principles of Urban Science 11

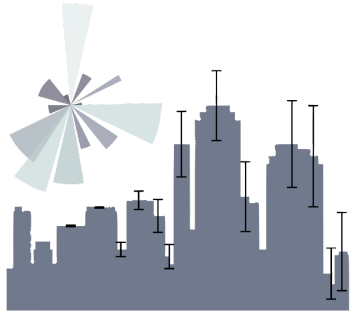


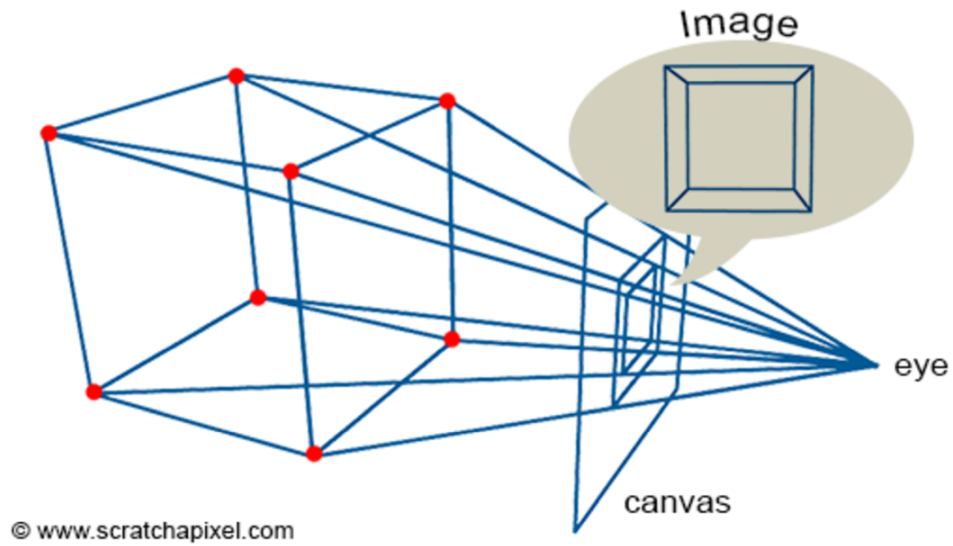
image processing

dr.federica bianco | *fbb.space* | *fedhere* | *fedhere*

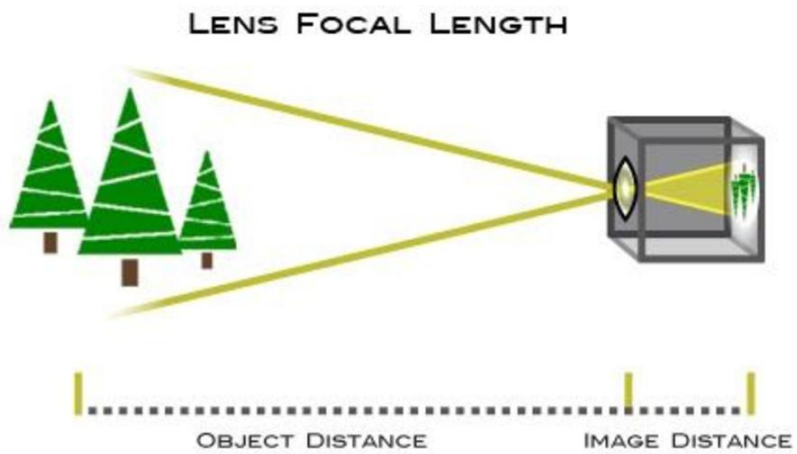
this slide deck:

slides.com/federicabianco/pus2020_11

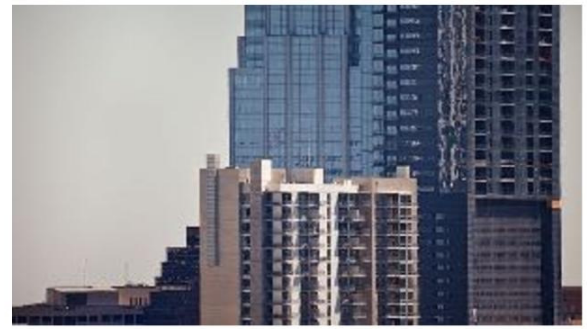
projection of 3D world in 2D



projection of 3D world in 2D



tele photo (800mm)

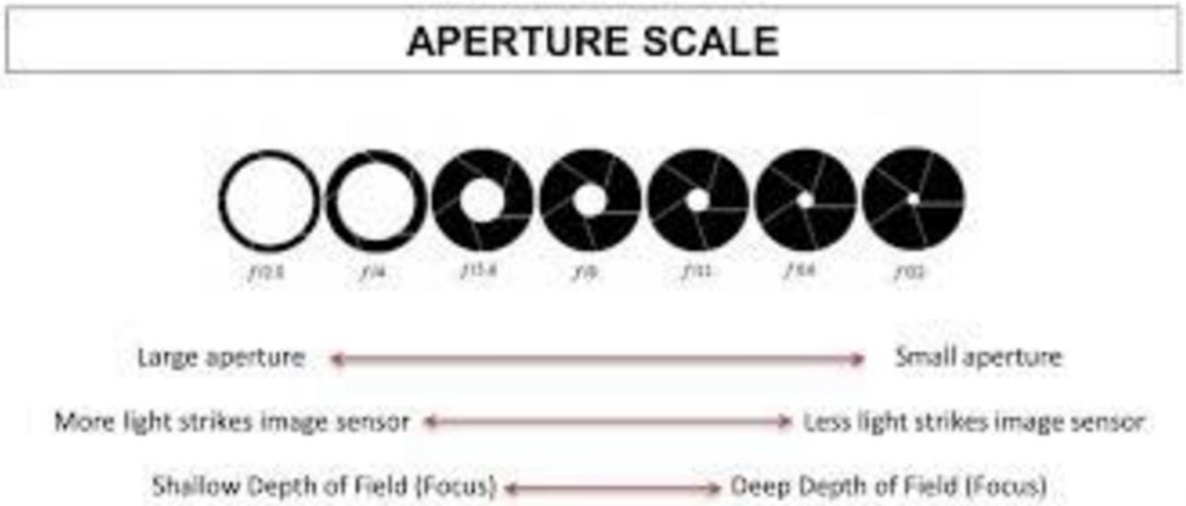


wide angle (15mm)

deformation demo
(google street view)

Focal Length (nikon)

projection of 3D world in 2D



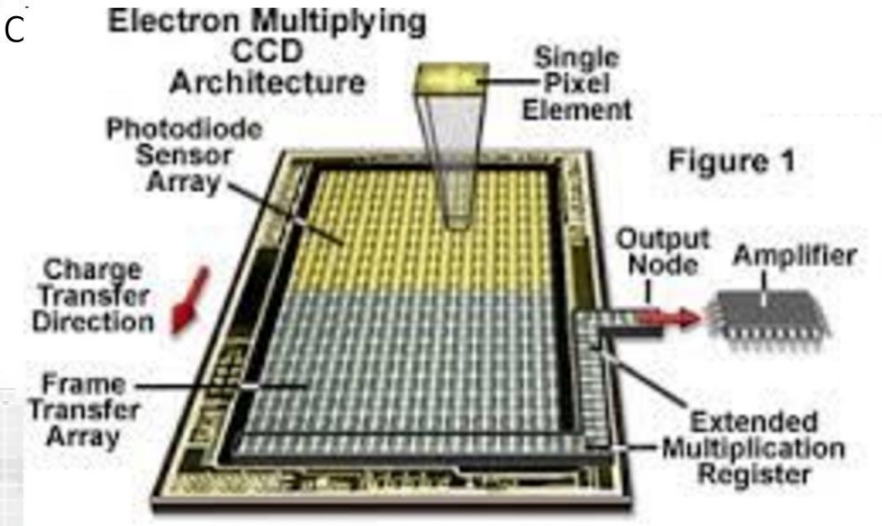
projection of 3D world in 2D

how digital cameras work

- a 2D array of light-sensitive photodiodes absorbs photons and releases electrons through the photoelectric effect.

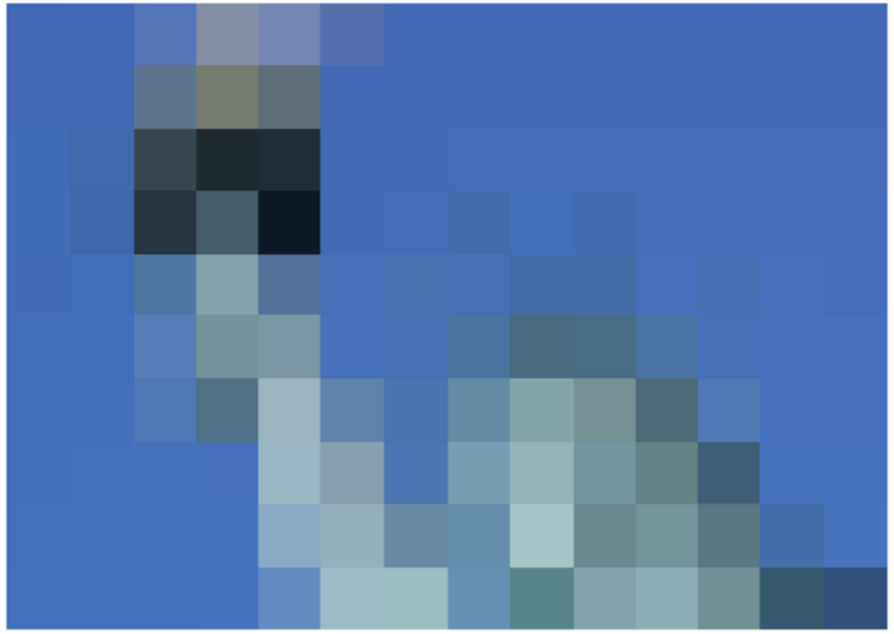
- electrons are stored in a well as an electrical charge that is accumulated over the length of the exposure. The charge that is generated is proportional to the number of photons that hit the sensor.

systematics: saturation, minimum threshold



Source: intel.com

resolution



ARCSECONDS PER PIXEL

We generally stick to the following subdivision of satellite images:

– Low resolution: over 60m/pixel

– Medium resolution: 10 - 30m/pixel

– High to very high resolution: 30cm - 5m/pixel

https://eos.com/blog/satellite-data-what-spatial-resolution-is-enough-for-you/

10m per pixel medium-resolution image from Sentinel-2

https://eos.com/blog/satellite-data-what-spatial-resolution-is-enough-for-you/

50cm high-resolution image from Pleiades satellite (Airbus)

