

IT'S A COLORFUL WORLD!



The **color** of an object depends on which **wavelengths** of light the object **reflects**. Each of these flowers is illuminated by *white* sunlight and reflects the color that you see.

Similarly,



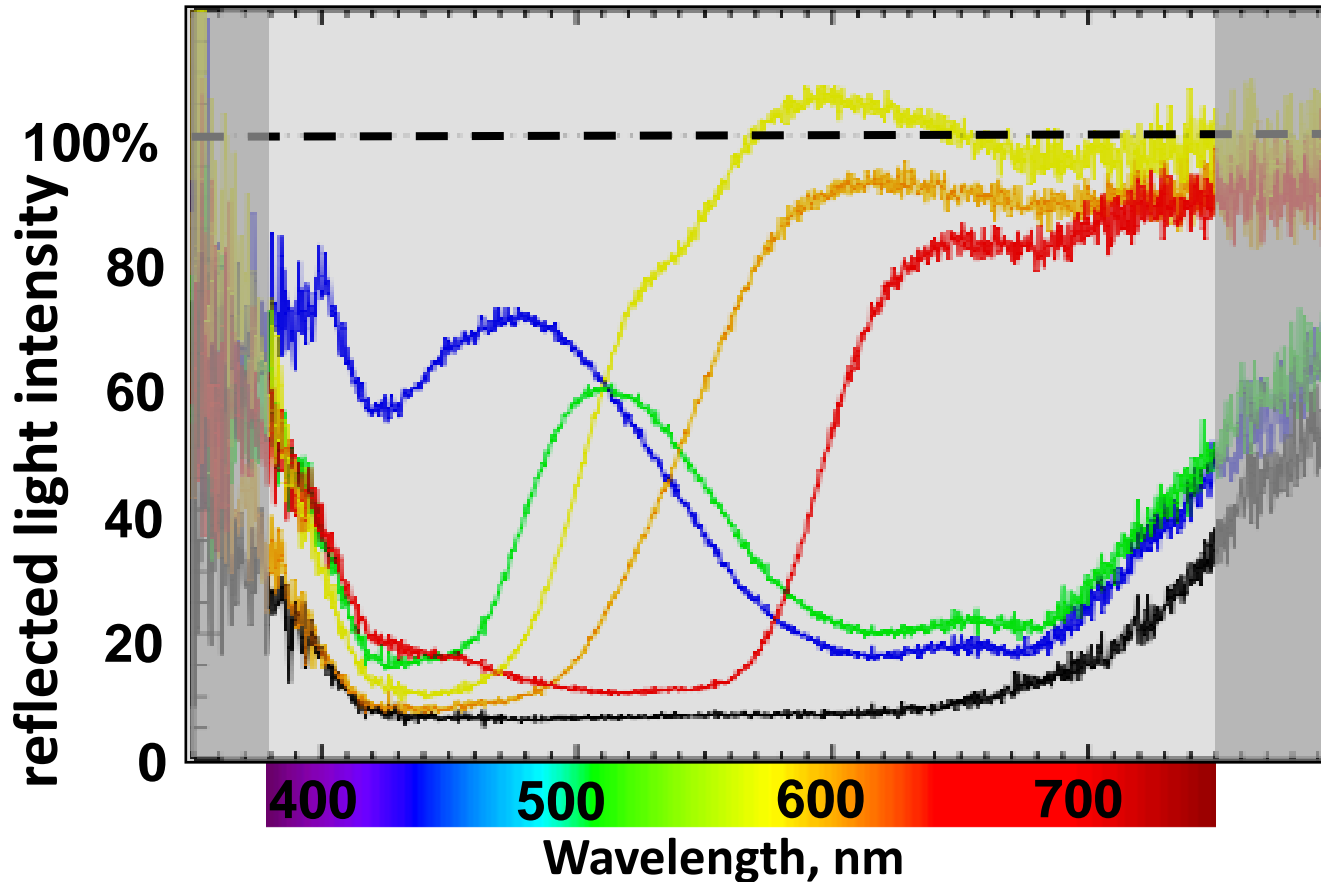
each of these **colored paper fans** is illuminated by *white* light and reflects the color that you see.



Can we measure it?

Reflected Light Spectrum

“How much of each color bounces off?”



