LIGHT AND OUR VISION

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The word **Light** usually refers to **visible light**, which is the part of the spectrum that can be seen by the human eye, for our sense of sight.
The main source of light on Earth is the Sun, which is a medium size star.

It is about 93,000,000 (93 million) miles away from Earth and so far away that light from it, traveling at 186,000 miles per second, takes about 8 minutes to reach us.

Sunlight provides the energy that green plants use to create sugars mostly in the form of starches, which release energy into the living things that digest them.

This process of photosynthesis provides virtually all the energy used by living things.
Historically, another important source of light for humans has been fire, from ancient campfires to modern kerosene lamps.

With the development of electric lights and power systems, electric lighting has effectively replaced firelight such as this cool photo of Hong Kong at night.
Some species of animals generate their own cold light, a process called bioluminescence.

For example, fireflies use their light to locate mates.

Thousands of species of Life in the oceans produce different types and color of light.
The Visible Spectrum - The human eye and visual system is sensitive to only a small portion of the total energy range.

The lining of the eye, the retina, contains light sensitive **Cone and Rod cells** which detect specific, but somewhat overlapping, ranges of the visible spectrum.

The human eye can see differences between 8 and 12 million colors.
Above the range of visible light, ultraviolet light becomes invisible to humans, mostly because it is absorbed by the cornea and the internal lens of the eye.

Furthermore, the rods and cones located in the retina of the human eye cannot detect the very short ultraviolet wavelengths and are in fact damaged by ultraviolet.

Many animals with eyes that do not require lenses (such as insects and shrimp) are able to detect ultraviolet light.

Under ideal laboratory conditions, people can see infrared and children and young adults may see ultraviolet wavelengths.
When you buy a pair of good sunglasses, be sure they protect your eyes from the 3 types of Ultraviolet light:

**UVC** - These are the highest energy UV rays and potentially could be the most harmful to your eyes and skin. Fortunately, the atmosphere's ozone layer blocks virtually all UVC rays.

**UVB** - They have slightly longer wavelengths and lower energy than UVC rays. Its radiation stimulates the production of melanin (a skin pigment), causing the skin to darken, creating a suntan.

But in higher doses, UVB rays cause sunburn that increases the risk of skin cancer. UVB rays also cause skin discolorations, wrinkles and other signs of premature aging of the skin.
UVA – **These rays** are closer to visible light rays and have lower energy than UVB and UVC rays. But they can pass through the cornea and reach the lens and retina inside the eye.

Overexposure to UVA radiation has been linked to the development of certain types of cataracts, and research suggests UVA rays may play a role in development of macular degeneration.
Solar radiation

- 5% UV
  - UVB
  - UVA
- 50% VIS
- 45% IR

epidermis

dermis

hypodermis

**ZINC OXIDE**

provides broad-spectrum (UVA/UVB) coverage, blocking 97% of the sun’s harmful rays.

This is important because UVA rays can prematurely age your skin, whereas UVB rays can burn your skin.
It is also interesting that certain insects and other living things, have color when you shine an Ultraviolet (UV) light on them.

Other living things in those same categories, can see Ultra-Violet light, to identify each other or sense a predator that glows.
The ability to see ultraviolet (UV) helps guide bees to the pollen containing parts of flowers.
The fovea and foveal pit are where visual acuity and color vision are the best because of the high concentration of cones. The fovea is located directly opposite the eye's lens system for optimum focusing.

Cells of the retina perform the initial processing of images and transmit the resulting neural impulses to the brain via the optic nerve. The retina of each eye has approximately 126 million receptor cells: 120 million rods and 6 million cones.

Rods are responsible for our night vision and cones for our day and color vision.
Outer segment of rod cell containing photosensitive chemicals

Nucleus

Rod

Outer segment of cone cell containing photosensitive chemicals

Nucleus

Cone
Cones - provide "photopic" or high acuity vision.

Provide our day vision

Produce high resolution images

Determine overall brightness or darkness of images

Provide our color vision, by means of three types of cones:

"L" or red, Long wavelength sensitive

"M" or green, Medium wavelength sensitive

"S" or blue, Short wavelength sensitive
Rods - provide "scotopic" or low intensity vision.

Provide our night vision ability for very low illumination.

Are a thousand times more sensitive to light than cones.

Are much slower to respond to light than cones.

Are distributed primarily in the periphery (outside) of the visual field.
Here we see the Mesopic region where both the rods and cones are functioning.

The lower light level allows the rods to replenish the light sensitive rhodopsin and begin functioning.

The cone receptors (red, green and blue) still have enough light to provide some amounts of color vision.

