

Tips, ideas and trends in  
scientific illustration,  
animation and graphic  
design for the smartest  
people on earth!

# graphic design

for

**scientists** and  
**researchers**

Text and Illustrations

by Dr. Agnieszka Kawaska

**Several guest contributions**

Updated fourth edition

Many thanks to my friends and readers of the first two editions of this document for their interest and feedback. My special thanks go to my guest contributors, in particular to Pieter Torrez with whom I had many fruitful discussions and whose suggestions have helped improve this document significantly. Last but not least, thanks to you, Dear Reader, for your interest. I hope that this document will prove to be useful to you. If you have comments or suggestions, drop me a line at [info@illuscientia.com](mailto:info@illuscientia.com).

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**\*Guest contributions by S. Arumugan (article 6), P. Torrez (article 8) and J. Lewicki (article 10).**



Hi, I am Agnieszka Kawska, I drink a lot of tea and I like photos of funny owls and chameleons. Oh wait, I actually wanted to tell you something relevant about myself... How about this: I did a PhD in theoretical biochemistry, my main PhD project focused on simulations of the biomineral growth on protein matrices. I have also several years of experience working in biophysics research. For more than seven years now, I have been working as an independent scientific illustrator and animator often directly with scientists. Highlights of my work include illustrating several high impact review articles (most cited in their field) and successful grant applications, as well as producing a dozen of short animations on, for example, selective neuronal illuminations, virus formations and blood tests.

When can I help you by providing the strong visuals your projects deserve?

# Introduction - general tips and recommended sources

This document is a collection of articles published in the last four years on my mailing list and later on my website. It is not meant to be a thorough overview of the vast topic that is graphic design, rather, it is an attempt to keep up-to-date with the trends in graphic design and illustration for scientific communications. A selection of available literature on this subject is listed below and it is there that you will find most information to start with. This document can be viewed also as a quick pointer to the already existing online sources on graphic design and data visualization in research.

## Interesting literature:

**“Ten simple rules to better figures”**, a PLOS Computational Biology publication by N. Rougier et al. from 2014, is a very good place to start with. The authors provide a basic guide to choosing the best way to represent your data depending on your target audience and the type of communication. At the end of the publication there is a list of useful open source software tools worth discovering (again).

This publication belongs to a whole series of interesting articles which titles start always with “Ten simple rules ...” and have been published over the years in PLOS Comp. Biol. on widely ranging topics like writing grants, establishing international collaborations and editing wikipedia, to name just a few. Have a look!

**“Preparing scientific illustrations”** by Mary Helen Briscoe is a good book to understand the basic ideas of illustrating biological and medical concepts. From general ideas on visual communication to treating photographs, preparing journal figures and presentation slides as well as working with scientific illustrators, all topics are covered. The main drawback of this book is its age: last edition dates back to the '90s. Many tips and solutions are therefore outdated

and don't include all tools that are now considered standard. Nevertheless, it is a noteworthy source.

**“The visual display of quantitative information”** by Edward R. Tufte is a very good book to rethink the way to display your data. It focuses on the essential role of data visualization, which is to reveal information and lay the facts before the reader's eyes. If you are used to applying default settings of your plotting software, this book may be an eye opener for you. It is full of examples to better understand the author's ideas and makes a strong case in favour of clarity and conciseness. Other books from the same author are also interesting, however if you only want to read one, then make it this one.

**“A guide to the visual analysis and communication of biomolecular structural data”** Nature Mol Cell Biol, Vol.15, 2014: concise essay by G. T. Johnson and S. Hertig on available resources including software tools and professional illustrator services that can help scientists generate better figures for a variety of contexts and audiences.

## Further resources:

**Library of science illustrations** hosted on [somersault1824.com/resources](http://somersault1824.com/resources) offers quality scientific images available on pay-if-you-want basis and made by professional illustrators with scientific backgrounds. The images are provided under a Creative Commons license so that you can create, share, build upon and redistribute beautiful slides for presentations or figures for your documents at no or very low cost. Full disclosure: some of my clipart is available there.

The **scidoodle.com** website gives tips for scientific images. The site administrator Sheila has a degree in biology and works as a graphic designer at research laboratories helping directly post-docs and graduate students. She explains many basic concepts and shares her tips about preparing publication quality scientific images with Adobe Illustrator.

The **betterfigures.org** is an occasional blog devoted to excellence in the graphics of climate science written by a climate scientist and statistician from UK. It showcases and gives constructive criticism of figures in climate research. This link might be helpful if you look specifically for help in climate data visualisation.

The **betterposters.blogspot.com** is a blog dedicated to making scientific posters informative and beautiful. It gives lots of useful tips and ideas. So many that searching through the published posts can be a challenge!

The **thefloorisyours.be/en** offers e-books and workshops on the art of scientific presentation (as their motto goes: life is too short for bad presentations). Their blog is full of interesting contributions on a variety of topics concerning the art of presenting as well as the design of presentations and posters.

The **clarafi.com** community of scientists, graphics professionals, students and educators is interested in offering a way into scientific visualization. They aim to facilitate the creation of accurate visualizations through intuitive software tools and high quality instruction. Their partially free (but mostly paid) tutorials on executing illustrations, story-boarding, animations and more can be a starting point for people that would like to either improve or launch their careers in scientific illustration / animation (yes, science visualisation is on the march!). The collection of original tutorials for life science professionals learning 3D visualization **molecularmovies.org** is now part of clarafi website as well. The tutorials are focused on Maya workflows but you can extract a general idea and adapt it to other 3D animation softwares.

**Gif tutorials by Eleanor Lutz** demonstrate how to create amazing gif animations with Photoshop. Eleanor is a PhD student in biology as well as an accomplished artist and in her tutorials she shares her workflow to making detailed and amazing medical gif animations. Have a look even if you do not intend to make any gifs, [tabletopwhale.com](http://tabletopwhale.com)

**Felice Frankel's youtube tutorials on science images** show how to use a scanner to produce beautiful and high quality images of, for example, microfluidic devices. The tutorials also explain general ideas of making visually attractive images. There is a wealth of information out there for you to dive in.

**A quick introduction on Blender by Russell Garwood**, palaeontologist at Imperial College in London, is available on request at

[academia.edu/3648763/Blender\\_for\\_scientists\\_A\\_quick\\_introduction](https://academia.edu/3648763/Blender_for_scientists_A_quick_introduction)

Blender is an open-source 3D computer graphics application that offers lots of possibilities (see page 44 for more info). If you are not familiar with Blender, this primer can help you get started.

**3D Scientific Visualization with Blender by Brian R. Kent**, (online ISBN: 978-1-6270-5612-0) is another source on using Blender in scientific context, more particularly in astrophysics and mathematics. It introduces the basics but also goes into detail on how this powerful software can be employed to get the most out of your data representation.



## Other interesting material online:

The **Vizbi.org** website and notably the talk “The art and science of cell biology” by Graham Johnson.

### **“Visualization of biomolecular structures: state of the art revisited”**

Computer Graphics, Vol. 36, No. 8, 2017: this report by B. Kozlikova et al. discusses the history and current trends in visualization of molecular structures, covering various levels of details, efficient display and image quality.

### **“The visualization transforming biology”**

Nature, Vol. 535, July 2016 by E. Callaway: examples of new tools for biodata visualization including very large sets of complex data.

### **“How animation can help scientists test a hypothesis”**

TED talk by Janet H. Iwasa on how 3D visualization can be used to better understand complex biological processes.

### **“Let my dataset change your mindset”**

TED talk by Hans Rosling on modern data visualization.

### **“Fonts in presentations and on posters”**

by Verena Resch, Luminous Lab: interesting blog post concerning an essential element of every graphic design that can make or break any scientific communication. It is a brief introduction of the two main font families and rules of the thumb when to use which as well as tips on font sizes for poster design:

<http://luminous-lab.com/2015/10/20/fonts-in-presentations-on-posters/>

### **“5 fonts that add credibility and professionalism to scientific**

**research”** from Ikumi Kayama, Studio Kayama, is another blog article that gives tips on good fonts making your poster and presentation designs look professional and slick:

<http://studiokayama.com/5-fonts-that-add-credibility-and-professionalism-to-scientific-research/>

**“Animations not so difficult after all”** is a blog article by Szymon Drobniak that tries to debunk the myth of animations being very complicated to make by sharing a range of tools and approaches from graphic software tools to programming in R. The article aims to get you started with creating animated images and graphs. <http://crastina.se/animations-not-so-difficult-after-all/>

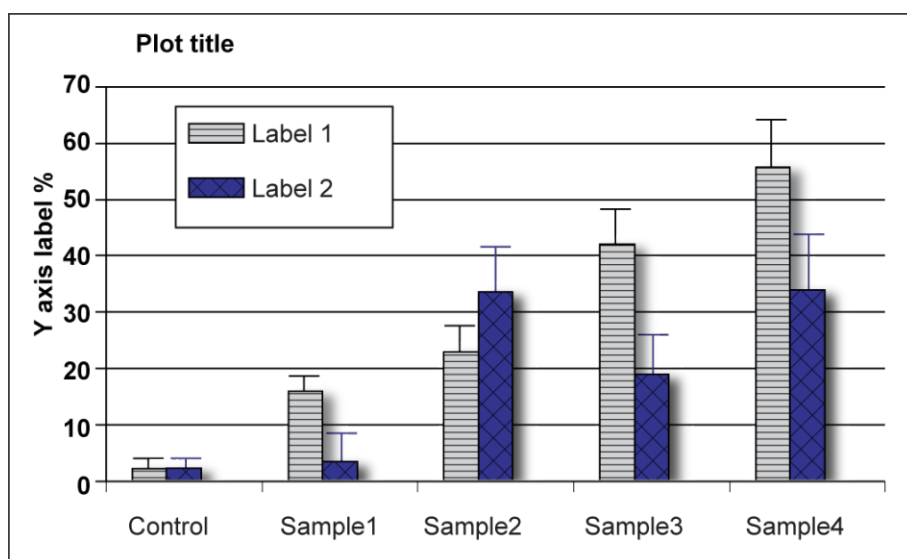
Another blog post **“A short guide to movie making”** by Wojciech Mosiejczuk aims to explain how with a normal camera and a basic microphone you can make a short film on your research that your audience will want to watch. Such short films are increasingly useful as publication teasers in form of video abstracts or even as full publications in journals like JoVE. <http://crastina.se/a-short-guide-to-movie-making/>

# Quick reminder of the basics

## Plots for publications

Publication figures can be very detailed as the readers will be able to peruse them as long as they need to. However, keep plots simple and focus only on presenting your data in the most clear way. Avoid default settings.

Example of a plot produced with typical default settings. Many elements are unnecessary and distract from the data.



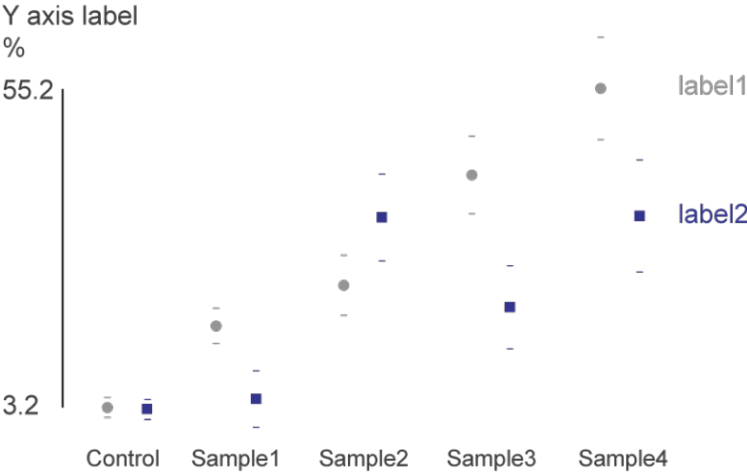
In general, try to keep in mind the following:

- for every plot element consider if it is genuinely containing information essential to the plot. **Keep** the so called “**data-ink ratio**” **high**. “Data-ink ratio” is a term coined by E. Tufte. You can think about it this way: if the plot is printed, how much ink will be used to carry valuable information and how much of will be used for visual effects?

- redundant elements like **plot titles**, **axis ticks**, **bolding of numbers**, **special effects (like drop shadows)** and **frames** are to be avoided. **Grid lines** can be conserved if sufficiently **pale and thin** to remain visible but unobstrusive;

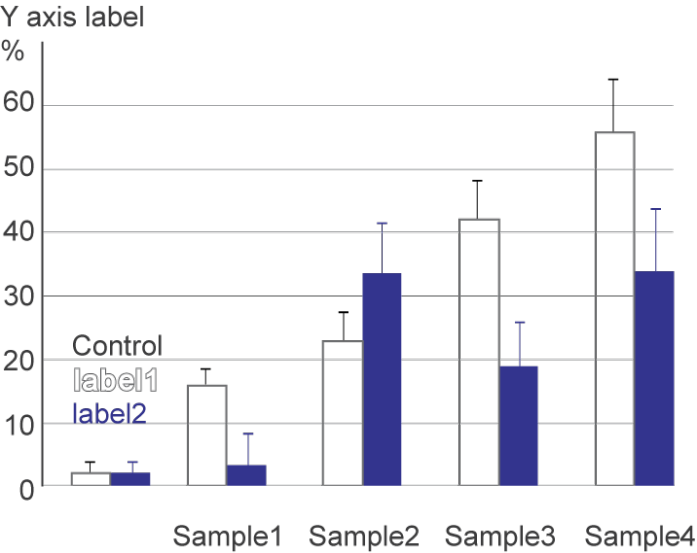
- where possible, **incorporate legends** into the data plot instead of keeping them separate and surrounded by a distracting box;
- **avoid fancy patterns** in form of dense dots or lines, cross-hatchings and similar. If used, try to keep the effect subtle.

Example of the same plot represented with an absolute minimum of elements to understand the information, resulting in a very high “data-ink ratio”. The plot title, the separate legend, the grid lines, the x axis are removed, the y axis transformed to show minimum and maximum values bringing this information to the reader's attention.



There is probably a sweet spot between these two extreme examples that suits best the given data representation for a given context.

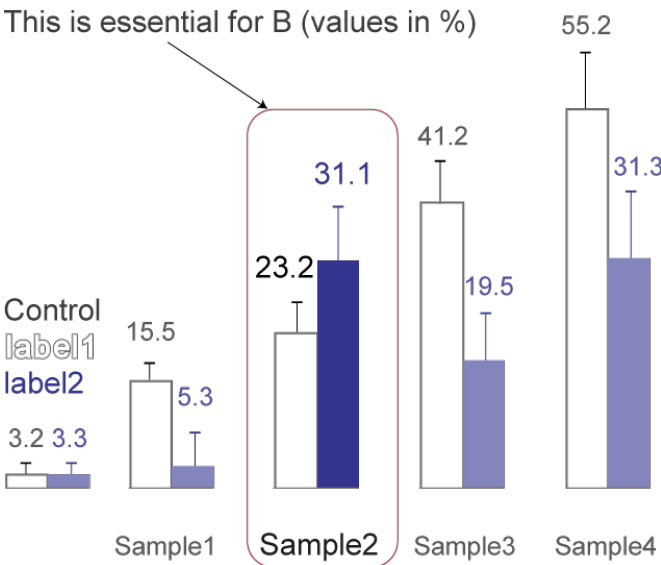
Example of the plot with a good “data-ink ratio” suitable for a publication. The two data sets are set apart by colouring the one and contouring the other - good and sufficient solution even if the figure is shown in grey scale. Only the necessary labels and y axis are kept. Grid lines are conserved but paled out, they remain optional. All the design looks lighter and slicker compared to the first version.



