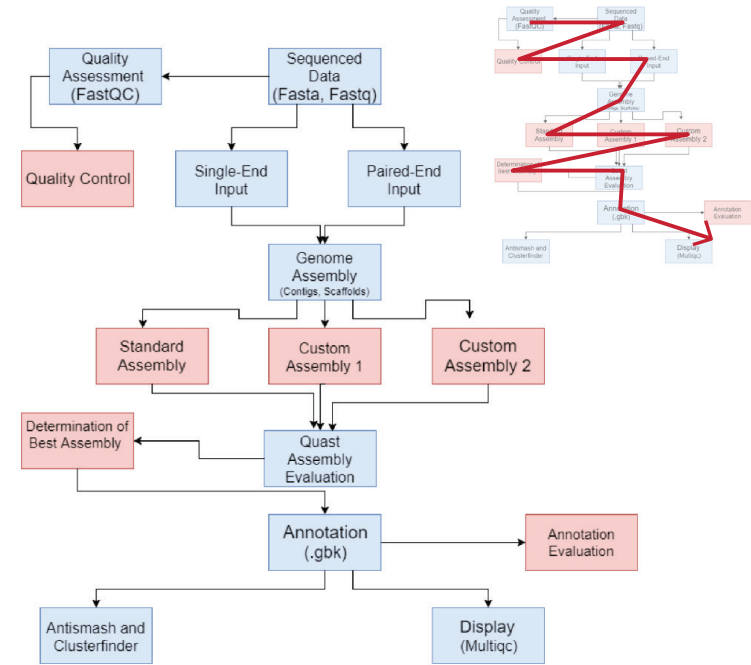
INTRO

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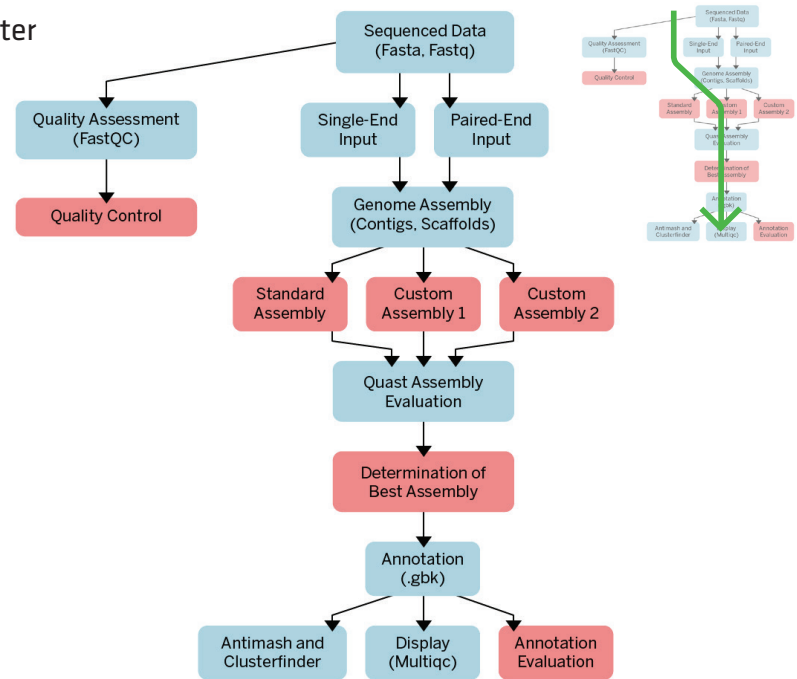
This flowchart is a bit more complex, and while it breaks from the grid more than the last example, spacing out the elements to this degree has created confusing associations. Elements that should be seen as connected are instead pushed so far away from each other that they seem to have a closer association with other parts around them. Aside from the spacing issues, the arrows take a lot of unnecessary right turns, and some placement decisions seem to be more about filling up the space than presenting information in the right order.

The redesigned figure closes in the space between related elements, making associations much more clear. It also reorganizes the elements in a way that leads the viewer's eyes in one general direction: top to bottom (no right turns).

before



after



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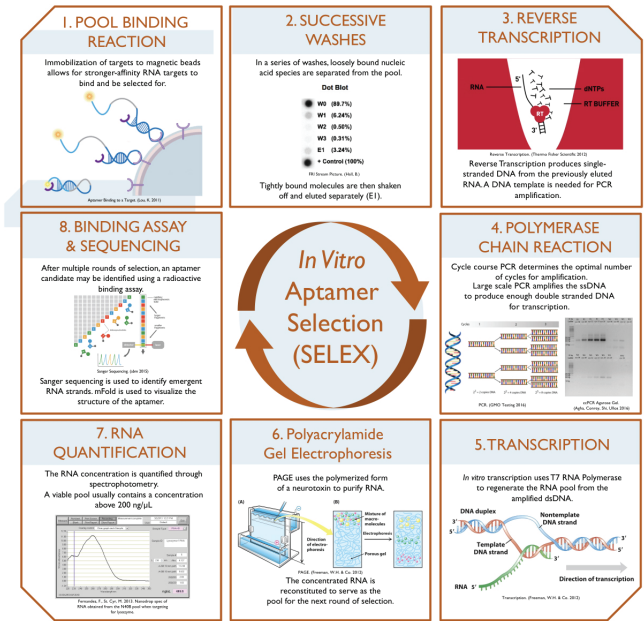
TEXT

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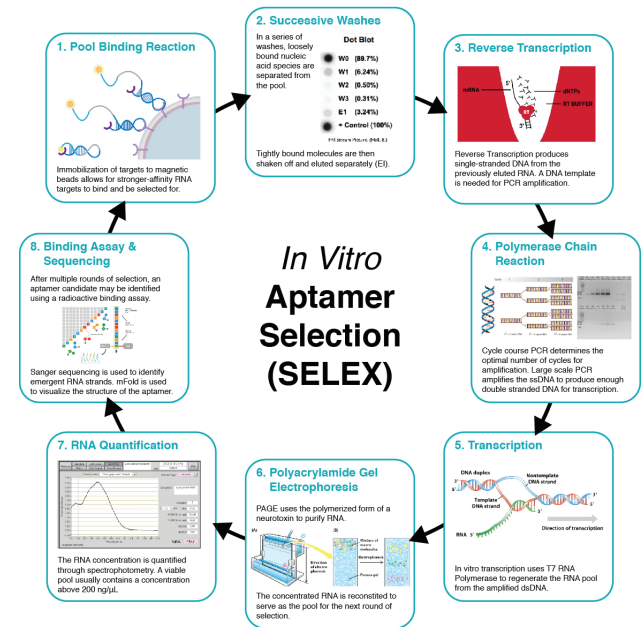
Figures that intend to depict a cycle are often set up in a grid format as well. This creates the same problem as the flowchart example, the viewer might initially read it left to right, one row after another. To guide the viewer's eyes in a circle instead of left to right, the blocks need to be broken out of a strict grid alignment, and take on a more circular form. Curved arrows throughout the figure can also clarify this order of sequence.

In this redesigned figure, the blocks are taken out of their grid alignment, and given enough space in between to add arrows that indicate a cycle.

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after



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simplify and declutter

Going with defaults of your graphics software can result in unnecessary details that clutter your graphic. Try removing anything that might detract from the message you are trying to convey. Here are a few ideas of ways to simplify the figure:

Is there an opportunity to remove unnecessary elements?

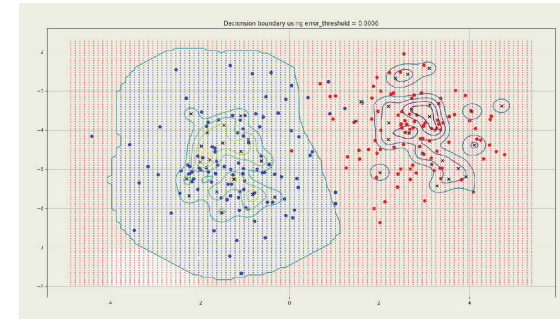
Look for borders, bounding boxes, background colors, shading, and axis markers that are not serving a purpose.