This occurs in moderately low light levels, like right after sunset.
Lighting or illumination is the deliberate use of light to achieve a practical or aesthetic effect. Lighting includes the use of both artificial light sources like lamps and light fixtures, as well as natural illumination by capturing daylight.

The image below shows some of the lighting on the Earth, at night, from the International Space Station.
HOW OUR VISION WORKS

Light travels from our eye to our Brain

Optic nerve
Made up of axons of ganglion cells, it carries neural messages from each eye to the brain

Optic chiasm
Point where part of each optic nerve crosses to the other side of the brain
The **occipital lobe**, at the back of the brain (shown in red in the top image), is one of the four major lobes of the cerebral cortex in the brain of mammals.

It is the visual processing center of our brain.
The temporal lobes (shown in red) are involved in processing sensory input into meaning, from our sight, hearing, visual memories, language comprehension, and emotional associations about them.
Note that our relaxed line of sight is not horizontal but actually tilts downward from 5 to 15 degrees.

Also, note the angle of sight for the various colors, for their maximum visibility.
THE SPEED OF LIGHT

The speed of light in a vacuum is defined to be exactly 299,792,458 meters per second (approx. 186,282 miles per second).

All forms of electromagnetic radiation (Infra-Red, Ultraviolet, etc.) move at exactly this same speed in a vacuum.
Light behaves both as a particle (photon) and as a wave.

Since the days of Einstein, scientists have been trying to directly observe both of these aspects of light at the same time.

Now, scientists have succeeded in capturing the first-ever snapshot of this dual behavior, which shows particles on the left moving upwards to the right and changing into waves.

[Visit this YouTube video for a visual demonstration: https://www.youtube.com/watch?time_continue=1&v=mlaVHxUSiNk]
TYPES OF VISION PROBLEMS

Most Common Adult Vision Problems

Blurred vision (called refractive errors) such as Nearsightedness, Farsightedness, Astigmatism, and Presbyopia

Age-related macular degeneration

Glaucoma

Cataract

Diabetic retinopathy

Most Common Childhood Vision Problems

Blurred vision (called refractive errors)

Crossed eyes (called strabismus)

Lazy eye (called amblyopia)
The most common vision problems are refractive errors, more commonly known as nearsightedness, farsightedness, astigmatism and presbyopia.

Refractive errors occur when the shape of the eye prevents light from focusing directly on the retina.

The length of the eyeball (either longer or shorter), changes in the shape of the cornea, or aging of the lens can cause refractive errors.

Most people have one or more of these conditions.
What is refraction?

Refraction is the bending of light as it passes through one object to another.

Vision occurs when light rays are bent (refracted) as they pass through the cornea and the lens. The light is then focused upside-down, on the retina.

The retina converts the light-rays into messages that are sent through the optic nerve to the brain. The brain interprets these messages into the images we see.
An Archer fish has to accurately compensate for the refraction in the water, when it squirts water to knock a bug down from a leaf.
WHAT ARE THE DIFFERENT TYPES OF REFRACTIVE ERRORS?

The most common types of refractive errors are nearsightedness, farsightedness, astigmatism and presbyopia.

**Nearsightedness** (also called myopia) is a condition where objects up close appear clearly, while objects far away appear blurry.

With nearsightedness, light comes to focus in front of the retina instead of on the retina.
Farsightedness, also known as hyperopia, is when the focused image is in back of the retina, instead of on it.

It is a common type of refractive error where distant objects may be seen more clearly than objects that are near.

Some people may not notice any problems with their vision, especially when they are young.

For people with significant farsightedness, vision can be blurry for objects at any distance, near or far.
Astigmatism is a common type of refractive error. It is a condition in which the cornea of the eye isn’t fully round so light doesn’t focus evenly onto the retina, the light-sensitive tissue at the back of the eye.

The cornea of a normal eye is curved like a basketball, with the same degree of roundness in all areas.

An eye with astigmatism has a cornea that is curved more like a football, with some areas that are steeper or more rounded than others. This can cause images to appear blurry and stretched out.
Presbyopia is a common type of vision disorder that occurs as you age.

Presbyopia results in the inability to focus up close, a problem associated with refraction in the eye.

The eye is not able to focus light directly on to the retina due to the hardening of the natural lens.

Aging also affects muscle fibers around the lens making it harder for the eye to focus on up close objects.

The ineffective lens causes light to focus behind the retina, causing poor vision for objects that are up close.
DIABETIC RETINOPATHY (DR)

All people with diabetes, both type 1 and type 2, are at risk for DR.

It is caused by damage to blood vessels in the back of the eye (retina). The longer someone has diabetes, the more likely he or she will get DR.

People with this condition may not notice any changes to their vision until the damage to the eyes is severe. This is why it is so important for people with diabetes to have a comprehensive eye exam every year.

