

WARNING

GRAPHIC CONTENT

baptiste auguié

PG | Post-Grad supervision advised



GRAPHICS 101

USE NAVY BLUE & MAGENTA

and your favourite font

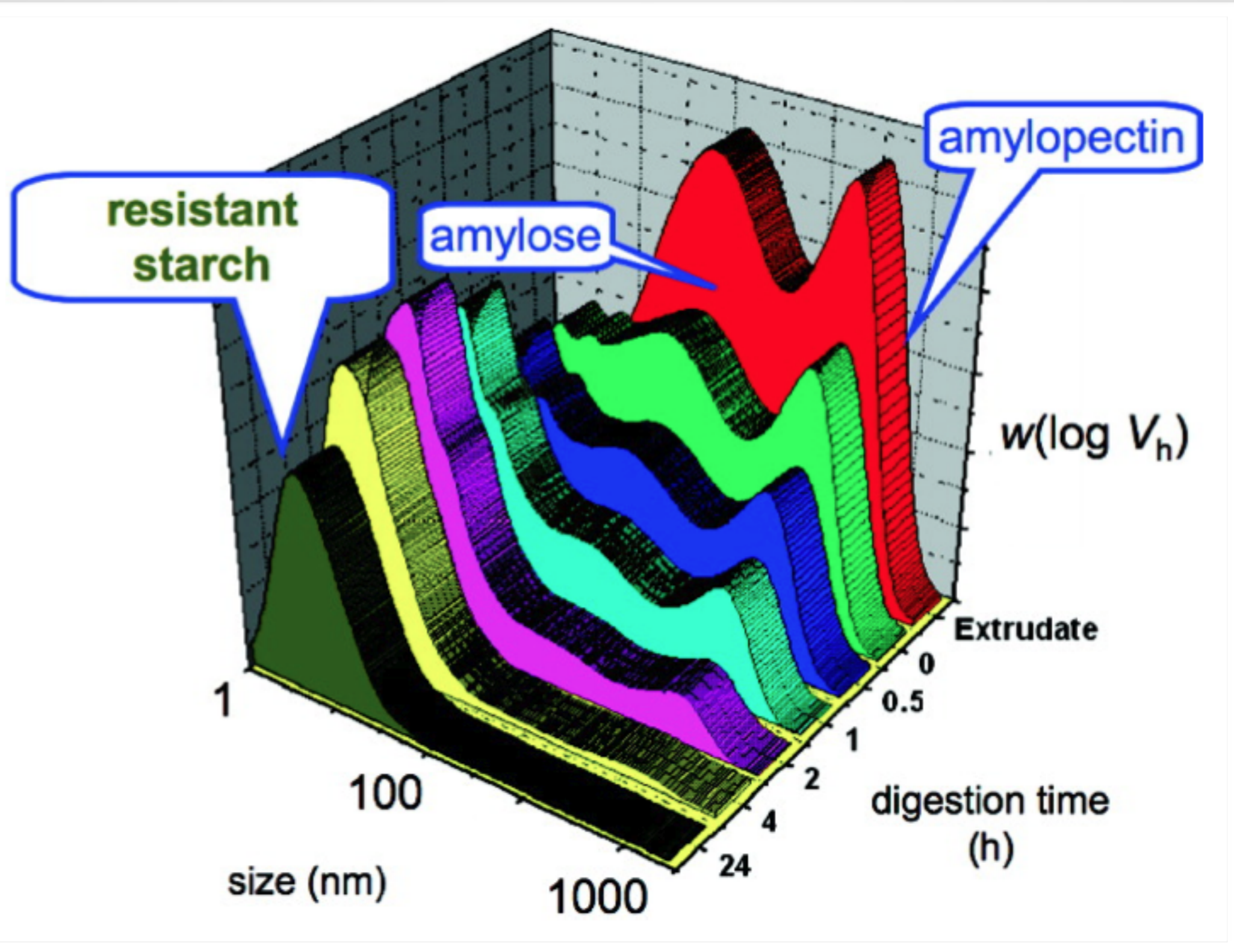
MY GOAL: challenge us
to think differently
about graphics

OUTLINE

- ▶ **MOTIVATION: A PHILOSOPHY OF GRAPHICS**
 - *The good*
 - *The bad, and the ugly*
- ▶ **FRAMEWORK: A GRAMMAR OF GRAPHICS**
 - *What's in a plot?*
 - *Tips and guidelines*
- ▶ **ILLUSTRATION: A VISION FOR GRAPHICS**
 - *Aesthetics and impact*
 - *TOC figures, slides, posters*

1 | MOTIVATION







Tatsuo Horiuchi
Excel artist



TOOLS DON'T MATTER

(but they do)

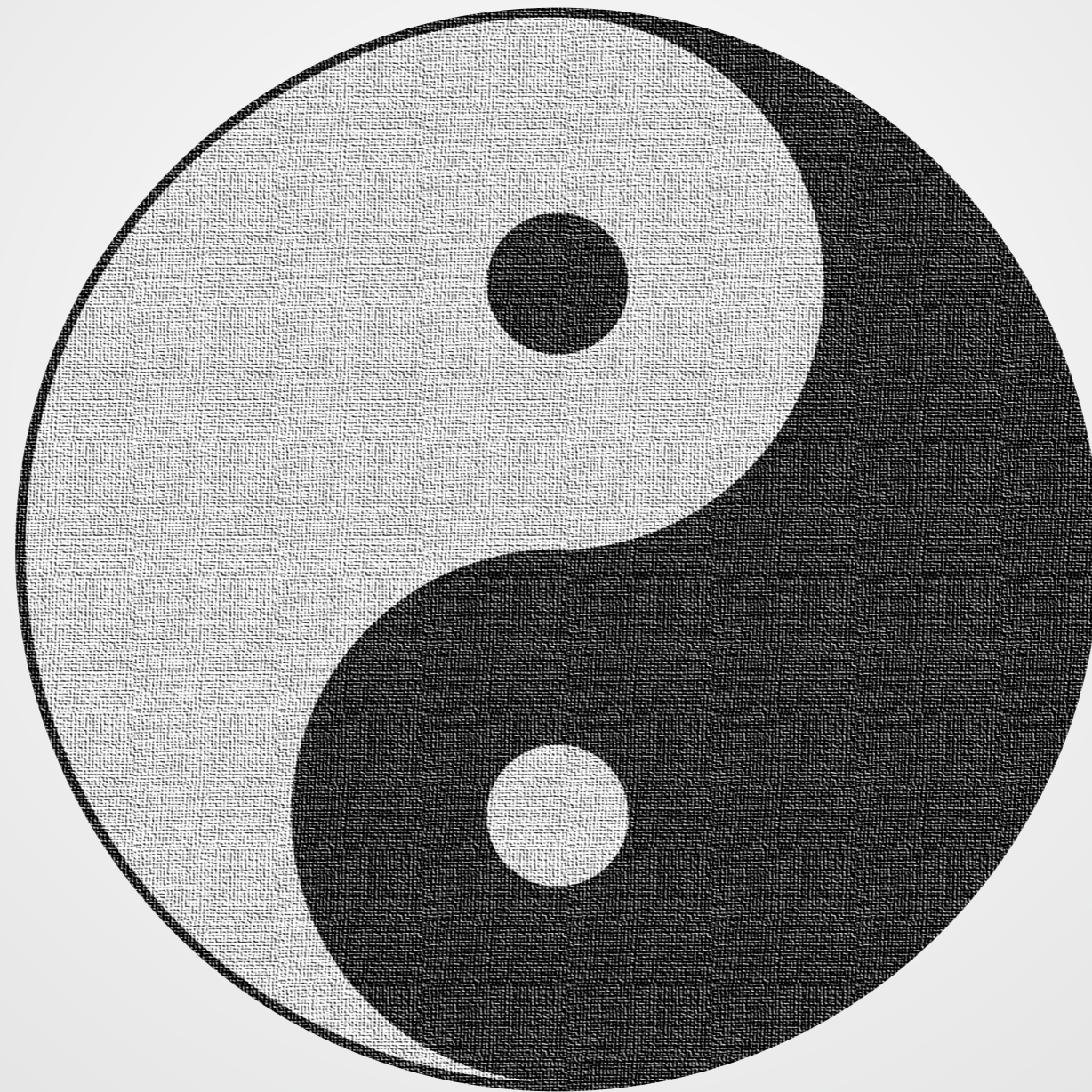
1 | MOTIVATION

(SOME ILLUSTRATIONS)

- worrydream.com/TenBrighterIdeas/
- jasondavies.com/maps/transition/
- mbostock.github.io/d3/talk/20111116/#17
- <https://observablehq.com>
- <https://www.visualcinnamon.com/>

A PHILOSOPHY OF GRAPHICS

ANALYTIC



Aesthetic

key message

DATA-TO-INK RATIO

be deliberate with
your pixels

1 | MOTIVATION

LETTERS

NATURE PHOTONICS DOI: 10.1038/NPHOTON.2012.300

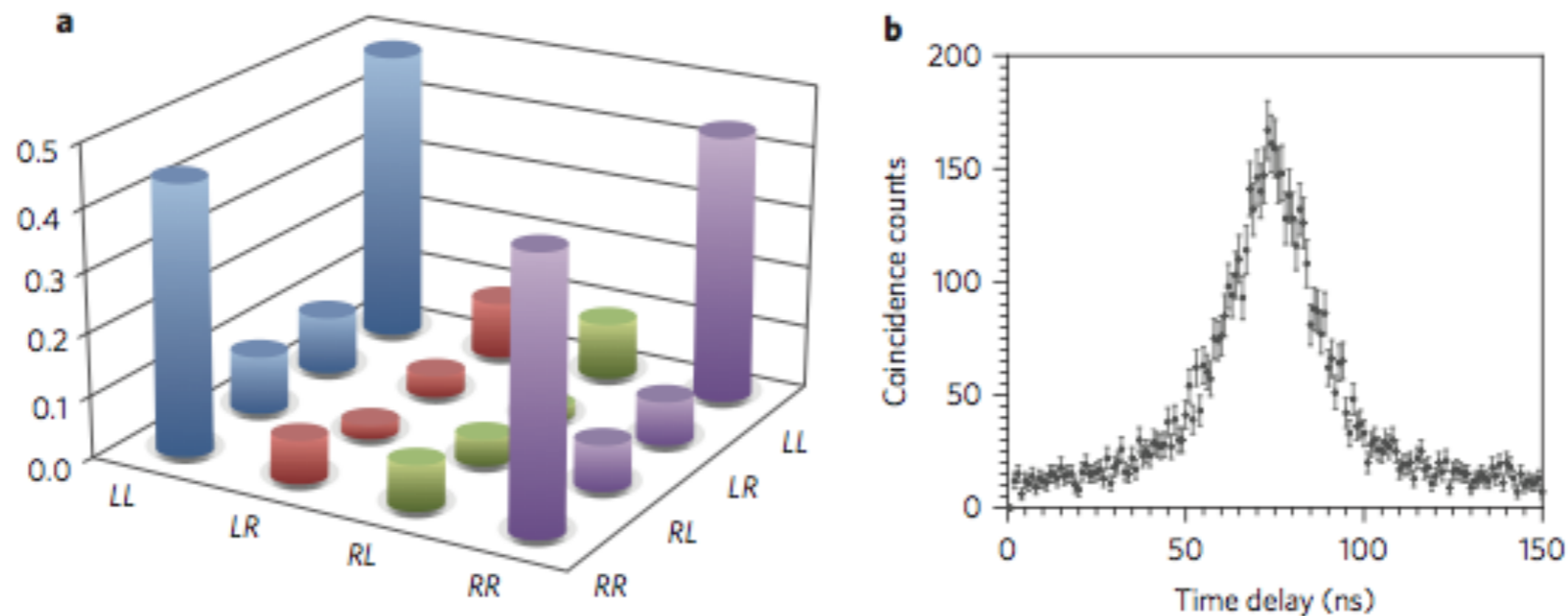
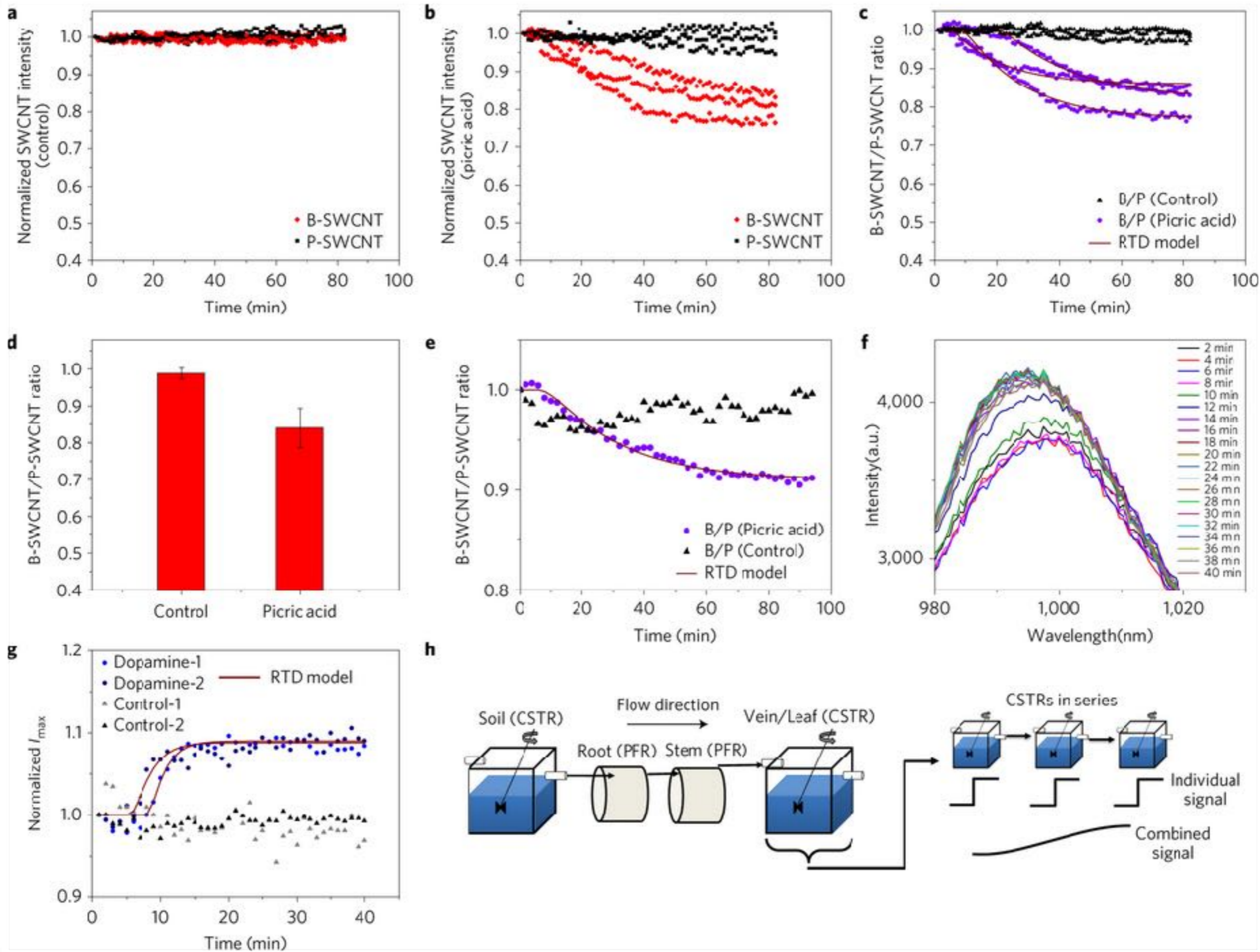
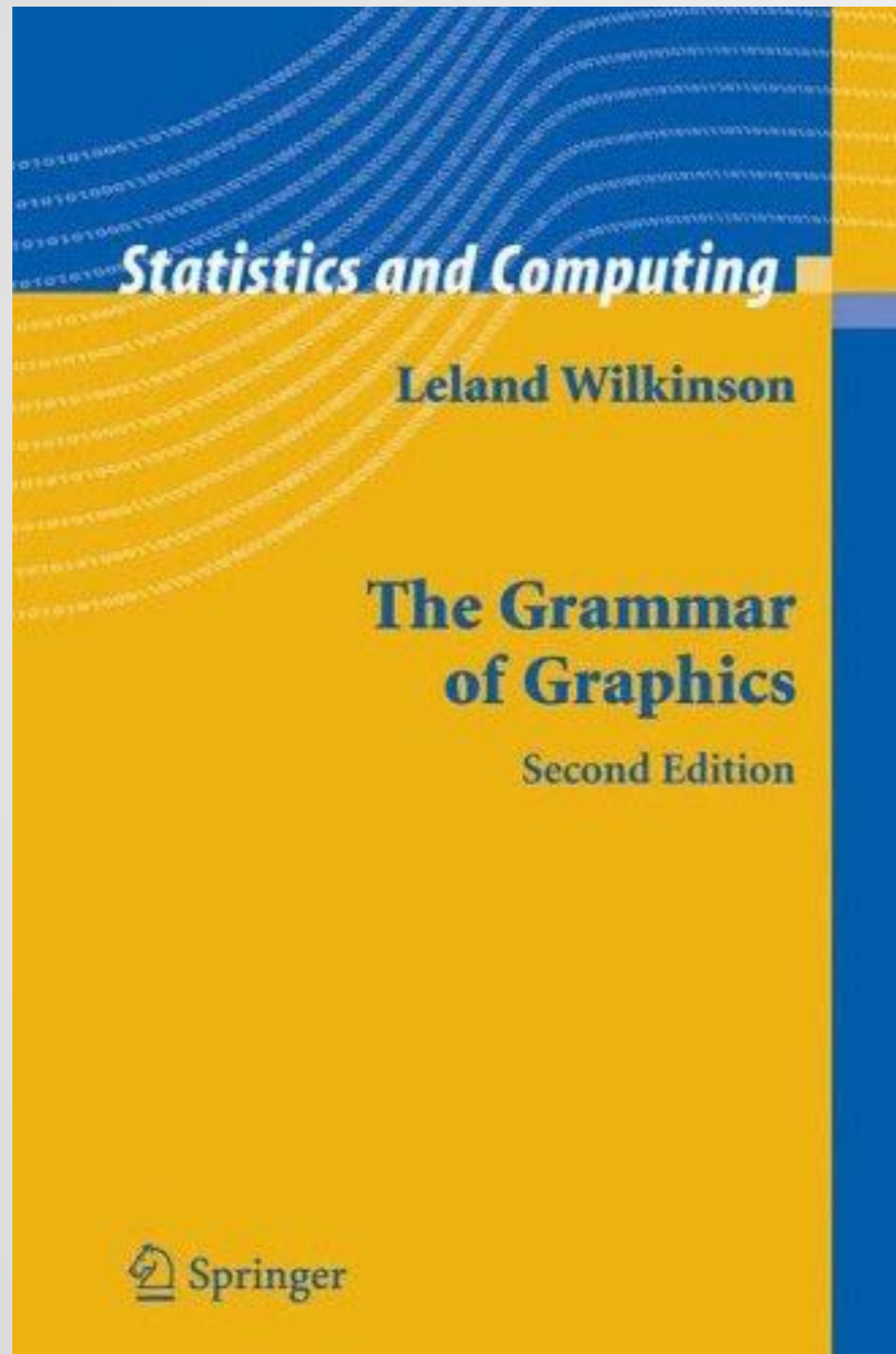


Figure 3 | NOON state characterization. **a**, Density matrix ρ (magnitudes only) from quantum state tomography, showing large coherence between $|LL\rangle$ and $|RR\rangle$ components. **b**, Measured correlation of the filtered CESPDC pairs (no background subtracted). The absence of modulation at the 2 ns cavity roundtrip time indicates the presence of a single cavity mode.



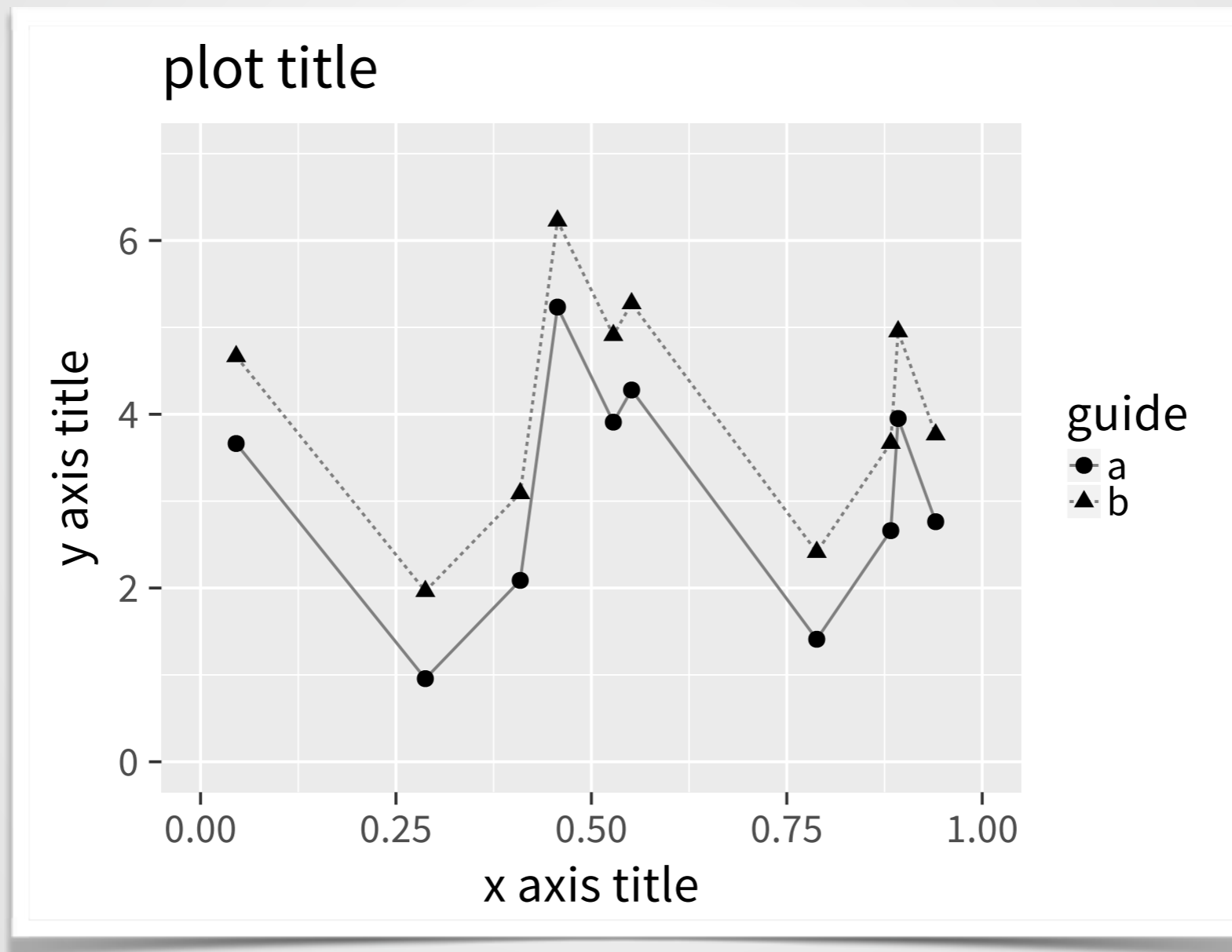
2 | GRAMMAR OF GRAPHICS



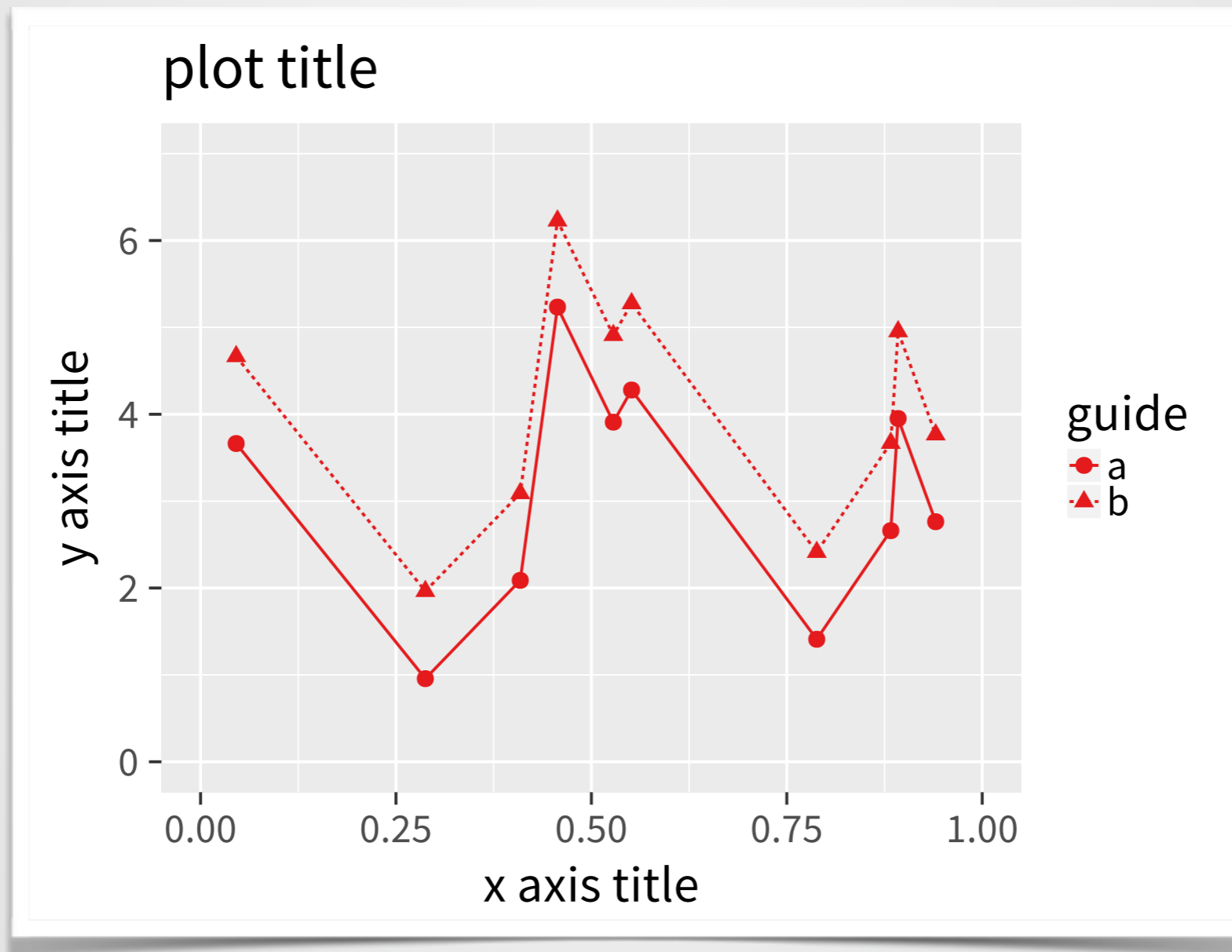
If charts are maps
of abstract worlds
the guiding principles
of graphics usage
could be derived
from the psychology
of perception.