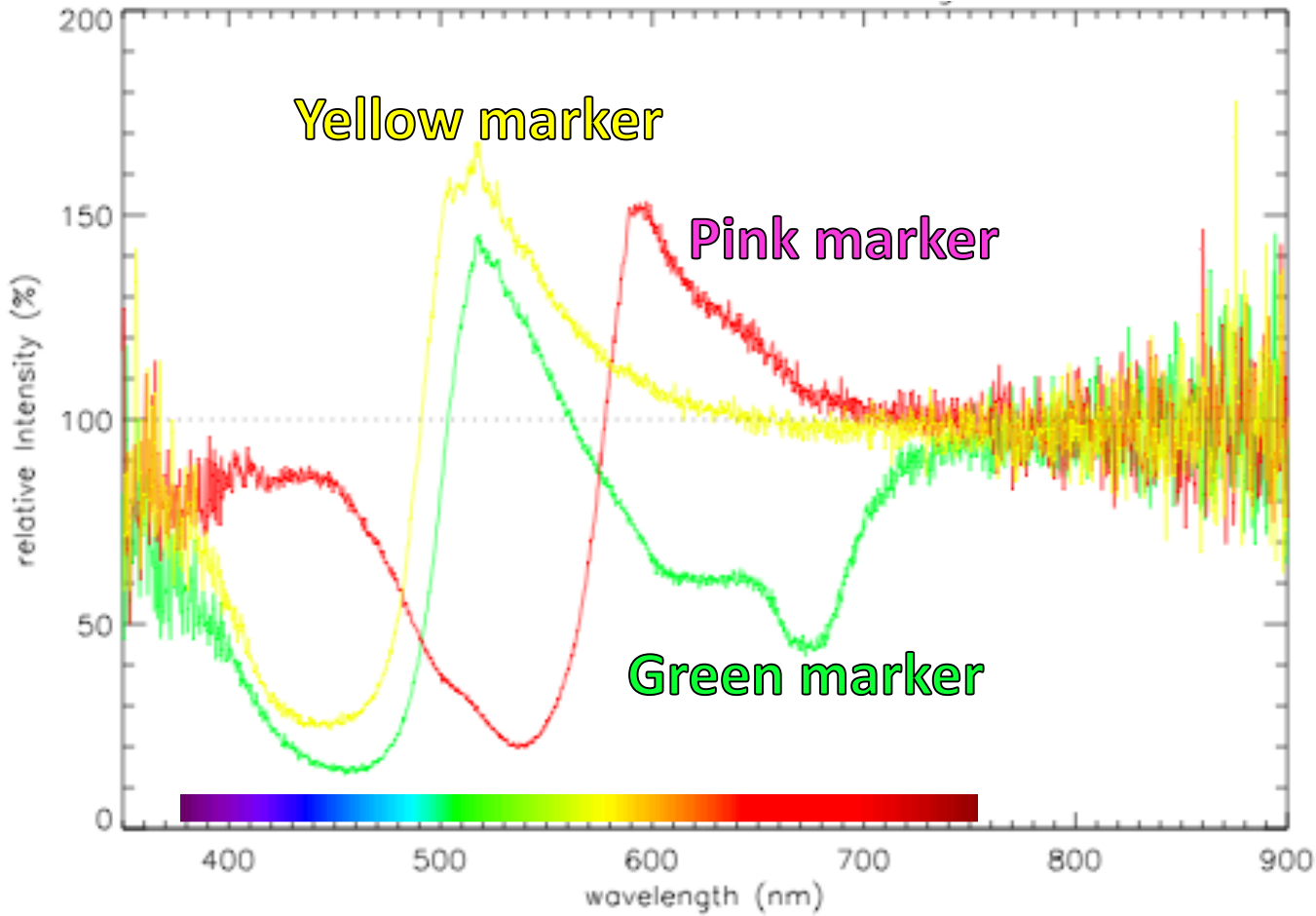
Selective reflection of sunlight off colored paper fans,

*blue
green
yellow
orange
red
black.*

Question: what would a white paper curve look like?
...and what about that pink fan?

Fluorescent Markers (Highlighters)

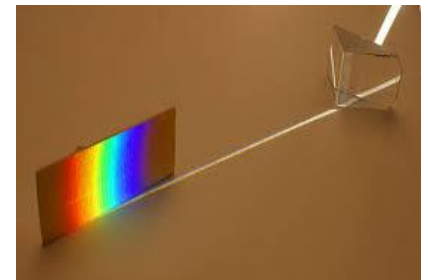
Light response under white light illumination



Fluorescent markers absorb white and re-emit colored light.

(note *signal above 100%* in certain spectral ranges)

Note: there is no pink wavelength of light...



... so how do we see color?

