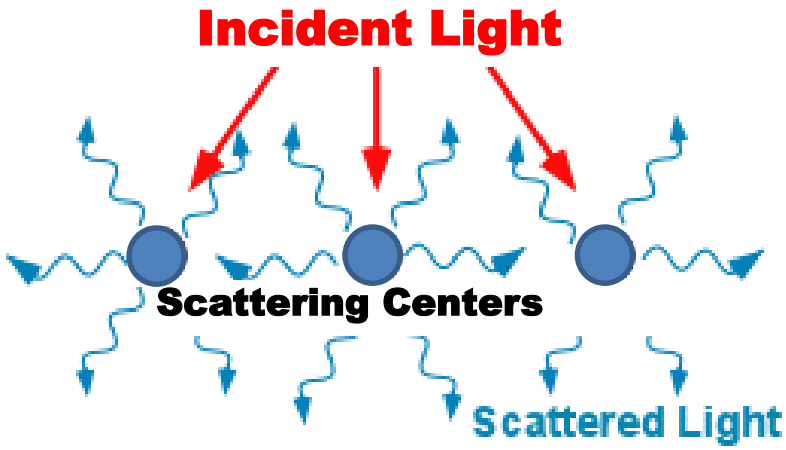
Scattering

light ray moves over to the side in all directions rather than forward, backward or being absorbed



- Scattering is due to **localized non-uniformities *(scattering centers)*** in the medium through which light passes.
- The **most critical factor** is the **scattering centers size relative to the wavelength of the light** being scattered.
- Amount of the **scattered light can strongly depend on the wavelength** of light.

I See Skies of Blue…

Sunlight contains all the colors.

Atmospheric molecules **scatter** light

Longer path through atmosphere means more scattering.

At sunset, violet, blue and green are completely scattered away, but red and orange are still there!

Violet and blue are scattered most…

…we see blue because our sensitivity to violet is very low!

…and Red Sunsets too!

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,

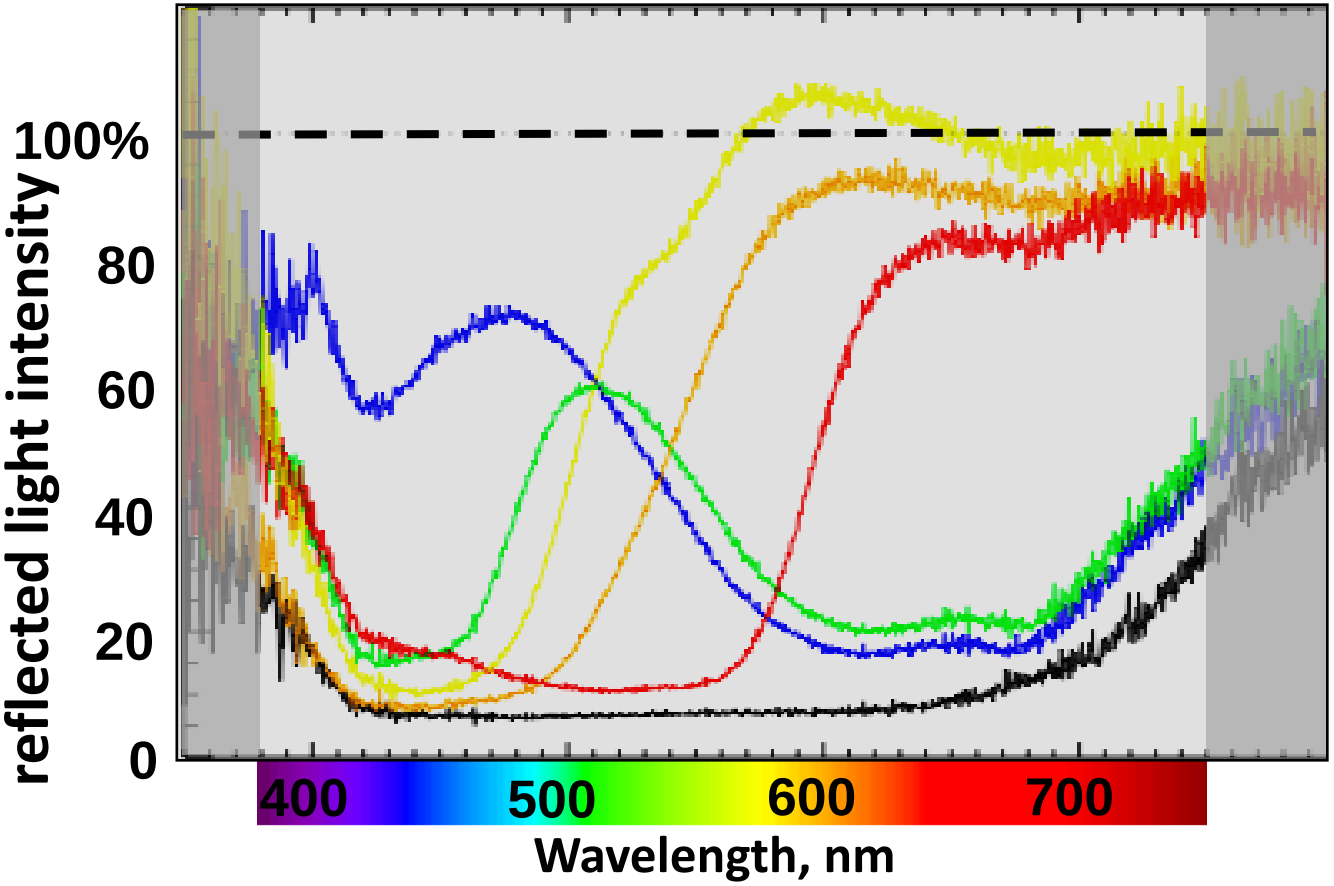
each of these colored paper fans is illuminated by *white* light and reflects the color that you see.