## Plots for presentations

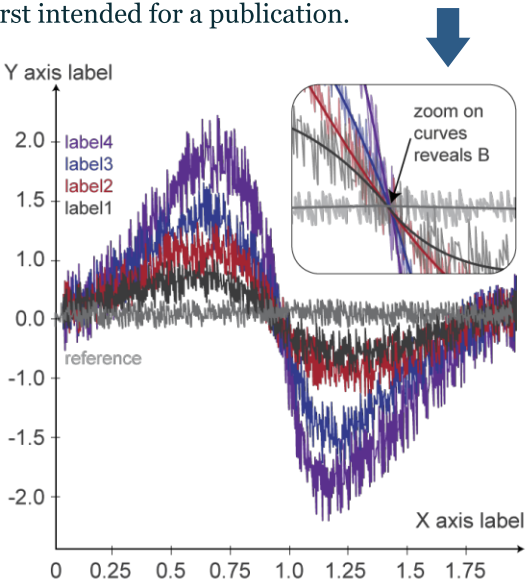
Plots intended for publications need usually adjustments to be used to their full effect on presentation slides. The plots should be presented in a way that facilitates the understanding and gets the core message across in a short amount of time. Adding conclusive titles can be a good idea:

Example of the plot adapted for a presentation slide. The y axis and grid lines have been removed as they are not useful in this case. The y values are explicitly written next to the corresponding data. The main result is highlighted by a subtle frame and remaining data is paled out. A conclusive title summarizes the take home message.

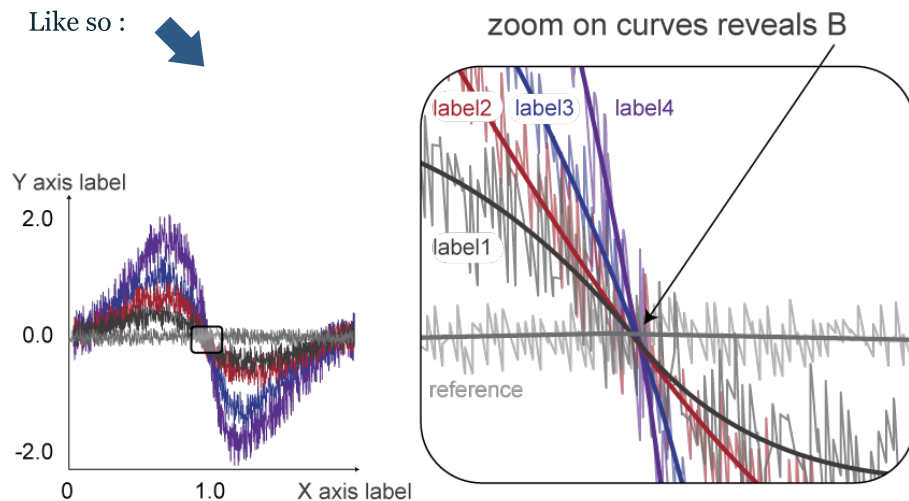


The next example has been at first intended for a publication.

It is a complex plot with an important message shown in the inset. Whereas a reader of the paper can spend some time on this figure considering all the details, this will not be the case during a presentation. On a slide, it is better to make life easier for your audience and highlight the principal message clearly.



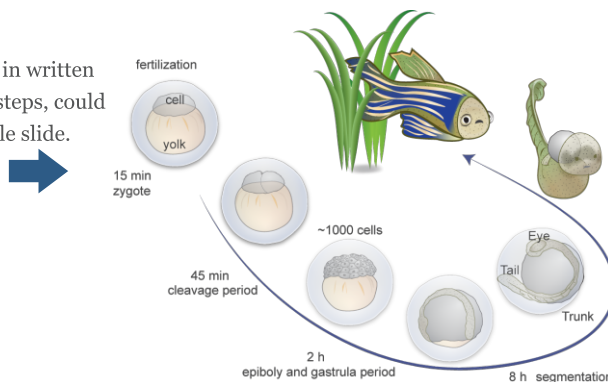
Like so :



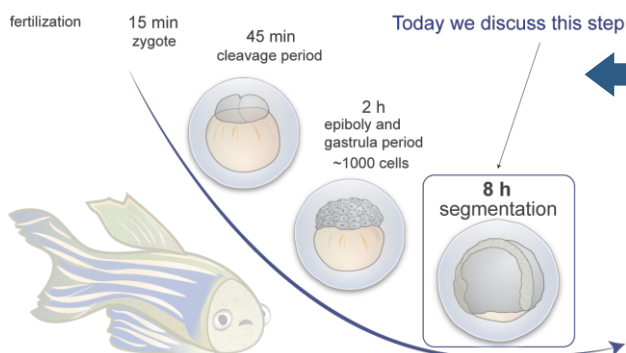
The inset is enlarged and draws now most of the attention. The curve labels are moved inside the zoom and the entire plot is shown with reworked axes.

These examples of plot adaptation for slides aim at giving hints what to focus on but each case will be different. Generally, it is not a good idea to use figures on presentation slides that were originally intended for a publication. The same applies to schematic representations.

Example of a figure that works in written communication but, with seven steps, could be already too detailed for a single slide.

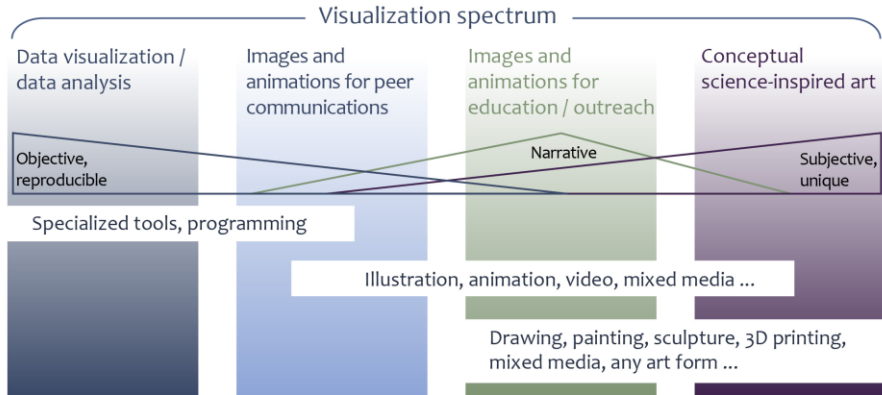


Zebra fish life cycle - initial steps



Here is an excerpt that could be a presentation slide - only the part the speaker wishes to talk about in more detail is shown.

## Designed scientific visuals - general classification



Adapted from G.T. Johnson et S. Hertig, Nature Reviews, vol. 15, 2014

Depending on their purpose and context, designed scientific visuals will be created with different techniques and their production will require different sets of skills.

### Data visualization / data analysis

Data visualizations are usually employed to analyse big and / or very complex data sets that would be difficult to analyze otherwise. A good example of data visualization is a movie showing the world map colour coded with the temperature increase over last 100 years (NASA data). These images represent part of a scientific result as they often reveal new insights about the data. They are designed by data scientists and programmers often specifically for the data set in question. Data visualizations aim to be objective and largely reproducible. In recent days, they become increasingly web-oriented and interactive. Their target public are peers as well as an interested wider audience.

### Images and animations for peer communications

The images and animations in this context take often form of simple graphic representations conveying a concise message about a scientific result in order to help understand it more quickly. They are an interpretation of the results employing often minor simplifications. Compared to data visualizations, they are more subjective and more narrative. The images and animations for peer

communications are most commonly prepared by the scientists themselves, but punctually the scientists will work with a professional illustration service. The latter need to offer a high level of expertise with a degree in a scientific field or long experience in scientific visuals to be an efficient help.

The images and animations for peer communications can be produced with a variety of tools, most commonly with graphic software like Adobe Illustrator, Inkscape and similar. They are usually part of a manuscript or are accompanied by a textual explanation. Their target public is a specialized one that knows the topic and its jargon. Taken out of their peer communication context the images and movies remain often too arcane to be easily understood and therefore are in general not suitable for a wider public.

## Images and animations for education and outreach

The next category involves any type of images and animations that aim to present scientific ideas and results to a public at large in a visually aesthetic and engaging manner. To achieve their mission of familiarising a general public with a complex topic, they often employ major simplifications and visual metaphors to convey their message. The images and movies are usually narrative and subjective with sometimes serious, and sometimes quirky and unique styles. They can be produced with a variety of techniques including hand drawing, painting, collage, stop motion movies and other traditional and modern techniques. These visualizations are produced most commonly by illustrators, graphic designers or artists, often in collaborations with or under a supervision of an expert. They are usually stand-alone artworks that can do without further textual explanations.

## Conceptual science-inspired art

The science-inspired artworks are artist's take on science, scientific results or scientific protocols - they convey how their author feels about it, what they associate with it or what they make of it. The creation draws inspiration from science but transforms the subject enough to be interesting independently of any scientific context. They are therefore fully subjective and unique pieces of art. These artworks can be in any shape or form. They are free of any educational or communication role but can nonetheless awaken interest in science.



# Vector versus raster graphics

You probably have heard about the two main types of graphics: vector graphics and raster graphics (if you are not familiar with these terms, check out wikipedia Vector graphics and Raster graphics). The crucial difference between the two consists in the fact that the vector graphics are losslessly scalable whereas raster graphics are not. Depending on what type of figure or design you aim at, you may want to use either vector or raster based software and formats.

Here are some guidelines which to choose when:

- ▶ you want a publication figure - turned - a poster figure - turned - presentation slide: vector graphics is your friend;
- ▶ you plan a one-time design like a cover image or an image to accompany a press release: raster graphics may yield more spectacular results;
- ▶ you need to retouch some of your bitmap images: raster graphics is your friend;
- ▶ you are not certain: go for the sure thing and start with a vector graphics software.


*Besides the most known examples of raster and vector graphics programs like Adobe Photoshop and Adobe Illustrator, other alternatives are available. For more information, see “Software tools...”, p. 62*



# Digital image file formats

To clarify one thing up-front: a digital image format is a storage format for a bitmap or raster graphics. The image format contains data about every pixel in the image and the image metadata like the creation date and camera settings, for example. A file format on the other hand is a format that can contain raster image data but also other elements like editable text or vector graphics.

Here is a quick visual overview for the most commonly used formats:

 web, screen
















 printing

image format	colour model	transparency	destination	remarks
JPG	RGB			generational degradation
TIFF	RGB / CMYK			layered images, image stacks
GIF	RGB			limited colour, animated images
PNG	RGB			lossless compression

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file format	colour model	transparency	destination	remarks
SVG	RGB			interactive, scriptable
EPS	RGB / CMYK			PostScript document
PDF	RGB / CMYK			includes PostScript, platform independent



*If you are not sure what RGB and CMYK stand for, see “Digital colour models ...”, p. 23. Similarly if you need a quick reminder on raster versus vector graphics, check out the article on raster and vector graphics p. 15.*

## Let’s have a closer look at image file formats first

**JPG or JPEG** (Joint Photographic Experts Group) format can handle **only RGB colour model** and does not allow for transparency. JPGs are routinely **compressed in a lossy way** which enables to considerably decrease the file size. Compression does not necessarily affect the image’s quality if it is applied moderately. However, **JPG file quality deteriorates over time** when repeatedly edited and saved again. Therefore, if it is necessary to create different sizes of JPG images, it is better to scale the same high resolution file for each of them. For example, if you have an 3000-px-wide image and you need a 900-px-wide preview image and a 150-px-wide thumbnail image, then create both images starting from the 3000-px one instead of scaling down first to 900px and from 900px to 150px. **JPG format is most adapted to complex images like photographs** and performs very poorly for line art images, simple plots and diagrams. As the RGB colour model is meant for on screen rendering, **JPGs are best suited for web and screen usage.**

**TIFF or TIF** (Tagged Image File Format) format is very flexible as it **supports both CMYK and RGB colour models** and, in addition, **allows for transparency** (which is enabled by a so called alpha channel). As TIFF supports multiple images, it can be used for image stacks. TIFF sizes can be substantial so a compression is often required. **TIFFs can be losslessly compressed** with LZW compression which tends to be most effective for images composed of uniform areas of a single colour, but lacks performance for complex photographic images. As TIFF supports both RGB and CMYK colour models, it could be in principle useful for both printing and web destinations. However, the TIFF format is not widely supported by web browsers and **remains more common in the printing business.** A version of the TIFF format, the **OME TIFF format tries to establish itself as a standard storage format for microscopy imaging.**

**GIF** (Graphics Interchange Format) image format is a small size format for images limited to **256 colours** (so called indexed-colour images) where one of the colours can be semi or fully transparent. Furthermore, **GIF supports multiple images** so it can be used for **image animation**. It performs **best when storing graphics with few uniform colours, such as simple diagrams, logos, and cartoon type of images**. Similarly to the TIFF format, it uses the LZW compression. Due to GIF's widespread support by image viewer software, it is still commonly used to provide image animation effects, despite its low compression ratio compared to modern video formats. **Screens only**.

**PNG** (Portable Networks Graphics) format was created as a free, open-source alternative to GIF. The PNG file format **supports RGB colour and transparency**. PNG is best suited to store **images with large, uniformly coloured areas but it is appropriate even for complex images like photographs** – where JPEG is the traditional choice – thanks to its lossless compression. PNG is particularly useful for presentation slides thanks to the possibility of having a transparent background in the image that helps fit it seamlessly into a design. **PNG works very well in web browsers and on screen** but is rarely suitable for printing.

## File formats capable of storing both raster and vector graphics

**SVG** (Scalable Vector Graphics) is an open source standard for an all-purpose **vector graphics format**. The SVG format is a flexible, **script oriented format** so it can be used in interactive web pages. Be aware that when running in a browser it is prone to hacking attacks. **As it is mostly used online, it is RGB based**. SVG file format is supported by Inkscape.

**EPS** (Encapsulated PostScript) file is a PostScript document that **is intended to be used as an image format**. An EPS file contains a complete **description of text, layout and graphics and includes its low-resolution preview**, allowing some programs to display the image on the screen. It can be easily placed within another PostScript document and it is fully supported by the LaTeX typesetting environment. As it **supports CMYK, it is widely used in**

**printing** and is often a preferred format for publication submission. It is however slowly replaced by the more complex and more powerful PDF format. It can handle RGB colour model too.

