# Work Environment Design

## Introduction to Ergonomics

Chapter 9-11

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# Value of Good Environment

- Plants with good working conditions outperform those with poor conditions
- Economic return on investment in better conditions is usually significant
- Good environment enables
  - Improves safety and morale
  - Reduces turn-over
  - Increases profitability
  - Reduces absenteeism
  - Improves convenience
  - Increases efficiency

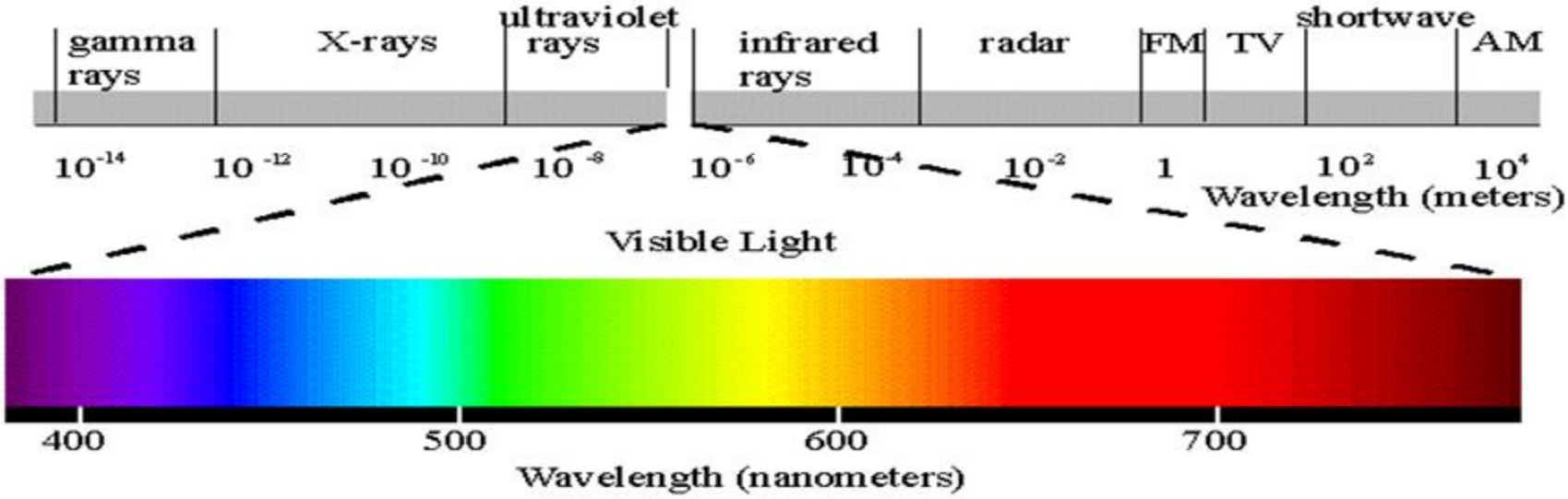
# Work Environment Design

- Temperature
- Lighting
- Noise
- Work Shifts
- Overtime

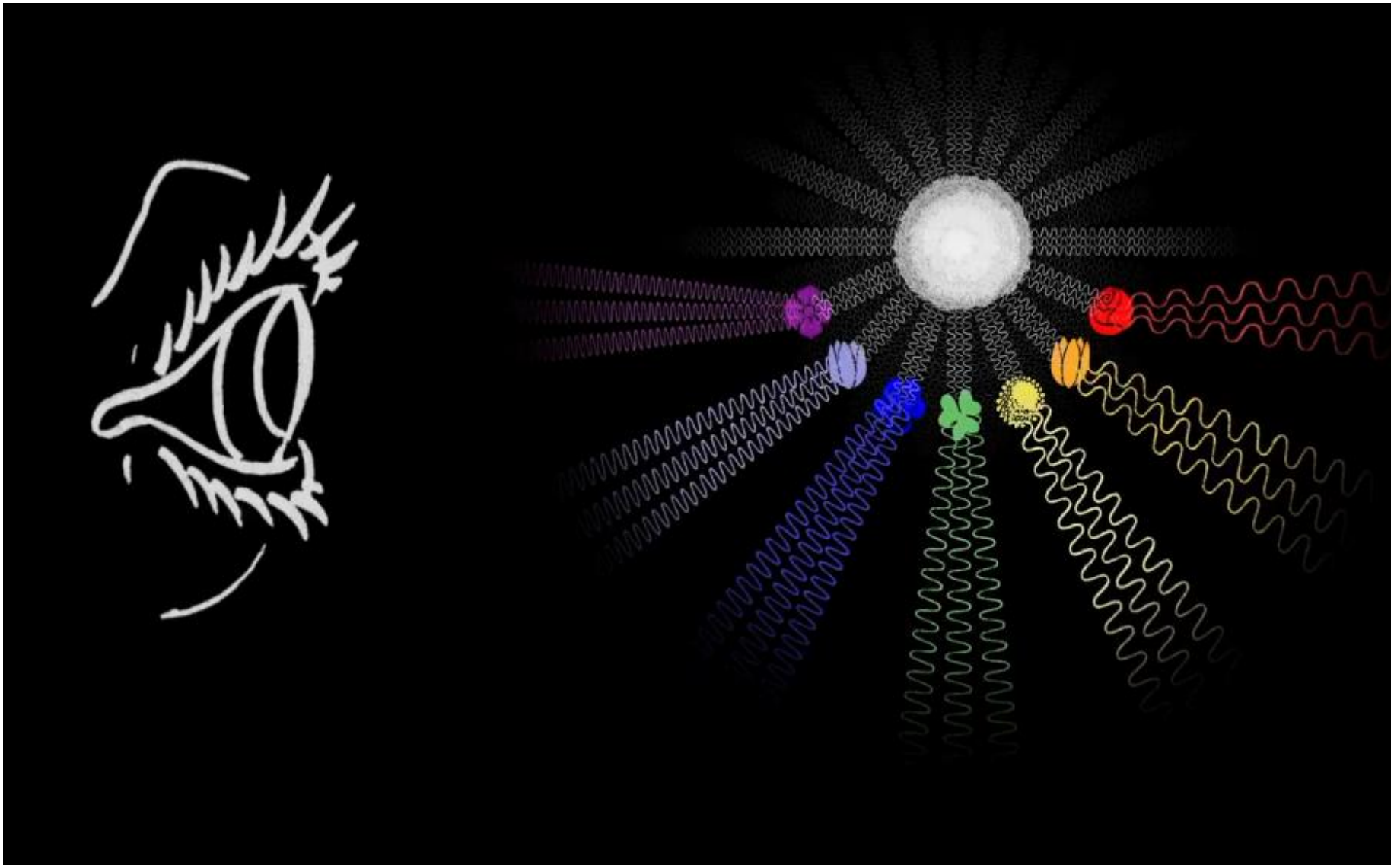
# Lighting

# Light

- Light is electromagnetic radiation that is visible.
- The electromagnetic spectrum is extremely wide but the visible part is extremely narrow.