The brain perceives color based on two major light detectors in the eye:

1. Cone cells detect color



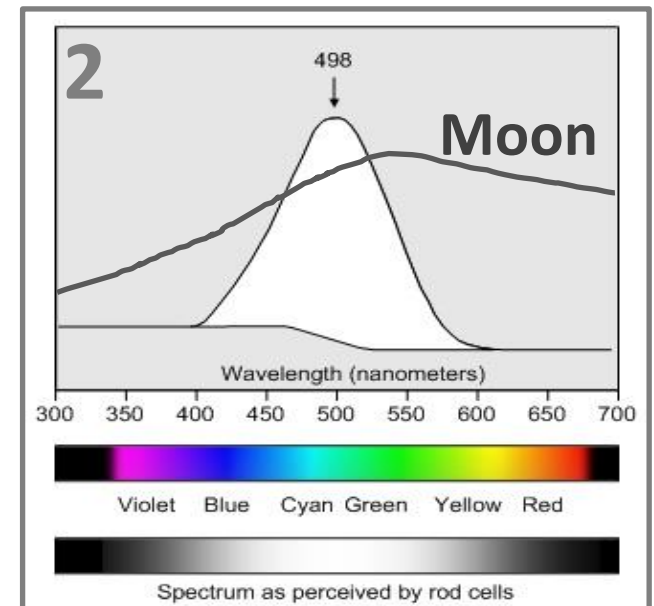
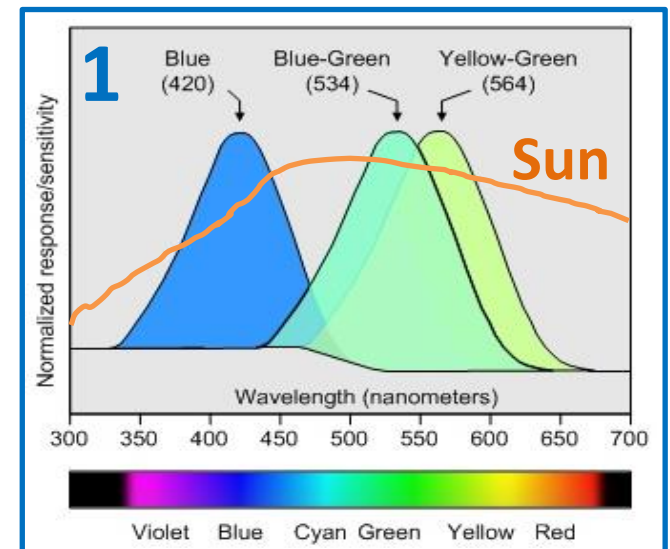
- each type of cone cell absorbs specific colors (wavelengths) of light
- the number of cone cell types creates the range and detail of color an eye can see (distinguish).

2. Rod cells detect intensity



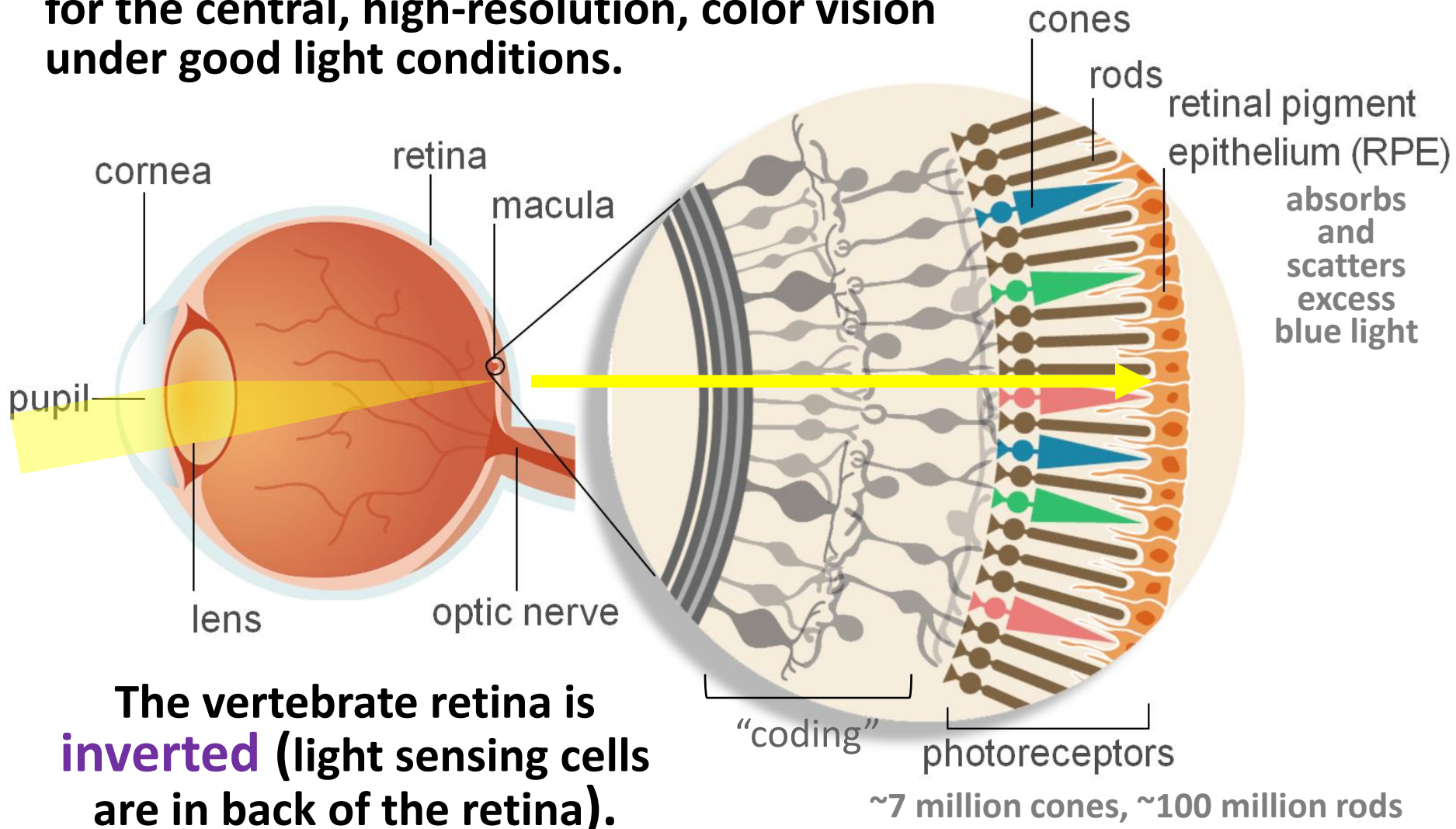
- shades of a color (either light or dark)
- ~1000x more sensitive than cone cells
- maximum sensitivity at ~500 nm
- retina contains about 20 times more rods than cones.

