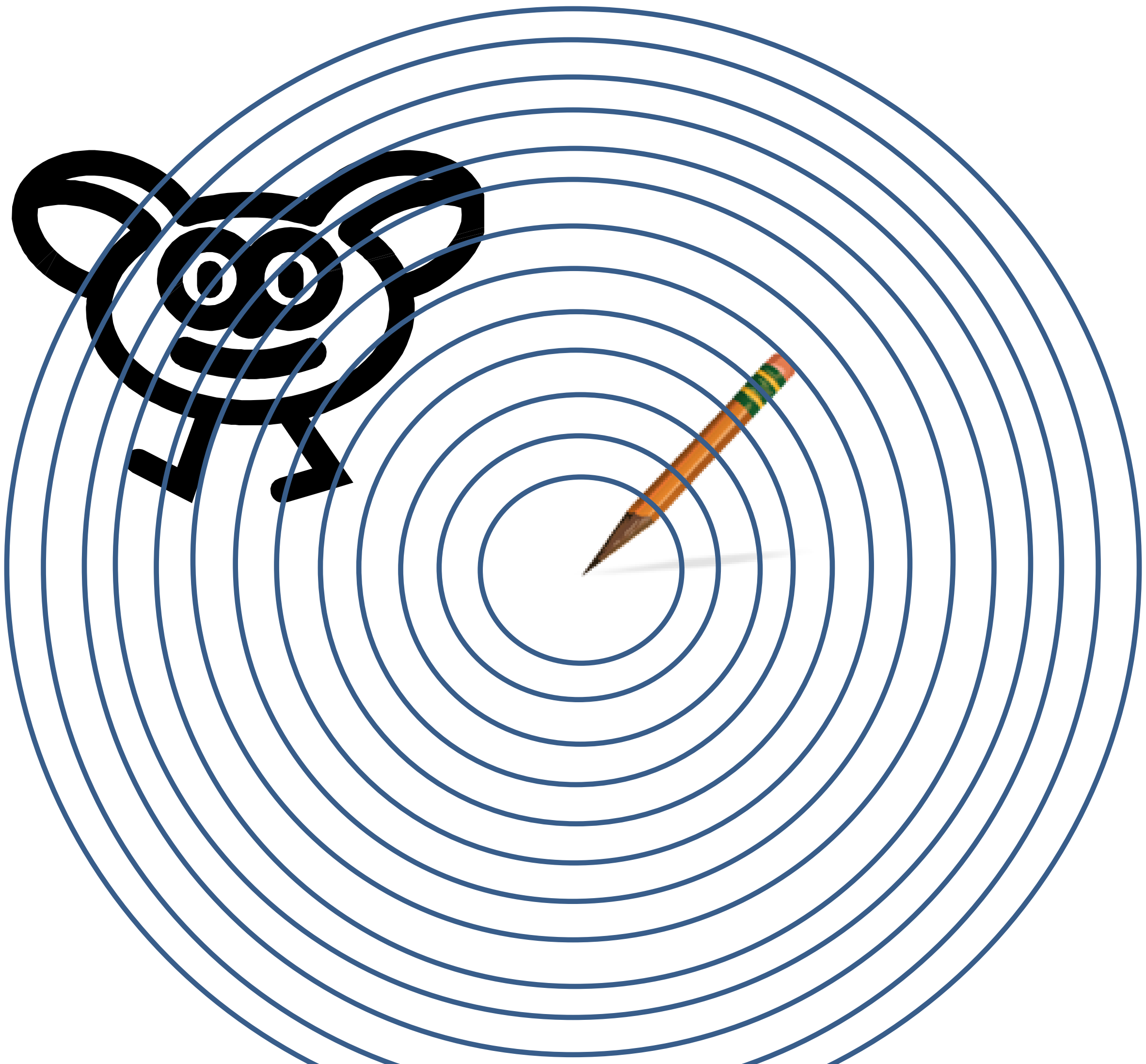
Ear Buds

- Vibrations go directly from speaker to your solid flesh and bone so low frequencies not lost.
- Uses your skull to amplify the sound via *sympathetic vibration*

Locating sounds



Elephants

Very good at localizing sounds.