**PDF** (Portable Document Format) is similar to EPS in that it also **encapsulates a complete description of the text, fonts, graphics, and other information needed to display a document**. Its purpose is to provide a **platform- and hardware-independent** rendering of documents. A pdf file contains typically a PostScript component generating the layout and graphics, a font embedding system and a structured storage system to tie these elements together. Supporting **both RGB and CMYK colour models**, PDF 1.4 was extended to allow for transparency as well. However, the latter might sometimes be ignored or rendered incorrectly if it is not compatible with a viewer. For example, including a PDF file with graphics in a PowerPoint presentation can result in such an incorrect rendering. Therefore, for graphics inclusion in presentation, it is safer to opt for image formats like PNG or JPG. **PDF format is ideal for printing purposes.**

## Bottom line:

- ▶ raster graphics are stored in image formats like JPG, PNG and TIFF and file formats like EPS and PDF;
- ▶ vector graphics are stored among others in SVG, EPS and PDF file formats;
- ▶ for printing purposes, use PDF, EPS or high resolution TIFF, with CMYK colour mode by default;
- ▶ for online or screen use, go for JPG, PNG or GIF image formats.

Sources and further reading:

OME TIFF format has a dedicated website that explains its advantages for storing microscopic data <https://docs.openmicroscopy.org/ome-model/5.6.0/ome-tiff/>

“Metadata matters: access to image data in the real world” by Melissa Linkert et al., JCB, vol. 189 (5), May 2010, p. 777. The article describes in more detail special formats for life science images and in particular microcopy images.

Wikipedia pages on image and file formats.

# Image formats and composition

## Golden ratio and rule of thirds in scientific illustration

The choice of the format depends on the type of communication, the space, and the message you want to deliver. If you prepare a presentation, you work mostly on slides with the landscape format. Posters are typically in portrait format but can also be in landscape or square format. Publication figures or plots can have many different formats.

When you have the choice of the format, consider this:

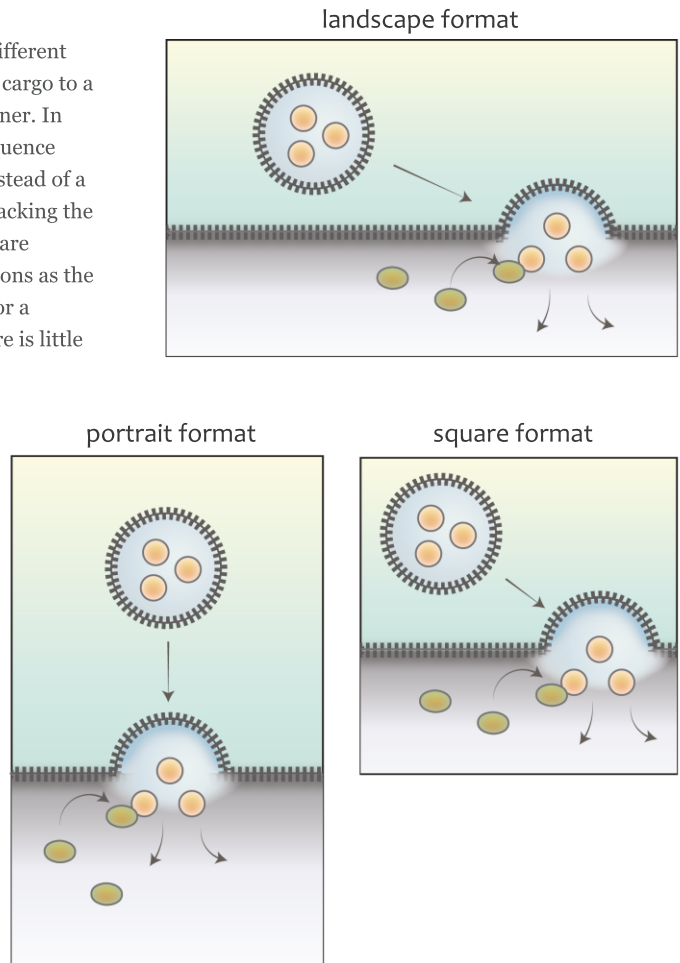
► **landscape** format (width:height > 1) is perfect for presenting a general overview, a sequence of events or a plot. Landscape format presents the facts in a sweeping, peaceful manner.

► **portrait** format (width:height < 1) presents the message in a more dynamic, sometimes even dramatic manner. You can stress, for example, how dramatically your measure increases / decays over time by using the verticality of this format. The portrait format lends itself well to highlighting the dynamic and / or exceptional nature of what you observed / measured.

► **square** format (width=height) is fairly neutral compared to portrait but can prove a bit more crowded and less balanced than landscape. It is a good choice if you lack space for the landscape format.

For special cases, less common formats can be adopted. For example, circular format is naturally suitable for presenting things of cyclic nature.

Landscape format shows different steps of a vesicle delivering a cargo to a cell in a neutral, relaxed manner. In portrait format, the same sequence looks a bit more dramatic, instead of a vesicle, it could be a virus attacking the cell to inject its material. Square format gives similar impressions as the landscape, however if labels or a legend need to be added, there is little extra space for it.



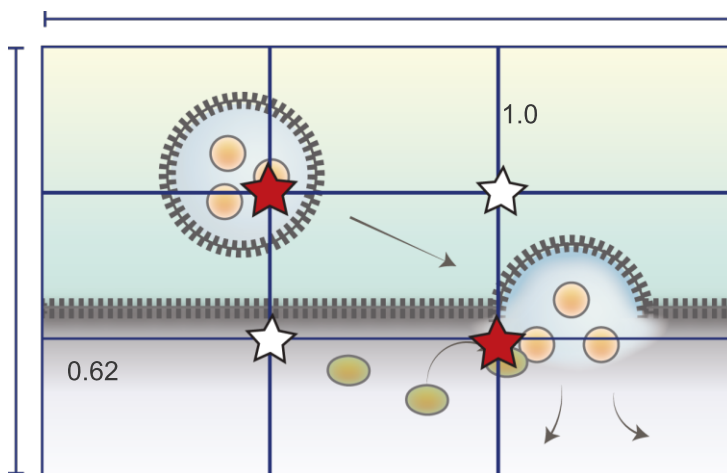
## Image composition: golden ratio and rule of thirds

It has been fascinating people for centuries, if not millennia. In 2010, the journal *Science* reported that it is present even at the atomic scale in the magnetic resonance of spins in cobalt niobate crystals. The golden ratio. When two dimensions are in the **ratio of approximately 1.618** they are in so called **golden ratio**. If it is used in image composition, it is said to yield a pleasing and harmonious result. In the example below, the format width to height ratio is 1.62.

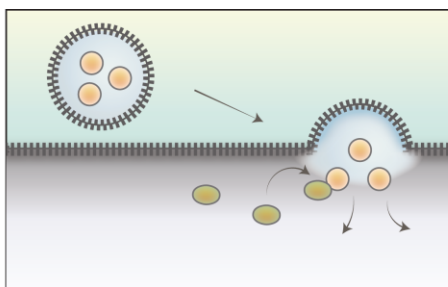
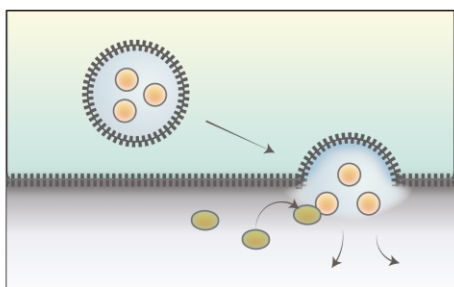
Another rule, maybe a bit less famous, is the rule of thirds. According to it, to create an interesting, dynamic composition, instead of simply centring the subject within the composition boundaries, divide the available space into nine equal parts by drawing two equally spaced horizontal lines and two equally

spaced vertical lines. The important compositional elements should be placed along these lines or their intersections. As you see, the vesicles in the figure below are in the vicinity of the line intersections and the dashed line is aligned with the lower horizontal grid line.

The indicated dimensions of this illustration of vesicular trafficking result from the golden ratio. The grid lines refer to the rule of thirds. Red stars show strong focal points in the composition, and as you notice, important elements of the figure are placed close to them. The white stars show unused focal points existing in the composition.



Compare the figure adhering to the rule of thirds (image on the left) with its analog ignoring it (image on the right). The scientific message is the same in both cases. The image on the left is simple but pleasing. On the other hand, the composition on the right looks a bit boring and unbalanced.





# Digital colour models RGB and CMYK

It seems like a futile endeavour to try to define a colour. Colour actually does not exist. What we call colour, is a perceptual property derived from the spectrum of light interacting with the light receptors of the spectator's eye. My colour perception varies probably a bit from yours and my sensitivity to colour is also likely to be slightly different from yours. However, in an effort to create some classification, colours may be defined and quantified by the degree to which they stimulate the receptor cells and can be further organised in a colour model to provide more or less reproducible representations. The inherent problem of colour being a perceptual property combined with technical constraints is reflected in the existence of many different colour models, each with their own usages. RGB and CMYK are the two most common ones.

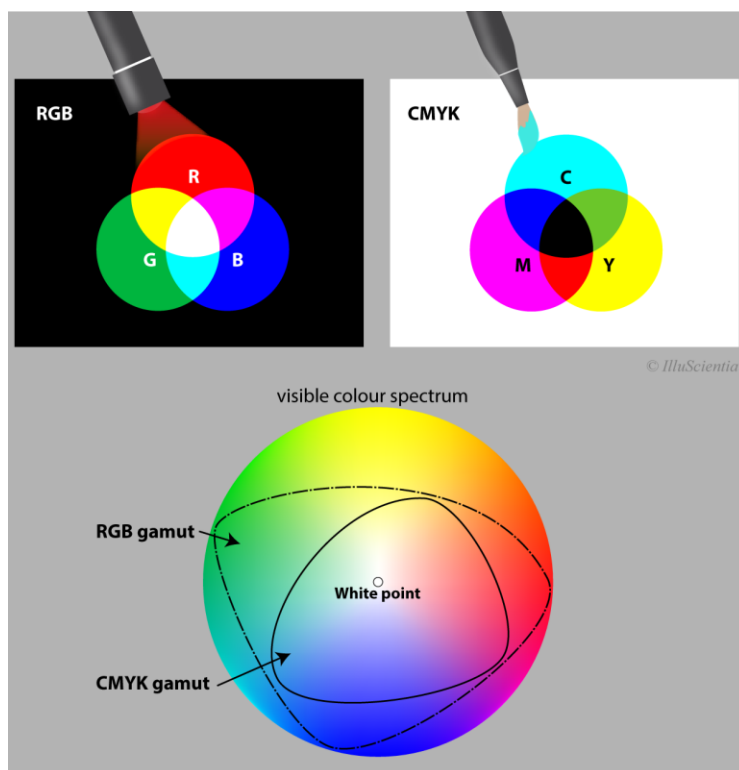
## How to use images to improve visual flow in a design:

**RGB colour model** is a colour model used in the digital world and stems from the **three primary colours: red, green and blue**. It is an additive colour model in which the three primary light colours add up in various proportions to reproduce a broad range of colours. Think of this model as painting with light: you start with a black background and by shining colour light onto it, you can create different colours. The more colour light you add, the brighter your colours get as you get closer to white. On your computer screen, this is achieved by regulating the intensity of red, green or blue light of each individual pixel. **RGB has quite a large colour gamut** (gamut is the range of colours that a colour model can represent) and allows for vibrant and saturated colours.

**RGB is device dependent** and the colour rendering varies from device to device, manufacturer to manufacturer, or even in the same device over time.

**CMYK colour model** originates from the printing press world and works with **four primaries cyan, magenta, yellow, and black** (K stands for “key”, “key plate” which in printing press carried the black ink). **It is a subtractive colour model** and hence, in a sense, an opposite of RGB: white is the natural colour of the paper to start with, while black results from a mixture of coloured pigments. As soon as you use colour ink on paper, the pigment absorbs part of the light spectrum which is subtracted from your background and you create a darker outcome. **CMYK has a relatively small gamut compared to RGB** and hence CMYK colours tend to appear onscreen a bit dull and lifeless. Bright and vibrant colours are difficult to achieve with CMYK. Also, as CMYK refers to physical printing on paper, even with the same CMYK colours the printed image is likely to look different depending on the type of paper it is printed on and its finishing (for example matte versus glossy).

RGB vs CMYK colour model and their respective gamuts (range of colours that can be represented by each model). The visible colour spectrum representation in the image is skewed as it is represented with RGB colours. The gamut limits are approximative.



## Colour models in the scientific context

In the scientific context, the vast majority of produced images are in the RGB model: micrographs, presentation slides, matlab plots ... so you do not necessarily get to choose the colour model. However, when creating a new figure or a new design from scratch, **a good rule of thumb is to define the colour model at the beginning of your work flow in accordance to what your principal destination is:**

- ▶ if the image is destined primarily for screen and online viewing you should always work in RGB;
- ▶ if you aim primarily for a printed material you should stick to CMYK;
- ▶ if you are planning to use the image as a publication figure, refer to your journal guidelines beforehand and follow their requirements.

Therefore, **for presentation slides, always use RGB. For posters, conference flyers or leaflets, go for CMYK.** In case of scientific figures, the primary destination has shifted in recent days from printing to onscreen rendering as most publications are published online in advance. So CMYK or RGB? For traditional reasons, **many scientific journals still specifically ask for CMYK figures.** If that is the case with your chosen journal, favour working in this model. At the same time **RGB images are also increasingly accepted by scientific journals.** If your journal is one of them, by all means, work in RGB. Be aware that some (open source) graphic tools offer by default only one colour model to work with, for example GIMP creates RGB images only. An extension called Separate+ for GIMP offers some colour management features including RGB to CMYK conversion.

However, **colour model conversion from RGB to CMYK is not straightforward** even if sometimes necessary. To be done correctly, it requires so called colour profiles to be included in the internal information of your image (ICC profiles). Nevertheless, even if your image is tagged with a colour profile, **there is no one way of converting one colour model into another.** As CMYK has a way more restricted colour gamut than RGB, the conversion outcome is usually approximative and sometimes requires manual tweaking afterwards to get closer to the look in RGB. Professional graphic software tools

like Adobe Photoshop offer usually several options for converting image colour modes depending on what exactly you want to achieve. If you have no access to Adobe, online converters exist and can do the conversion for you. In any case, if you must convert RGB to CMYK, be careful and **check if no data or detail loss occurred**. Some colours like very saturated cyans and blues can become almost indistinguishable when converted to CMYK. Bear in mind that each colour conversion or transformation also decreases the final image quality. The bottom line being, the conversion is feasible but if you can avoid it by planning ahead, do so.



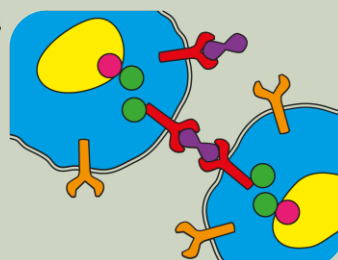
A related article “Digital image file formats”, p. 16, explains which file format is able to store which colour model(s).