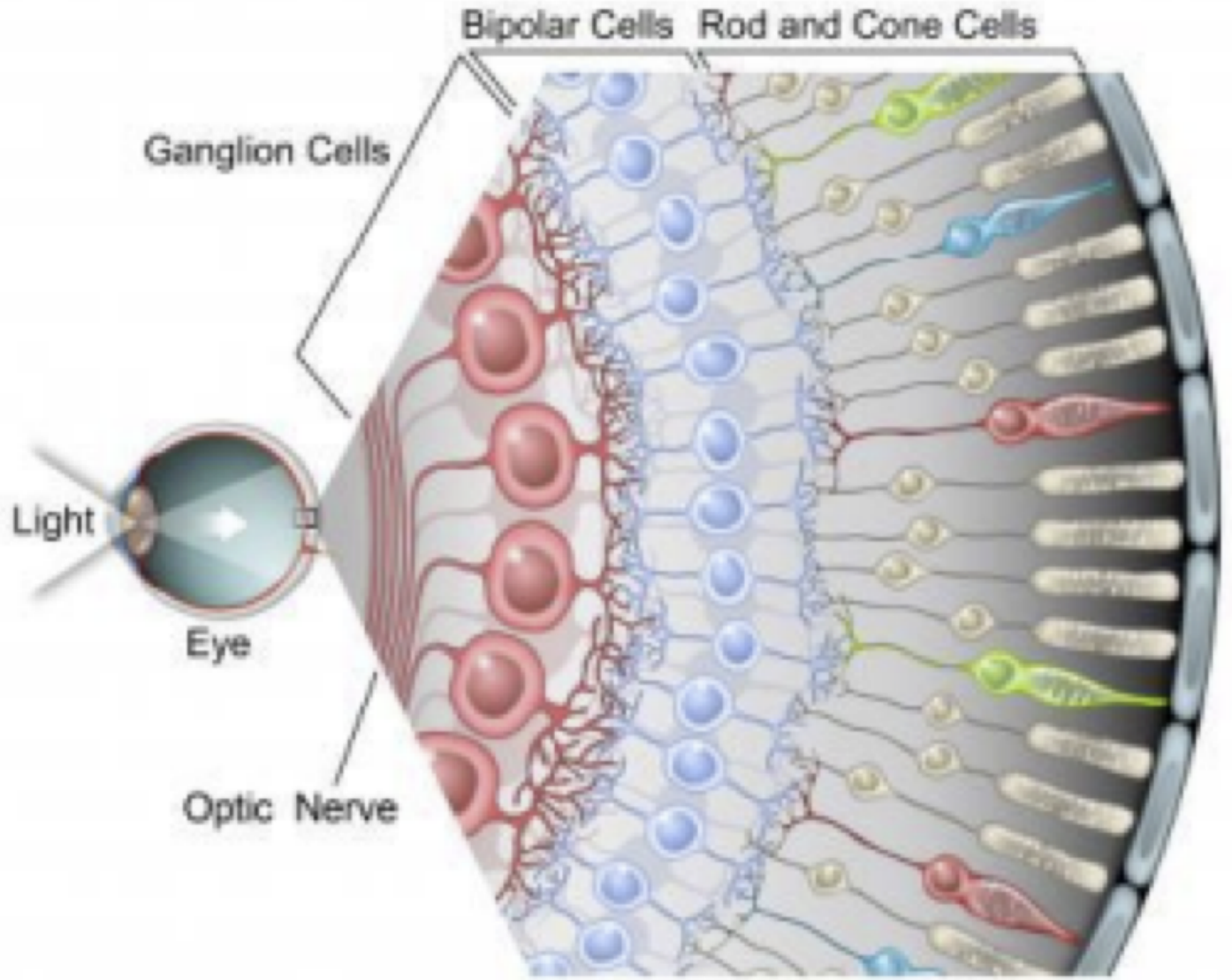
https://eos.com/blog/satellite-data-what-spatial-resolution-is-enough-for-you/

Color representation

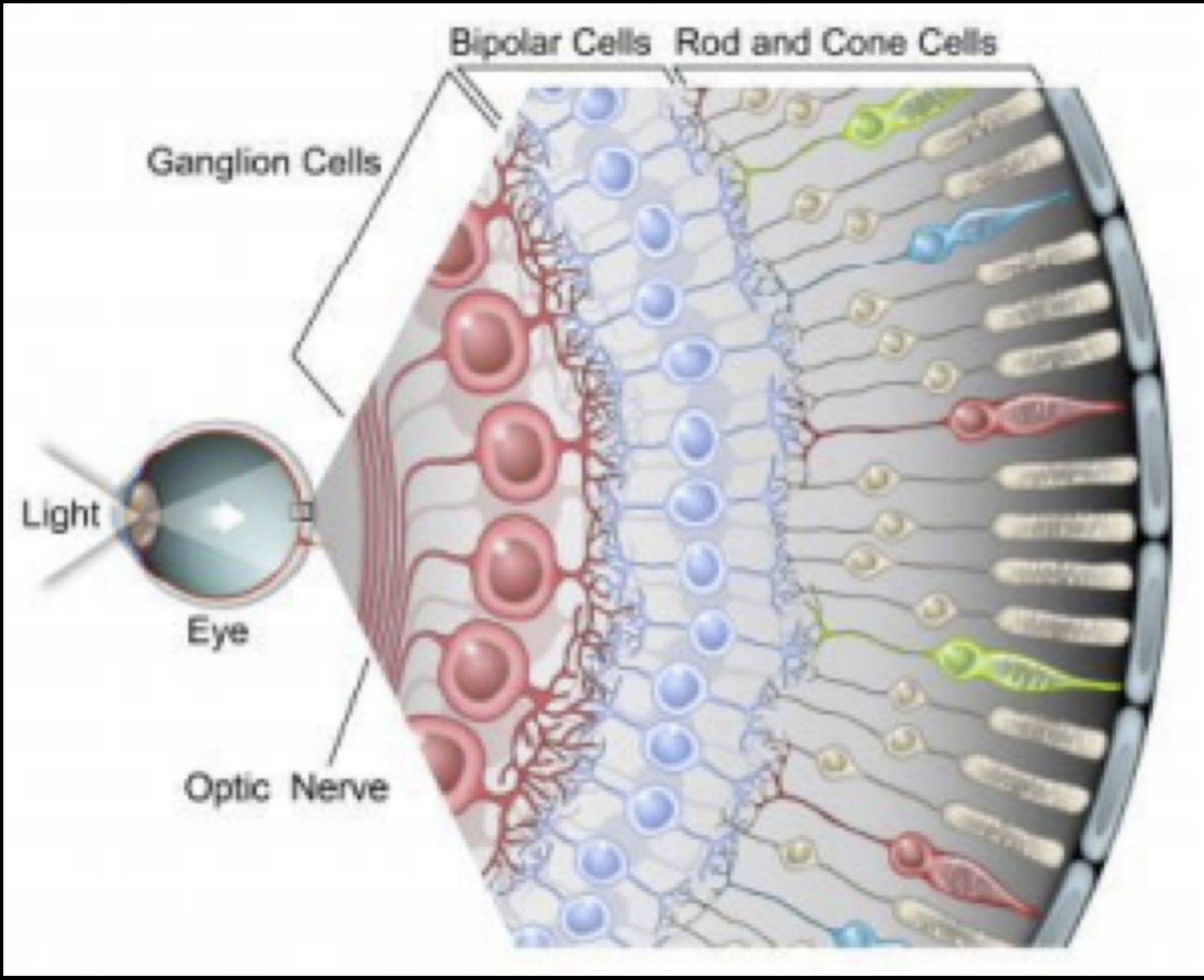
Different choices for color spaces

- **RGB**
- **Normalized RGB**
- HIS, HSV, HSL
- Fleck HSV
- TSL
- YcrCb
- Perceptually uniform colors
- CIELAB, CIELUV
- Others
- YES, YUV, YIQ, CIE-xyz