”

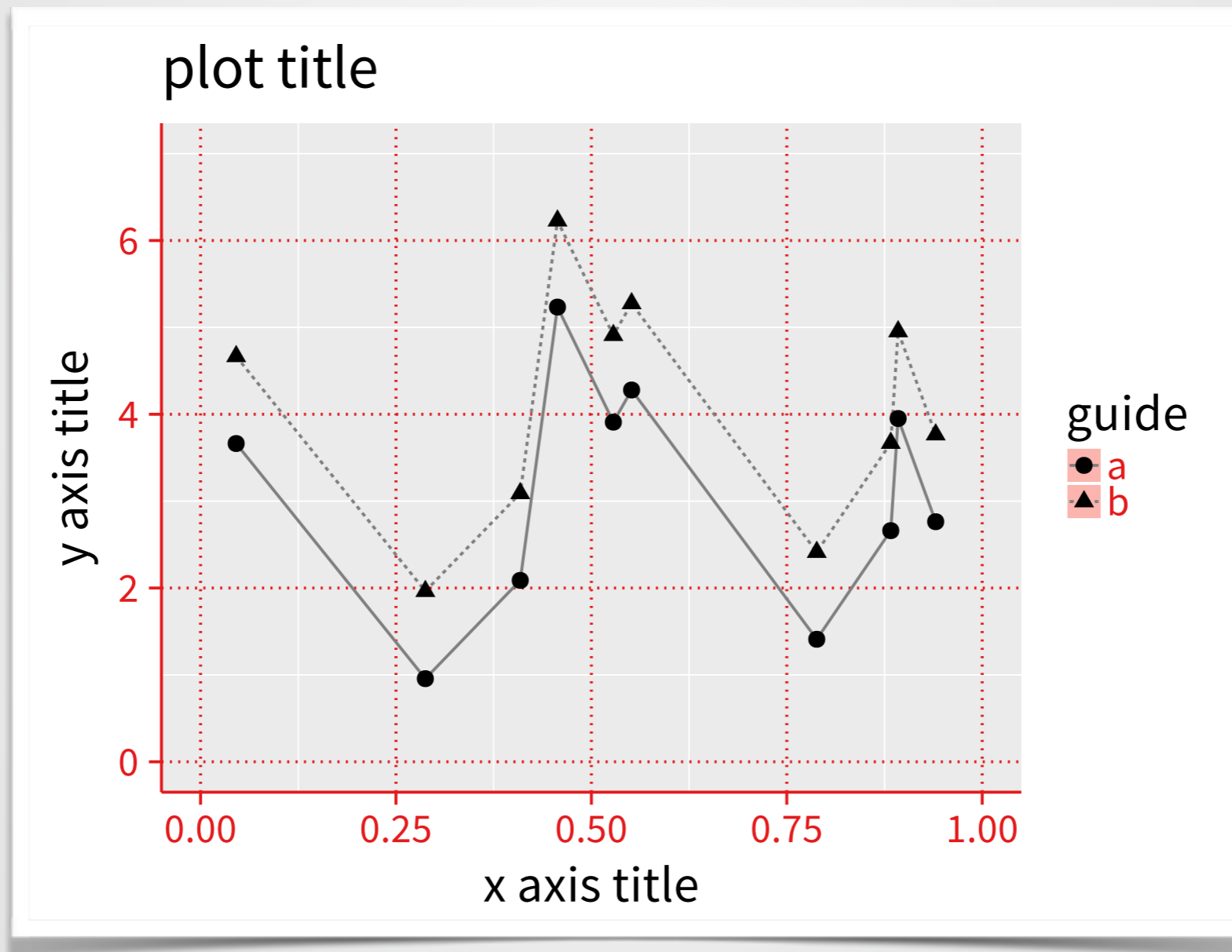
ANATOMY OF A PLOT



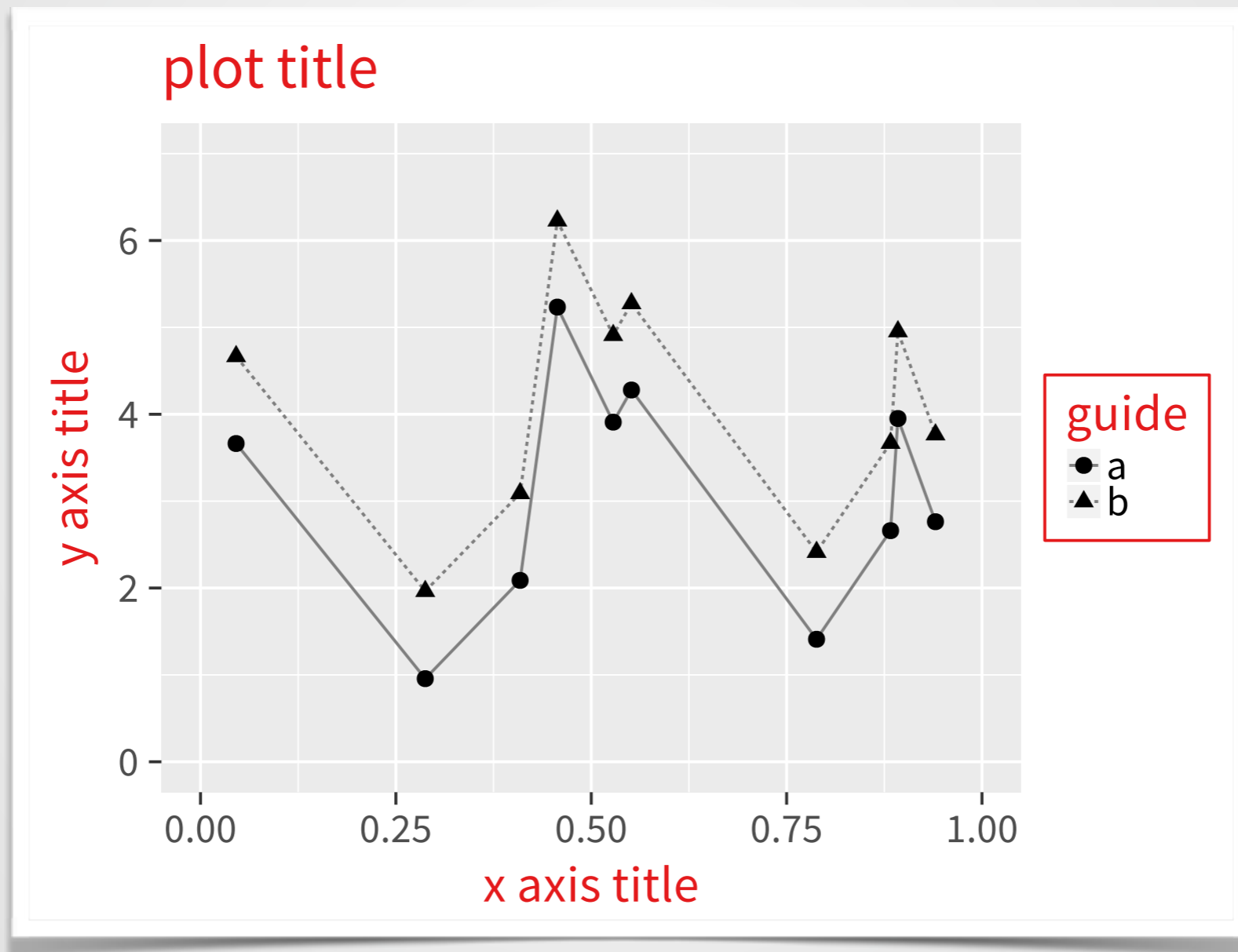
ANATOMY OF A PLOT • *THE DATA*



ANATOMY OF A PLOT • *GUIDES*

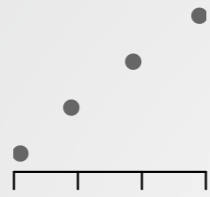


ANATOMY OF A PLOT • *ANNOTATIONS*

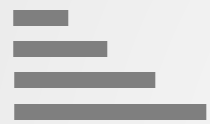


GRAMMAR OF GRAPHICS – MAPPING DATA

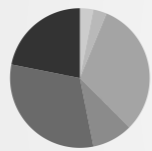
- position



- length



- angle



- area



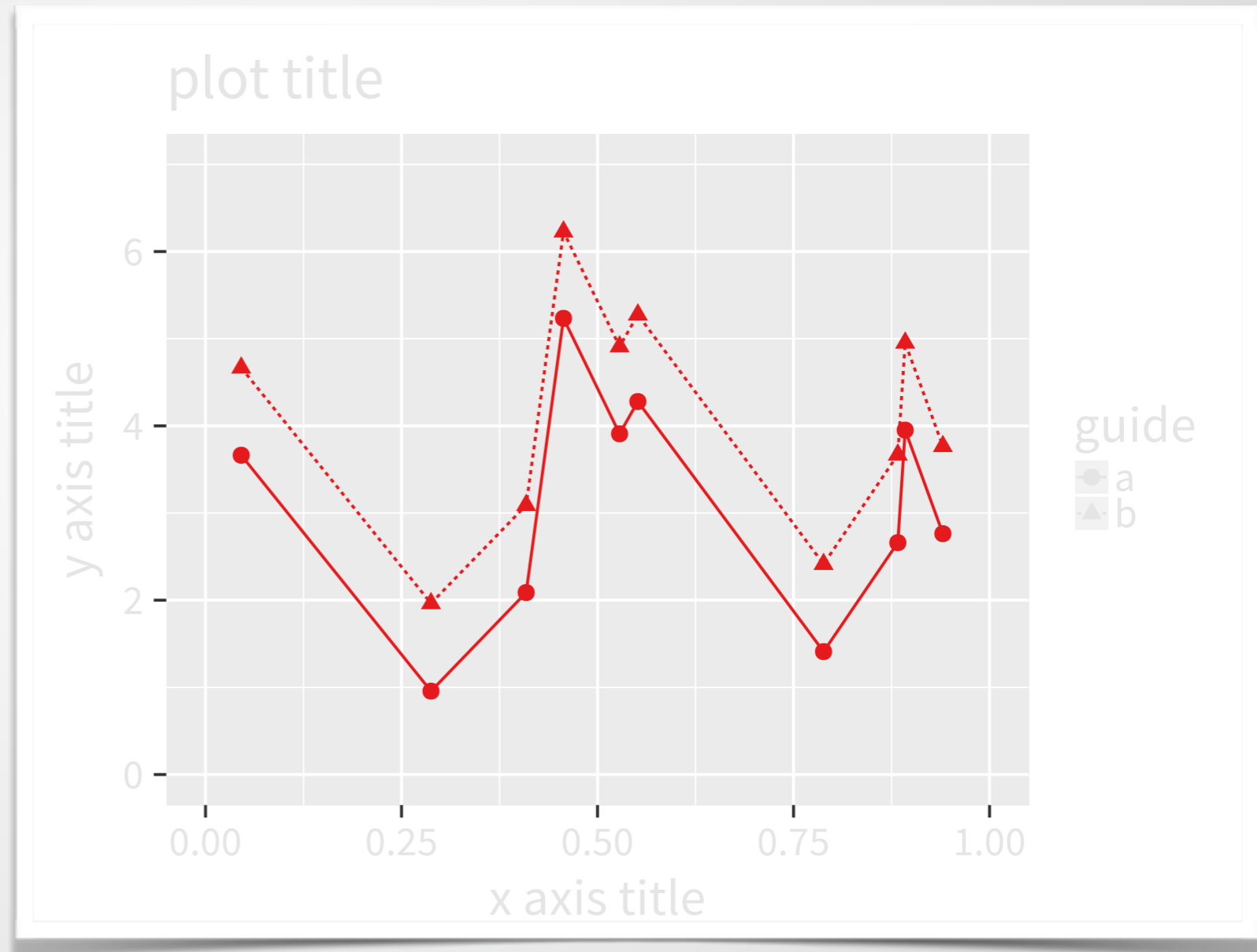
- colour



- shape



- line type, size, time, ...



EXPRESSIVITY, LEGIBILITY, REPRODUCIBILITY

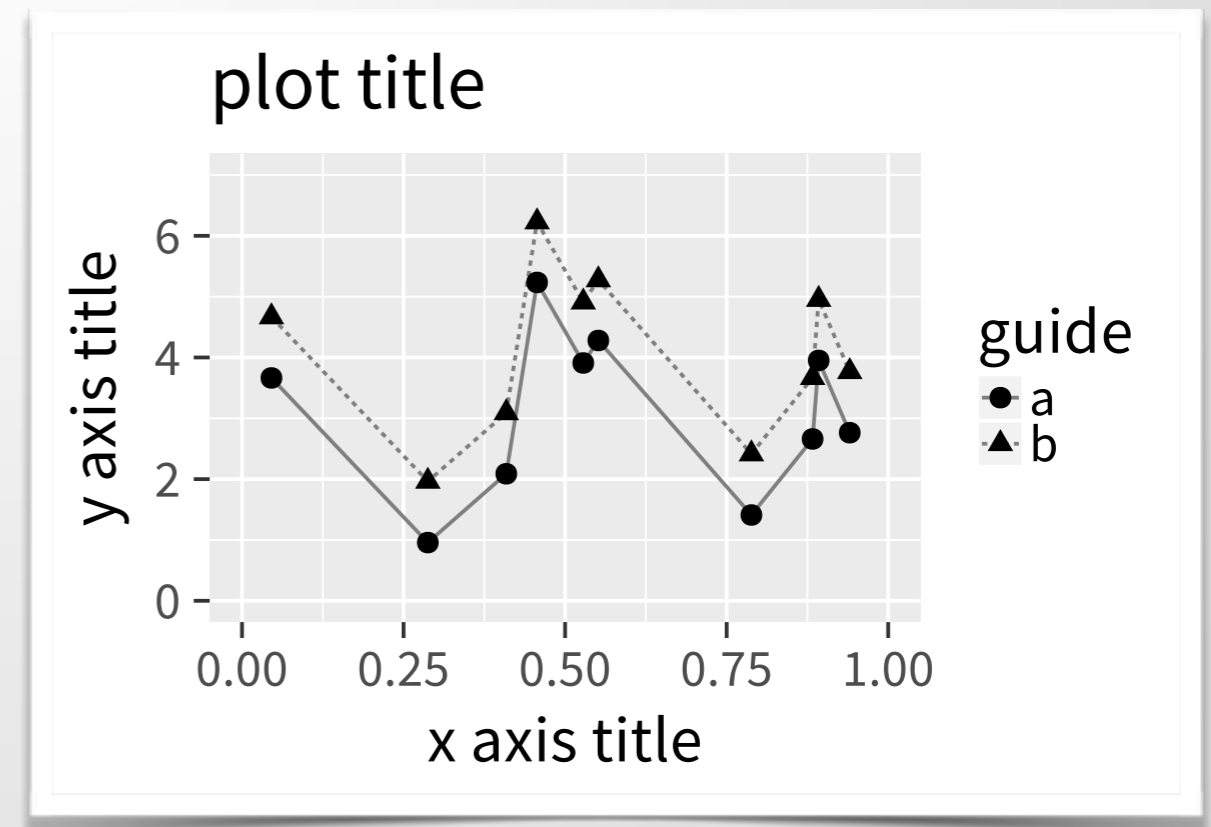
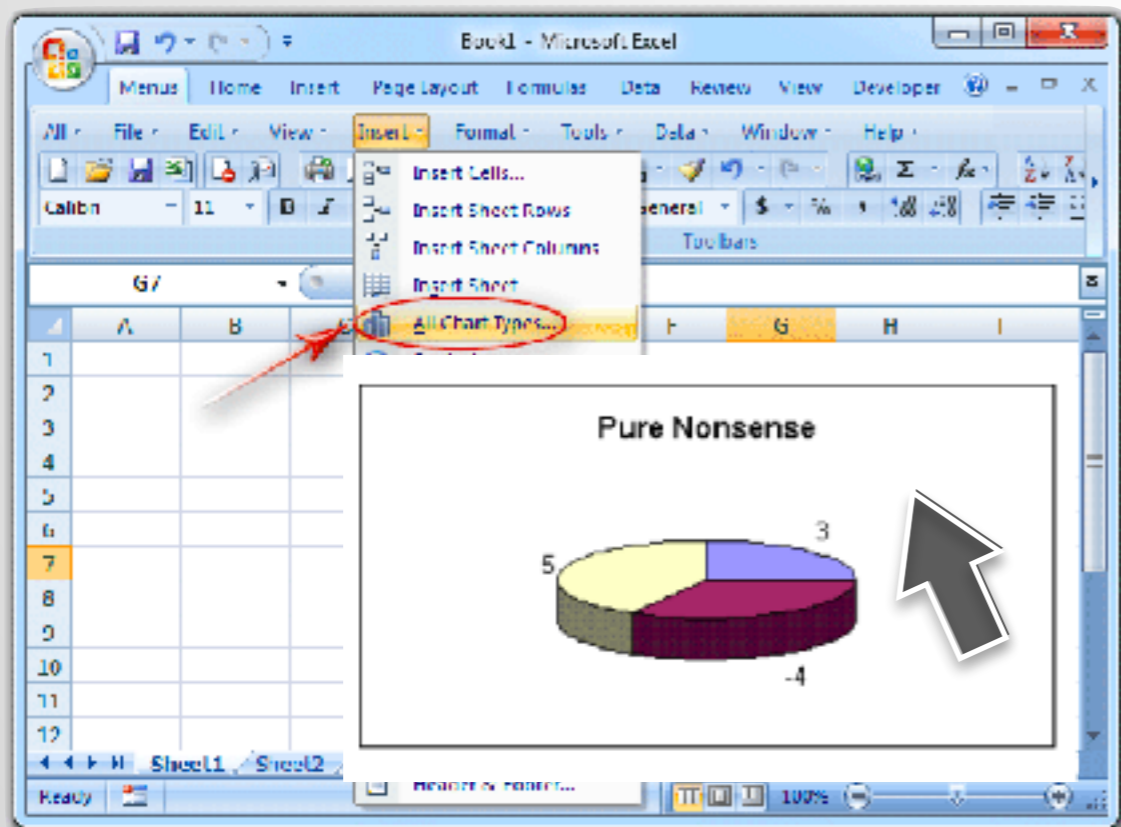
Point & Click

Yeah but, no but, yeah but, no but!!!
yeah but ... I swear * * * * * !!!?!!!!
... but yeah _(ツ)_/ **COMPUTER SAYS NO**

Ctrl-Z

Grammar of Graphics

```
plot(data, map(x, y)) +  
  layer(point, map(colour = z)) +  
  layer(line, map(linetype = t)) +  
  theme(fontsize = 12)
```



MAPPING DATA TO GLYPHS

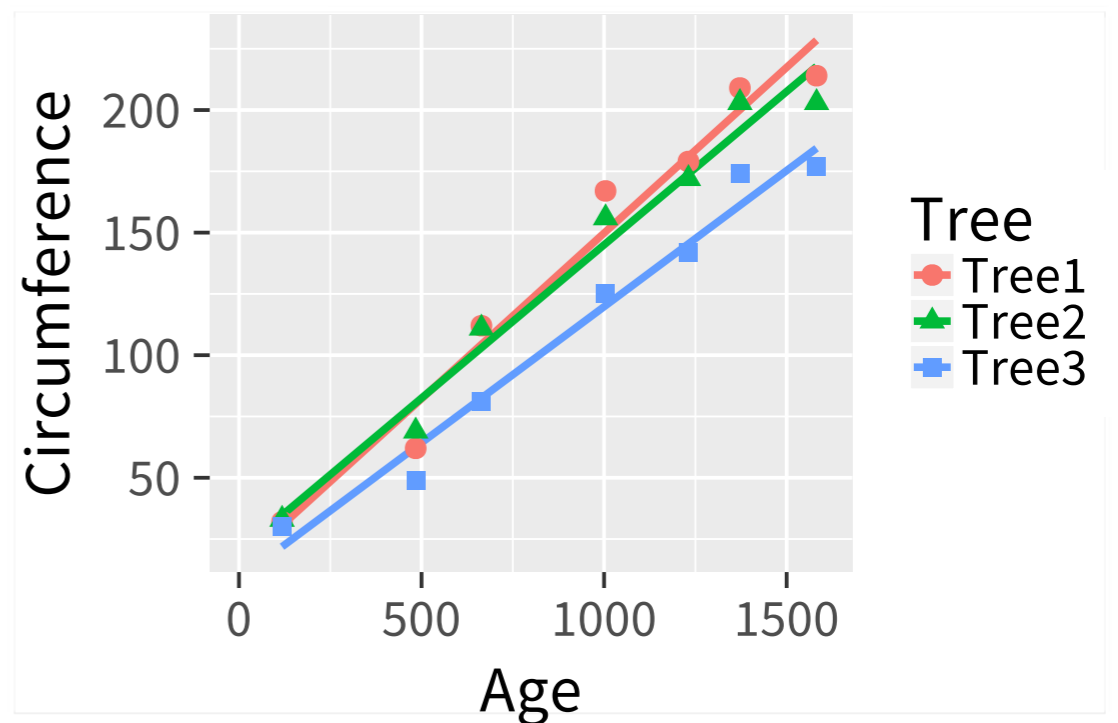
```
plot(data = d,  
      mapping = map(x = age,  
                    y = circumference)) +  
  layer(type = point,  
        mapping = map(shape = Tree,  
                       colour = Tree)) +  
  layer(type = line,  
        mapping = map(colour = Tree))
```

	Tree	age	circ.
1	Tree1	1582	214
2	Tree1	118	32
3	Tree2	118	33
4	Tree2	1372	203
5	Tree3	484	49
6	Tree3	1372	174
7	Tree3	1004	125

mapping

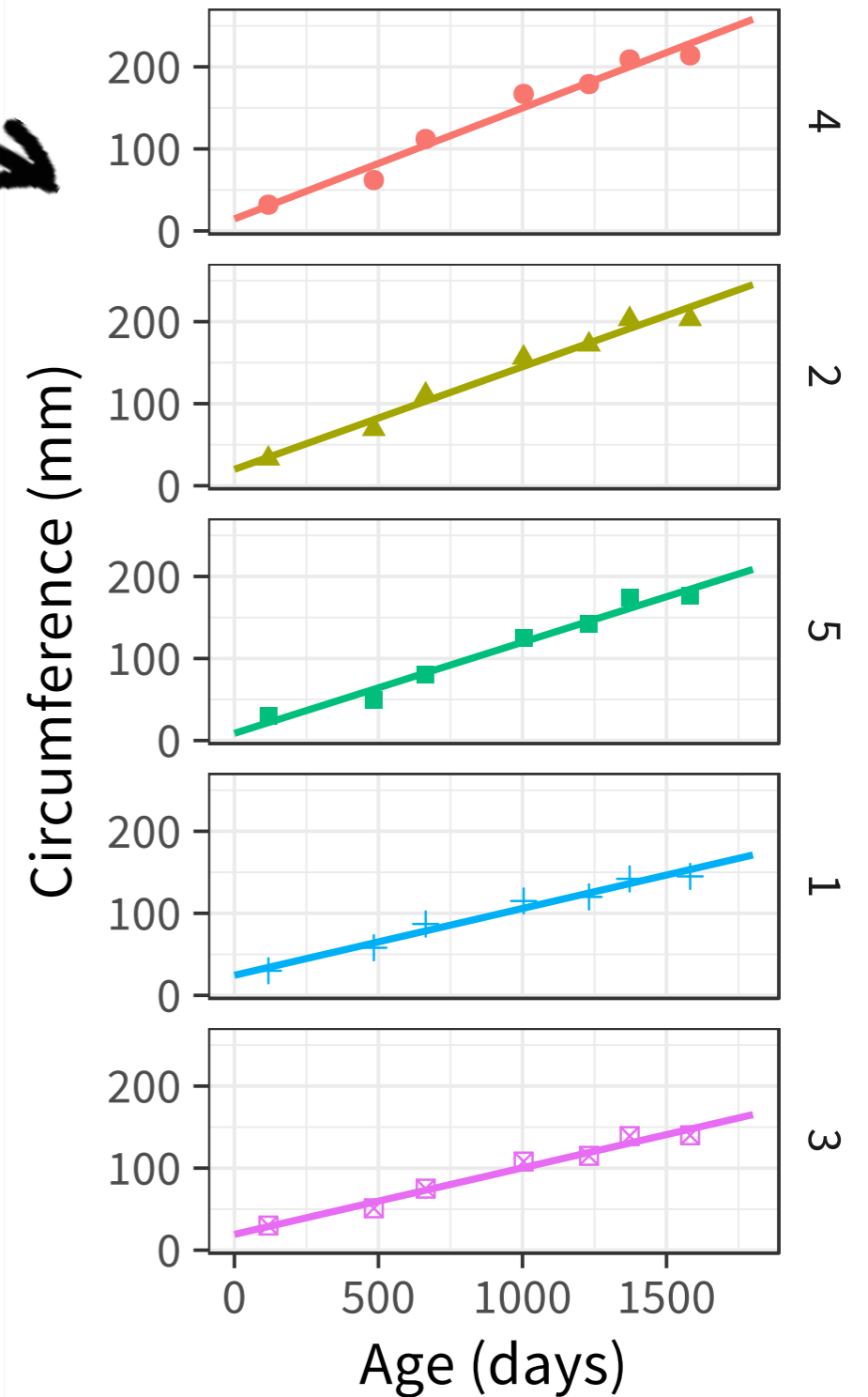
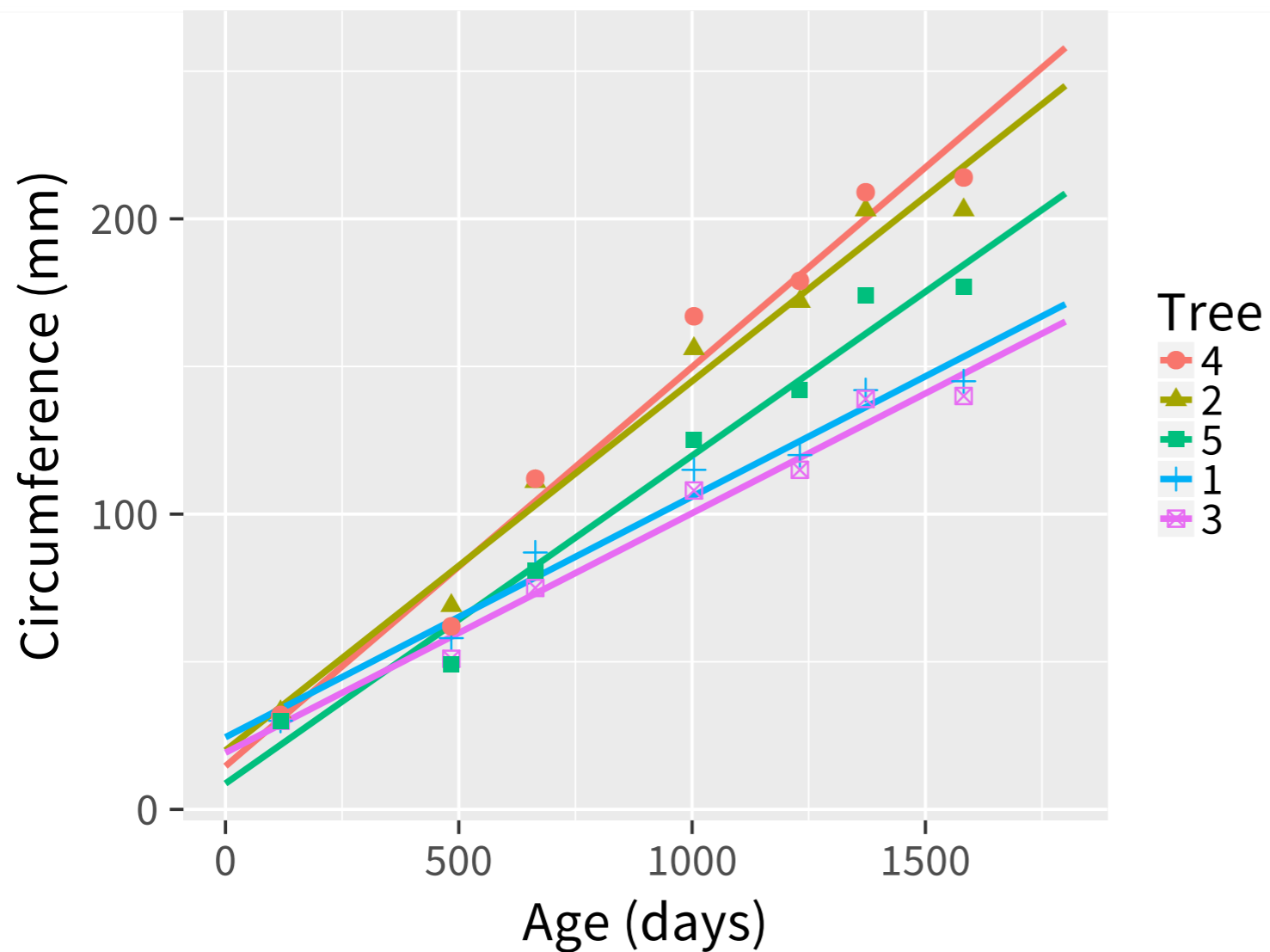


guides

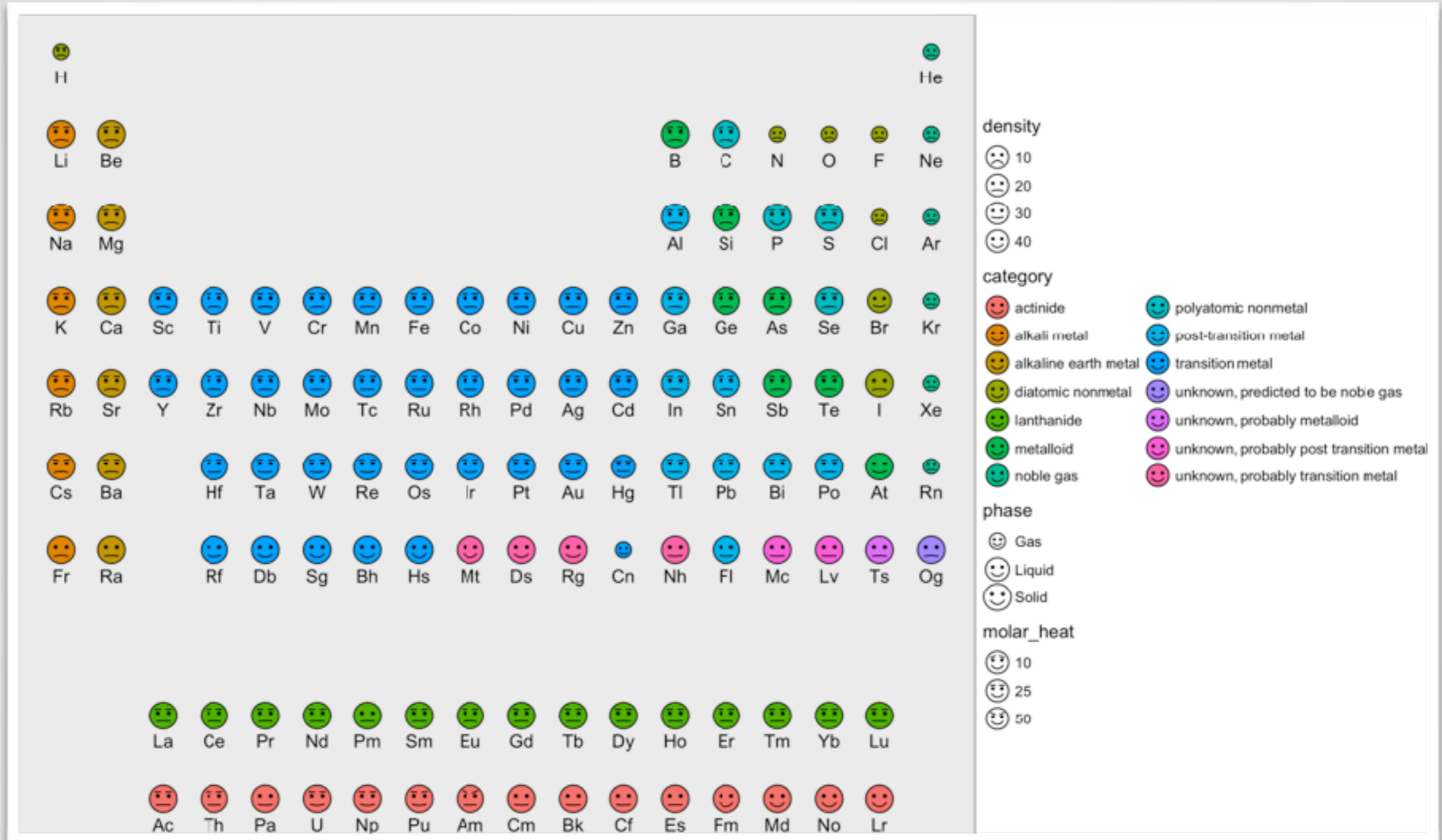


GRAPHICAL EXPLORATIONS

```
last_plot() +  
  facet_grid(Tree ~ .) +  
  theme_publication
```



MAPPING DATA TO VISUAL ATTRIBUTES



CONSIDER DIFFERENT VISUAL ATTRIBUTES



credit: @nicgaston

But different representations of the **exact same data** can lead to different understanding and, more importantly, to different decisions.

