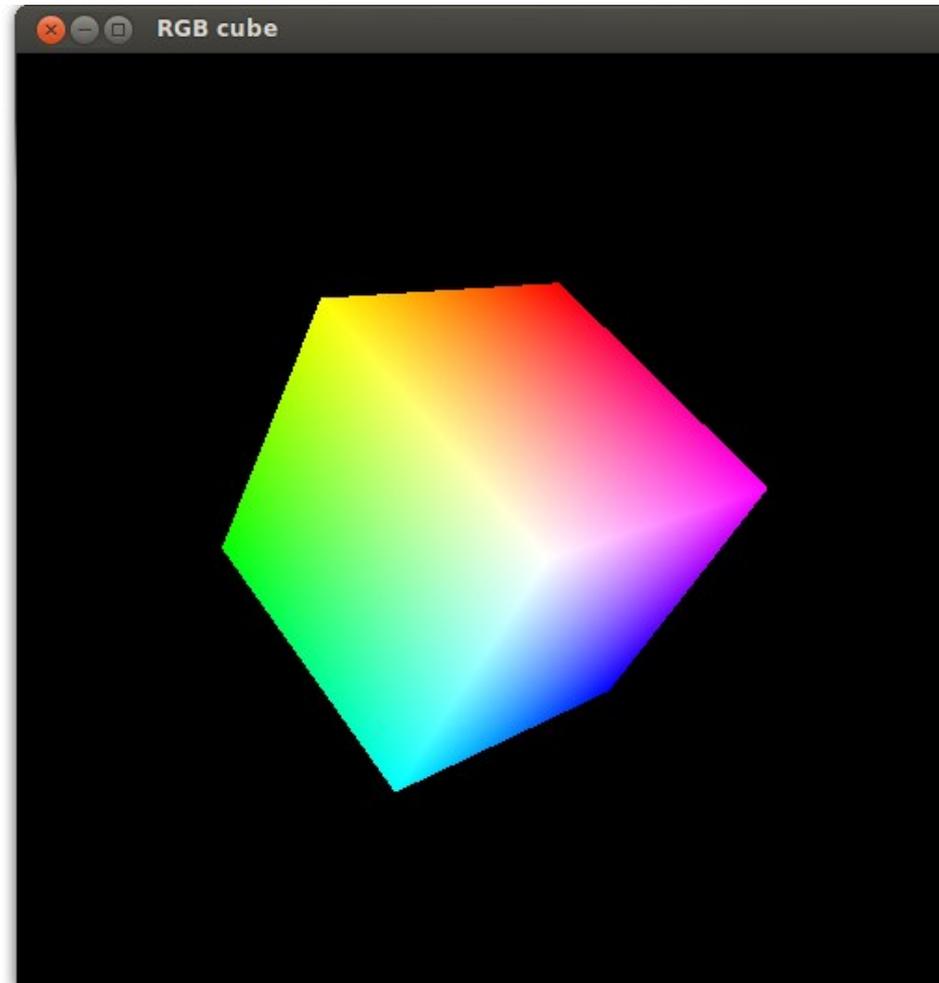


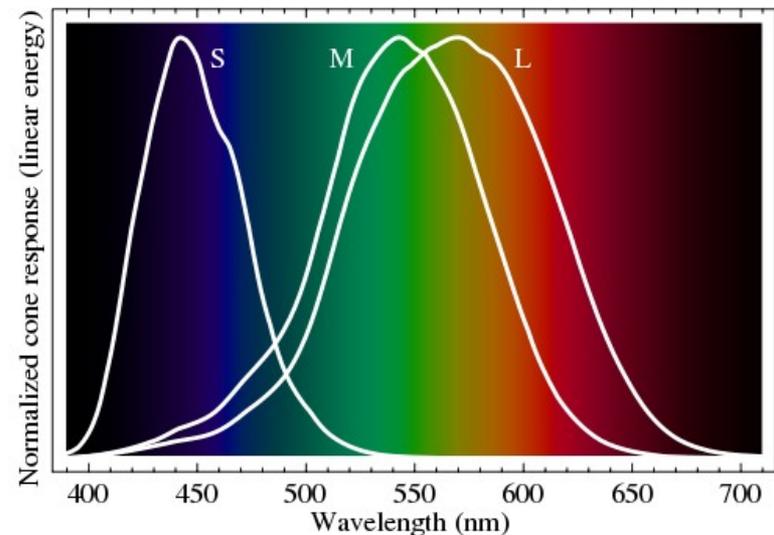
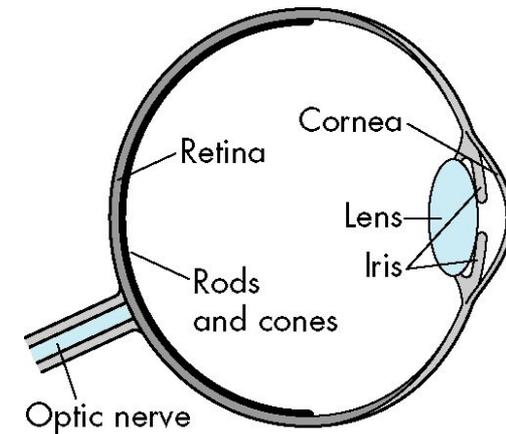
# Color

- Chapters 1.4.2, 2.5-2.6



# The human visual system

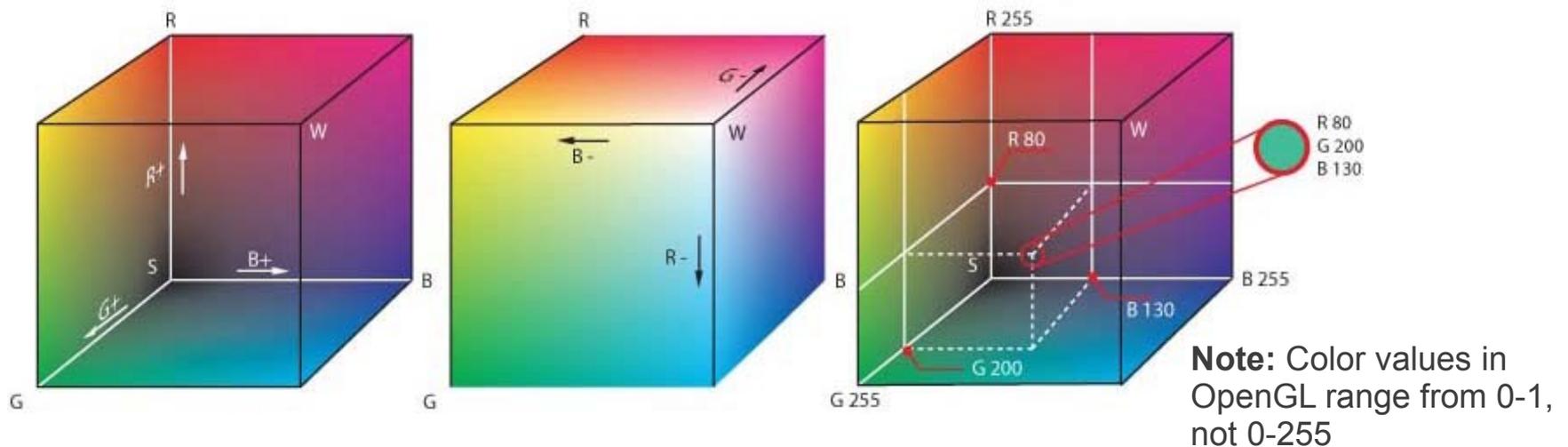
- The human eye has two types of light sensors: **rods** and **cones**.
- Rods sense luminance, or "brightness", but not color. They have slower response time than cones but are about 100 times more sensitive to light.
- There are three types of cones:
  - S**, blue-sensitive
  - M**, green-sensitive
  - L**, red-sensitive



