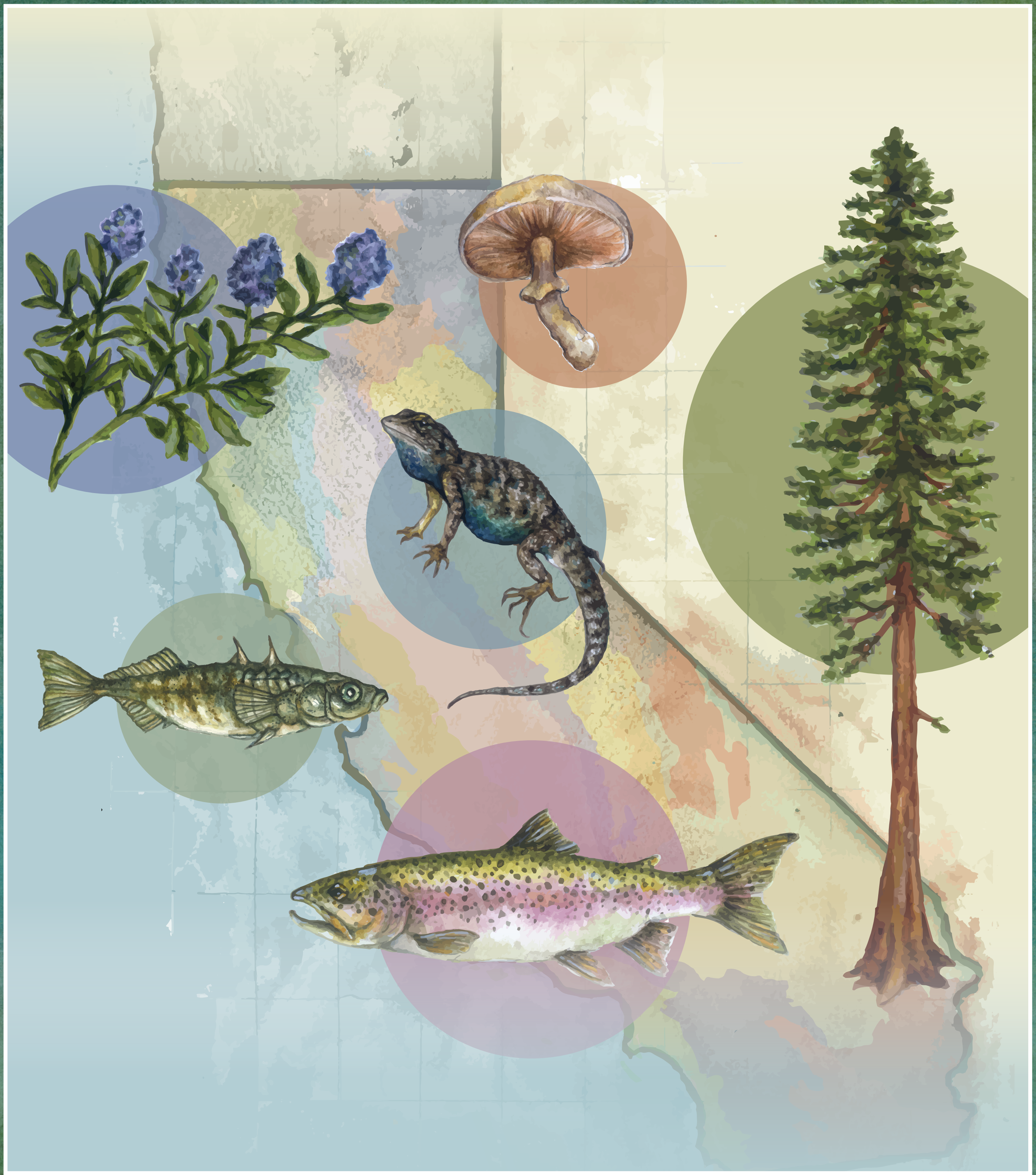
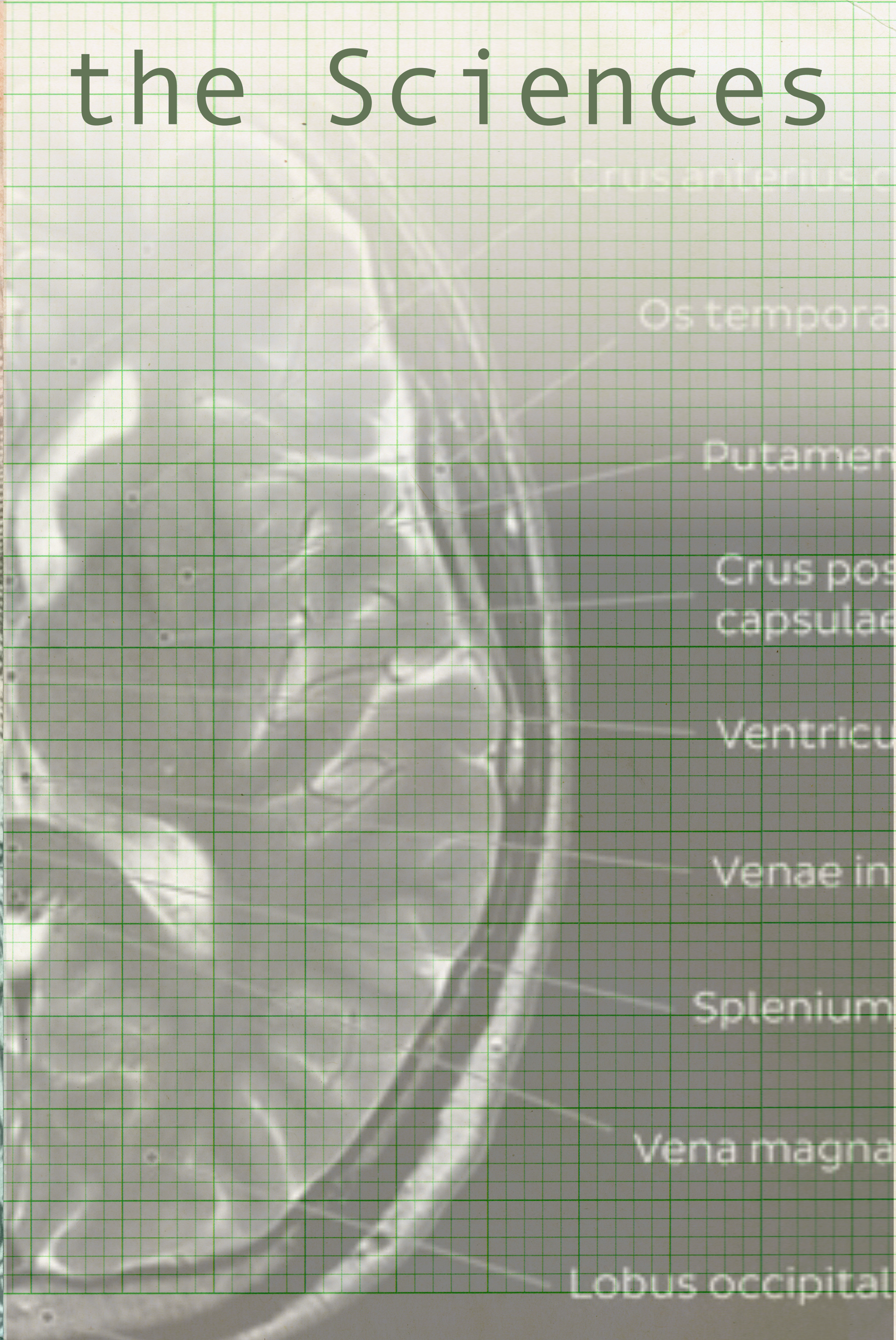
# Visualization & Illustration in Science

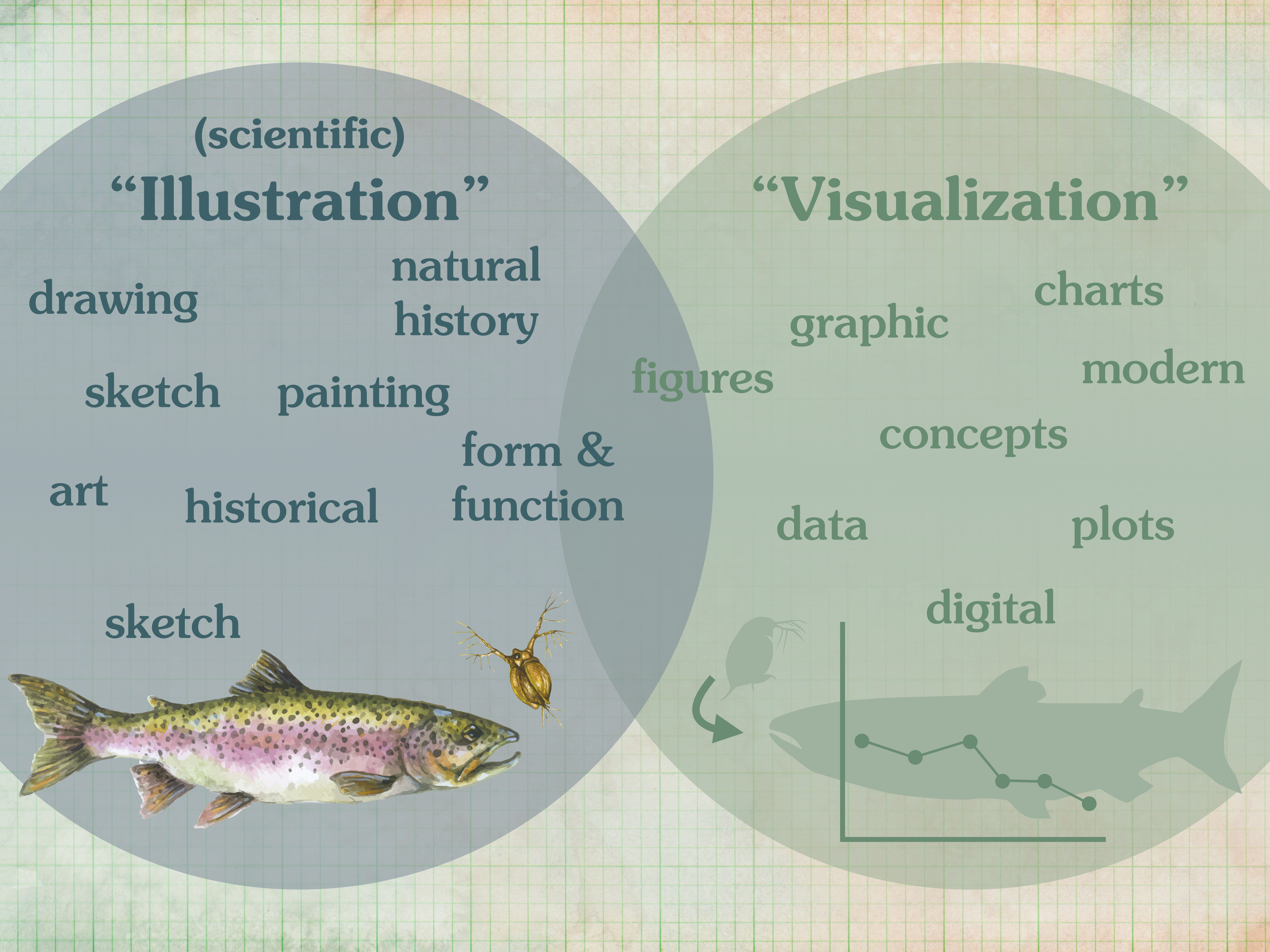
Simone Des Roches
University of Washington



# the "Arts"

# the Sciences




(scientific)
“Illustration”
drawing
natural
history
sketch
painting
form &
function
art
historical
sketch
“Visualization”
charts
graphic
figures
modern
concepts
data
plots
digital

(scientific)

## “Illustration”

using “art in the service of science”

## “Visualization”

using charts, diagrams, figures to represent data, concepts, models

(scientific)

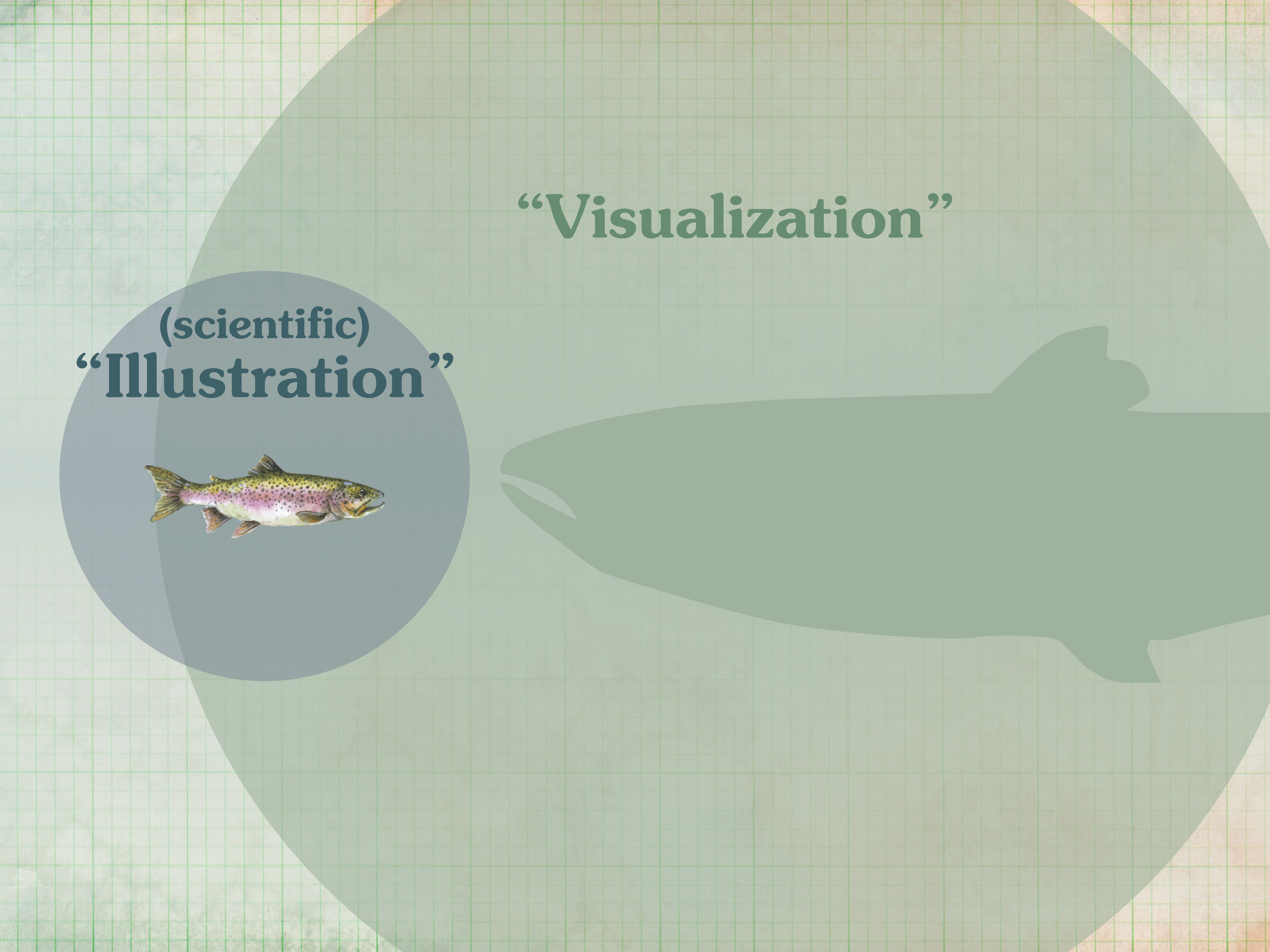
# "Illustration"

to help
engage and
entertain the
audience

communication

# "Visualization"

to help explain
concepts &
demonstrate
findings


"Visualization"
(scientific)
"Illustration"

# “Science = art.
# They are the same thing.

Both science and art are human attempts to understand and describe the world around us. The subjects and methods have different traditions, and the intended audiences are different, but I think the motivations and goals are fundamentally the same.

I think one of the most primitive innate needs of humans is to understand the world around us, and then to share that understanding”

Dave Featherstone
Professor of Biology and Neuroscience
in response to the Quora question:
“Has an art ever become a science?”