Graphs and charts often include bounding boxes that do not serve any purpose, more grid lines than necessary, and increments on the axis that are labeled too frequently. Try to reduce labeling axes down to what is necessary to convey the information accurately. This will bring more attention to the data, instead of the elements surrounding it.

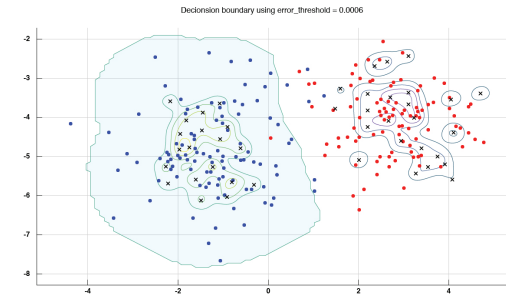
In the first example, the graph has plotted out every point in the grid, whether it relates to the data or not. This creates a lot of noise on the graph that crowds out the actual data points. It's also set against a background color that further diminishes the emphasis on data points by reducing contrast. The redesigned figure focuses the viewer's attention on the data by removing these unnecessary features.

In the second example, the graph is cluttered by too many lines. The border encompassing the entire figure is not serving any purpose and should be removed. The graph doubles up on axes, instead of having one vertical axis and one horizontal, it has them on all four sides. It also uses more hatch marks on the axes than are necessary to convey the information. The redesigned figure strips down the graph to only what is needed, and gives the sections a bit more height so the vertical hatch marks and their labels are easier to see.

before



after



before

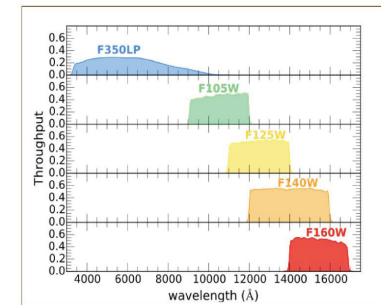


Figure 1. Set of filters to identify high-redshift galaxies from visible to IR: F350LP, F105W, F125W, F140W, F160. (Calvi et al. 2015)

after

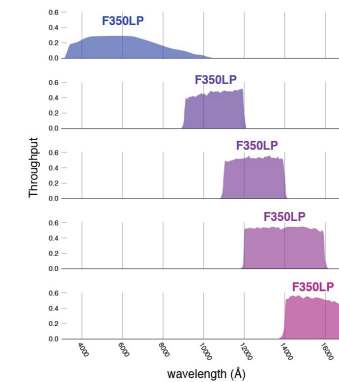


Figure 1. Set of filters to identify high-redshift galaxies from visible to IR: F350LP, F105W, F125W, F140W, F160. (Calvi et al. 2015)

One of the quickest fixes you can make to improve the appearance of your figure and reduce a sense of clutter is to remove border lines around shapes. Removing these lines will give the image a more polished look, and it will allow the text to have more contrast against the shapes.

Figures often use arrows that are bulkier than they need to be, so instead of just removing the border lines on these, try minimizing the space arrows take up in order to give the shapes and text more breathing room.

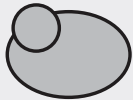
CHANGE THIS



TO THIS



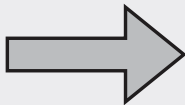
CHANGE THIS



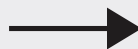
TO THIS



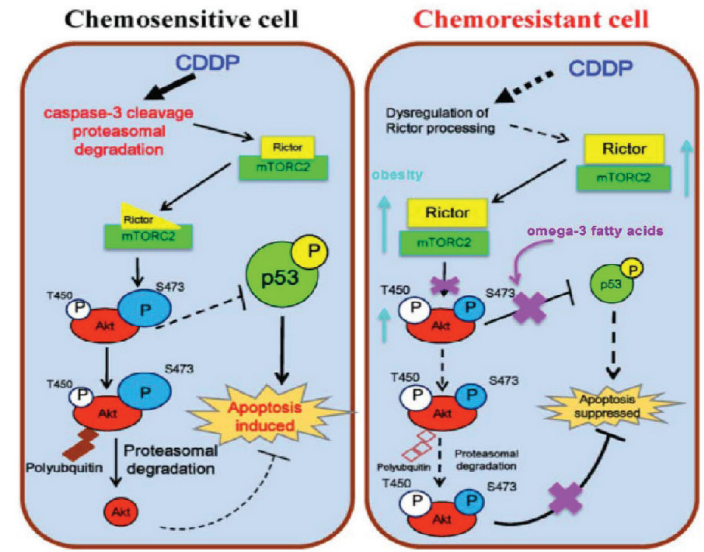
CHANGE THIS



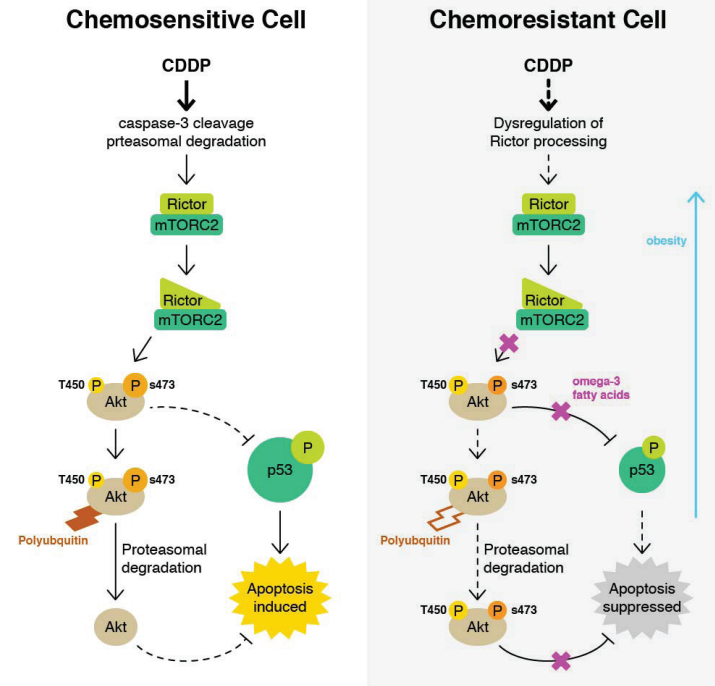
TO THIS



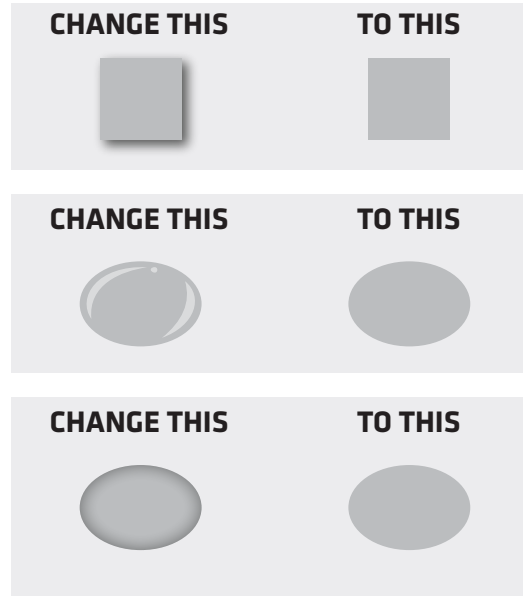
before



after



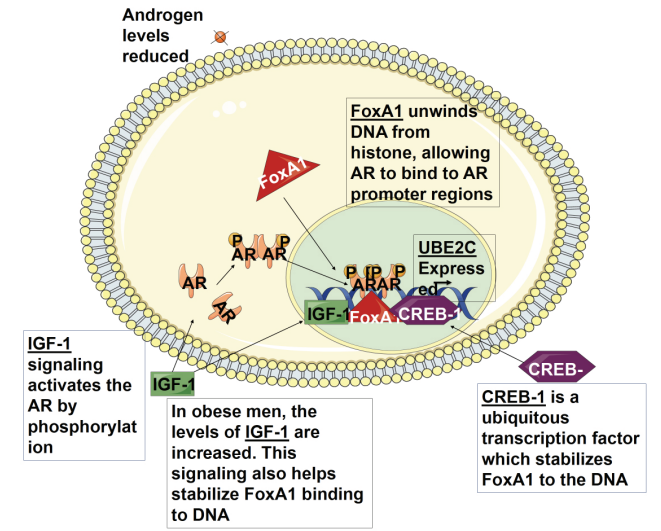
Sometimes the elements in figures are given a lot of 3D qualities, like drop shadows or highlights. Unless the dimensional quality is important for the viewer to understand what process the figure is depicting, it's best to remove these effects and focus on the essential features of those shapes.