Sources and further reading:

“Color Figures in Biophysical Journal: RGB versus CMYK” by Dianne McGavin et al., Biophys. J., Vol. 88, Issue 2, February 2005, pp. 761-762.

## Colours in scientific figures

Often enough I see schematic representations in scientific papers or presentations that look something like this: ➡



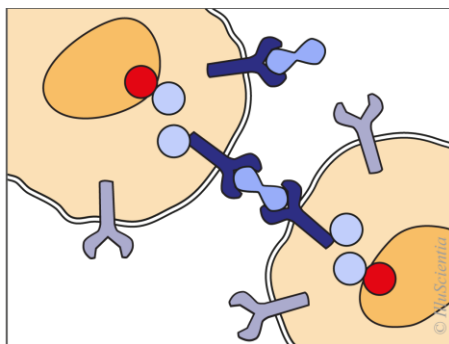
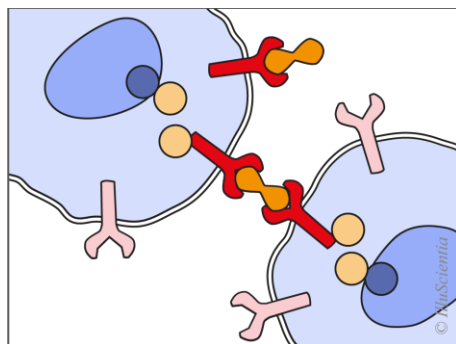
As many as seven colours are used, with same level of intensity (red, blue, yellow, orange, violet, green, magenta). The outcome looks... colourful. The downside is that this colourfulness does not help carry the scientific message. At this level of colour intensity and abundance, there is no hierarchy and no more distinction between elements. This image could be in black and white instead and the level of information would be exactly the same.

Here are some ideas how to use colour more effectively:

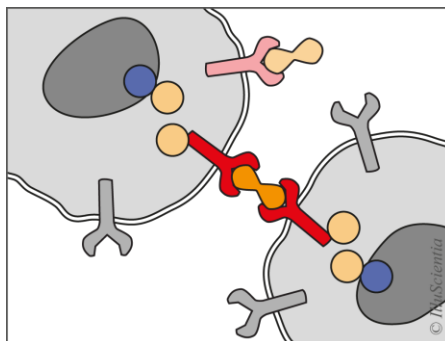
- ▶ choose maximally **2-3 colours per figure** and vary their saturation and brightness to increase the number of colour combinations with tints and shades;
- ▶ use **complementary and / or analogous colours** for colour harmony (colours opposite each other or neighbouring on the colour wheel). For example: orange and blue are a complementary pair, magenta and violet are a neighbouring pair;
- ▶ use **warm colours** (colours closer to red on the colour wheel) to **push elements visually into the foreground**. Analogously, **cold colours** will **push** them **visually into the background** so use them for elements that play a secondary role;
- ▶ **create contrasts** by introducing **pale tints and darker shades of the same colour** instead of only using different contrasting colours of similar intensity;
- ▶ be consistent in your **colour code**: if you have **several figures** in a presentation / publication, highlight the **same elements** with the **same colours** in all of them (varying intensity and brightness if necessary). This way the colour code helps your audience read the figures more efficiently;

► use **colour punctually**: highlight in colour only the elements that really constitute the core of your message. Keep the rest of your image in grey scale. This is a very powerful way of using colours.

These figures use 3 colours: red, orange, and blue. Additionally shades of red, blue and orange are employed. Both figures highlight in particular the elements in intense red, orange and blue with secondary elements being paler and appearing to be in the background. The figure on the left seems to focus mainly on the two receptors connected via a common ligand due to highlighting in red and orange. On the other hand, the figure on the right draws more attention to outcome of this connection and the reaction in the cell nucleus.



This figure uses spot colours. Colouring only some elements and keeping the rest in grey scale can actually be the most effective way of highlighting chosen elements.



Further reading on the topic related to colour figures and colour in data visualization:

"Why should scientists be worried about colour?" by Bernice E. Rogowitz and

Lloyd A. Treinish from IBM Thomas J. Watson Research Center, NY, describes possible problems of colour choices in data visualization.

# Colour-blind friendly designs

Text author: Senthil Arumugan, CellPhyLab

Scientists use very often red and green hues as main highlighting colours. However, for people suffering from colour vision deficiency, the red-green images look almost like a monochrome image with red and green virtually indistinguishable from each other. If colour is the only difference in images, part of your audience will be excluded from immediate understading of your message. Despite of what you might think, this fraction is not negligibly small but can refer to up to 8% of male and 0.5% of female readers. Besides, there are also reasons of good practice not to rely solely on colour to distinguish between different elements.

Here is how to design in a colour-blind friendly manner:

- ▶ for graphs, **plot your data using different shapes for your data points along with different colours**, which makes it accessible to all readers and prevents any confusion while interpreting data;
- ▶ **change the colour brightness** or hue as the **contrast** is something that **remains preserved** even if colours are not - example: whereas red and green at 100% of saturation look practically the same to a colour-impaired reader, red at 70% of saturation and green at 100% of saturation will appear slightly different;
- ▶ if you publish **microscopy images**, **provide the grey scale images of the individual images in the supplementary material** to allow readers to download and re-overlay in the colour combination that suits them best;
- ▶ another solution is to **provide the images with a different than red-green colour combination** in the supplementary material. Remember to provide simultaneously several colour combinations, not only the magenta/cyan one;
- ▶ **test your figures** to realise how colour-blind people will see it. This can help you filter out and adjust these colour combinations that are particularly

difficult for colour-blind readers:

- **online** with websites like **vischeck.com**, which show the images corrected for colour-blind readers;
- in **Gimp**: in the tab View > Display Filters > Color Deficiency, select and add to the available filters. It will simulate the image as it would appear to a person with a certain type of colour vision deficiency;
- in **Scribus**: try the Color Wheel plug-in, it can help to visualize colours seen by colour-blind people;
- in **Adobe Illustrator / Photoshop**: Choose View > Proof Setup > Color Blindness, and then choose either Protanopia-type or Deuteranopia-type.

The mentioned considerations should not be just limited to figures in publications but can apply generally to any figure, presentation slides, plots or visual data where colours are used to distinguish elements.

Sources:

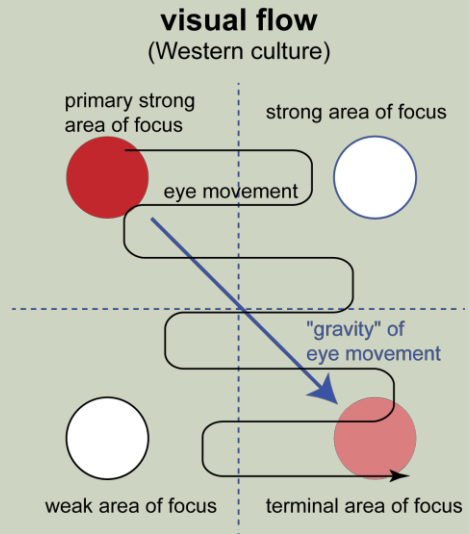
“How to make scientific figures and presentations friendly to colour-blind people” by Masataka Okabe and Kei Ito



# Figures and images in scientific poster design

Visual flow is the way you guide a viewer through a poster so they look at the information in the order you want them to. ➡

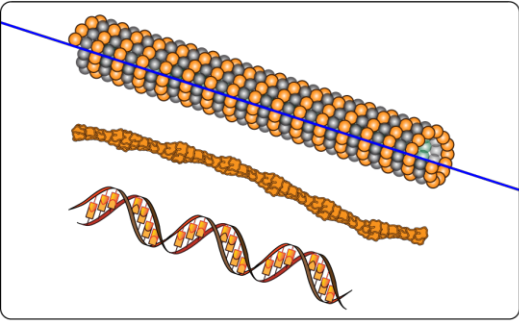
There are simple solutions to guide your viewer, for example, numbering or adding arrows to indicate the sequence. However, more subtle ways exist to achieve the same effect.



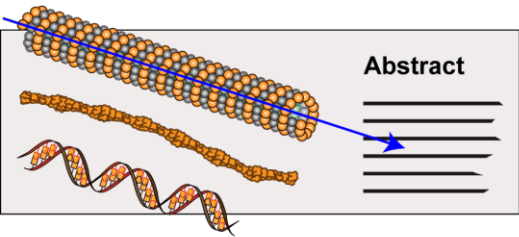
## How to use images to improve visual flow in a design:

- ▶ choose your **images** in such a way that they alone **already tell your story**;
- ▶ bear in mind that **images create strong focus points** on your poster so place them in such a way that the visual equilibrium is maintained and attention is drawn to the parts that you want to highlight;
- ▶ remember the “**visual weight**” sequence: **plot < schematic illustration < photo or photorealistic image**. **Colour images** always “**weight**” **more than black and white** ones. Visually a photo will create a stronger focus than a plot or a schematic representation;
- ▶ look for **natural directional elements in your images**. If the directionality is strong and you place your images disregarding it, you may involuntarily make your viewer look off your poster and move on to the neighbouring one without even reading through one half of your introduction;
- ▶ **link your images with the text** by alignment or additional elements.

Natural directionality

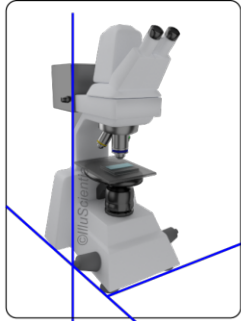


Example of alignment and linking of a text and an image to enhance the visual flow.

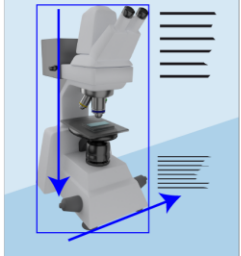


Natural directionality in images can be used to improve and reinforce the visual flow in a layout.

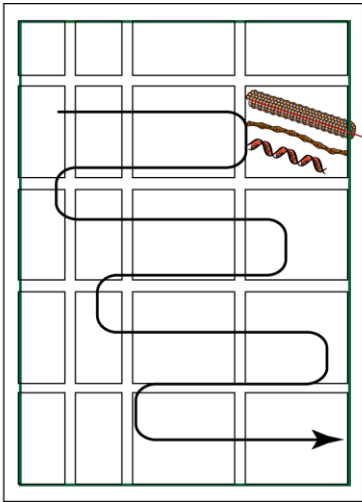
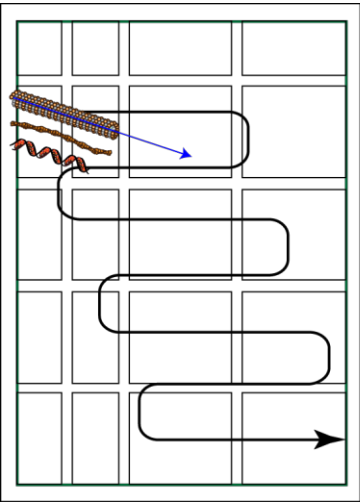
Multiple directionality



Alignment and linking by adding a decorative colour change along the natural directionality



Example of an image directionality aligned in favour (left) or against (right) the visual flow in a layout.

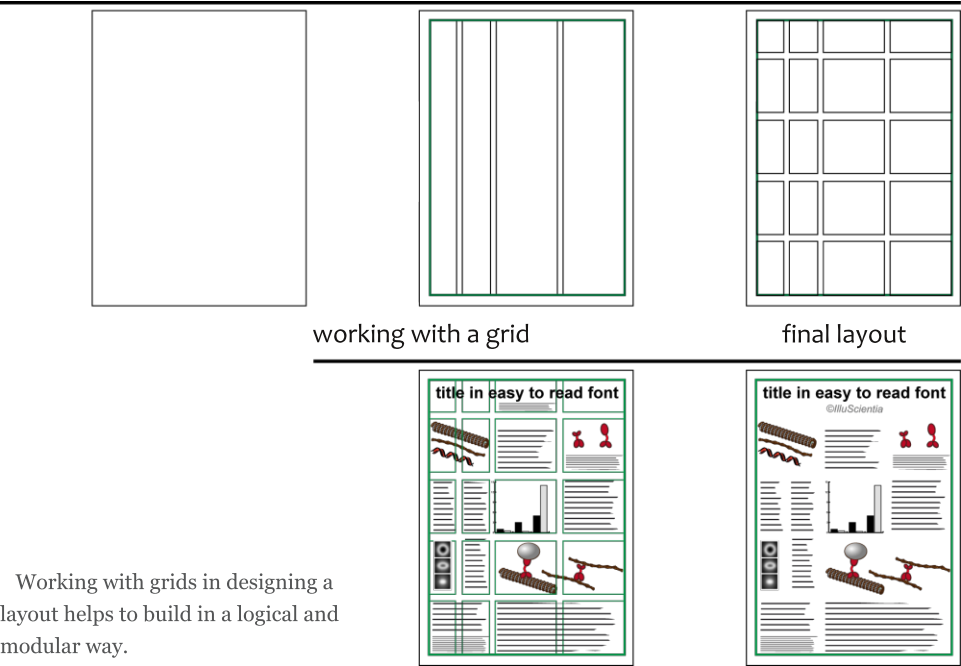


Directionality of the image placed in this layout makes the viewer naturally look off the poster

## Grids in Layout Design

There is a tool graphic designers and scientists alike use a lot even though they don't mean exactly the same thing. **Grids**. For a graphic designer, a grid is a division of a page into horizontal and vertical spaces taking into account margins, spacing between vertical columns and horizontal rows and spaces between blocks of text and images. **Grids help to build the design in a logical, modular way and make it way more consistent.** The decisions concerning the number of columns and / or rows, the spacings and margins are yours to make. This initial grid should reflect your intended visual flow and be in alignment with the quantity and the hierarchy of your information. Once you set up your underlying grid, be consistent in placing your elements on it. However, elements can occasionally break out of your grid as it is not cast in concrete. An image or a text that overlaps a margin is an example of grid breaking and might be a way to add an extra focus to this element. Be careful though and always think twice why exactly you want to break out of the grid.

setting up a grid



# Tips on poster design

Text author: Pieter Torrez, MSc

This article was featured on [thefloorisyours.be/en](https://thefloorisyours.be/en)

As a marine scientist with a creative mind I started studying biology at the University of Ghent. As soon as I got more involved into the academic world through conferences and presentations by researchers I experienced a lack of adequate graphic skills in scientific research. But how do you decide which graphic elements are needed in your poster presentation if you do not have a background in graphic design?