- Large space between ears
  - Bigger time delay between right and left ear
  - Bigger difference in loudness/intensity between right and left ear

- Extend ears perpendicularly to better localize
- One young Asian elephant who was tested could localize to 1 degree.
- Online Humans and Dolphins can also do this.

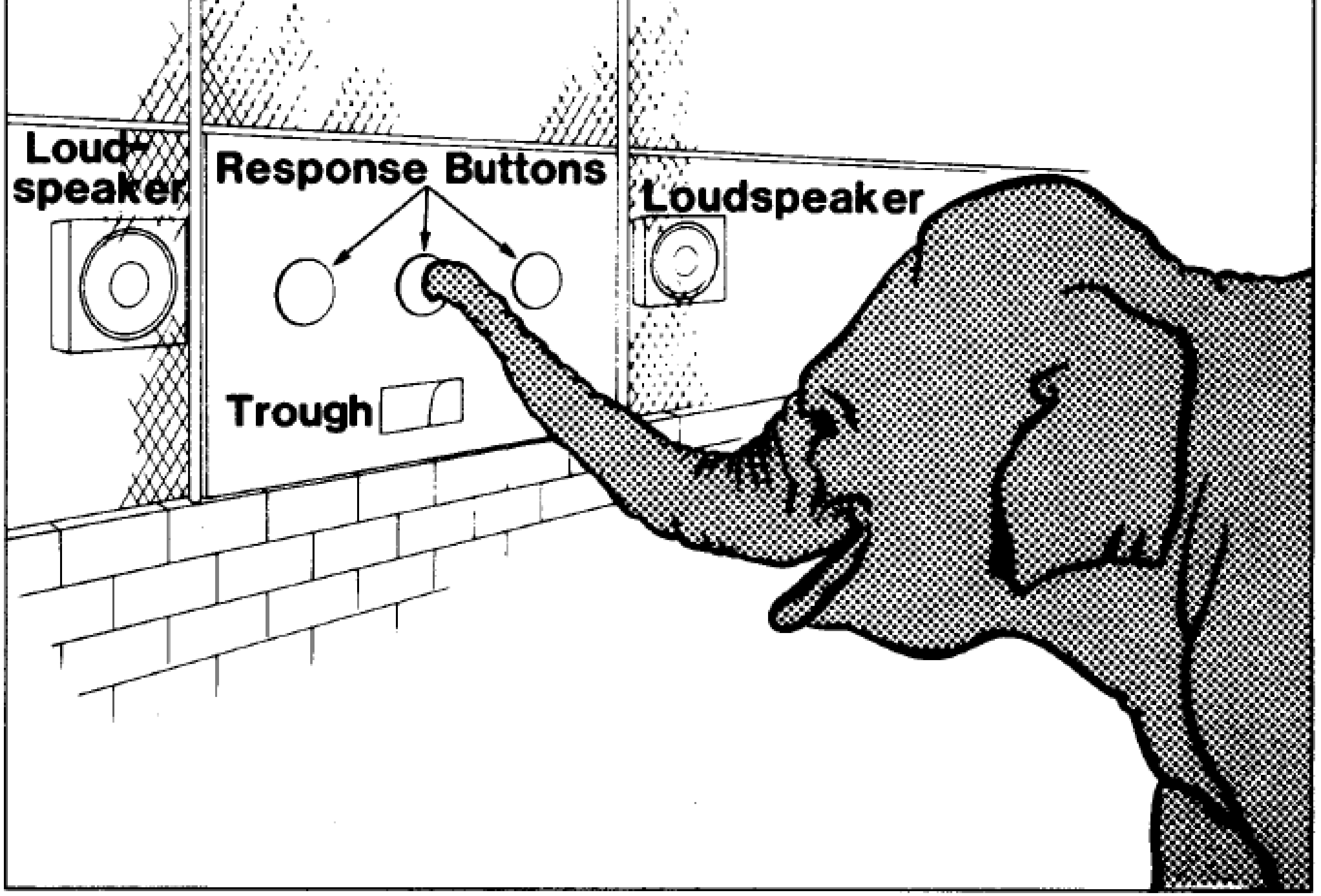


Figure 1. Response panel used to test the elephant. (The elephant was trained to initiate a trial by pressing the center button and then to press the left button or right button, depending on which of two stimuli was presented. Correct responses were rewarded with a fruit-flavored sugar solution delivered into the trough.)