# art and science converge as you go back in time: artists had to be scientists

Yellow ochre was **an earth (mineral) pigment** used in some of the first known art by humans in ancient caves

Egyptian Blue was a **synthetic pigment** created 5000 years ago by mixing copper with a calcium, silica sand and potash (a strong base)

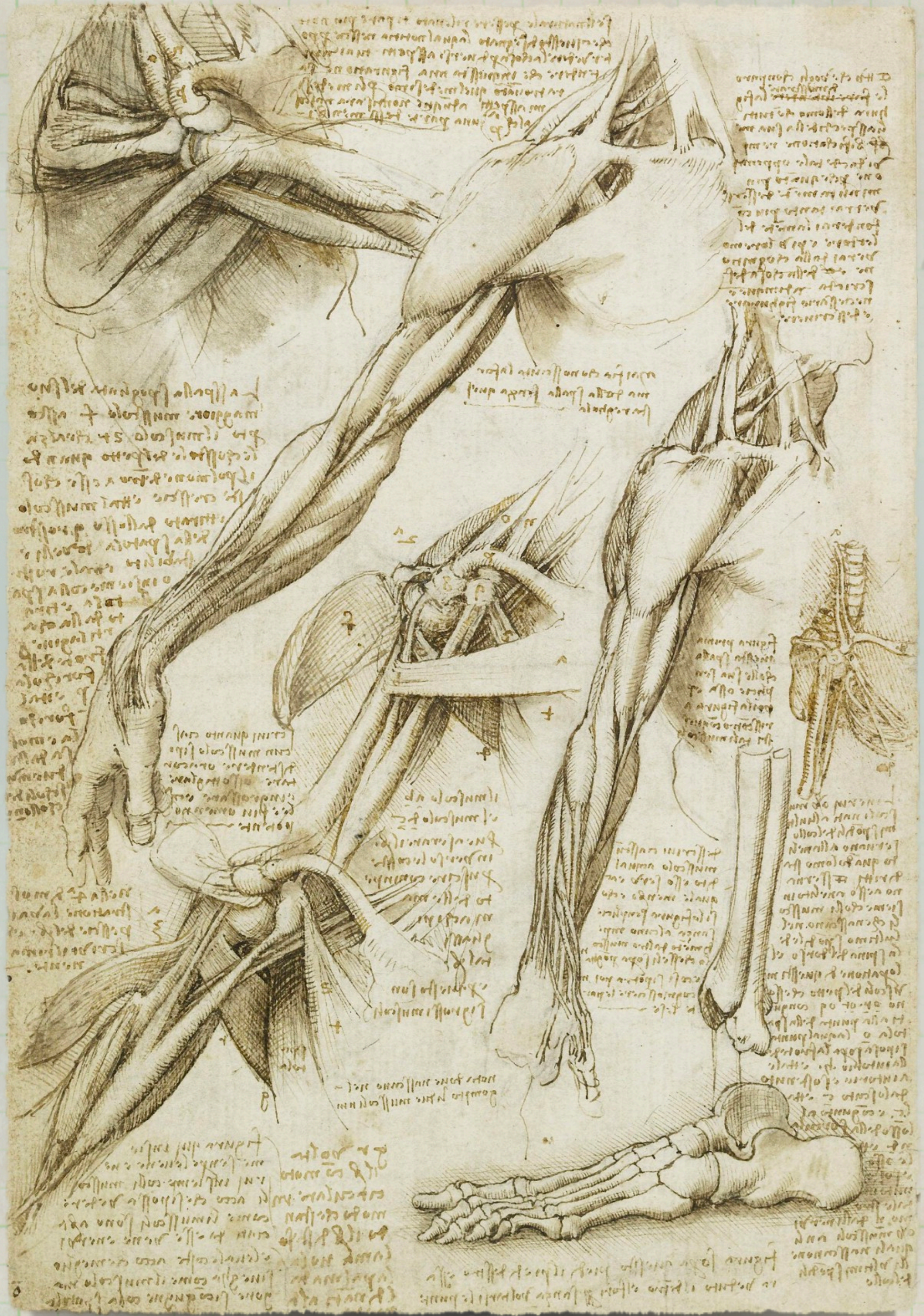
Crimson Lake was **an organic pigment** collected from kermes insects; Madder Lake was from roots of the madder plant.

indigo from
Costa Rica


ochres from
California

art and science converge as you go back in time: scientists had to be artists

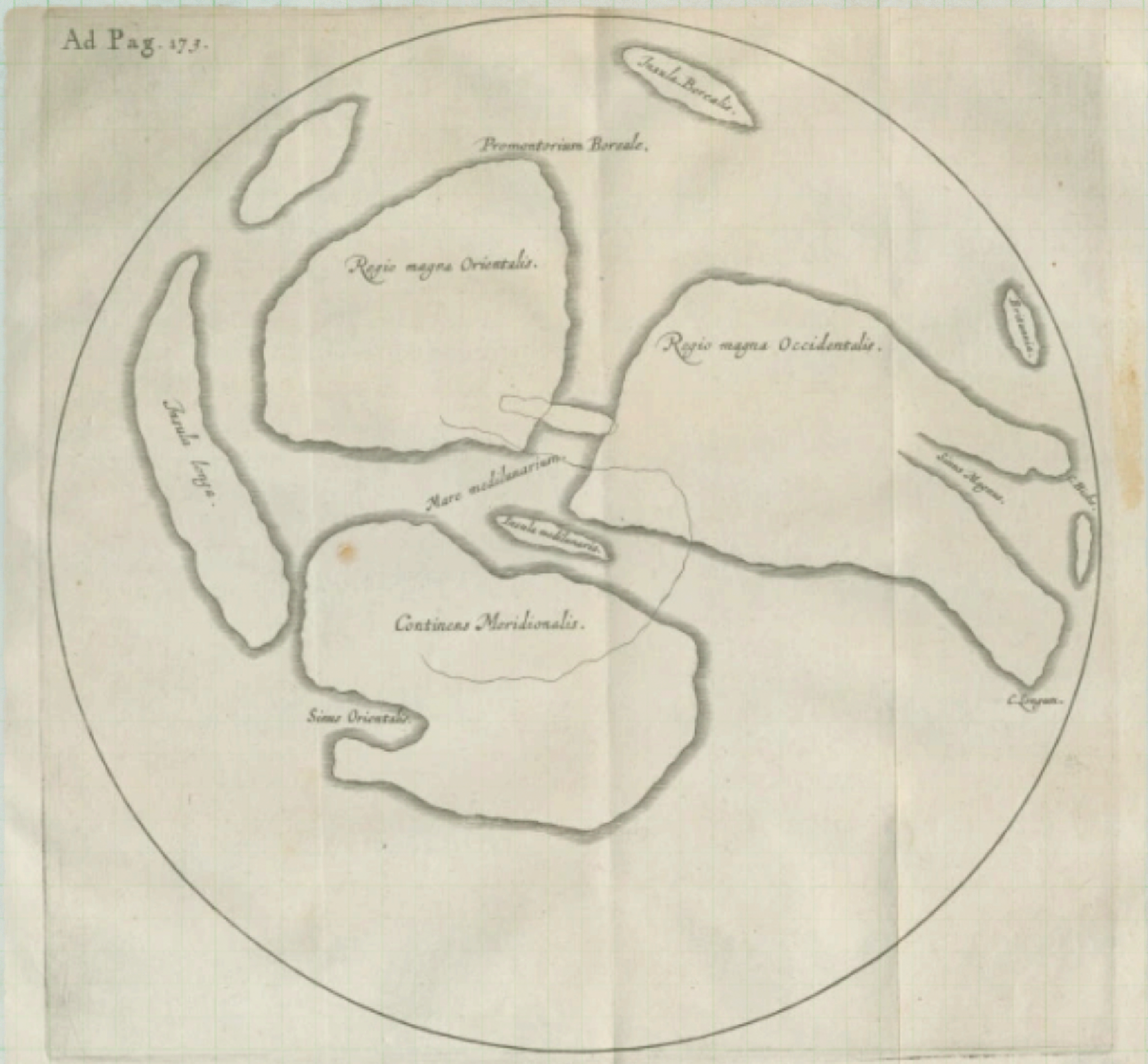
Alfred Russel Wallace



Leonardo DiVinci

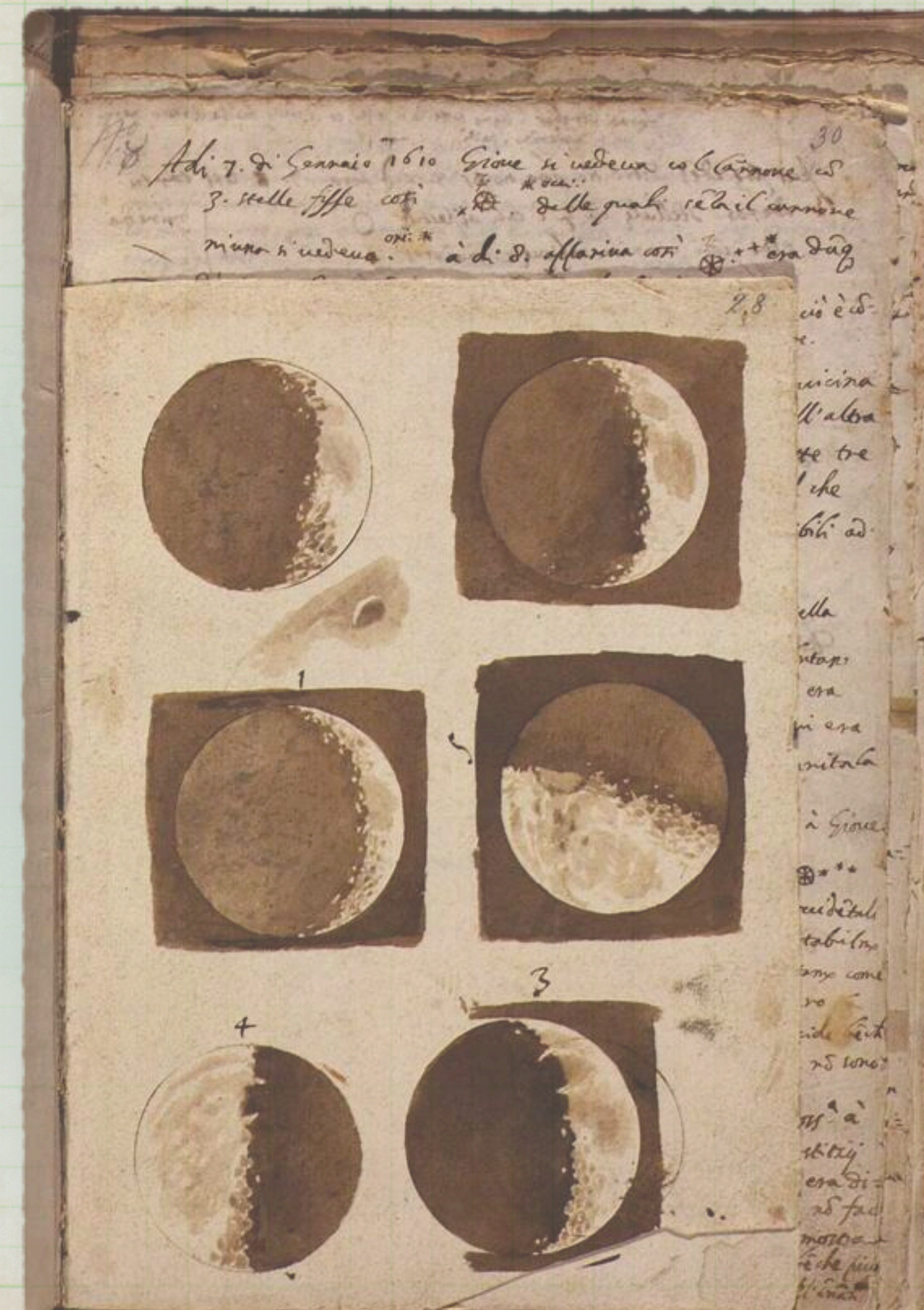
# astronomy

## before telescopy




“The Moon”
William Gilbert early 1600s

## after telescopy



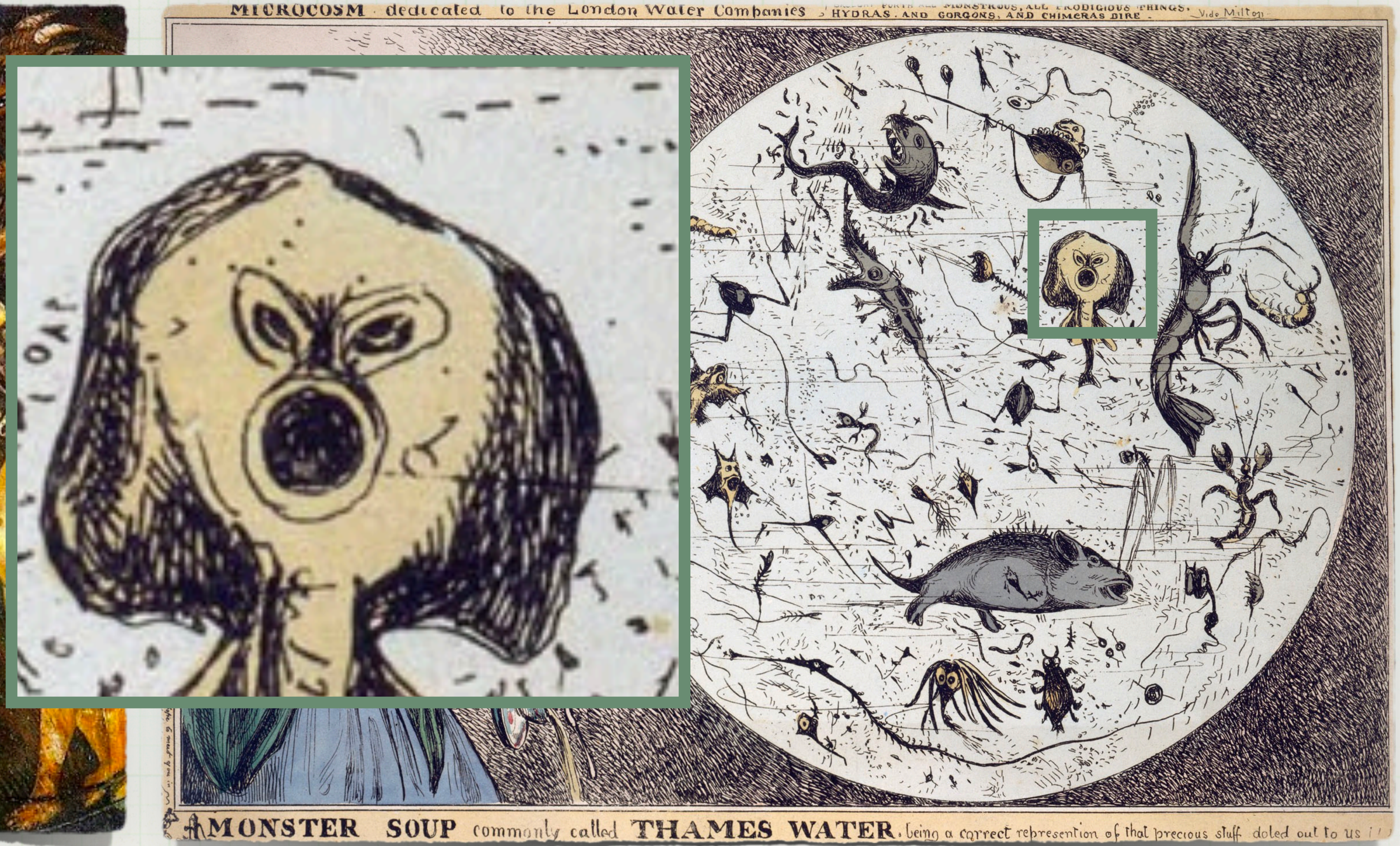
“Phases of the Moon”
Galeleo late 1600s

# epidemiology

## before microscopy

"The Last Judgement"
(The Black Plague)
Taddeo di Bartolo 1400s

## after microscopy




"Monster soup commonly called Thames water, being a correct representation of the stuff doled out to us"
William Heath 1828

# *natural history*
## before photography

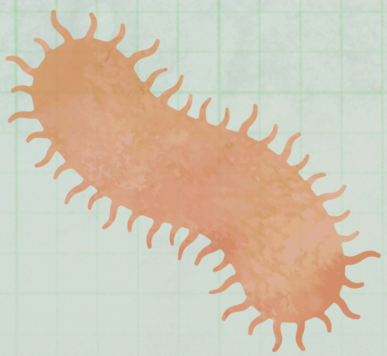
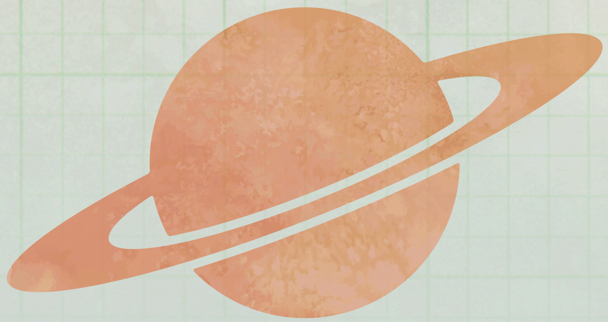
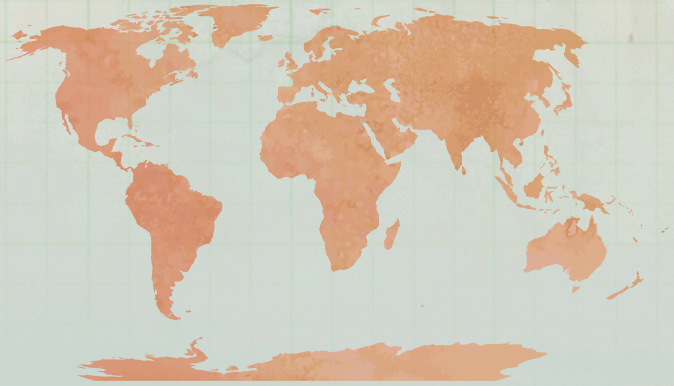
John Lewin 1808

people relied on others - explorers, scientists, natural historians, artists - to observe, perceive, & communicate the natural world


"Silkworm Life Cycle"
Maria Sibylla Merian 1600s

“Surinam Caiman”
Maria Sibylla Merian 1600s

technology has allowed us to "see" and therefore understand what was previously...

too small

too far

too remote



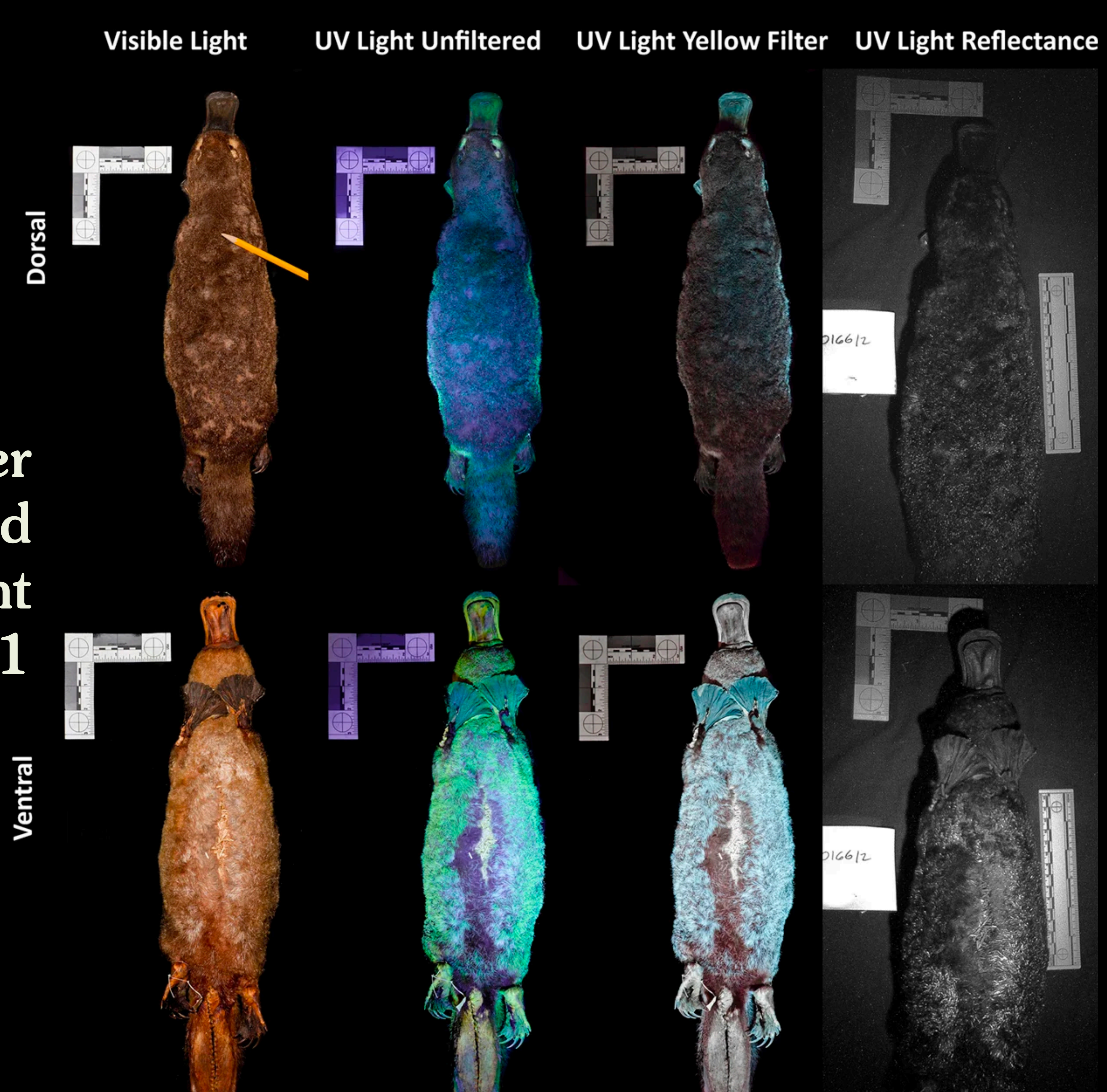
## how has technology changed the role of art in science communication?