color is defined by wavelength

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.

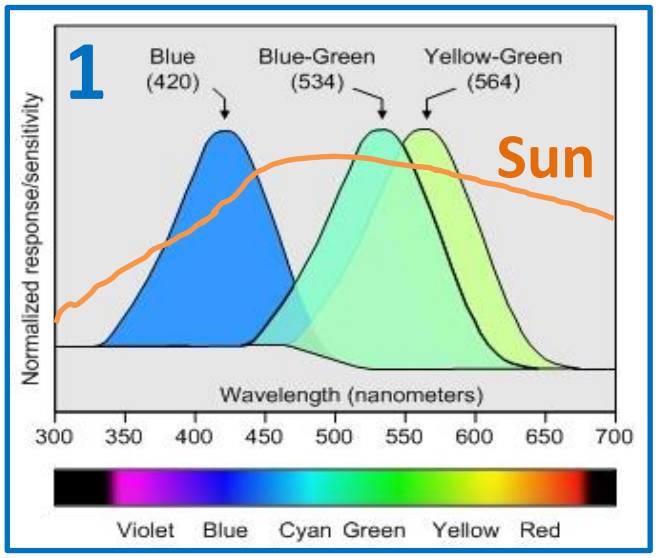
Question: what would a white paper curve look like?
…and what about that pink fan?

… so how do we see color?