Eye Physiology and color perception deficiencies

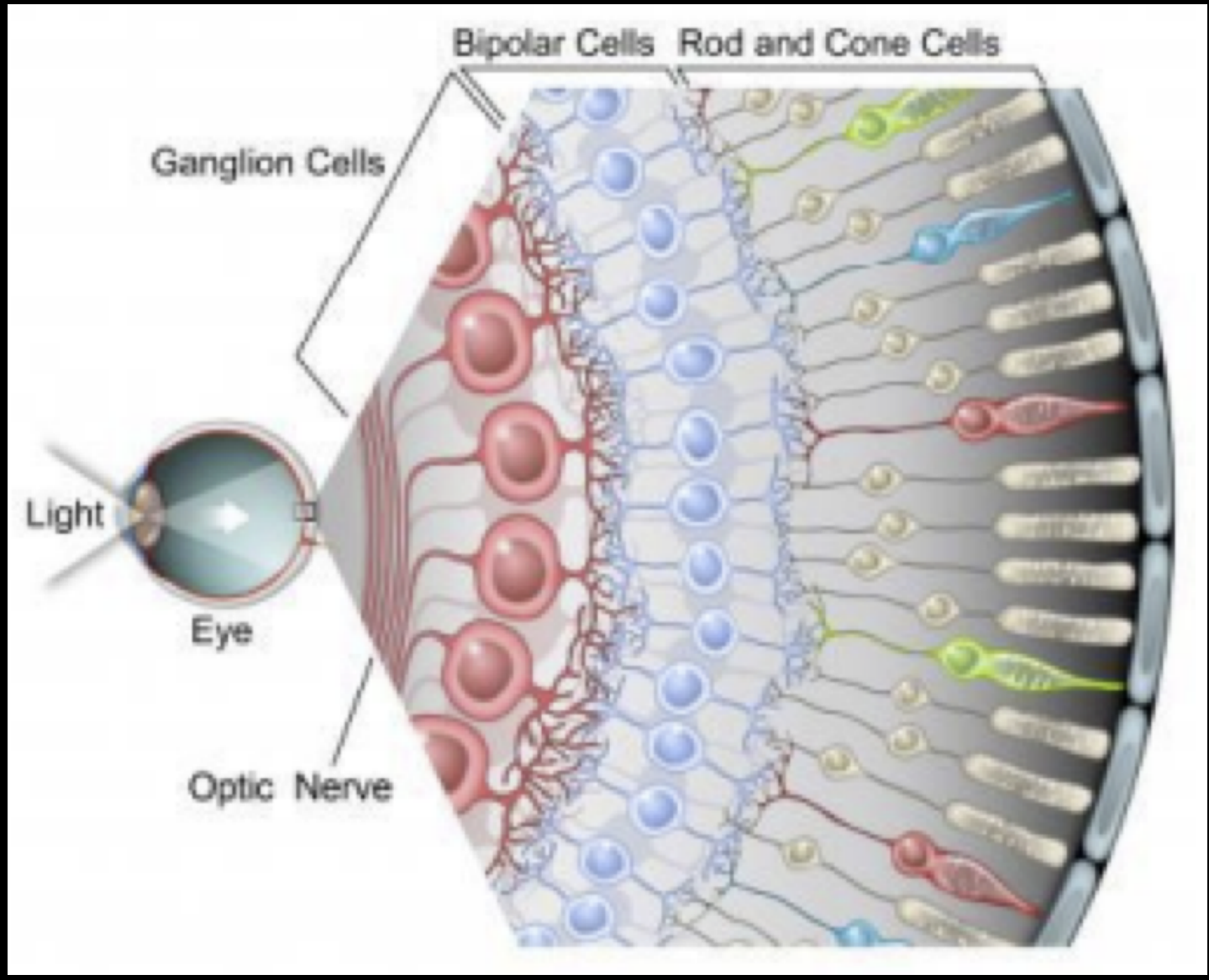


Rods | Cones

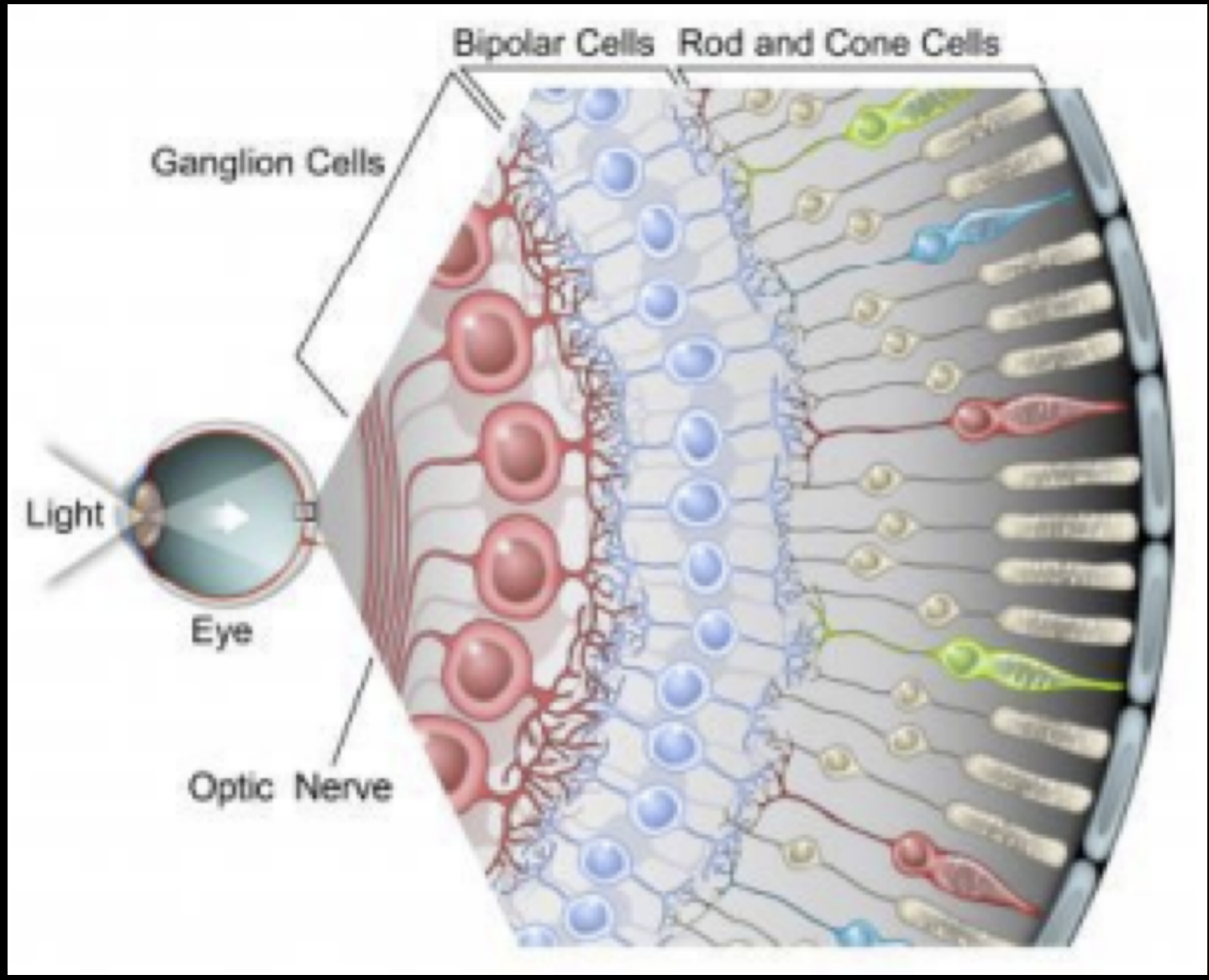

Bipolar Cells
Rod and Cone Cells
Ganglion Cells
Light
Eye
Optic Nerve

Rods | Cones

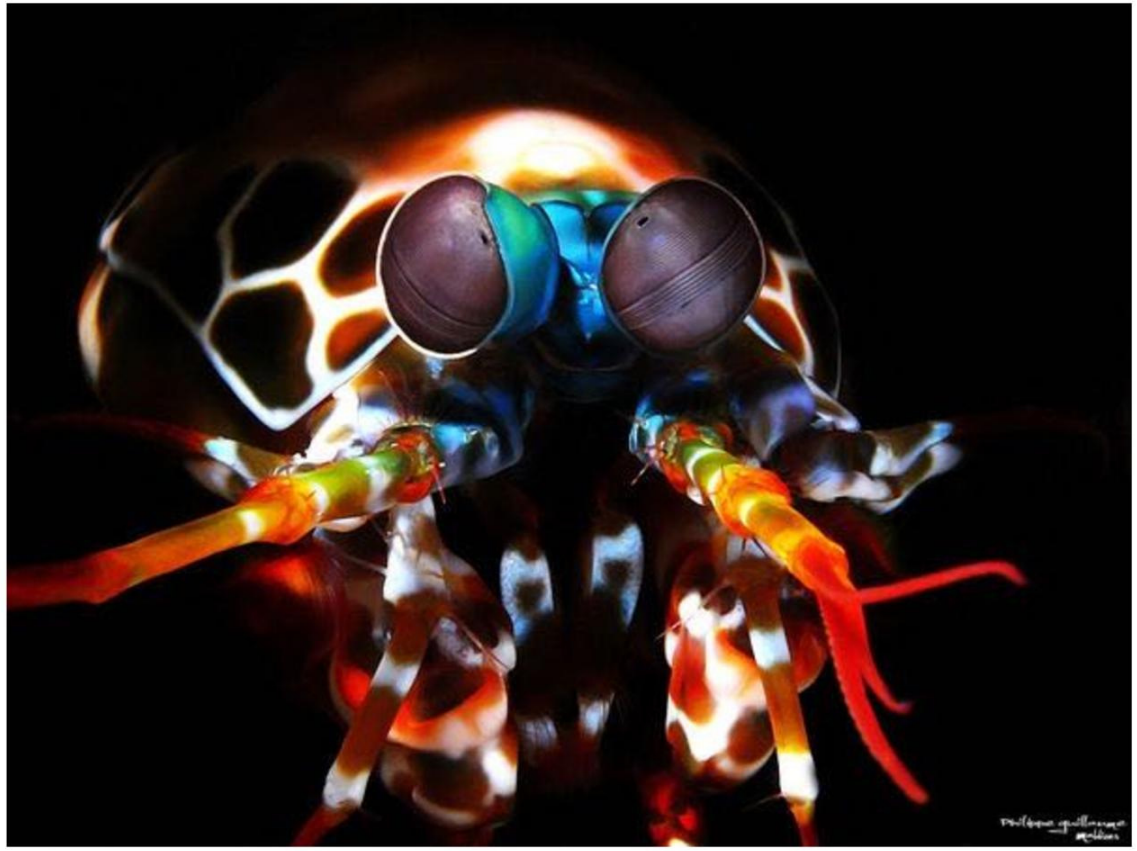
Brightness | Color



Rods	Cones
Brightness	Color
80M	5M

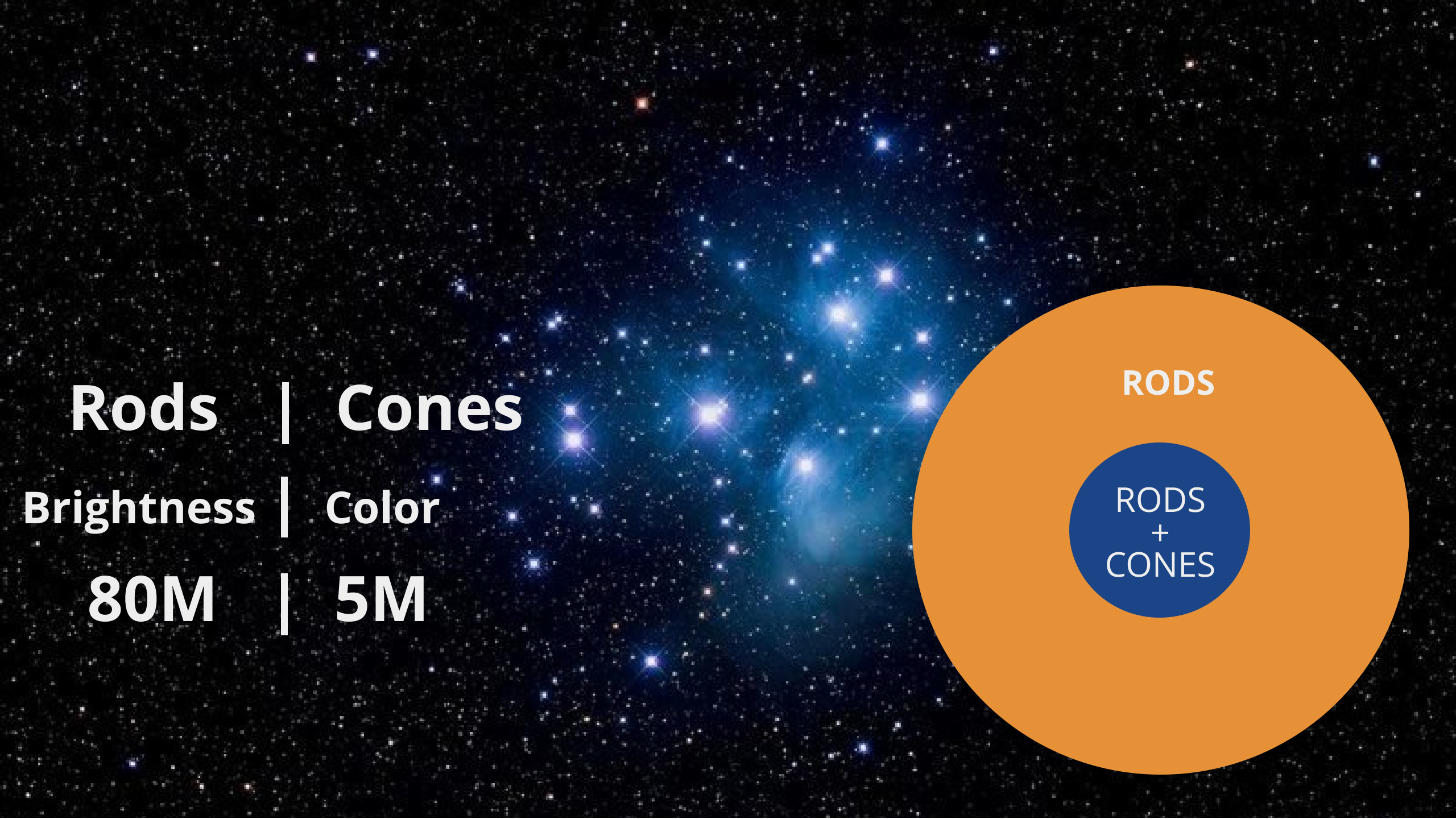


Color perception



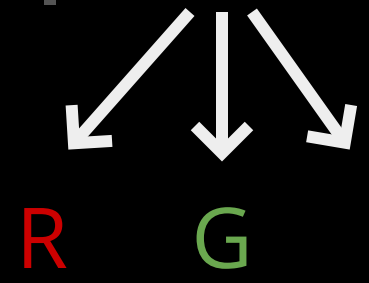
Within each large, roving eye, mantis shrimp have twelve types of color-sensitive cells called photoreceptors. That's four times as many as we humans have, despite our self-assurance that we have the best vision in the animal kingdom.

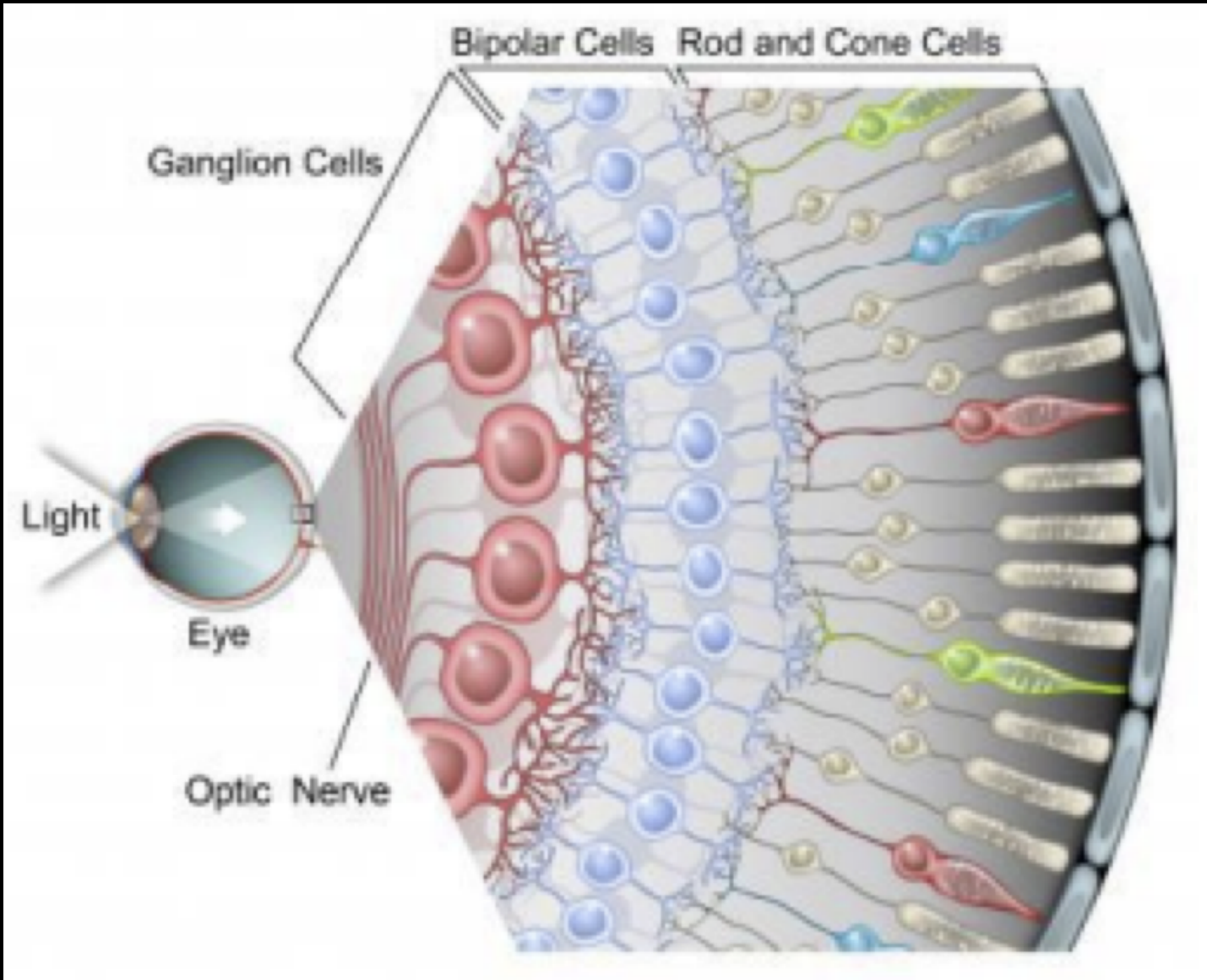
Source: Intel.com


Rods | Cones
Brightness | Color
80M | 5M
RODS
RODS + CONES

Rods | **Cones**

Brightness | **Color**





color blindness

Color blindness (color vision deficiency, CVD) affects approximately

1 in 12 men (8%) and 1 in 200 women

in the world.