-R. KOSARA

BENEFITS OF SCRIPTING GRAPHICS

- ▶ **EXPLORING MORE POSSIBILITIES**
 - Save time
 - Try multiple variations
- ▶ **CONSISTENCY**
 - Reproducible code & aesthetics
 - Self-documenting analysis

SUMMARY • KEY POINTS

- ▶ **SHOW THE DATA ‘AS NATURE INTENDED’**
 - Maximise data-to-ink ratio (*no chart junk*)
 - Sort and organise (*meaningful order*)
 - Consider transformations (*log, difference, ...*)
- ▶ **HELP THE READER**
 - Proximity of things to compare
 - Axes aligned to ease comparisons
 - Deliberate use of colour and labels

TIP #1 | AVOID RESCALING IMAGES



Donec leo. Morbi vulputate convallis est. Integer aliquet. Pellentesque aliquet sodales urna.

Columnwidth: 3.18143in

Textwidth: 6.50127in

Include the figures without rescaling,

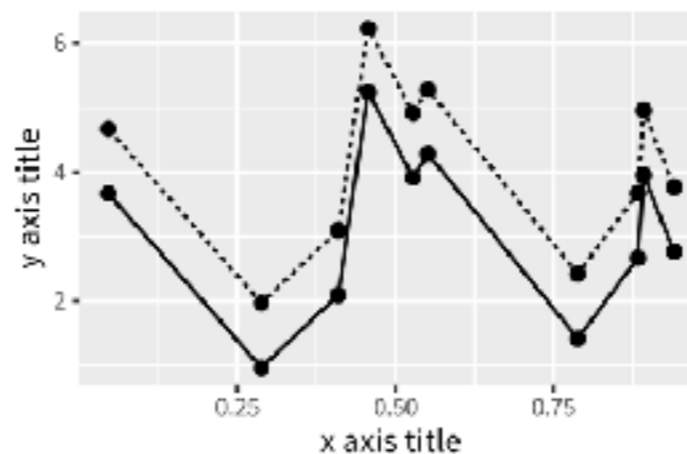


Figure 1: Nunc sed pede. Praesent vitae lectus. Praesent neque justo, vehicula eget, interdum id, facilisis et, nibh. Phasellus at purus et libero lacinia dictum. Fusce aliquet. Nulla eu ante placerat leo semper dictum.

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem. Nullam

lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet ali-

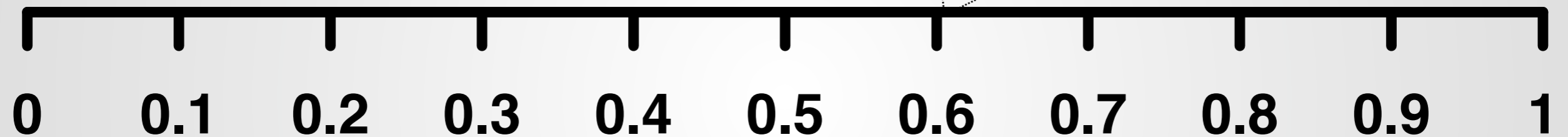
L^AT_EX tip

```
\usepackage{layouts}
\printinunitsof{in}\prntlen{\columnwidth}
\printinunitsof{in}\prntlen{\textwidth}
```

TIP #2 | FILE FORMATS

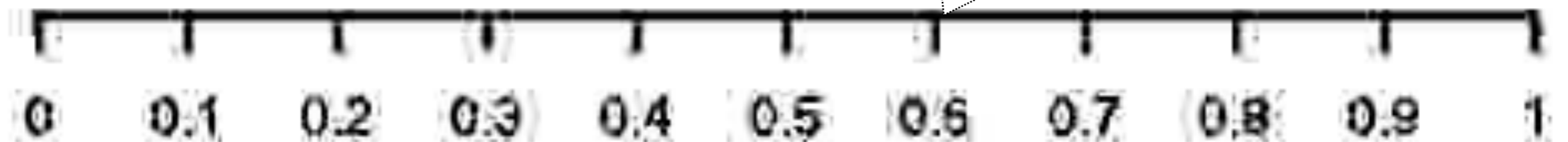
- ▶ **VECTOR FORMAT**

.eps, .svg, **.pdf**

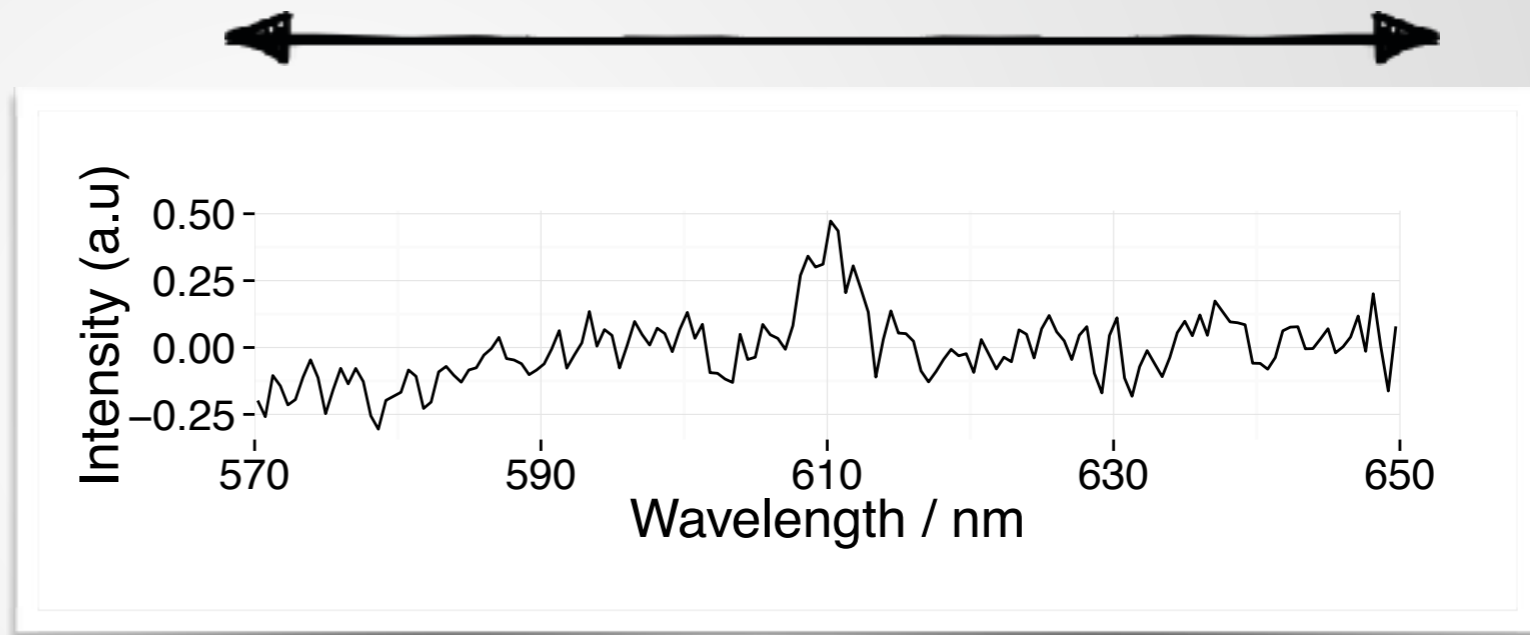
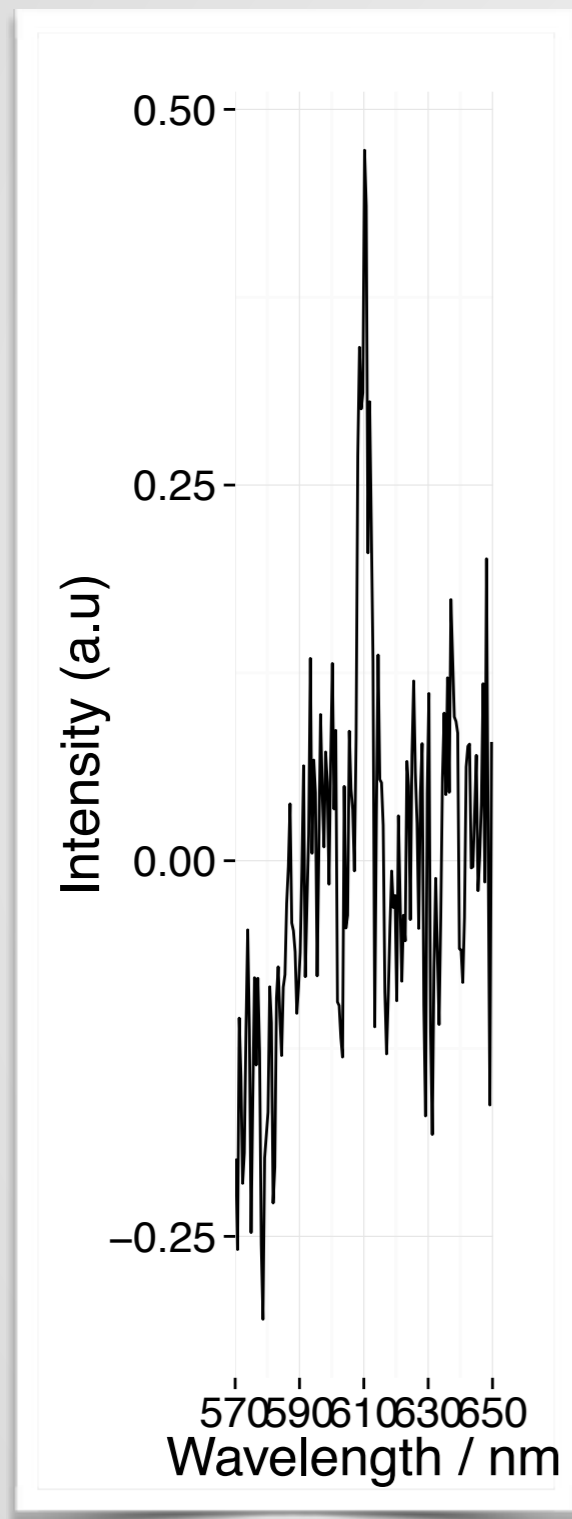


- ▶ **RASTER FORMAT**

.jpg, .tiff, **.png**



TIP #3 | ASPECT RATIO



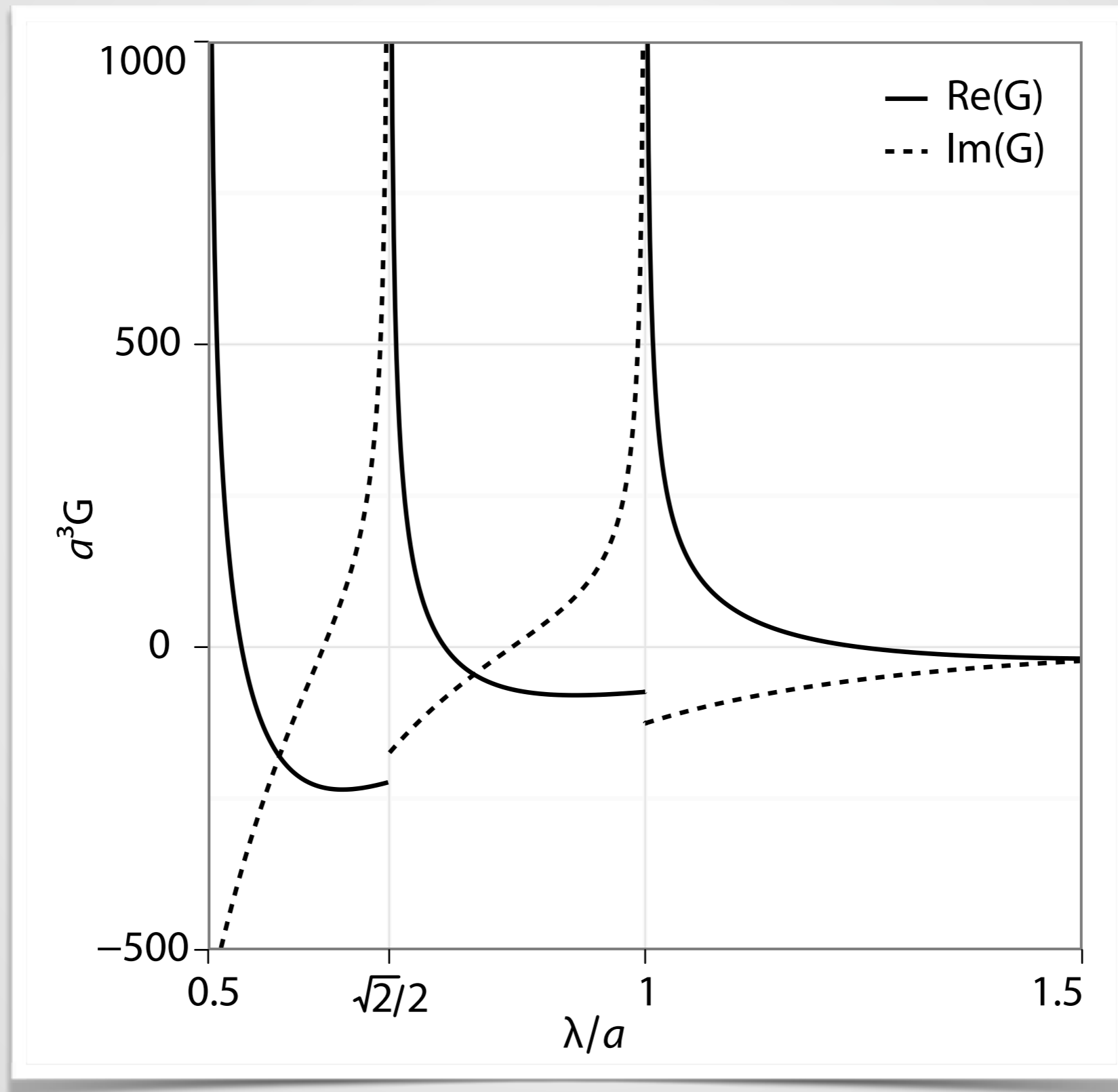
- Try
- "banking" at 45°
 - standard ratios