before

PREDICTIVE MODEL

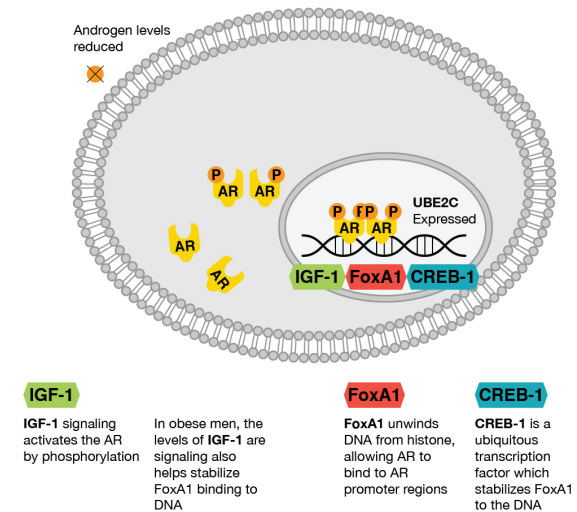
We have hypothesized that obesity promotes greater FoxA1/AR activity by growth hormone IGF-1.



after

PREDICTIVE MODEL

We have the hypothesized that obesity promotes greater FoxA1/AR activity by growth hormone IGF-1



Is there an opportunity to minimize the elements included?
 If you're showing a pattern, how many pieces can you reduce it down to? If you're showing a structure, can it be zoomed in to make the important elements more visible? If you're showing a process, can any minor steps be eliminated to make it more succinct?

This example is showing the expansion of a structure as more spacers are added, and it repeats the same process nine times in order to show a general trend. While this might be the number of repetition the researcher documented, for the purpose of illustrating how it works, the trend can be established more succinctly.

The redesigned figure cuts the process down to five repetitions instead of nine, zooming in a bit to make the individual elements more visible, which also allows the trend to become more apparent to the viewer.

before

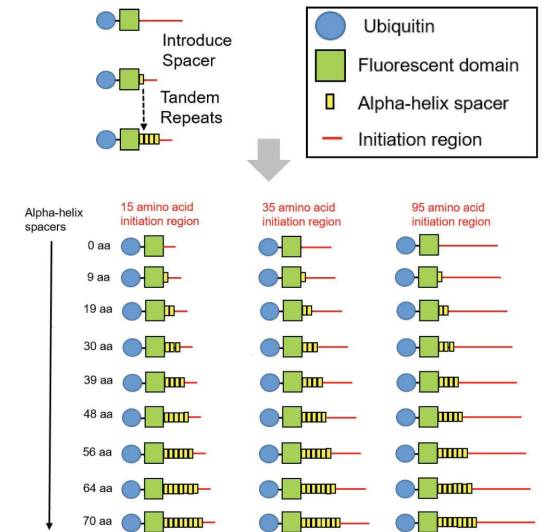


Figure 5: Model proteins with varying space between ubiquitin tag and initiation region. Model proteins built off central fluorescent domain flanked by N-terminus ubiquitin domain and C-terminal initiation region. Tandem alpha-helix spacers were inserted to increase distance between ubiquitin tag and initiation region. Substrates with increasing initiation regions lengths were made.

after

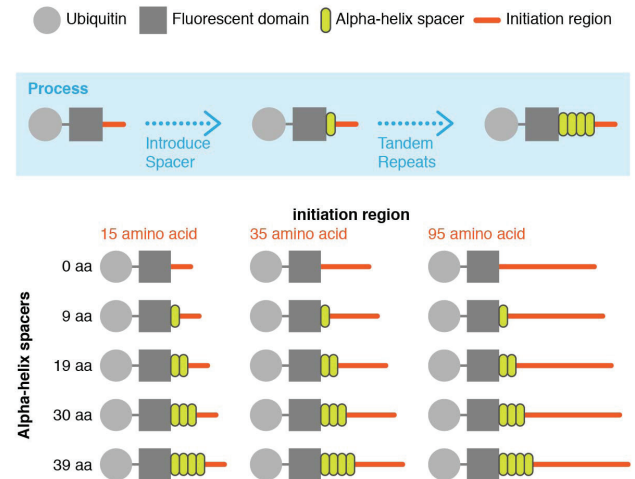
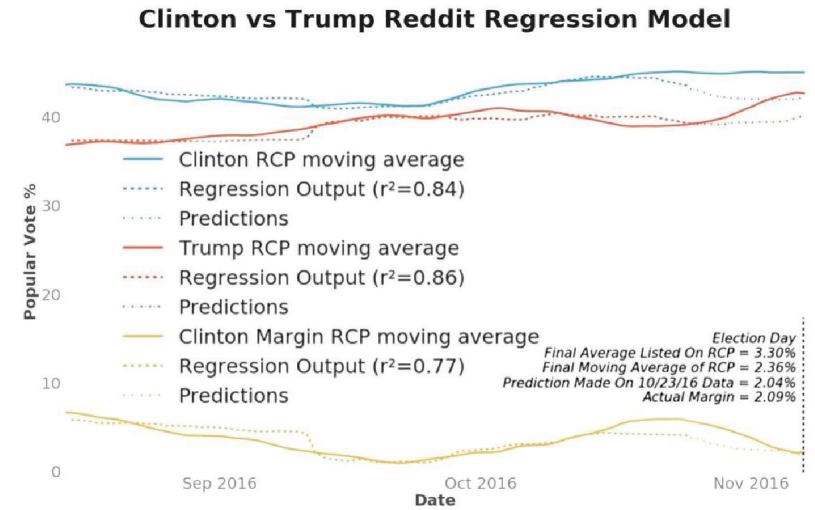


Figure 5: Model proteins with varying space between ubiquitin tag and initiation region. Model proteins built off central fluorescent domain flanked by N-terminus ubiquitin domain and C-terminal initiation region. Tandem alpha-helix spacers were inserted to increase distance between ubiquitin tag and initiation region. Substrates with increasing initiation regions lengths were made.

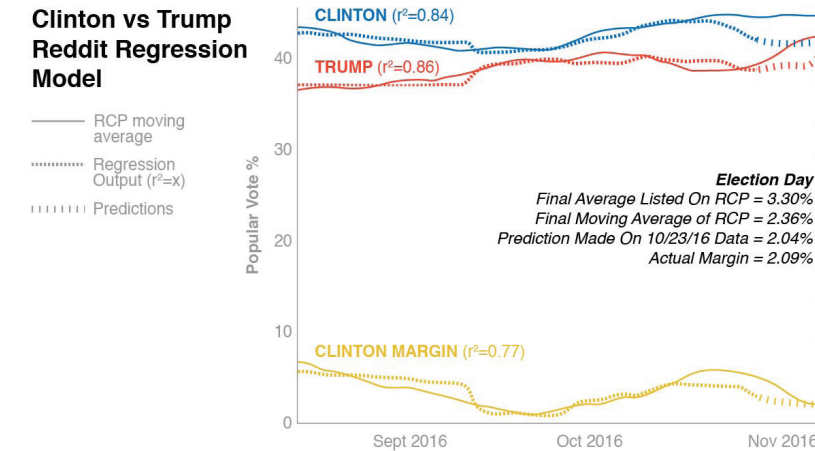
Is there an opportunity to streamline repetitive elements?
 If the figure includes repetitive elements, consider creating icons and a legend, instead of assigning the same label many times throughout the figure. This can also be achieved by grouping similar elements and assigning one label to the group if the nature of the information would allow for a different composition.