# Light



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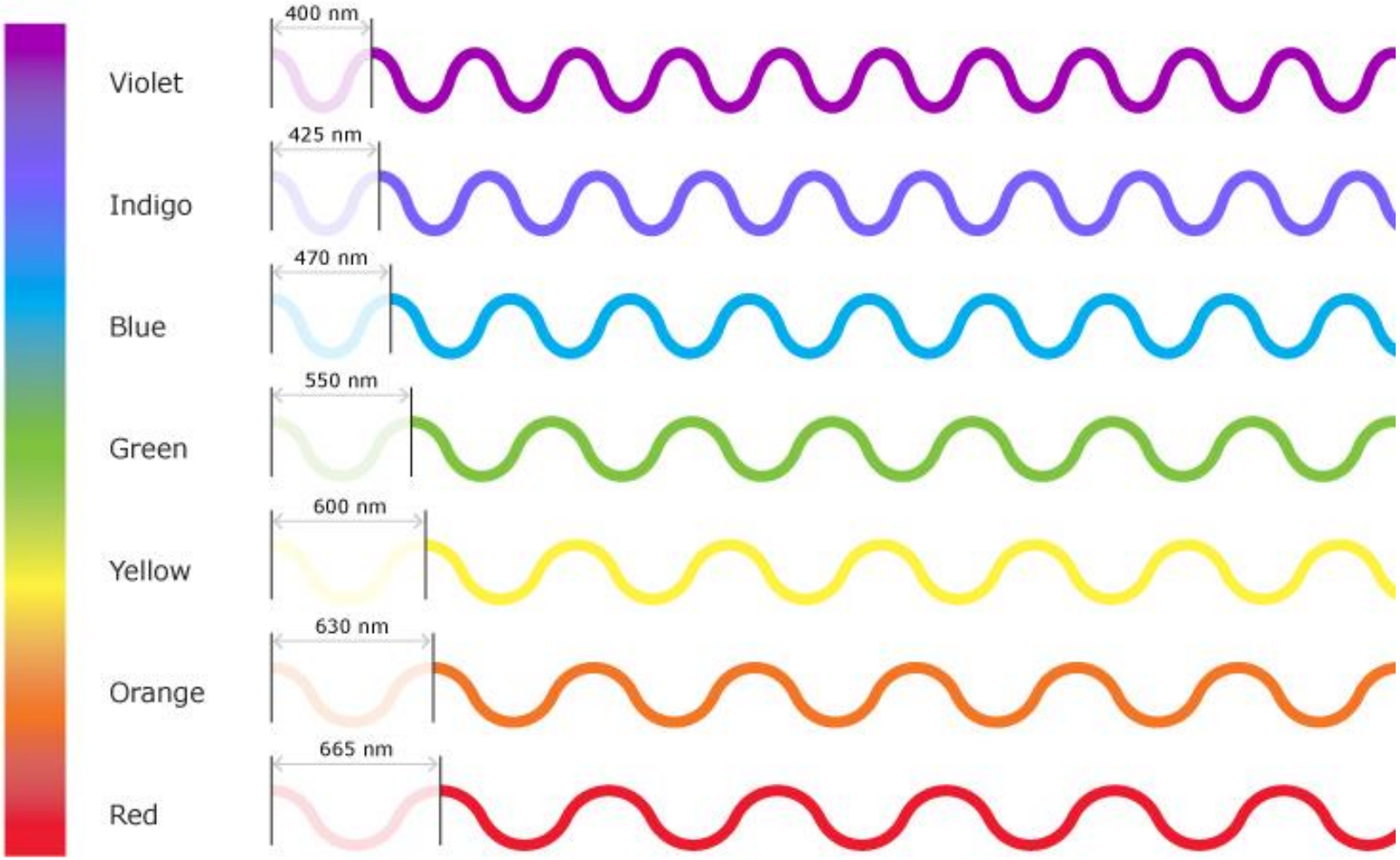
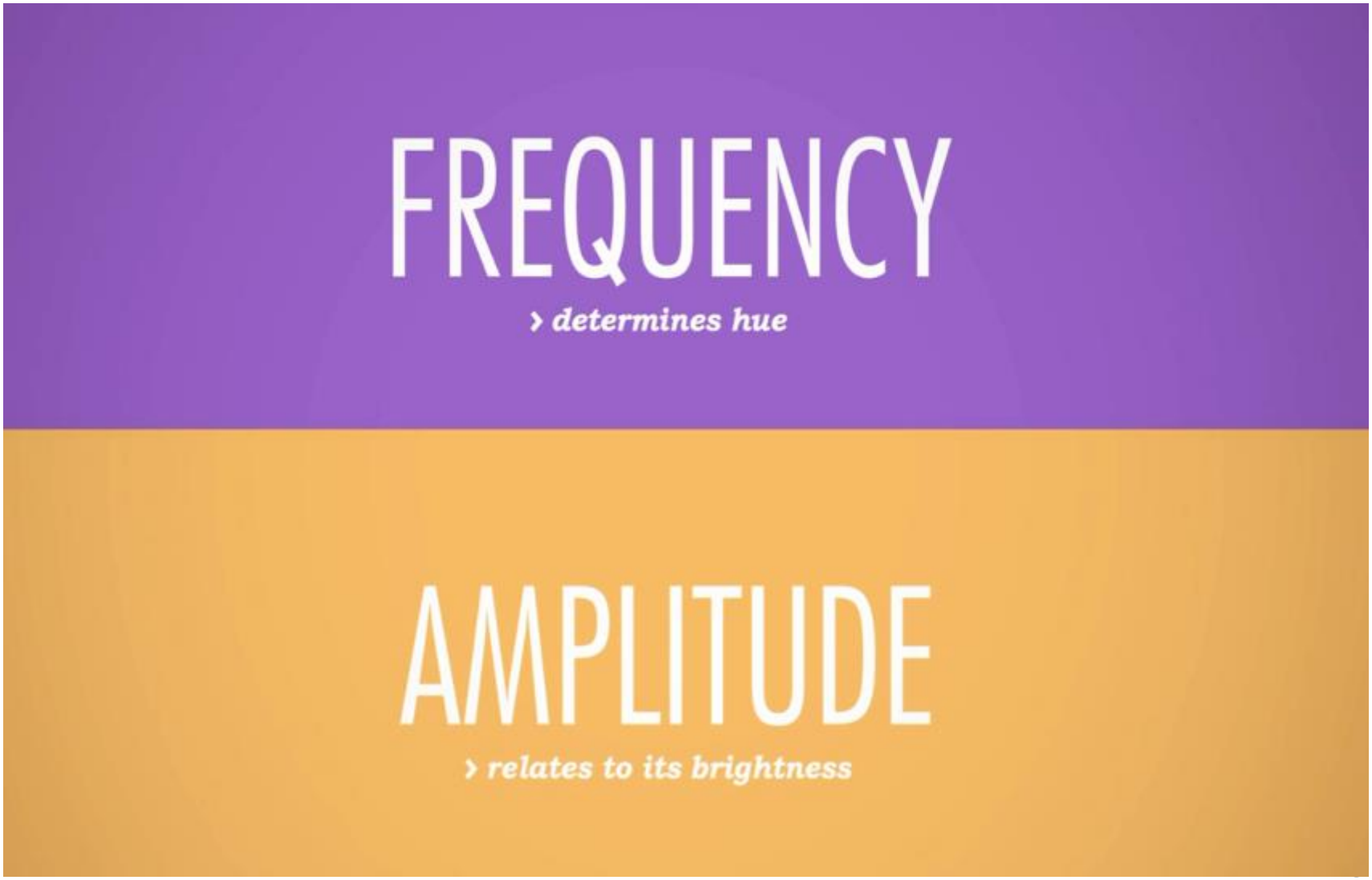