- 7 year old Indian Elephant
- Independence, KS Zoo
- 2.2 m tall
- 1.1 m between ears
- 50 L per test

Bat, Dolphin and Whale Communication

- Was it easier to see or hear the whales?

A. See them

B. Hear them

Bat, Dolphin and Whale Communication

- Sound travels well through the water but as you get deeper or further apart, it's hard to depend on the eyes.

Sound vs. Sight

What detector do you think dolphins and whales use to hunt?

A. Ears only
B. Eyes only
C. Ears and eyes – primarily ears
D. Ears and eyes – primarily eyes

Echolocation vs. Sight

- Whales and dolphins have good vision.
- Whales and dolphins see better than bats, but both use echolocation as their primary tool.

Sound vs. Sight

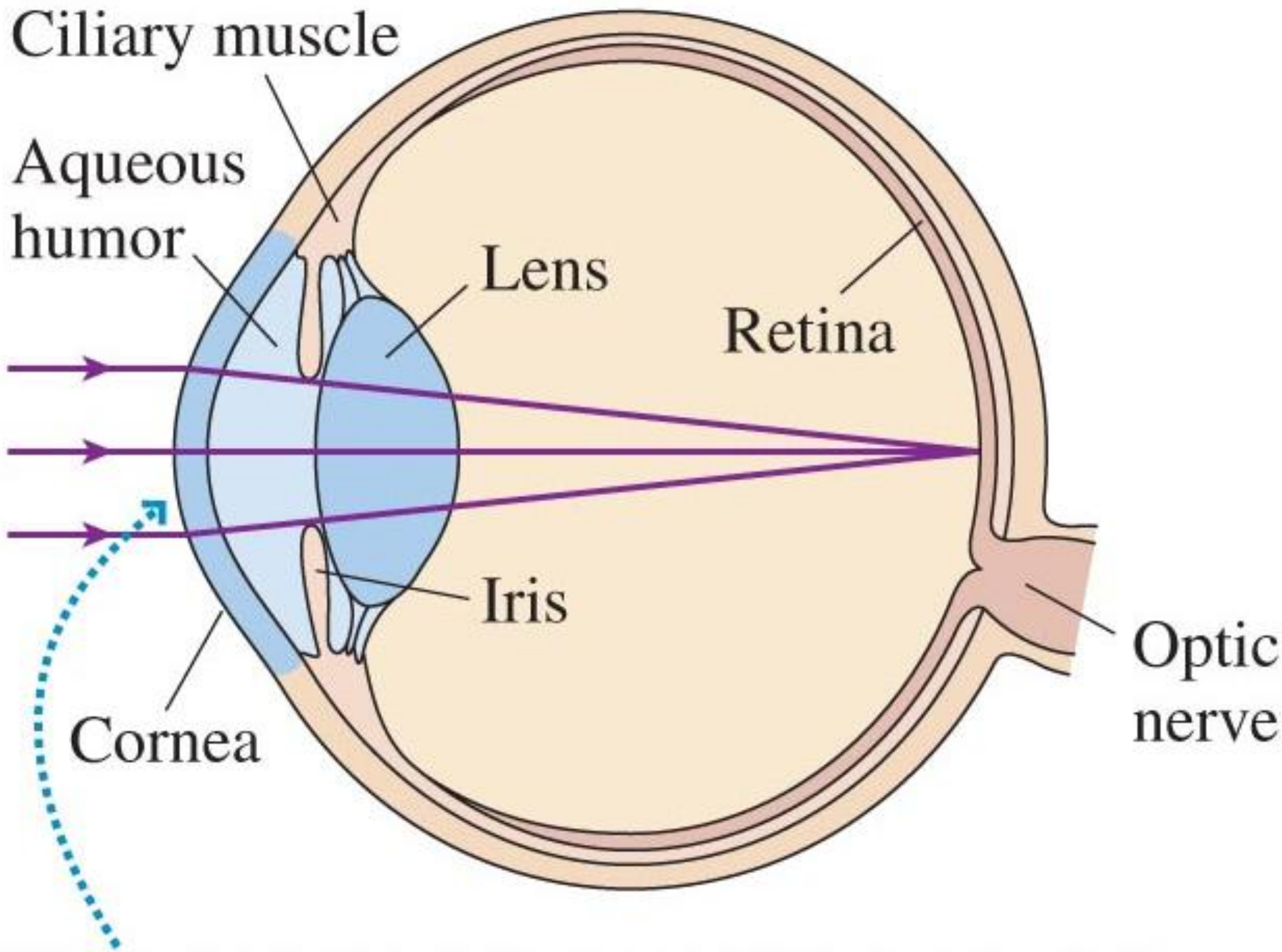
What detector do you think dolphins and whales use to hunt?