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

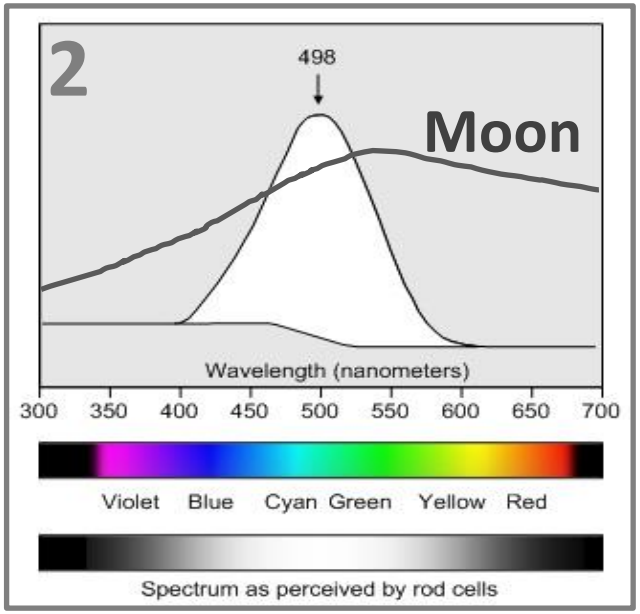
1. Cone cells detect color

- 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

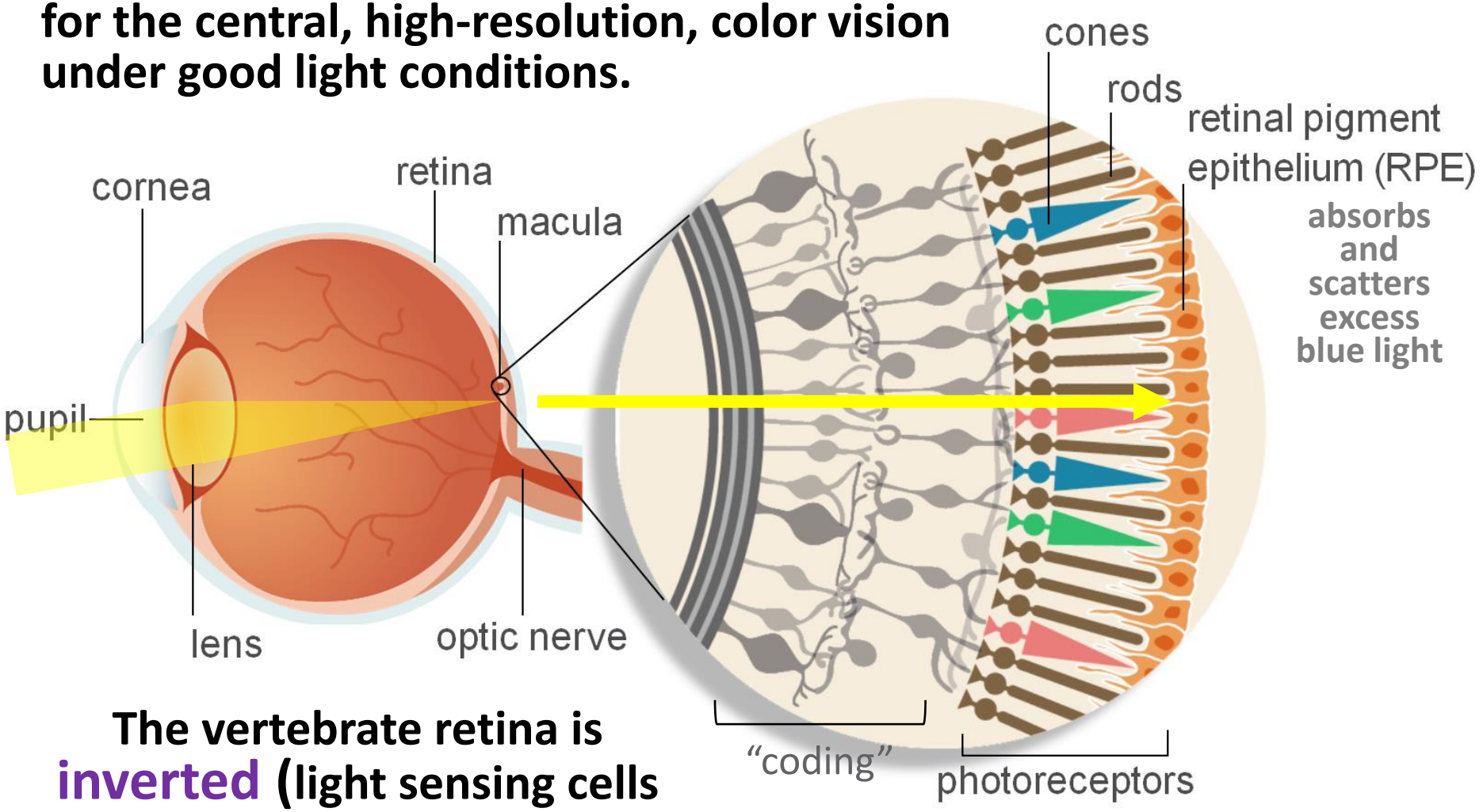
- shades of a color (either light or dark)
- ~1000x more sensitive than cone cells
- maximum sensitivity at ~500 nm
- retina contains about 20 times more rods than cones.



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.