This figure already includes a legend, but the legend repeats itself and can be more streamlined. The lines are grouped together by color, and the line quality defines their meaning. The redesigned figure simply labels the meaning of the three colors within the graph, and represents the three different line types with gray in the legend. This reduces the entries in the legend from nine down to three, freeing up space and making associations clearer.

before



after

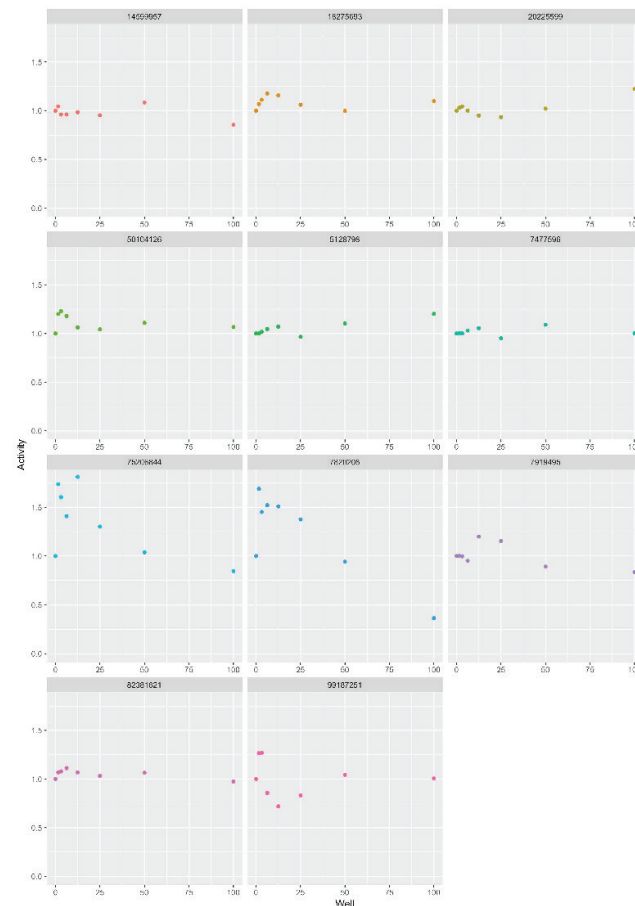


Is there an opportunity to combine/layer elements for clarity? Sometimes figures section off information unnecessarily, forcing the viewer to mentally draw connections that could easily be drawn for them with an improved design. Examine all of the separate boxes and dividers that are in your figure, and look for ways that similar information could be combined to create less work for the viewer. If the same graph or layout of elements is being repeated with different data, try layering these sections on top of each other instead of showing them side by side.

This figure is presenting 11 different sets of data, but the data sets are all being given their own graph. Showing 11 graphs in such a small space requires everything to be extremely scaled down, compromising legibility. The separation also makes it hard to compare the data and draw conclusions. Since the parameters of the graphs are identical (same axes and increments), this is a good opportunity to layer the content.

The redesigned figure layers all 11 data sets on top of each other in the same graph, defining each color by a legend below. This allows the viewer to easily see the most dense areas and draw conclusions about the information being presented.

before



after

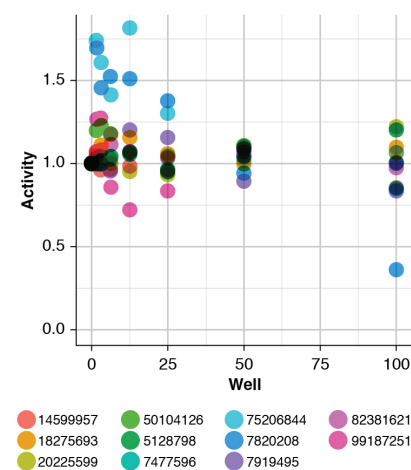


Figure 9. Inhibition assay plots for top compounds from virtual screening

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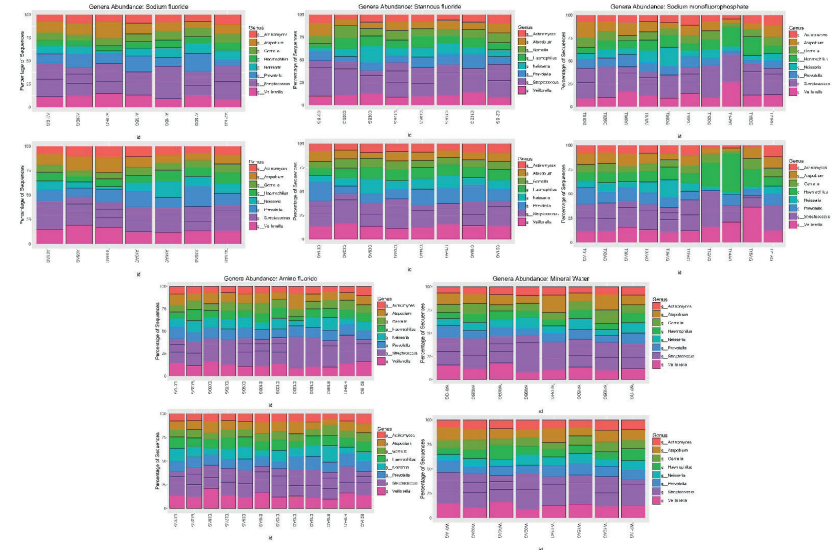
TEXT

RESOURCES

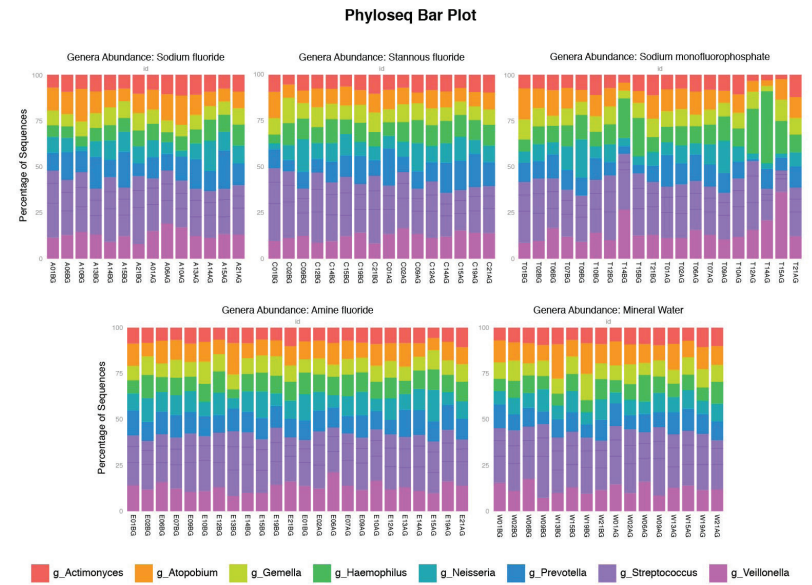
This figure is overwhelming in its density of information, but many of the elements are being repeated, and others are taking up more space than necessary. This figure is essentially five sets of bar graphs, and each set is separated into two groups.

In the redesigned figure, the two bar charts within the sets are combined, reducing the separate graphs down to five instead of the original ten. The separate legends are removed (since they say the same thing), and replaced by a single legend at the bottom. Instead of the vertical axis being labeled in every graph, it is only labeled twice, once per row. These changes freed up some space to elongate the bars, making the shifts in color more apparent.

before



after



Is the legend needed or can the information be more succinctly labeled?