TIP #2 | ASPECT RATIO

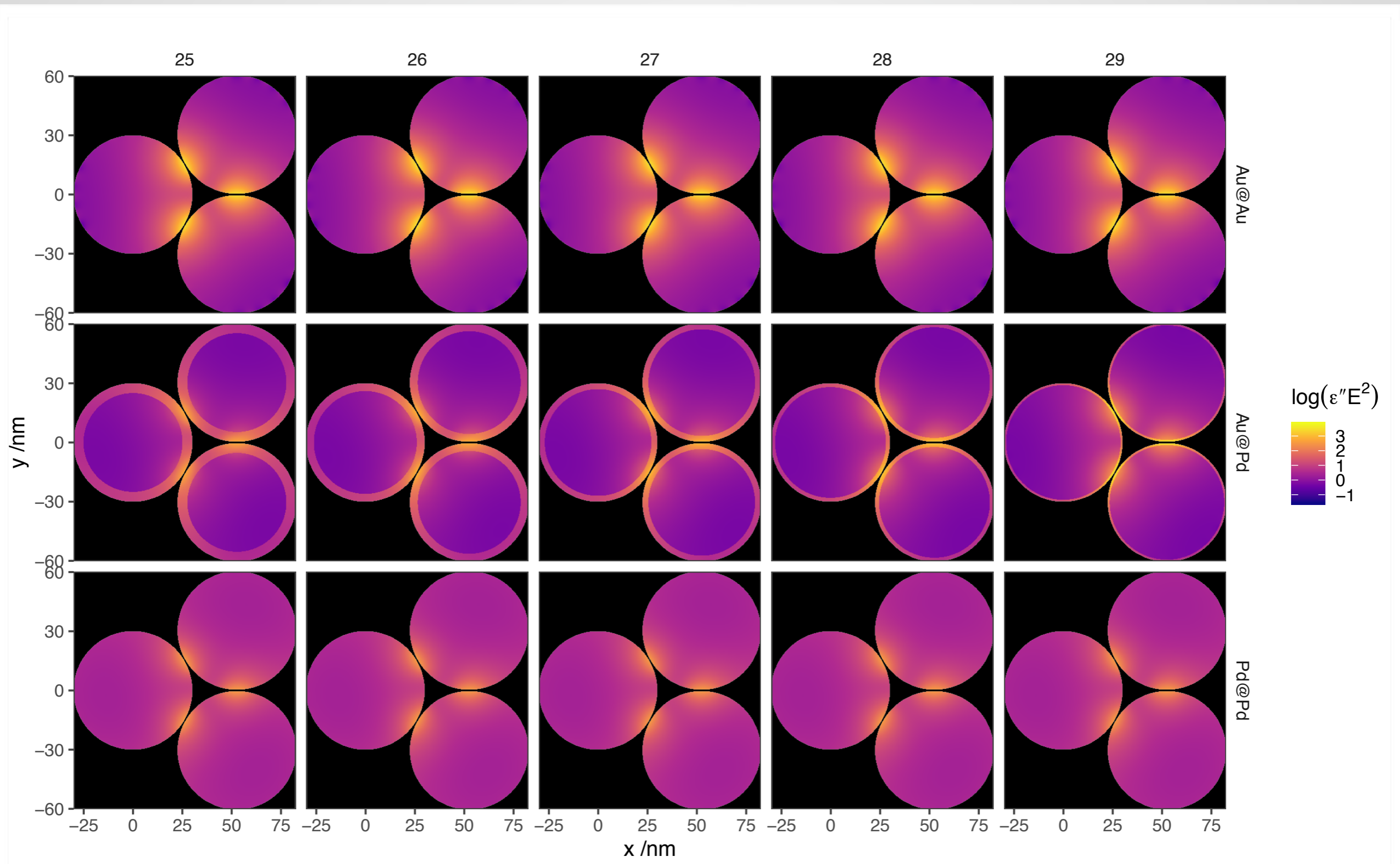
<https://xkcd.com/1732/>



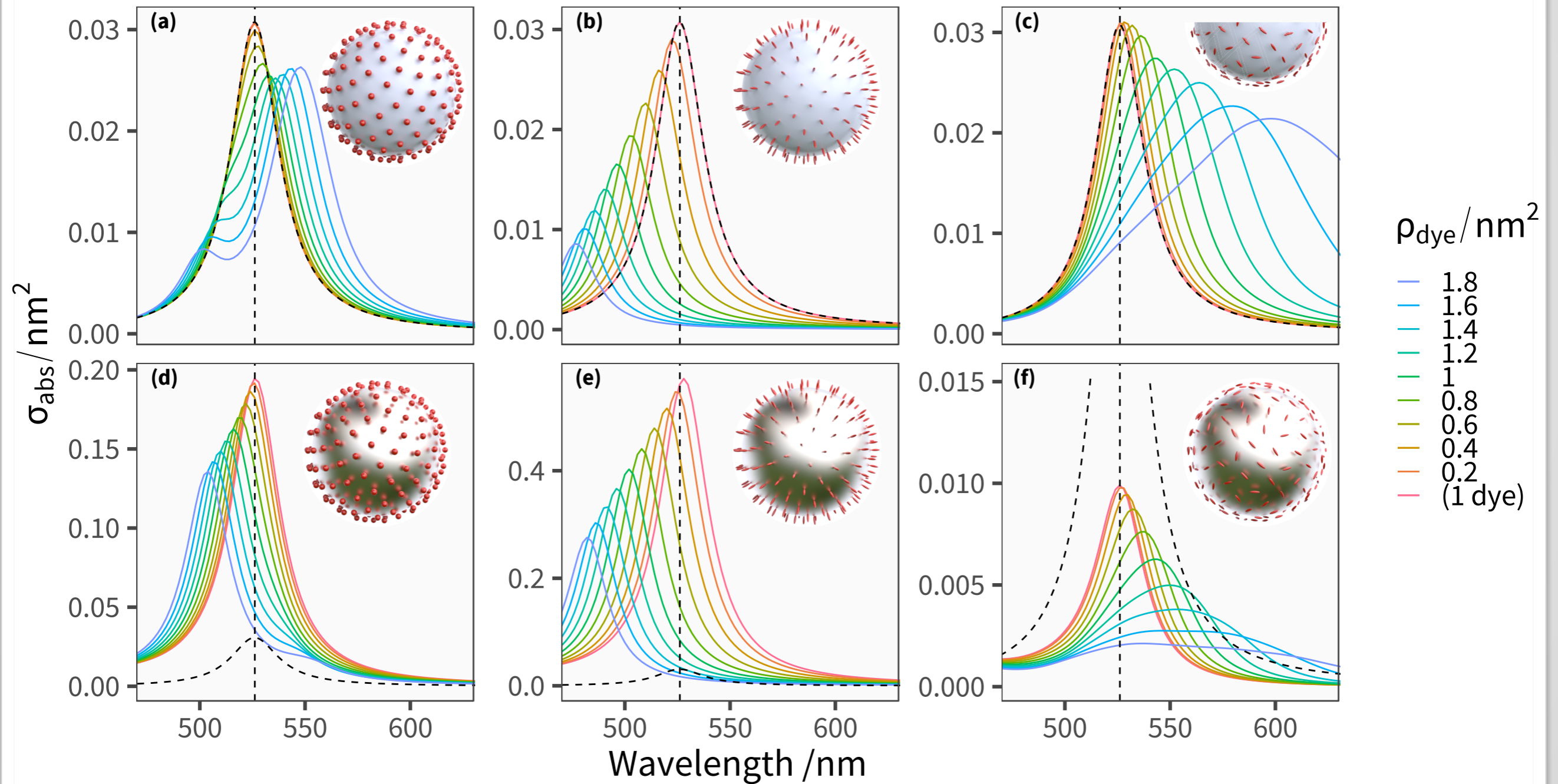
TIP #4 | DATA-TO-INK RATIO — IS MORE



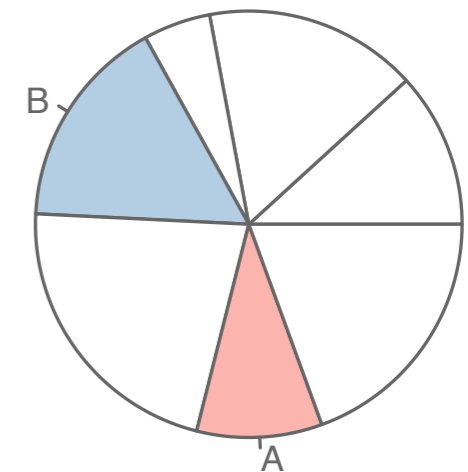
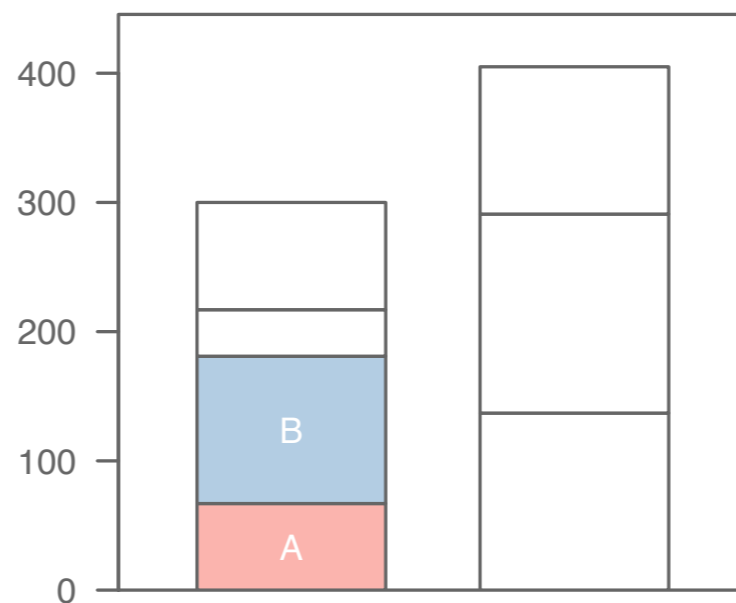
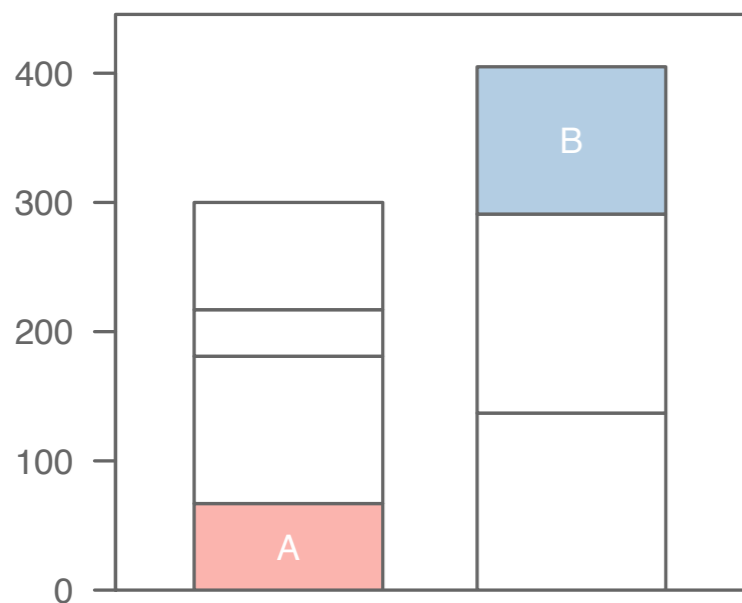
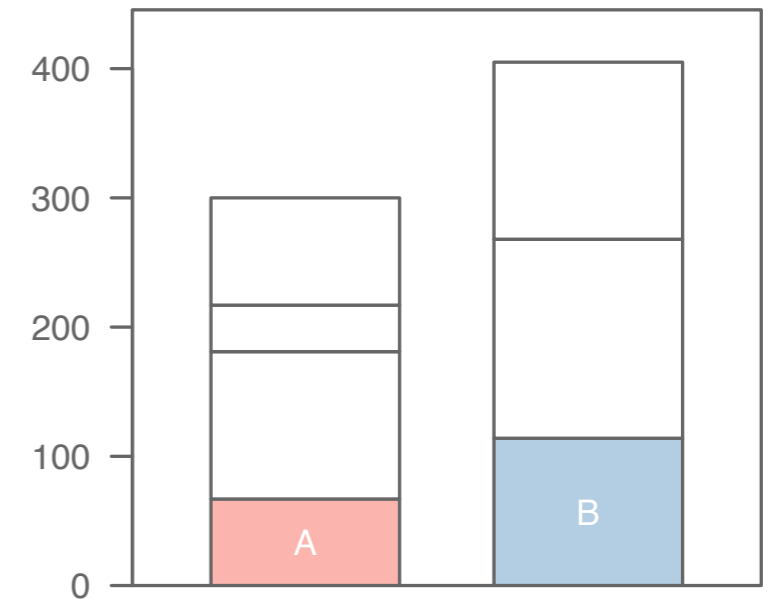
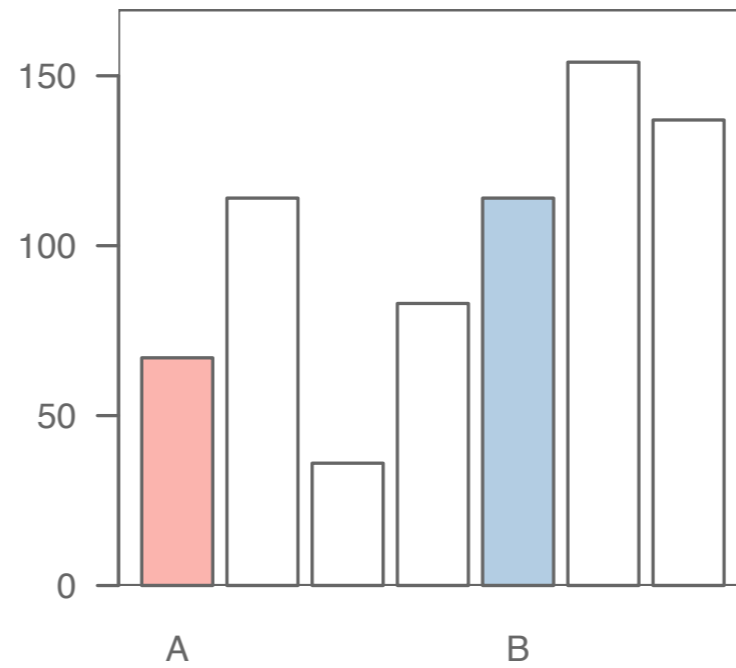
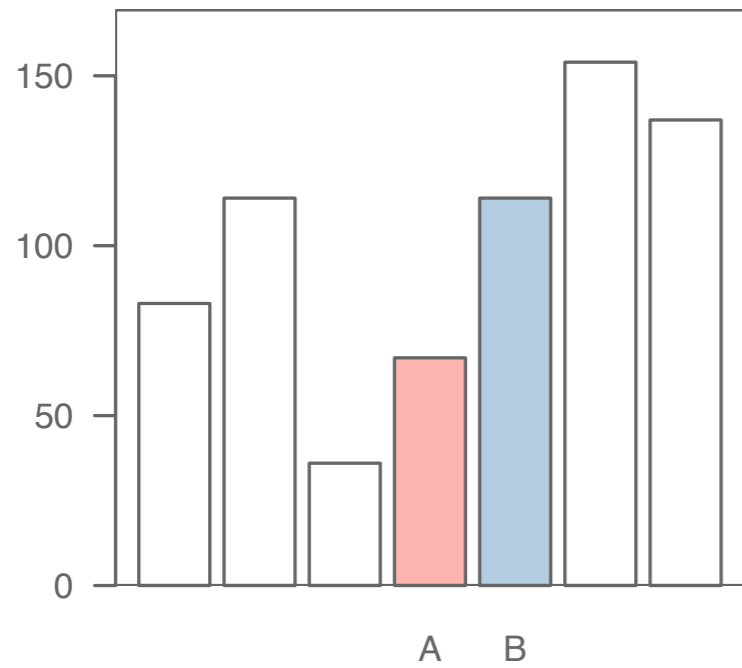
TIP #6 | SMALL MULTIPLES



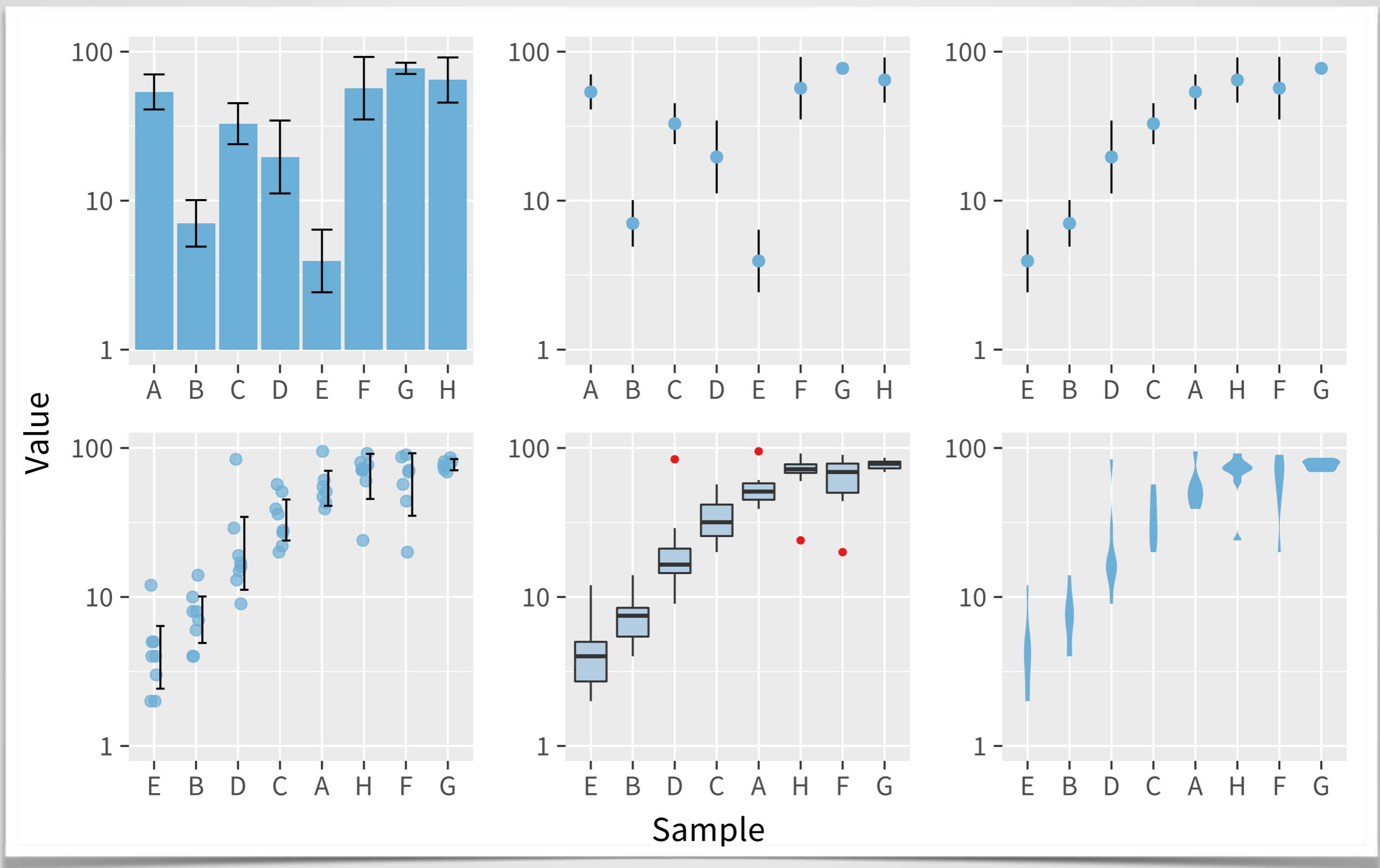
TIP #6 | SMALL MULTIPLES



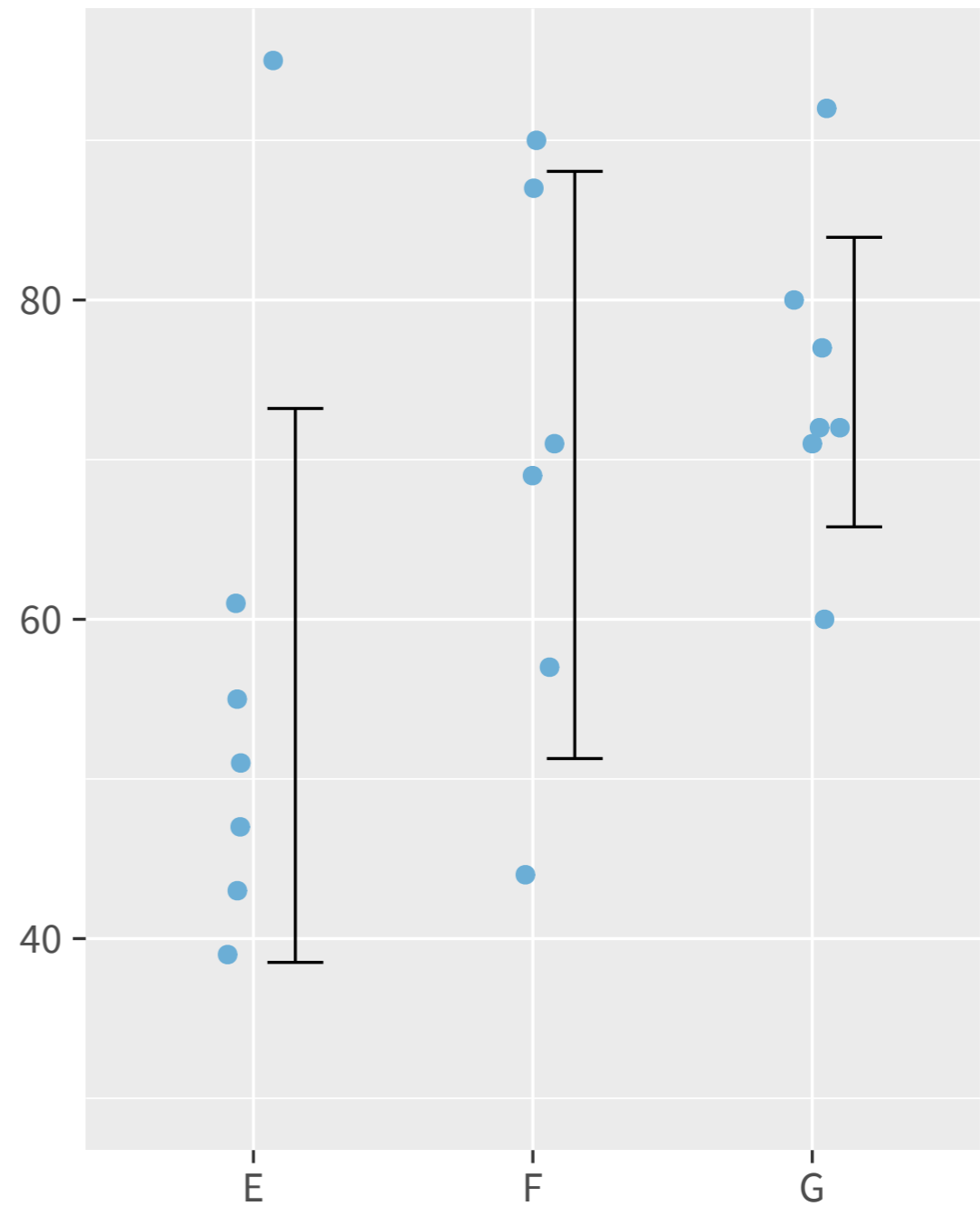
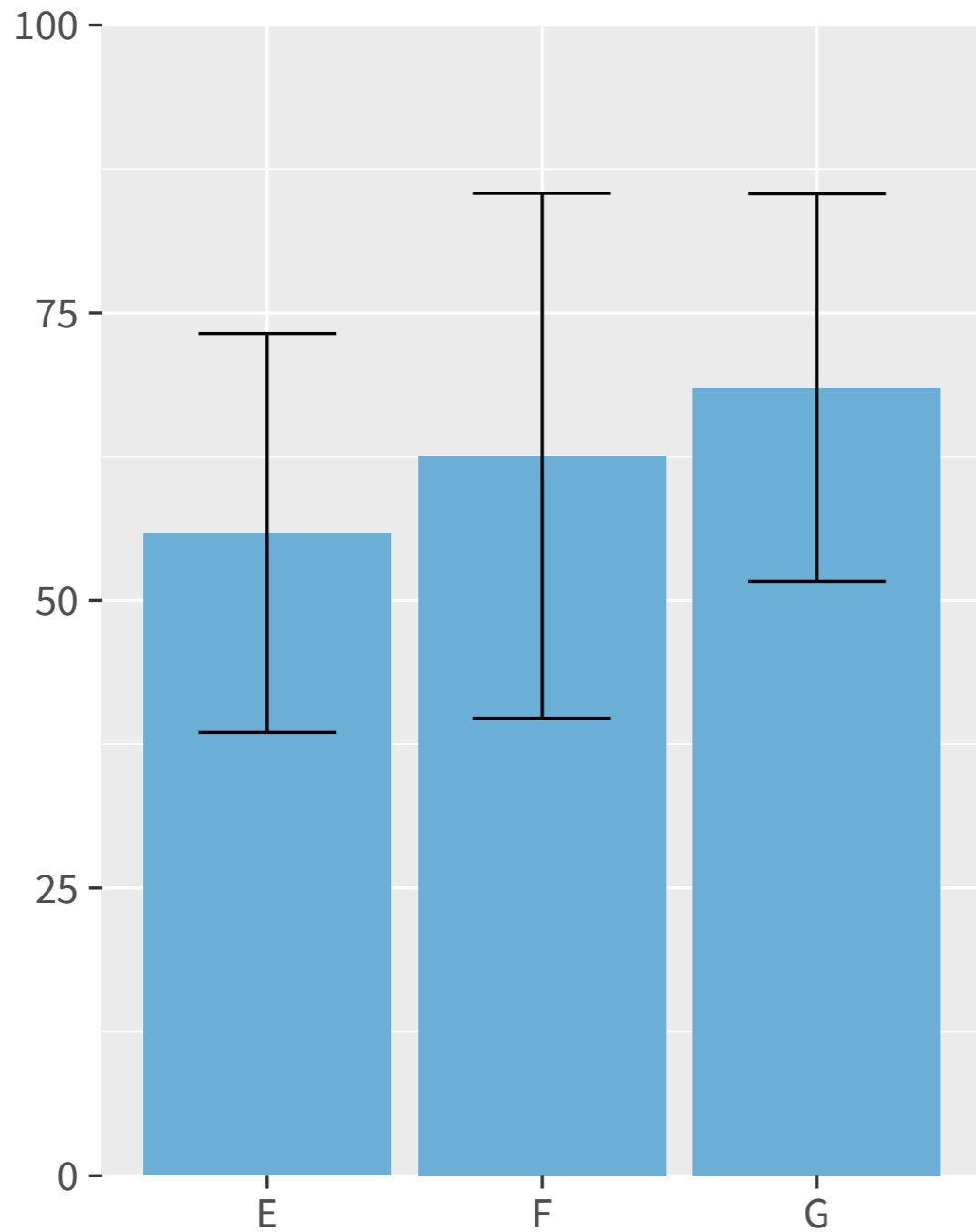
TIP #7 | MAKE IMPORTANT COMPARISONS EASIER



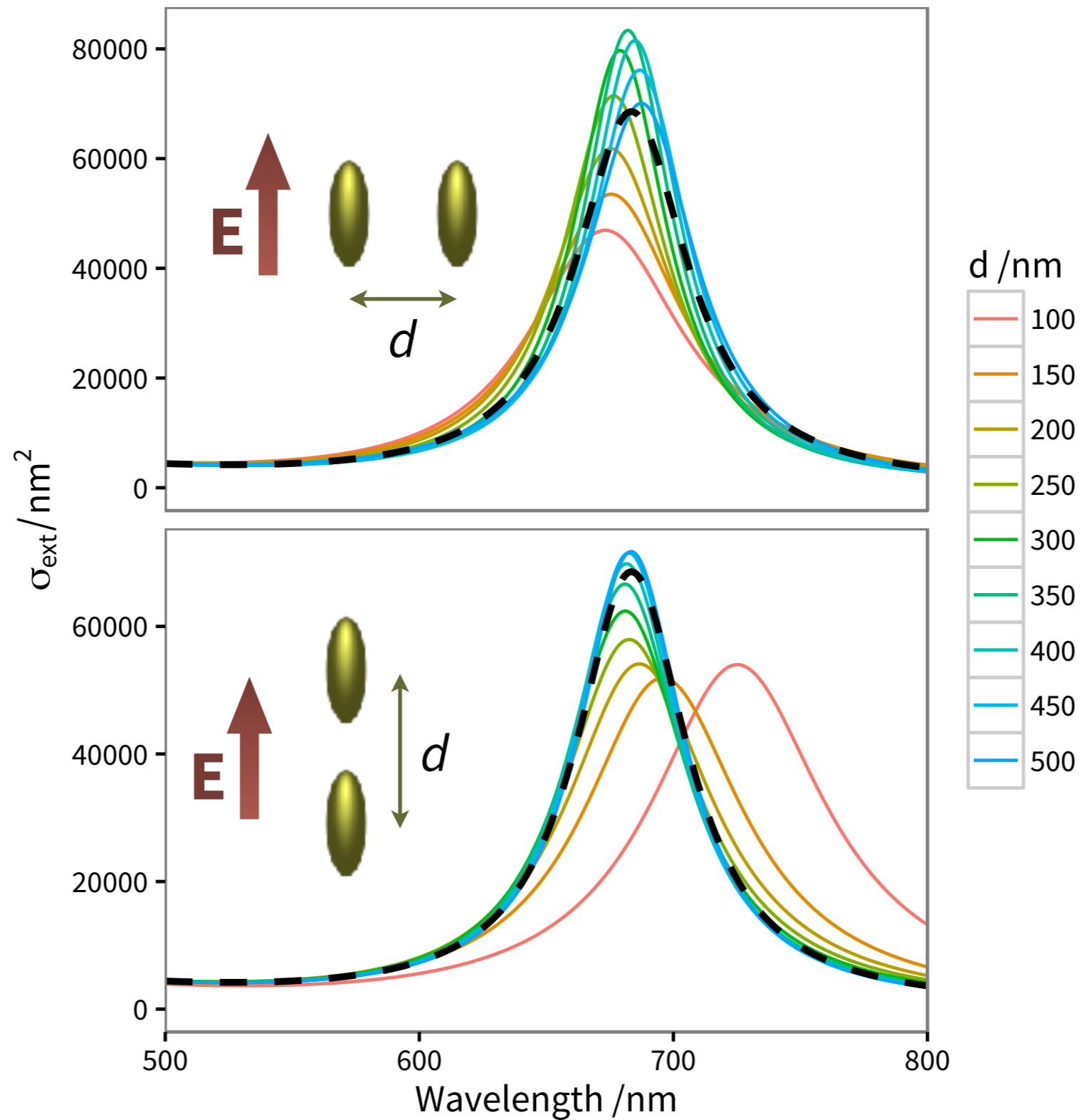
TIP #8 | DYNAMITE PLOT ALTERNATIVES



ALWAYS INCLUDE 0? IT DEPENDS



TIP #9 | CONTEXTUAL ANNOTATIONS



TIP #10 | USING COLOURS

- ▶ **USE COLOUR TO SYMBOLISE**

Be logical & follow conventions

- ▶ **USE COLOUR TO PRIORITISE INFORMATION**

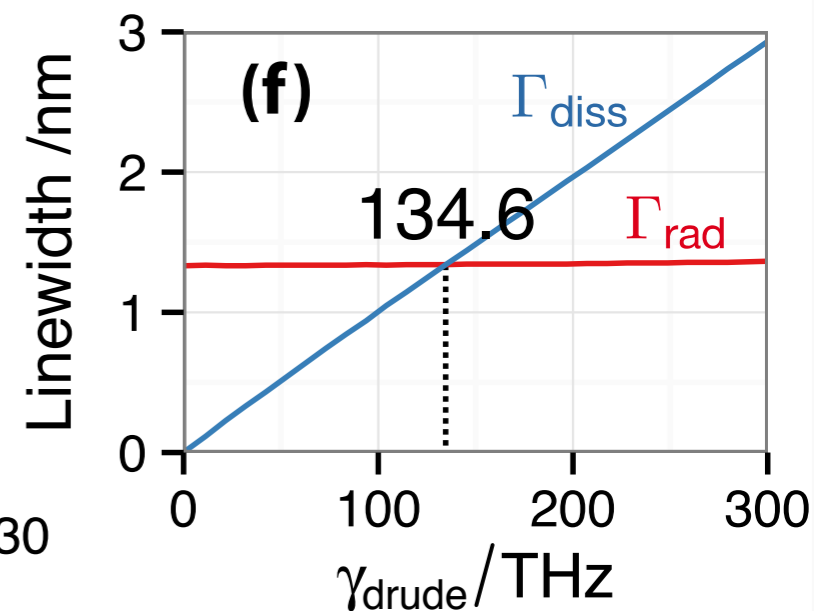
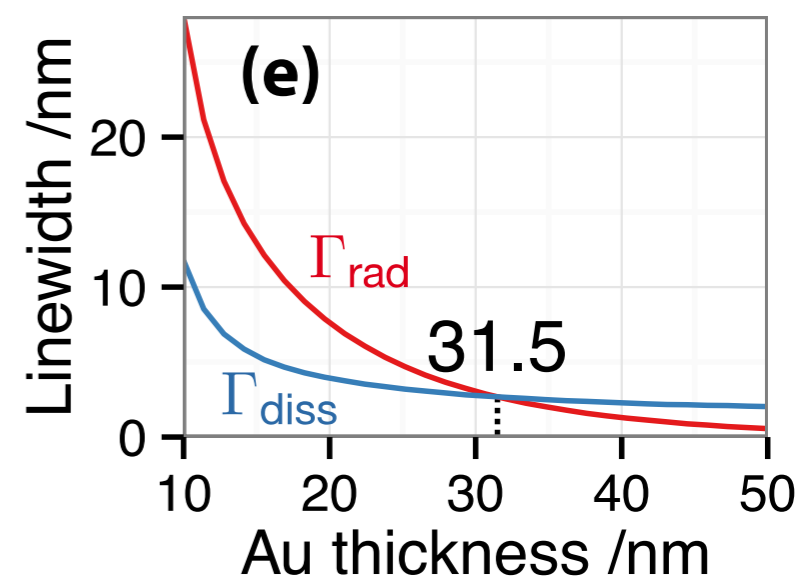
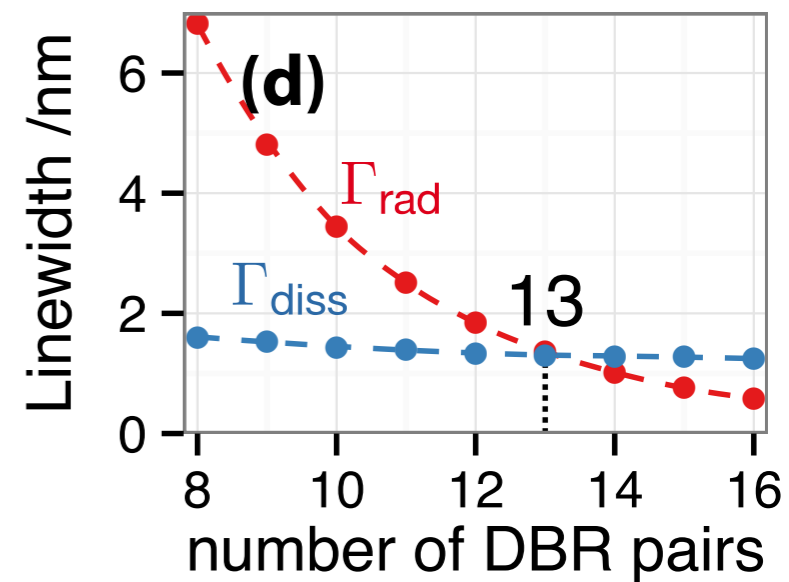
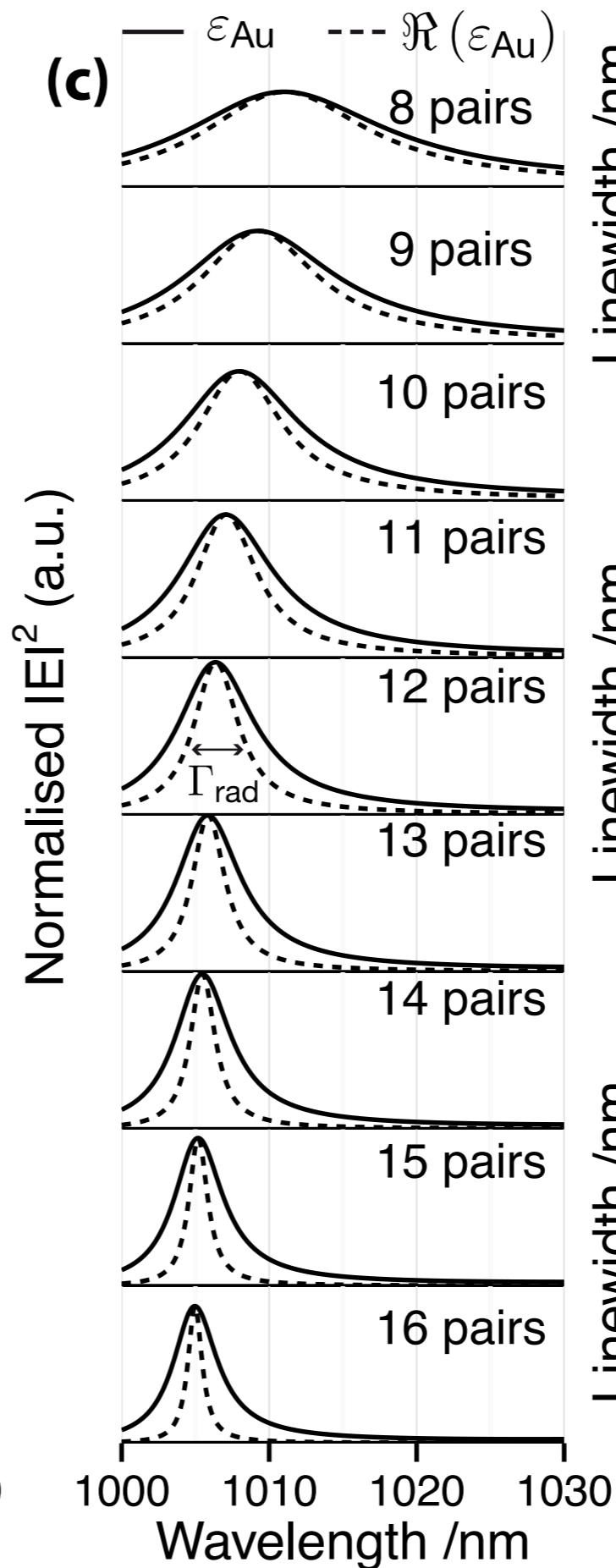
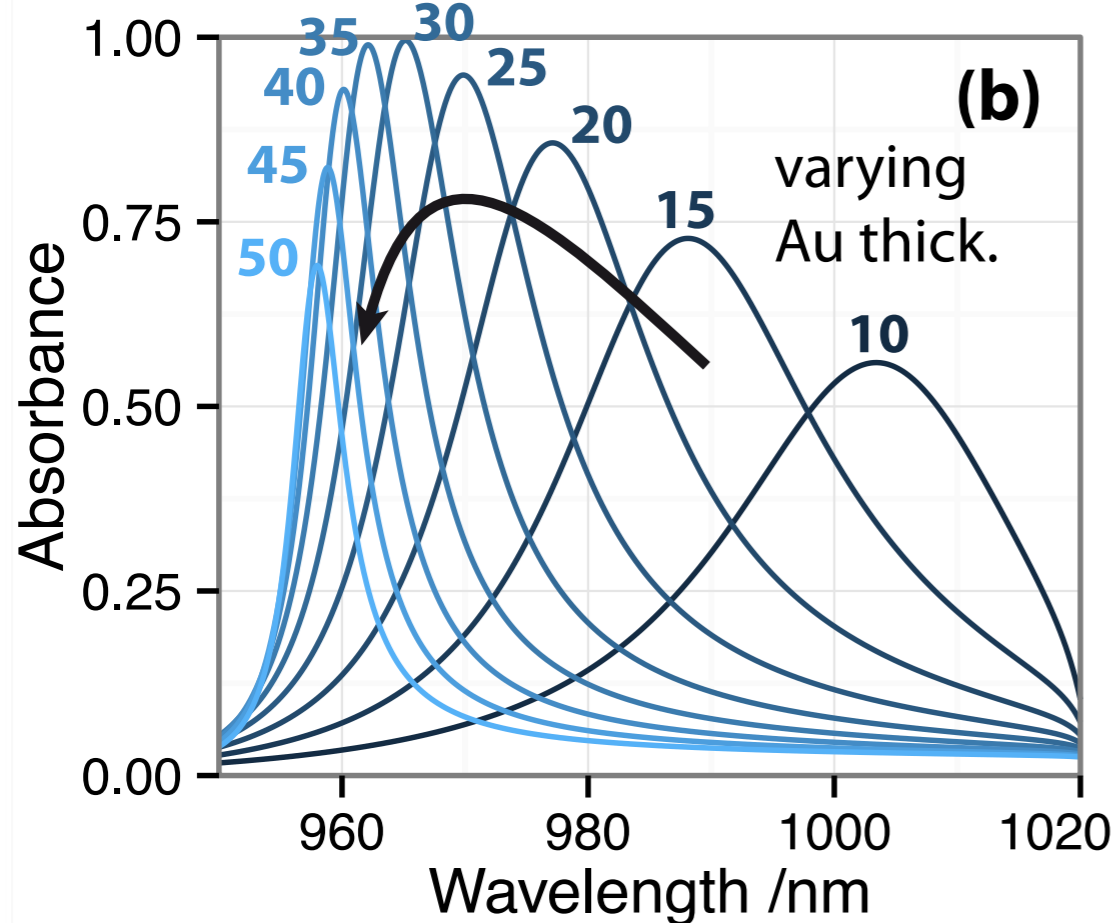
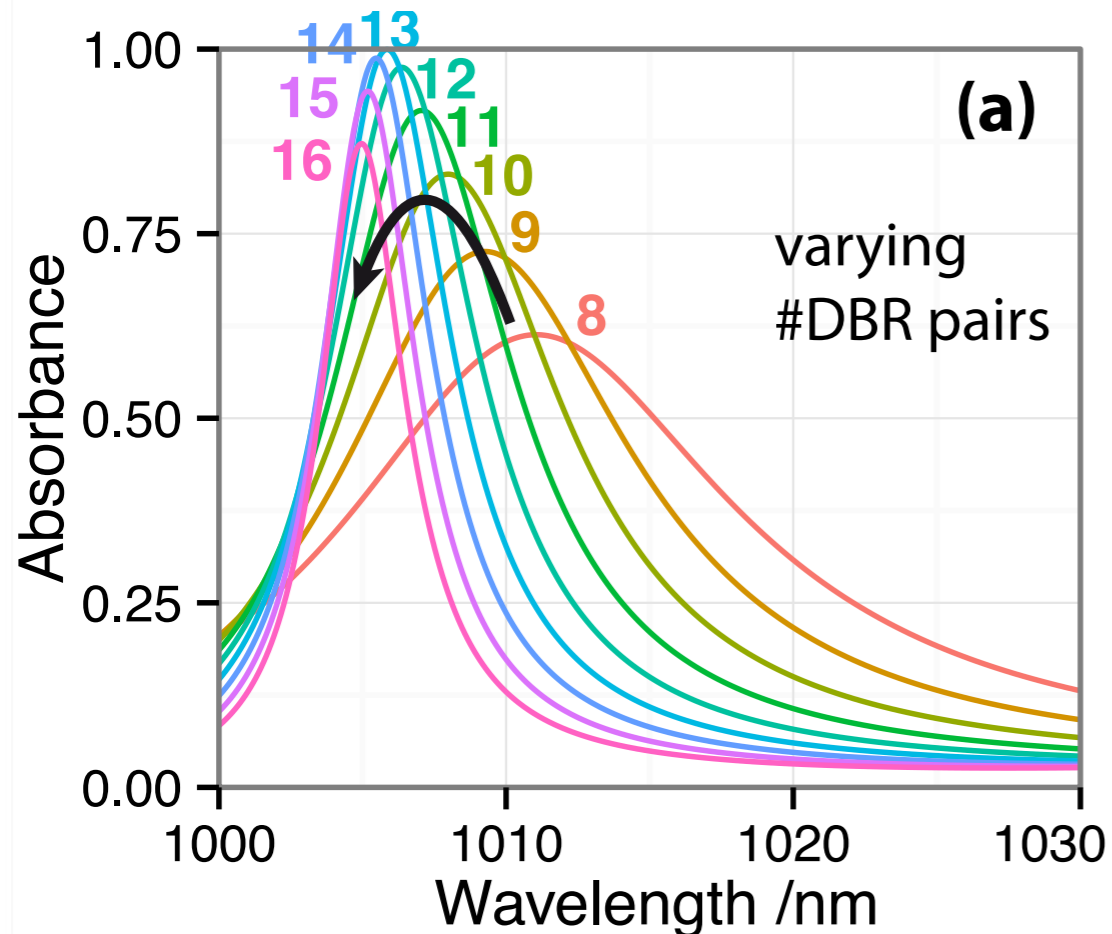
Smaller areas brighter, larger areas lighter

