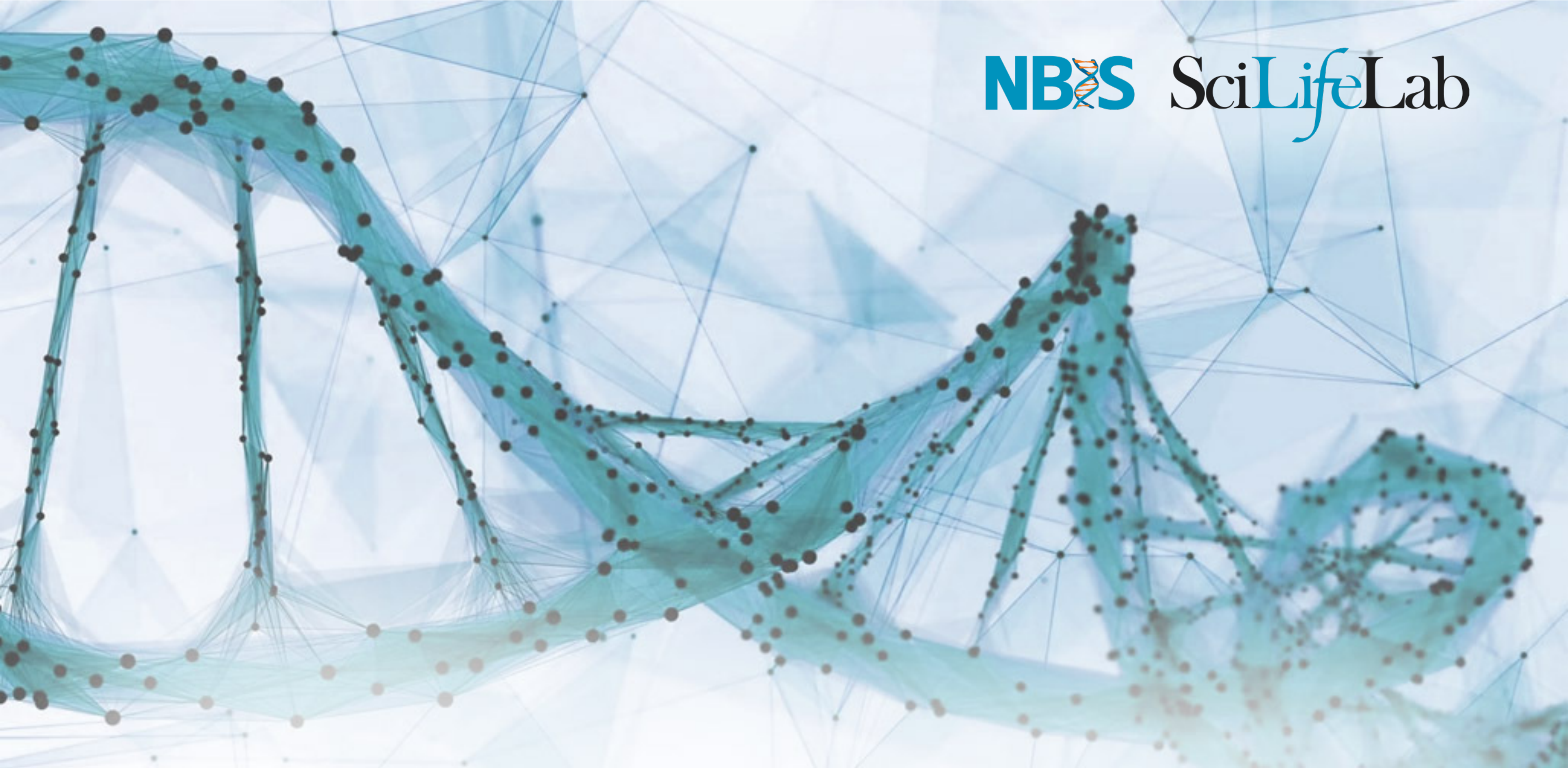


Vector and bitmap images

Workshop on ggplot

Markus Ringnér

Outline

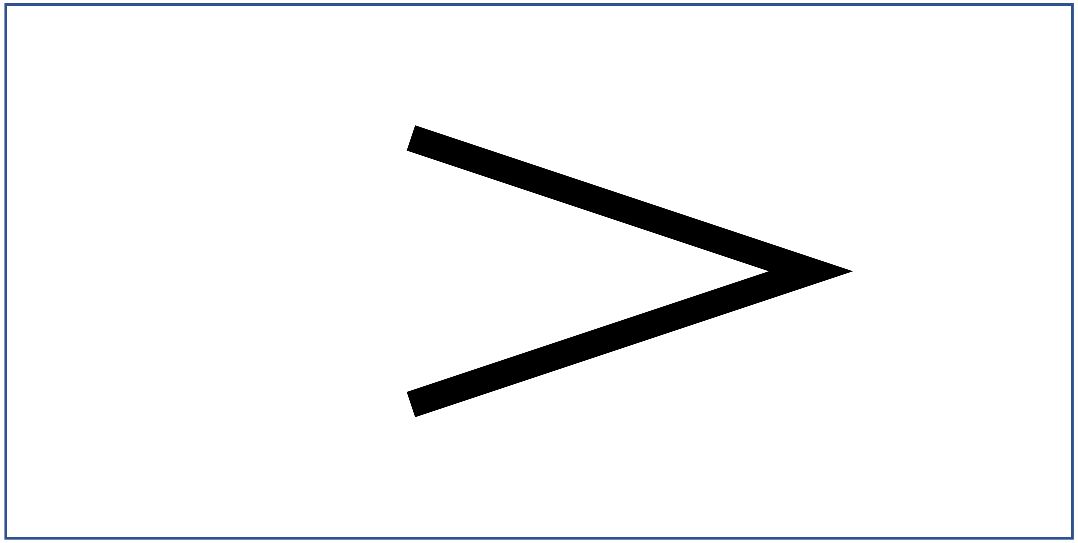
- No R or ggplot in this lecture.