satellite photo
composite of 1000s of
photos of the moon
Andrew McCarthy
2020

## how has technology changed the role of art in science communication?

colored Transmission Electron Microscope image of SARS-CoV-2 NIAID-RLM 2020

# how has technology changed the role of art in science communication?




platypus photo under visible and filtered and unfiltered UV light
Spaeth Anich et al. 2021

## our awareness, comprehension, appreciation, of nature still relies on illustrations and visualizations


illustration of dodo
pre-extinction
1670s

taxidermy composite
reconstruction of dodo
Rowland Ware 1890s

modern reconstruction
of dodo
Hildegard Enting
2019

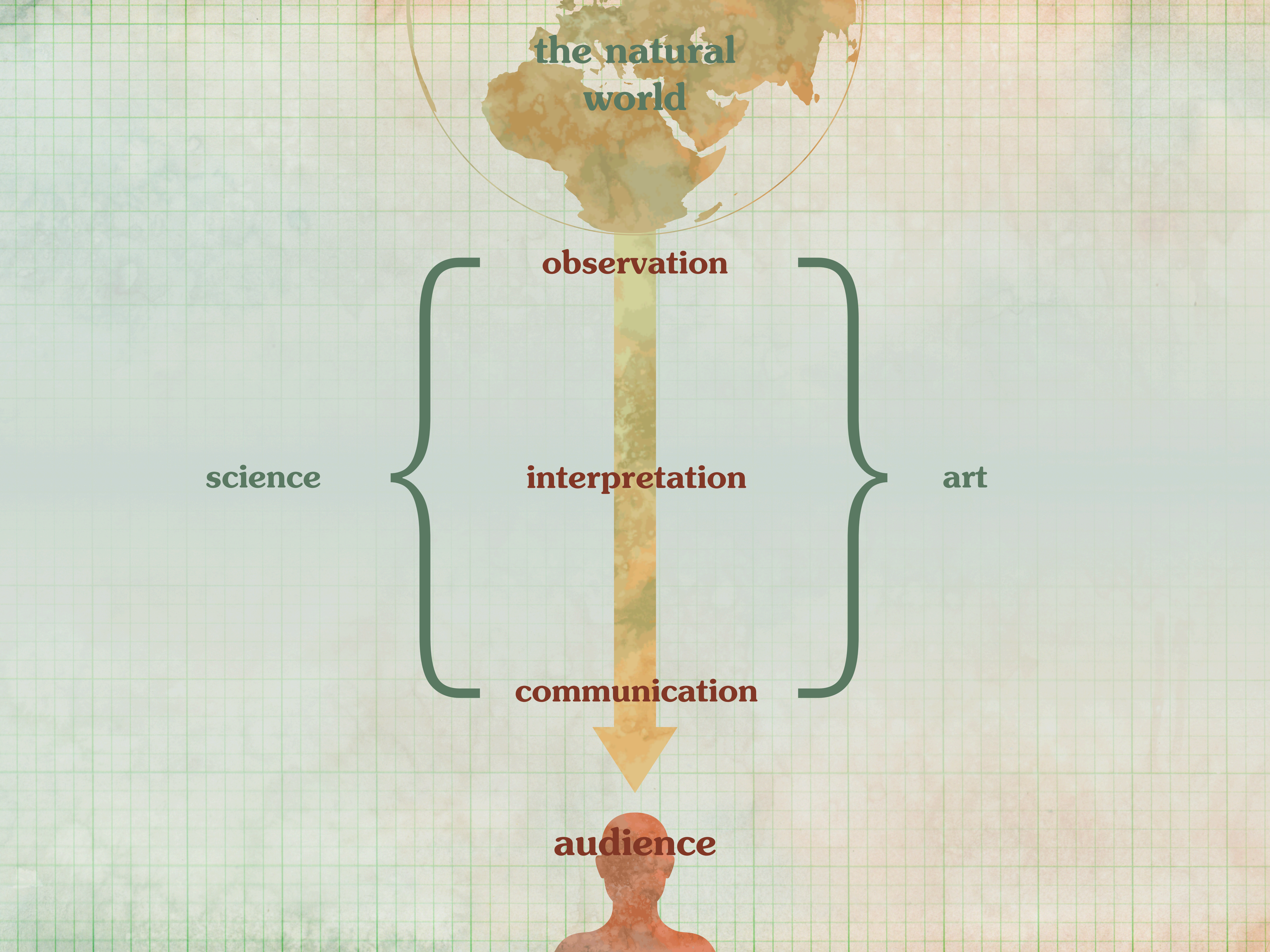
https://www.vice.com/en/article/vvbqq9/the-dodo-didnt-look-like-you-think-it-does

"{Data} visualization is a mix of science and art.

Sometimes we want to be closer to the **science** side of the spectrum = in other words, use visualizations that allow readers to more **accurately** perceive the **absolute values** of data and **make comparisons.**

Other times we may want to be closer to the **art** side of the spectrum and create visuals that **engage** and **excite** the reader, even if they do not permit the most accurate comparisons."

Jonathan Schwabisch, "Better Data Visualizations"



the natural world
observation
science
interpretation
art
communication
audience

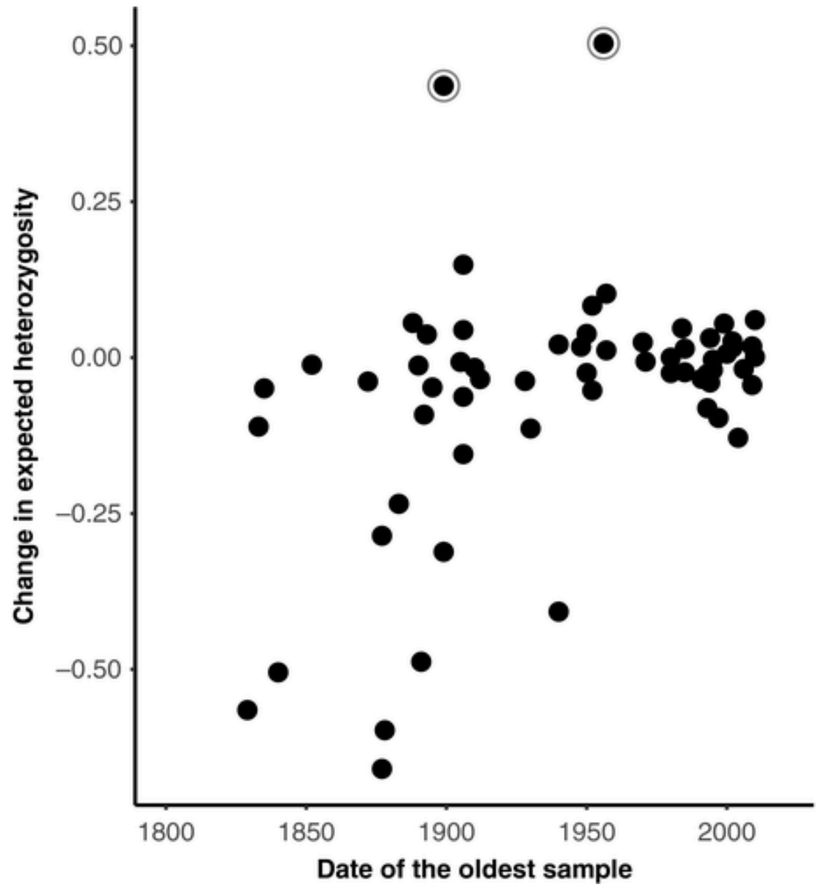
## Science REACHES the audience through illustration & visualization

1. **Representative:** does the image represent something in nature? a concept? data?
2. **Easy:** does the layout of the image make it as easy as possible to understand?
3. **Accessible:** is the image accessible to all (or target) audience (e.g., colour-blind friendly)?
4. **Consistent:** are colours/shapes consistent & intuitive (i.e. is the style coherent?)
5. **Honest:** are any data displayed honestly?
6. **Enhancing:** does art/visualization enhance (rather than distract from) the message?
7. **Sensitive:** is imagery sensitive to audience's experiences and identities?

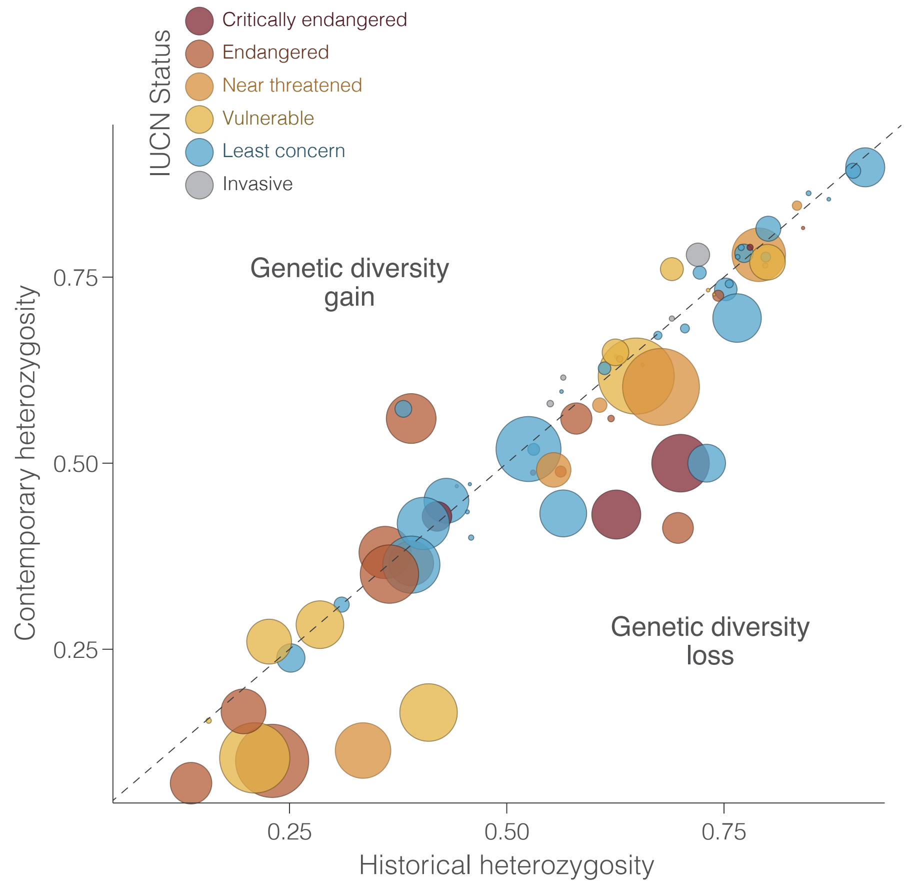
# 1. Representative: does the image represent something in nature? a concept? data?

## Experiment with different ways of representing the same concepts, patterns, & data - can you add information without complicating the message?

*e.g.,* both figures show species declines in heterozygosity over the last 200 years - changing the colour and size of points communicates additional information: i.e., IUCN status




Leigh et al. 2019. Evolutionary Applications

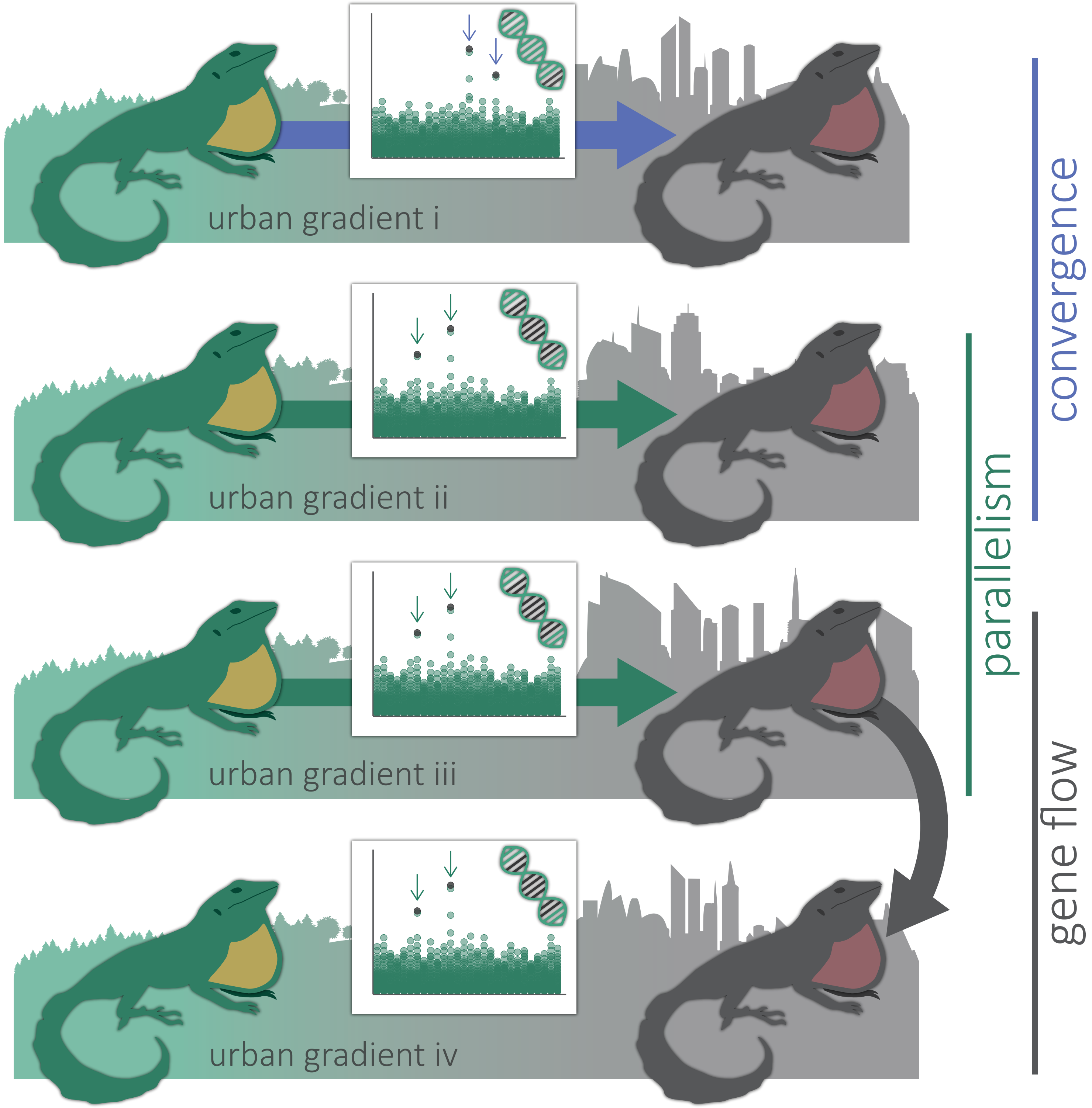



Des Roches et al. 2021. Nature Ecology & Evolution

## 2. Easy: does the layout of the image make it as easy as possible to understand?

**Simplify to the most essential elements using <u>repetitive</u> imagery**

***e.g.,*** repeated lizards & natural-urban background show how similar patterns of urban evolution can arise through different processes