- ▶ **USE COLOUR TO IDENTIFY A RECURRING THEME**

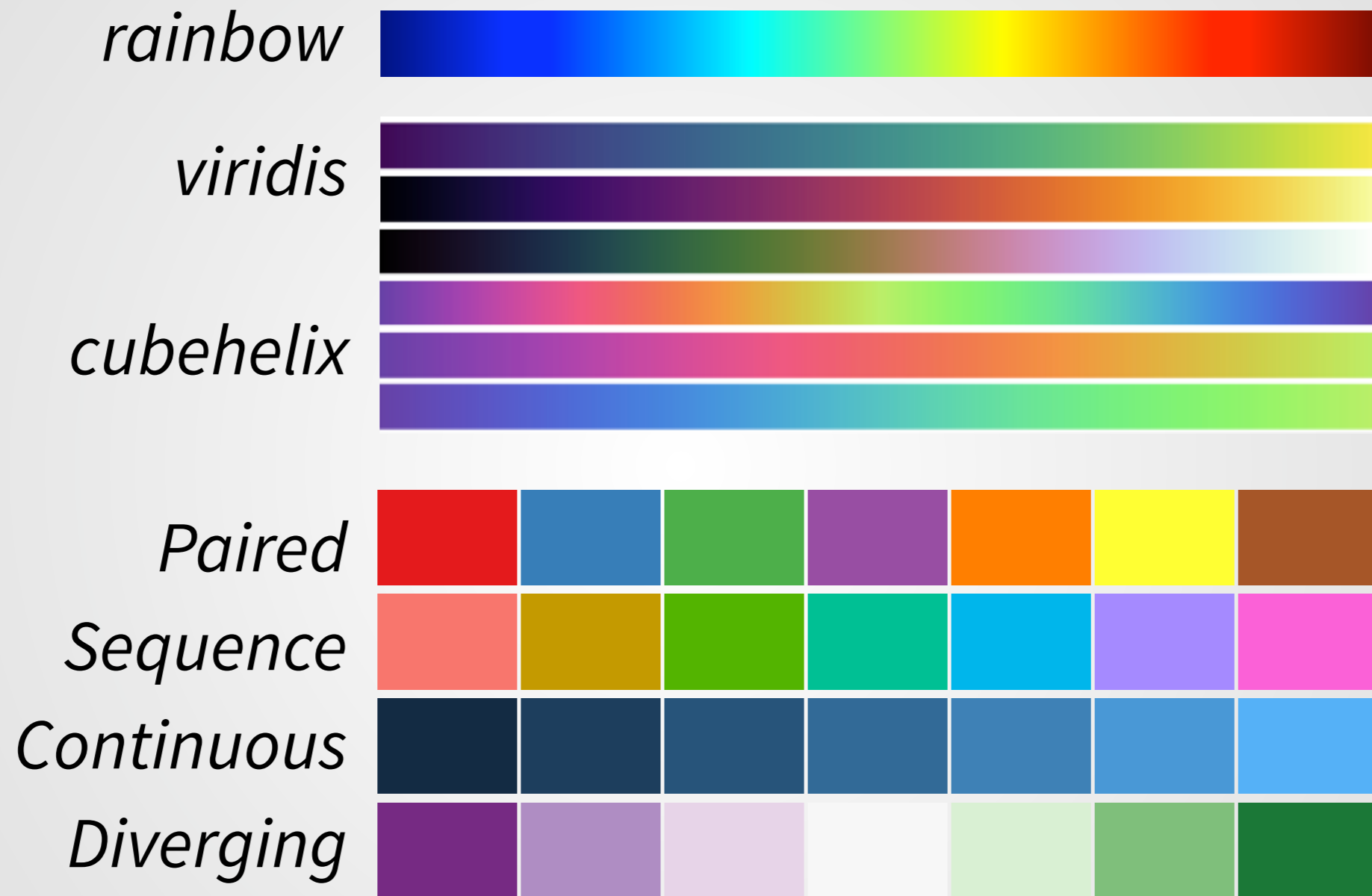
Be consistent

Use colour to explain, never just to decorate. **Do not** make something pretty for the sake of prettiness or because colour is available.

-Jan White



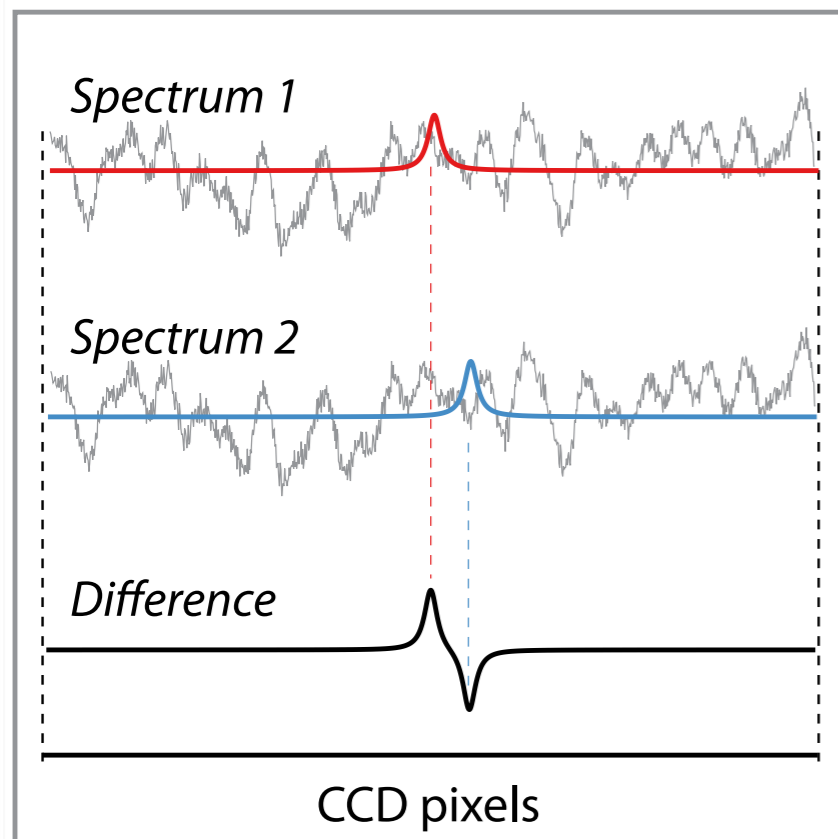
CHOOSING COLOUR PALETTES



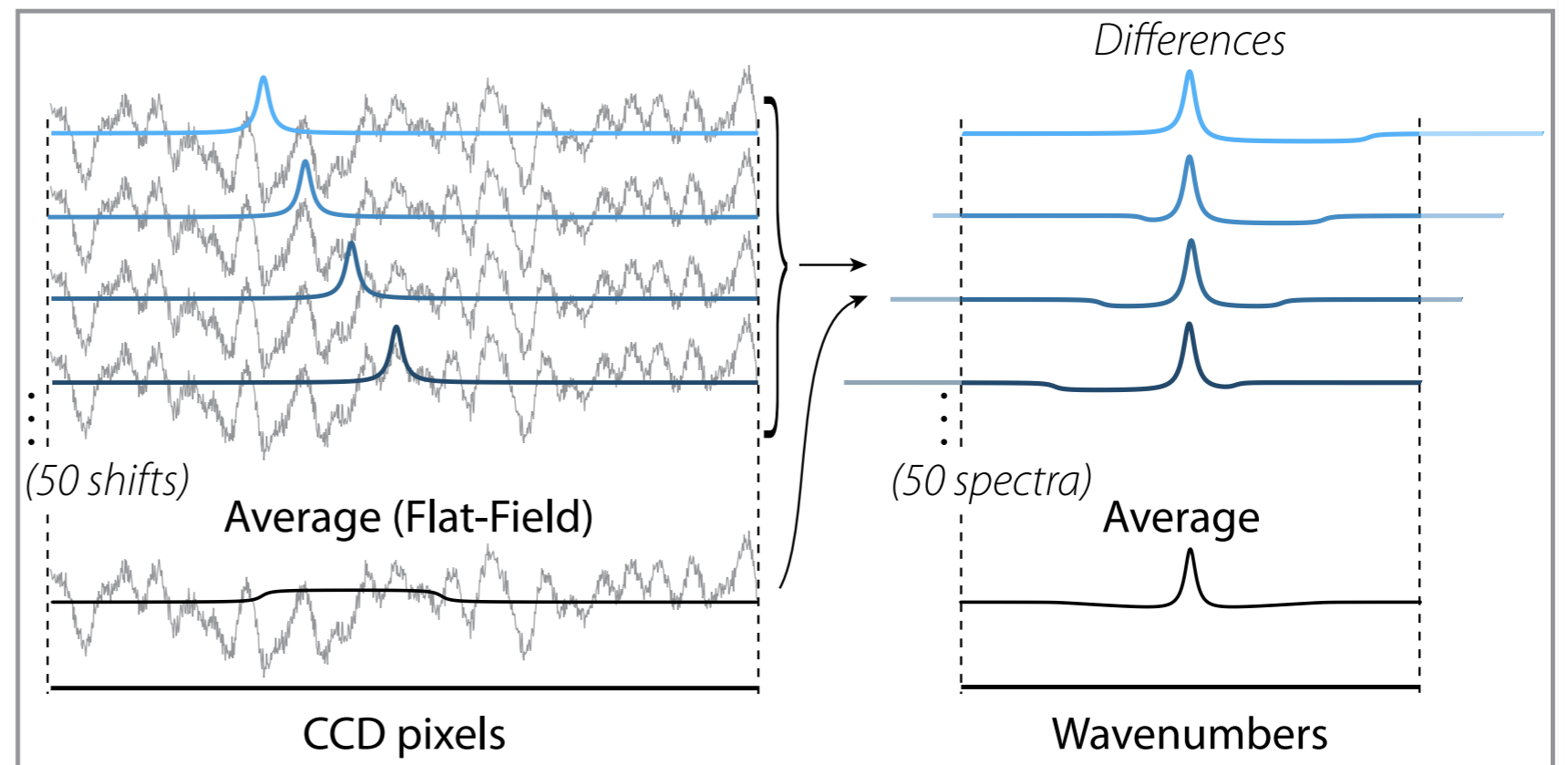
Note: ~8% of males, 0.5% of females, are **COLOUR BLIND**

COLOUR HELPS IDENTIFY, FOCUS, ORGANISE

Subtracted-Shifted RS

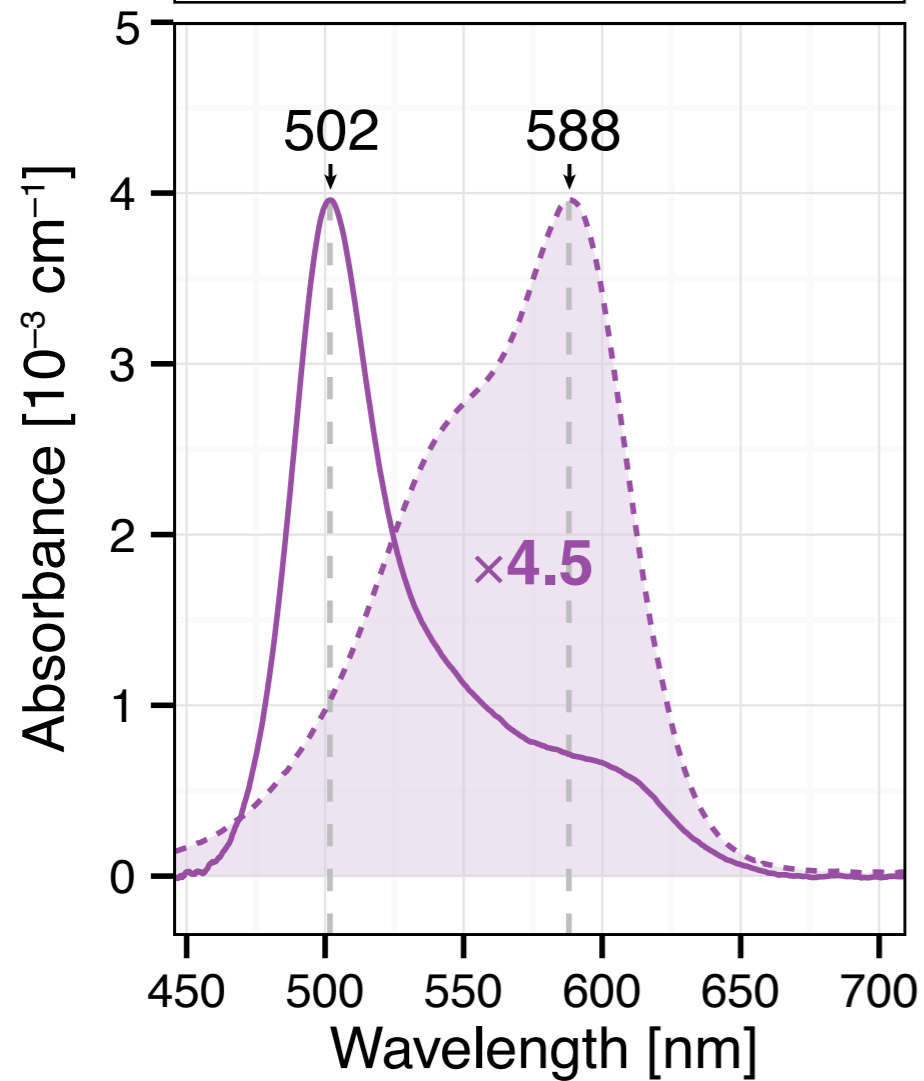
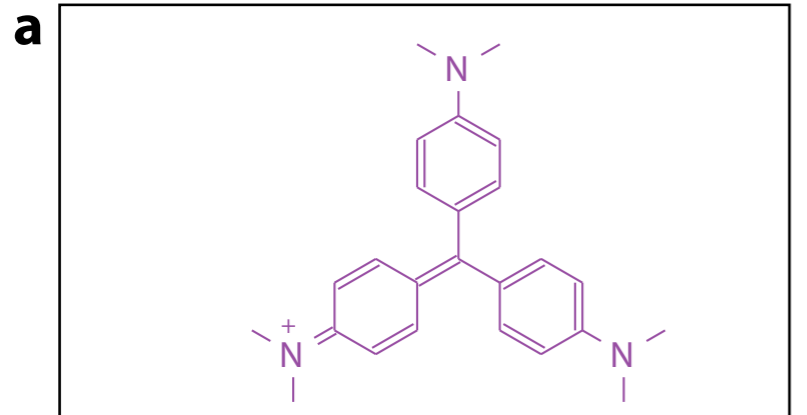


flat-field-corrected Continuously-Shifted RS

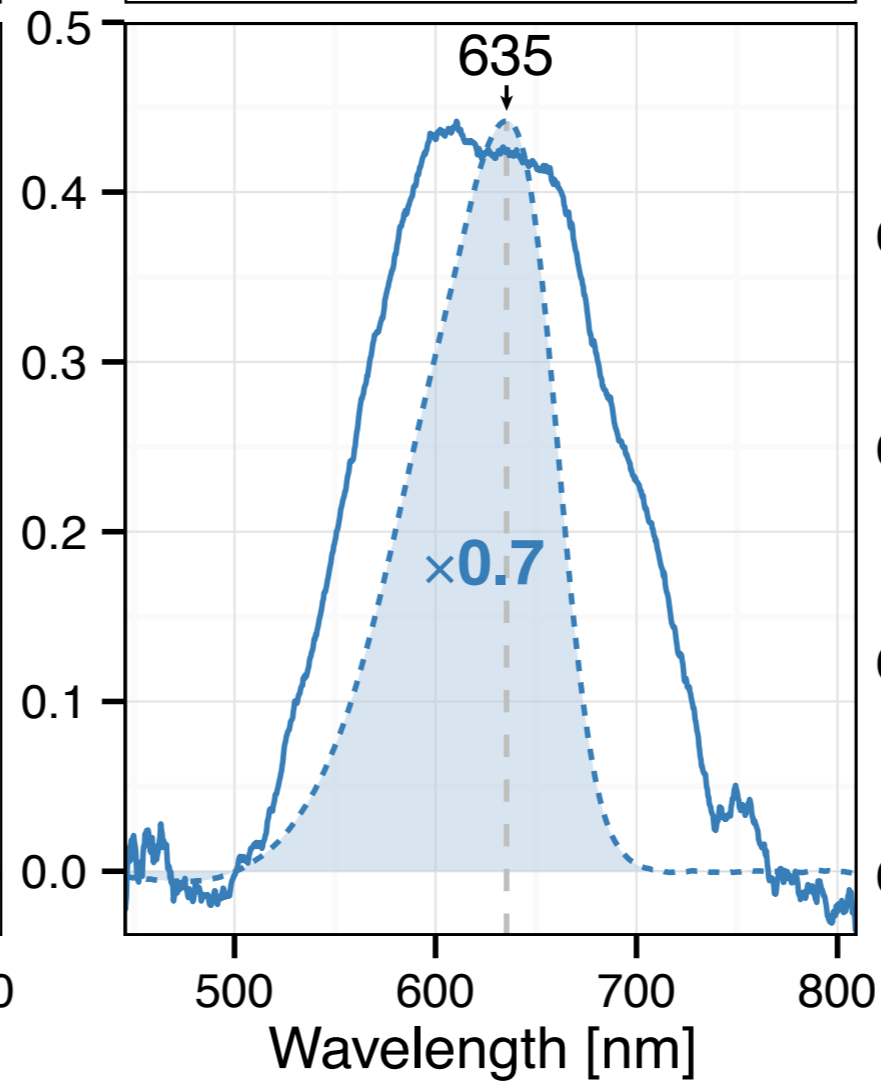
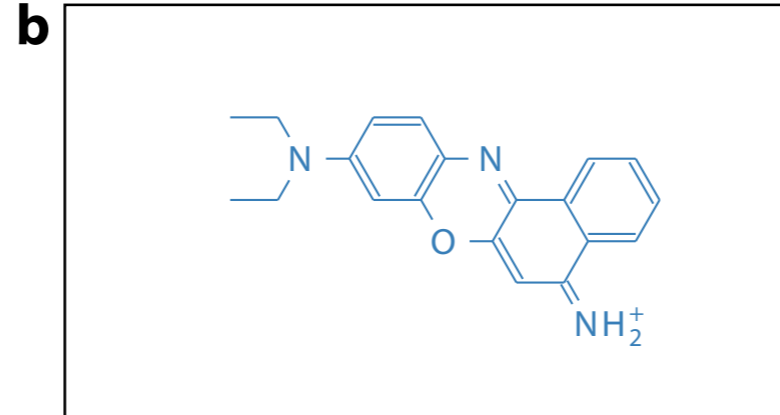


COLOUR AND CONTEXT

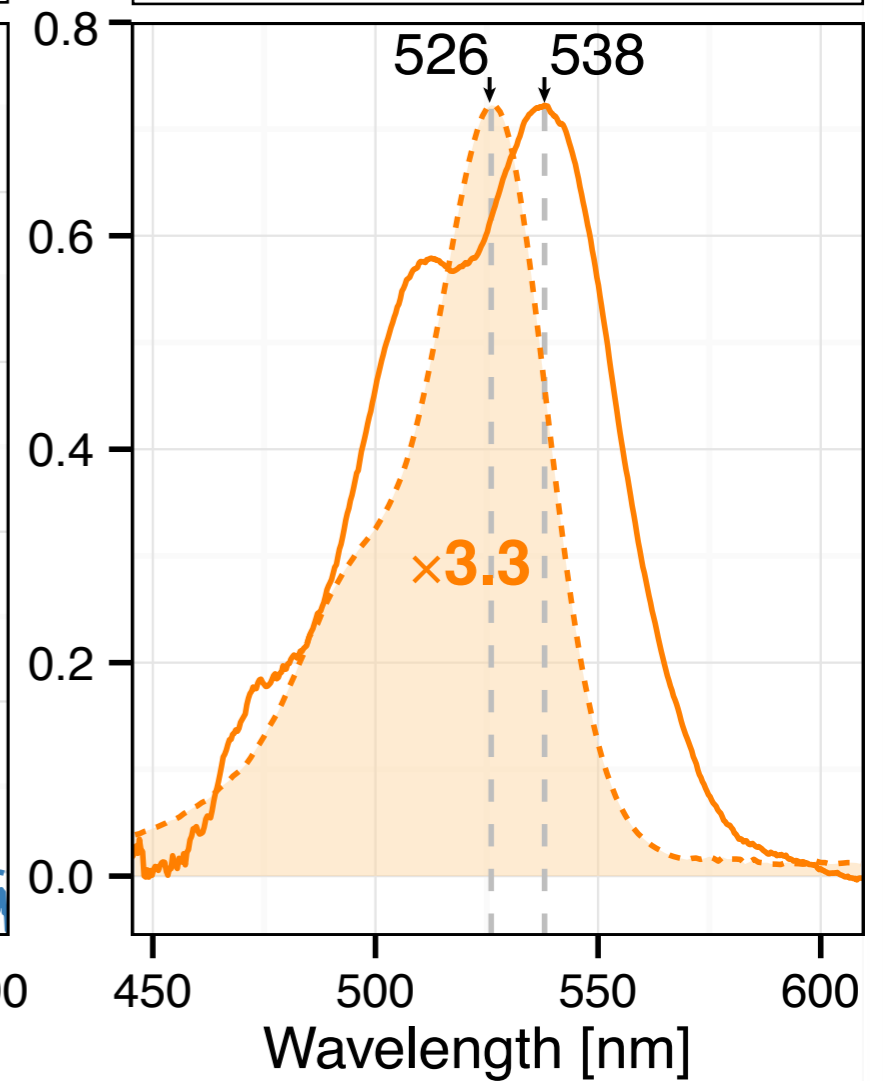
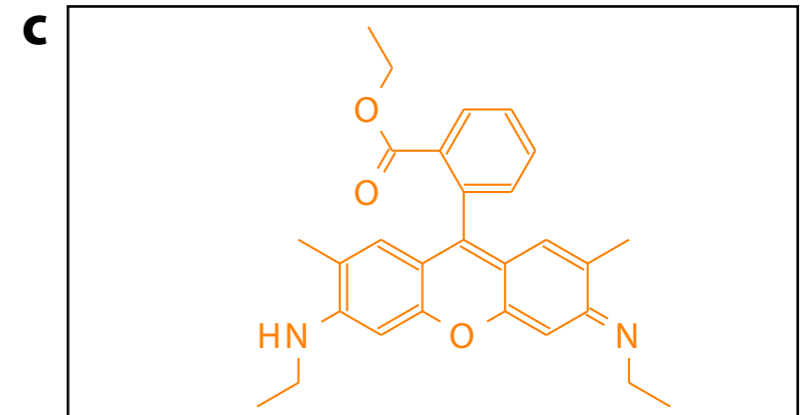
Crystal Violet (10nM)