- Once you have designed and produced your plot, how do you make sure it can be used in publication quality figures?

What is an image?

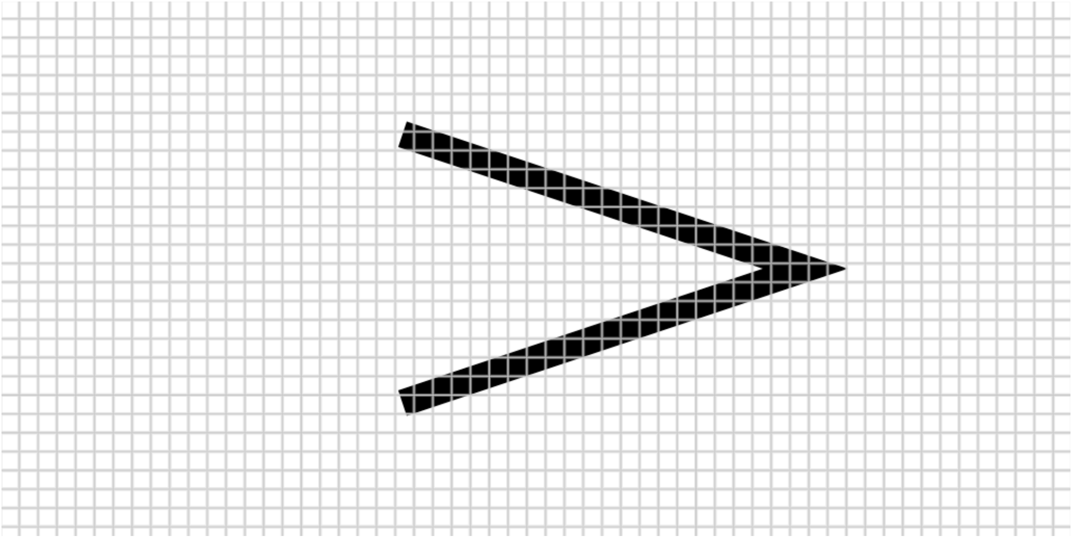
How are images stored on computers?

This is an image!