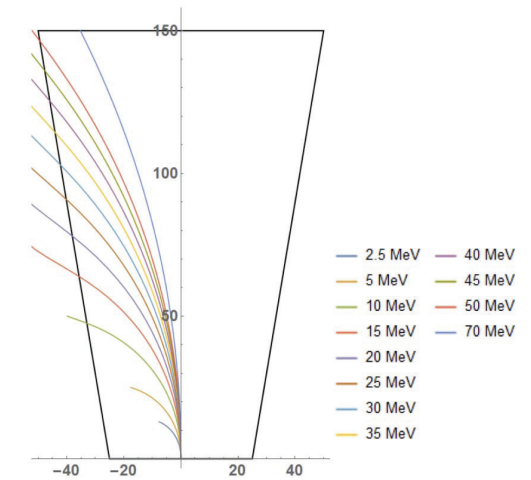
Legends are helpful when elements are repeated over and over, but if the legend is essentially one-to-one (one entry in the legend for one element in the figure), it might read better if the information is consolidated and the labels are integrated into the larger figure.

This figure is a good example of the one-to-one legend described above. The entries in the legend are not labeling elements that repeat throughout the figure, they each refer to only one element. Not only is the legend unnecessary, it makes it harder for the viewer to discern the connection by showing them in the reverse order (blue line at the top of the list is labeling the blue line at the bottom of the graph), and choosing colors that are too similar (multiple yellows, multiple light greens, etc).

In the redesigned figure, the labels are taken out of the legend, and are placed directly beside the element they refer to. Without a separate legend, it's no longer necessary to give each line a new color, and they are instead shown in the same color.

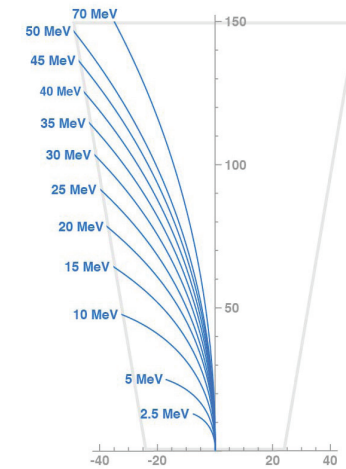
before

Computing Electron Paths for Various Energies



after

Computing Electron Paths for Various Energies



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create emphasis with color

Color, if used with intentionality, is the easiest and clearest way to lead the viewer to the most important part of the graphic and guide their conclusion. Assigning a new color to each new element might seem like a logical approach, but if it creates a rainbow colored graphic, everything (and therefore nothing) appears to be the most important part. Consider these changes to improve your approach to color:

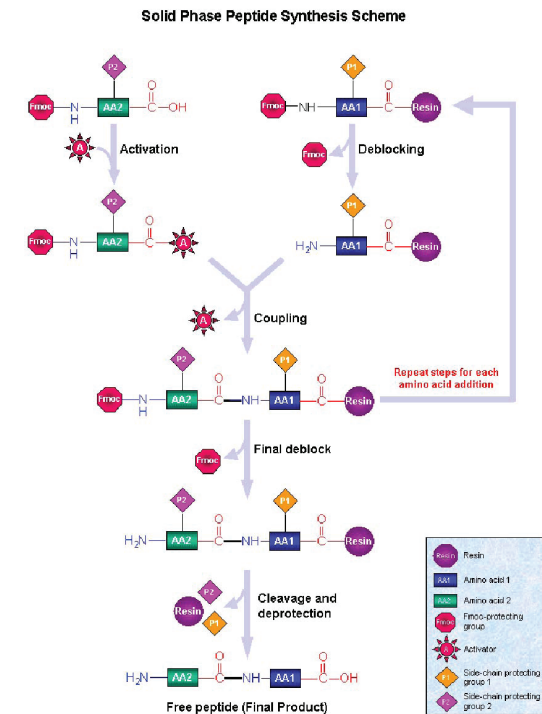
Simplify the overall color palette.

Can related elements be shown in different shades of the same color, instead of different colors? Creating a relationship between the elements using color makes it easier for the viewer to already understand the context of how things fit together before diving into the particulars.

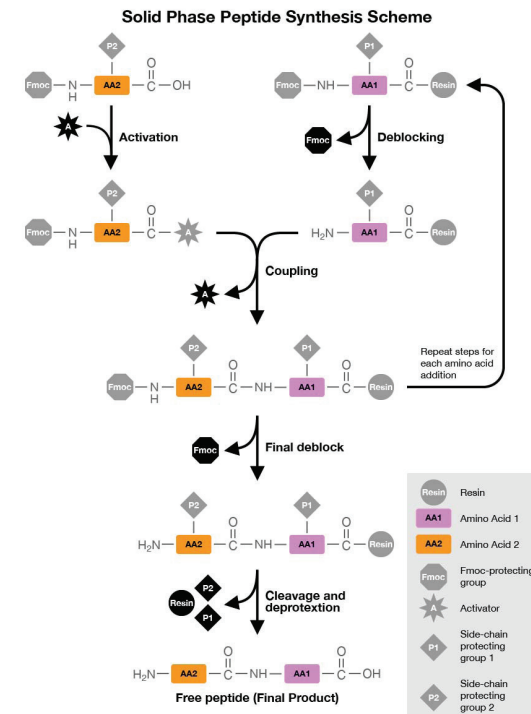
In this figure, the original version uses color arbitrarily, assigning a new color to every new component. Using such a wide variety, especially when all are bright colors, makes it hard to discern at a glance what is important, and how they all relate.

In the redesigned figure, the most important elements are highlighted with color, and everything else is gray or black. With this new color palette, it is easy to discern that the figure is depicting the process of the orange element and the purple element coming together, and in each transitional stage, an element is added or removed. The arrows, labels, and the key element for each stage are all visually linked by being shown in black.

before



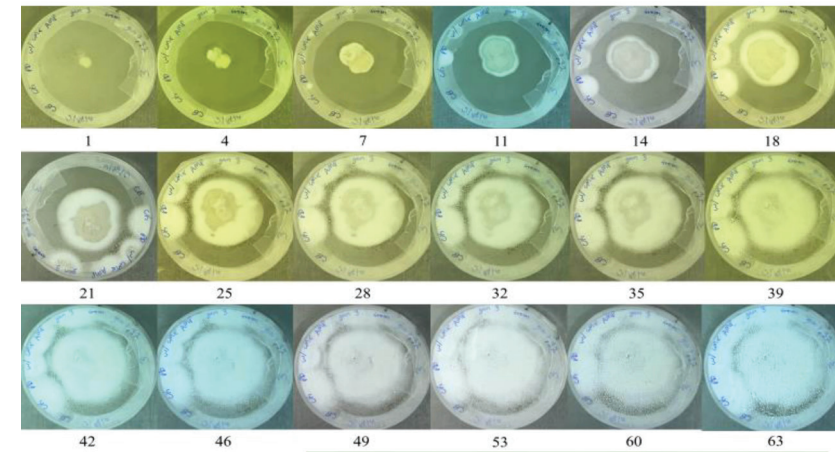
after



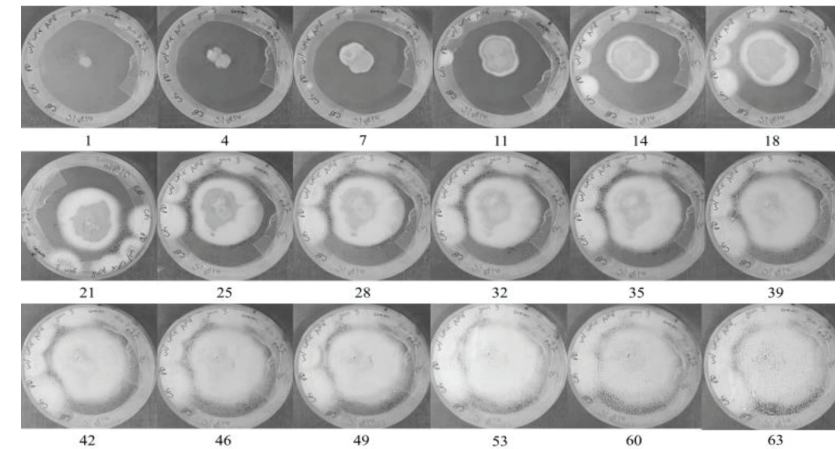
If the colors are not serving a function, go monochromatic.
While colorful figures might look more exciting, sometimes a monochromatic version of the same image actually clarifies what you are trying to draw attention too.

