EDUCATIONAL ASSIGNMENT for JOSEPH JOHN WUNDERLICH for his 3rd trimester of 10th grade
This assignment covers the following Educational Objectives (Subjects marked with a "■" are the main subject, and those marked with an "□" are secondary subjects):

□ 1. READING (ENGLISH)
□ 2. WRITING (ENGLISH)
3. ALGEBRA 2
■ 4. CHEMISTRY
5. WORLD HISTORY
6. LATIN II
7. WORLD CULTURAL ARTS
8. PHYSICAL EDUCATION

***ASSIGNMENT**: Research Science in high technology*

JOSEPH'S WORK:

SUMMARY: Joseph was curious about this subject, so he researched it and brought all of the information below to his father – who then decided to make it into a lecture that Joseph participated in.

Human Vision Lecture

By Joseph Thomas Wunderlich III PhD ***and* Joseph John Wunderlich IV**
Elizabethtown College EGR/CS 230 Microcomputer Architecture

Many notes from ***Vsauce*** Video *"What is Video?"*
http://www.youtube.com/watch?v=buSaywCF6E8 plus added images and notes**:**

"**Beta Movement**" – if images move fast enough, the human brain can't comprehend them as separate images, so the illusion of motion is created.

- Initially, "MOVIES" with sequences of still photos recorded chemically on celluloid photographic film.
- Now, **VIDEO** (Latin: "I see"), is a sequence of electronic images captured at a FRAME RATE (in **F**rames **P**er **S**econd)
- But human eye & brain is different; brain receives a continuous stream of electrochemical data in response to photons incident on retina in eye, as we track objects.
- Visual Cortex of Brain holds info for ~1/15th second, so if images change more than 15 times per second, the "Beta Movement" effect results in our thinking there is smooth motion. (i.e. if an animation moves faster than 15 Frames per sec, it will look fluid).

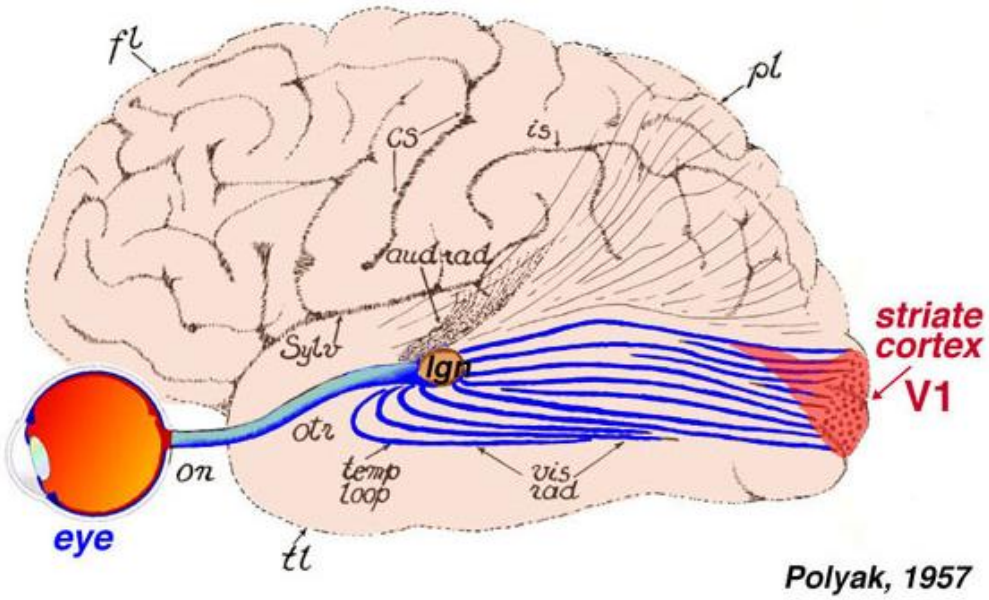


Figure 8. Visual input to the brain goes from eye to LGN and then to primary visual cortex, or area V1, which is located in the posterior of the occipital lobe.
Adapted from Polyak (1957).
Image from: http://webvision.med.utah.edu/imag eswv/capas-cortex.jpg