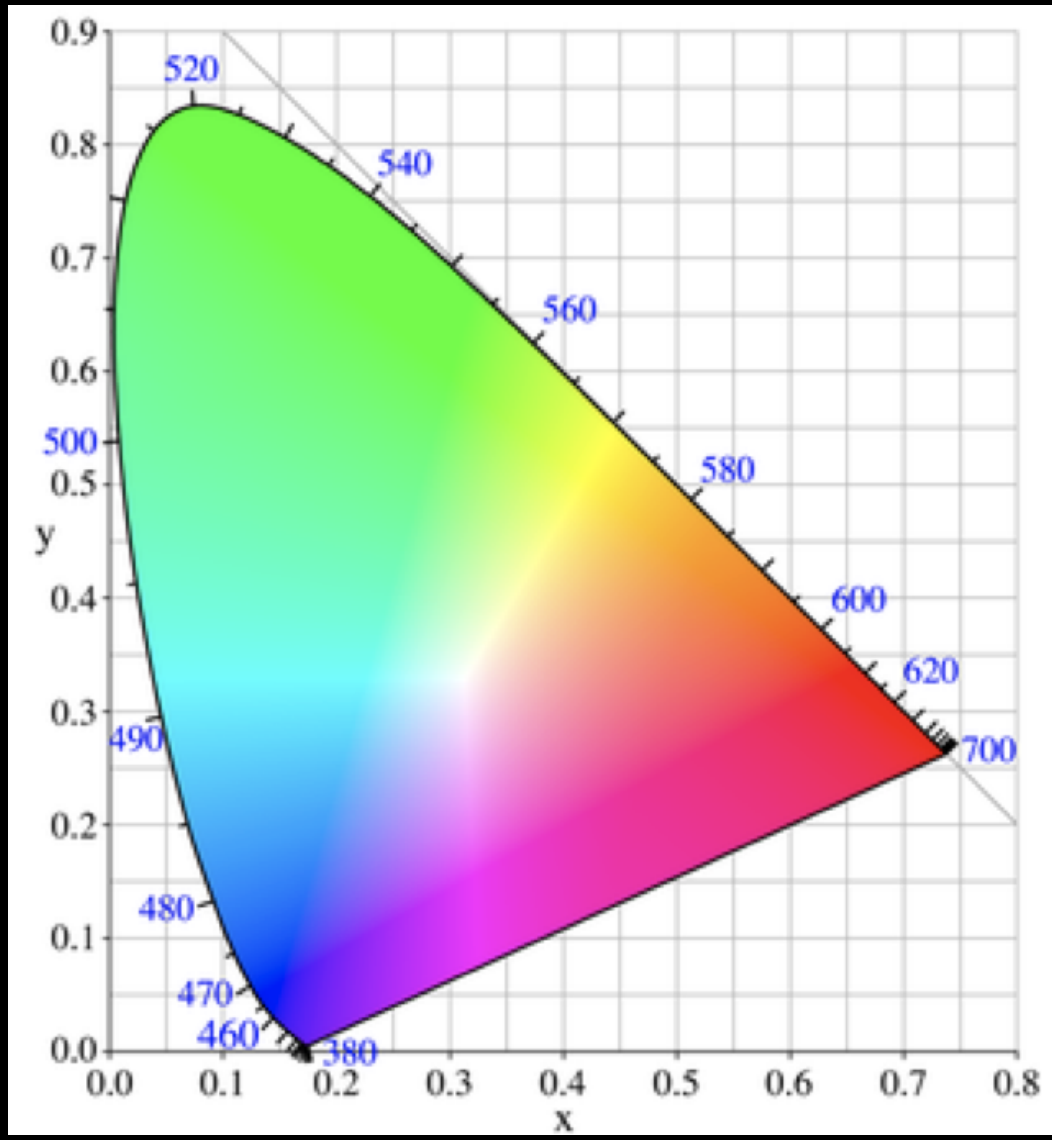
Worldwide, there are approximately 300 million people with colour blindness, almost the same number of people as the entire population of the USA!

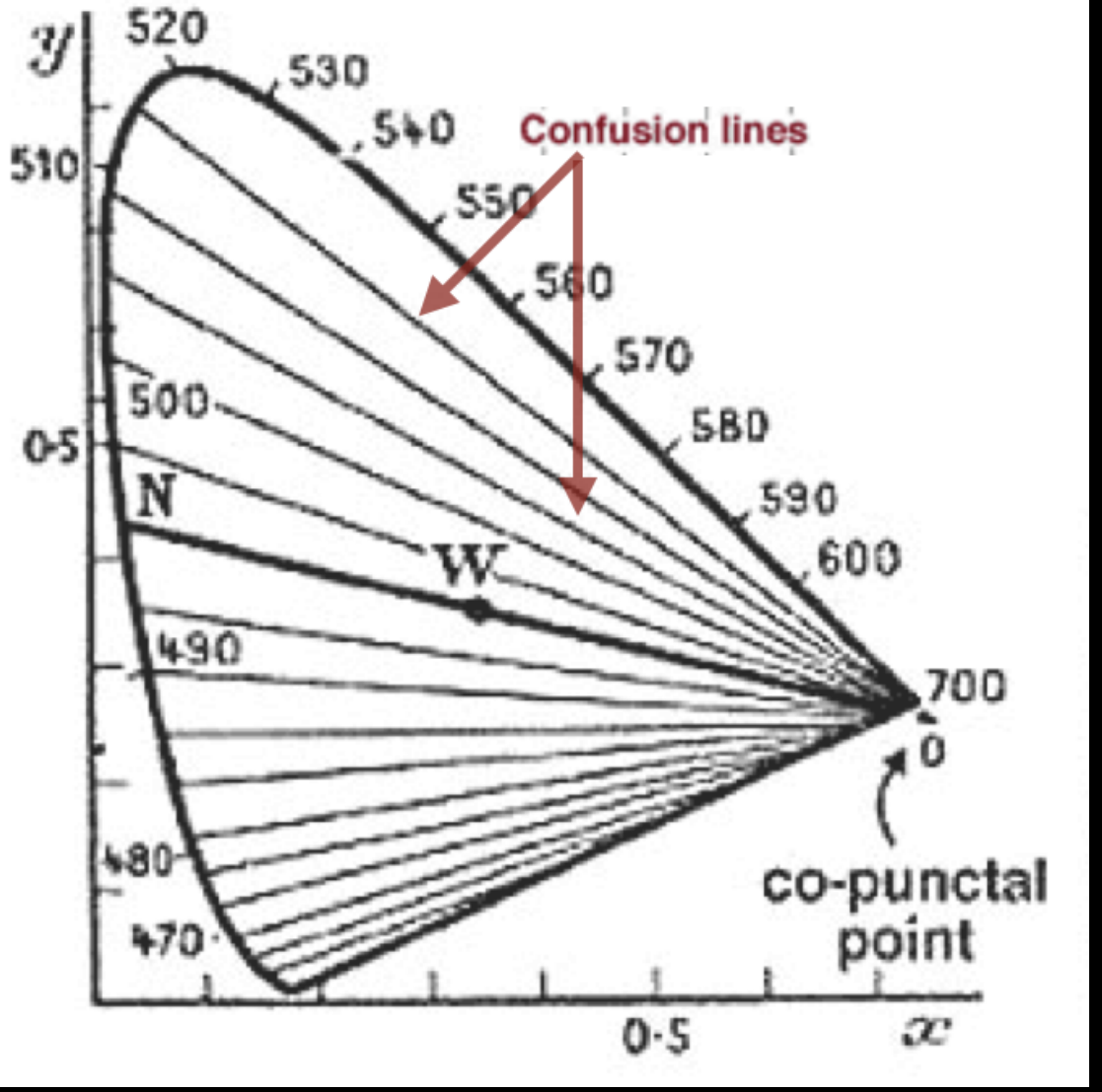
http://www.colourblindawareness.org/colour-blindness/