The purpose of this figure is to show the growing form in the petri dish, but the different colors make it hard to compare, and might even lead the viewer to try and draw meaning from the blue vs. yellow tinted pictures. By converting the pictures to grayscale, it is much easier to see the form grow as the slides progress.

before



after



Create contrast.

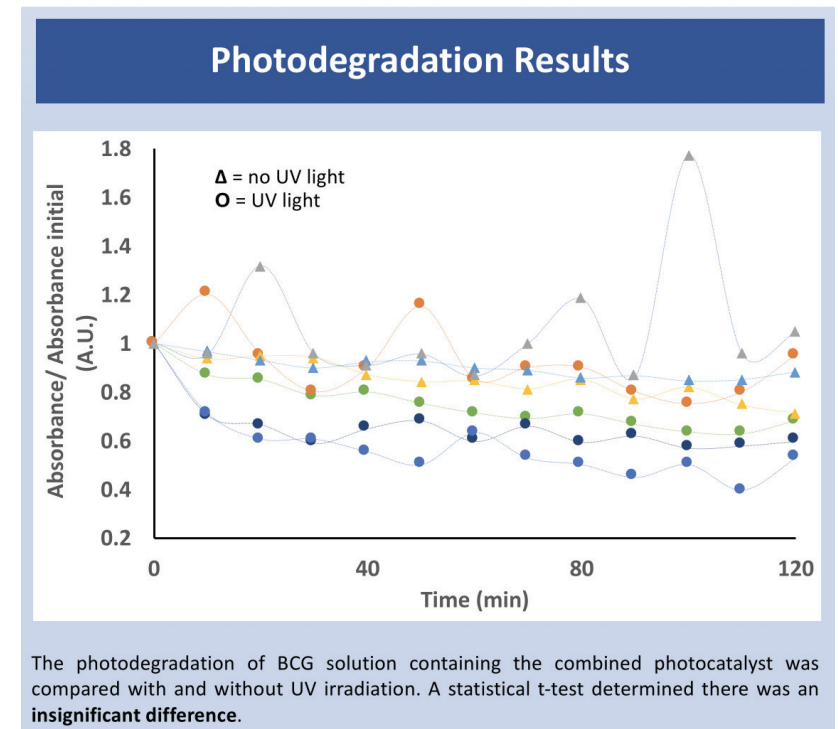
Call attention to important elements by making them:

- Highly saturated (vibrant colors) against other desaturated (grayscale) elements
- Dark against light elements, or vice versa
- Warm colors against cool colors, or vice versa

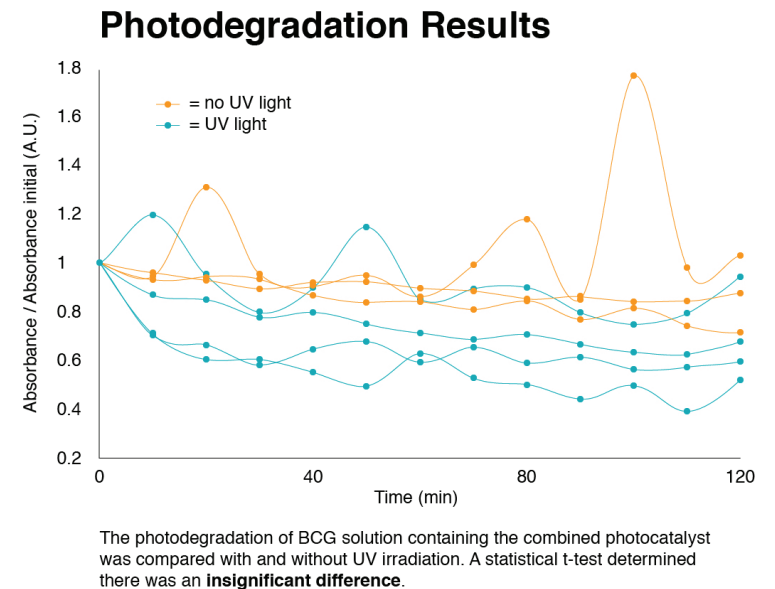
This figure seeks to compare the lines defined as “UV light” and the lines defined as “no UV light”, but this distinction is indicated only by circles vs. triangles on the lines, which are small and hard to see, especially since they often overlap. The new color for each line doesn’t seem to serve any purpose besides simply indicating a new line, since there is not a legend labeling the colors.

In the redesigned figure, the compare/contrast nature of the data is made much more clear by using only two colors, one for “UV light” and one for “no UV light”. The two colors stand out against each other by being cool vs. warm, and both stand out against the graph by being the only vibrantly colored elements against black.

before



after



Is the color palette lending itself to the tone of your message, or detracting from it?

If a graph is showing results with a positive impact on humans or the environment, showing the data in harsh or alarming colors might create the wrong mood. (Examples: Data showing cancer patients surviving from a new drug should have a positive tone, but might still seem distressing if results are presented in stoplight red. Data showing an outbreak of disease should be disconcerting, but would feel harmless if results are presented in light blue.)

These bar charts are recording indicators of fear and physical abuse in a relationship, yet the color palette being used is playful and childlike. There is a dissonance between the feelings the color palette evokes and the feelings that the data should evoke.

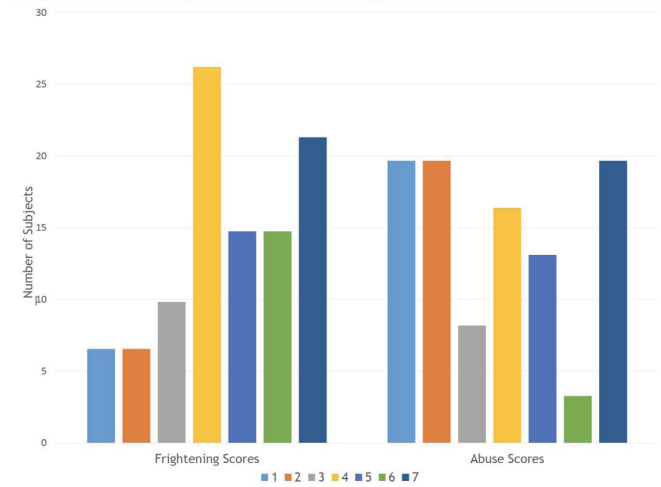
The redesigned figure uses a spectrum of color instead, with low scores (no fear, no abuse) being a calming blue, and high scores (significant fear, significant abuse) being an alarming red. The spectrum of colors also shows how the bars relate to each other, instead of seeming unrelated (in the original), they are now clearly showing an escalation.

This pie chart is also depicting concerning information, a population's level of food security. In the original, "very low food security" should be the most concerning element, but it is being shown in green, a color that usually indicates all is well.

In the redesigned figure, a familiar "stoplight" color palette is being used. Green is good (high food security), red is bad (very low food security), and yellow is the middle status.