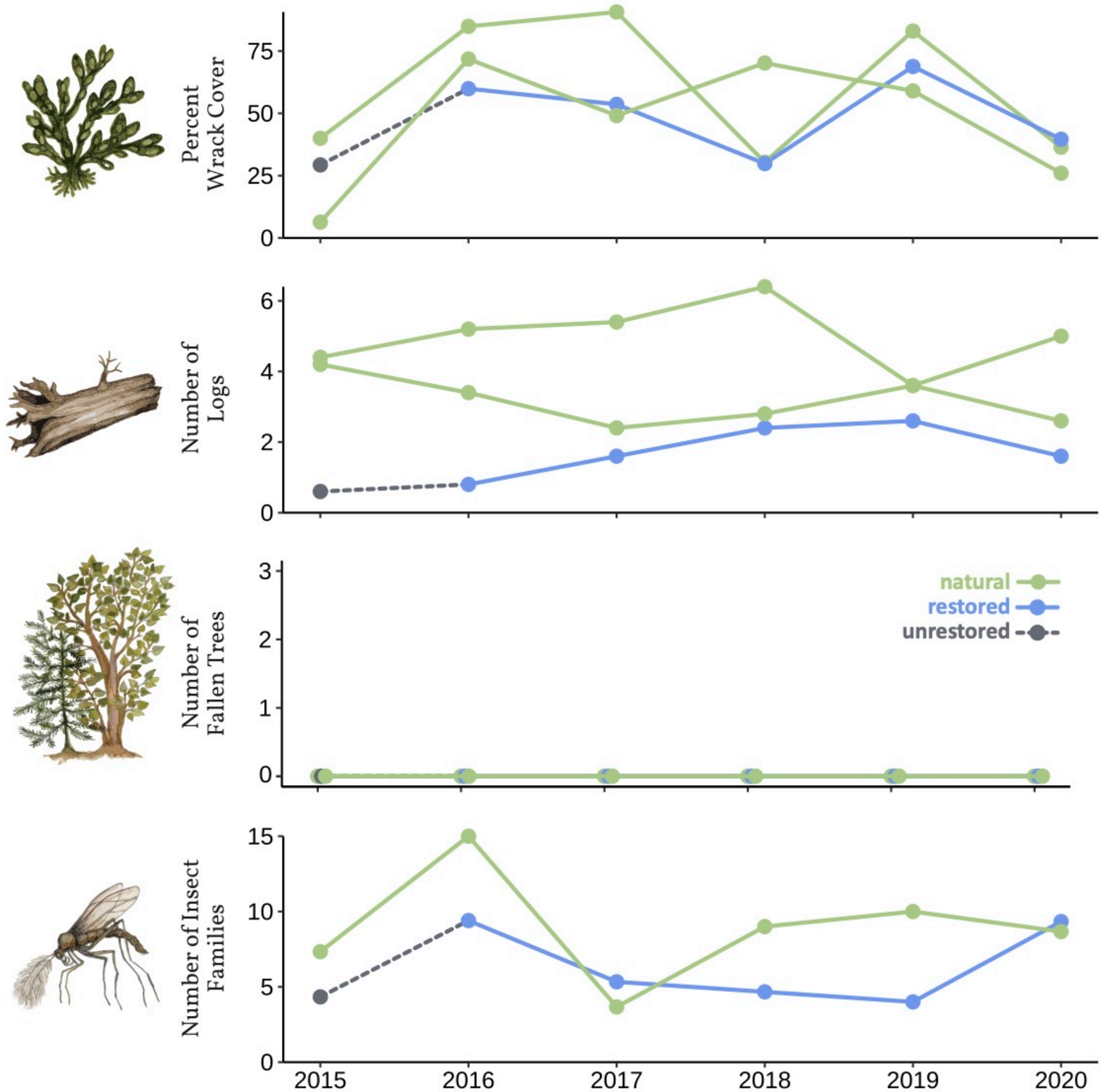



Lambert et al. 2021. Trends in Ecology & Evolution

# 2. Easy: does the layout of the image make it as easy as possible to understand?

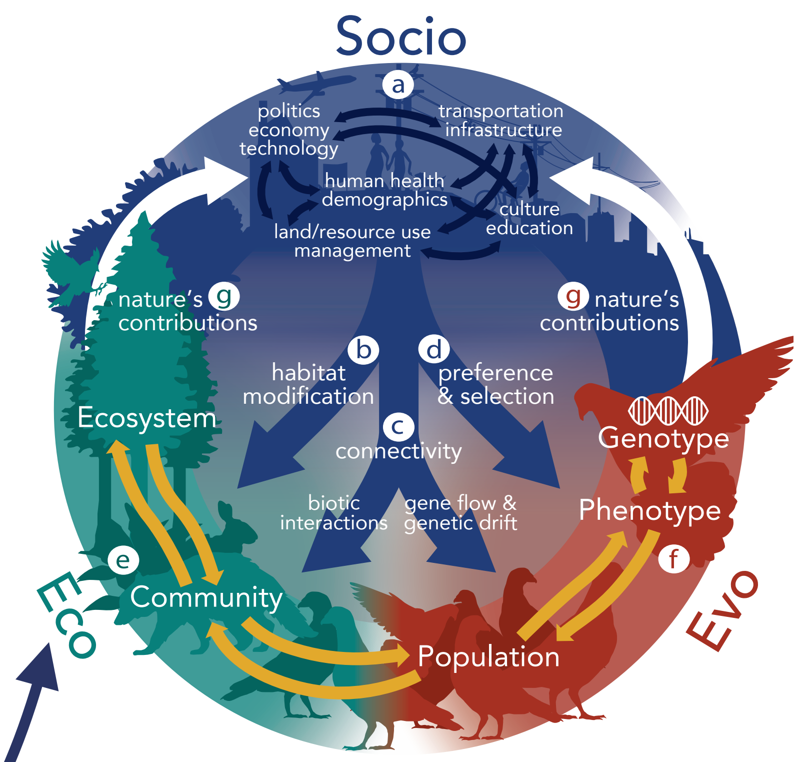
## Simplify to the most essential elements using repetitive imagery

*e.g.,* use faceting to highlight different parts of the same data or plot different data on the same axes



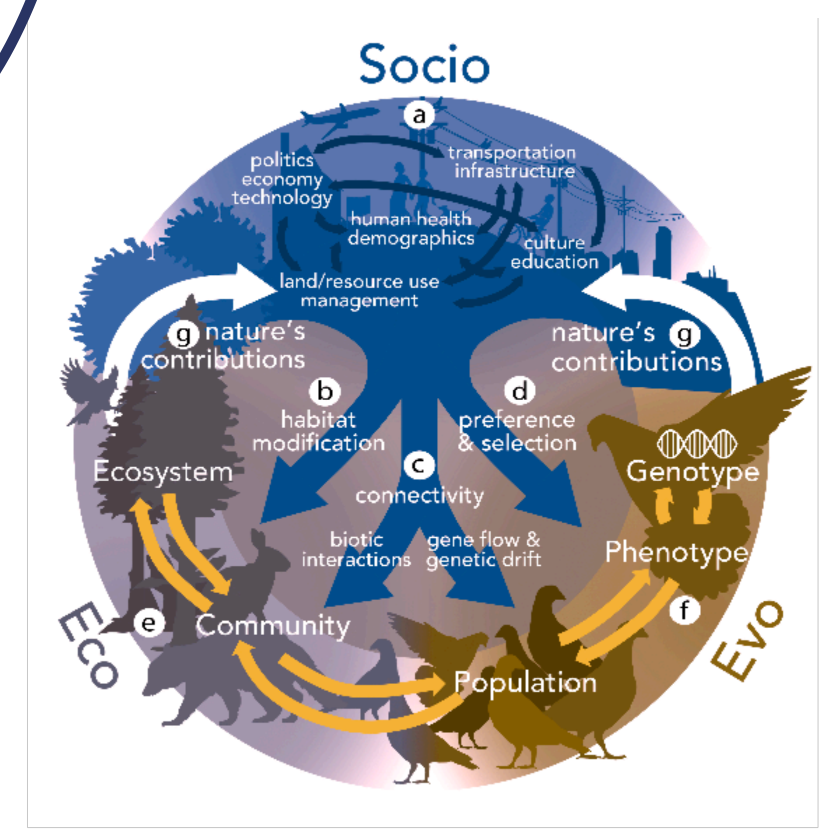
## 3. Accessible*: is the image accessible (e.g., colour-blind friendly)?

***Alternatively, "Audience": are you communicating appropriately for your audience?**




**Identify target audience, perceive the imagery as they would. Can you modify your figure so it is more inclusive?**

***e.g.,*** **ensure colours are colourblind-friendly & try not to refer to colours by name - instead, use a legend, or incorporate the "key" into the figure itself**

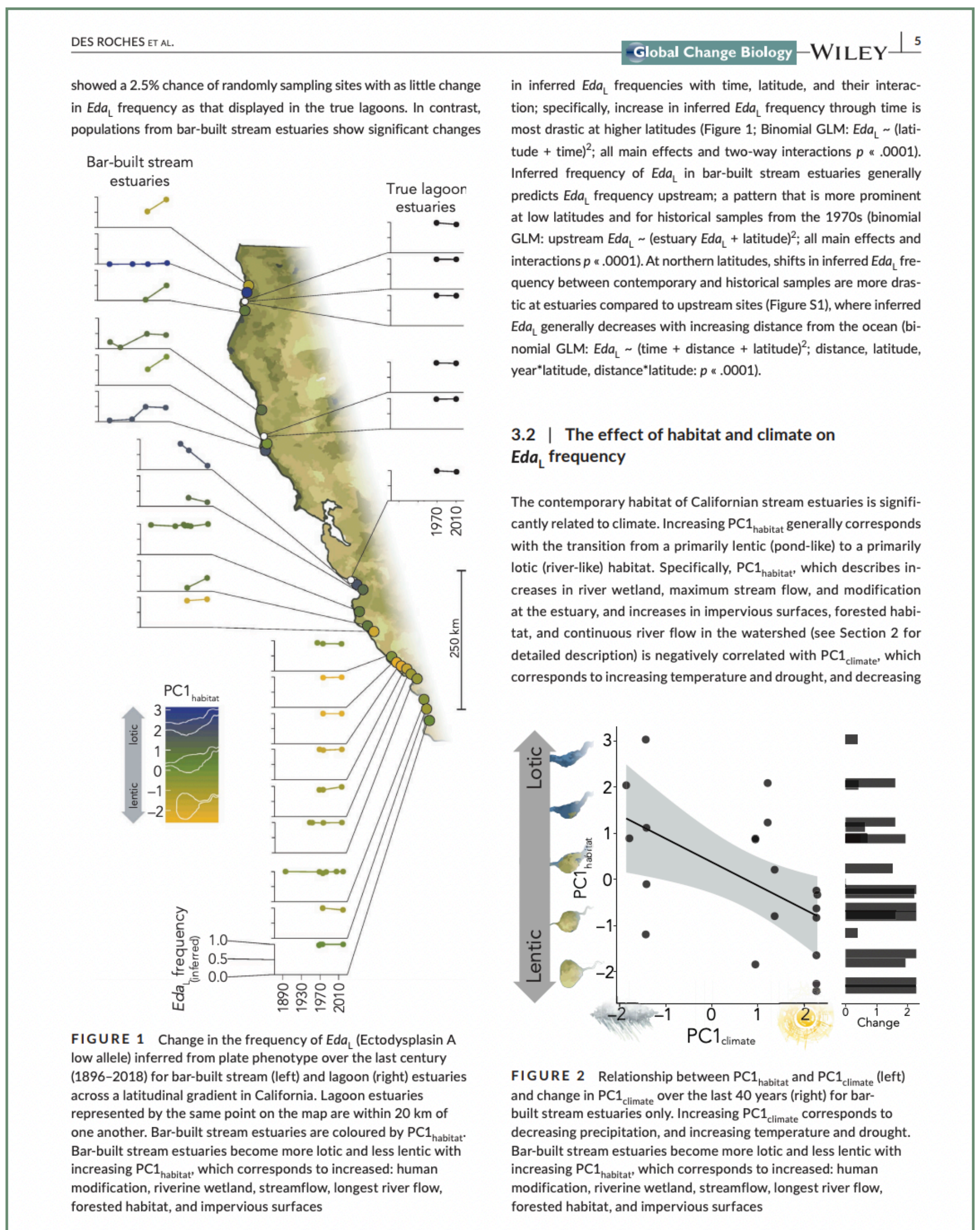



https://www.color-blindness.com/coblis-color-blindness-simulator/
https://www.colororacle.org/

Des Roches et al. 2020. Evolutionary Applications

# 3. Accessible: is the image accessible (e.g., colour-blind friendly)?

## Is your audience reading a paper or listening to a presentation?
## Is the presentation over Zoom or is it in person?





showed a 2.5% chance of randomly sampling sites with as little change in $Eda_L$ frequency as that displayed in the true lagoons. In contrast, populations from bar-built stream estuaries show significant changes in inferred $Eda_L$ frequencies with time, latitude, and their interaction; specifically, increase in inferred $Eda_L$ frequency through time is most drastic at higher latitudes (Figure 1; Binomial GLM: $Eda_L$ ~ (latitude + time)$^2$; all main effects and two-way interactions $p$ « .0001). Inferred frequency of $Eda_L$ in bar-built stream estuaries generally predicts $Eda_L$ frequency upstream; a pattern that is more prominent at low latitudes and for historical samples from the 1970s (binomial GLM: upstream $Eda_L$ ~ (estuary $Eda_L$ + latitude)$^2$; all main effects and interactions $p$ « .0001). At northern latitudes, shifts in inferred $Eda_L$ frequency between contemporary and historical samples are more drastic at estuaries compared to upstream sites (Figure S1), where inferred $Eda_L$ generally decreases with increasing distance from the ocean (binomial GLM: $Eda_L$ ~ (time + distance + latitude)$^2$; distance, latitude, year*latitude, distance*latitude: $p$ « .0001).

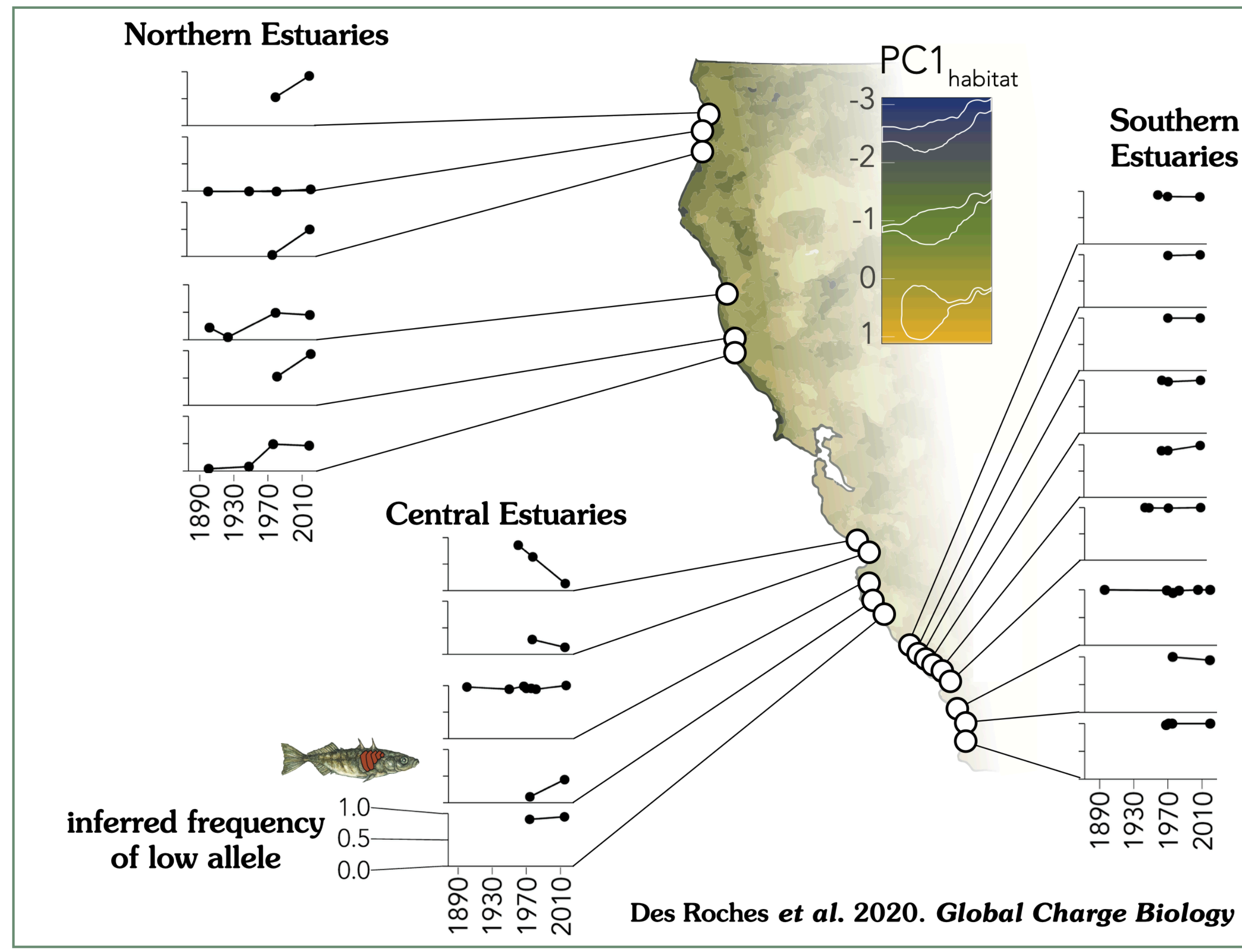
### 3.2 | The effect of habitat and climate on $Eda_L$ frequency

The contemporary habitat of Californian stream estuaries is significantly related to climate. Increasing $PC1_{habitat}$ generally corresponds with the transition from a primarily lentic (pond-like) to a primarily lotic (river-like) habitat. Specifically, $PC1_{habitat}$, which describes increases in river wetland, maximum stream flow, and modification at the estuary, and increases in impervious surfaces, forested habitat, and continuous river flow in the watershed (see Section 2 for detailed description) is negatively correlated with $PC1_{climate}$, which corresponds to increasing temperature and drought, and decreasing



**FIGURE 1** Change in the frequency of $Eda_L$ (Ectodysplasin A low allele) inferred from plate phenotype over the last century (1896–2018) for bar-built stream (left) and lagoon (right) estuaries across a latitudinal gradient in California. Lagoon estuaries represented by the same point on the map are within 20 km of one another. Bar-built stream estuaries are coloured by $PC1_{habitat}$. Bar-built stream estuaries become more lotic and less lentic with increasing $PC1_{habitat}$, which corresponds to increased: human modification, riverine wetland, streamflow, longest river flow, forested habitat, and impervious surfaces

**FIGURE 2** Relationship between $PC1_{habitat}$ and $PC1_{climate}$ (left) and change in $PC1_{climate}$ over the last 40 years (right) for bar-built stream estuaries only. Increasing $PC1_{climate}$ corresponds to decreasing precipitation, and increasing temperature and drought. Bar-built stream estuaries become more lotic and less lentic with increasing $PC1_{habitat}$, which corresponds to increased: human modification, riverine wetland, streamflow, longest river flow, forested habitat, and impervious surfaces