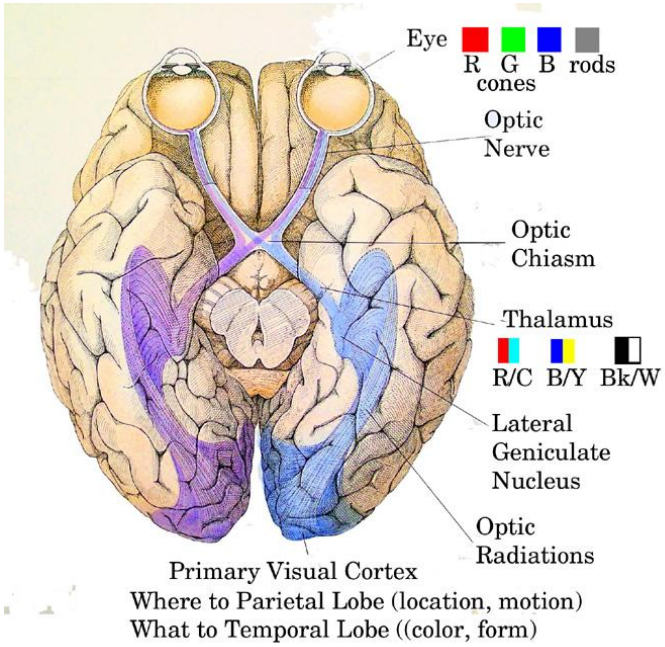


Image from:
http://artguildct.org/AGCT%20Program%20Folders/2005%20folders/2005%2011%20Bill%20Franklin/BF%201b%20DH%20p061%20pathway%20from%20eyes%20to%20primary%20visual%20cortex%204405.jpg

Humans will get a headache when watching video's with too high of a frame rate (some as high as 1000FPS) because digital capture does not typically add "MOTION BLUR" like the human brain does to really fast moving objects.

The following is from https://www.youtube.com/watch?v=4I5Q3UXkGd0 plus some added notes**:**
(Notes on *Vsauce* Video *"What is the Resolution of the Eye?"*)

RESOLUTION compared to a camera or screen:
Typical electronic resolution is measured by number of pixels:

- **VHS** Tapes: **480 pixels x 320 pixels** = 153,600 = 0.15 Megapixels
- Standard Laser Disc **CD** (Compact Disc): **570 x 480** = 273,600 = 0.27 Megapixels
- **DVD** (Digital Video Disc) CD: **720 x 480** = 345,600 = 0.35 Megapixels
- **Blue Ray** CD **1280 x 720** = 921,600 = 0.92 Megapixels
- **IMAX 1000 x 7000 = 7 Megapixels**

But, resolution is more about **distinguishing fine details** which includes more than the pixel density. and is a function of:

1. Number of pixels
2. Amount of light
3. Size of sensors
4. What the millions of pixels are encoding →

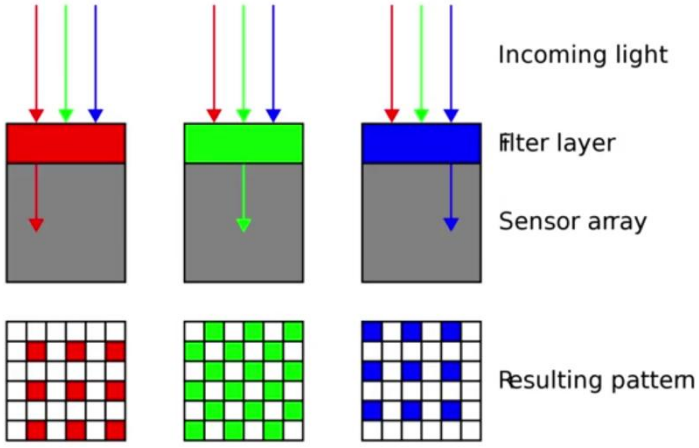
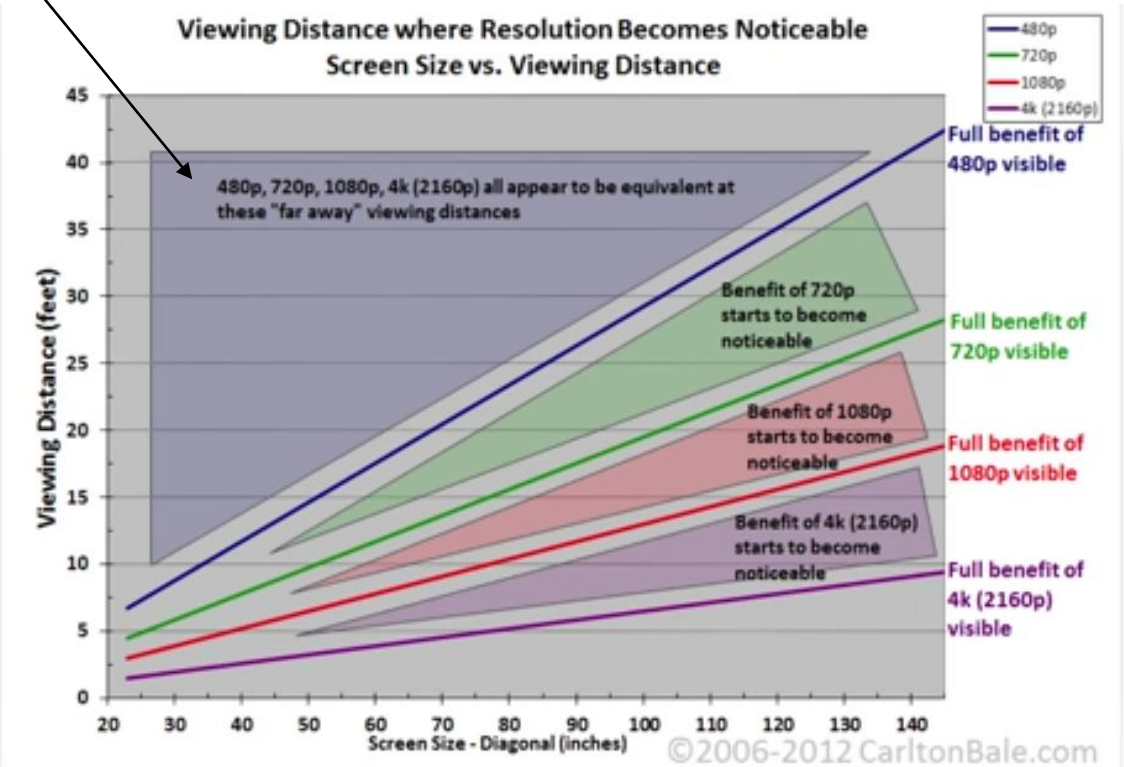


Image from https://www.youtube.com/watch?v=4I5Q3UXkGd0

5. How close the object is
    - Some things clearly seen up close, blend into background at a distance
    - On a small enough screen, from far enough away, low and high resolutions on screen aren't resolved differently by human eye:



from the very helpful: carltonbale.com/1080p-does-matter

Image from https://www.youtube.com/watch?v=4I5Q3UXkGd0

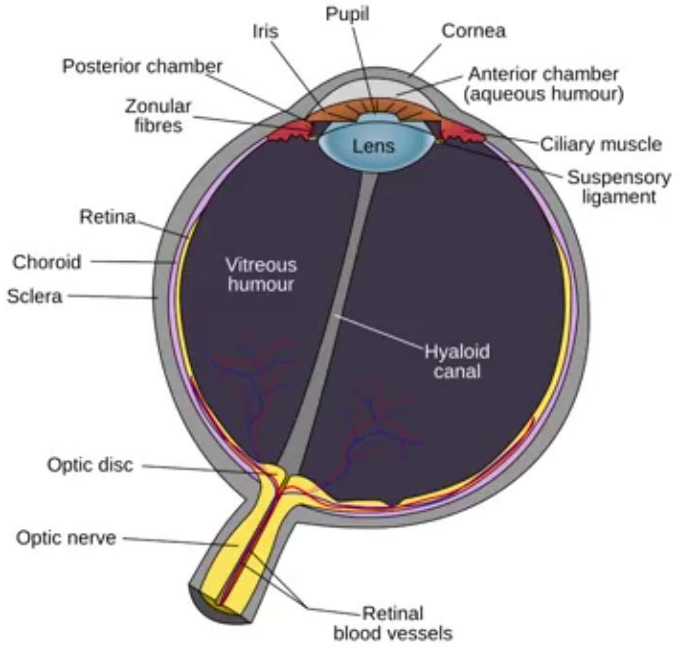
6. **Spatial Resolution:** How different nearby pixels are.
    - For example, if you keep number of pixels the same, but go **out of focus**