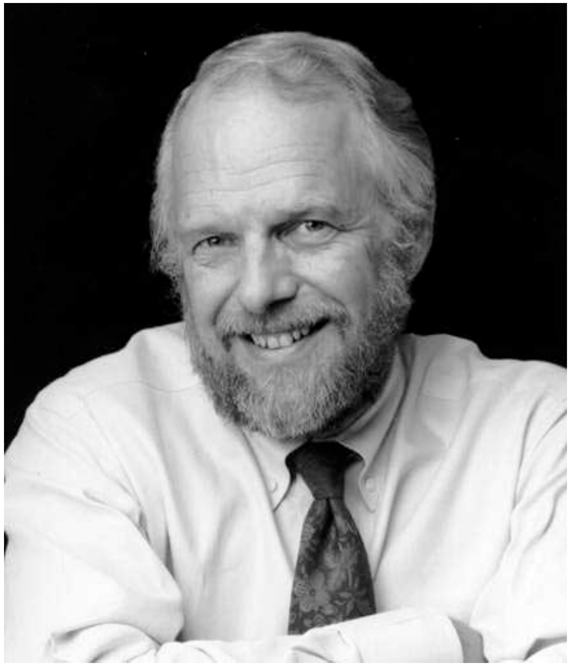
Now it is art!

Bitmap (or raster) image



- File size depends on resolution
- Number of pixels * 1 bit (black/white).

John Warnock

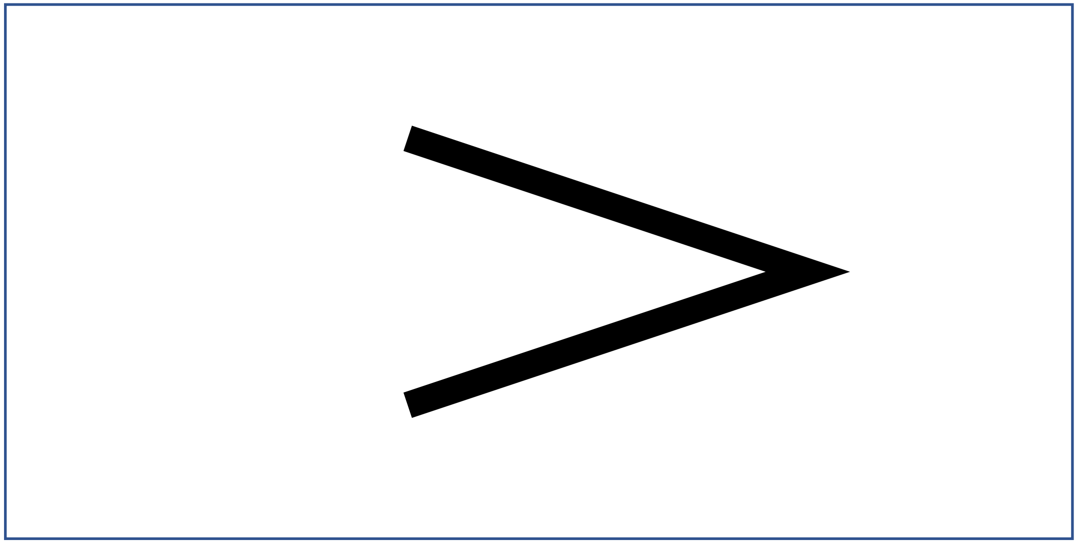


- A Hidden Surface Algorithm for Computer Generated Half-Tone Pictures (1969).
- Inventor of postscript, pdf, …

Key idea was to describe all of the content of pages for printing not as collections of spots, but at a much more abstract level – as geometry.

Vector image
in (encapsulated) postscript

ps_example1.eps



```
%!PS
%%Creator: Markus Ringnér
%%BoundingBox: 0 0 400 200
%%End Comments
newpath
150 50 moveto
300 100 lineto
150 150 lineto
10 setlinewidth
stroke
```

File sizes of images

```
$ wc ps_example1.eps
       10      24      149 ps_example1.eps
```

- Vector image file size: 149 characters.
- Image size (bounding box): 400 * 200 points. 1 pt = 1/72 inches.
- Bitmap image at 300 dpi gives:
  (300*400/72)*(300*200/72) = 1,388,889 pixels
- 32-bit tiff with no compression:
  1388889*32/(8*1024*1024) = 5.3 Megabyte

```
$ ls -lh ps_example1.*
-rw-r--r--  1 markus  staff   149B Nov  2 16:41 ps_example1.eps
-rw-r--r--@ 1 markus  staff   5.3M Nov  2 17:20 ps_example1.tiff
```