## 3. Accessible: is the image accessible (e.g., colour-blind friendly)?

# Remember visualization is not just about "sight"

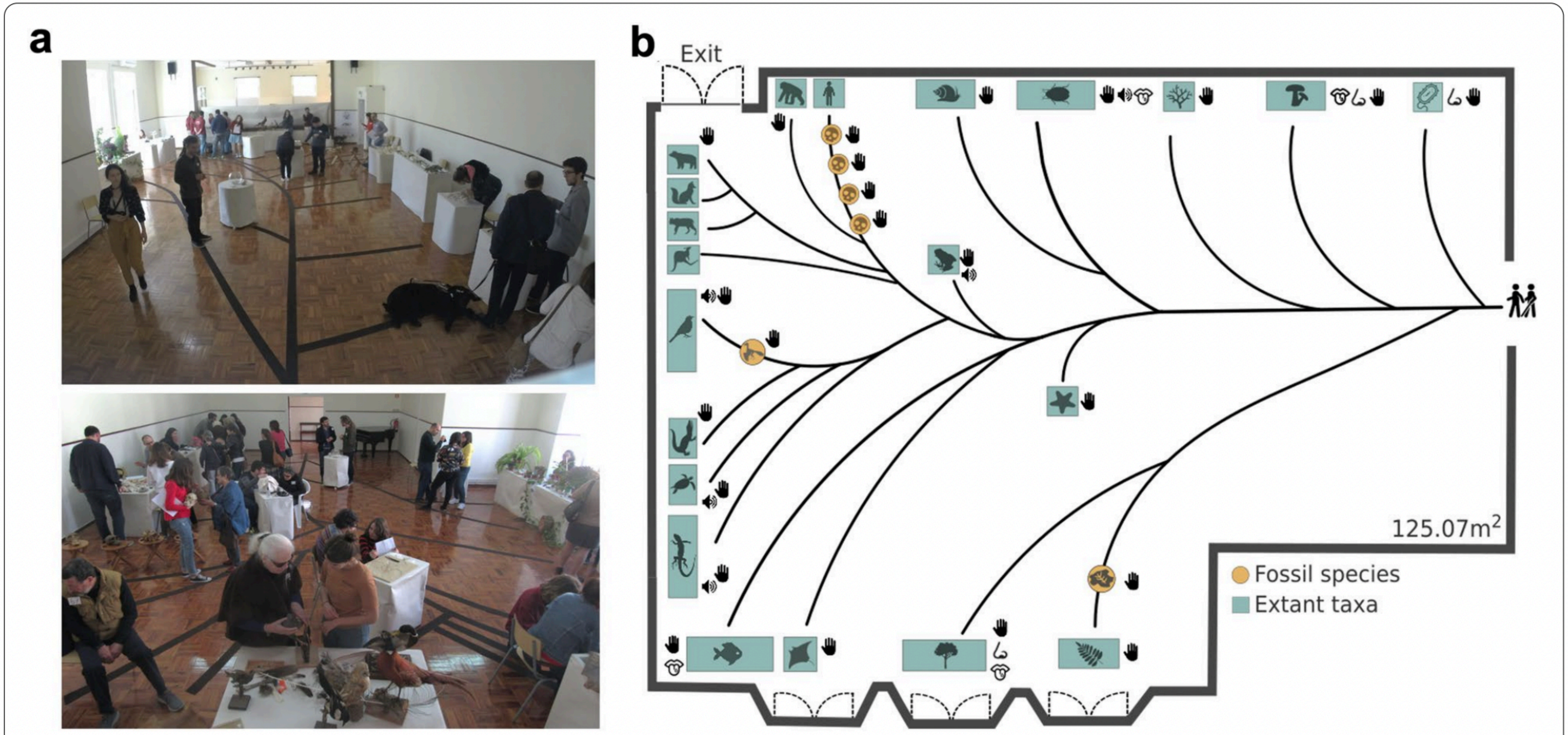
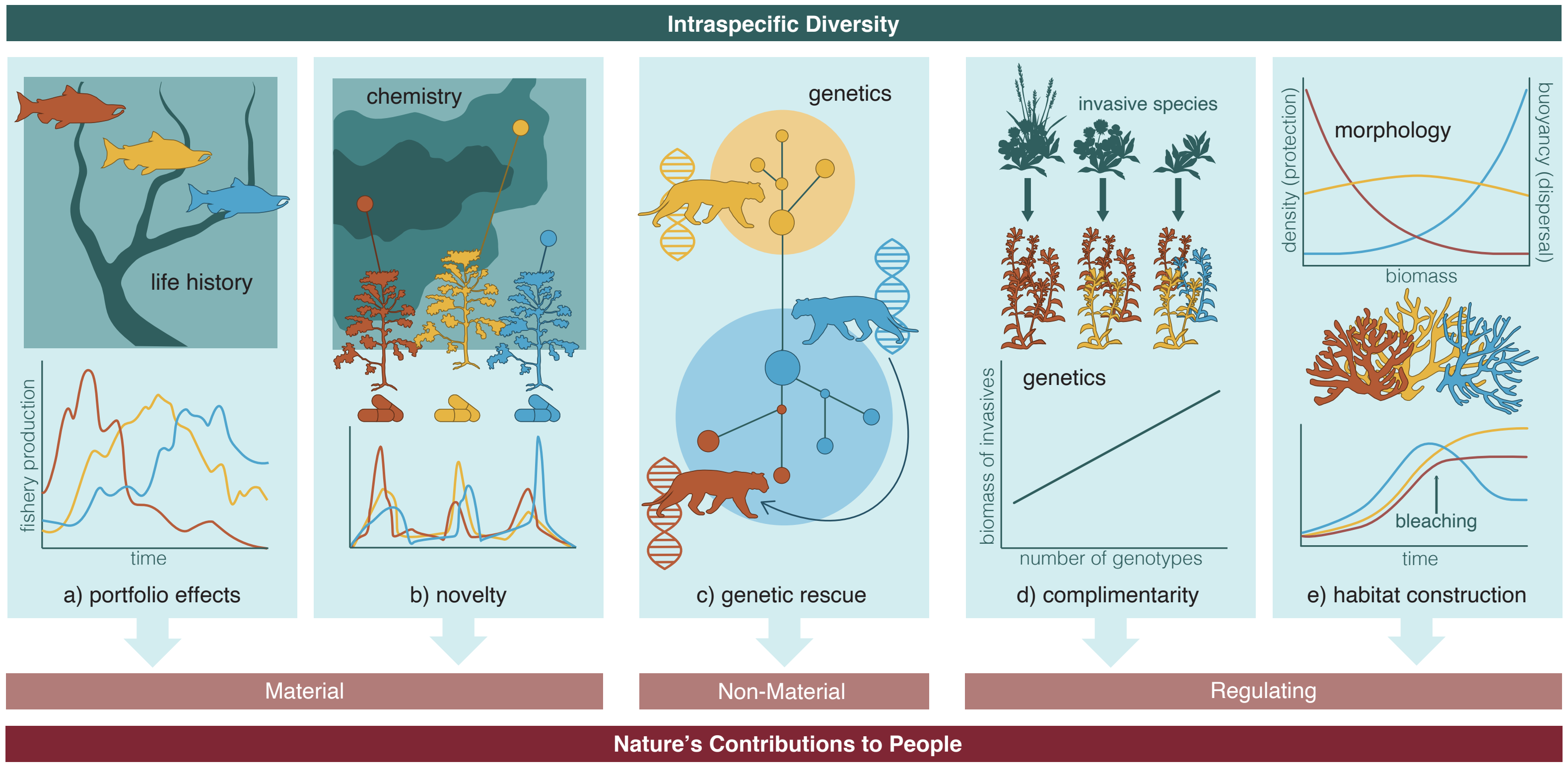
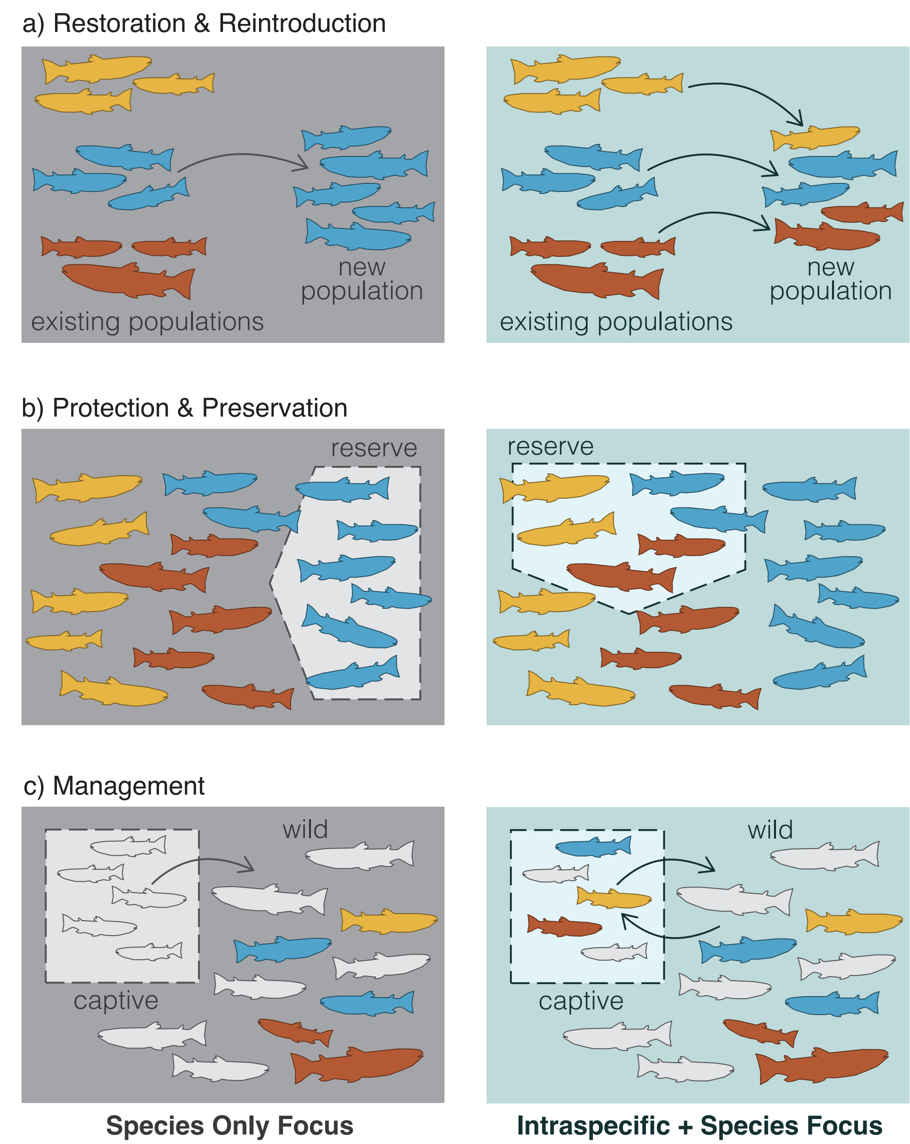



**Fig. 2** The multisensory tree-of-life (**a**) Photos of the room with the assembled MSToL and (**b**) blueprint of the room with all represented taxa and stimulated senses. The branches of the phylogeny were cut out in carpet making the phylogenetic relationships among groups of taxa accessible for visually impaired people (see Additional file 1: Table S1 for a complete list of materials and Additional file 2: Fig. S1 for detailed branch photos)

Laurentino et al. 2021. Evolution Education Outreach

# 4. Consistent: are colours/shapes consistent & intuitive (i.e. is the style coherent?)




## Use the same colours and shapes across different figures and use a consistent order in figures and text

***e.g.,*** shapes represent different species while red, yellow, blue colour show intraspecific variants

Des Roches et al. 2021. Nature Ecology & Evolution

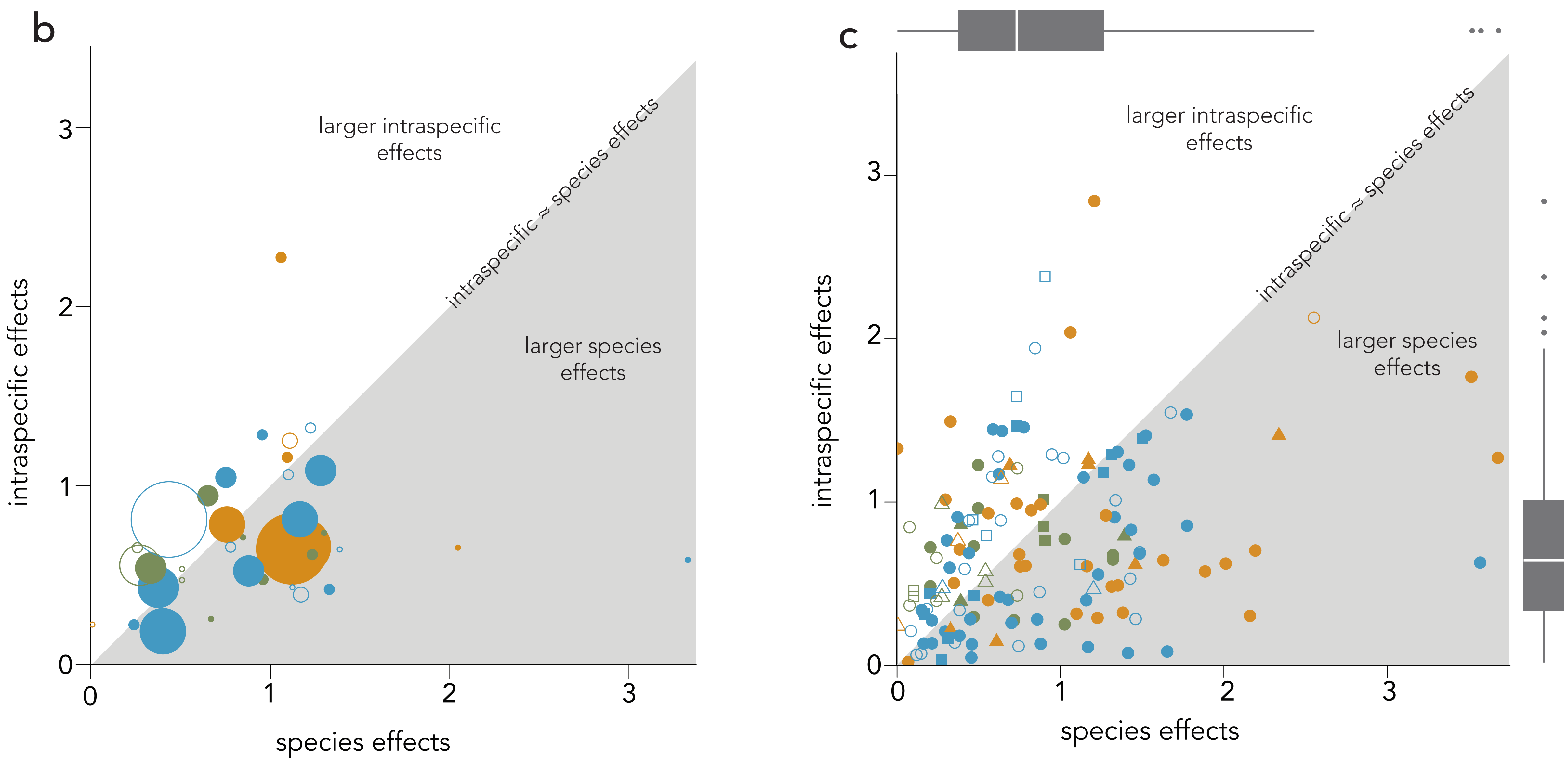
## 5. Honest: are any data displayed honestly?

If all models are wrong, ***but some are useful***…
then all figures are lying, ***but some are honest***

# 5. Honest: are any data displayed honestly?

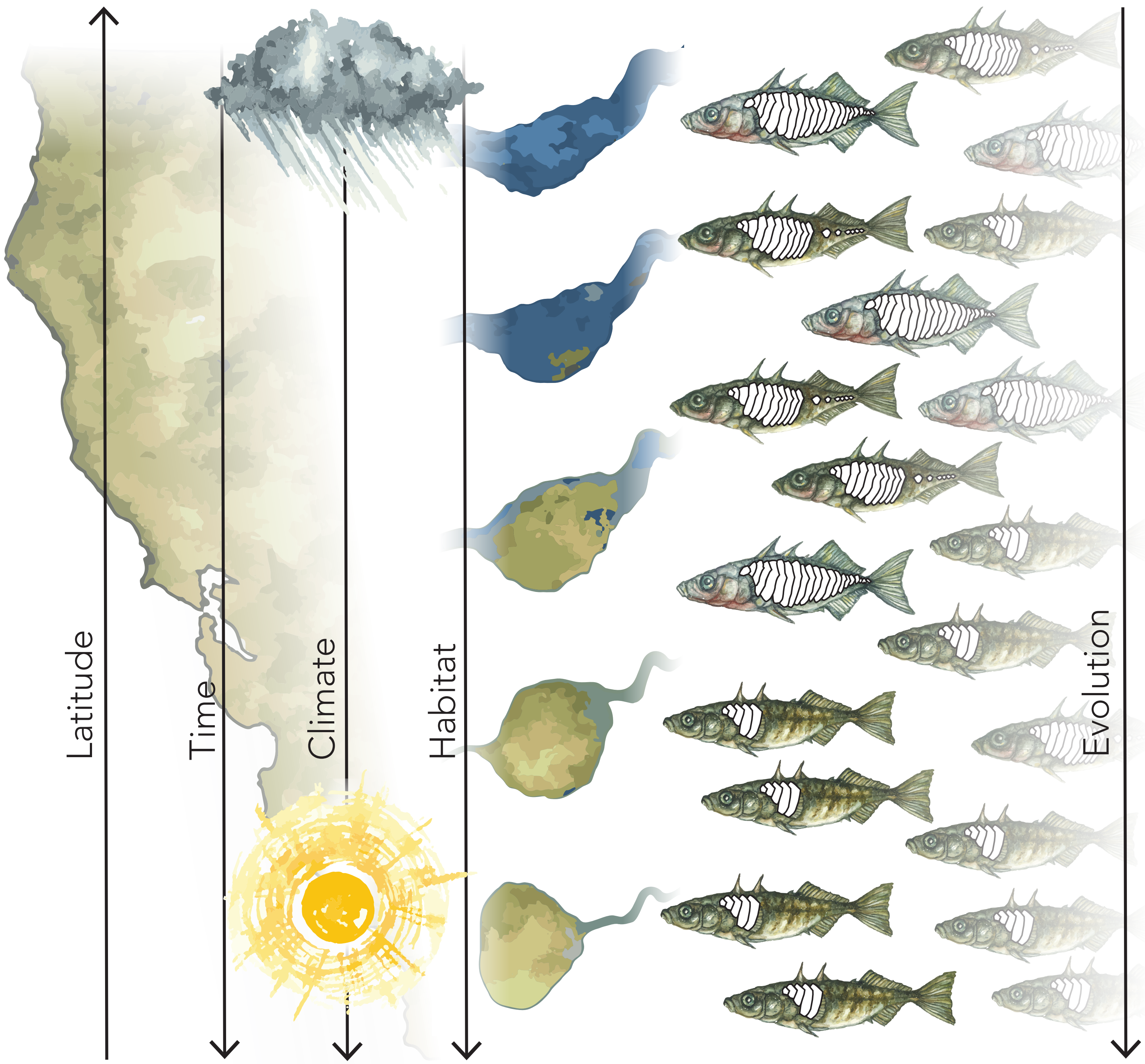
## To get the full message across, showcase the same data in different graphs