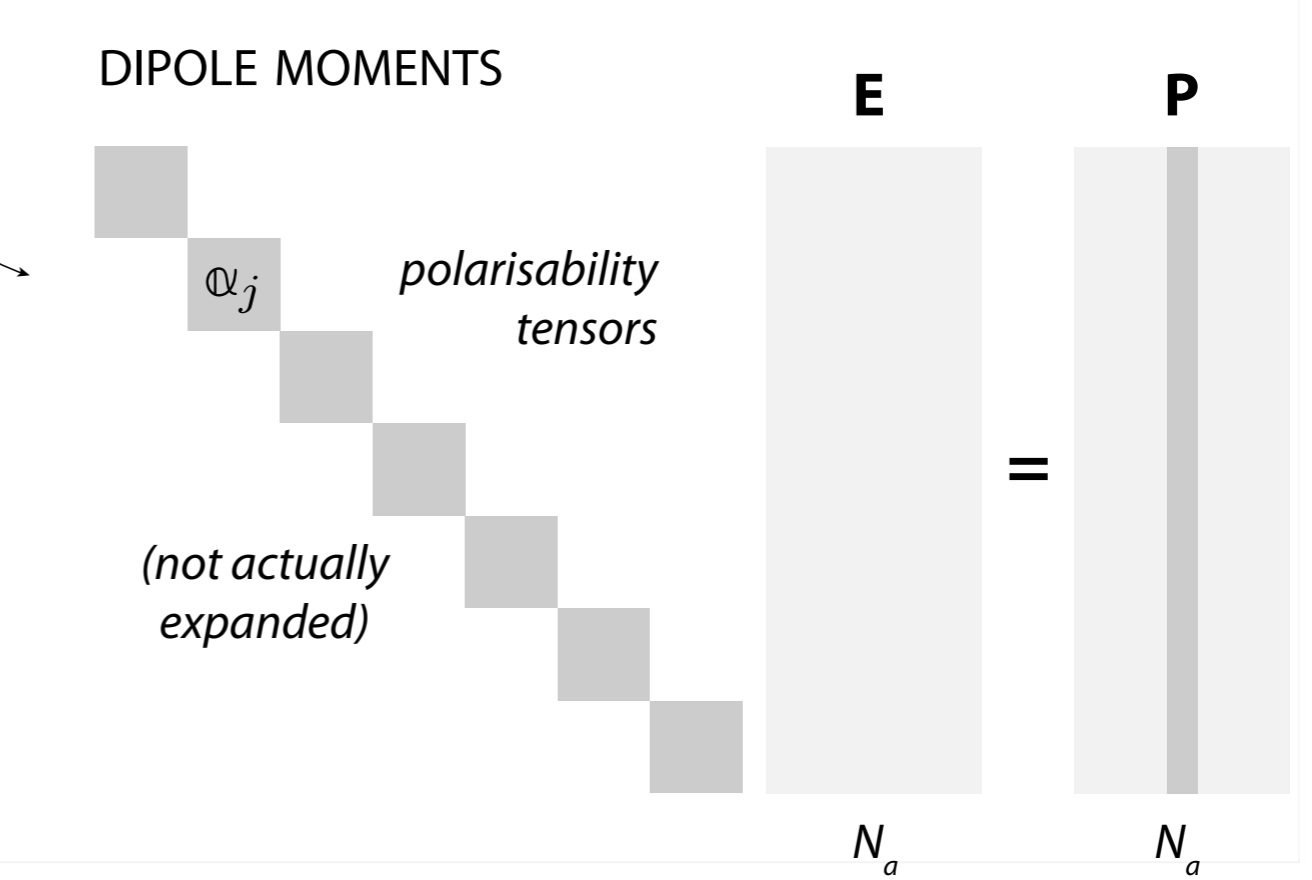
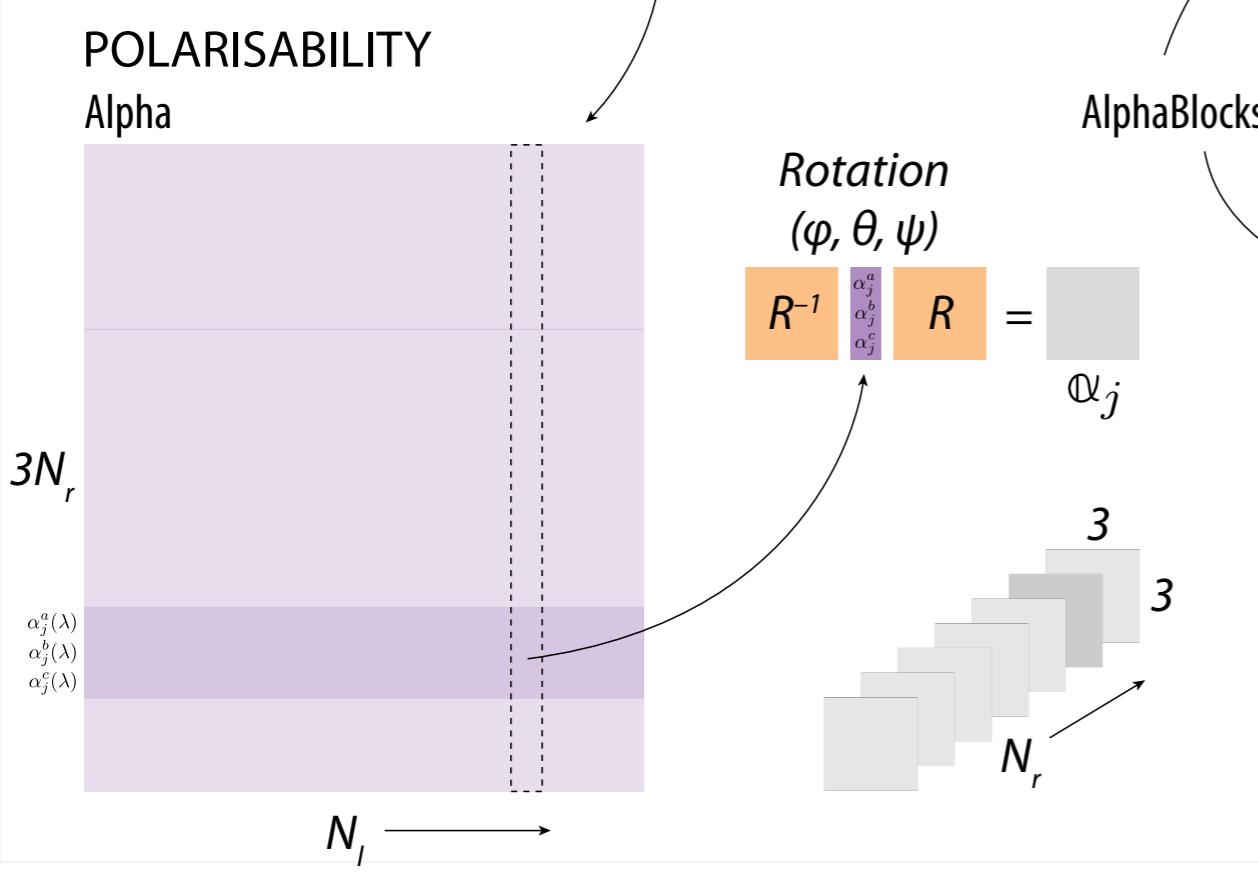
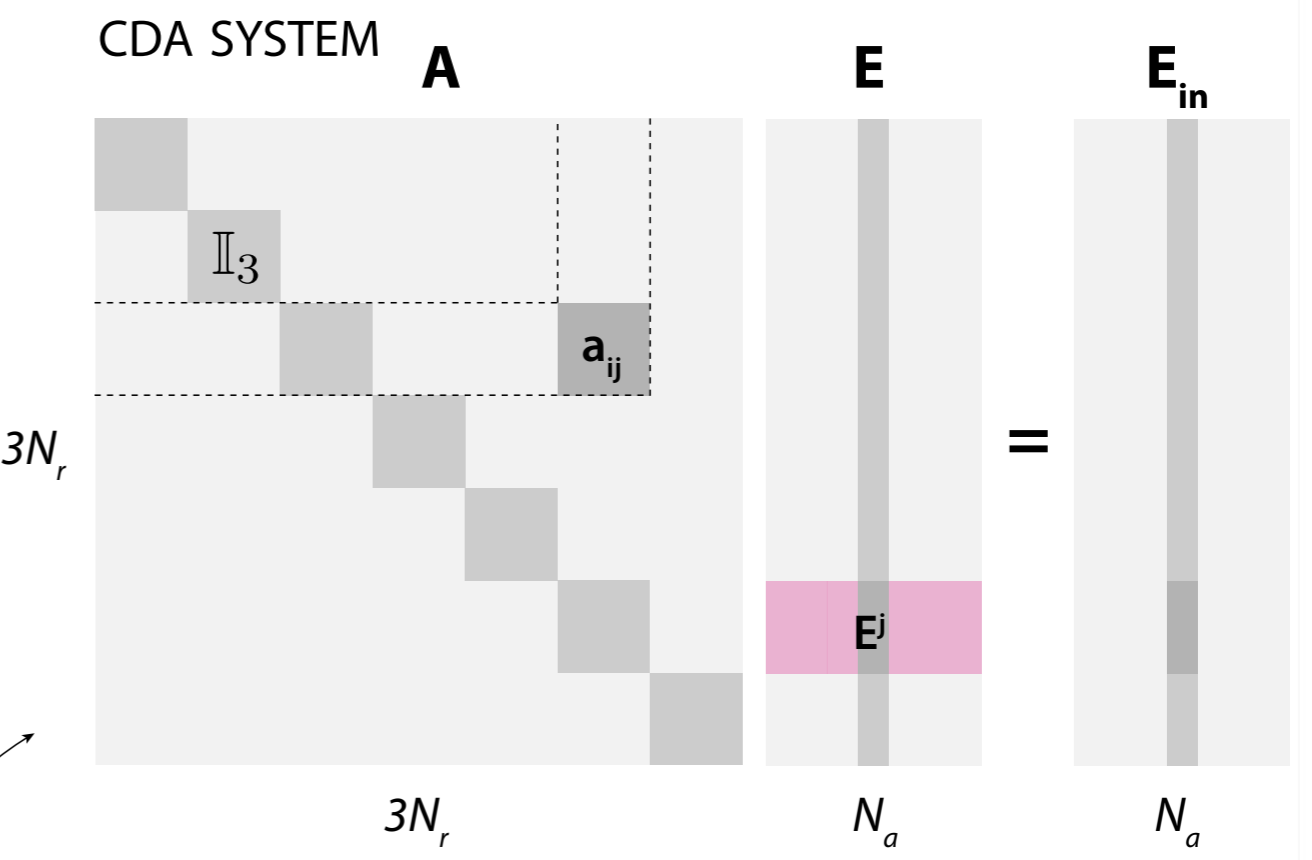
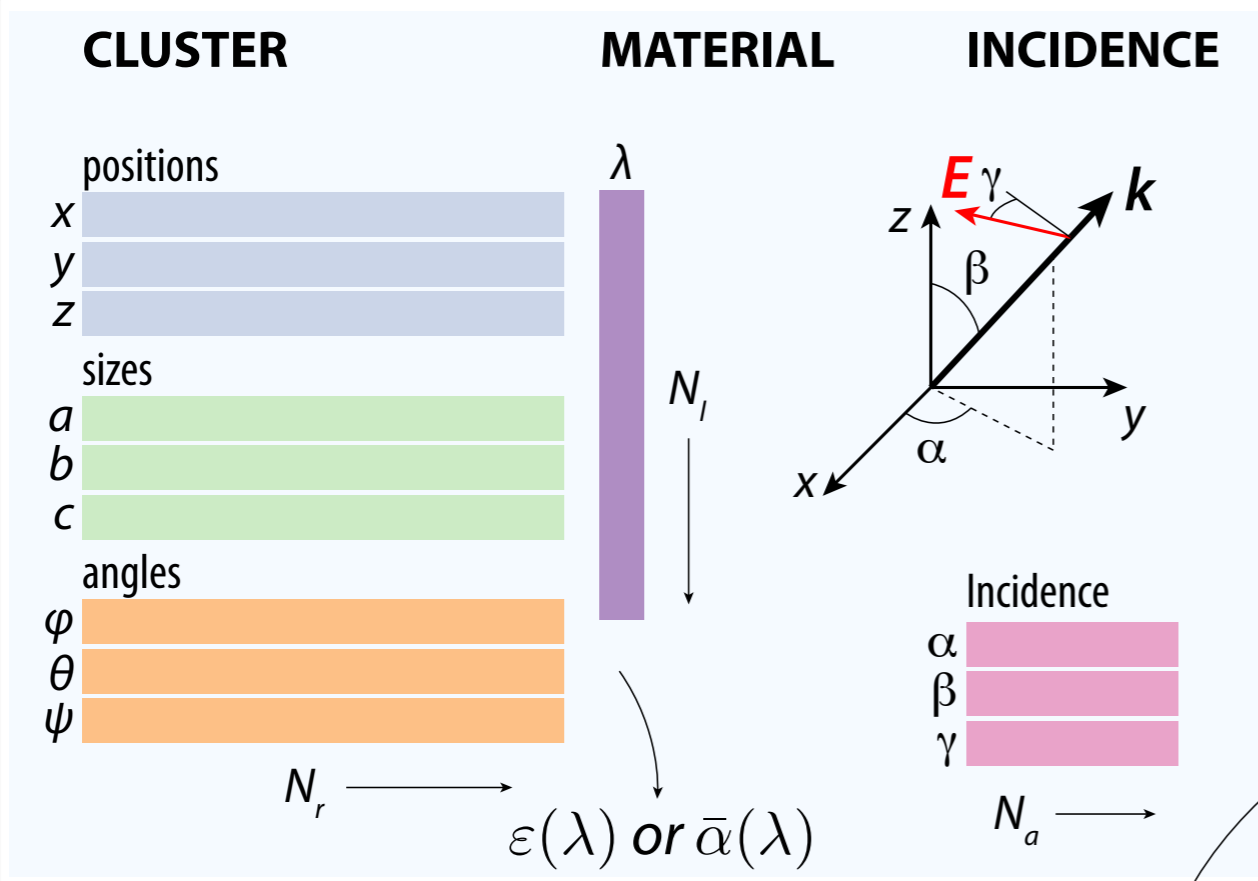


Nile Blue A (10nM)

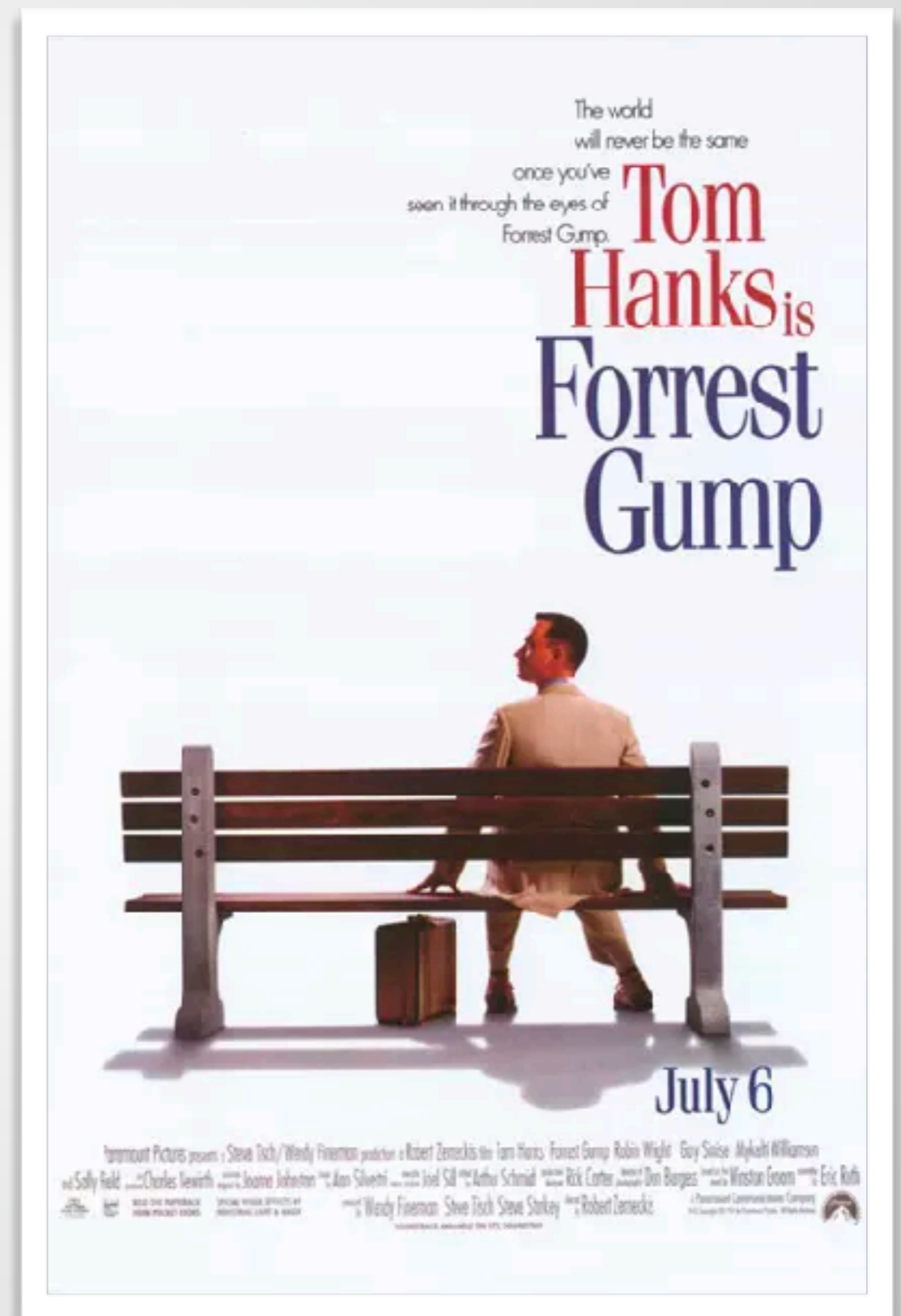


Rhodamine 6G (2.5nM)

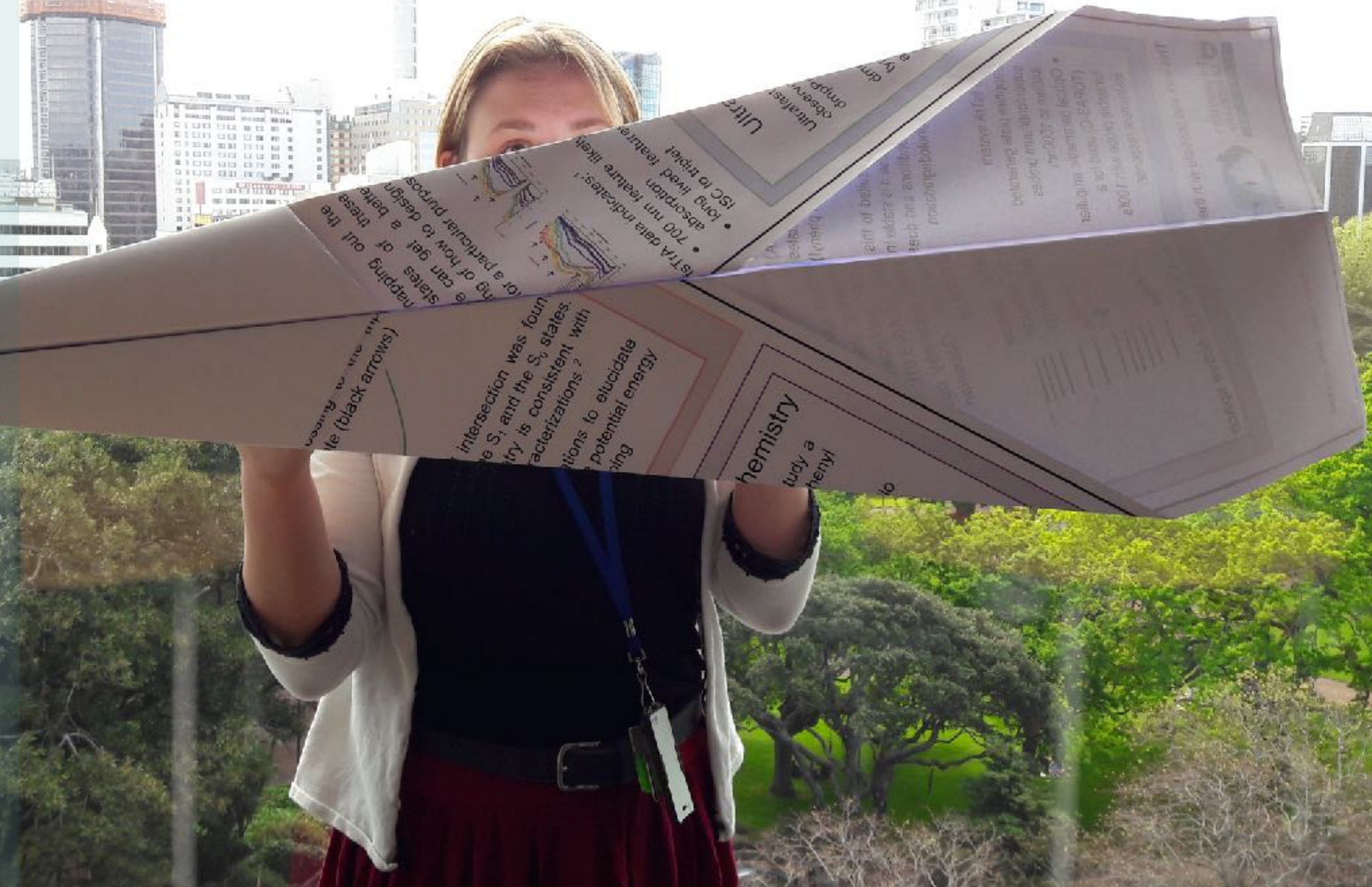




4 | POSTERS & MISC. GRAPHICS



WHAT IS THE POSTER FOR?



WHAT GOOD IS A POSTER?

▶ **POSTERS CAN BE EFFECTIVE FOR**

- Lab advertisement (appealing, introductory)
- Discussing our research less formally
- Showing the “big picture” – *e.g. xkcd.com/980*

▶ **POSTER USE IS VARIED**

- Interactive discussion vs individual viewing
- Serious vs introductory – *consider your audience*
- ¿A lesser oral presentation?

THE TEMPTATION OF THE
AVAILABLE RICHES IS
IRRESISTIBLE

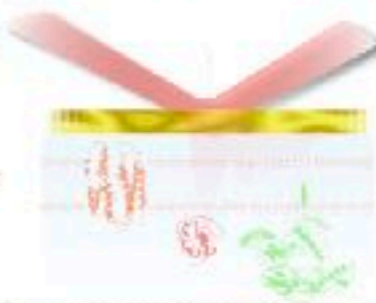
—Jan White

Surface Plasmon-Polaritons in Biosensing

Baptiste Auguie*
Prof. Bill Barnes

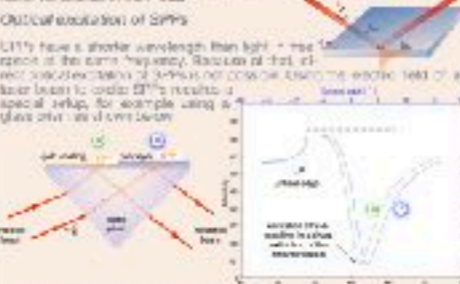
Tin Film Processes Group
School of Physics, University of Exeter,
Exeter, Devon - EX1 1QL - UK

* ba208@ex.ac.uk
<http://projects.ex.ac.uk/atto/>



What is a SPP?

Surface Plasmon-Polaritons are electromagnetic waves propagating along the interface between a dielectric and a metal. The electric field characterising such waves extends into an adjacent dielectric medium. For SPP propagating on planar surfaces, the decay length is typically 200 nm in the dielectric, and about 10 nm in the metal.



SPPs have a shorter wavelength than light of the same frequency. Because of that, evanescent excitation of SPPs is not possible using the electric field of a laser beam incident on a glass prism. A special setup, for example using a glass prism and a laser beam, is required to excite SPPs. This results in a sharp dip in reflectivity for a particular angle. Here we plot reflectivity curves for two different sensors.

Interest in biosensing

- coupled plasmon - metal - dielectric hybrid
- can enhance gas sensitivity any change in refractive index in the two half spaces is resonant to the surface mode is a huge change in the excitation of SPPs occurs (resonance condition)

We go further

- chemical detection: increase signal to noise ratio going into orders of magnitude greater sensitivity for SPPs (SPR sensors)
- no chemical label is required to indicate that a chemical has been present
- reducing the sensing volume, using localized plasmon resonances in nano-structures (surface Plasmon Resonance)

Attogram Sensitivity Project

The Attogram project, in collaboration between the Universities of Nottingham and Exeter aims to find the most sensitive technique to measure optically when molecules in real time. Current methods make use of Attogram Sensitivity. Total Reflection of light at a very sensitive angle of incidence on the surface of a glass prism base. What is a SPP? This sensing method is being used and improved in Exeter with an ultra sensitive differential surface plasmon (D-SPP) dip sensor technology designed by Dr. L. Hooper, having a sensitivity as accurate as a 10⁻⁶ change in refractive index of molecules under study.

Another topic of interest is the design of arrays of nanoparticles, which support so-called Surface Plasmons when they are excited optically. These structures are expected to be even more sensitive in the presence of molecules near the surface, as the electromagnetic field is partly confined in some hot spots where any change in refractive index may strongly change the plasmon resonance.

Differential SPR ellipsometry

Looking at incident reflected beams plane polarized at the incident angle is not the most accurate method as you can not, however, it has been shown that a polarized incident beam can improve sensitivity by two orders of magnitude. This technique involves measuring the phase shift of two different states of polarization, typically s and p, being reflected by the plasmon resonance.

Phase shift of a wave can be the direction of oscillation of the electric field.

- directly across in time, showing a phase shift
- two orthogonal s and p rays in polarized light ray (s-polarized) and p-polarized light ray (p-polarized)
- the sensitivity is characterized by the phase difference between the two orthogonal states of polarization p and s.

Particle Plasmons

By exciting silver metal particles in a plasmon mode, SPPs become localised and the structure will like a resonant cavity or at the constant or stationary. This leads to characteristic changes in the colour of light absorption, and scattering being strongly related to the particle size, spacing and surrounding media. The colour change is related to the surface plasmon resonance, around some very sensitive 'hot spots'.

These methods are being used to make these particles, such as:

- Monolayers of nanoparticles acting as a film
- metal deposition
- UV lithography
- e-beam lithography
- self-assembly
- colloidal particles

UV lithography

UV lithography is a process of creating patterns on a substrate by exposing it to ultraviolet light through a mask. The light causes a change in the surface of the substrate, which is then developed to reveal the pattern.

UV lithography is used to create patterns on a substrate, which are then used to create structures on the surface of the substrate.

Pattern scrub

- The most sensitive is being held to increase the amount of light and design the optical setup
- shape of the particles
- array pitch
- material
- wavelength

Observation techniques

- such as light scattering
- fluorescence
- reflectance and transmission

Experiments on Biology

- DNA (Double-Strand) binding probe
- protein binding (cell) - cell surface
- gene expression monitoring by RNA binding

Automation for process control (using an array probe to detect the presence of molecules in a cell).

Conclusions

SPPs have been used to provide an efficient technology for sensing. Here we have looked at better sensors for life and pathological processes in real time. Different techniques are being explored. Differential SPR ellipsometry. By looking at polarized beams rather than intensity and using gold nanowires, one can increase sensitivity by a factor of 10 and a new external system is being developed to compensate for thermal and pressure variations.

Localized SPPs

With many different production techniques available, such as self-assembly of films and structures, particle arrays now give us the opportunity to carry out many measurements and making good use of a localized surface plasmon resonance.

References

- 1) "Study of the effect of surface plasmon resonance on the detection of DNA molecules." Journal of Applied Optics, vol. 40, pp. 3034-3039 (2001).
- 2) "Design of silver nanoparticles: field confinement and spectral position of localized surface plasmon resonance." Ming-Kai, S. J. J. Journal of Applied Optics, vol. 40, pp. 3034-3039 (2001).

Acknowledgements

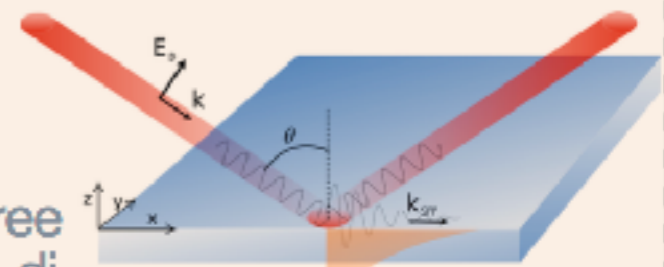
Engineering and Physical Sciences Research Council (EPSRC) D. A. L. Hooper, D. L. Hooper and Dr. James Buckley from Exeter for their kind and helpful comments.