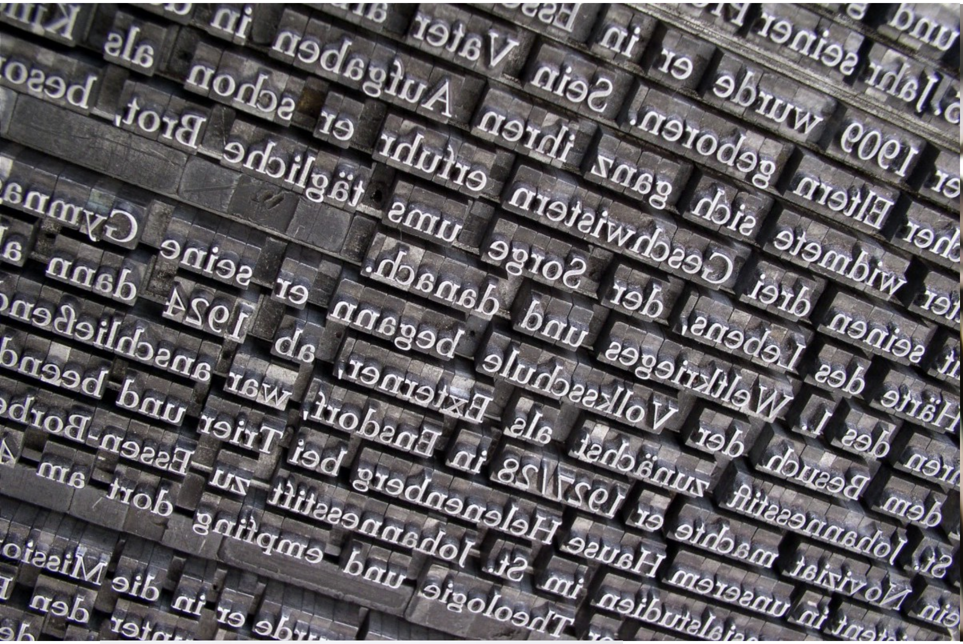
Lossless compression of bitmap image

```
$ ls -lh ps_example1.*
-rw-r--r--  1 markus  staff   149B Nov  2 16:41 ps_example1.eps
-rw-r--r--@ 1 markus  staff   5.3M Nov  2 17:20 ps_example1.tiff
-rw-r--r--@ 1 markus  staff    33K Nov  2 17:21 ps_example1.png
```

- 5.3M / 149B = 5.3*1024*1024/149 ≈ 37000
- 33K / 149B = 33*1024/149 ≈ 200

```
$ du -h ps_example1.*
4.0K ps_example1.eps
5.3M ps_example1.tiff
 36K ps_example1.png
```

Fonts (bitmap)

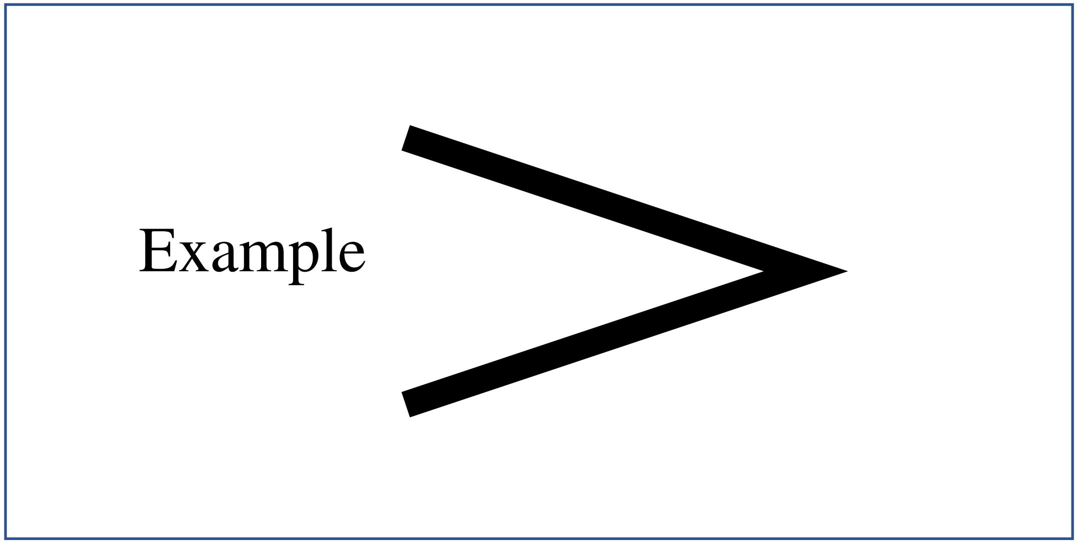


Before the 1990s there were typicallt only bitmap fonts on computers and printers; raster images of glyphs only available in certain optimized sizes (Axis).