## How to create a beautiful poster — in five tips:

► **draw a scheme of your scientific poster.** Start by drawing a sketch with the non-visual (text) and visual elements (graphs, images, photographs,...) you are going to use and decide in which programs you will be able to prepare each and combine them. There are numerous graphic design programs that can be used for free to design graphics for a poster. Among others:

**Rstudio and ggplot2** offer endless possibilities once you are acquainted with the software. However it can take a while to start with R programming language. You can find several R beginner courses on the internet, two popular sites for R are **r-bloggers.com** and **zevross.com**. There you will have example datasets and the code behind them which you can copy and customize for your graphs. See a gallery of amazing graphs made with RStudio at [https://gallery.shinyapps.io/genome\\_browser](https://gallery.shinyapps.io/genome_browser)

**Qgis** is a free and open source geographic information system to plot your data on a map. In recent years a lot of beginner tutorials for this tool have been published on youtube which makes the learning curve less steep;

► **use maximally 2-3 colours.** Colours have a graphical and functional role. Firstly, they invite the reader to stop at your poster, secondly colours are used to structure the information (titles, subtitles, ...) so readers can easily process it. The more colours are used on a poster, the harder it is to see through the

structure of the poster and the less appealing it will be to read further. If you do not know which colours to pick, it is a good idea to use colours which can link the poster to your institute / university or topic. This way you will create a cohesive colour code connecting your work automatically to your institute and / or your topic. ➡

A tool I often use is the **eyedropper**. It allows you to pick a colour from a picture so you can get the colour code and use it in your design. To get an eyedropper you can use the following programs: Paint, Adobe Photoshop, Gimp or **instant-eyedropper.com** (Windows), or an online tool like **imagecolorpicker.com**;

► **accompany your text with the right visuals that fully support the information given in the text.**

The use of visuals (images, graphs, ...) can be very beneficial for your poster. Select the ones with the best quality. Add fine-tuned figure captions;

► **reduce the amount of text.** 1/10 of a second is needed to get the sense of a visual scene. It is important to reduce the text as much as possible and to write your information to the point. Remember, there are no scientific events where you get a price for the number of words. Icons can be useful to replace text but be aware that some icons can have multiple meanings. Popular websites to find icons are **iconfinder.com**, **icons8.com** and **thenounproject.com**;

► **add a picture of yourself.** It can be really helpful for potential readers to find you in the crowd and to establish new contacts (and that is one of the main reason why you want to present a scientific poster, right?) If you cannot be present at the conference to answer potential questions you can add a little box with sheets containing an extensive summary of your research or a copy of a publication of the content of your scientific poster if already published.

Using your institute visual identity on the example of University of Ghent: yellow and blue colours of the logo could be your poster color code.



Connecting visually to your topic: if, for example, you do research on gulls you can pick the dark grey and yellow colours from an image of a gull to create your own colour scheme.



# Tips and tricks to design scientific presentations

Scientists presenting their data almost always start by introducing their topic and then moving on to showing the collected data. The high level of technical information often produces slides cluttered with intricate plots which makes it difficult to follow the presentation.

There are essential steps that should precede any attempts to design a presentation, like considering the targeted public, choosing the core message and crafting a narration, all of which are described in detail elsewhere (see sources below).

From the point of view of design however, simple tricks exist that always improve the clarity of your presentation slides:

- ▶ **choose a font and colour scheme for your slides** (1-2 main fonts and 2-3 main colours plus their tints/shades) and **be consistent** in using them throughout the entire presentation;

- ▶ assure the best **contrast between foreground and background elements**. Colour combinations like dark blue on black or yellow on white do not provide enough contrast. Personally, I prefer the combination of a clear background with dark, nearly black text but a dark background and light colour for text and figures is providing an equally good contrast. If you choose a **dark background** for your slides and need to **invert the colour scheme of your publication figures**, make sure the resulting colours contrast well with the background. On a darker background, light elements look more slender so increasing the font and line widths may be a good idea as well;

- ▶ **avoid “boxed” figures**: for example, a rectangular white background surrounding a plot on a black slide will always appear very distracting. The best is to **remove the figure background** entirely, however do it only if you have access to the native format and the software with which it was created. If that is

not the case **soften the edges** by, for example, rounding or blurring them. Simply cutting out background colour pixels from raster images is usually producing very poor quality images and hence, not recommended. You can also **consider showing the figure at the full slide size** which can remove the problem of edges completely. Check however if your figure has a good enough resolution for that (ideally it should be 1024 by 768 px);

► if showing movies, the rule of thumb is **one movie per slide**. As for figures, if there is a colour difference between the slide and movie backgrounds and if the movie resolution allows it, show it at full slide size to avoid visible edges;

► **less text** is almost always a good idea: the slide is there to corroborate the story told by you. It is not there to have your audience read the text instead of listening to you. Ideally slides should tell your story through shown images with a minimal amount of additional text. Obviously this does not concern legends and labels that are necessary for understanding;

► **image resolutions of 96-150 ppi are completely sufficient** for slides. If you use paper figures that are intended for print with 300 ppi or higher, reduce their resolution as a high resolution does not give you any advantage on a screen. This will also keep your presentation size reasonable. Additionally, if the figure colour settings are CMYK (suitable for print purposes but sometimes problematic on screen), convert it to RGB.

Always adapt your publication figures for your presentations. Whatever the origins of the figure, it should match the font / colour scheme used in your current presentation: if it is a figure taken from a different presentation, be sure to adapt its font / colour scheme accordingly. It is really worth the effort.

*For more information on how to adapt publication figures for slides, see “Introduction...”, p. 13*



Further sources:

Muse of Fire: Storytelling & The Art of Science Communication by Tim Miller, published 2015 on [spokenscience.com/publications](http://spokenscience.com/publications).

Look up the lecture(s) by J.-L. Doumont on creating effective slides: “Design, Construction, and Use in Science” on youtube.



# Rethinking presentation design

Text author: Jakub Lewicki

There are more than 30 million presentations created every day in Microsoft PowerPoint. 120 million people are using this tool to illustrate their talks in education and business. It is undeniably powerful, useful and popular and it is hard to imagine academic talks without slides like the PowerPoint ones. But a fresh and unconventional alternative to traditional slides exists. When I first saw a presentation created with it, it managed to recapture my attention and wake my curiosity again on a long day filled with ppt presentations.

This tool is called **Prezi** and is a cloud-based application with a for-free option for creating presentations with a completely different principle than PowerPoint or other similar to PowerPoint softwares. **There are no conventional slides in Prezi. Instead, all the information, text, pictures, graphs and other multimedia are put on one canvas. Then the user chooses the pathway through the presentation to show the content in a dynamic way** just like defining a track for a camera movement. This technique is called zooming user interface (ZUI) and it allows for movement not only in 2 dimensions but also to zoom in and out to structure the content emulating a third dimension of height above/below your content. To better understand what I just described and how it works, fasten your belt and check out: **Free falling through prez.**

## Prezi for scientists

One glance suffices to know that Prezi offers a completely different approach to making a presentation than PowerPoint or other slide based softwares. But does that mean the approach is also better? It depends very much on the context and the type of presentation. Because of the dynamism that Prezi offers it can be a **great tool for creating science popularization presentations.** This less



conservative tool allows for **more freedom of design** and an application of a **less linear talk flow**. However, if used wisely, **Prezi can be also a powerful solution to create a beautiful, engaging and fresh scientific presentation**. Here's an example: **“The better angels of our nature”** by Steven Pinker of Harvard University.

Prezi's main feature “ZUI” is **excellent for presenting graphs, more complicated schemes and micrographs**. Very often I see large figures on slides that are unreadable because of their dimensions. Due to their complexity, it is hard to focus on details even with laser pointer assistance. Prezi helps to overcome this issue by allowing the user to guide the audience through all the details zooming into the particular places of micrographs or crucial fragments of graphs.

Another interesting application consists in **creating short presentations from scientific posters**. Very often during conferences selected participants are offered to show short teasers of their posters. But seldom have I seen an even remotely useful visual support for that. Files prepared for printing in dimensions of 70 by 100 cm are just illegible if shown on one slide. On the other hand, without too much effort, Prezi can import your PDF poster and convert it into a short presentation focusing on each part of it. Here's an example how I used this tool to show my own poster: **<https://prezi.com/fvwj2epfcqb/poster-presentation>**

I have also used the same material to create a fun version of the poster teaser for a science popularization event to attract and engage the audience (warning: opening slide has an audio!):

**<https://prezi.com/6ii9bbmoguod/poster-slam-building-brains-in-spider-webs>**

## Downsides

Prezi has its weaknesses, too. The first and major criticism is the fact, that when too much rotations and extreme zoom-ins and zoom-outs are used, the audience can feel a bit dizzy or just lost and overwhelmed. There seems to be an analogy here to the PowerPoint syndrome of the late 90's. At the beginning many users

were fascinated with all the options provided by this software, and as a result, too many unnecessary animations, sound effects and slide transitions led to messy and annoying presentations. It is the same with Prezi – **its features have to be used wisely and with moderation.**

Because of the completely different principle of Prezi, it can be a bit **difficult at the beginning for users that are used to conventional slides.**

However there are short tutorials available on the product's website. Also, your PowerPoint slides can be directly imported to Prezi to create a new presentation, but best effects are usually achieved when you prepare everything from scratch.

If you usually provide your audience with **presentation handouts** you have to know that this is **trickier with Prezi.** The software can generate a PDF version of all the snapshots however they might be less note-taking friendly.

With all that in mind I recommend you give Prezi a chance. If you are not sure about the possible reception by the audience test it first in a smaller meeting. I can guarantee you one thing – because of its freshness and novelty, you will get more attention which can lead to a larger engagement and eventually a better understanding of your talk. In science, the content is the key, but do not forget that the way you convey your message can really open the right door for your research.



*If, for any reason, you do not feel comfortable using an online and cloud based solution you can always check out Sozi - inkscape plugin. For more information on Sozi, see “Software tools...”, p. 62*

# Tips on biomolecular images

Illustrations of molecular representations appear regularly in scientific publications and communications as they are used extensively in structural and functional studies. A wealth of effective graphics tools is available for rendering atomic structures in several standard representations (a list of software particularly adapted to biomolecular images is available at rcbs website).

Here is a handful of compiled tips extracted from my own experience and sources listed below:

- **make it a habit to generate many figures for different contexts in one go:** a figure for publications with high quality rendering and resolution (300 ppi) and a figure with a transparent background (png format) at 72 or 96 ppi for presentations. If it is a complex structure and you are likely to need different aspects highlighted, anticipate and prepare the different versions in advance. If you think a gif of the rotating structure would be useful, generate the gif file as well. Much of this image generation can be automated in short scripts but it depends on your software of preference. This saves time of searching for the right file every time you need to generate a different version;
- **show only the level of detail required** to convey the specific scientific message in the given context: trying to highlight at the same time ligands, hydrogen bonding and the solvent accessible surface will most probably produce a confusing image. So, for example, highlight ligands if you write about them in particular but save the solvent accessible surface for another image;
- if your communication shows several images of 3D molecular structures, **define a reference orientation** early on, and indicate it in subsequent views to show how the following images relate to it. Similarly, introduce clear symbolic conventions and adhere to them throughout your entire communication;
- tools are tools: they have been developed with a specific purpose in mind and often enough excel in some tasks but not in all. So **explore and**

**experiment with different tools** rather than stick always with a familiar one. The initial effort invested in learning a feature-rich package will repay soon enough. Instead of trying to twist a tool not meant to produce the result you want, just turn to a different tool that can do it in a wink of an eye;

► **use anti-aliasing:** if ribbons, tubes or stick representations are rendered on a white background, particularly in a cartoon style (edges darkened) the edges often appear to be quite jagged. This is referred to as aliasing and occurs because a pixel is finite and defined to belong entirely to the structure or the background, even if the centre of the pixel falls directly on the boundary line. To create images suitable for publication, most programs have anti-aliasing options that you should use in order to smooth out the jagged edges. Anti-aliasing is computing intense and makes most sense for single images, less so for animations;

► **journal covers feature often molecular images based on structural data.** Covers are nonetheless tricky to create as a certain degree of artistic licence and an extensive amount of post-processing of raw graphics are usually required. If your idea is just a high quality image of your structure, use a software tool that allows for high resolution rendering (2480 x 3508 pixels for an A4 image at 300 ppi). Try GPU-accelerated or graphic card rendering to speed up the process. Truly stunning results can be obtained by exporting your 3D structure into a professional 3D animation software. If you happen to know how to use a 3D animation software, save your structure as .stl or .vrmf / .vrm mesh in your molecular visualisation tool. Most 3D softwares like Maya or Blender can import .stl or .vrmf or work with dedicated plugins like ePMV that import your structure for you;

► **move it:** simple movies of molecules where the molecule is static and the camera is rotating are easily made in most of visualization softwares. In general, **between 40 to 72 frames per 360° rotation are necessary.** The movie should end with the same frame as it starts to have a smooth transition when it is played in a loop. Movies of dynamic molecules showing, for example, conformational changes can be generated with Bioblender (not all representation) or in other 3D animation softwares. The latter have however a steep learning curve;

► **make it real: your 3D structures can be 3D printed** – showing the 3D print of the molecule your structural studies focus on, is a great way to engage with your audience during a poster session or a presentation. I guarantee that the

response will be more than positive. Ask your local 3D workshop for further help or watch a tutorial on Blender workflow to prepare a 3D model for printing.

Further reading:

C. Mura and al., An introduction to biomolecular graphics, PLoS Comput Biol. 6(8): e1000918, August 2010. This post is largely based on this work.

D. Goodsell, Visual Methods from Atoms to Cells, Structure, Volume 13, Issue 3, pp. 347–354, March 2005

# Scientific animation as a tool for researchers

Have you seen the high-end scientific animations about inner life of a cell?

A three minute animation shows a whole chapter of a textbook in a mind blowing manner. This kind of animation exceeds by far what a statistical researcher needs in their work. However, simple and relatively easy to produce videos or animations are a great tool to deliver your message efficiently. Animations can enliven your presentations as well as your websites and consequently, generate more interest in your work.

## Animations in research communication

Some signs that indicate an animation may be a better way to communicate your message than a static illustration:

- ▶ the schematic representation of your **model contains six or more consecutive steps**;
- ▶ your schematic representation tries to show **simultaneous processes** (for example you need to use more than three arrows to indicate what is going on);
- ▶ you want to represent a **highly complex structure or data** (three layers of complexity or more);
- ▶ the **processes** you want to represent are **spatially and dimensionally dynamic**;
- ▶ your model tries to combine **several orders of magnitude in scale or time**.

Depending on your topic, an animated version of your basic schematic representation may be already a good solution. In this case all you need to do is to separate your detailed image into several images containing individual steps that can be easily animated in your presentation. For molecular topics, going

from a single image of a 3D representation to an animated version is usually just a step away, and may bring a way clearer message. Many software tools used routinely by scientists can be employed to this end (Chimera, Pymol, VMD). Where there is will, there is usually a way, too!

## Animations in higher education

Computer animations are still a relatively new educational tool that helps students, in particular, to better understand spatially and dynamically complex processes. Moreover, it has been demonstrated that using animations to communicate temporally and spatially dynamic ideas and processes reduces the abstraction associated with them. Simply put, shown as an animation, students grasp the process as a whole instead of seeing it as a collection of individual steps.