A. Ears only
B. Eyes only
C. **Ears and eyes – primarily ears**
D. Ears and eyes – primarily eyes

Light

- Eyes similar to ears in many ways
- Light energy/waves, enter eyes (instead of air vibrations)
- Cornea and lens focuses the light on the back of the eye (instead of vibrations traveling along bones into cochlea).
- Energy is sensed by cone and rod cells (instead of hair cells)

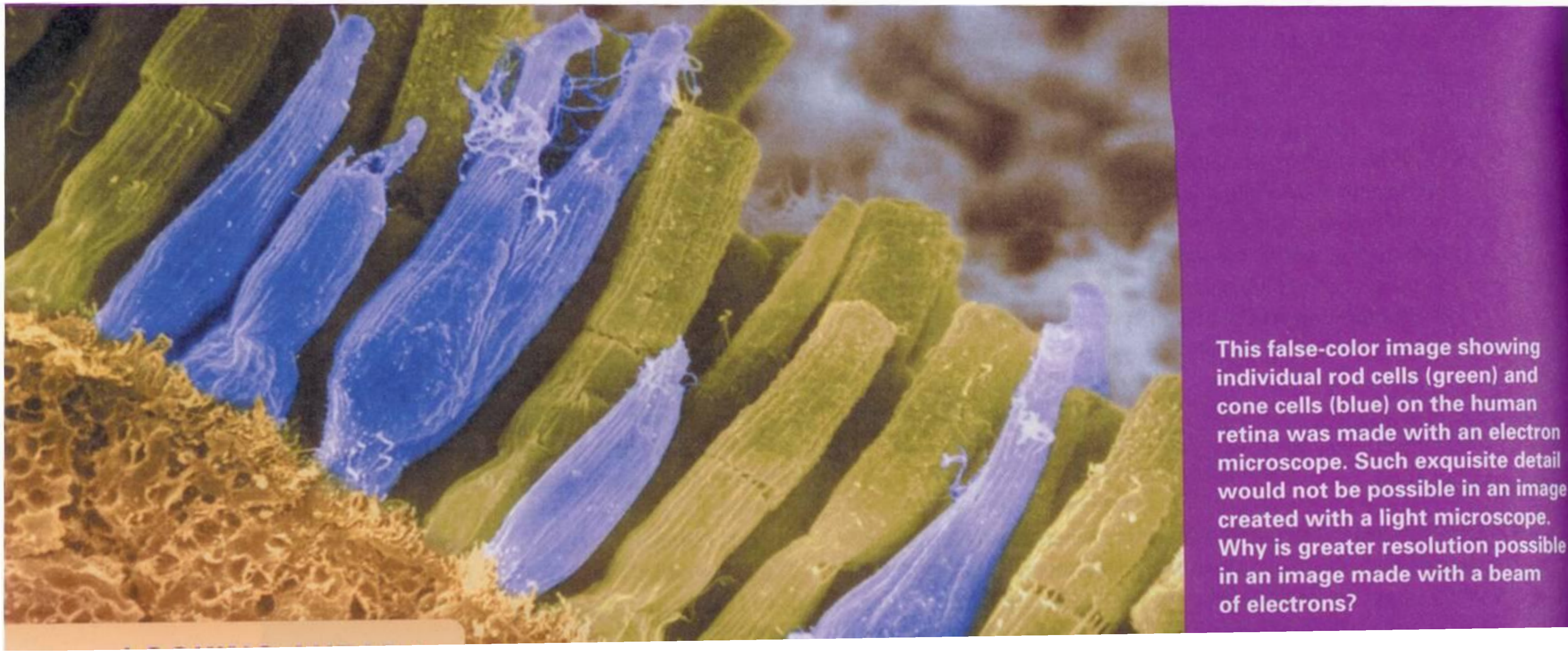
The Human Eye



Light

- Light energy/waves, enter eyes
- Cornea and lens focuses the light on the back of the eye
- Energy is sensed by cone and rod cells.

Rod Cells (green) – Cone Cells (blue)



False color image

Color Vision

In dim light, are cones or rods more sensitive?