Fonts (scalable)

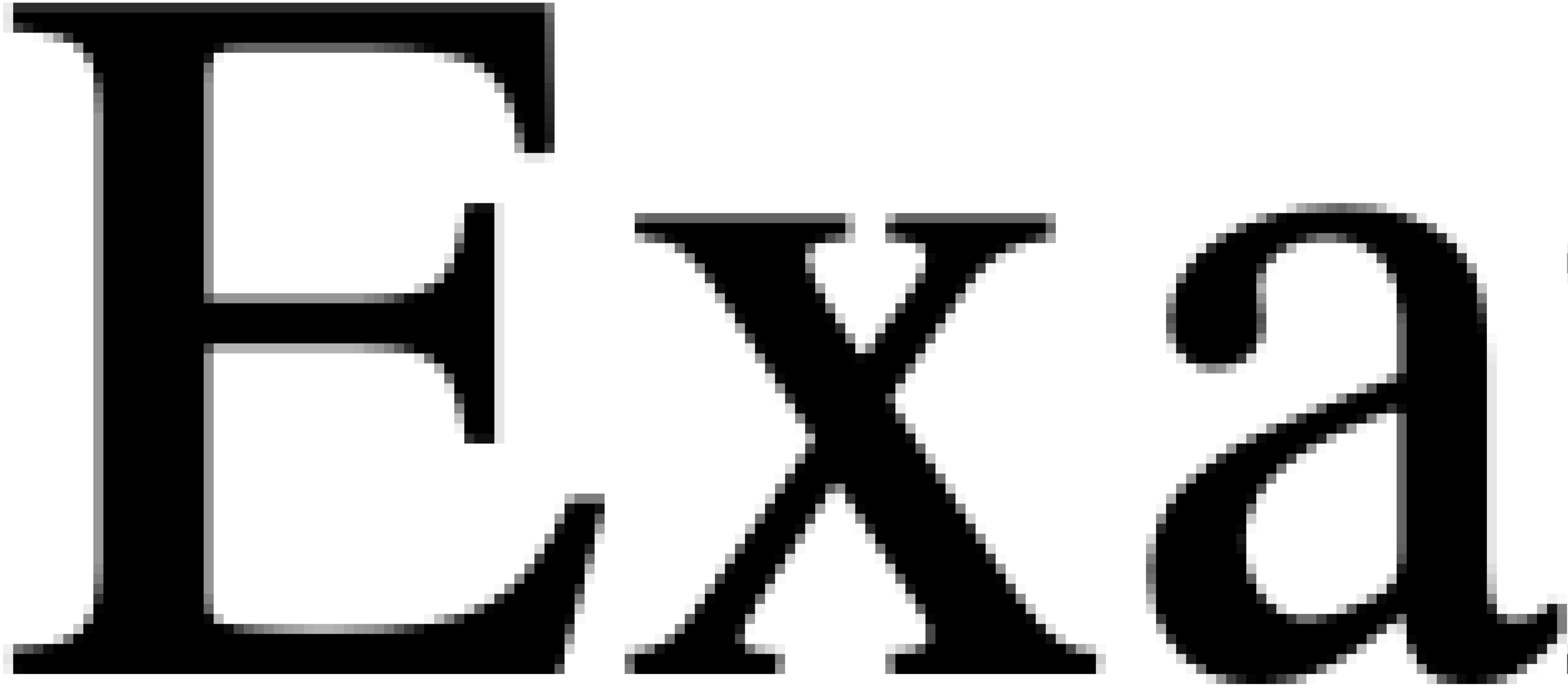
```
%!PS
%%Creator: Markus Ringnér
%%BoundingBox: 0 0 400 200
%%End Comments
newpath
150 50 moveto
300 100 lineto
150 150 lineto
10 setlinewidth
stroke

/Times-Roman findfont
24 scalefont
setfont
newpath
50 100 moveto
(Example) show
```



- Special facilities in the PostScript language:
  Characters from fonts
- Apple LaserWriter (1985 with postscript)
- Can make your own fonts.
  Programming language, even recursive functions.