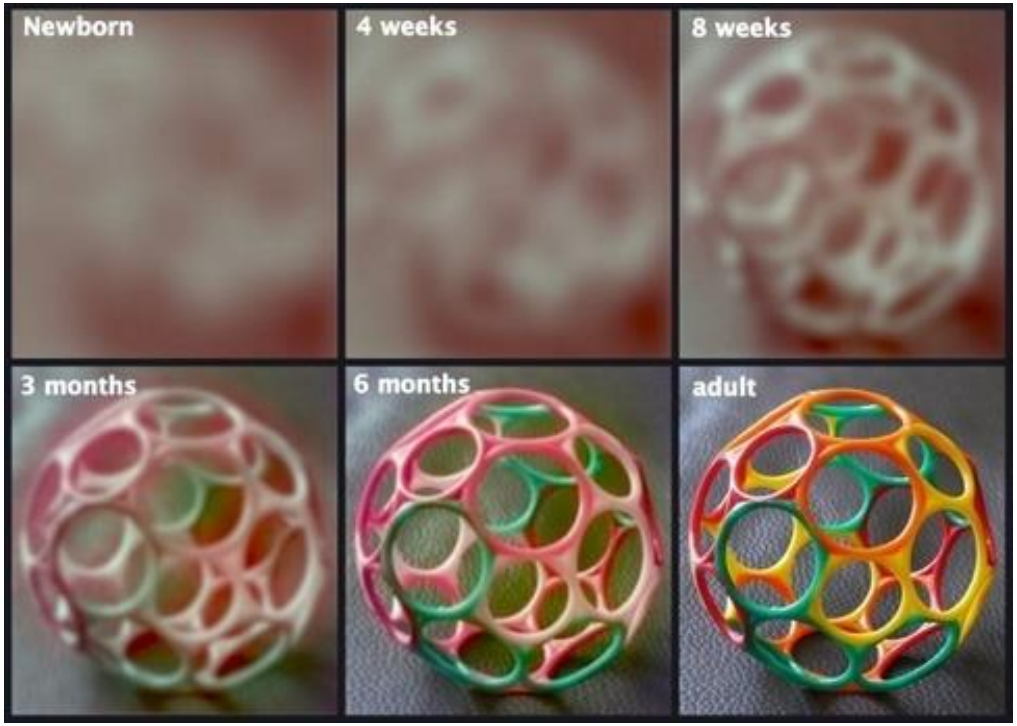


The vertebrate retina is inverted (light sensing cells are in back of the retina).

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.

Do you see what I see?

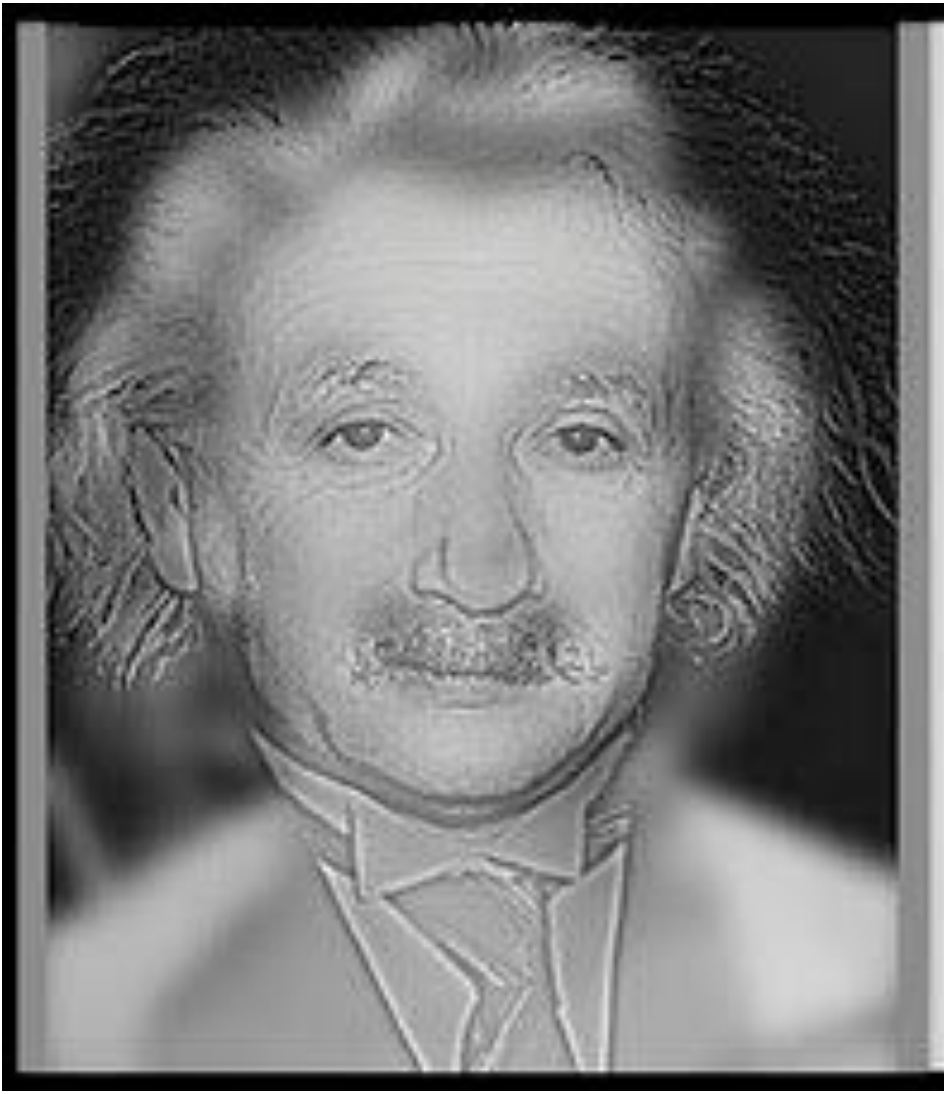


Image recognition
is based on
current observation
and
prior information.

It is another
very important
learned skill**!**