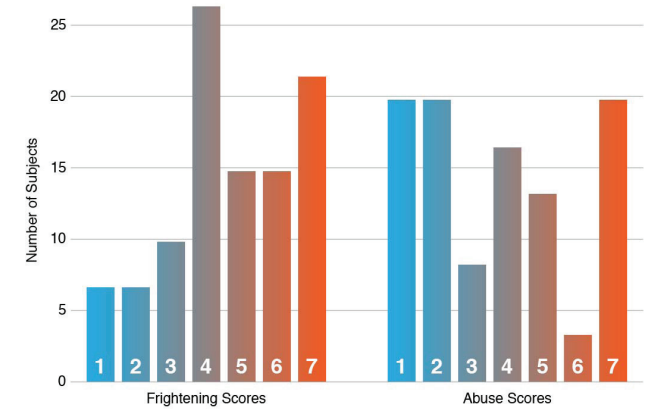
before

Graph 1. Frequency Distribution for Frightening and Abuse Scores



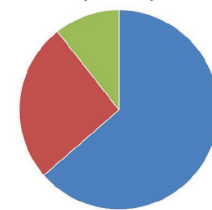
after

Frequency Distribution for Frightening and Abuse Scores



before

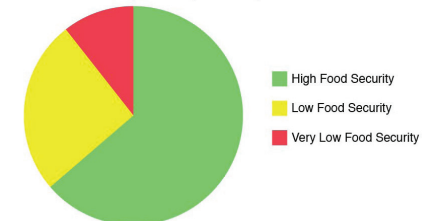
Food Security Status Distribution (n = 695)



■ High Food Security ■ Low Food Security ■ Very Low Food Security

after

Food Security Status Distribution (n = 695)



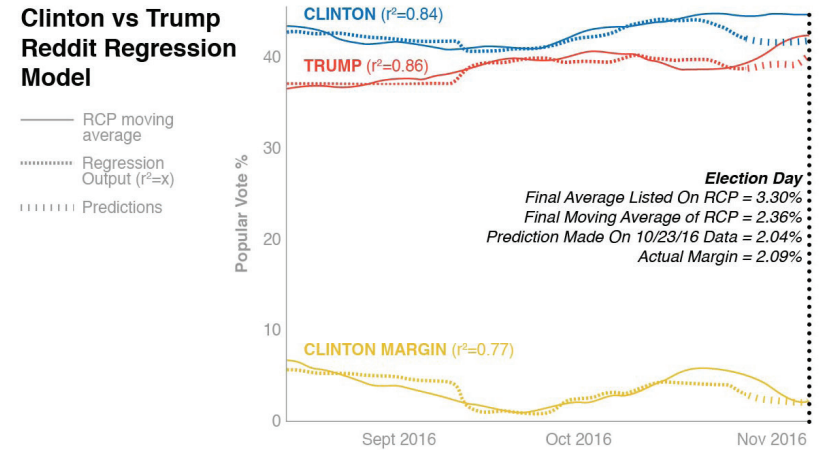
■ High Food Security ■ Low Food Security ■ Very Low Food Security

Are there colors that are already familiar to the content?

Take advantage of the viewer's existing color associations when you see the opportunity to do so. A study of plants might do well to utilize shades of green. Data concerning temperature would be best represented in a spectrum of reds and blues.

Since this figure concerns candidates in the presidential election, it utilizes the familiar color association of blue for the democratic candidate and red for the republican candidate.

Clinton vs Trump Reddit Regression Model



INTRO

MESSAGE

COMPOSITION

SIMPLICITY

COLOR

TEXT

RESOURCES

refine text treatment

Aligning text and streamlining the style can go a long way in reducing a sense of clutter in the figure. Consider these changes:

Choose the right font

Serif fonts are fonts that cap off letters with horizontal lines (Like This) and san serif fonts (used here) are fonts that do not have these caps. San serif fonts are usually more appropriate for scientific figures, as they are simple and don't add unnecessary complexity to an already complex image. Helvetica, arial, and calibri are widely used examples of san serif fonts.

Reduce differences in style

Remove any bold, all caps, italics, or different colors, then add these back in as necessary. You only need to change one aspect of the text to show that it is a different kind of information. For example, to differentiate a title of a process from a label on a component, you can make it bold, *or* a different color, *or* a larger size, but not all three.

Reduce text size when possible

Think about how big the graphic will be viewed, and aim to choose a text size appropriate for that scale. The text is usually static information included for context; it doesn't need to be the loudest thing in the graphic.

Adjust justification of paragraphs

For multiple lines of text (3+), use left or right justification instead of centered. Centering text is often a default, but it requires more work from the viewer, as it gives nowhere for the viewer's eyes to anchor as they move through the lines.

Align similar information

Create visual associations between bits of information by aligning them horizontally or vertically in the figure.

Rethink placement of labels

Scientific figures often draw a line or arrow from a label to the element it is naming, but this can be confusing if arrows are also being used to represent something in the diagram. Positioning labels closer to their element can clarify the label and declutter the figure.

CHANGE THIS



TO THIS



CHANGE THIS

THING 1
THING 2

TO THIS

THING 1
THING 2

CHANGE THIS



TO THIS



CHANGE THIS

For multiple lines of text, use left or right justification instead of centered.

TO THIS

For multiple lines of text, use left or right justification instead of centered.

CHANGE THIS



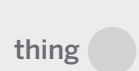
TO THIS



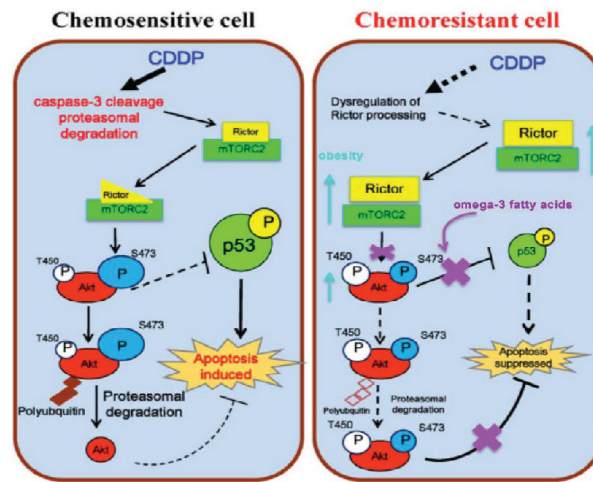
CHANGE THIS



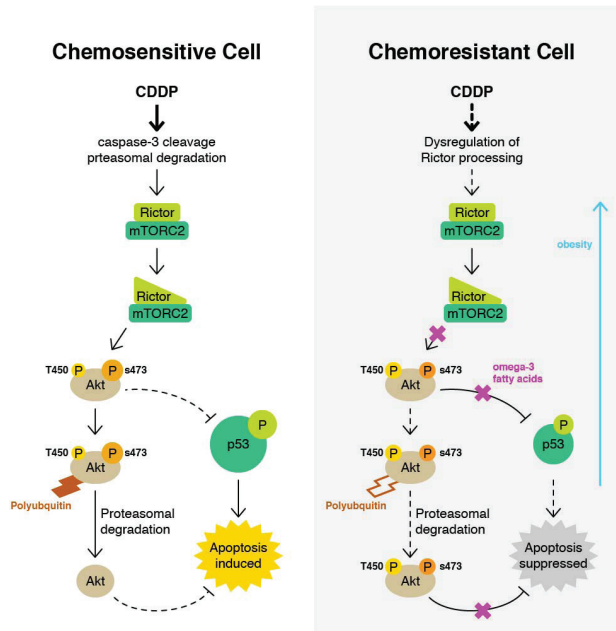
TO THIS



before



after



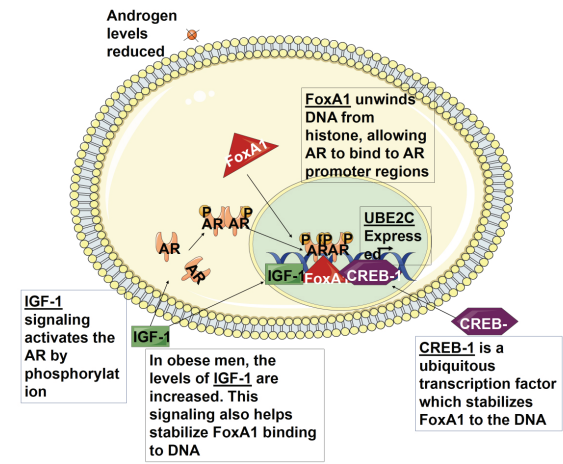
Text improvements in this redesign:

- Single font (title of figure was serif, labels sans serif)
- Removed the many different text colors, added back in where the distinction was most needed.
- More uniform text sizes
- Aligned similar information (first few steps of the process now go straight down, labels to "P" elements lined up)
- "omega-3" label moved closer to element, removed arrow

before

PREDICTIVE MODEL

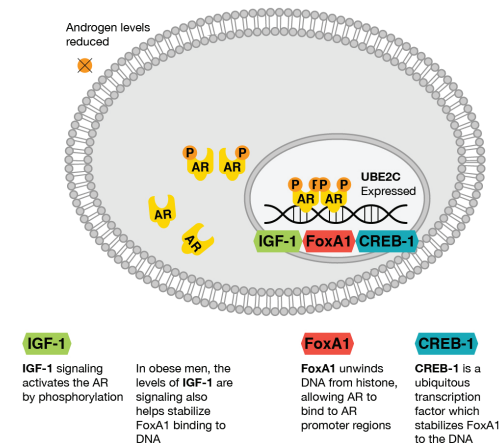
We have hypothesized that obesity promotes greater FoxA1/AR activity by growth hormone IGF-1.



after

PREDICTIVE MODEL

We have hypothesized that obesity promotes greater FoxA1/AR activity by growth hormone IGF-1



Text improvements in this redesign:

- Removed unnecessary bolding, underlines, and borders of text boxes, instead made a distinction with simply bolding: IGF-1, FoxA1, CREB-1
- Aligned similar information below diagram
- Removed arrows from label to element, information below functions more as a legend, defining elements

INTRO

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COMPOSITION

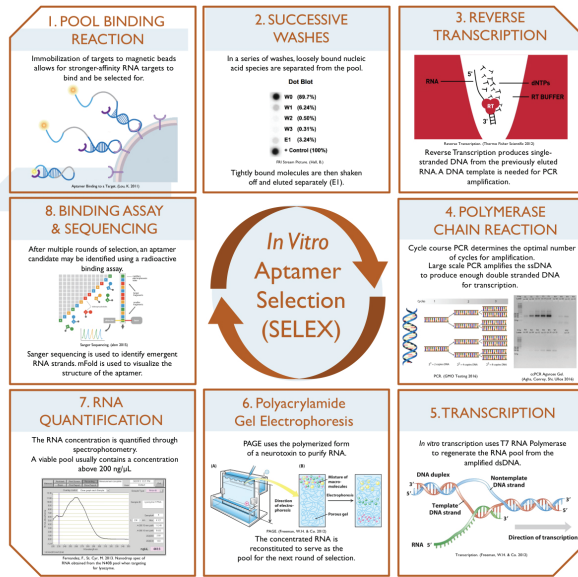
SIMPLICITY

COLOR

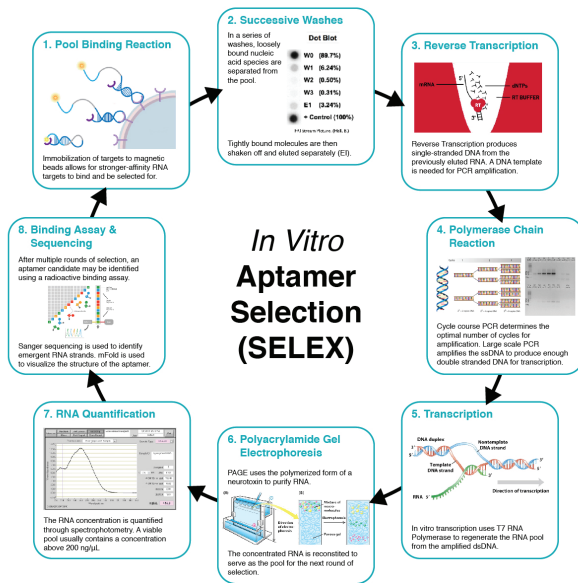
TEXT

RESOURCES

before



after



Text improvements in this redesign:

- Removed all caps and background color from titles, these features were unnecessary because a clear distinction is already being made with the different text color and larger size.
- Changed centered text to left justified

before

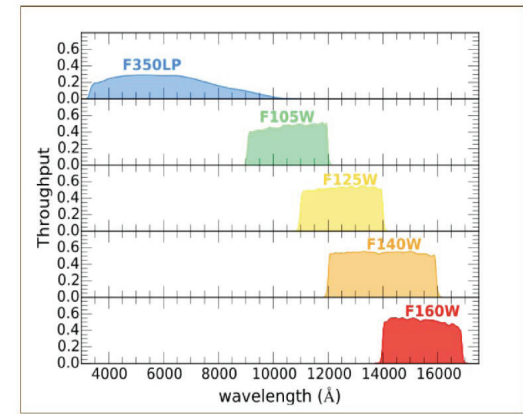


Figure 1. Set of filters to identify high-redshift galaxies from visible to IR: F350LP, F105W, F125W, F140W, F160. (Calvi et al. 2015)

after

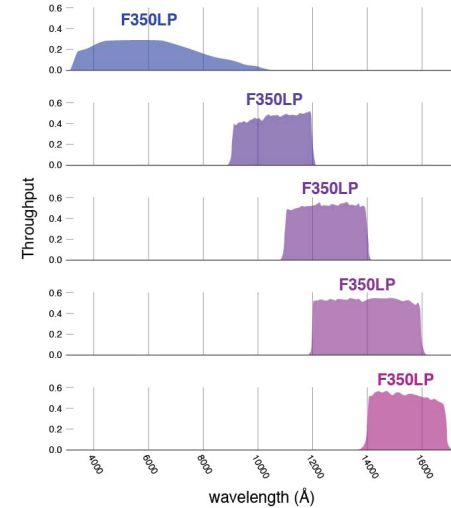


Figure 1. Set of filters to identify high-redshift galaxies from visible to IR: F350LP, F105W, F125W, F140W, F160. (Calvi et al. 2015)

Text improvements in this redesign:

- Single font (labels were sans serif, caption was serif)
- Scaled down labels for increments and gave them more space
- Colored labels are all centered above their shape

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checklist summary

Reference this checklist for a quick reminder of design principles as you work through revisions of your own scientific figures. You can find a printer-friendly version of this in a separate pdf on the same web page.

■ MESSAGE

The purpose of this figure is to _____

[compare/contrast, show a pattern, show a process, show a relationship/connection, show change, show variability]

■ COMPOSITION

- Draw your intended path for the viewer's eyes as they "read" through the figure. Is it a straight line, or more of a circle or zig-zag?
- Rework the composition to lead the viewer's eyes from left to right or top to bottom.

■ SIMPLICITY

- Remove all unnecessary:

<input type="checkbox"/> bounding boxes	<input type="checkbox"/> lines around shapes
<input type="checkbox"/> frequent grid lines	<input type="checkbox"/> frequent increment markers
<input type="checkbox"/> background colors	<input type="checkbox"/> shadows or shading
<input type="checkbox"/> repetitive elements	<input type="checkbox"/> minor steps in a process
- Assign symbols to repetitive labels and add a legend that defines the symbols
- If entries in the legend are one-to-one (one entry in the legend for one element in the figure), remove the legend and integrate labels into the figure.
- If your figure is a collection of panels, consolidate panels of similar content if possible. Think about which elements of the current panels can instead exist in the same space.

■ COLOR

- Simplify the color palette. Identify similar elements and assign similar colors or different shades of the same color.
- Identify elements that are included only for context, not a part of the essential data, and convert to shades of gray.
- Remove colors that serve no function or colors that represent an aspect not relevant to the message.
- Apply vibrant colors to most important elements
- Apply warm colors vs. cool colors for compare/contrast data
- Consider mood created by the color palette (positive or negative, somber or light) and adjust to fit the subject
- Utilize familiar color associations for the subject

■ TEXT

- Choose an appropriate font. San serif, modern, and readable at a small scale are all good rules of thumb.
- Reduce style differences (bold, italics, all caps, different sizes, different colors)
- Left or right justification for 3+ lines of text
- Align similar/related information
- Reposition labels to where a line/arrow between the label and the element it names is no longer needed