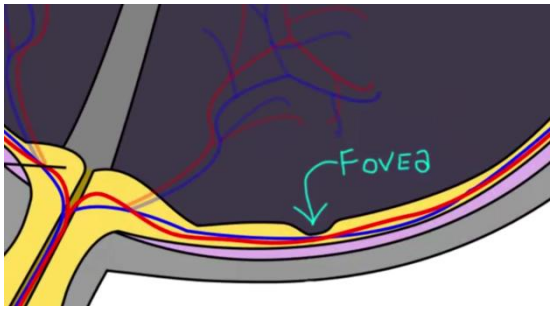
A better question than "*What is the Resolution of the Eye*" for comparing human vision to a digital image is:

"How many pixels on a screen do you need to fill your entire field of view, and make it look like real life, without any detectable pixilation ?"

HOWEVER, a camera captures an entire frame at once but**:**

1. **Our eyes move and our brain amalgamates a constant stream of info,**
2. The **info we capture** in a single glance is actually **very poor** compared to a camera
3. **We filter** out info that we don't care about, or that doesn't change (glasses. nose)
4. We **only** receive **high-quality info (20-20 vision and optimal color vision) in the center <u>2 degrees of our field of view</u>**; controlled by the "Fovea" (Lain: "Pitfall") part of the retina.





Images from: https://www.youtube.com/watch?v=4I5Q3UXkGd0

5. We have a **blind spot** (where optic nerve connects to retina)

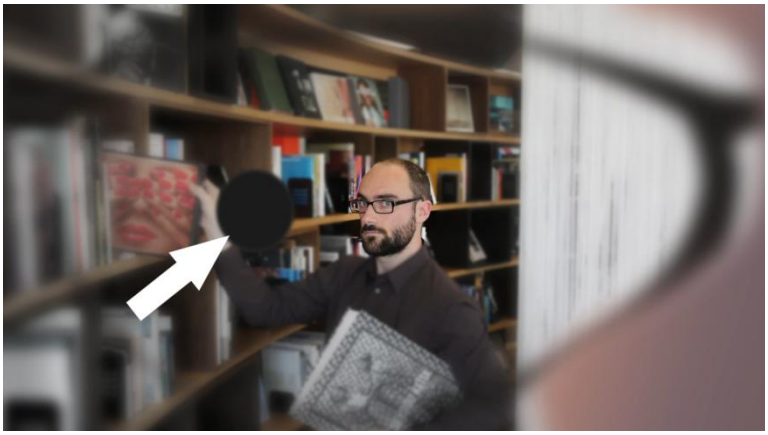


Image from: https://www.youtube.com/watch?v=4I5Q3UXkGd0

We compensate for all of this by:

A. Our eyes constantly moving; dragging foveal resolution wherever we need it
B. Our brain's complex visual system fills in details by:
   - Merging images from both eyes
   - Making guesses

SO, OUR VISION IS NOT LIKE A CAMERA ! *But we can still answer the question:* "<u>How many pixels on a screen do you need to fill your entire field of view, and make it look like real life, without any detectable pixilation</u> ?"