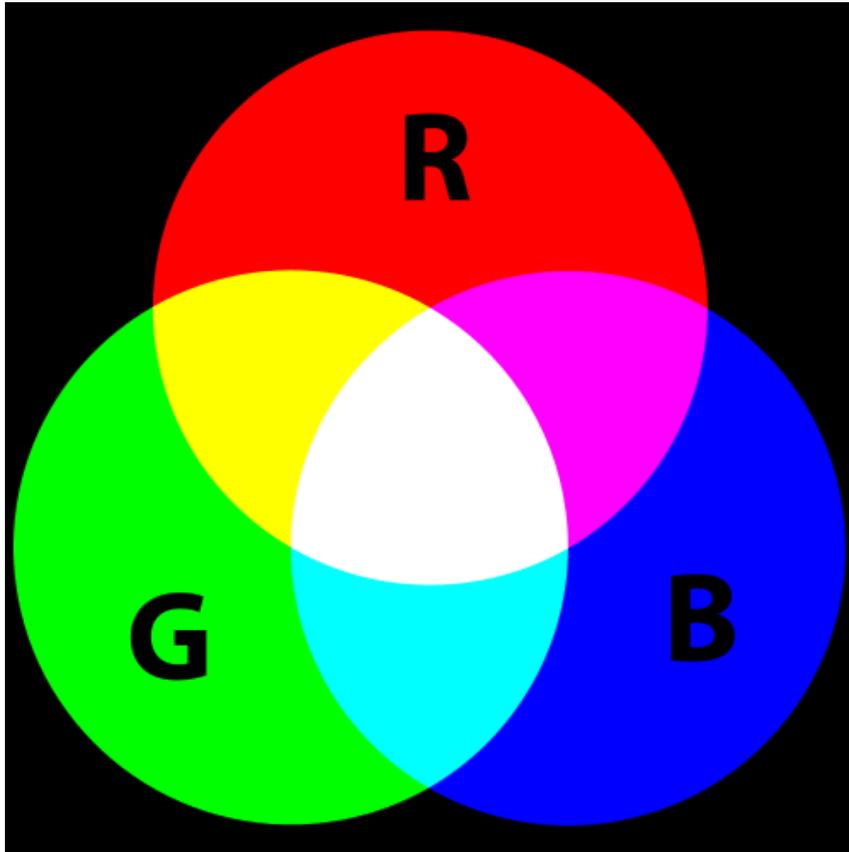
# The RGB/CMY color space

- **RGB (Red Green Blue)**: for additive color mixing, e.g., on a computer display
- **CMY (Cyan Magenta Yellow)**: for subtractive color mixing, e.g., in printing