## Videos in science popularization

If you asked around on a street, most people would tell you that images and short videos or animations are the best way to get their attention and make them interested in a scientific message. So if a science popularization event comes up next time, try producing a short video on your topic of choice and be assured of a more interactive reaction of your audience. Your video does not have to be very elaborate, actually simpler is better, in particular if it turns out a bit funny, too. Humour is always a great way to engage with a non-specialist audience.

## Videos helping to commercialize a scientific result

If your research yields a result that can be commercialized, you are likely to want to licence it or find investors and customers to turn it into a company. In such cases, I would argue, video is the tool to go for. Depending on the topic, it can be a footage shot with a camera or an animated sequence or a combination of both. These videos should be short and outline a patented process or highlight specific advantages in a process in a clear and accessible manner. Instead of spending hours trying to make potential investors or industrial partners understand the basics, this type of video can get your discussion quickly to a level

where details are sorted out. In this context, a short video is simply a fast lane to convince your potential partners and customers and get your project going.



*Further suggestions of 3D programs specially designed for scientists that can help produce short animations are MolecularFlipbook and BioBlender. For more information on the latter tools, see “Software tools...”, p. 62*

Sources and further reading:

J. H. Iwasa, “Bringing macromolecular machinery to life using 3D animation, Current Opinion in Structural Biology”, Vol. 31, April 2015, pp 84-88.

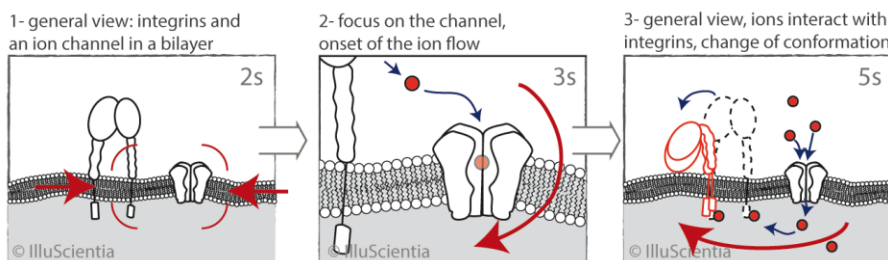
P. McClean et al. “Molecular and cellular biology animations. Development and Impact on Student Learning.” Cell Biology Education, 4(2), 2005, pp 169-179, (+ citations therein).



## Storyboarding animations

Many processes and data stacks in science cannot be simply depicted by still images. Animated images are sometimes the only way to convey or even uncover the whole information hidden in the data. The ability to produce a computer animation or a short video at an acceptable cost and within a reasonable amount of time has created new possibilities for the scientific content. If your aim is to create a very simple animation of a rotating molecule or stitch together plotted data to visualize their change over time, you can do without a storyboard. In any other case, a storyboard is a crucial step of preparing an animation / video production, in particular, if you plan to work with several people or to outsource the production.

In its narrow definition a storyboard is a simply visual outline in the form of illustrations, photos or images displayed in a linear sequence for the purpose of designing a motion picture or an animation.



An excerpt of a storyboard for a (imaginary) scientific animation. The sequence of images helps visualize the intended content of the planned animation and suggests some of the technical details of the production.

### Why is it important to have a storyboard before starting an animation production?

► **a storyboard visualizes each necessary event and their sequence,** thus making sure nothing of importance is left out and there is a **logical continuity between events;**

- ▶ a storyboard **can be shared** for inspection with your collaborators or just interested people to have their feedback;
- ▶ it **saves time and money** as first corrections and adjustments can easily be included at this stage before embarking on the time consuming full scale production;
- ▶ it **helps define the general aesthetics and the level of detail** as well as the graphic environment for the final animation in agreement with the intended events;
- ▶ it gives you an overall **rough estimate of the video length** so it can help evaluate the initial time and budget investment of the production.

## What should a storyboard for a scientific animation / video contain:

- ▶ indication of **movement direction and its quality** (for example, a protein moves closer to a binding site);
- ▶ property changes like **change of colour or opacity, size or shape** (in our example: the protein conformation changes when binding);
- ▶ **highlighting of a given event** by special effects (for example adding glow upon molecule binding);
- ▶ **change of scene** (for example change from a molecular to an atomic view);
- ▶ storyboard should **indicate camera movement / zooming in and out** (for example moving along a structure to give a better sense of it or get closer to focus on a given detail);
- ▶ even though this is the trickiest part sometimes, a storyboard should estimate **timing for each event** shown in an animation.

Generally, a storyboard should be as specific as possible in terms of how the events should unfold, describing visually the type of movement and / or change. There is usually **no text** included on the storyboard itself but **keywords can be used** to clarify some points. If the project is complex, the storyboard is often accompanied by a **script** giving context to each image panel. Additionally, it is a good idea to **number or label each panel** for reference. If there is an alternative way of visualizing events this can be included too and should be numbered or labelled accordingly.

In the strictly scientific context, animations are frequently without a soundtrack as they are often used during scientific conferences where the speaker provides the explanation. However, if you intend the animation to be viewed for example online, consider adding **a spoken track or subtitles**. In the latter case, prepare the text together with the image panels of the storyboard. Visually, storyboard for scientific projects can be kept in simple **black and white with colour use reserved only for special highlights**. If the storyboard is visually simple, it is a good idea to prepare a separate image of a more finished look to exemplify the intended aesthetic choices in the finished video / animation.

Special software tools for storyboard design exist but in the context of scientific animations, there is no real need for them. Any graphics software will do or just a sheet of paper and a pen.

## Shortcomings of storyboards:

- ▶ timing of each event is likely to need adjustments depending on the context;
- ▶ the look of the movement itself is often hard to capture on single images or describe in words. This is where a first draft of the animation comes in play.

## Commissioning a storyboard, an animation ...

If you plan to commission a scientific animation / video from a professional designer, they will create one for you based on your script / explanations. In that case, when the first storyboard has been created, be sure to check several times before giving any feedback the following points:

- ▶ **are all necessary events / movements / changes referenced visually?** Remember that if an event is not shown in the storyboard it is not going to appear in the first animation draft either.
- ▶ **are the events and their exact sequence shown correctly?**
- ▶ **is the depicted level of detail appropriate** to reflect correctly all the events?
- ▶ **is the suggested timing matching your intended length?**
- ▶ **have all the people involved in the project agreed on the storyboard?**

If something is unclear, simply ask. Always bear in mind that **the storyboard is the step where most of the corrections should occur in the animation production**. Altering an existing animation draft substantially is always more time consuming and difficult than changing the storyboard. It might seem like quite an effort to create a storyboard but going through this step is the best way to ensure that your animation / video project runs efficiently and results in a truly useful communication tool appreciated by your public.



*Suggestions of 3D programs specially designed for scientists that can help produce short animations are MolecularFlipbook and BioBlender. For more information on the latter tools, see “Software tools...”, p. 62*

Further reading:

The Art and Science of Computer Animation by Stuart Mealing

Blog article on crastina platform “Shining a light on the dark art of animation” by Claudia Stocker

<http://crastina.se/the-crastina-column-september-shining-a-light-on-the-dark-art-of-animation/>

# Graphical abstracts for scientific publications

## As simple as possible but not simpler

Graphical abstracts for scientific publications in the form of a single, concise image have been around for a relatively short time, starting in 2009 to the best of my knowledge. Most of the time they are intended only for the online synopsis of the article. Well designed, graphical abstracts allow readers to quickly gain an understanding of the main take-home message of your paper. They encourage browsing, make the message of the paper more accessible to scientists from other fields, and help readers decide rapidly if your paper is relevant to their research interests or not. The typical graphical abstract consists of just one panel, sometimes divided into sub-panels. Owing to its unique purpose, a graphical abstract needs to be distinct from figures or diagrams included in the paper itself.

### Here is a summary of general guidelines for graphical abstract design:

- ▶ depict **one process** or make clear **one point**, only. It should reflect the very **essence of your take-home message**, nothing more or less, so let yourself be guided by Ockham's razor in choosing your point;
- ▶ respect the **visual flow** by providing a clear start and end of the narrative image, “reading” **from left to right and / or from top to bottom**;
- ▶ if relevant, **provide graphically a broader context** of the obtained results or presented processes (examples: if it is a cellular study, show visually to what type of tissue / species it refers, if it is a protein, what sub-cellular organelles it refers to, if it is a new device / technology, what is the main application ...);
- ▶ try to **avoid** including **plots**: **all the parts** should be **in a visual form**, it is a graphical abstract after all!

► be **parsimonious with text** and labels, use **only simple labels**, clear also to non-specialists. Employ **fonts like Arial, Helvetica or Myriad** with **font sizes larger than 12 pt**: online images are usually quite reduced in size so smaller fonts are hardly legible;

► **use colours** but use them in an effective manner: create a **restricted palette of few colours** for your entire image and use them consequently, **avoid** only **saturated, primary colours** that are usually too dominating for small images.

If you want to see examples of redesign of existing graphical abstracts and successful graphical abstracts have a look at already available sources like the graphical abstract guidelines from Cell Journal. They are specifically aimed at biology but the examples are very well explained and with some extrapolation applicable to other topics as well.



More hints on effective colour use are included in the separate article “Colours in scientific figures”, p. 27. An alternative to a graphical abstract is a video abstract. Be sure to have a look at the article concerning the latter, p. 53.

# Video abstracts - Audioslides - for scientific publications

Graphical abstracts for scientific publications in the form of a single image may not be particularly interesting in some cases. Some authors feel this is actually a poor way of representing a scientific paper. Therefore, a newer trend seems to be going away from a simple graphical abstract and towards a video abstract in the form of a short presentation with a voice-over. Within 3-5 minutes, I personally would favour three minutes, you walk a potential reader through the highlights of your paper in your own words showing chosen figures or specially prepared slides.

Some of Elsevier journals offer the possibility to directly upload and link such audioslides to the corresponding manuscript. Even if your journal does not provide it, you can anyway make a video in this style on your own. Nowadays almost every lab has a website and can embed videos or links to videos posted on any available video platform.

## What is in it for your scientific publication - the advantages of video abstracts:

- ▶ a video abstract is by far **more comprehensive** than a graphical abstract giving a **real opportunity to explain the basics** of your results;
- ▶ you can **include movies** that are in supplemental materials of your paper and can possibly be the best illustration of your findings;
- ▶ a video abstract gives your publication a more **friendly appearance** as you explain it in **your own words** and one can hear **your voice**;
- ▶ you can use the video to **share your publication on social media** and hence **boost the impact** of your paper;
- ▶ making short video abstracts for your bigger publications and storing them on your website, provides a very **efficient video library** for the **major**

**highlights** of your work. Your potential **students and collaborators** can **have a first-hand quick overview** of the scope of your work even if they can not meet you in person.

As a video abstract is essentially a short presentation with a voice-over, you are practically rehearsing your future presentations. You show your paper figures, adapted as usual for your presentations by removing smaller fonts or parts of the data that are too detailed for slides, which is what you are doing on a regular basis anyway, right? Recording voice and turning a ppt presentation into a video is explained in detail on MS support website (latest ppt versions). Recording voice in any other audio recording program and adding it to your suitably adapted and scaled images in any slide or video editing software like Windows movie maker or Blender video editor, works perfectly well, too. The production of such a video can be a bit daunting at first but once it is done, you can use the video infinitely in a variety of contexts and next time round, it is going to be a piece of cake! Well, almost!

Don't forget that the general guidelines for graphical abstracts apply to video abstracts as well!

*Since writing this post in 2015, I have seen several video abstracts that consisted of the visual of the scientist just reading the abstract or the introduction of their paper. Needless to say, this is a very poor way of using this tool.*



If you have not read the article about graphical abstracts jump from here right to page 51.



# Augmented reality tools for communications

Let us imagine that you have a scientific poster showing still images extracted from an image sequence or representing a 3D structure. This can be enough to illustrate your point, but sometimes you need the full information contained in a movie or 3D structure to fully explain your message. A common fix is to present the full movie or a rotating 3D structure on your laptop or tablet next to your poster but it is a bit of a hassle though. These situations are a fairly common occurrence in biology-related fields.

Have you ever wondered if there was a better way of doing it? Have you ever thought of using augmented reality (AR) tools for science dissemination?

One of the AR tools for linking printed images to movies is Artivive. Originally an app aimed at fine artists, its principle is to link a physical image — for example a printed poster — to a movie that is stored in the app database. When a smartphone user (you or your audience) points their phone at the poster within the app, it will automatically identify your image. The app does it by detecting the features of your image and comparing them against the target images in their data base. Once the image is identified, the app launches and plays the linked content. Through the camera view of the phone, the recognised image is replaced by the video giving it an illusion of playing in real world. The app has proven to be very reliable in recognizing the uploaded images and starting the linked movies.

If you want to give it a go, here are a few points to keep in mind:

► to upload your target image and the linked movie, **you need to create an account on Artivive — it is free for students.** In the free version the

number of projects (image + linked movie) is limited to 5 per account;

- ▶ your printed image must be identical with your uploaded target image. The **aspect ratio of the image and the movie should also be identical**. You can use the first frame of your video as your target image in which case you don't need to upload a separate image;

- ▶ the maximal size of your image must not exceed 12MB, video size should be smaller than 100MB, **accepted formats are jpg and png for images and any video type or gif for videos**;

- ▶ **the movies have to be short** as the app works only when being pointed at the image so the phone needs to be held up for the duration of the sequence. The app developers recommend movies that are **no longer than 45 s, I would say 30 s or less** are ideal;

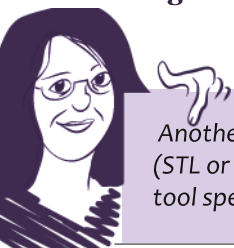
- ▶ it is best to have a **movie relating directly to your printed image**. For example some crucial elements of the image could be shown throughout the whole sequence to **keep the connection between the image and the watched movie**. A movie that uses the printed image just as a starting point or shows completely different information voids a bit the purpose of the linked content. Remember that you or your audience will still need to hold their phone up to the image to watch your full video even if your movie switches to showing different content.

## Some advantages of an AR poster:

- ▶ **anybody who has the app on their phone can watch your movie whether you are present at your poster or not**. It suffices to indicate that your poster is an AR exhibit;

- ▶ if you often show still images that are part of an image sequence or depict a 3D structure, **using an AR image can save space on your posters and help it be self-explanatory at the same time**;

- ▶ while linking the poster to an uploaded video content could be achieved also via a QR code or a website address, **an AR image remains a stand alone image**.



Another existing AR tool Vuforia allows to link target images with 3D object (STL or OBJ meshes) instead of videos. As of January 2020, Schol-Ar — an AR tool specifically for science — is being developed.

# Images for social media

## How to quickly transform an existing paper figure into an image for general public

Let's say you have a bigger scientific publication coming out soon and you would like to have an image to share together with the news of your results. This may be a classical press release or a note on your personal website or, what is more and more common, a post on your blog or social network platforms like Facebook, Twitter, Pinterest ... The latter is a great way to engage with people interested in your research and it is very image hungry!

Below, I show a case study how to quickly prepare an image for precisely this purpose!