***e.g.,*** **all response variables in meta-analysis (left), and summarized by study (right)**



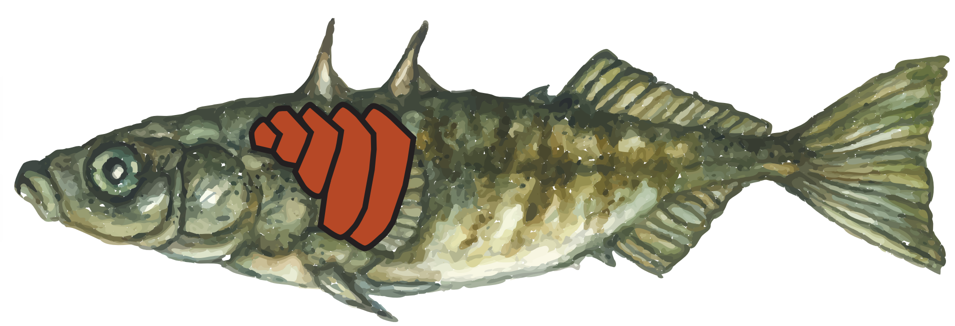

Des Roches et al. 2021. Nature Ecology & Evolution

## 6. Enhancing: does art/visualization enhance (rather than distract from) the message?



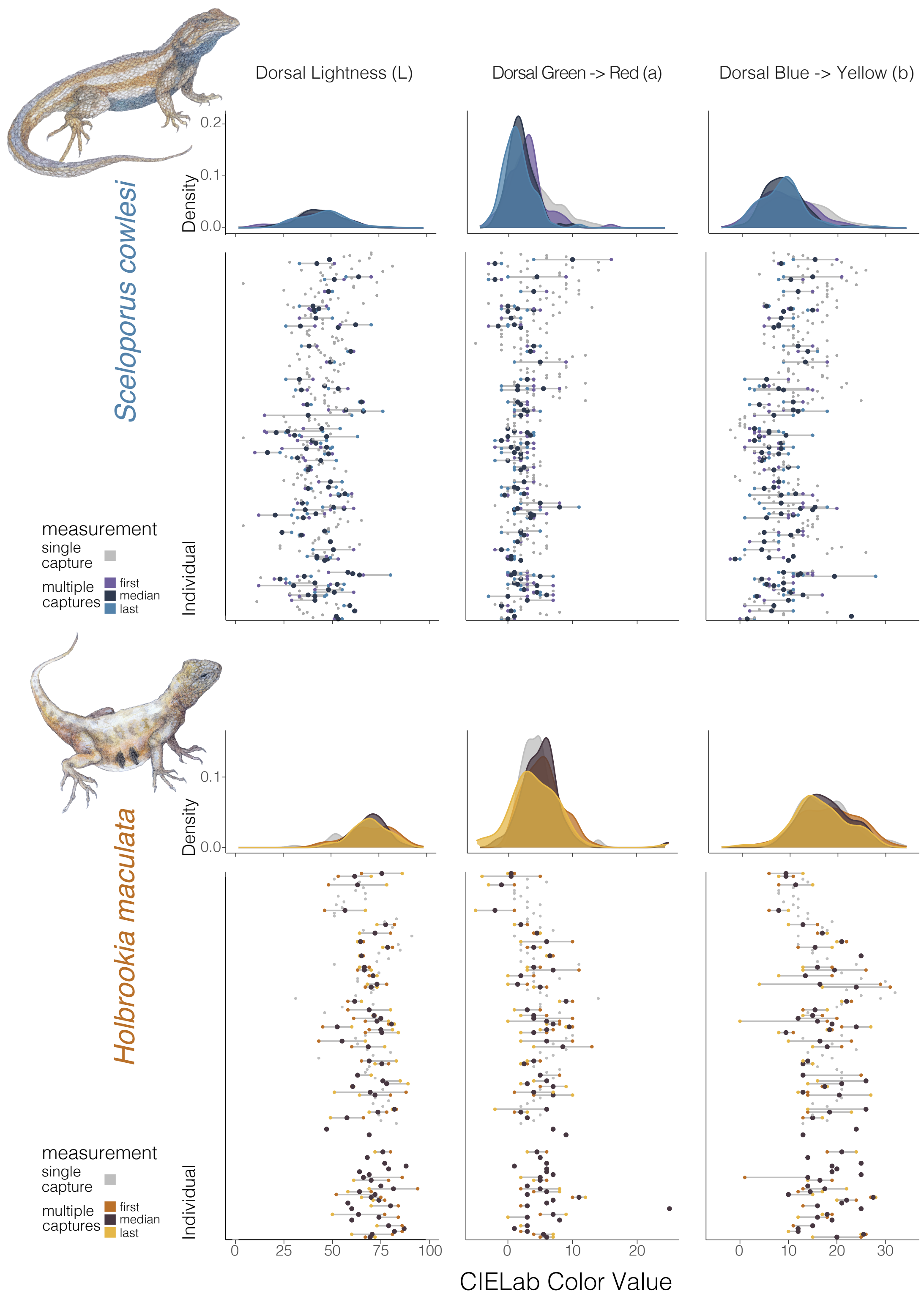

Illustrations like can display your intimate knowledge of a species. Not an artist yourself? Collaborate with a student or friend!

*e.g.,* overlaying the illustration with a simpler image of the important feature (number of plates) can highlight the pattern



Des Roches et al. 2020. Global Change Biology

# 6. Enhancing: does art/visualization enhance (rather than distract from) the message?




## Create aesthetically appealing images!

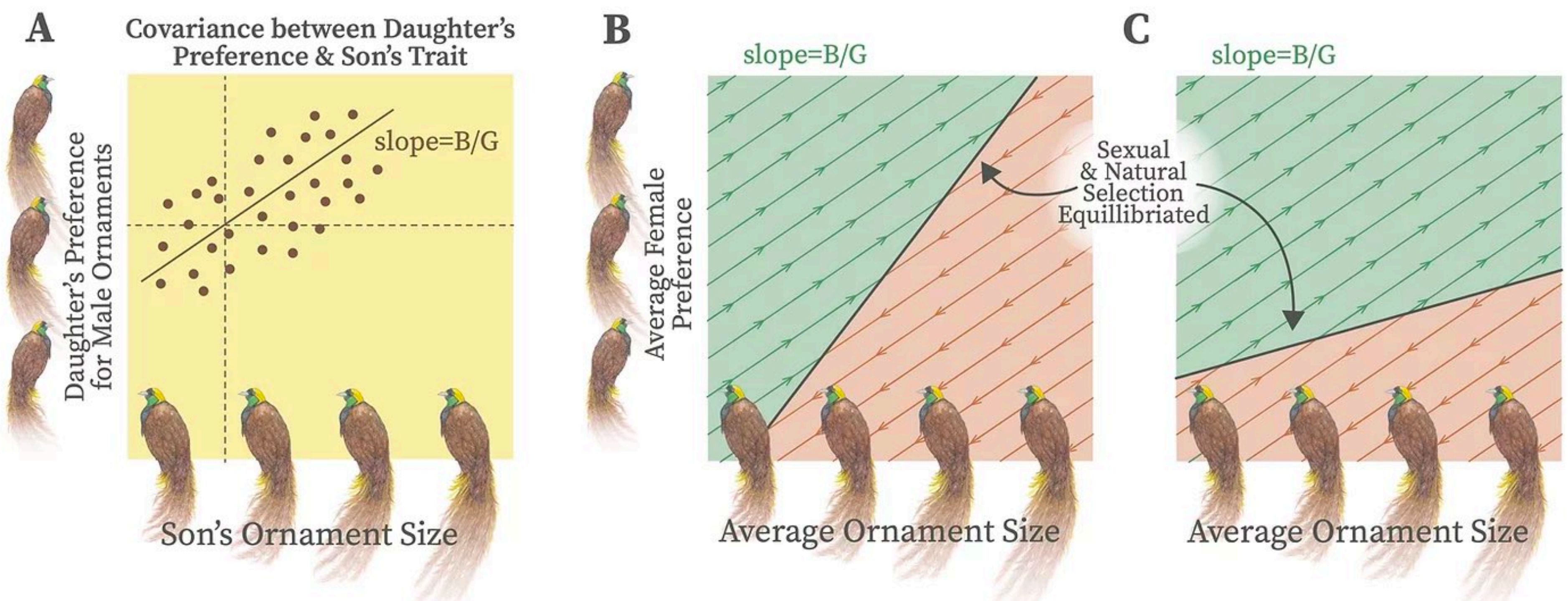
*e.g.*,

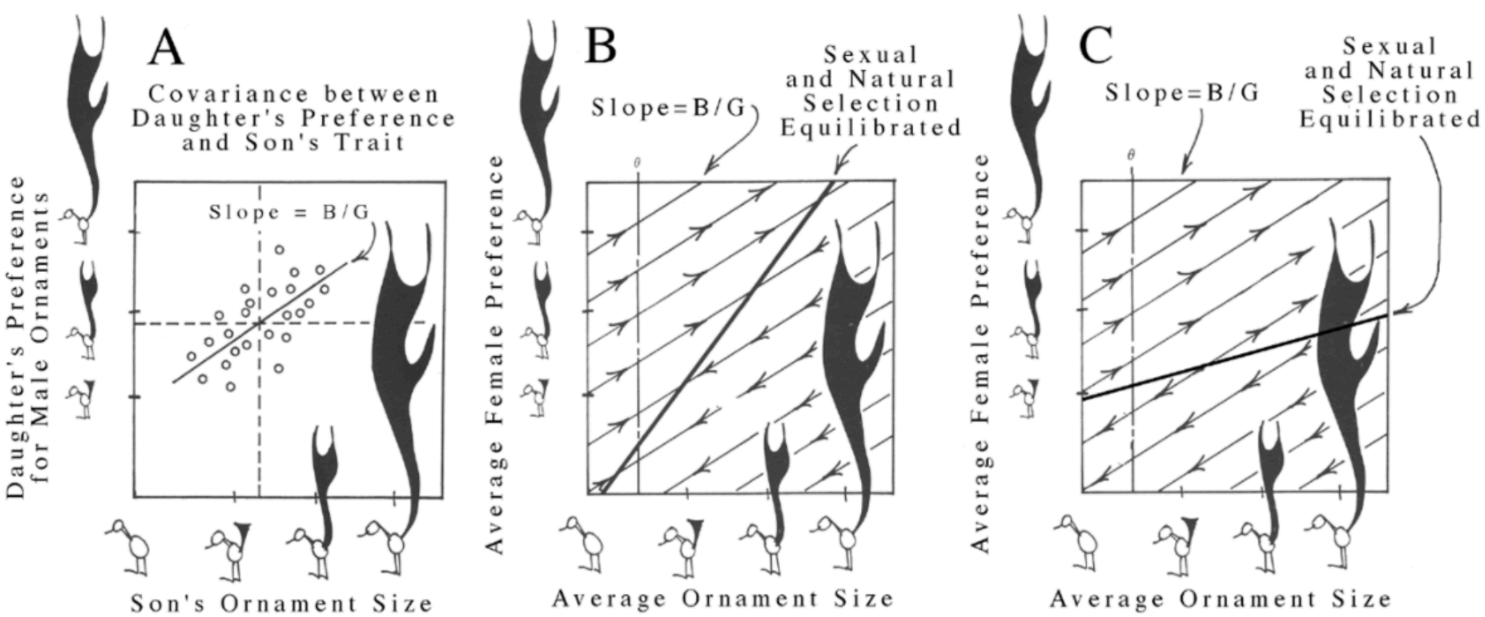
a) Match colours between illustrations & plots
b) Convert images to vectors (in Adobe Illustrator) to make them easier to work with

Des Roches et al. in prep.

# 6. Enhancing: does art/visualization enhance (rather than distract from) the message?

## a) Match colours between illustrations & plots



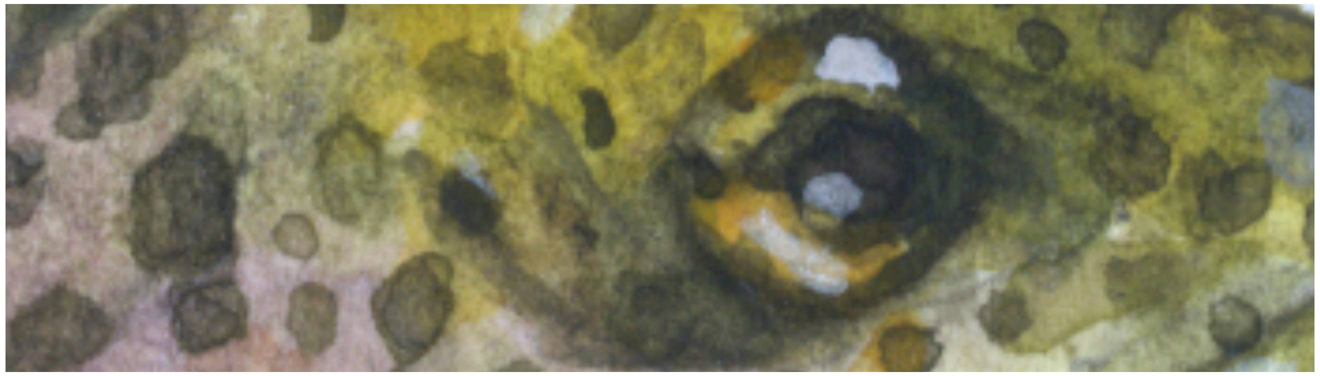




the eyedropper tool is your friend!

# 6. Enhancing: does art/visualization enhance (rather than distract from) the message?

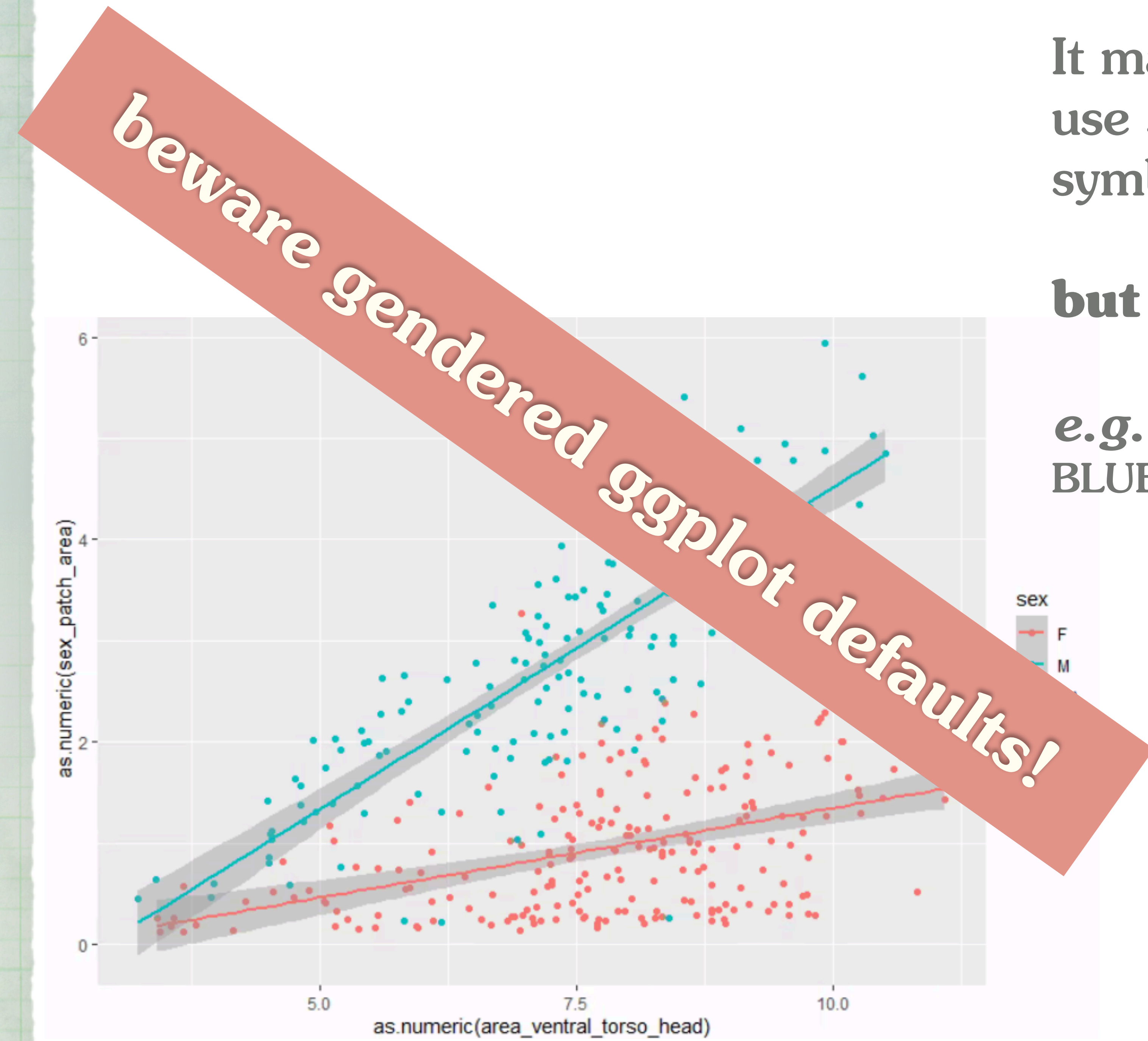
b) Convert images to vectors (in Adobe Illustrator) to make them easier to work with

Raster = dot matrix, i.e., as scanned (*e.g.*, jpeg, tiff, psd)



Vector = polygons, i.e., "image traced" in Illustrator (*e.g.*, svg, pdf, ai)

## 7. Sensitive: is imagery sensitive to audience's experiences and identities?




It may be tempting & even intuitive to use socially & culturally-relevant symbols