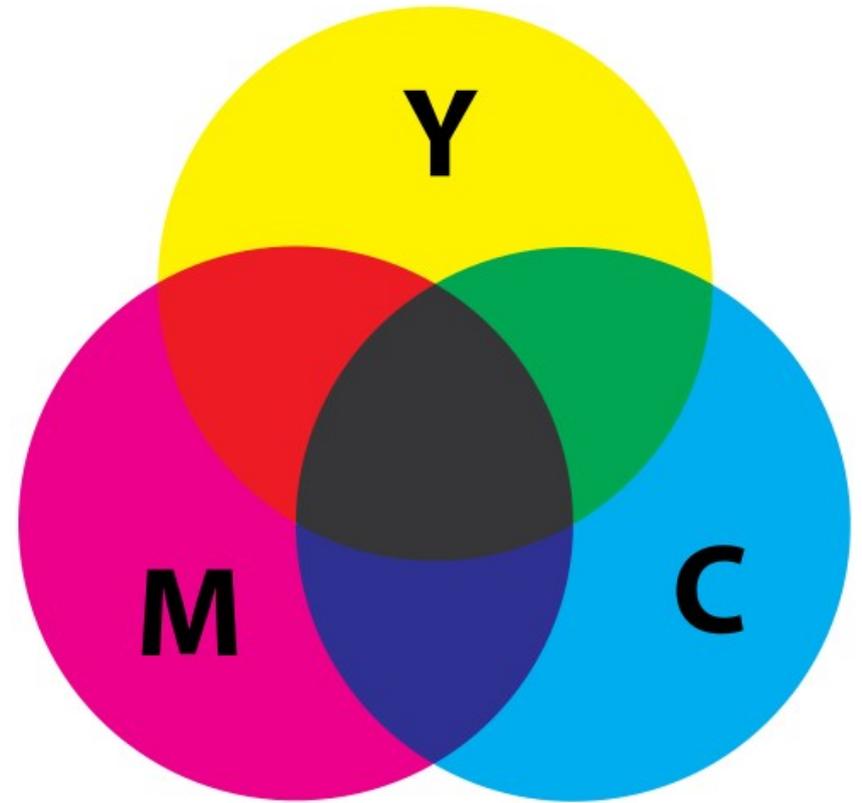
$$[C, M, Y] = [1, 1, 1] - [R, G, B]$$



# Additive vs. subtractive color mixing



$R + G + B = \text{white}$  (additive)



$C + M + Y = \text{black}$  (subtractive)

# RGB in computer displays

- A display system such as a LCD monitor uses only 3 primary colors (red, green, and blue) to display nearly all colors in the visible spectrum
- Each pixel is composed of three tiny light sources (one for each primary color and cone type). When viewed at a distance, these separate light sources will blend together to a solid color