Scaling images (bitmap)



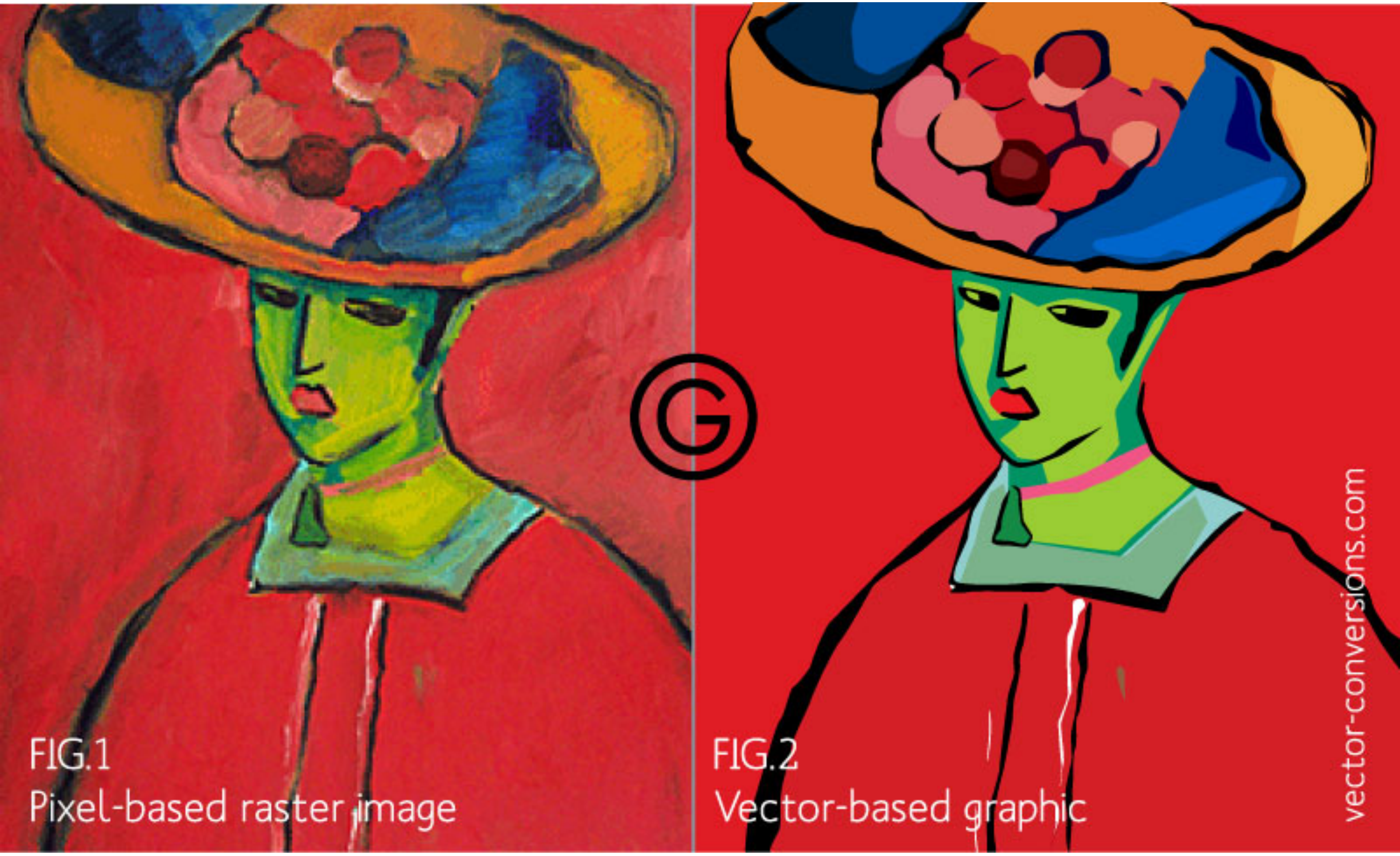
Scaling images (vector)

- Also scaling to small sizes. For example gene names in dense plots.