color blindness

http://www.colourblindawareness.org/colour-blindness/

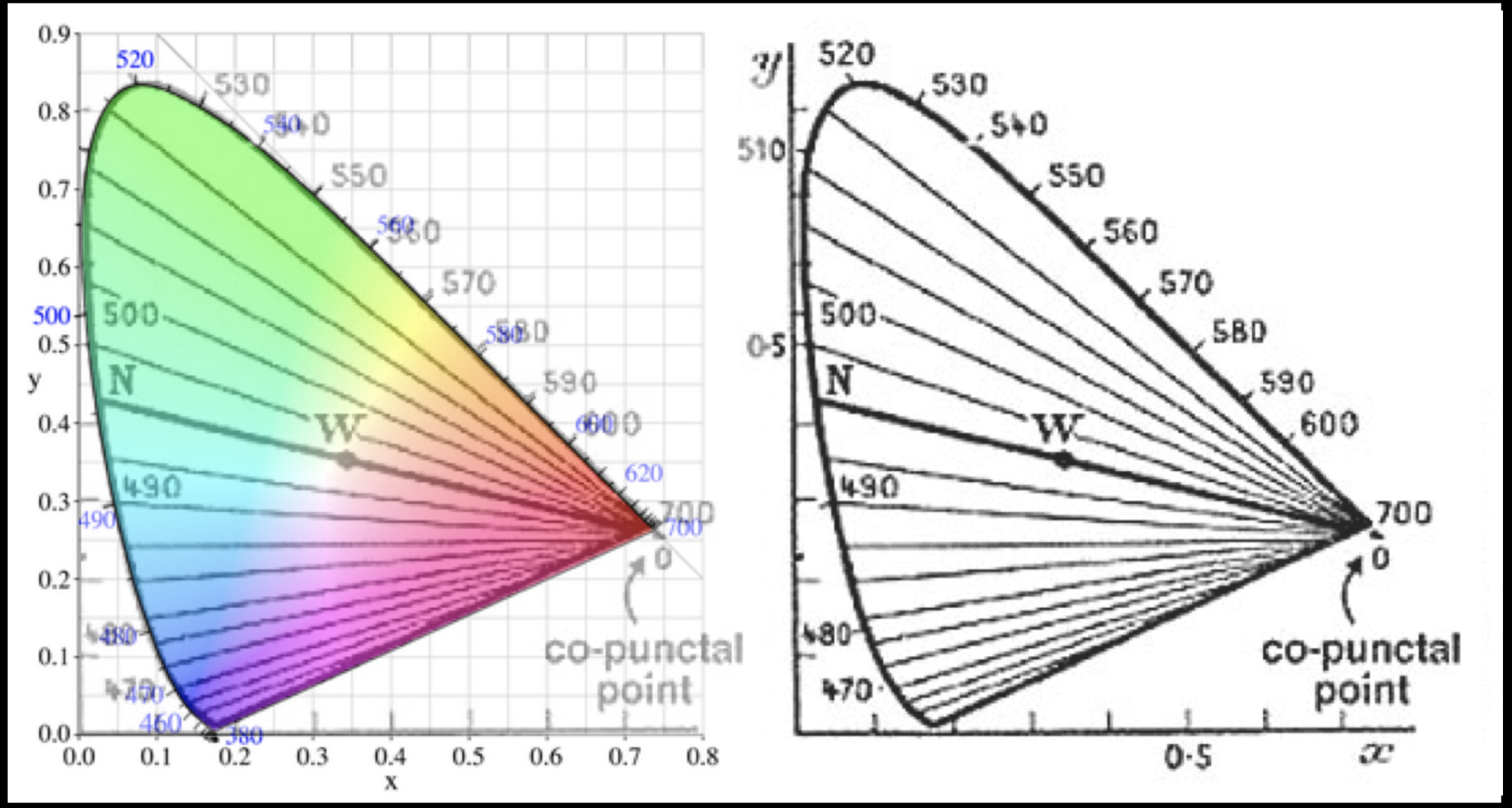
color blindness





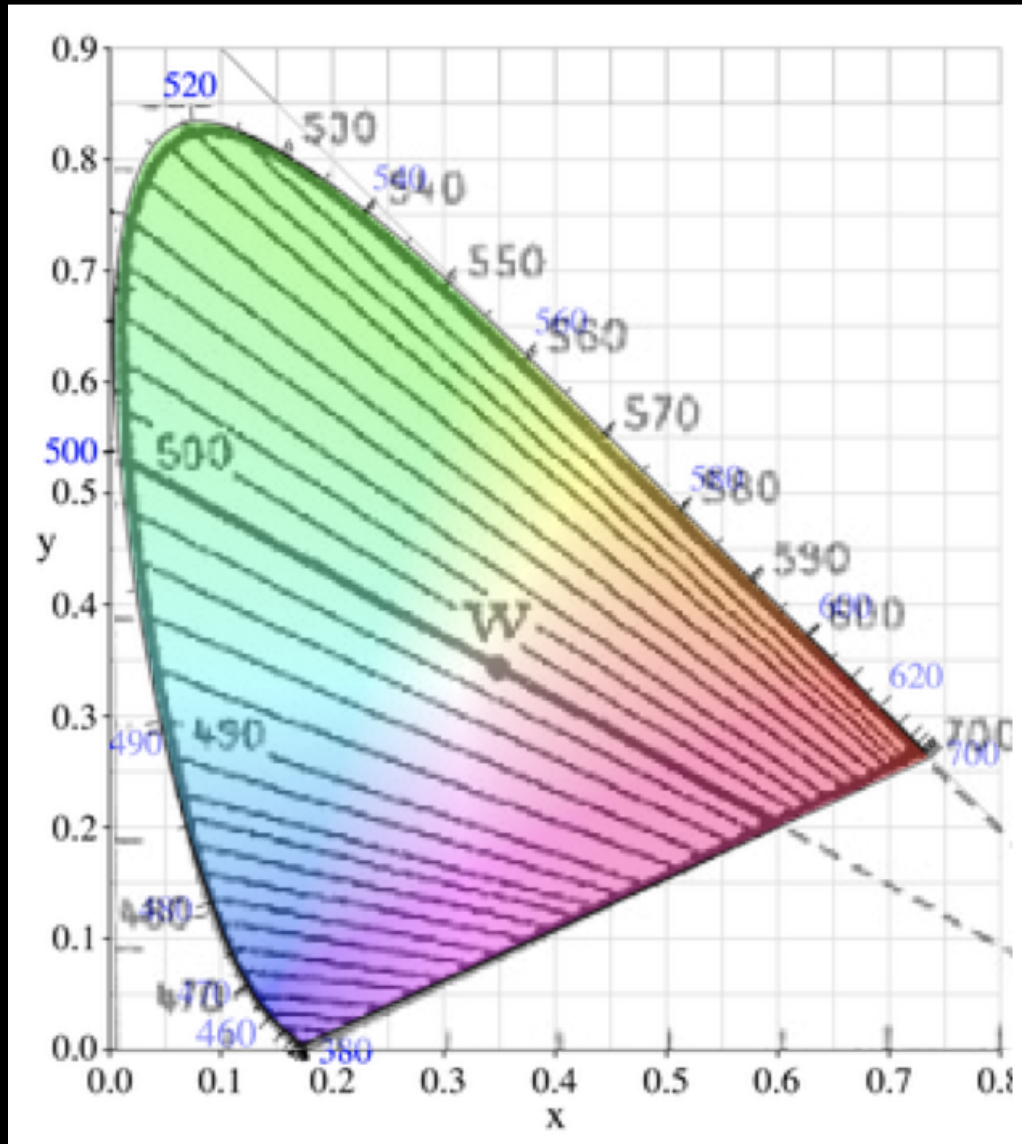
Protanopia

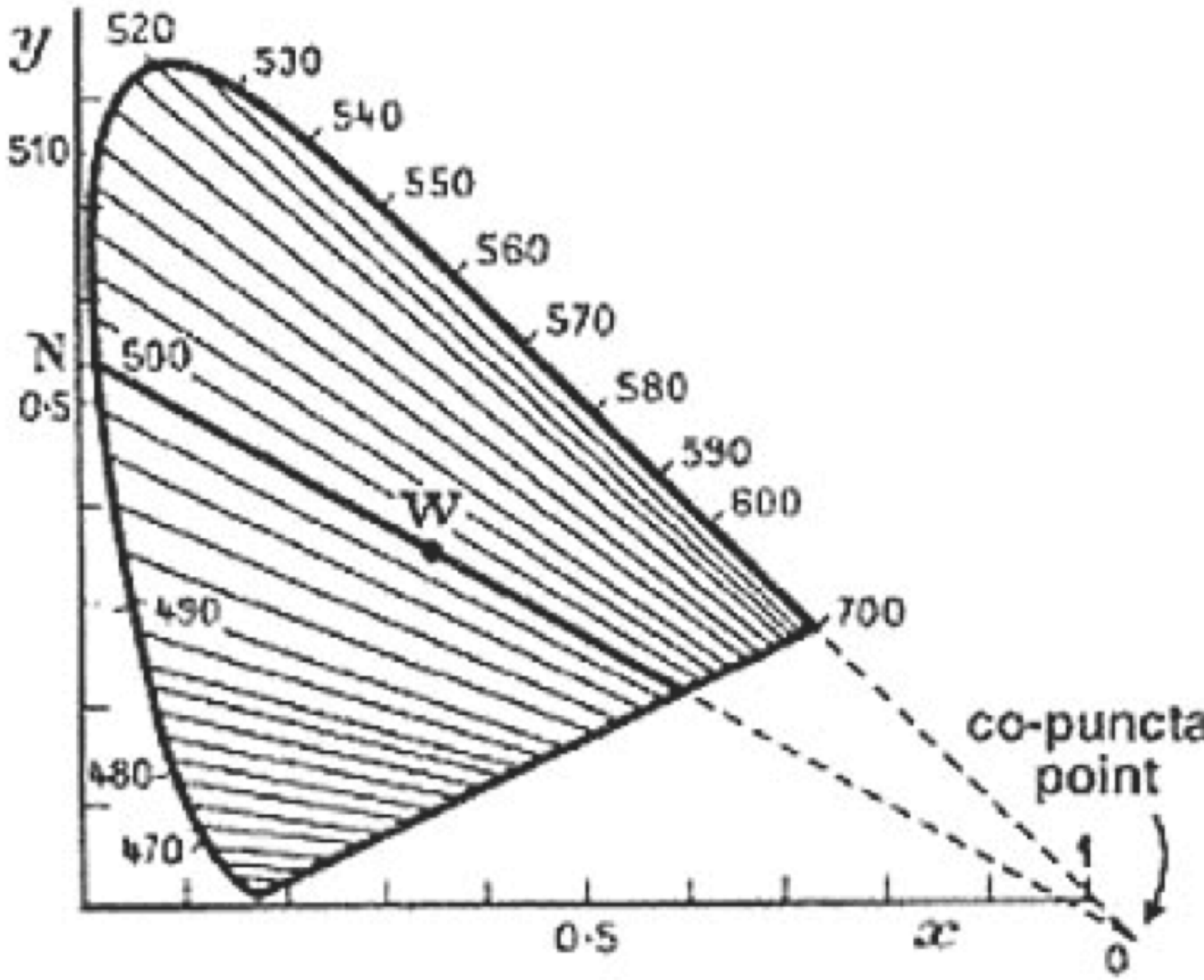
color blindness



Protanopia (red-blind)