(* ba208@ex.ac.uk)
<http://projects.ex.ac.uk/atto/>

Attogram Sensitivity

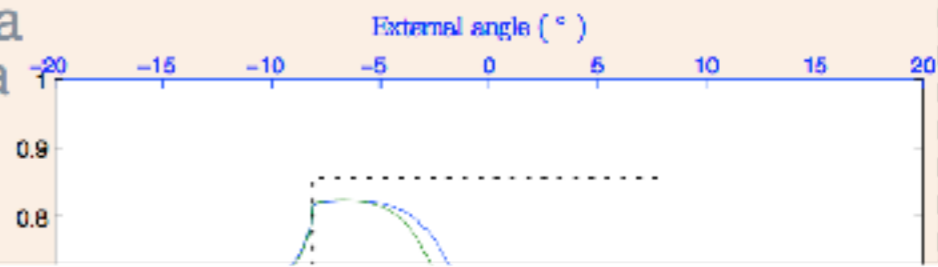
The Attogram project, in collaboration with the University of Nottingham, aims to find the most sensitive technique to detect changes in refractive index. Current methods make use of Attenuated Total Reflection (ATR) on a glass prism. The electric field of a laser beam is incident on a glass prism at an angle theta. A thin metal layer is coated on the surface of the prism. The incident light is totally internally reflected, but a portion of its energy is coupled into the metal layer, exciting SPPs. This results in a sharp dip in reflectivity for a particular angle. Here we plot reflectivity curves for two different sensors.

both media. For SPP propagating on planar surfaces, the decay length is typically 200 nm in the dielectric, and about 10 nm in the metal.



length than light in free space. Because of that, direct excitation of SPPs is not possible. Using the electric field of a laser beam incident on a glass prism requires a special setup, for example using a glass prism and a laser beam.

using a



POSTER PRESENTATION GUIDELINES

▶ **TELL A COMPELLING STORY**

- Focus on main points
- Attract the viewer's attention
- Use few words, lists

▶ **TEST FOR EFFECTIVENESS** – print, discuss, iterate

▶ **MAKE THE BEST USE OF THE MEDIUM**

- Complement with discussion (*prepare it*)
- Consider other supports (*tablet, 3D model, ...*)
- Be original, but not distracting (*message first*)

POSTER TIPS

▶ **FONTS**

- Few styles, consistent
- 24pt minimum
- Appropriate (e.g. Helvetica, not *Zapfino* or Comic Sans)

▶ **STRUCTURE**

- Not an abstract: be concise
- Results first: get the attention
- Good flow: reading order must be obvious

POSTER TIPS

▶ **FOCUS ON WHAT'S IMPORTANT**

- Use *only* what's required for your story
- Find a beautiful illustration
- Be consistent and structured

▶ **FACILITATE THE COMMUNICATION**

- Choose meaningful colours and illustrations
- Design with balance (not *too big*, *use of negative space*)
- Be ready to present and engage

CRITICAL COUPLING OF LIGHT to TMM SURFACE-PLASMONS

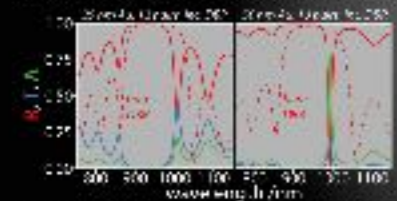


Baptiste Auguie, Viviana Villafañe, Axel Bruchhausen, Alejandro Hainstein
 Centro Atómico Bariloche e Instituto Balseiro, San Carlos de Bariloche, 8400 Río Negro, Argentina

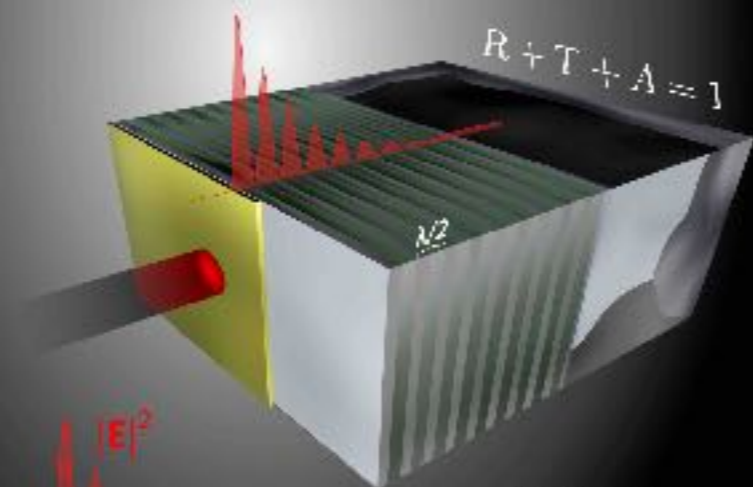


Introduction

Tamm plasmons (TPs) are electromagnetic modes confined between a Distributed Bragg Reflector (DBR) and a noble metal (e.g. gold). In contrast to surface plasmons, they may be excited at normal incidence, and present a high-quality factor, making them promising candidates for enhanced light-matter interaction, non-linear optics, optomechanical coupling [2,3]. Upon excitation of TPs, a dip in reflectivity is observed, which may be optimized to reach 0% (critical coupling), and optical energy is redistributed in transmission and absorption [4].



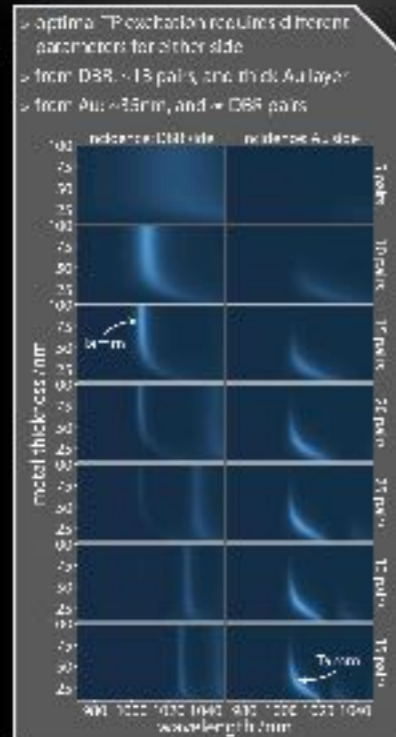
In this work, we describe the conditions that yield vanishing reflectivity at the TP resonance, and further discerns the regime of total absorption.



Au-DBR structure
 $Au-9x(GaAs/AlAs)-GaAs$

Critical coupling

- transparency, $T=1$, only in a dissipationless gain/loss resonator
- $R = \frac{1 - \frac{1}{Q_{DBR}} - \frac{1}{Q_{Au}}}{1 + \frac{1}{Q_{DBR}} + \frac{1}{Q_{Au}}} = \frac{1 - \frac{1}{Q_{DBR}} - \frac{1}{Q_{Au}}}{1 + \frac{1}{Q_{DBR}} + \frac{1}{Q_{Au}}}$
- $R=0$ (critical coupling) when $\frac{1}{Q_{DBR}} = \frac{1}{Q_{Au}}$
- If $\frac{1}{Q_{Au}} > \frac{1}{Q_{DBR}}$, complete absorption



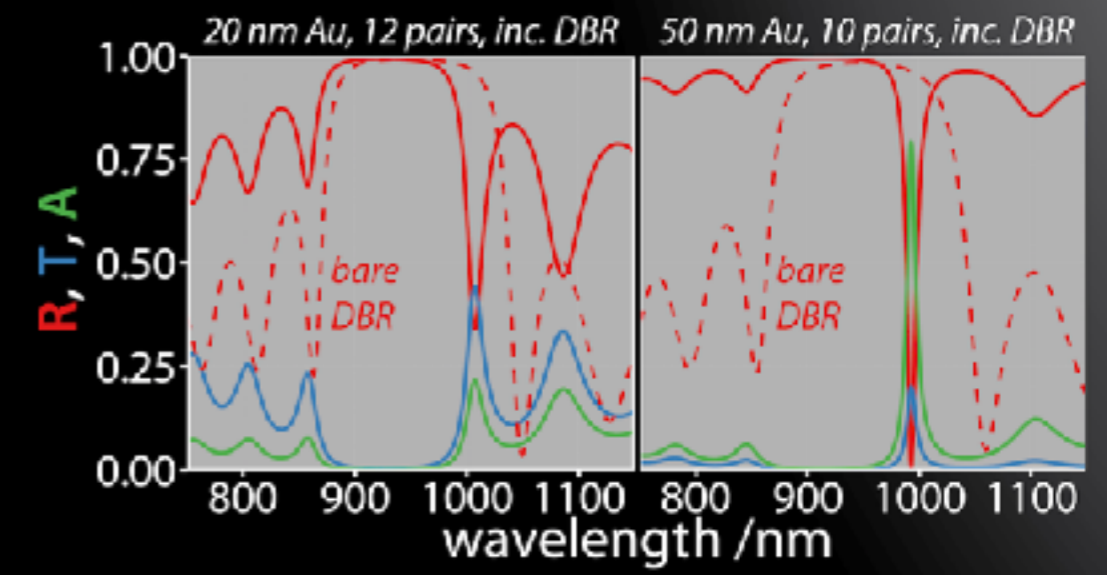
Conclusions

- The theory of open resonators and critical coupling sheds light on so far counterintuitive features of Tamm modes.
- A regime of complete absorption can be reached, with optimal field enhancement.
- Applications may include thermal emitters, optical communications, and sensing.

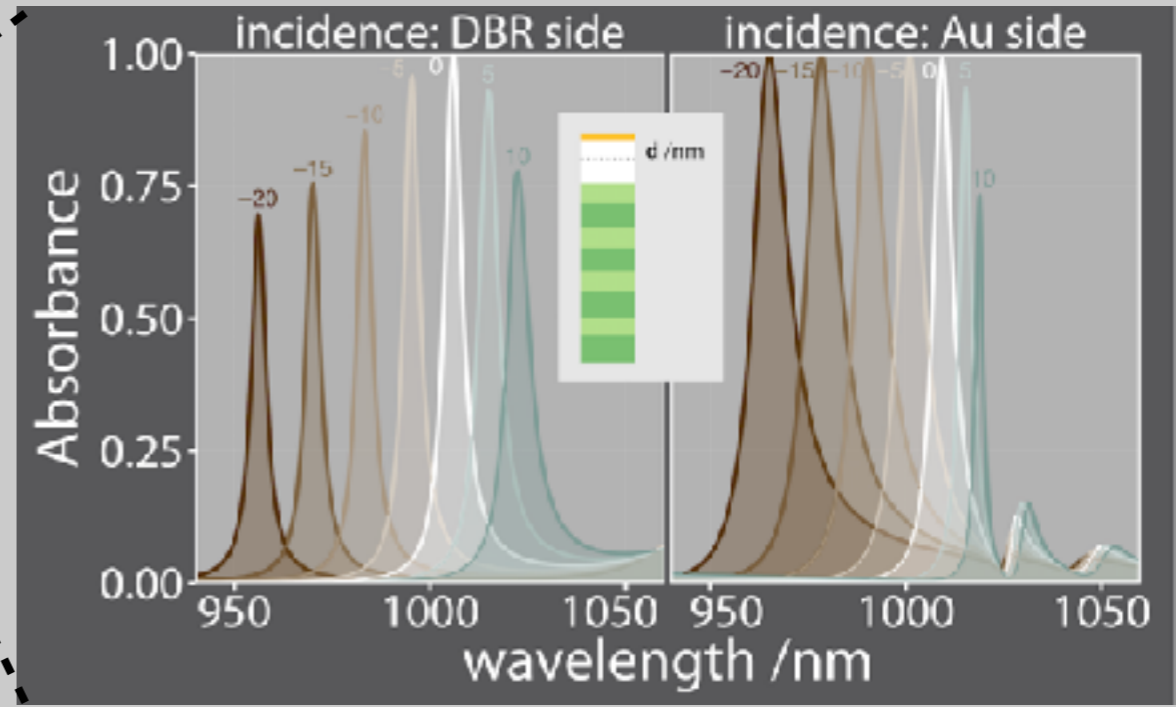
References

- [1] Phys Rev 3 75(10), 2007
- [2] Opt Lett 38(5), 2013
- [3] App Phys Lett 100(12), 2012
- [4] Rev Mod Phys 80(4), 2008

0% (critical coupling), and optical energy is redistributed in transmission and absorption [4].



In this work, we describe the conditions that



RADIATIVE CORRECTION FOR ELECTROMAGNETIC SCATTERING

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Motivation— With the recent increased interest in the optical properties of nano-particles, there has been a strong incentive to develop simple methods to solve the electromagnetic (EM) scattering problem for sub-wavelength objects of general shape and composition. The quasi-static approximation is particularly well suited for the rapid and accurate modeling of such small scatterers. However, because this approximation intrinsically neglects radiation, it cannot satisfy the conservation of energy. The recurring issue of defining a rigorous self-reaction correction has thus resurfaced in this particular context. To date, this correction has been introduced only heuristically, and only for the simplest cases. We propose a formalism in which such radiative corrections (RC) to EM scattering can be justified rigorously and generalized to any other cases including point or body scatterers and to any multipolar order.

— THE CASE OF A POINT DIPOLE —

- Power extracted by such a dipole from the EM field is $P_{\text{ext}} = \frac{1}{2} \text{Re}(\alpha_0) |\mathbf{E}_{\text{ext}}|^2$
- Also the power absorbed P_{abs} in the electrostatics approximation
- Energy conservation $P_{\text{ext}} = P_{\text{abs}} + P_{\text{rad}}$ is violated for optical properties

Self-field correction polarizability

$$(\alpha^{\text{RC}})^{-1} = \alpha_0^{-1} - G$$

- Enforces energy conservation, but G is infinite...
- Common prescription: use the finite, imaginary part

$$\alpha = \frac{\alpha_0}{1 - i \frac{k_0^3}{6\pi\epsilon_0\epsilon_1} \alpha_0}$$

— T-MATRIX FOR LIGHT SCATTERING —

Relates field expansions of incident and scattered fields in a basis of vector spherical wavefunctions.

$$\begin{pmatrix} \mathbf{p} \\ \mathbf{q} \end{pmatrix} = \mathbf{T} \begin{pmatrix} \mathbf{a} \\ \mathbf{b} \end{pmatrix}$$

With

$$\mathbf{E}_{\text{inc}}(\mathbf{r}) = \sum_{\nu} \alpha_{\nu} \mathbf{N}_{\nu}^{(i)}(k_1 \mathbf{r}) + \alpha_{\nu} \mathbf{N}_{\nu}^{(j)}(k_2 \mathbf{r}),$$

$$\mathbf{E}_{\text{sc}}(\mathbf{r}) = \sum_{\nu} \beta_{\nu} \mathbf{N}_{\nu}^{(j)}(k_1 \mathbf{r}) + \beta_{\nu} \mathbf{N}_{\nu}^{(i)}(k_2 \mathbf{r}).$$

Link with S-matrix: $\mathbf{S} = \mathbf{I} + 2\mathbf{T}$

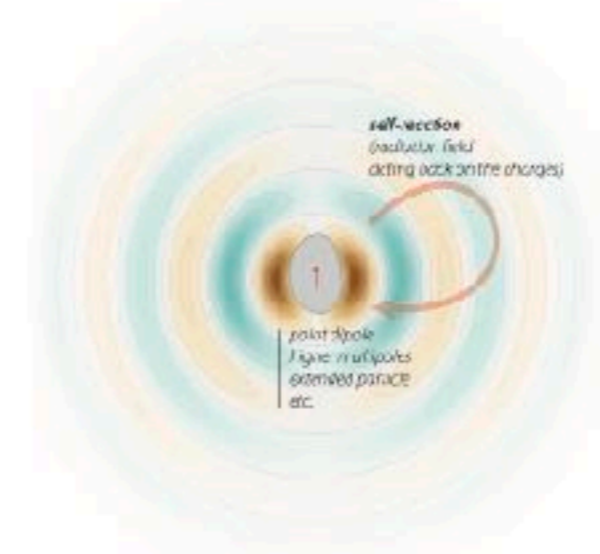
Cayleigh transform

We define a response matrix, \mathbf{K}

$$\mathbf{K} = i(\mathbf{I} - \mathbf{S})(\mathbf{I} + \mathbf{S})^{-1}$$

Energy conservation

$$\mathbf{T} + \mathbf{T}^\dagger = -2\mathbf{T}^\dagger \mathbf{T} \Leftrightarrow \mathbf{S} \mathbf{S}^\dagger = \mathbf{I} \Leftrightarrow \mathbf{K} = \mathbf{K}^\dagger$$



Another representation of self-reaction

— RIGOROUS RC IN THE T-MATRIX FRAMEWORK —

- Energy conservation is expressed as $\mathbf{K} = \mathbf{K}^\dagger$ (non-absorbing)
- Absorbing particles: $i(\mathbf{K} - \mathbf{K}^\dagger)$ is Hermitian positive semi-definite (\mathbf{K} is dissipative) (generalizes $\text{Im}(\alpha) \geq 0$ for a response function α , to matrices)
- Given an (truncated, approximate...) expression for \mathbf{K} , we obtain a radiatively corrected T-matrix, automatically satisfying energy conservation.

$$\mathbf{T}^{-1} = -i\mathbf{K}^{-1} - \mathbf{I}$$

Example of a point dipole

Using the approximate T-matrix from electrostatics, $\mathbf{K}_e^{(0)} = -i \frac{\epsilon_0^2}{6\pi\epsilon_0\epsilon_1} \alpha_0$

We justify

$$\alpha = \frac{\alpha_0}{1 - i \frac{k_0^3}{6\pi\epsilon_0\epsilon_1} \alpha_0}$$

Recent examples scattered in the literature

General multipole correction from Mie theory [5] $\alpha_n = \left[1 - \frac{(n+1)k_0^{2n+1}}{n(2n-1)!(2n+1)!} \alpha_n \right]^{-1} \alpha_n$

Non-axisymmetric scatterers [6] also [7] with magnetoelectric coupling $\alpha^{-1} - (\alpha^{-1})^\dagger = \frac{ik^3}{3\pi} \begin{pmatrix} \chi/\epsilon_0 & \gamma \\ 0 & \mathbf{I}/\mu_0 \end{pmatrix}$

Outlook— Using this formalism, radiative corrections to EM scattering can be justified rigorously and directly generalised to finite or body scatterers, and to any multipolar order. Notably, these results trivially reproduce, and make a connection to, several independent results for special cases that were scattered in the recent literature.

Remarkably, the use of the K matrix avoids the appearance of any infinities in the derivation of the radiative corrections, which we believe may have implications beyond EM theory.

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- [2] A. Wokaen et al. *Phys. Rev. Lett.* **48**, 957 (1982)
- [3] M. I. Mishchenko, L. D. Travis, and A. A. Lacis, *Scattering, absorption and emission of light by small particles*, 3rd ed. (Cambridge Univ. Press, 2002)
- [4] R. G. Newton, *Scattering theory of waves and particles* (McGraw-Hill, New York, 1966)
- [5] G. Colas des Francs, *Int. J. Mol. Sci.* **10**, 393 (2009)
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- [7] I. Grbic et al. *Phys. Rev. E* **63**, 245102 (2001)



Plasmonic Optical Activity

Baptiste Auguie



Co-workers:
Química Física
 Andrés Guerrero-Martínez
 Luis M. Liz-Marzán
Química Orgánica
 José Lorenzo Alonso-Gómez
 M. Magdalena Cid

MOTIVATION

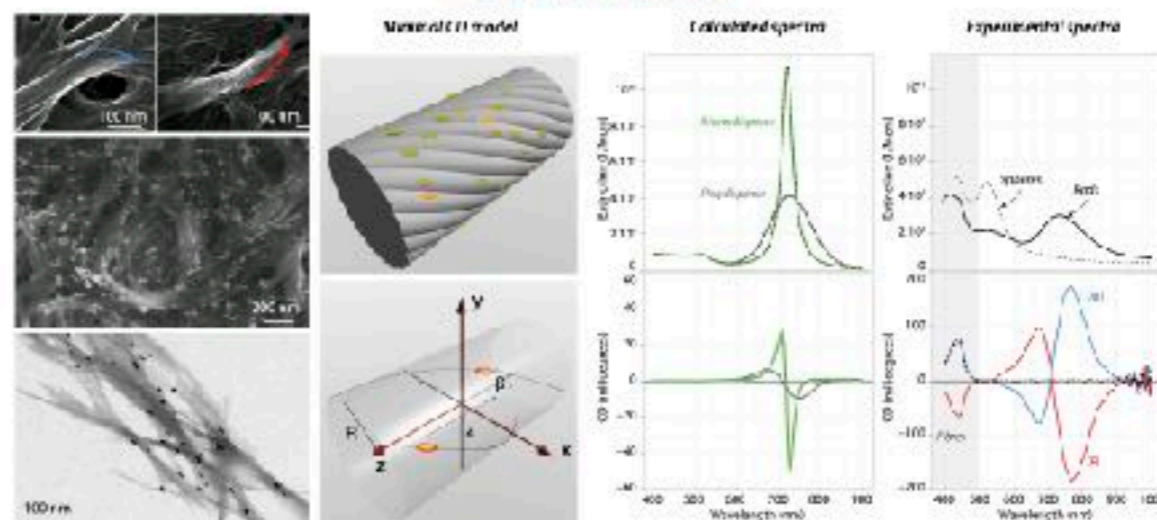
A natural pairing with stereochemistry and biological applications, combined with the pursuit of negative refraction, have triggered an immense activity in the design of chiral metamaterials, from microwave frequencies to the visible. In the vast array of proposed designs, the focus has been largely on periodic, often 2D or 3D, structures. In contrast, colloidal synthesis offers the perspective of producing truly 3D chiral and complex structures at mass scale with a versatile and complementary manufacturing process.

Different scales of metallic helical fibers
 The coupled-dipole approximation provides an intuitive and encompassing framework to describe optical activity arising in chiral (helical) structures.



Fluorescence structures from colloidal chemistry can enrich the emerging field of metamaterials and widen its scope of applications with hybrid designs.

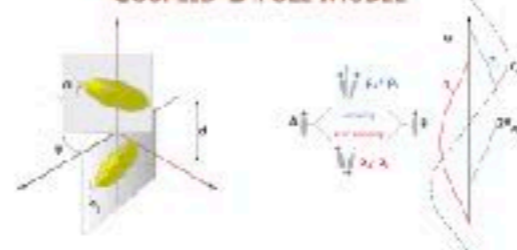
EXPERIMENTAL RESULTS



Highly-symmetric shapes such as nanorods do not generally produce optical activity, and an average ensemble of such particles freely moving in solution is intrinsically achiral. A rapidly expanding number of studies (1-3) have led, therefore, to a quest for the design of chiral optical activity via without conformation of aggregates ordered onto a suitable template.

The data reported above were obtained from assemblies of gold nanorods onto helical fibers [1]. The difference in definition for left-handed and right-handed circularly polarized light, defined as circular dichroism (CD), poses its a mirror-image spectrum for the two helical enantiomers. Modeling suggests such optical activity results from electromagnetic interaction between nanorods.

COUPLED-DIPOLE MODEL



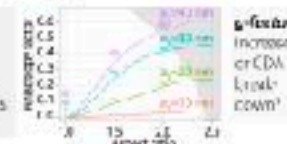
Classification of chiral rods
 Minimal model of plasmonic optical activity [2, 4]. Coupling between dipole approximation of helix.

Exciton coupling
 The first theory of coupled-dipoles, recently revisited in the context of plasmon hybridization.

The intense CD signals coincide with the excitation of localized plasmon resonances and offer a promising avenue of research at the interface between nano-optics, chemistry, and materials biology and create a link between the shape of the CD spectra and movement of a general mechanism known as exciton-coupling in organic chemistry.

OUTLOOK

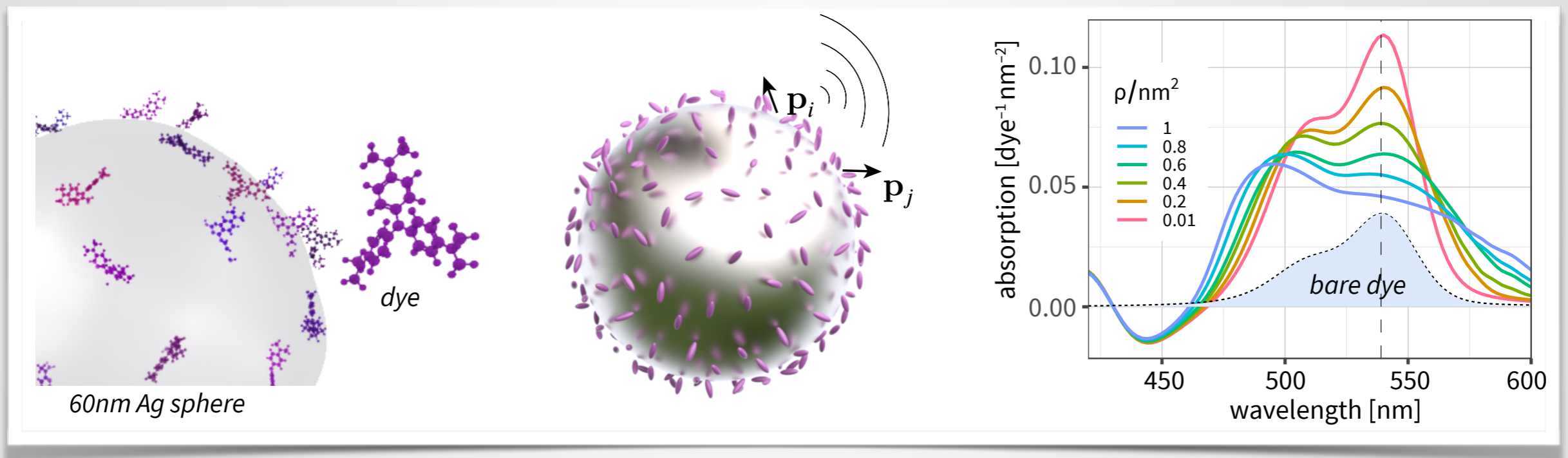
Beyond what we know –
 Building on these first analogies, assemblies of plasmonic particles provide new perspectives into the mechanism of optical activity and its relation to chirality at the nanoscale.