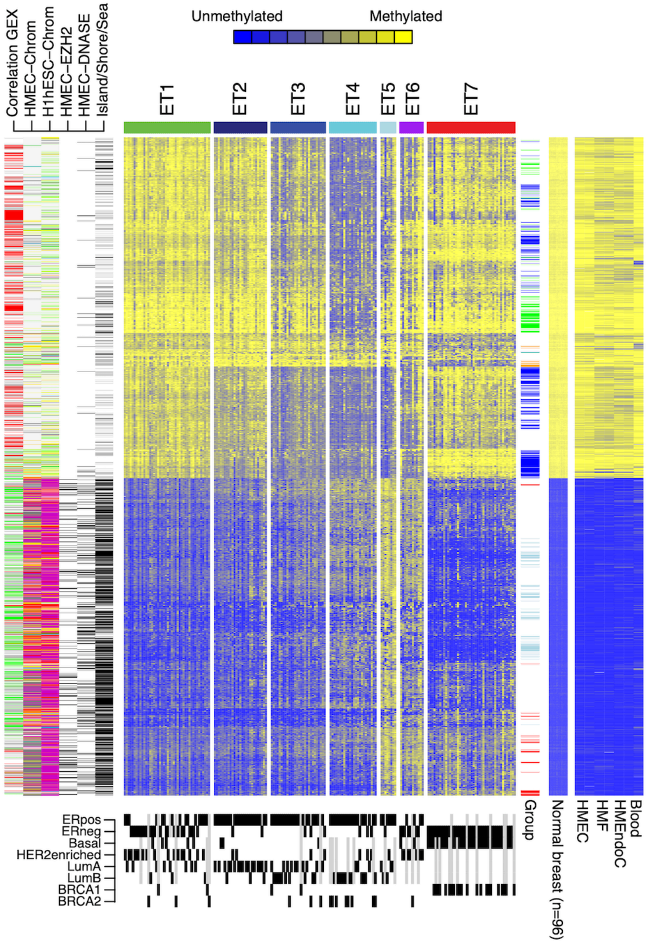
Vector images vs bitmap images

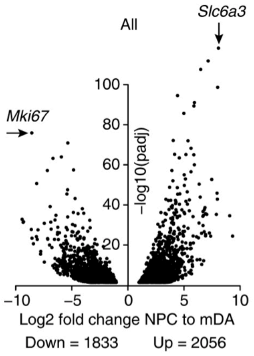
- In terms of file size, vector images are typically much smaller than the corresponding bitmap.
- Vector images are scalable (redrawn to compensate for scale changes). Bitmap graphics are affected by resolution.
- Vector images are simple to edit (Adobe Illustrator, Affinity Designer, …)
- Bitmap fonts can be faster to draw/print (not requiring computer processing).
- Vector graphics are not suited for photographs.
- Drawing vs Painting.

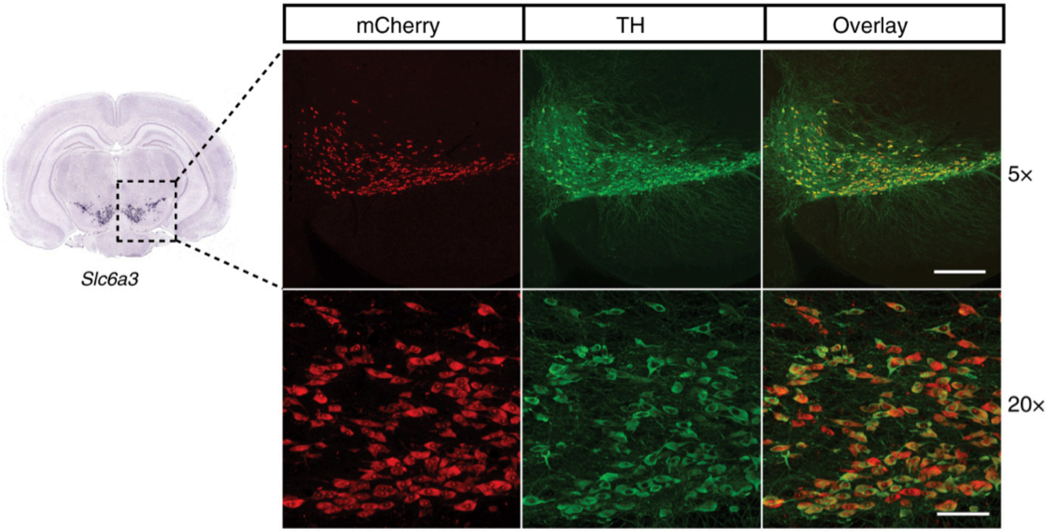
Painting vs Drawing



Mixing bitmap and vector graphics







- File size of vector image larger than of corresponding bitmap? “Photograph”?
- Convert to bitmap as late as possible and to the requested size and resolution.
- Have “code” to regenerate your plots for new sizes and resolutions.