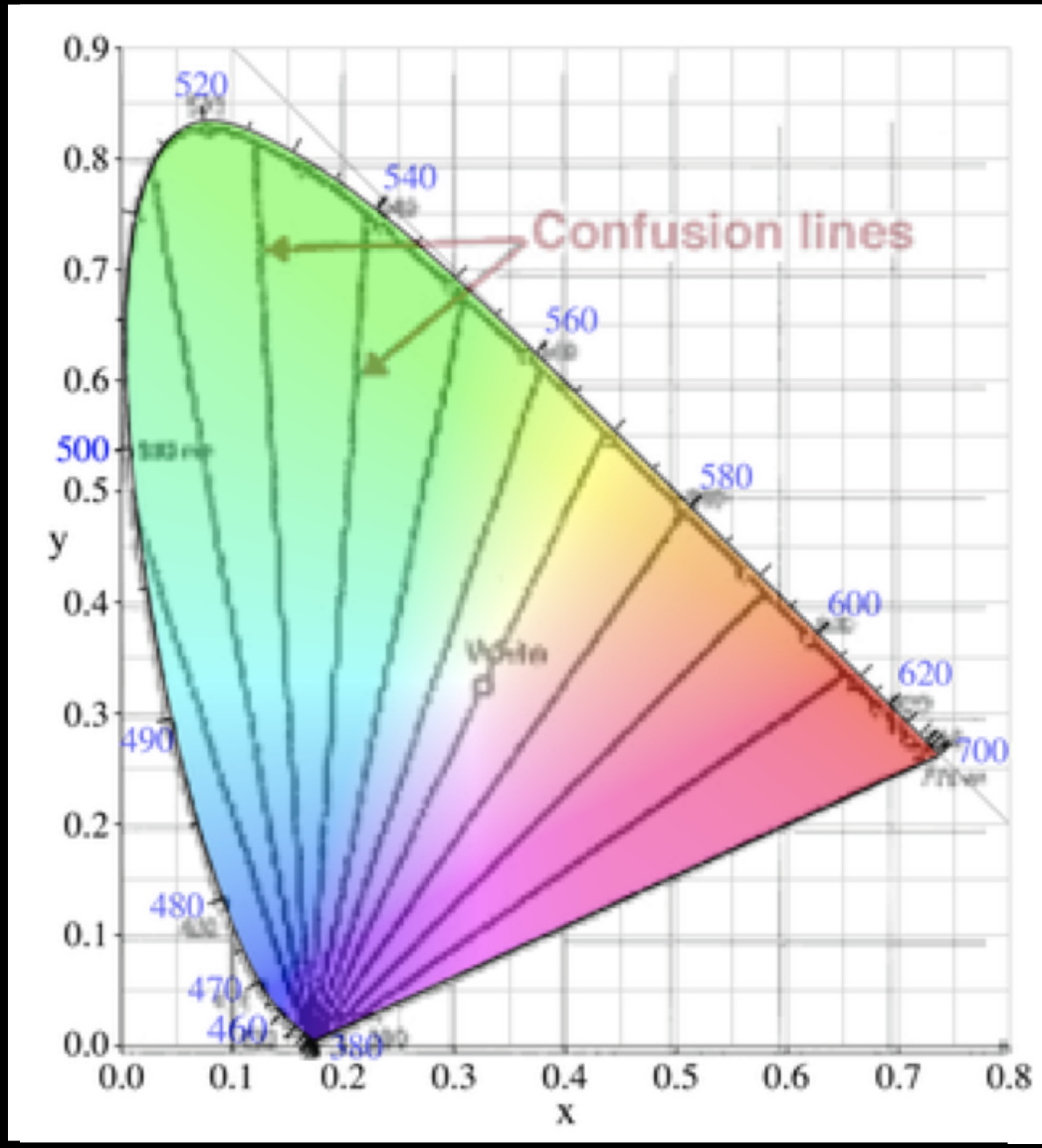
color blindness

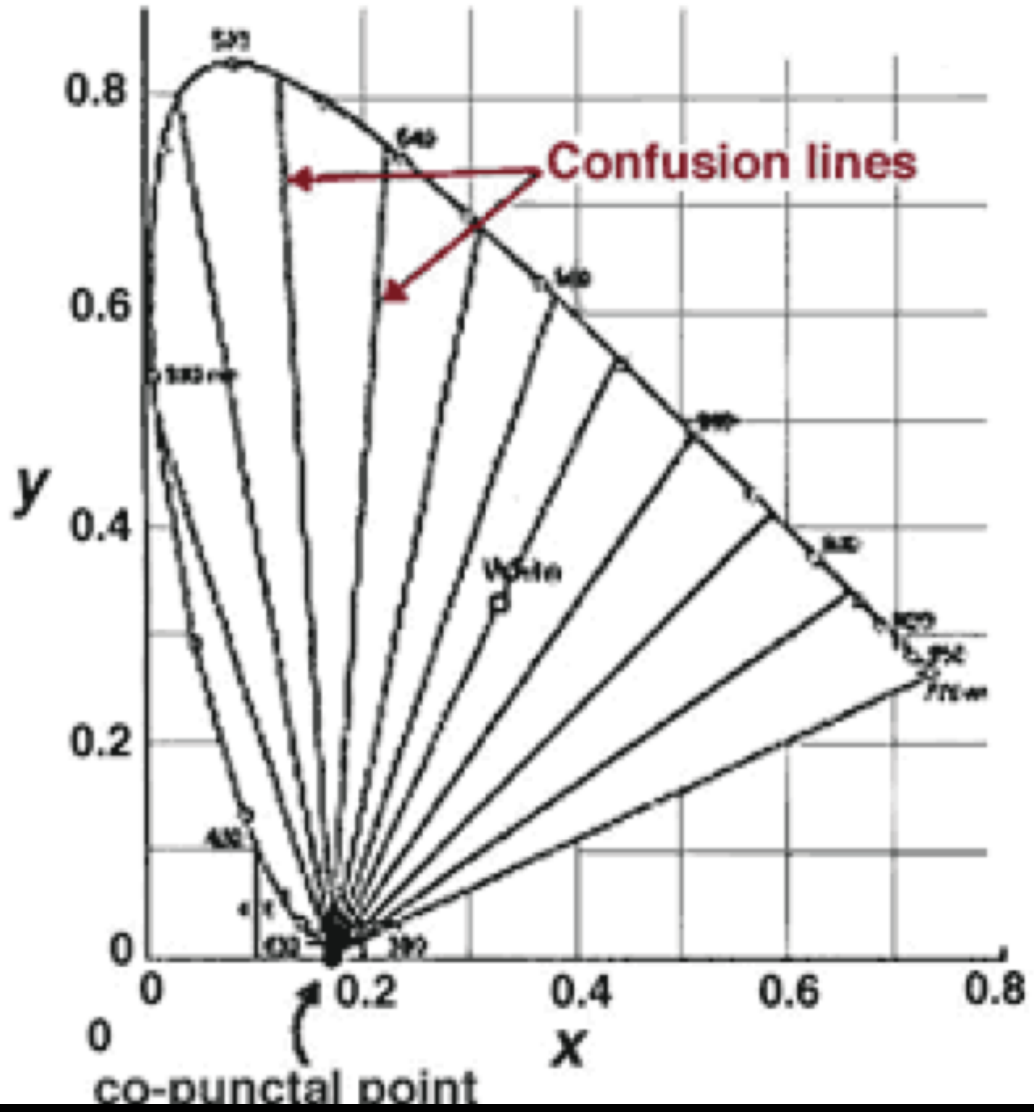




Protanopia (green-blind)

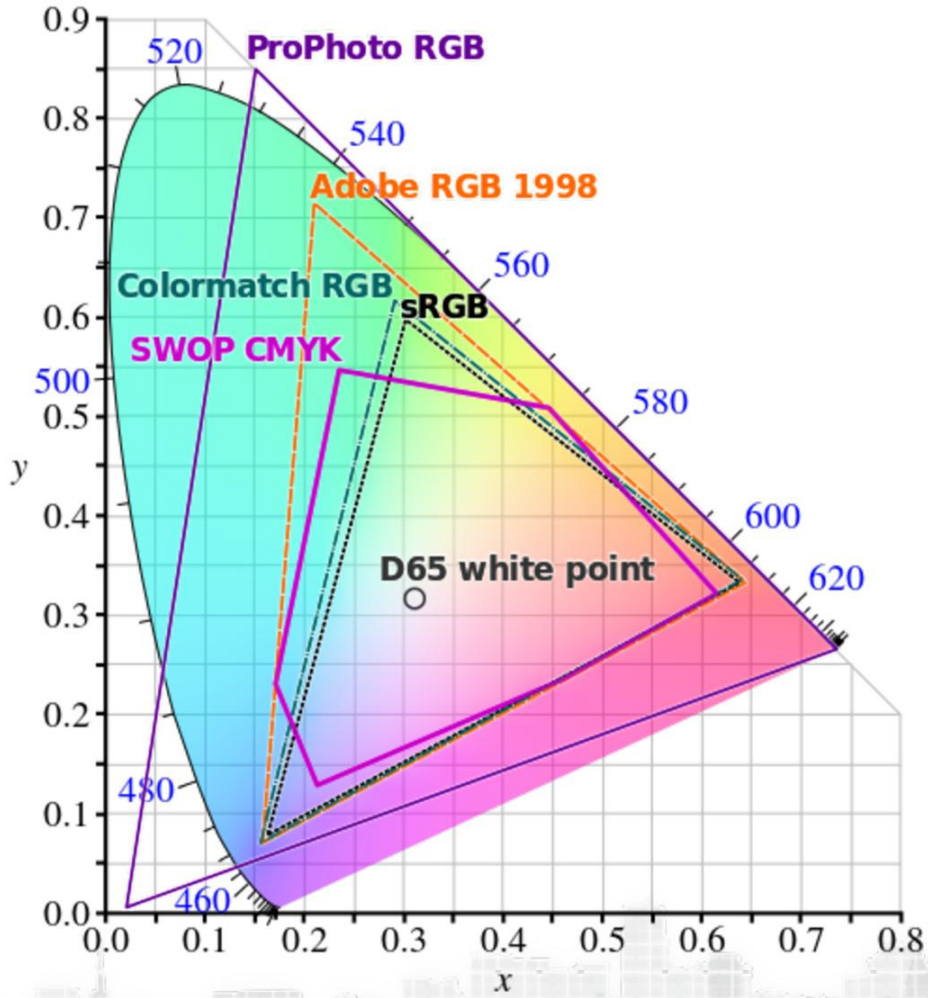
color blindness





Tritanopia (blue-blind)

Color representation



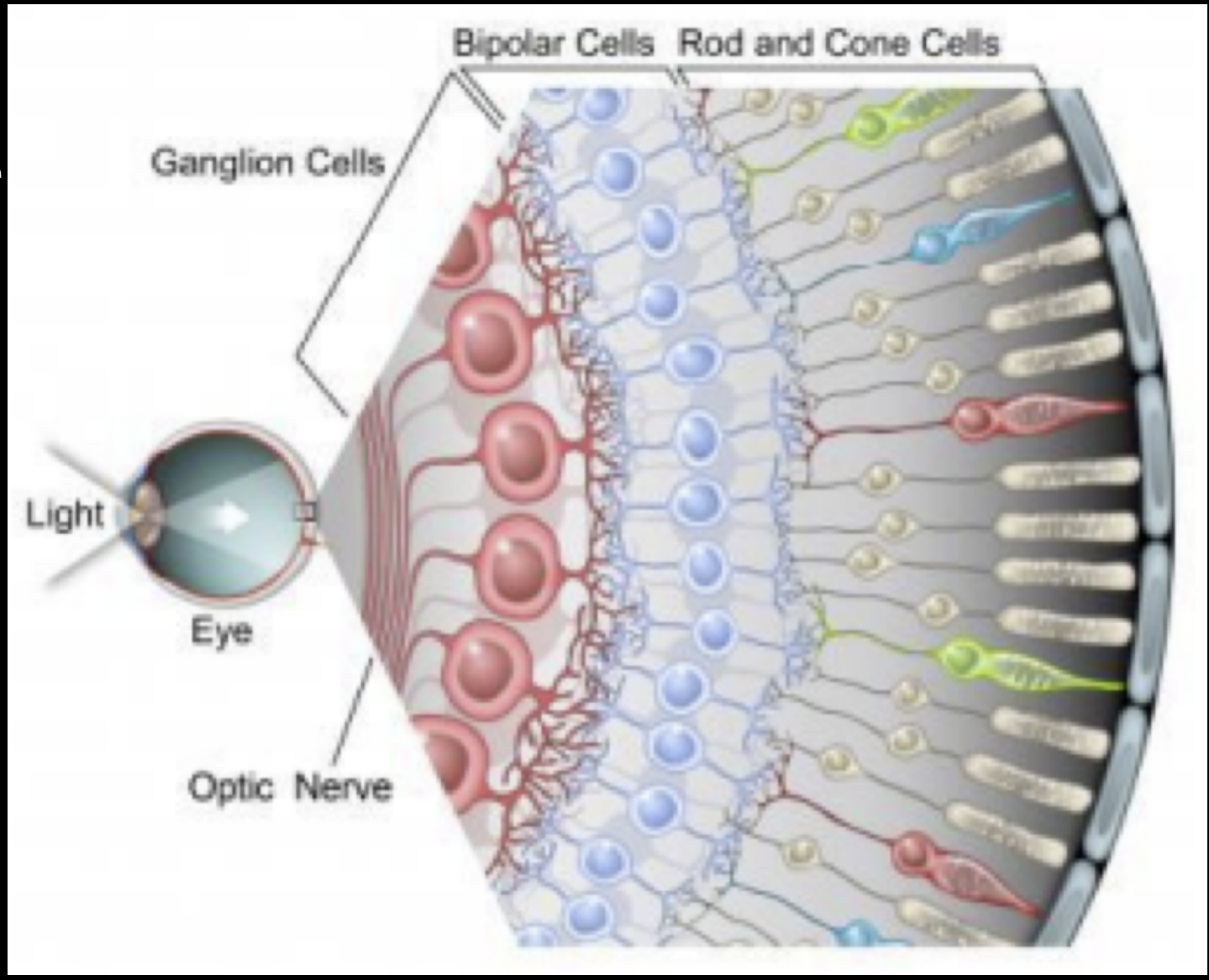
small differences can still be percieved as colors are also associated to brightness