I already hear you say: I spend enough time preparing figures for the paper itself, I will just use one of these! Well, that is usually not a good idea and here is why: you have a completely different audience for your paper (specialists) than for your press release (science interested non-specialists). Moreover, figures in publications are usually in need of the context provided by the text, whereas figures for general public should be largely self-explanatory and visually attractive enough on its own.

There are essentially **two types of images** that can be used in this context. The first is a **“narrative”** one: it will **tell a story** to the viewer about your discovery or visually sum up the main hypothesis. The second type is a **“presentation”** image: an image, for example, of an atomic structure of a newly described crystal, of a new device or a zoom into a micrograph revealing an interesting pattern or texture. Depending on your publication, you may want to go for a “narrative” or a “presentation” type of image. Keep in mind that a “narrative” image is usually more time consuming to make but also more educational for your audience. “Presentation” image, on the other hand, can be visually very strong and more effective in attracting attention.

## Case study: transforming an existing figure into a “narrative” illustration

Starting out from a typical publication figure:



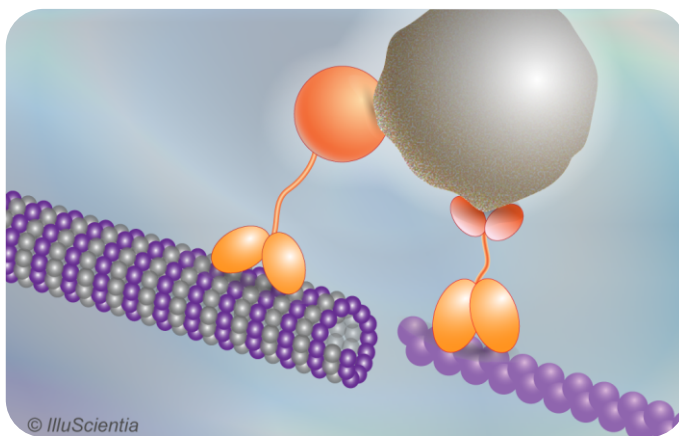
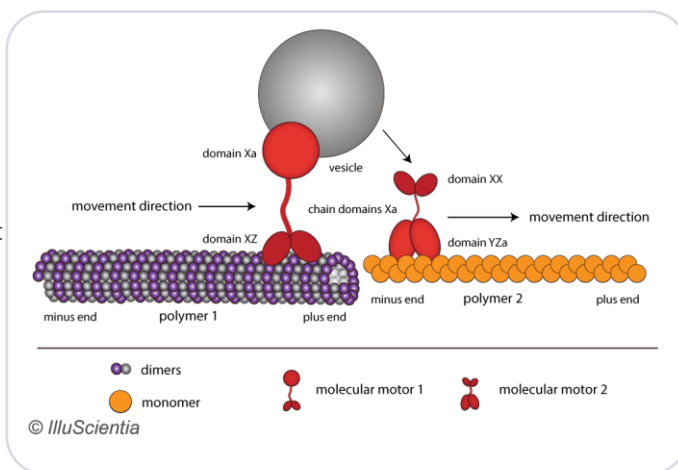
► **remove all labels, arrows, legends and any text** that is meant for other scientists in your field (scale bars can stay if relevant);

► **rework your composition.**

Whereas in a schematic figure you usually stick to representations that are very simple, often symmetrical, devoid of any perspective and fancy arrangements, here on the contrary you can scratch your creative itch. Try, for example, to **look for interesting points of view, angles, diagonals or add a bit of a perspective view...** In general, **avoid too many symmetrical elements and arrangements** and **take also into account the image format, the golden ratio and the rule of thirds**;

► **add background** which can be uniform or more nuanced depending on what you like, its purpose is to give cohesion to the whole picture but not dominate it. If you stick with a white uniform background make it a conscious choice;

► **play with colour choices, try colour gradients** (position them off centre), adopt more **complex**



**appearances**, add **textures**, introduce **irregularities**, in short, make the picture “richer” in details to dwell on;

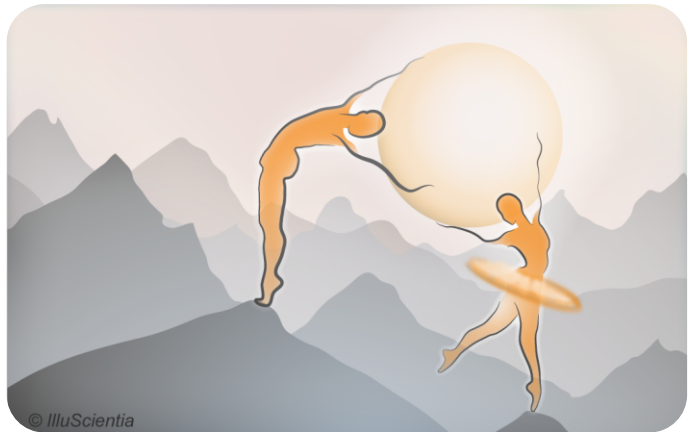
► you can further **add special effects like shadowing, halos, glows** and similar. However be critical and don't overdo it. Get inspired by images that you find pleasing! Don't forget to **have fun** with it!

*The whole process is summarized online in a short **gif animation***

As a side note, there is another type of images that are useful in this context: conceptual images that convey your message in a metaphorical way. For the illustration shown above, I have created this imaginary landscape with two

ballet dancers (but possibilities are boundless): ➡

These images can be often sourced from the internet. If you find an image that suits you, check that it is released under creative commons licence or, if it is copyrighted, ask for permission to use it. Cite the image source.



*For a general introduction to the image composition, see article “Image formats and composition”, p. 20. Make sure you choose right file format for your destination by looking up “Digital image file formats”, p. 16.*

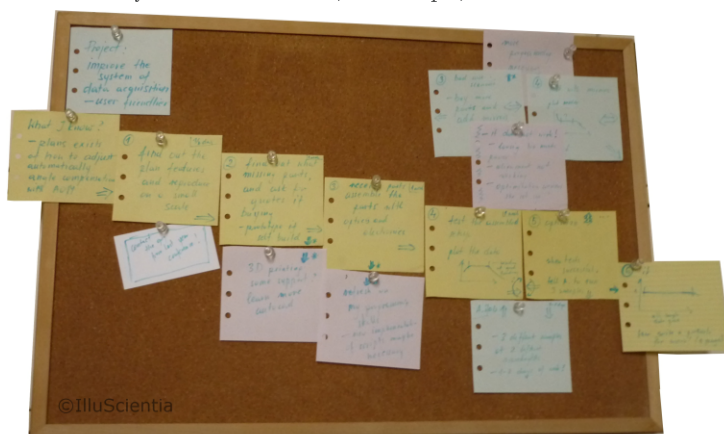
# Using storyboarding technique for research design

Does your team often work on the premise “first do the research, then just write down the results”? Does this lead sometimes to a stressful and inefficient process? Have you ever had a nice project idea late in the evening that then somehow slipped your mind and you can’t quite remember what it was anymore? If any of this sounds familiar, next time try to storyboard your projects! It can be immensely helpful to streamline, debug and flesh out initial ideas.

## Storyboard - broad definition

As it is mentioned in the article on “Storyboarding animations”, p. 47, a storyboard is a visual outline in the form of illustrations, photos or images displayed in a linear sequence. **A broader definition of a storyboard refers to a visual outline, a flowchart in a way, which attempts to visualize a process showing all necessary potential steps time- and sequence wise in order to achieve a desired outcome or solve a problem.**

An example of a storyboard as a visual tool for project design: yellow papers indicate main tasks to be accomplished, other indicate questions, comments, problems and possible workarounds. Digital version of the same storyboard would involve, for example, slide-oriented software.



If you have ever watched a police movie in which at some point criminal investigator writes down known facts on bits of paper and pins them on a board or wall along with photos, hints, and any complementary pieces of information in an attempt to piece it all together and maybe uncover invisible links, then you have seen a type of storyboarding technique. This understanding of a storyboard makes it a useful tool any time **a complex process needs to be split into smaller actionable tasks** and can be used in many scientific projects like research design, paper or grant writing, poster design, to name just a few. A **storyboard indicates key tasks and minor activities** (example: list useful techniques, measure samples, plot the data ... ), **possible partial outcomes, loose ideas and likely obstacles**, keeping in mind what the final objective is. It should be detailed enough to provide a clear story with all the elements necessary, however, **it should also be flexible and dynamic since a storyboard is meant to evolve as you progress with your project**. Depending on how things develop, **new tasks can be added, others can be removed or rearranged**. When a given task is completed, a brief summary is provided and the storyboard is updated accordingly. Such a visual outline of a project has key advantages:

- ▶ by being written down and visually noted, **storyboard can envision a research project and give it a more concrete and committed feel**. It can also identify possible intermediate findings or results that can be interesting by themselves, thus, creating an added value to the set goal;
- ▶ **it can be quickly reviewed and commented on** by your team members providing an early feedback;
- ▶ **it eliminates inconsistencies early on, includes uncomfortable questions and counter-arguments** that otherwise might be left unnoticed or unanswered until the day you face a tough question from your audience (or a reviewer ...);
- ▶ **it streamlines your efforts as you never lose sight of your intended take-home message**. If the time comes when you get bogged down by details it can always show you what you are aiming for, what has already been achieved and what is next to do;
- ▶ **it can help with procrastination** as it splits an often daunting overall goal into smaller, easier manageable tasks that can be tackled also on down days;



► it is in particular **beneficial for larger or interdisciplinary teams** where many collaborators need to produce a consistent story. A storyboard accessible to all should clearly show what their contribution is, where it fits in the story and when it should be done.

A great **example of storyboarding in a scientific context is starting out a future publication draft or a grant application** not by writing paragraph headlines but **by outlining the content of figures and their legends**. Once the main figure drafts are there and tell a consistent story, the accompanying text is fairly easy to write. The storyboarding of a scientific paper before actual writing is a great way to save on time and energy invested in every communication.

## How to storyboard your research project?

It all depends on your personal preferences and habits but one traditional approach is to grab **post-it notes** (or similarly sized sheets of paper) and find a place where they can be attached (wall, board, window ... ), ideally for a prolonged period of time. **Each post-it will contain only one idea, comment, task, image ...** Scribble your main goal and what your current ideas are. As you brainstorm, add smaller and bigger actions that can bring you to your goal, draw possible figures or mark what data plots will be necessary. Note down any ideas, questions and possible obstacles for each step. Try to **arrange the post-its in a way so that you have a story timeline going from your current situation to what you want to achieve**. Feel free to **rearrange, add and remove elements**. Once you have your main outline, invite colleagues to look at it with you and adjust your storyboard depending on their feedback. As your storyboard develops organically, keep track of changes by, for example, photographing it periodically and saving the images for later reviews if necessary.

**If you prefer digital, slide-oriented software has everything you need.** Each slide is one post-it containing one idea / comment / task / question / image. Once you have your initial storyboard, save it and don't overwrite. Create a copy with a new date when you make your updates. The advantage is that a slide presentation can be easily shared with far away collaborators for feedback. Whichever way you go and whatever your unique way of storyboarding is, the



important part is to look at it periodically to see how you progress, update it and keep clear track of where you started out and what happened so far.

If you are not familiar with this type of technique, it might take a little while to make it yours. And for some people, it might never work. Give it a try and see for yourself.

*Related articles are “Scientific animations ...” p. 44 and “Storyboarding animations”, p. 47.*



Sources and further reading:

“Storyboarding for research” by P. Dunleavy is a very good article with a detailed discussion of the tool especially in context of PhD thesis. This post is partially based on this article.  
<https://medium.com/advice-and-help-in-authoring-a-phd-or-non-fiction/story-boarding-research-b430cebd5ccd>

“Storyboarding a presentation or a talk” by Melissa Clarkson

<http://sites.ieee.org/pcs/using-a-storyboard-to-plan-a-presentation-2/>

“Storyboarding in education” by Andrianes Pinantoan

<https://www.opencolleges.edu.au/informed/teacher-resources/using-storyboards-in-education/>

# Software graphics tools for researchers

Here is a compilation of mostly free 3D and 2D graphics software tools useful for researchers and worth (re-)discovering.

This list is not exhaustive and does not include tools that are not WYSIWYG like povray or LaTeXDraw.

## 3D animation tools

Having a hypothesis concerning spatially and temporally dynamic processes on a molecular level? Wondering how to test it quickly? Have you heard about

**MolecularFlipbook.org** ?

Flipbook creator Janet Iwasa believes that testing your hypotheses in a three-dimensional scientific animation can help clarify your ideas.

The Molecular Flipbook is a free animation toolkit designed specially for researchers in biology or biology-related fields. This tool makes it easy to create simple short animations from pdb files. The website is meant to be a collaboration platform, therefore the created molecular models and animations can be freely shared, viewed and edited with fellow scientists. It comes with a small library of already existing source files that you can grab and use. It can be a valuable resource for free scientific animations.

**Blender** is an open-source 3D computer graphics application. It was initially developed for the entertainment industry but as it is cost-free it is increasingly hijacked by scientists and engineers. As mentioned in the article on biomolecular images, it can be used to import meshes created in specialized scientific softwares, finalise the design and render high quality images suitable for publications or cover artwork. However, its main strength lies in actually creating meshes and animating them. As every 3D software, it has a myriad of options and possibilities. It has a steep learning curve (see p. 8 for introductory literature) but

if you are willing to invest the time, there is no limit. Think about a modern cinema style animations. Blender is capable of producing such high level imagery. If you do feel that it is a bit over the top for what you need, check out...

**BioBlender**, a specially customized fork of Blender project for molecular animations, offering rapid production times and quick modifications if necessary. It can be used for: molecular visualization (import and visualization of PDB files), Molecular Dynamics simulation (protein model transition from one conformation to another) and complex protein surface property visualizations (e.g. MLP and EP surface properties). While the Blender interface can be scary at first, BioBlender itself is located only in one tab of Blender and can be learnt relatively fast. For the moment it has some limitations, but it may be a good idea to keep an eye on it if your core research is in structural biology.

## Big data visualization

**ParaView** is an open source software tool for interactive, scientific visualizations. It can be utilized to analyze qualitatively and quantitatively even extremely big data sets as it is designed for parallel computing. It supports variety of formats, including 3D meshes. ParaView can be further customized and extended by scripts written in python.

## Vector graphics tools

**Affinity Designer** is the new kid on the block of commercial software tools trying to defy the giant Adobe Illustrator. Launched in 2014, Designer offers as professional an environment as Adobe at a fraction of the cost of the latter. Instead of the per-subscription scheme of recent Adobe products Designer can be purchased per licence. If you know Illustrator, Designer is very easy to learn and use. Affinity Designer comes with all the familiar pen and shape tools to quickly create forms and shapes for your schematic representations, customize your plots and composite figures. It may lack some advanced Illustrator tools like perspective grids or shape builders but these tools are not commonly used by non-designers anyway. On the other hand, Designer has features that Illustrator does not have, like history panel that allows you to undo a chosen operation from

the list. Moreover it is a sort of hybrid software that goes in the direction of merging vector graphics and pixel-based operations in one seamless work flow. The software developers took seriously compatibility question and Affinity Designer is able to open and edit native Adobe file formats like PSD and AI with relative ease. That means that you can work with your old Illustrator files in Designer. Saving to AI format is not possible though, you can save either to the native format .affinity or export to PSD instead. Apart from that Designer images can be saved to all of the common formats like vector file formats EPS, PDF, and image formats PNG, JPG, GIF and TIFF.