Warning signs of diabetic retinopathy includes blurred vision, gradual vision loss, floaters, shadows or missing areas of vision, and difficulty seeing at nighttime.

<table>
<thead>
<tr>
<th>Normal vision</th>
<th>Vision with diabetic retinopathy</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Normal Vision" /></td>
<td><img src="image2.png" alt="Vision with diabetic retinopathy" /></td>
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</tbody>
</table>
AGE-RELATED MACULAR DEGENERATION (AMD) – It is a disease that blurs the sharp, central vision needed to see straight-ahead.

It affects the part of the eye called the macula that is found in the center of the retina. The macula lets a person see fine detail and is needed for things like reading and driving.

The more common dry form of AMD can be treated in the early stages to delay vision loss and possibly prevent the disease from progressing to the advanced stage. Taking certain vitamins and minerals may reduce the risk of developing advanced AMD.

The less common wet form of AMD may respond to treatment, if diagnosed and treated early.
GLAUCOMA - There are different types of glaucoma, but all of them cause vision loss by damaging the optic nerve.

Glaucoma is called the “sneak thief of sight” because people don’t usually notice a problem until some vision is lost.

The most common type of glaucoma happens because of slowly increasing fluid pressure inside the eyes.

Vision loss from glaucoma cannot be corrected. But if it is found early, vision loss can be slowed or stopped. A comprehensive eye exam is important so glaucoma can be found early.
CATARACT

A cataract is a clouding of the lens of the eye.

It often leads to poor vision at night, especially while driving, due to glare from bright lights.

Cataracts are most common in older people, but can also occur in young adults and children.

Cataract treatment is very successful and widely available.
COLOR BLINDNESS - It can be of many types ranging from:

1) Very slight difficulties in discriminating different colors
2) Difficulties in seeing red or green or both
3) Inability to see blue, and/or
4) The total absence of color vision.

Color vision also changes with age.

As the lens of the eye yellows, it absorbs short wavelengths and reduces our ability to see blue.

Also, the amount of light entering the eye is reduced, so that all colors appear dimmer.

[Color Vision Test Images]

**Color Vision Test**  Normal color vision = "5"  Red/Green color deficiency = "2"

[Link to Youtube Video]
Red-green color vision defects are the most common form of color vision deficiency. It occurs in about 1 in 12 males and 1 in 200 females.

**Blue-yellow** color vision defects affect males and females equally. This condition occurs in fewer than 1 in 10,000 people worldwide.

**Blue cone** monochromacy is rarer than the other forms of color vision deficiency, affecting about 1 in 100,000 people worldwide, affecting males much more often than females.

The absence of seeing colors is called **Monochromacy** and is very rare.
<table>
<thead>
<tr>
<th>What People With Regular Vision See</th>
<th>What Red-Green Color Blind People See</th>
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</thead>
<tbody>
<tr>
<td>25</td>
<td>25</td>
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<td>29</td>
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<td>45</td>
<td>56</td>
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</table>
Normal color vision

Red-green confusion, a form of “color blindness”
GREEN COLOR-BLINDNESS

NORMAL VISION
DEUTERANOMALY

RED COLOR-BLINDNESS

PROTANOPIA
TRITANOPIA

BLUE COLOR-BLINDNESS
For most individuals viewing the example on the left, below, "red" will appear closer.

However, thirty percent (30%) will perceive "blue" as closer, and ten percent (10%) will perceive both as being in the same plane.

The examples also show that these pure colors should never be used with each other, as they are difficult to look at and make the eyes tired quickly.

The pure red primary should never be used on a pure blue primary background.

This generates chromostereopsis or depth through color perception. It also creates reading difficulties.

The pure blue primary should never be used on a pure red primary background.

This generates chromostereopsis or depth through color perception. It also creates reading difficulties.
15I'7 17 4M4Z1IG 7H47
Y0U C4I R34D 7H15 3V3I
7H0UGH 0ILY 4
M1I0R17Y 0F 7H3
"L3773R5" 4R3 C0RR3C7?
7H3 И30C0R73X 15
4M4Z1IG! 4IN D0 Y0U
I071C3 7H47 R34D1IG
7H15 B3C0M35 M0R3
4UT0M4T1C 45 Y0U G0
4L0IG? 7H15 15 7RU3
3V3I 7H0UGH R1GH7 I0W
Y0U 4R3 U1L1K3LY 70 B3
C0I5C10U5 0F WH1CH
5YMB0L5 4R3 R3PL4C1IG
WH1CH L3773R5.
SO WHY IS THE TEXT SO EASY TO READ?