Although we can view Text, Shapes, and Colors differently at varied fields of view:

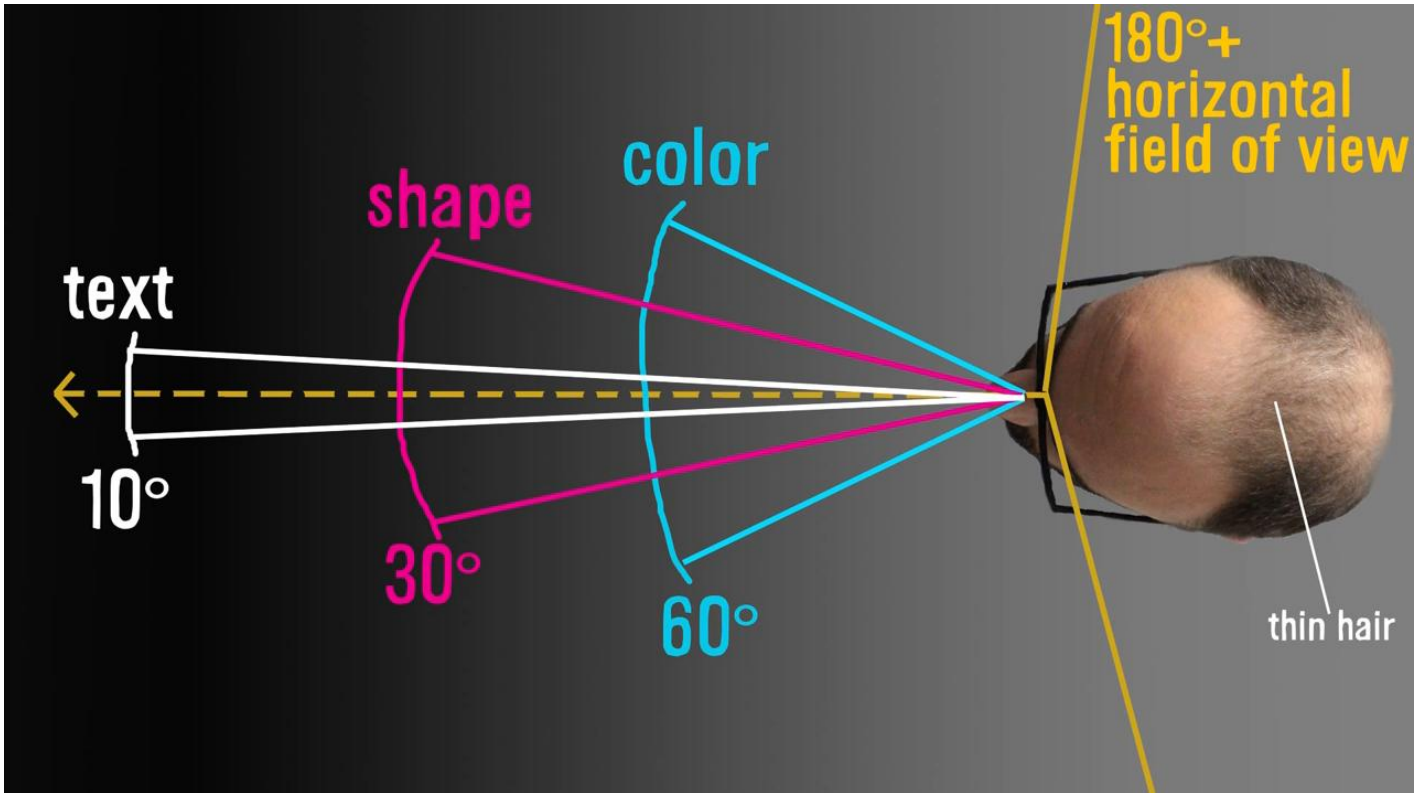


Image from: https://www.youtube.com/watch?v=4I5Q3UXkGd0

in
https://mail.etown.edu/owa/auth/logon.aspx?replaceCurrent=1&url=https%3a%2f%2fmail.etown.edu%2fowa%2f
assumptions are made to estimate a complete life-like field of view at all times in a 120 degree field of view (even though we can see somewhat for 180+ degrees in our peripheral vision) of **576 Megapixels**

However, considering our Fovea, only **7 Megapixels** of high-quality info are packed into those 2 degrees of view., and since we constantly move our eyes around, it is estimated that we only need those 7 Megapixels (where we are looking at) to be completely rendered, plus only one more Megapixel to keep track of our remaining field of view.

Also, there is no evidence *(this requires further research)* that anybody has a complete photographic memory; And most people only store a very small fraction of what they are looking at, So there is no analogy in the brain to a saved high-resolution image file.

And we typically don't discrete-ize our experiences and memories like images and videos.