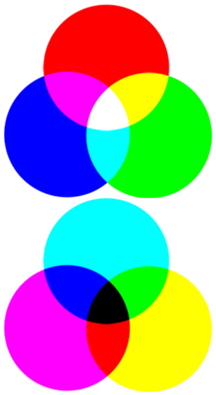
File formats

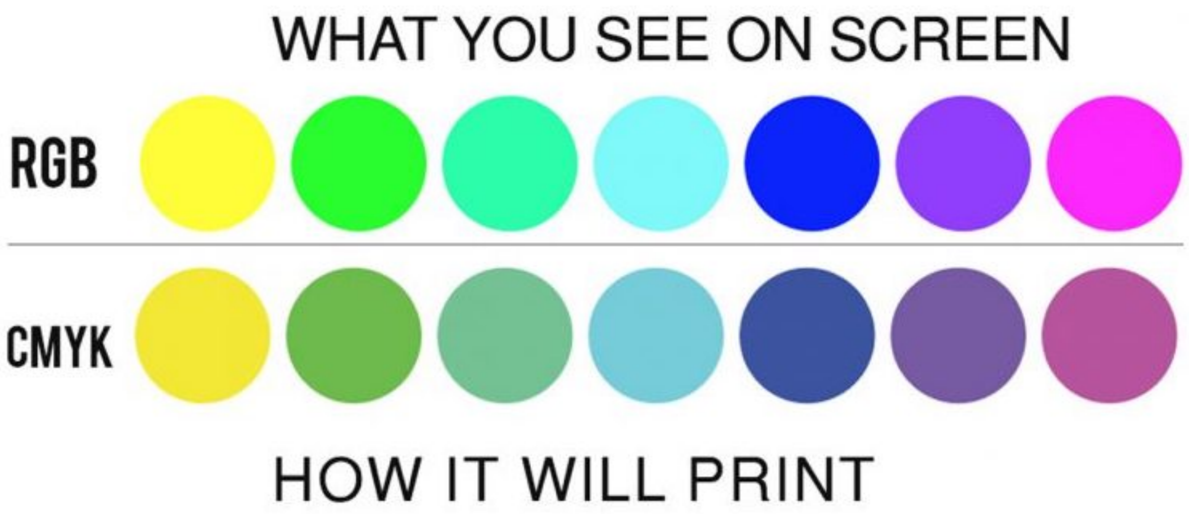
- Vector graphics: pdf, eps, svg, …
  (compound formats)

- Bitmap file formats: jpg, png, tiff, …
  (lossy or lossless data compression)

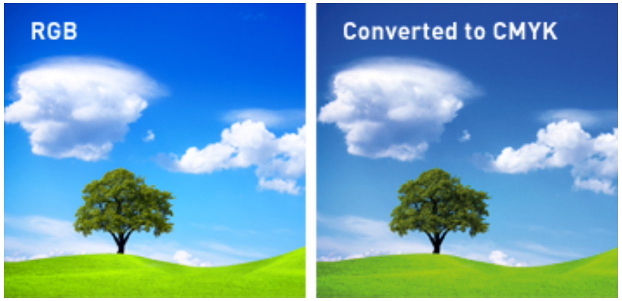
RGB and CMYK

- Primary colors are arbitrary, but …
- RGB: Red-Green-Blue – additive type of color mode
- CMYK: Cyan-Magenta-Yellow-Black – subtractive type of color mode
- Cyan, magenta, and yellow are lighter than red, green, and blue.





- If you are going to print: CMYK
- If only to be seen digitally: RGB
- Most modern printers will convert automatically, but …



Conclusions

- Hopefully this has provided some helpful initial thoughts on how to produce publication quality figures.

Thank you. Questions?