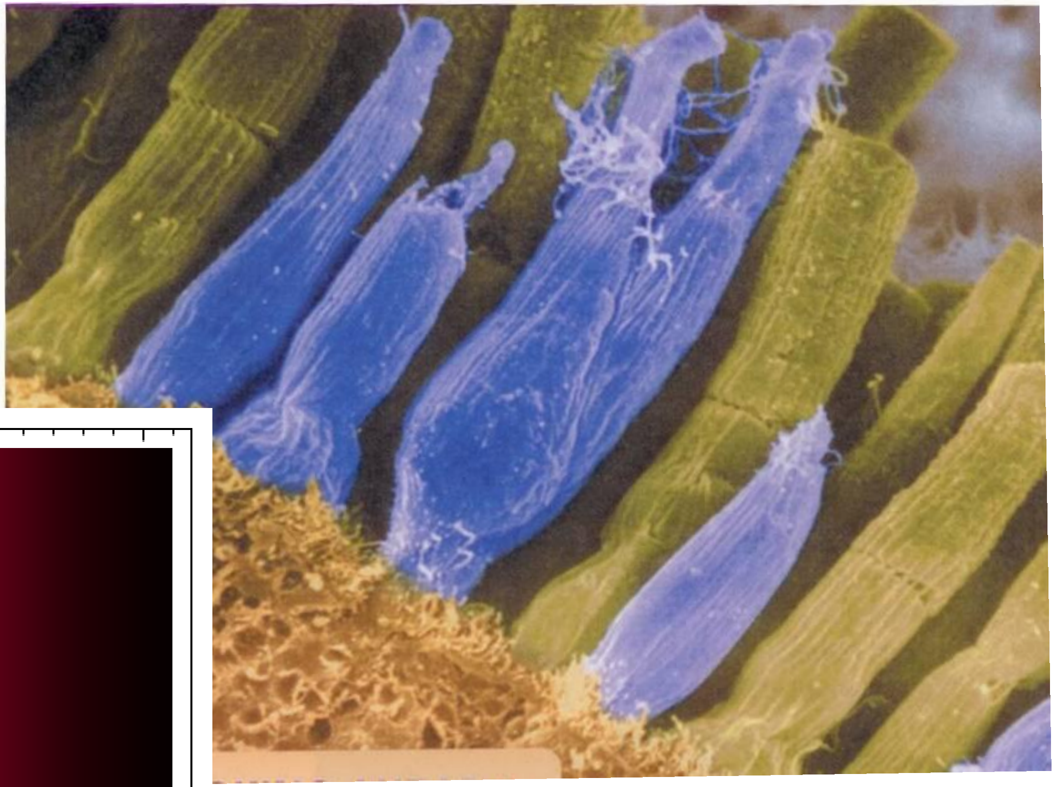
A. Cones

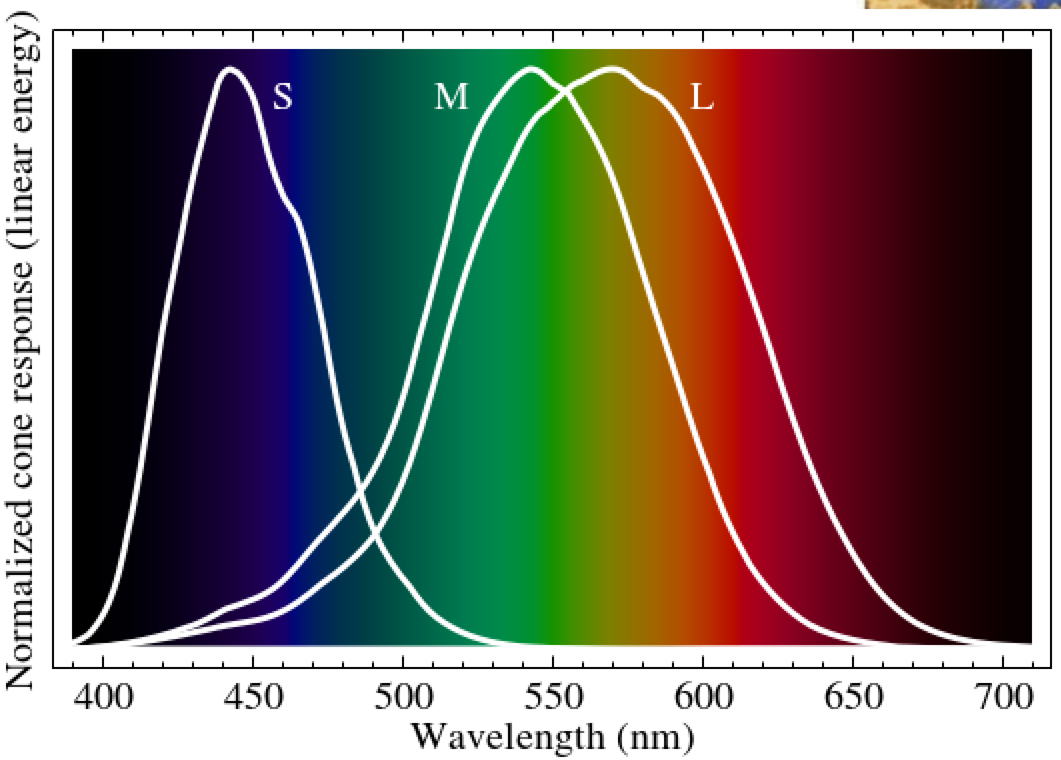
B. Rods

C. Equal

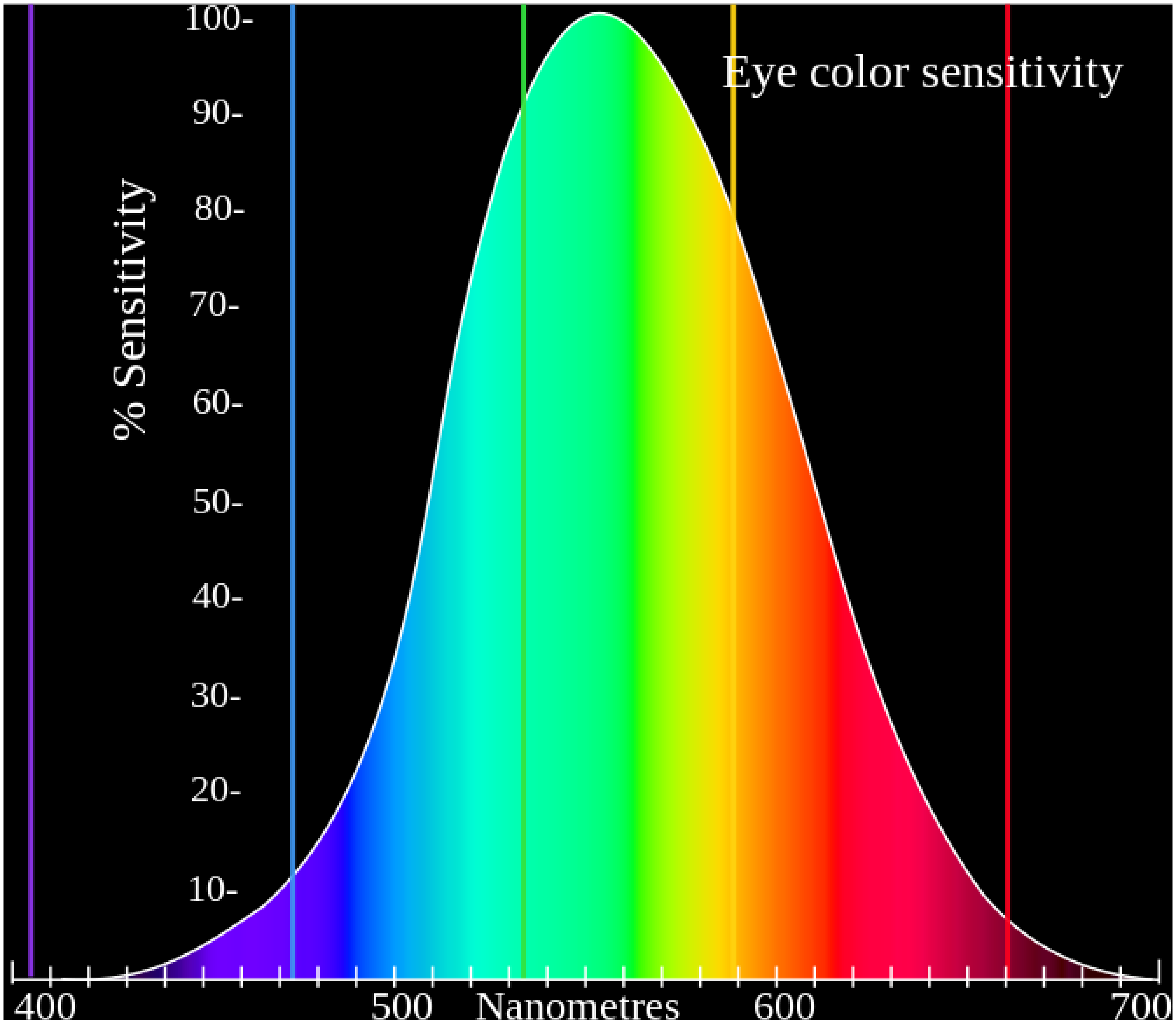
Cones – 3 types in humans

1. Sensitive to red
2. Sensitive to green
3. Sensitive to Blue





Color Sensitivity



Color Blindness

I. Most People
II. Red-blind
III. Green-blind
IV. Violet – blind
V. Totally color blind

Animal Color Vision

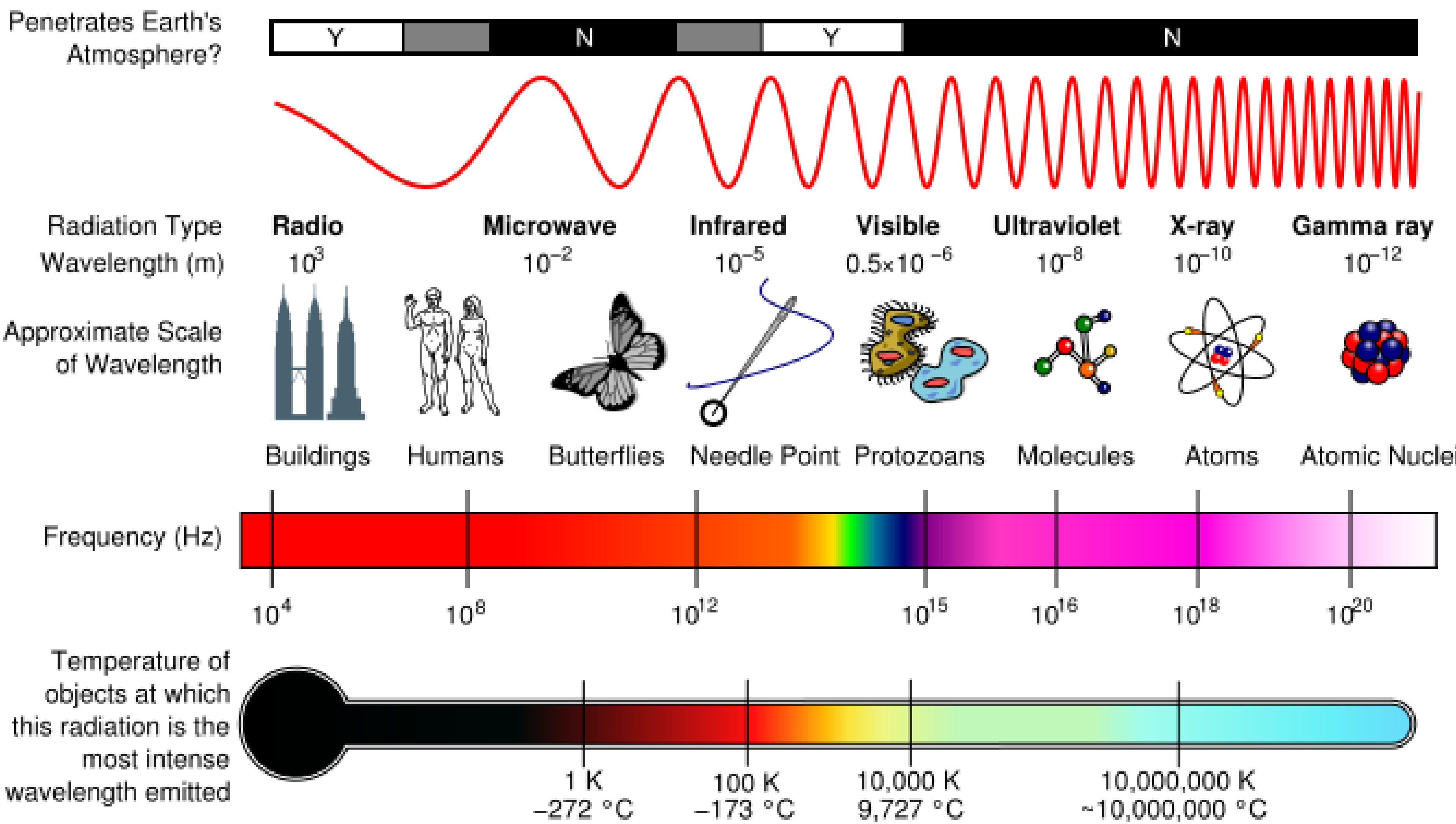
Color vision table

Name of state	Number of cone cells	Approx. number of colors perceived	Porters
Monochromacy	1	100	marine mammals, owl monkey, Australian sea lion, achromat humans
Dichromacy	2	10,000	most terrestrial non-primate mammals, color blind primates