If you look for professional software to do your graphics but the Adobe subscription scheme does not do it for you, Affinity Designer may be all you'll ever need ... that is, if it continues its promising start on the market.

**Inkscape** is a vector graphics editor that lends itself well to creating simple figures or even fairly complex designs like an entire poster. Despite being vector-based, it offers some features of raster graphics as well. It can be used to improve script-generated plots or extract elements from a pdf file in order to transform them further. Similar features are offered in **Xara Xtreme** but this tool is free only for Linux platforms.

Inkscape extension **Sozi** is an alternative to Prezi (see page 38) provides a different way to make a presentation, for example a short pitch or poster presentation. Sozi, once installed, allows to create a navigation path, zoom and move over the content of your presentation laid out on a practically infinite workspace. You can create your content entirely from scratch in inkscape or load an image created elsewhere, and then define your presentation steps. Saved as .svg file, any browser (offline) allows you to play such a presentation consisting in a series of translations, zooms and rotations that permit to focus consecutively on each element you want to show.

Sozi does not require you to store your data in the cloud and allows you to work entirely offline. If you are familiar with inkscape already, it takes just minutes to learn the basics of Sozi! Give it a try!

**Scribus**, a possible alternative to PowerPoint for poster design, is an open source desktop publishing program with powerful features for handling text and images. Simple to use tools include text wrapping around images, linking text

boxes, setting up font styles and variable line spacings as well as an efficient organisation of layouts. Images are stored as links to files, so if you update your figures, the poster is updated automatically. The output is a PDF file so all vector graphics remain intact. This document have been created with Scribus.

## Raster graphics tools

**Gimp** is already a well known program ideal for such tasks as photo retouching, bitmap image composition, and creation of photorealistic images. What's more, the latets versions partially supports vectors too, enabling you to keep your lines and contours crisps as in vector graphics and at the same time apply special effects available in raster graphics.

*If you are actually not sure what vector or raster graphics are and what it has to do with your choice of software, see the short article on page 15. For suggestions of other tools in particular for creating compelling graphs and plots, see the guest contribution “Tips on poster design”, p. 34.*



# Working with a scientific illustrator

I am often asked about it and it seems that this is a somewhat puzzling topic for scientists and researchers: why and how to work with a scientific illustrator. So here is a short attempt to explain the reasons and the basis of a successful collaboration between a scientist and a scientific illustrator.

## Why working with an illustrator?

As a scientist, it is vital for your career to communicate, the better you are at it, the higher impact your work will have. During the long years you spent specialising in your field, you are trained to communicate prevalently in a verbal way: to write and to present orally. In contrast, learning to communicate visually in a clear manner, is more often than not, neglected and considered of lesser importance. In consequence, most scientists never really learn how to communicate effectively through images. Moreover, scientists are trained to focus on high accuracy and to dwell on the every last detail of their topic which makes it likely to forget that not everyone has their detailed knowledge, and to lose sight of the bigger picture. Deeply immersed in their specialised research, scientists tend to spend relatively long time on preparing complex figures and are inclined to think that no one else could translate their complex message into a clear picture. And that is precisely when working with a scientific illustrator can be very beneficial.

A scientific illustrator learns how to synthesize and to communicate complex messages in a clear and visually accurate way. By having a scientific background but at the same time not being an expert of a particular specialisation, the illustrator can assess more objectively what is essential for a scientific communication. An experienced illustrator can help to present a complex message concisely by stripping it off the details that might be unnecessary to the message. This is one of the biggest advantages of working with a scientific illustrator: seeing the whole picture instead of a collection of details.

To recapitulate, if you are a scientist, here is why it can be a good idea to work with a scientific illustrator:

- ▶ **your message** is presented **in clear and visually appealing images**;
- ▶ **your ideas** are **expressed in a way** that **you yourself would not think of** or could not realize;
- ▶ you **learn from the illustrator** to improve the way you translate your ideas into visuals;
- ▶ you **save time** by outsourcing the time consuming image creation;
- ▶ you **have high quality tailor-made visuals** at your disposal.

## How to work with a scientific illustrator?

The collaboration with an illustrator is based, like every good collaboration, on discussions and a mutual exchange of ideas. It requires usually an iterative process to find the most adapted visual solutions to a given problem. To make this process run smoothly, **before contacting an illustrator**, you might want to prepare, if already available, a draft of the planned communication or relevant extracts of it for which the visual(s) is/are intended. If you already have some first ideas on your images, it is good to discuss them with all your collaborators involved in the project. If relevant, note your personal preferences, for example: “We have so far always represented this in this form or colour”. This can help to maintain coherence between your already existing images and the images that the illustrator will create. If you feel like it, you can prepare simple sketches which can be hand drawn or look for existing examples that can serve as a reference in terms of content and / or style. Ideally, get in touch sufficiently in advance before your deadline.

**During the discussion** with your chosen illustrator, if you know exactly what you want, summarize briefly the purpose and the main take home message of each image in your communication. If you are not sure yet what you need, take advantage of the illustrator's expertise and ask for suggestions. Illustrators love to conceptualize ideas and to design images that best express the chosen message.

**After the initial discussion**, you can go back to doing what you are actually trained for: research. In the meantime, the illustrator will delve into your topic and produce first drafts. Once the drafts are ready, you receive them to check whether they correspond to your needs and expectations. If several people are involved, you should collect the comments from all of them and, in case of contradictions, clarify those before going back to the illustrator with your feedback. The latter will then update the drafts accordingly and resubmit them to you for another cycle of checks and corrections. Personally, I am comfortable to do up to three iterations on figures but every illustrator handles this differently so you should ask in advance. Once you are happy with the drafts, I prepare the final files in several formats and deliver them to you. For publication / grant application figures, I provide an editable source format, so you can reuse them in the future. This is also not always the case, so again be sure to ask your chosen illustrator in advance.

The above described procedure applies only to creating single images. Working on an animation requires a slightly different approach and makes it necessary to include additional steps in the process. It will be a topic of a separate article in the future.

I hope you can see now that the collaborations with illustrators are quite straightforward and can be very rewarding for both sides: enhanced communication impact, mutual learning and a time saving relationship based on experience and trust. Simply put: the best of collaborations!

Further reading:

“Science-graphic art partnerships to increase research impact” *Nature communications Biology*, Vol. 2, august 2019: this comment by C. K. Khoury et al. discusses the modalities, the advantages and the challenges of collaborations between scientists and graphic designers to communicate more efficiently scientific ideas to wider public. It is based on a pilot project for this type of collaborations.



# What is the role of scientific illustration ?

The scientific illustration is often uniquely identified with the images created in the context of science popularization. In consequence, it is often considered by scientists as a “dispensable addition” to science. However, the scientific illustration – broadly understood as visualizations, schematic representations, illustrations, animations – has a way more varied use and role. This article would like to remind of the important contributions of visuals in the scientific and other equally serious contexts.

## In the context of scientific research

**Illustrations are created to formulate ideas of scientific hypotheses / theories / models.** They are usually made by scientists themselves or with help of an experienced scientific illustrator. In this case, **the role of the images is to help the process of thinking. These images are an important tool to form, select and fine-tune ideas as well as to provide a first step to communicating them in a fast and text-independent manner.** They can be both, very schematic or highly elaborate. An advanced example of the latter is the use of 3D visualization tools to test, verify or complete a hypothesis concerning spatially and temporally dynamic processes in a molecular or cellular context. From my experience, the design of most of the scientific communications starts by creating / choosing figures that tell a coherent and convincing story. If the images present a clear and easy to follow story, this reflects the clarity of the underlying thoughts. The accompanying text then is relatively straightforward to write.

## In the context of science popularization

**Images are created to communicate ideas to a larger public** and are usually created by illustrators / artists. In this case, **the images serve as carriers of scientific concepts for a broader audience. Their role is to grab the attention, quickly familiarize with basic ideas and help to remember them.** These images are usually very eye-catching and spectacular but they are often less focused on conveying complexity and accuracy. Their big advantage is that they are usually language independent and hence more accessible. They are often based on or inspired by some versions of images obtained or created in a purely scientific context even if they seem very different.

## In other serious contexts: medicine, forensic science, archaeology...

The role of the **anatomical drawings** was extremely important in exploring human and animal anatomy and remains a very powerful tool in medical context. Medical illustrations and animations are widely used in dedicated books, TV documentaries, teaching and training materials, communications with patients, and popularization magazines, to mention just a few. Moreover, highly specialized medical illustrations are used to plan in advance and execute complicated surgical operations (check the example of conjoined twin separation).

Reconstruction and detailed visualization of, for example, wounds sustained by a victim of a crime or an accident are very helpful and can be decisive **in forensic and legal context**. Many historical and present examples show the importance of visual representations: mapping of cholera cases helped to clearly identify the contaminated source of water in London in 1854, some car insurance companies have accidents reconstructed in short 3D animations, and many forensic labs use routinely visualizations of crime tools, trajectories or wounds to better understand the presumed events.

**Natural illustrations** continue to be the golden standard despite the power of today's photography. The reasons for it are numerous: illustrations allow to

depict chosen specimen in high detail and unobscured by shadows or artefacts. A plant or an animal can be shown in all its forms in one image disregarding the current season or its age. A natural illustration has a synthetic and categorizing role as it can show an averaged out specimen. Hence it contributes to classification and description of the biodiversity.

**Archaeological or palaeontological illustration** of extinct civilizations or species play a great role in understanding our past and the evolution of our planet. With each illustration, a piece of our culture and the history is brought back to life and into our knowledge system. The fascination with dinosaurs and ancient cultures would be difficult to explain without the work of illustrators, sculptors and animators who help make them tangible again. Of course, every illustration reflects the ideas and concepts that are believed to be valid at the moment of the illustration creation so they can become obsolete with the further progress of research.

This list is far from exhaustive but it should already show that illustrations are an effective tool for science and other serious contexts. Far from being dispensable “additions”, they function as powerful vectors of scientific messages, concepts and theories within and outside of the scientific community. Their universal appeal can have a huge impact on how science and research are perceived in the society.

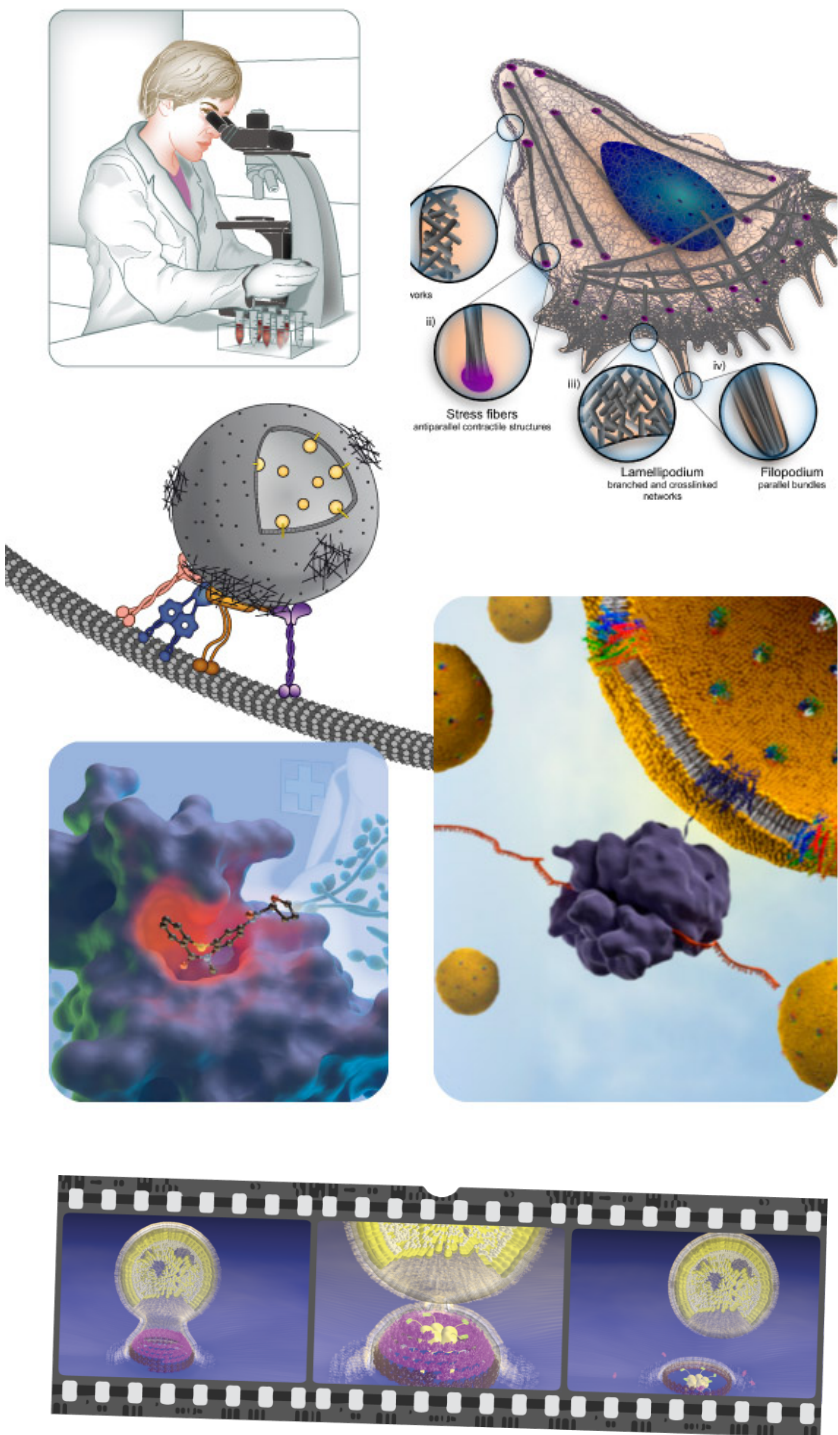
**Bring**

**your  
scientific  
message**

**to life!**

# Scientific Illustration & Animation

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# Scientific Illustration & Animation

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IlluScientia unites scientific knowledge and experience in research with artistic skills and professional computer graphics. We can provide an all-around visual service your projects deserve!

### So what exactly can we help you with?

- ▶ figures for major scientific publications, reviews, grant applications, book chapters;
  - ▶ short animations for scientific presentations or publications;
  - ▶ high-end images for press communications, presentations, show rooms, posters, websites;
  - ▶ journal cover designs;
  - ▶ design of conference flyers and posters
- ... and more!

### Your advantages are numerous:

- ▶ high quality images that boost your communication impact;
- ▶ source files in your chosen format for future use;
- ▶ your deadlines and confidentiality are always respected.

Interested?

I look forward to hearing from you!

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