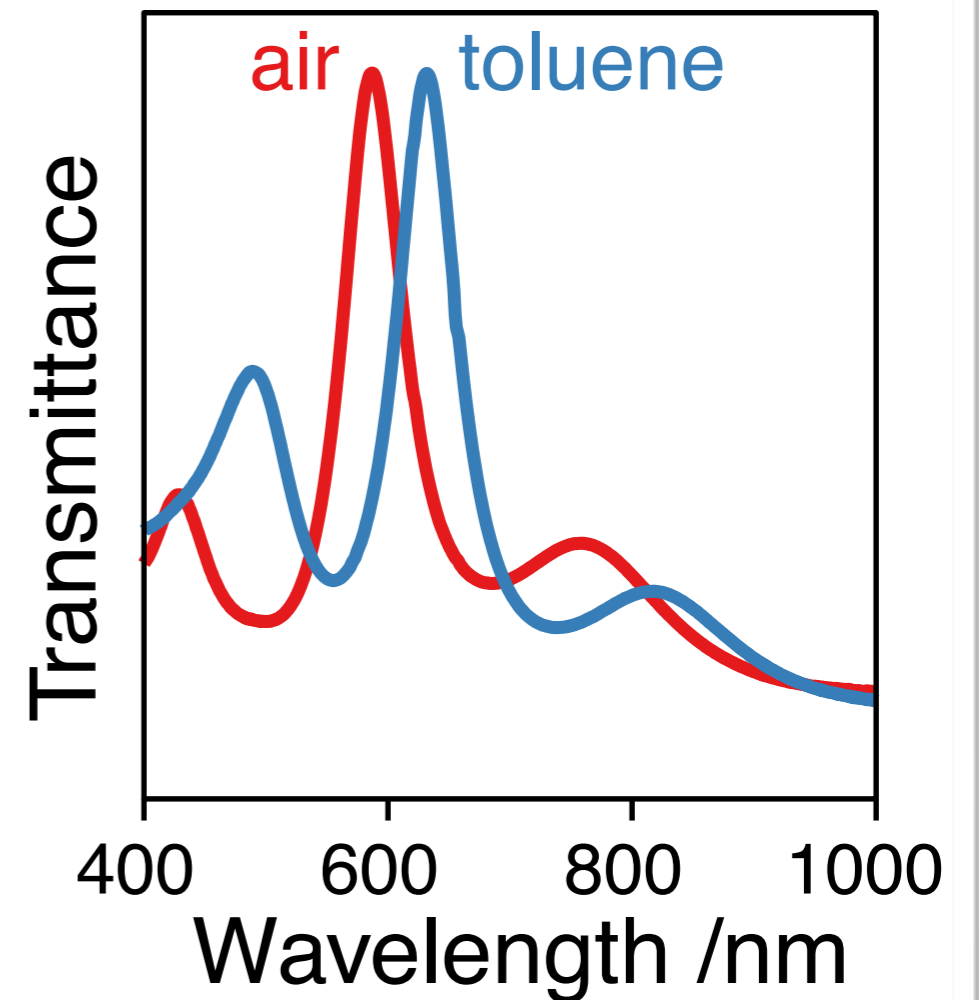
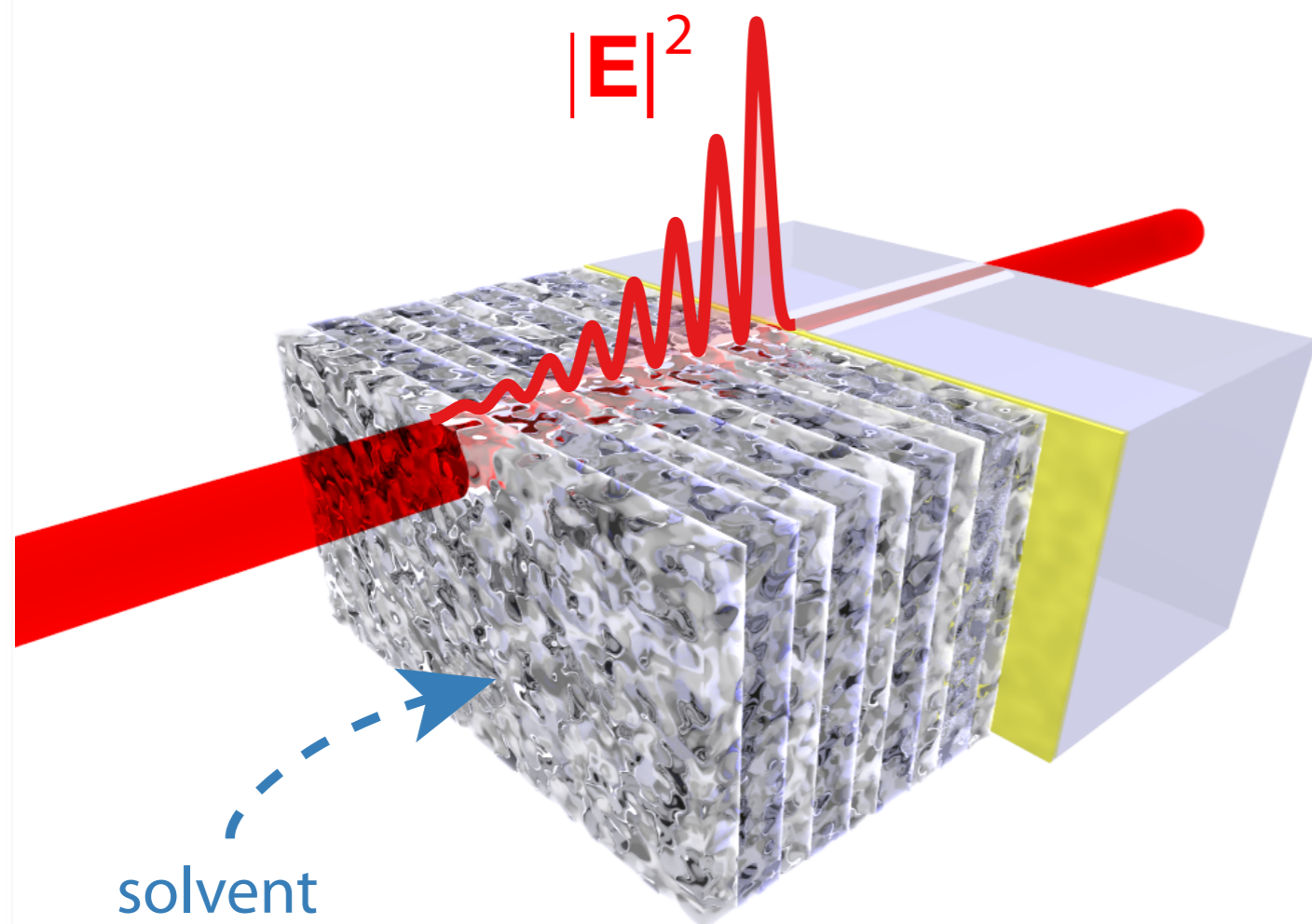
- With regards to nano-optics and plasmonics, we propose:
- Frontier modeling, beyond the coupled-dipole approximation (CDA)
 - Quantification of higher-order modes, influence of substrate/substration mode
 - CD spectroscopy as a tool to investigate the symmetry of plasmonic assemblies
 - Large-scale numerical optimization of optical activity in nanoparticle clusters

References:
 [1] A. Guerrero-Martínez et al. *Prog. Chem.* 50 (2011)
 [2] B. Auguie et al. *J. Phys. Chem. Lett.* 2 (2011)
 [3] A. Guerrero-Martínez et al. *Nano Today* 6 (2011)
 [4] <http://www.proceedings.spiedigitallibrary.org/>
 (Xavier Javier Garcia de Abajo (CSIC, Madrid))

5 | TABLE OF CONTENTS GRAPHICS



5 | TABLE OF CONTENTS GRAPHICS



If progress is to be made in graphics,
we must be prepared to set aside
old procedures when better ones are
developed, just as is done in other
areas of science.

—W.S. Cleveland

5 | RESOURCES

- ▶ J.L. Doumont • *Trees, maps, and theorems*
- ▶ Jan White • *Graphic design for the electronic age*
- ▶ Edward Tufte • *The visual display of quantitative information*
- ▶ serialmentor.com/dataviz
- ▶ socviz.co
- ▶ ft.com/vocabulary
- ▶ data-to-viz.com

ADDITIONAL LINKS

- ▶ https://github.com/kbroman/Talk_Graphs
- ▶ <http://www.perceptualedge.com/examples.php>
- ▶ <http://colinpurrington.com/2012/example-of-bad-scientific-poster/>
- ▶ <http://tools.medialab.sciences-po.fr/iwanthue/>
- ▶ Aspect ratio: <http://vis.berkeley.edu/papers/banking/>
- ▶ <http://earthobservatory.nasa.gov/blogs/elegantfigures/2013/08/06/subtleties-of-color-part-2-of-6/>
- ▶ Show the data, don't conceal them
<https://doi.org/10.1111/j.1476-5381.2011.01251.x>

SOFTWARE SUGGESTIONS

▸ **PLOTS**

- Python, R, ...
- D3, Vega-lite, plot.ly (interactive)
- Tableau (expensive)

▸ **SCHEMATICS & LAYOUT**

- Inkscape (open-source)
- Adobe Illustrator, Indesign (expensive)



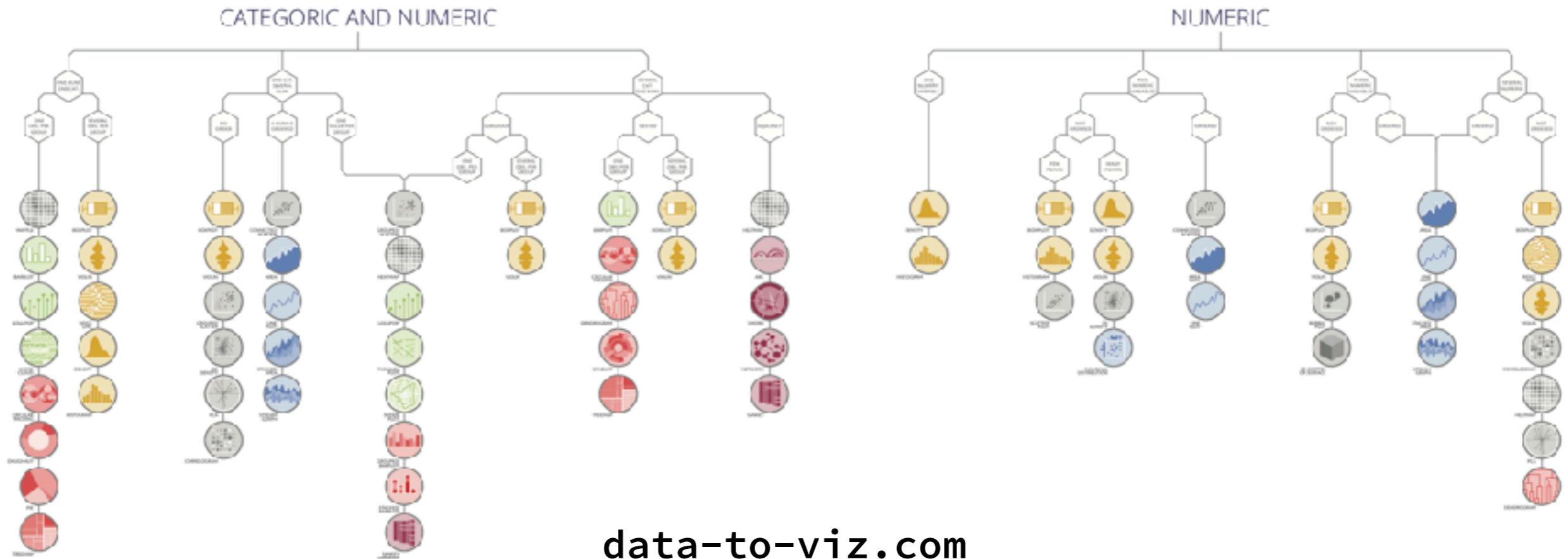
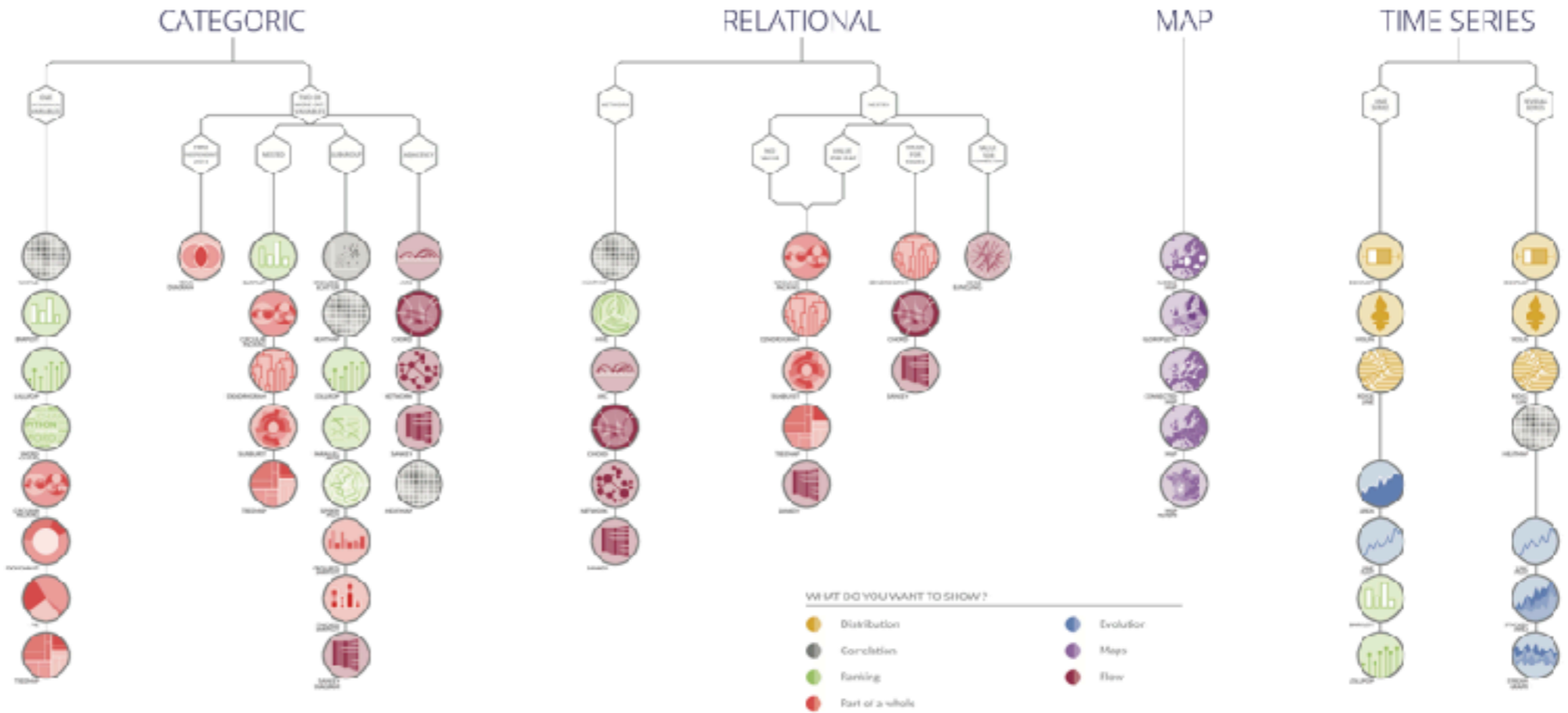
from Data to Viz

'From Data to Viz' is a classification of chart types based on input data format. It will help you find the perfect chart in three simple steps:

- 1 Identify what type of data you have.
- 2 Go to the corresponding decision tree and follow it down to a set of possible charts.
- 3 Choose the chart from the set that will suit your data and your needs best.

data-to-viz.com is a world with endless possibilities and this project does not claim to be exhaustive. However, it should provide you with a good starting point. For an interactive version and much more, visit

data-to-viz.com



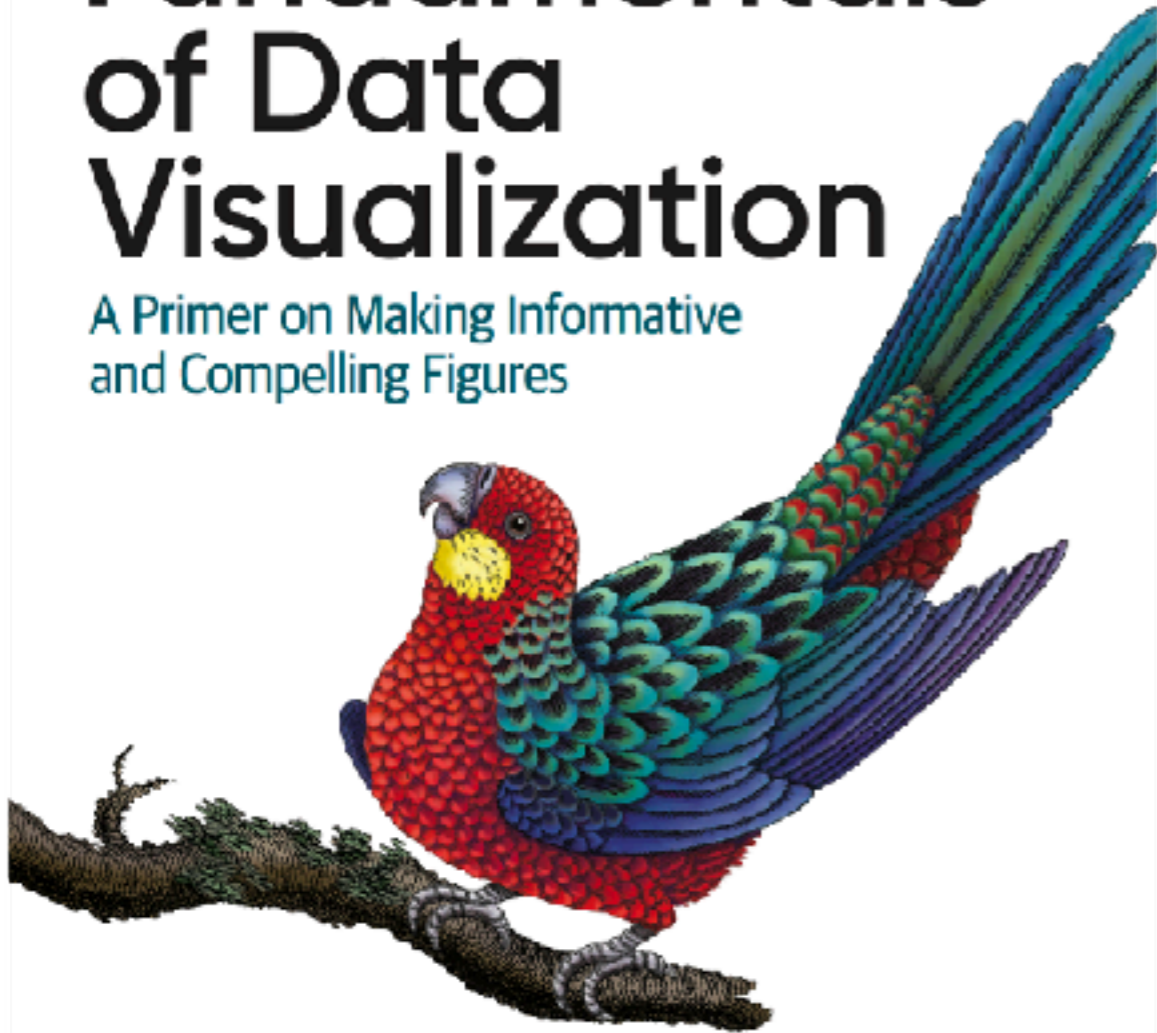
data-to-viz.com

Deviation	Correlation	Ranking	Distribution	Change over Time	Part-to-whole	Magnitude	Spatial	Flow	
<p>Emphasise variations (+/-) from a fixed reference point. Typically the reference point is zero but it can also be a target or a long-term average. Can also be used to show sentiment (positive/neutral/negative).</p> <p>Example FT uses Trade surplus/deficit, climate change</p>	<p>Show the relationship between two or more variables. Be mindful that, unless you tell them otherwise, many readers will assume the relationships you show them to be causal (i.e. one causes the other).</p> <p>Example FT uses Inflation & unemployment, income & life expectancy</p>	<p>Use where an item's position in an ordered list is more important than its absolute or relative value. Don't be afraid to highlight the points of interest.</p> <p>Example FT uses Wealth, deprivation, league tables, constituency election results</p>	<p>Show values in a dataset and how often they occur. The shape (or 'skew') of a distribution can be a memorable way of highlighting the lack of uniformity or equality in the data.</p> <p>Example FT uses Income distribution, population (age/sex) distribution</p>	<p>Give emphasis to changing trends. These can be short (intra-day) movements or extended series traversing decades or centuries: Choosing the correct time period is important to provide suitable context for the reader.</p> <p>Example FT uses Share price movements, economic time series</p>	<p>Show how a single entity can be broken down into its component elements. If the reader's interest is solely in the size of the components, consider a magnitude-type chart instead.</p> <p>Example FT uses Fiscal budgets, company structures, national election results</p>	<p>Show size comparisons. These can be relative (just being able to see larger/smaller) or absolute (need to see fine differences). Usually these show a 'counted' number (for example, barrels, dollars or people) rather than a calculated rate or per cent.</p> <p>Example FT uses Commodity production, market capitalisation</p>	<p>Used only when precise locations or geographical patterns in data are more important to the reader than anything else.</p> <p>Example FT uses Locator maps, population density, natural resource locations, natural disaster risk/impact, catchment areas, variation in election results</p>	<p>Show the reader volumes or intensity of movement between two or more states or conditions. These might be logical sequences or geographical locations.</p> <p>Example FT uses Movement of funds, trade, migrants, lawsuits, information; relationship graphs.</p>	
<p>Diverging bar A simple standard bar chart that can handle both negative and positive magnitude values.</p> <p>Diverging stacked bar Perfect for presenting survey results which involve sentiment (eg disagree/neutral/agree).</p> <p>Spine chart Splits a single value into 2 contrasting components (eg Male/Female).</p> <p>Surplus/deficit filled line The shaded area of these charts allows a balance to be shown – either against a baseline or between two series.</p>	<p>Scatterplot The standard way to show the relationship between two continuous variables, each of which has its own axis.</p> <p>Line + Column A good way of showing the relationship between an amount (columns) and a rate (line).</p> <p>Connected scatterplot Usually used to show how the relationship between 2 variables has changed over time.</p> <p>Bubble Like a scatterplot, but adds additional detail by sizing the circles according to a third variable.</p> <p>XY heatmap A good way of showing the patterns between 2 categories of data, less good at showing fine differences in amounts.</p>	<p>Ordered bar Standard bar charts display the ranks of values much more easily when sorted into order.</p> <p>Ordered column See above.</p> <p>Ordered proportional symbol Use when there are big variations between values and/or seeing fine differences between data is not so important.</p> <p>Dot strip plot Dots placed in order on a strip are a space-efficient method of laying out ranks across multiple categories.</p> <p>Slope Perfect for showing how ranks have changed over time or vary between categories.</p> <p>Lollipop chart Lollipops draw more attention to the data value than standard bar/column and can also show rank and value effectively.</p>	<p>Histogram The standard way to show a statistical distribution - keep the gaps between columns small to highlight the 'shape' of the data.</p> <p>Boxplot Summarise multiple distributions by showing the median (centre) and range of the data</p> <p>Violin plot Similar to a box plot but more effective with complex distributions (data that cannot be summarised with simple average).</p> <p>Population pyramid A standard way for showing the age and sex breakdown of a population distribution; effectively, back to back histograms.</p> <p>Dot strip plot Good for showing individual values in a distribution, can be a problem when too many dots have the same value.</p> <p>Dot plot A simple way of showing the change or range (min/max) of data across multiple categories.</p> <p>Barcode plot Like dot strip plots, good for displaying all the data in a table, they work best when highlighting individual values.</p> <p>Cumulative curve A good way of showing how unequal a distribution is: y axis is always cumulative frequency, x axis is always a measure.</p>	<p>Line The standard way to show a changing time series. If data are irregular, consider markers to represent data points.</p> <p>Column Columns work well for showing change over time - but usually best with only one series of data at a time.</p> <p>Line + column A good way of showing the relationship over time between an amount (columns) and a rate (line).</p> <p>Stock price Usually focused on day-to-day activity, these charts show opening/closing and high/low points of each day.</p> <p>Slope Good for showing changing data as long as the data can be simplified into 2 or 3 points without missing a key part of story.</p> <p>Area chart Use with care - these are good at showing changes to total, but seeing change in components can be very difficult.</p> <p>Fan chart (projections) Use to show the uncertainty in future projections - usually this grows the further forward to projection.</p> <p>Connected scatterplot A good way of showing changing data for two variables whenever there is a relatively clear pattern of progression.</p> <p>Calendar heatmap A great way of showing temporal patterns (daily, weekly, monthly) - at the expense of showing precision in quantity.</p> <p>Priestley timeline Great when date and duration are key elements of the story in the data.</p> <p>Circle timeline Good for showing discrete values of varying size across multiple categories (eg earthquakes by continent).</p> <p>Seismogram Another alternative to the circle timeline for showing series where there are big variations in the data.</p>	<p>Line The standard way to show a changing time series. 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Use sparingly (if at all) for obvious reasons.</p> <p>Arc A hemicycle, often used for visualising political results in parliaments.</p> <p>Gridplot Good for showing % information, they work best when used on whole numbers and work well in multiple layout form.</p> <p>Venn Generally only used for schematic representation.</p> <p>Waterfall Can be useful for showing part-to-whole relationships where some of the components are negative.</p>	<p>Column The standard way to compare the size of things. Must always start at 0 on the axis.</p> <p>Bar See above. Good when the data are not time series and labels have long category names.</p> <p>Paired column As per standard column but allows for multiple series. Can become tricky to read with more than 2 series.</p> <p>Paired bar See above.</p> <p>Proportional stacked bar A good way of showing the size and proportion of data at the same time - as long as the data are not too complicated.</p> <p>Proportional symbol Use when there are big variations between values and/or seeing fine differences between data is not so important.</p> <p>Isotype (pictogram) Excellent solution in some instances - use only with whole numbers (do not slice off an arm to represent a decimal).</p> <p>Lollipop chart Lollipop charts draw more attention to the data value than standard bar/column - does not HAVE to start at zero (but preferable).</p> <p>Radar chart A space-efficient way of showing value of multiple variables - but make sure they are organised in a way that makes sense to reader.</p> <p>Parallel coordinates An alternative to radar charts - again, the arrangement of the variables is important. Usually benefits from highlighting values.</p>	<p>Basic choropleth (rate/ratio) The standard approach for putting data on a map - should always be rates rather than totals and use a sensible base geography.</p> <p>Proportional symbol (count/magnitude) Use for totals rather than rates - be wary that small differences in data will be hard to see.</p> <p>Flow map For showing unambiguous movement across a map.</p> <p>Contour map For showing areas of equal value on a map. Can use deviation colour schemes for showing +/- values</p> <p>Equalised cartogram Converting each unit on a map to a regular and equally-sized shape - good for representing voting regions with equal value.</p> <p>Scaled cartogram (value) Stretching and shrinking a map so that each area is sized according to a particular value.</p> <p>Dot density Used to show the location of individual events/locations - make sure to annotate any patterns the reader should see.</p> <p>Heat map Grid-based data values mapped with an intensity colour scale. As choropleth map - but not snapped to an admin/political unit.</p>	<p>Sankey Shows changes in flows from one condition to at least one other; good for tracing the eventual outcome of a complex process.</p> <p>Waterfall Designed to show the sequencing of data through a flow process, typically budgets. Can include +/- components.</p> <p>Chord A complex but powerful diagram which can illustrate 2-way flows (and net winner) in a matrix.</p> <p>Network Used for showing the strength and inter-connectness of relationships of varying types.</p>

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Fundamentals of Data Visualization

A Primer on Making Informative and Compelling Figures



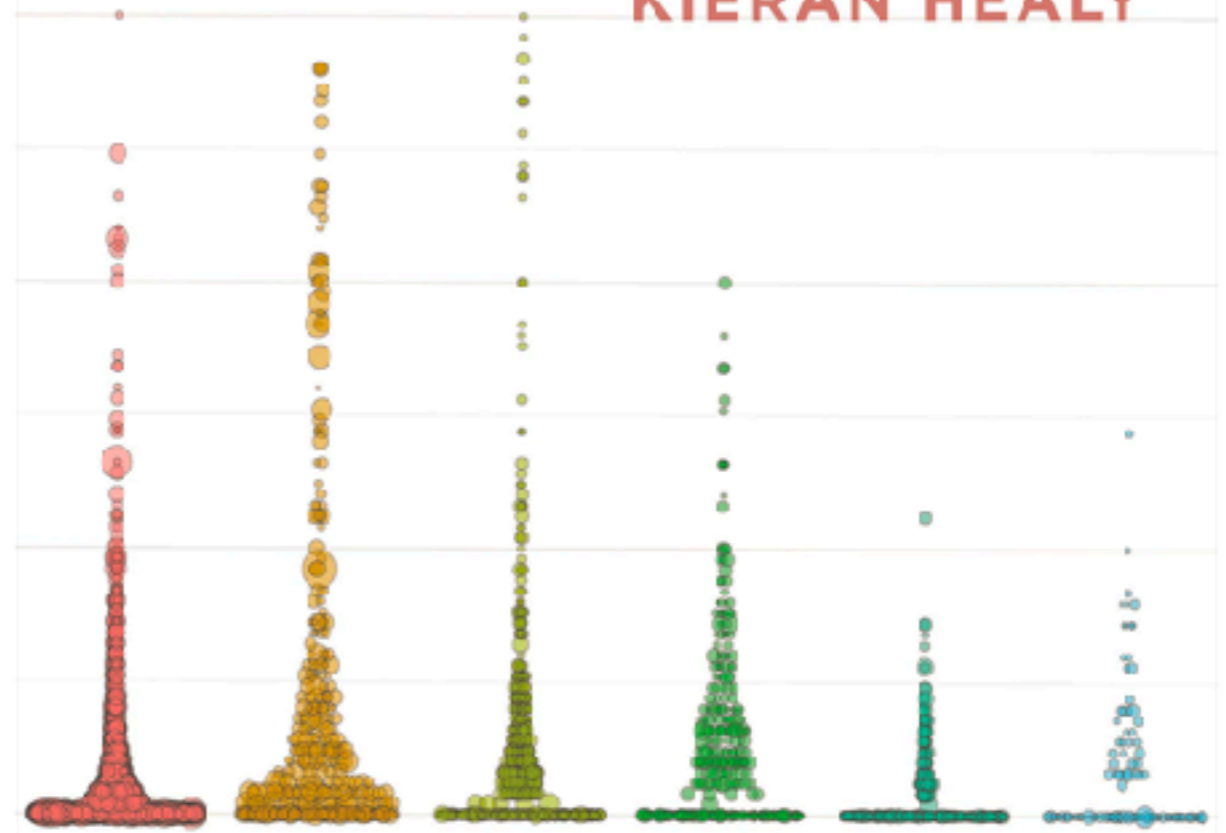
Claus O. Wilke

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DATA VISUALIZATION

A PRACTICAL INTRODUCTION

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