Rods | **Cones**

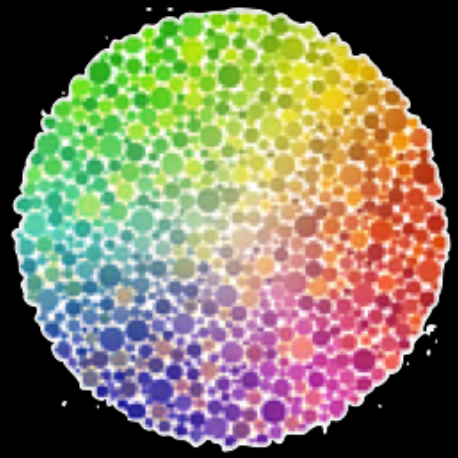
Brightness | **Color**

R G B

brightness: 31% 59% 10%



http://colororacle.org/



Kelly 1965 designed a list of 22 maximally contrasting colors for colorblind compliance (the “Kelly colors”):

https://medium.com/@rjurney/kellys-22-colours-of-maximum-contrast-58edb70c90d1

TABLE I—COLORS OF MAXIMUM CONTRAST

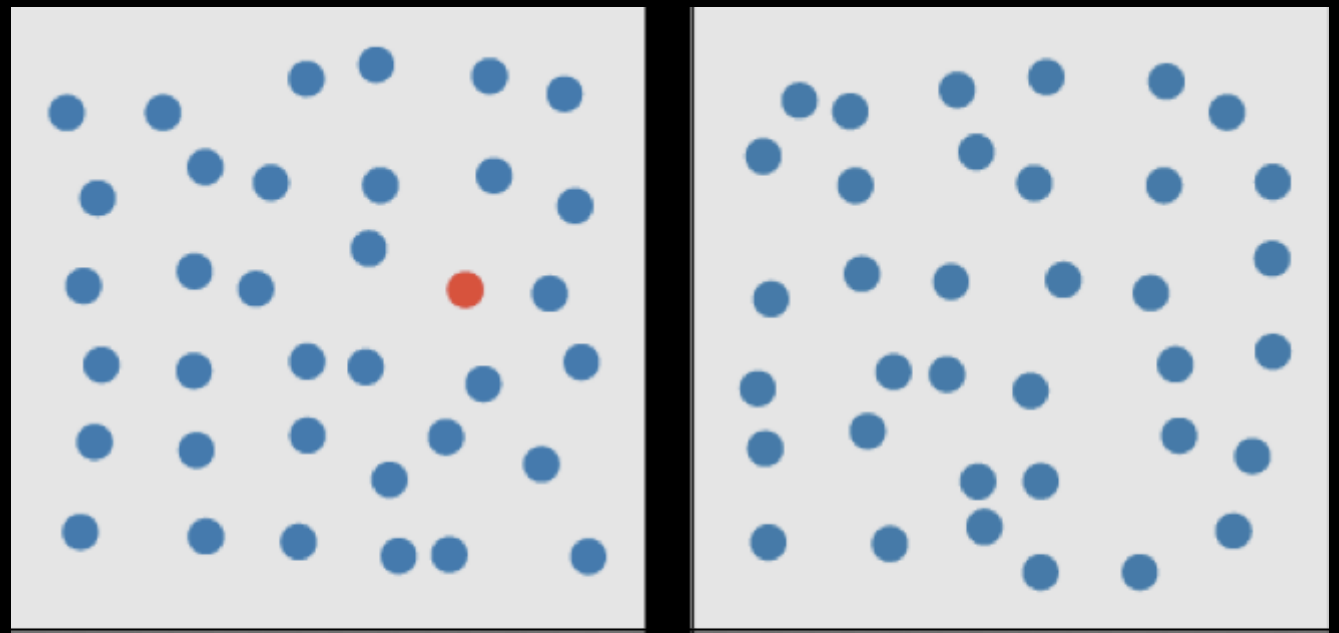
Color Serial or selection number	General color name	ISCC-NBS centroid number	ISCC-NBS color-name (abbreviation)	Munsell renotation of ISCC-NBS Centroid Color
1	white	263	white	2.5PB 9.5/0.2
2	black	267	black	N 0.8/
3	yellow	82	v.Y	3.3Y 8.0/14.3
4	purple	218	s.P	6.5P 4.3/9.2
5	orange	48	v.O	4.1YR 6.5/15.0
6	light blue	180	v.l.B	2.7PB 7.9/6.0
7	red	11	v.R	5.OR 3.9/15.4
8	buff	90	gy.Y	4.4Y 7.2/3.8
9	gray	265	med.Gy	3.3GY 5.4/0.1
10	green	139	v.G	3.2G 4.9/11.1
11	purplish pink	247	s.pPk	5.6RP 6.8/9.0
12	blue	178	s.B	2.9PB 4.1/10.4
13	yellowish pink	26	s.yPk	8.4R 7.0/9.5
14	violet	207	s.V	0.2P 3.7/10.1
15	orange yellow	66	v.OY	8.6YR 7.3/15.2
16	purplish red	255	s.pR	7.3RP 4.4/11.4
17	greenish yellow	97	v.gY	9.1Y 8.2/12.0
18	reddish brown	40	s.rBr	0.3YR 3.1/9.9
19	yellow green	115	v.YG	5.4GY 6.8/11.2
20	yellowish brown	75	deep yBr	8.8YR 3.1/5.0
21	reddish orange	34	v.rO	9.8R 5.4/14.5
22	olive green	126	d.OlG	8.0GY 2.2/3.6

"#023fa5", "#7d87b9", "#bec1d4", "#d6bcc0", "#bb7784", "#8e063b", "#4a6fe3", "#8595e1", "#b5bbe3", "#e6afb9", "#e07b91", "#d33f6a", "#11c638", "#8dd593", "#c6dec7", "#ead3c6", "#f0b98d", "#ef9708", "#0fcfc0", "#9cded6", "#d5eae7", "#f3e1eb", "#f6c4e1", "#f79cd4"

preattentive tasks

https://www.youtube.com/embed/UFNzATczkDU?start=16&enablejsapi=1

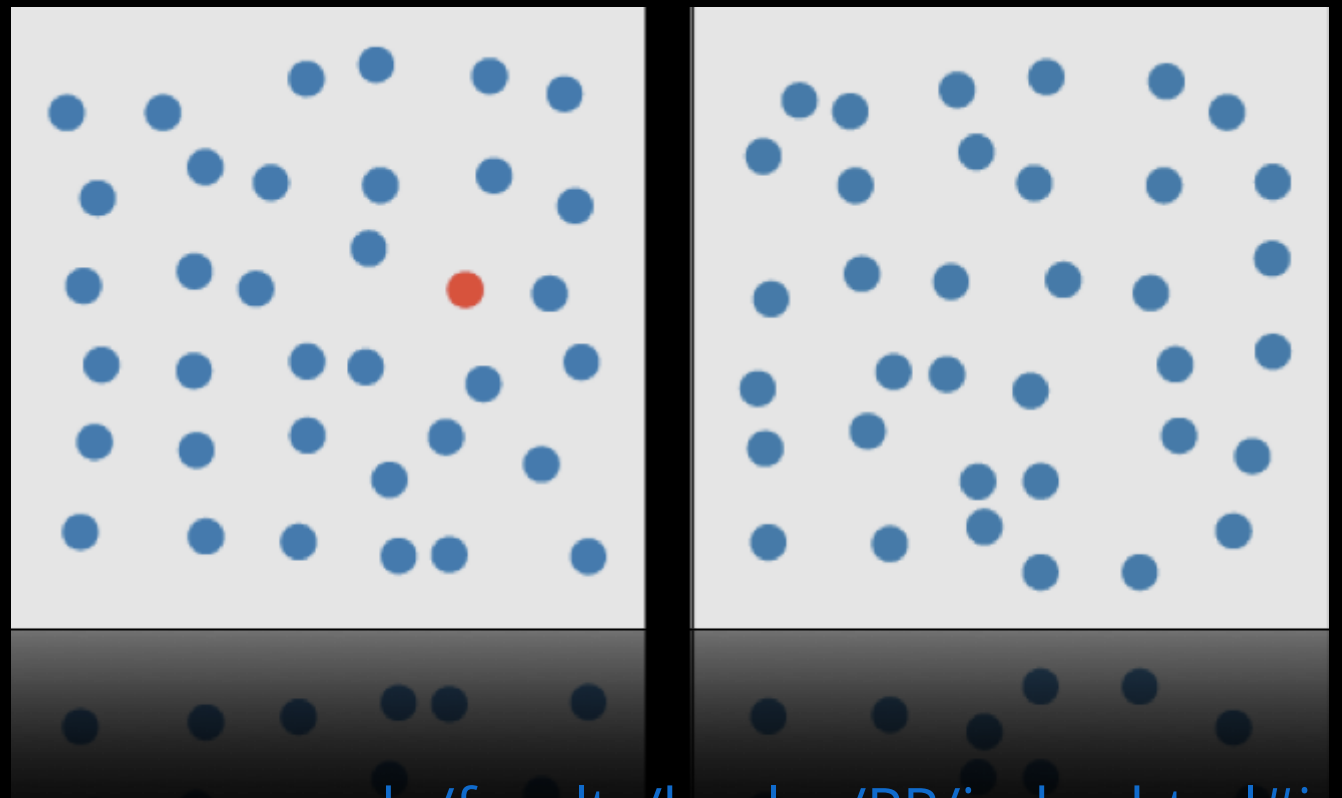
preattentive tasks



a limited set of visual properties that are detected very rapidly and accurately by the low-level visual system.

(tasks that can be performed on large multi-element displays in less than 200 to 250 milliseconds)

preattentive tasks



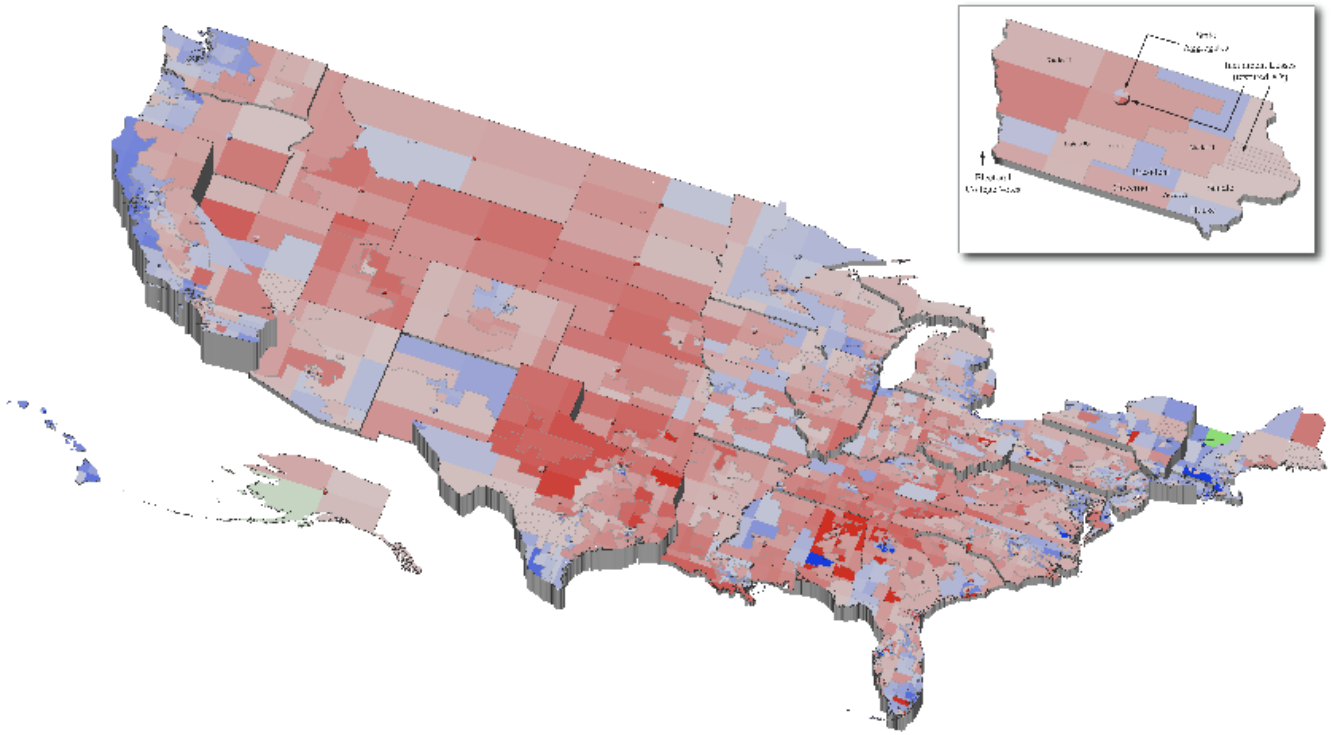
http://www.csc.ncsu.edu/faculty/healey/PP/index.html#jscript_search

how can you leverage preattentive tasks in your vizs

Christopher G. Healey

perceptually-motivated multidimensional visualization of recent U.S. election result