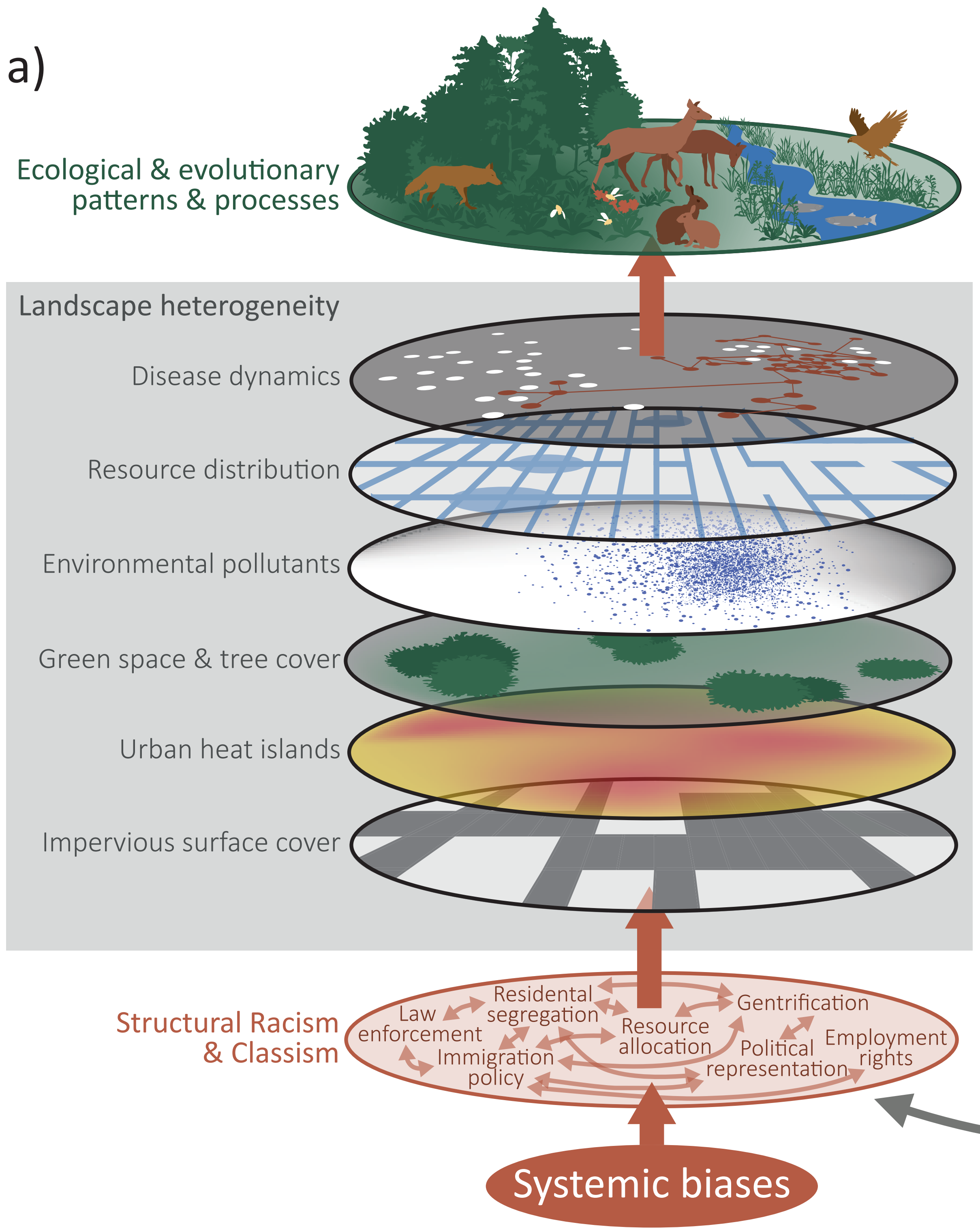
**but we can do better!**

***e.g.***, there is NOTHING inherently PINK or BLUE about males & females! Switch it up!

**female**

**male**

## 7. Sensitive: is imagery sensitive to audience's experiences and identities?




Schell et al. 2020. Science

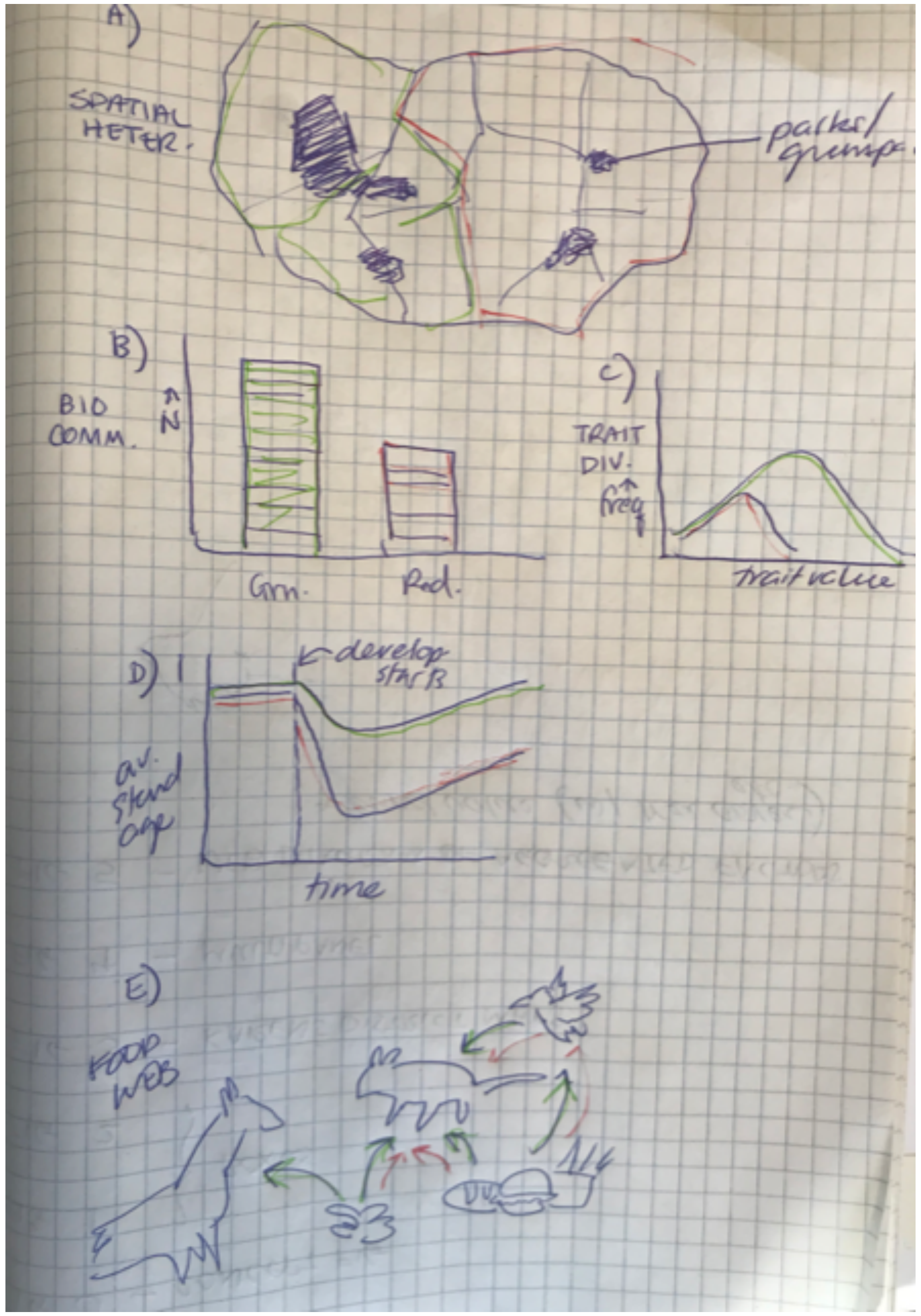
It may be tempting & even intuitive to use socially & culturally-relevant symbols

**but we can do better!**

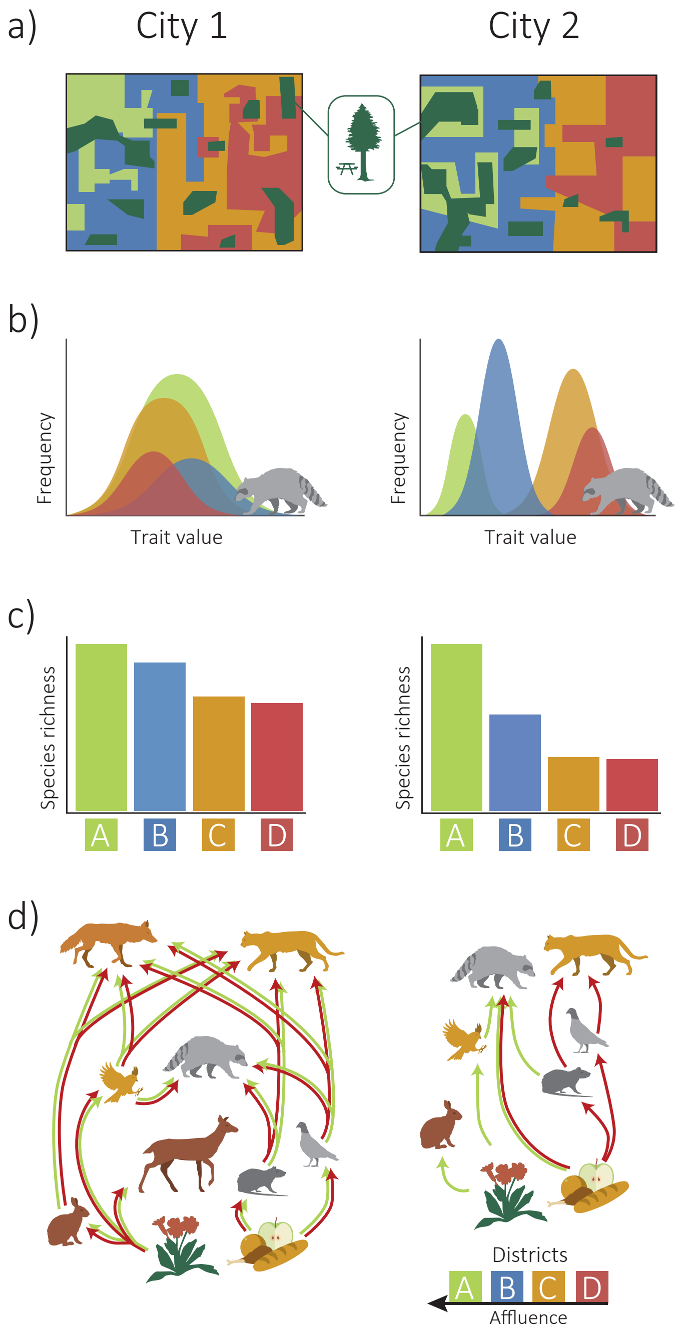
***e.g.***, use TEXT instead if you are concerned about how to depict a sensitive or loaded topic