Photopic vision – bright light, cones.
Scotopic vision - in the dark, rods.



Human Eye Structure

The **macula** has high concentration of cones and is responsible for the central, high-resolution, color vision under good light conditions.



The vertebrate retina is **inverted** (light sensing cells are in back of the retina).

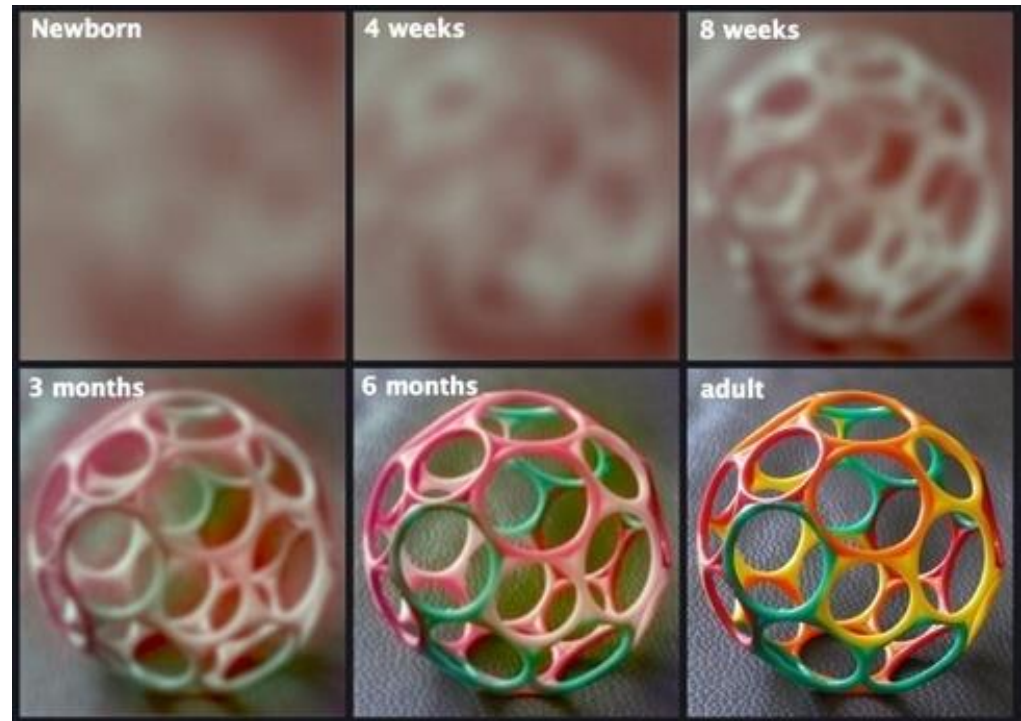
~7 million cones, ~100 million rods

Learning Process

Our **visual abilities** such as focusing (accommodation), moving the eyes accurately (eye tracking), using the eyes together (eye teaming), and the brain processing what it sees (visual processing including color recognition) are **learned skills**.



- At birth, we can only see as far as **7-10 inches away** and in **two dimensions** only.
- By 1 month, the useful sight distance grows to about 3 feet, **depth perception** and **3D vision** begin to appear.
- By 6 month, vision is almost fully developed, **clarity** and **sharpness** close to an adult.



By ~3 years of age complete development of color vision is achieved.