According to research at Cambridge University, it doesn't matter in what order the letters in a word are, the only important thing is that the first and last letter be at the right place. The rest can be a total mess and you can still read it without problem. This is because the human mind does not read every letter by itself, but the word as a whole.
THE GOLDEN RATIO

By making a rectangle where the ratio between the long and short sides is 1.618034, called by the Greek letter Phi, $\Phi$, we create a golden rectangle, like the one in the middle, below!

Most people would select it, out of the 3 examples, because it is the most pleasing to the eye. The number has fascinated generation after generation, and culture after culture.

It is also known as the Golden Section, Number, Spiral, or the Divine Proportion.
Leonardo Fibonacci discovered a mathematical series which converges on the number phi. $\Phi$

He started with 0 and 1, and then each new number in the series is simply the sum of the two before it.

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, . . .

The ratio of each successive pair of numbers in the series approximates phi (1.618. . .), as 5 divided by 3 is 1.666..., and 8 divided by 5 is 1.60. After the 40th number in the series, the ratio is accurate to 15 decimal places.

1.618033988749895
The significance of Phi and the Fibonacci number series is that they correspond to all kinds of growth processes in Nature, including in our own bodies.
In each of the red/blue bars shown in the figure, the red portion of that bar is to the blue proportion in the same ratio as 1 is to 1.6180339887.

This never-ending number is called the "Divine Proportion" and is symbolized by the Greek letter, phi (ϕ).

\[
\frac{BD}{AB} = \phi; \quad \frac{EF}{DE} = \phi; \quad \frac{DG}{AD} = \phi; \\
\frac{CF}{FG} = \phi; \quad \frac{CD}{DE} = \phi;
\]

Beyond those shown here, other divine proportionalties also exist. For example, the width of the lips is in divine proportion to the width of each eye, the width of the shoulders is in divine proportion to the width of the waist and so on.
Vitruvian Man – Leonardo da Vinci

Vitruvius

A Roman architect.

In his book, he claimed that a temple should be based on human proportion, because the human body is the model of perfection.
ASTON MARTIN SPORTS CARS
There is always a reason for Beauty
The concentric circles follow Golden Ratio

Yep, that's a $221M design ladies & gents!
What are pixels?

The term *pixel* is short for "picture element", and pixels are the tiny building blocks that make up all digital images.

Much like how a painting is made from individual brush strokes, a digital image is made from individual pixels.

But like any good magic trick, what we're seeing is really an illusion. And to break the illusion, we just need to look closer. To view the individual pixels in an image, all we need to do is zoom in.
Clicking a few times on one of the woman's eyes, lets us zoom in on it.

if I zoom in close enough, we start seeing that what looked like a continuous image is really a bunch of tiny squares. These squares are the pixels:
If we zoom in even closer, we see that each pixel displays a single color.

The entire image is really just a grid of solid-colored squares.

When viewed from far enough away, our eyes blend the colors together to create an image with lots of detail., but up close, it's pixels that create our digital world.
Most Smart Phones have 8 – 12 Megapixels for taking digital pictures. With this number, you can print out a good quality picture but you can’t zoom in on the picture very much until you start to see pixels.

Here are some typical examples:
Stepwise magnification by 6% per frame into a 39-megapixel image.

In the final frame, at about 170x, an image of a bystander is seen reflected in the man's cornea.

https://www.youtube.com/watch?v=ey4UGvBljy0
This illustration shows how much magnification can be reached with a close circuit TV system, for scanning cities for suspicious people.

The distance to the man is 3 soccer fields!!
USING A LONG ZOOM ON A CAMERA WITH 53,000 MEGAPIXELS, TO FLY DOWN TO SEE THE LOGO OF A BENTLEY CAR, ON THE INSIDE

https://www.youtube.com/watch?v=XMTd3bYenu8
OR LOOKING DEEP INTO A WOMAN’S EYE?

https://www.youtube.com/watch?v=0vnA_KlojLg
SO FAR IN THE PHOTO PRESENTATIONS, WE HAVE PROGRESSED FROM SMART PHONES WITH MAGNIFICATION ABILITIES OF 8 – 12 AND 36 MEGAPIXELS. (MILLION PIXELS)

WHAT IF WE COULD GO TO SHANGHAI, CHINA AND LOOK THROUGH A MAGNIFYING DEVICE THAT HAS 195 BILLION PIXELS?

http://sh-meet.bigpixel.cn/?from=groupmessage&isappinstalled=0
The Hubble telescope using 1.5 billion pixels of magnification, took this photo which is just part of the Andromeda galaxy.

The image shows over 100 million stars and star clusters. Andromeda is our closest neighbor galaxy and is 2.6 million light years away!!

https://www.youtube.com/watch?v=udAL48P5NJU