Trichromacy	3	1 million	most primates, especially great apes (such as humans), marsupials, some insects (such as honeybees)
Tetrachromacy	4	100 million	most reptiles, amphibians, birds and insects, rarely humans
Pentachromacy	5	10 billion	some insects (specific species of butterflies), some birds (pigeons for instance)

The photo of the flower on the left shows how it appears to our eyes, in visible light. But there's more to the story! The false-color view of the flower on the right shows its appearance in the ultraviolet, beyond the range of human vision, revealing pigments we can't see. Whose eyes are these pigments intended for?

Electromagnetic waves

Here's another representation of Electromagnetic waves. This one shows you examples of the size of the different waves and at what temperature an object must be to emit these waves.



How was all this discovered?

One tiny bit at a time!

Galileo, an Italian astronomer and physicist, was the greatest contributor to our understanding of sound.

He demonstrated that the frequency of sound waves determined the pitch.

This was done by scraping a chisel across a brass plate producing a screech. Galileo then related the spacing of the grooves induced by the chisel to the pitch of the screech.

How was all this discovered?

One tiny bit at a time!

Leonardo DaVinci - (1500) discovered that sound travels in waves

Marin Mersenne - (1640) first measured the speed of sound in air.

Robert Boyle - (1660) discovered that sound waves must travel in a medium

Sir Isaac Newton - (late 1660's) relationship between the speed of sound and the density and compressibility of the medium.

Daniel Bernoulli - (mid 1700's) explained that a string could vibrate at more than one frequency.

Acousticians

- Architectural acousticians
- Instrument makers
- Concert hall designers
- Speech scientist
- Hearing specialist
- Medical acoustics
- Animal bioacousticians
- Underwater acousticians

Career Profiles

- Read a career profile
- Each person in the group describes their scientist to the rest of the group.