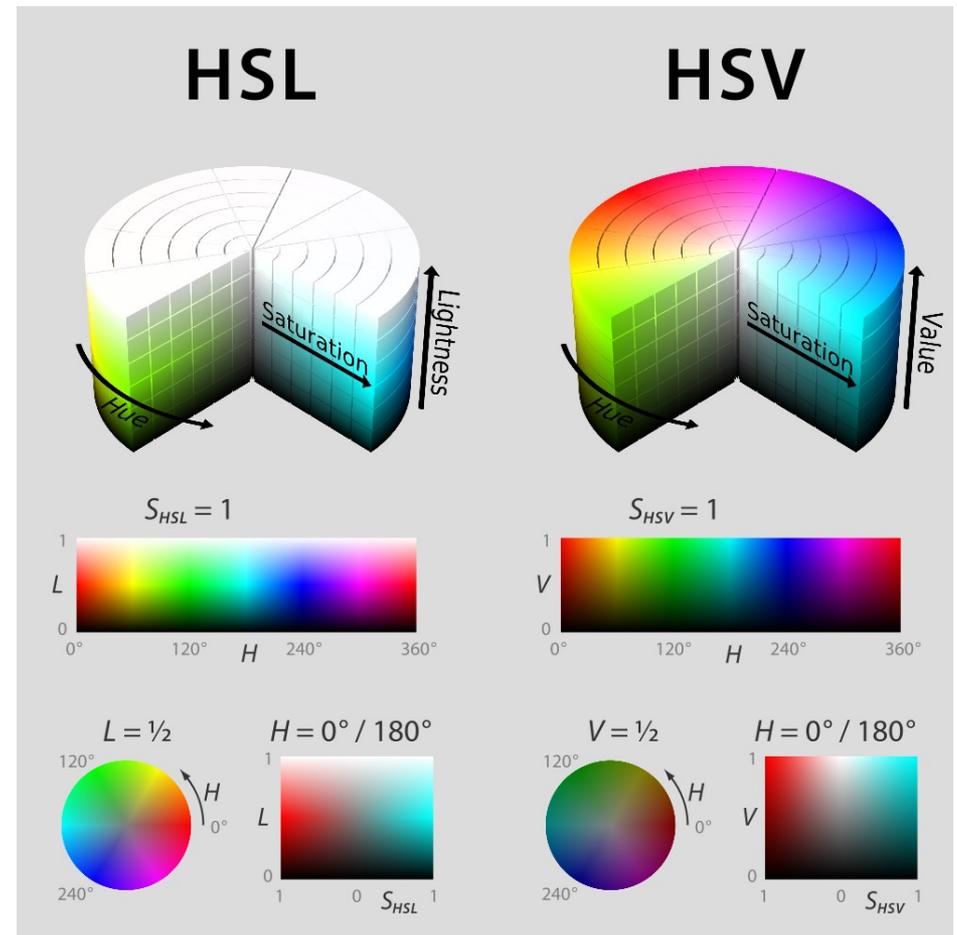
Individual pixel

# True-color framebuffer

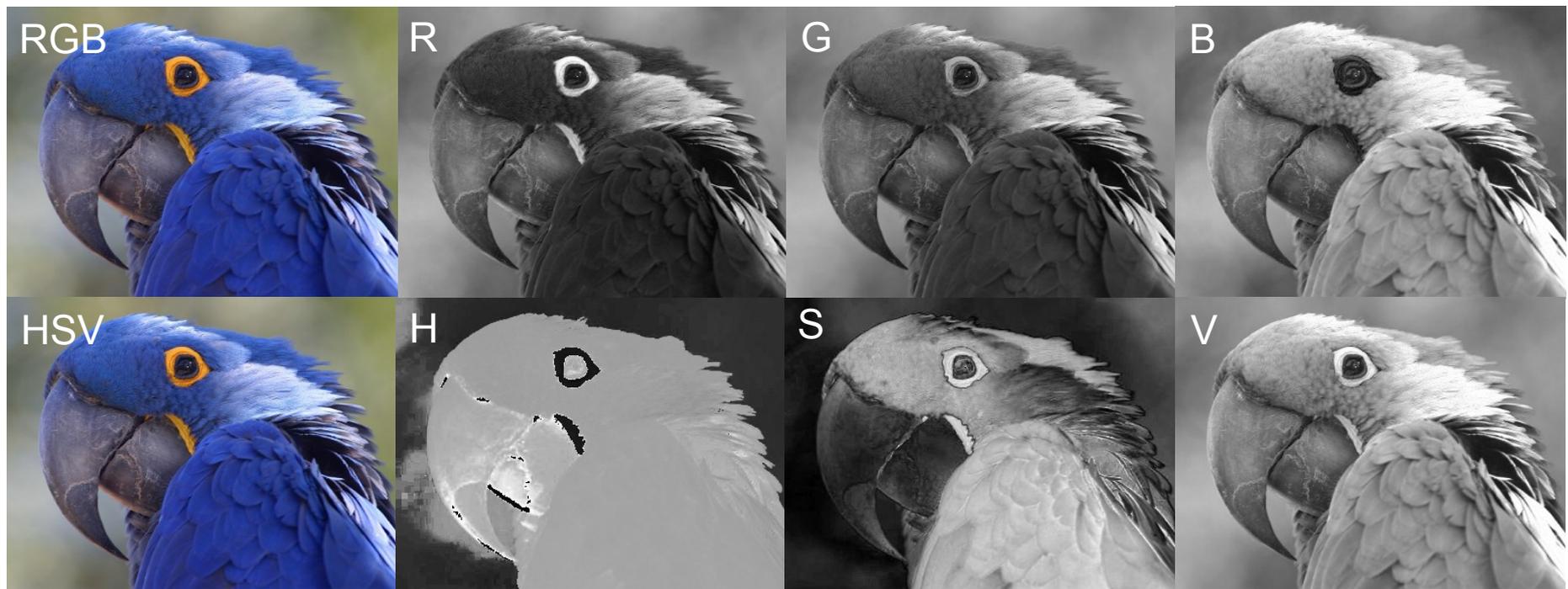
- Store RGB values directly in the framebuffer
- Typically, a pixel is represented with 24 bits: 8 for red, 8 for green, and 8 for blue
- A 24-bit framebuffer can represent  $2^{24}$  (16 million) simultaneous colors, which is enough for most applications
- Standard in modern graphics systems

# The HSV/HSL color spaces

- Decouple intensity from color information
- Three components:
  - Hue (angle)
  - Saturation (radius)
  - Value, Lightness (height)



# RGB vs. HSV



# Choosing color space

- OpenGL and GLSL assumes that colors are represented as RGB or RGBA values
- Converting RGB colors to HSV/HSL can be useful for, e.g., toon shading and other image-based postprocessing effects where you want to decouple intensity from color
- You can use HSV and other non-RGB color spaces internally in your application program, as long as you convert the resulting colors back to RGB before rendering
- Regardless of which color space is used in the application, RGB is the norm in modern displays

# Gamma correction

- Compensates for the non-linear response of LCD/CRT monitors
- See assignment 3, part 1