https://www.csc2.ncsu.edu/faculty/healey/PP/



how can you leverage preattentive tasks in your vizs

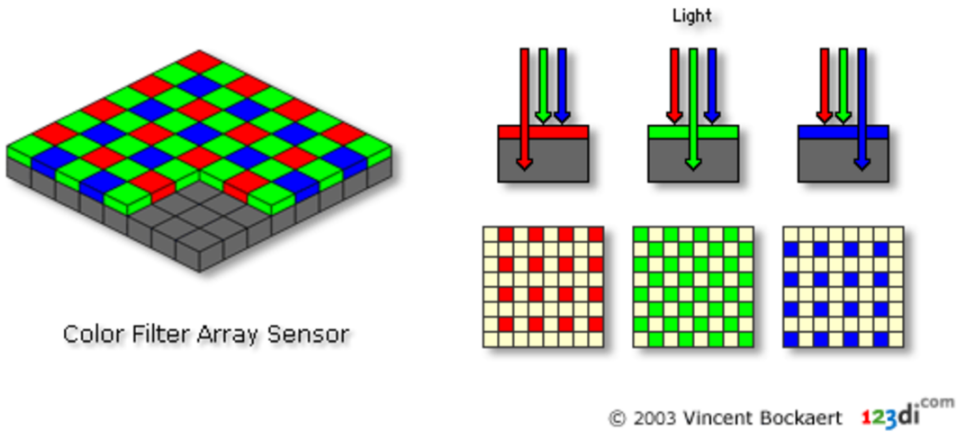
http://morphocode.com/data-city-urban-visualizations/

how can you leverage preattentive tasks in your vizs

https://www.youtube.com/embed/IGQmdoK_ZfY?enablejsapi=1

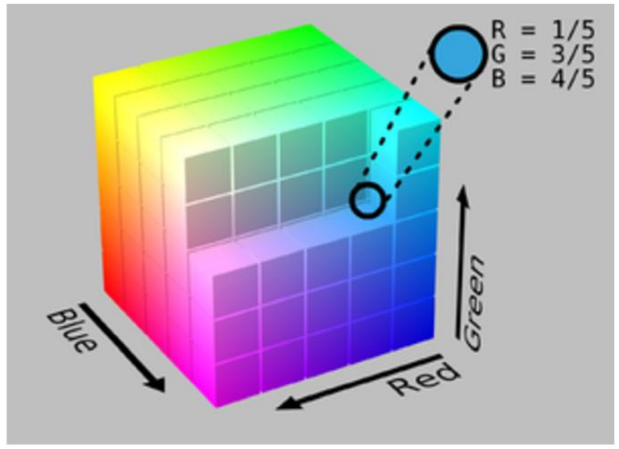
don't overdo it.... our brain can miss obvious things if directed to focus on tasks

Color representation

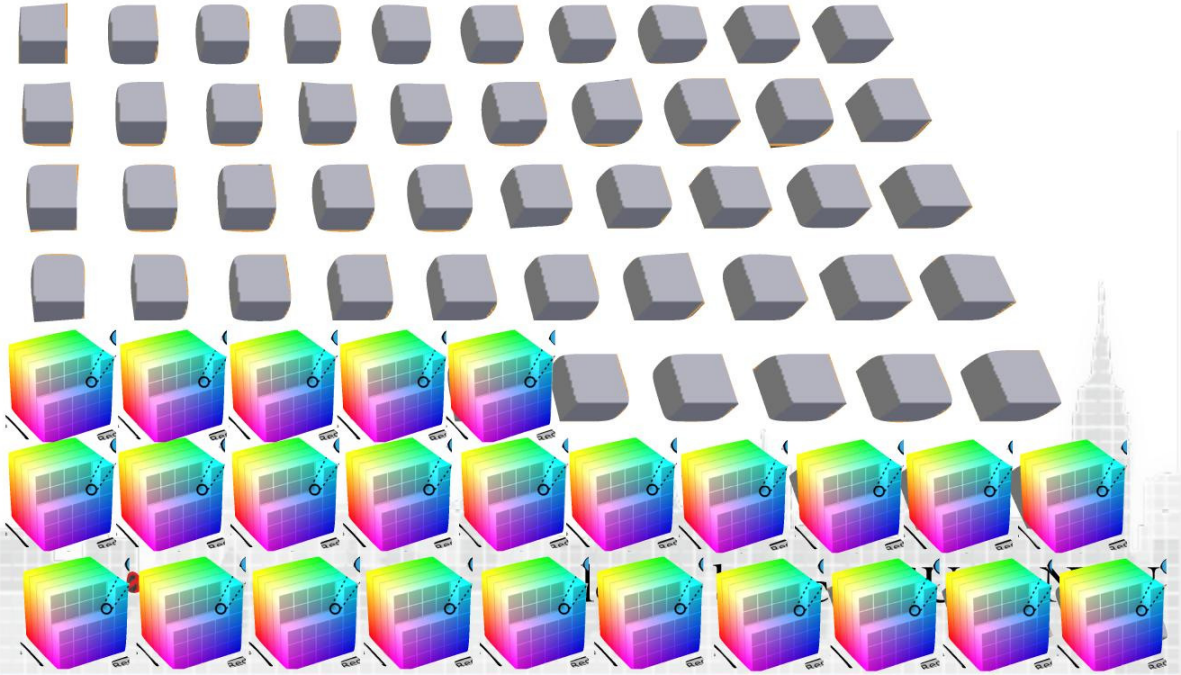


each pixel must read 3 colors

Color representation



single pixel representation



pixel array

Source: Intel.com

image from a computer point of view

```
print (nd.imread("esb.jpg").shape)
imshow(nd.imread("esb.jpg"))
```

Last executed 2017-01-30 07:04:35 in 827ms

```
(652, 236, 3)

<matplotlib.image.AxesImage at 0x106631610>
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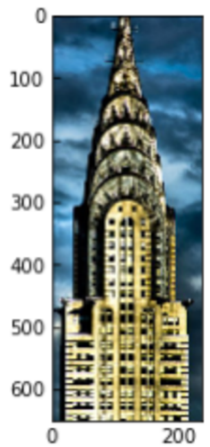


limitations and possible systematics

- location dependent deformation
- low light cutoff (complete loss of info)
- saturation (complete loss of info)
- pixelization (loss of details)
- color bias (calibration)

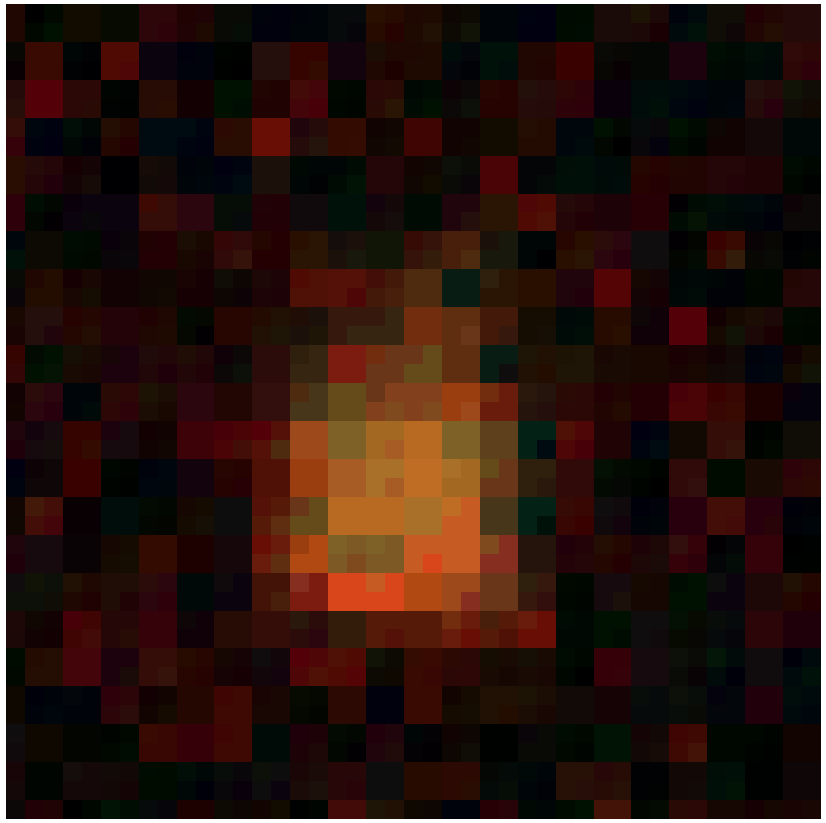
limitations and possible systematics

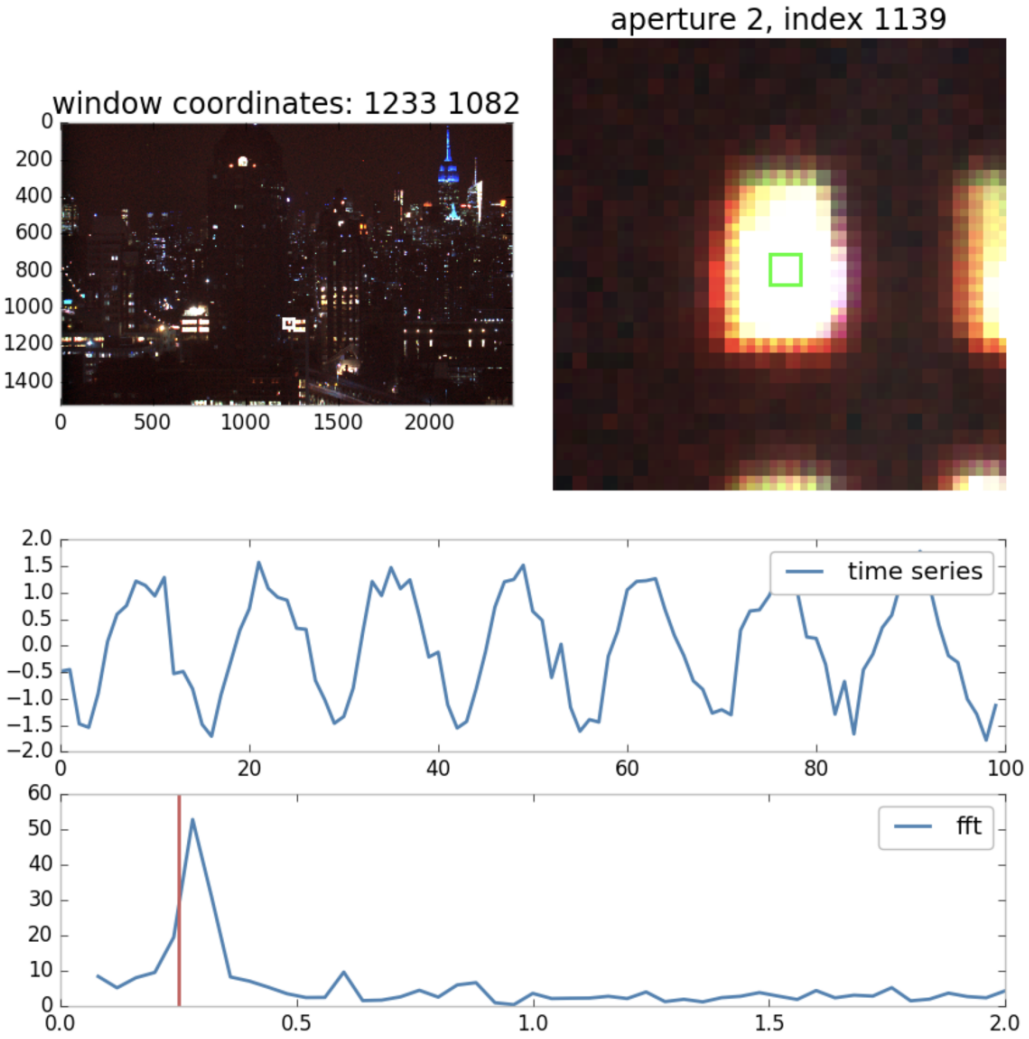
https://www.colorado.edu/earthlab/2019/11/05/out-shadows

application of kmeans clustering to image analysis

reading

Urban Observatory - HyperTemporal Imaging study of Grid Dynamics





Urban Observatory - HyperTemporal Imaging study of Grid Dynamics