# Just like you would revise a manuscript, revise your figures!

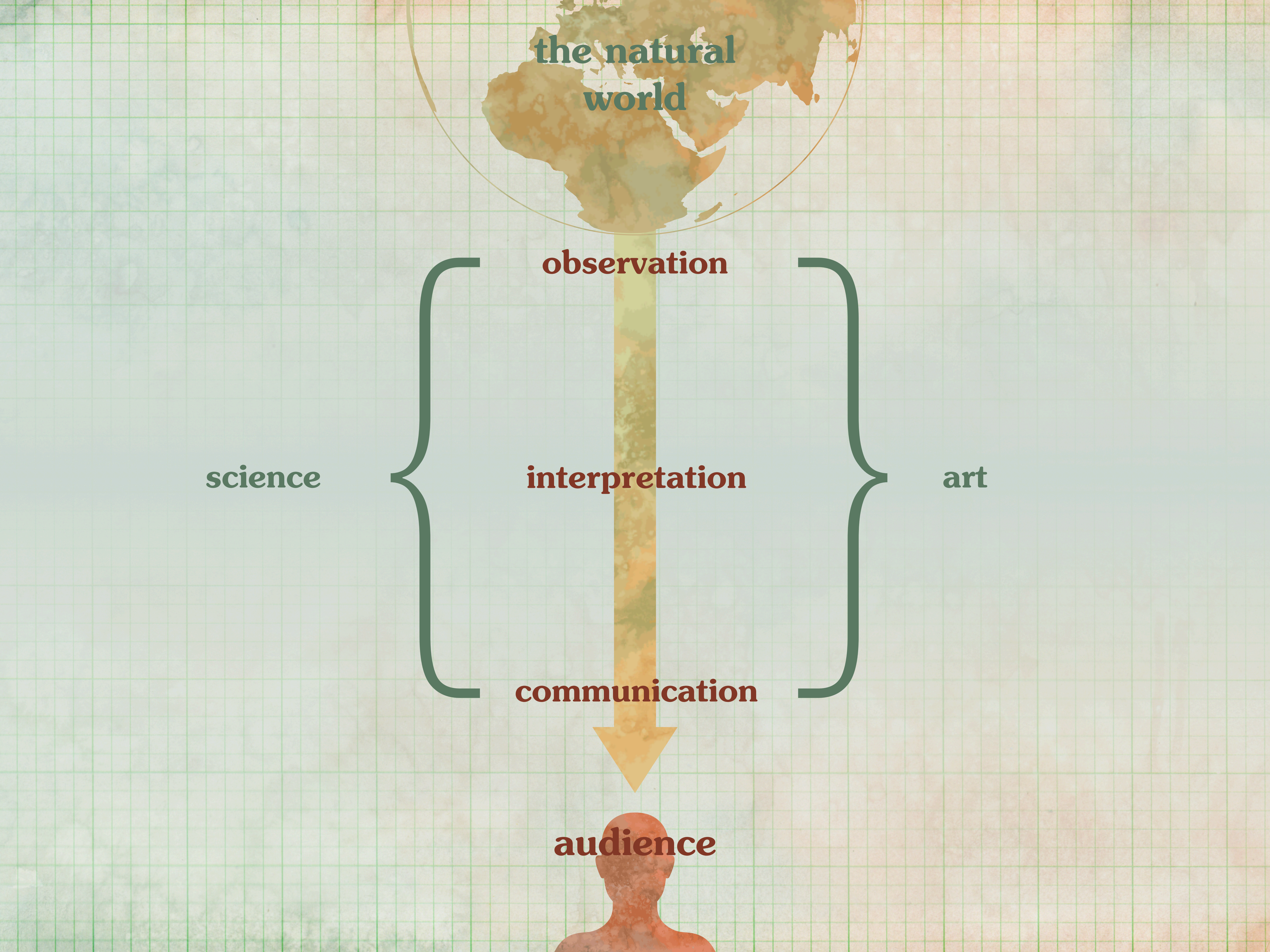
## how it started

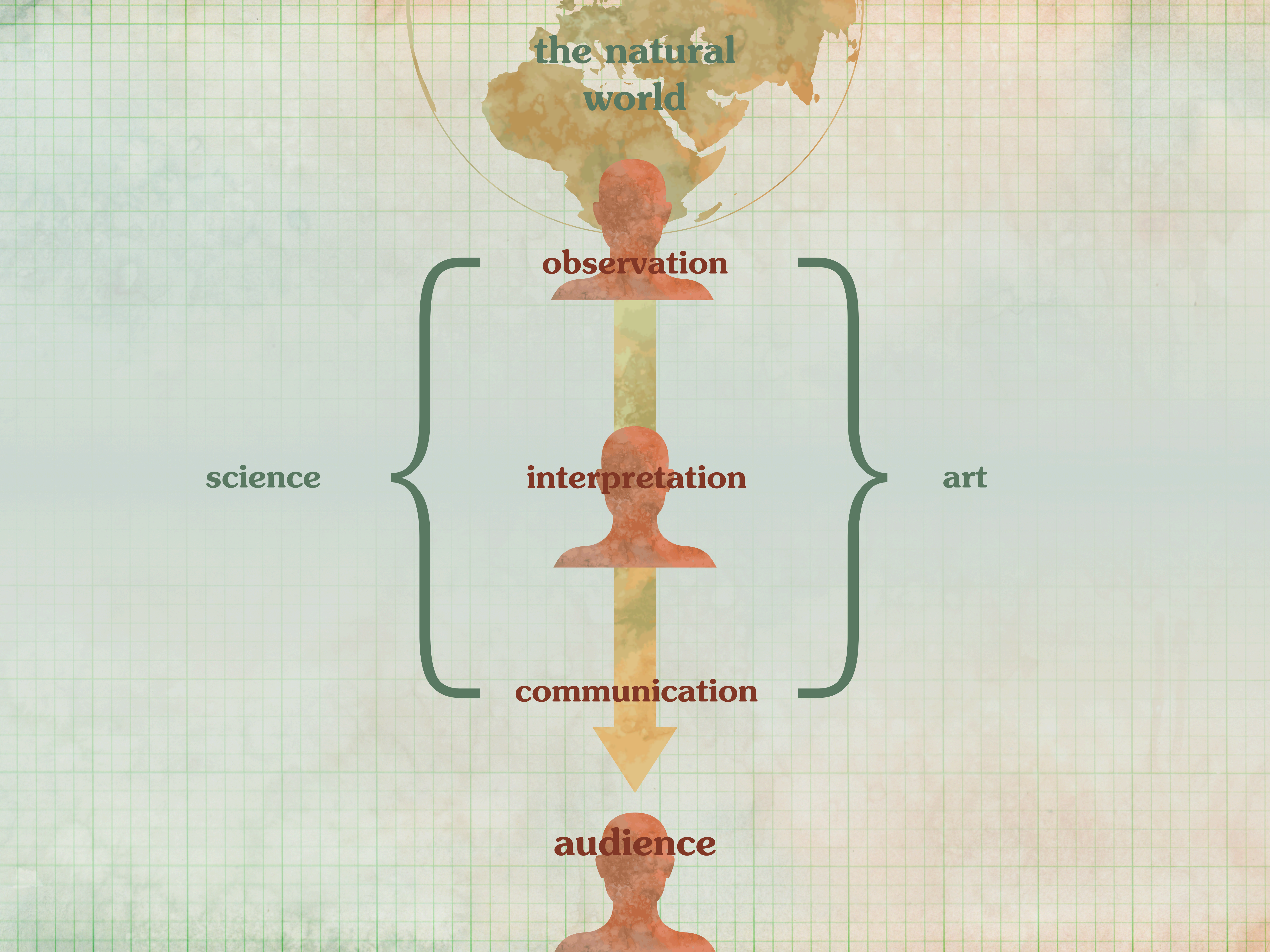



## how it's going




Schell *et al.* 2020. Science


the natural world
observation
science
interpretation
art
communication
audience


the natural world
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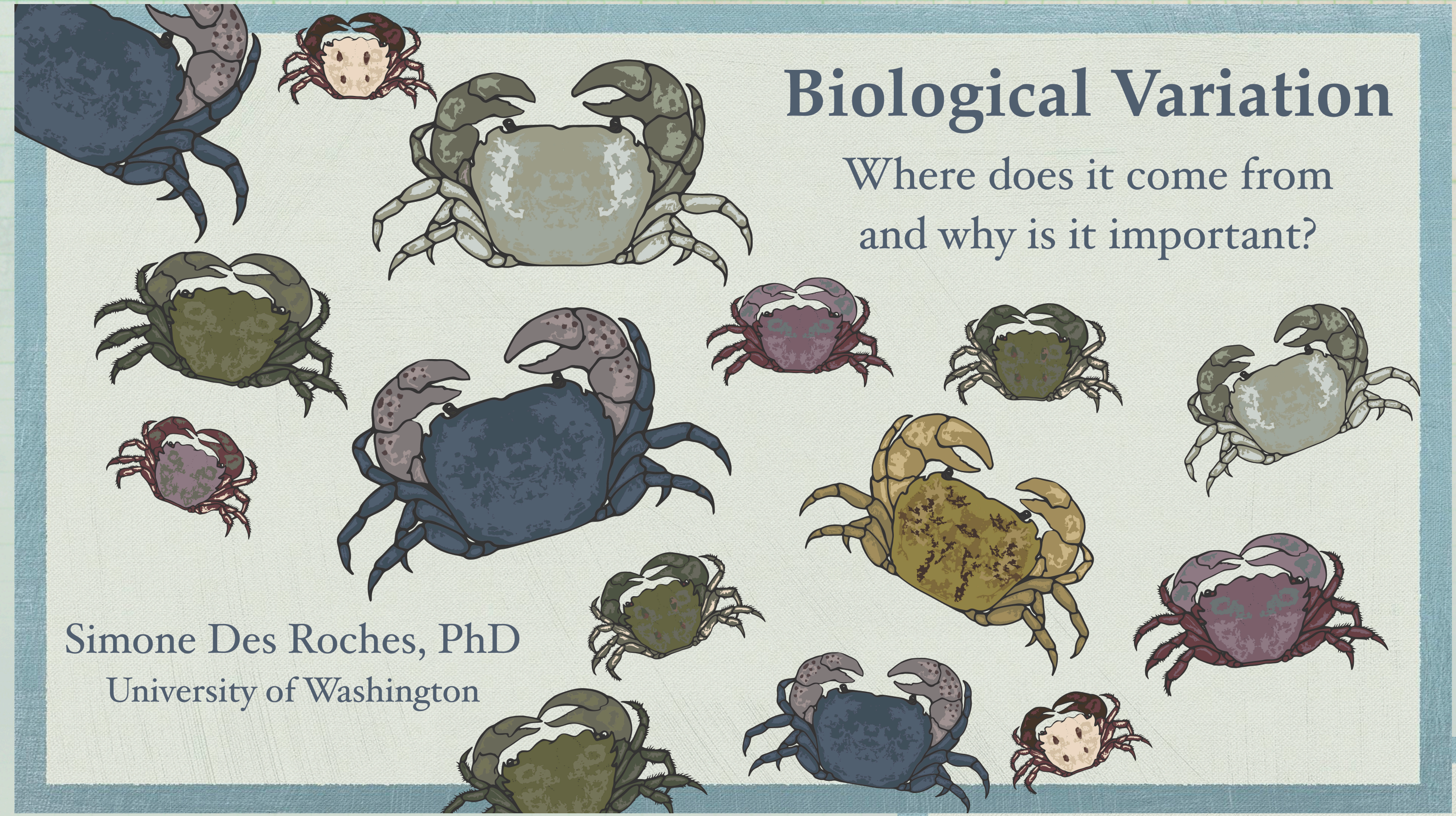
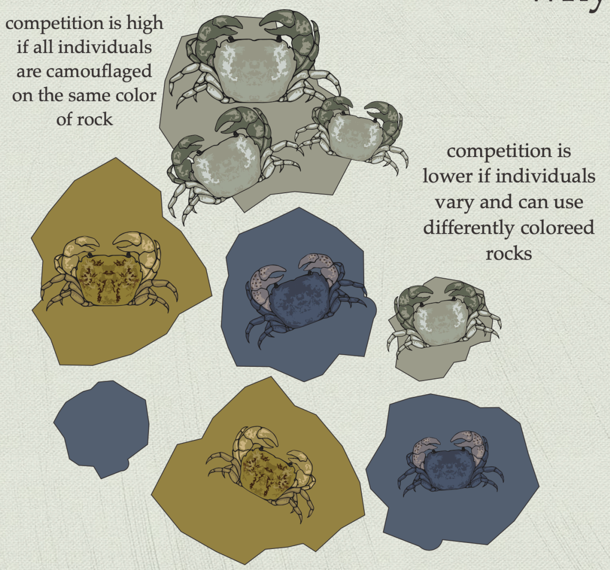
# Going a step further with community (citizen) science




**Participatory science?**
**Participatory sci-art!**

## intraspecific variation

why is it important?



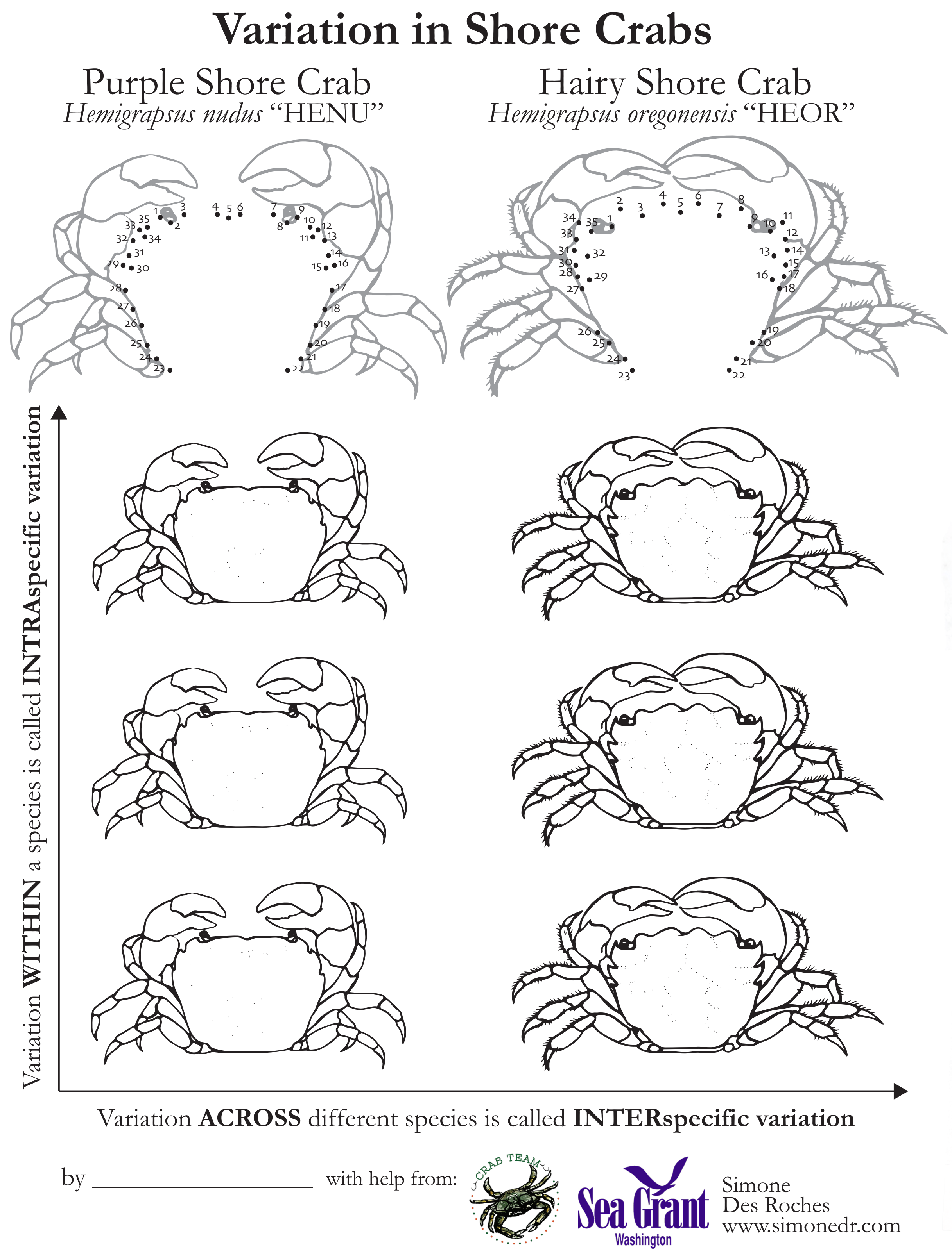

*for example*

**Morphological variation** is important because it means members of the same species can divide up resources.

If all individuals were the same, they would have to compete for these resources.

With variation, individuals of different types can use different types of resources.

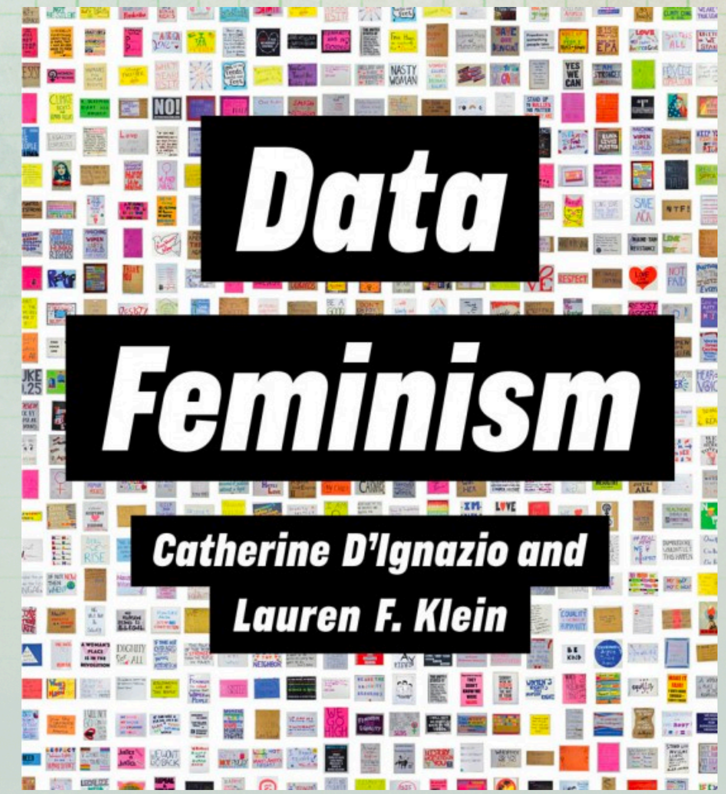
# Going a step further with community (citizen) science

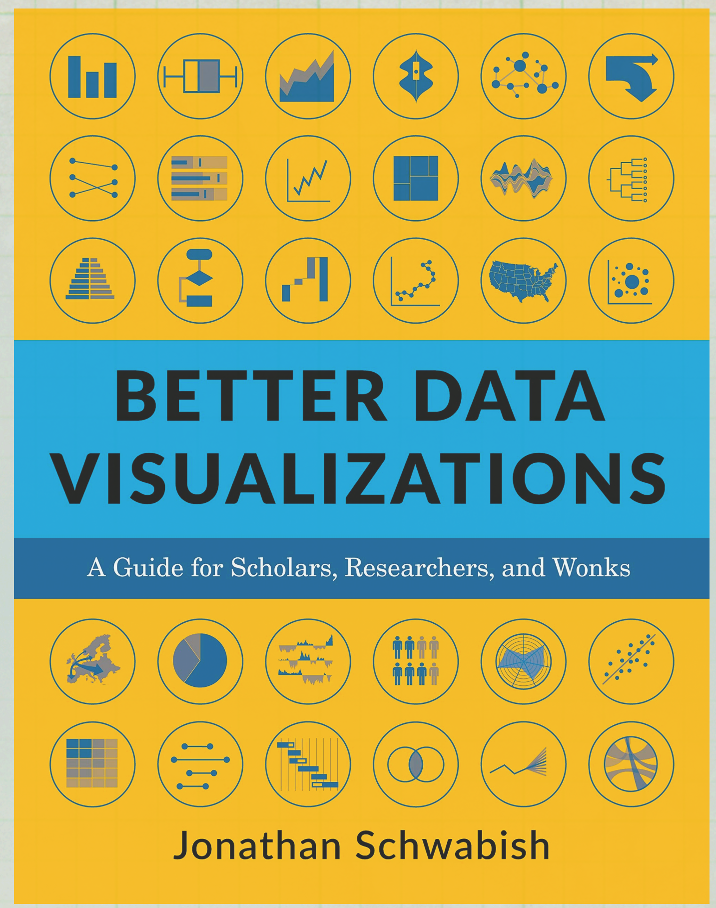


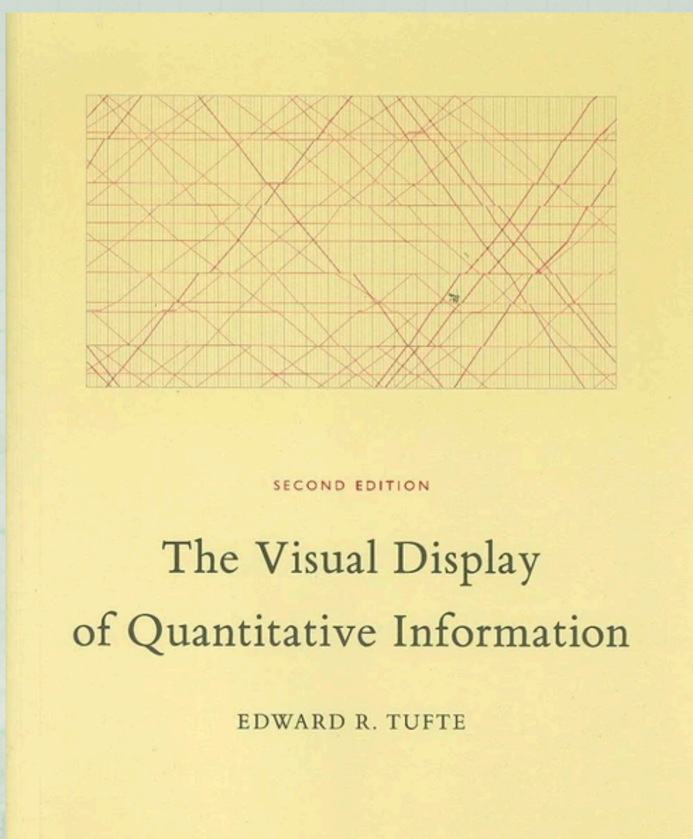

## volunteer artwork!

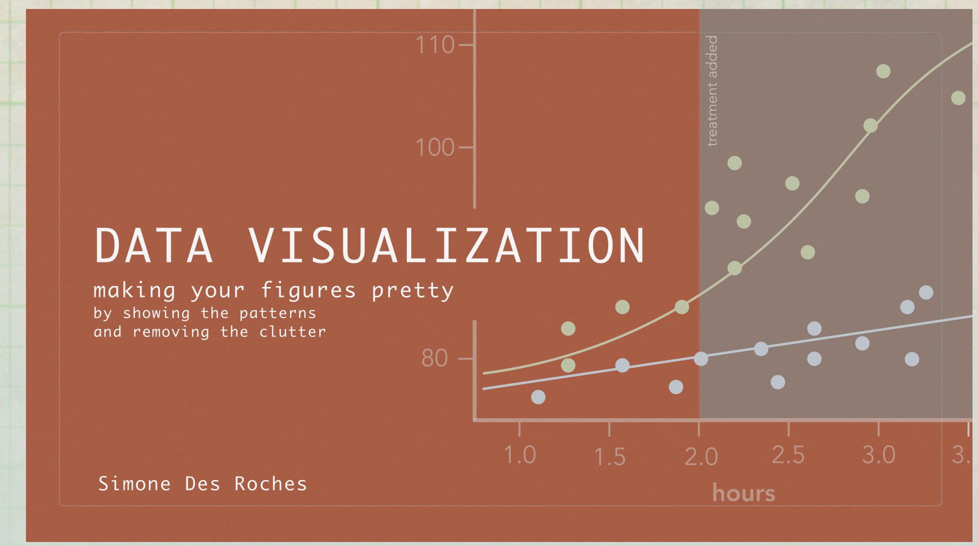
# Thank You!

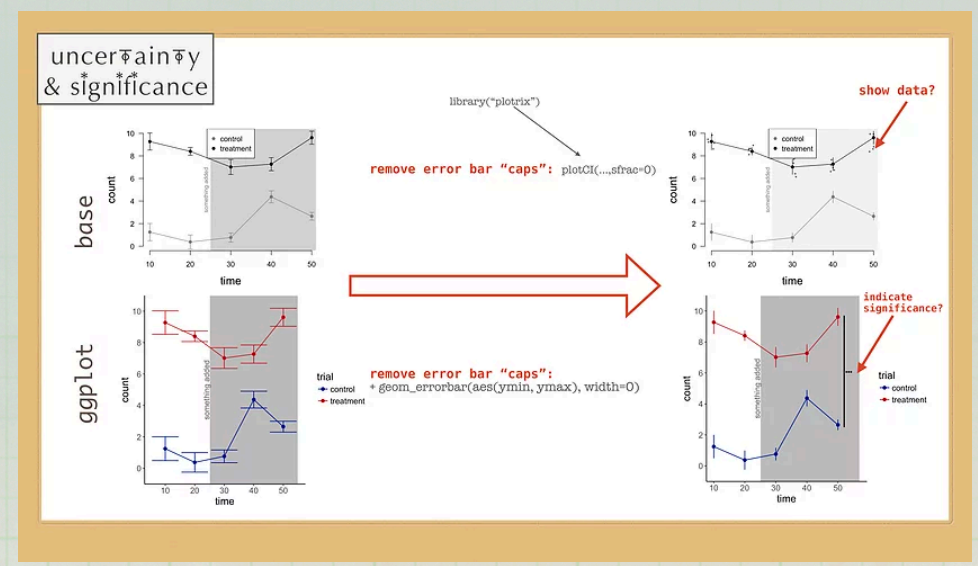
## Further Reading:

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