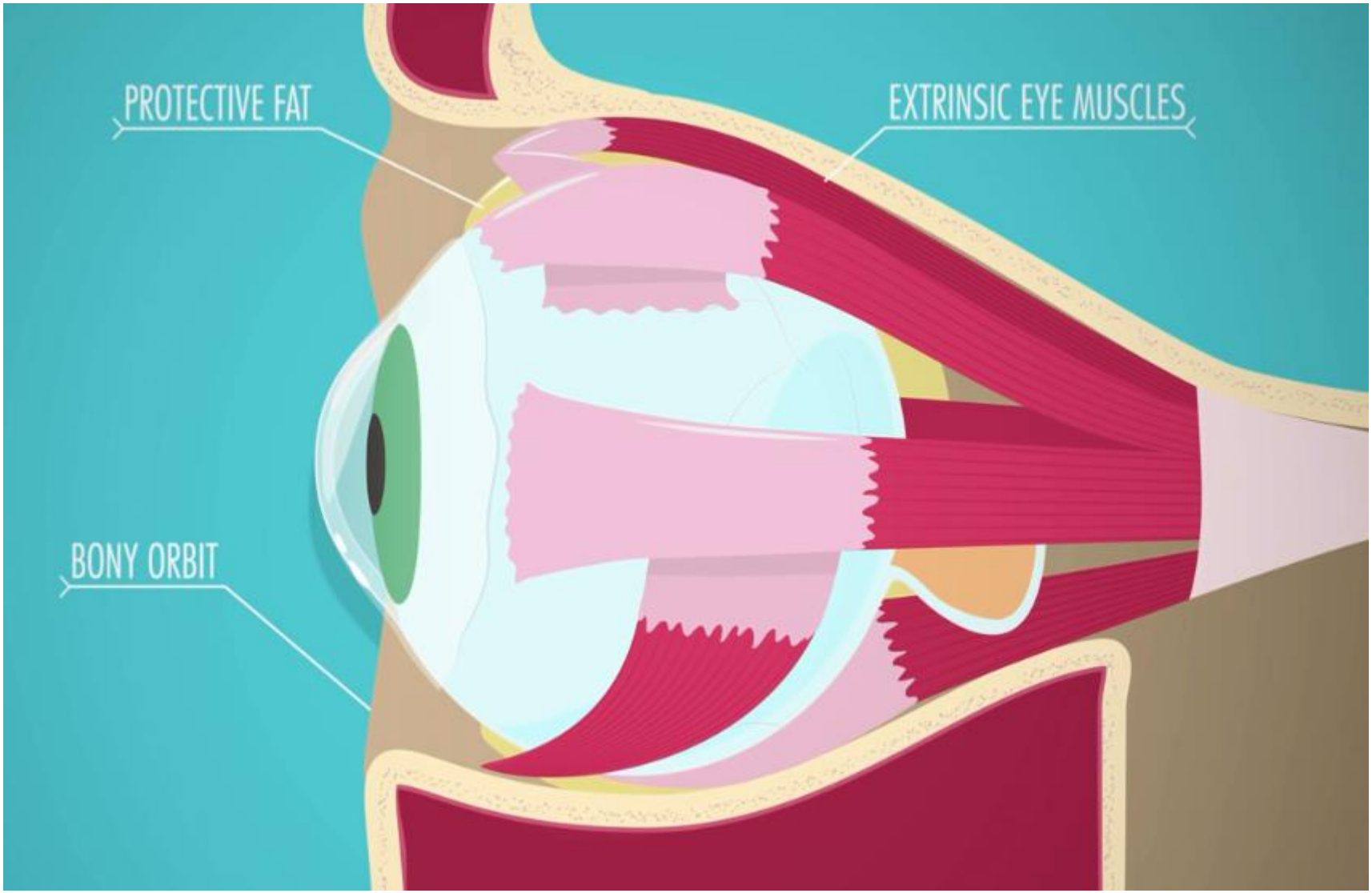

400 nm
Violet
425 nm
Indigo
470 nm
Blue
550 nm
Green
600 nm
Yellow
630 nm
Orange
665 nm
Red

# Light


FREQUENCY
› determines hue
AMPLITUDE
› relates to its brightness

# Vision and The EYE



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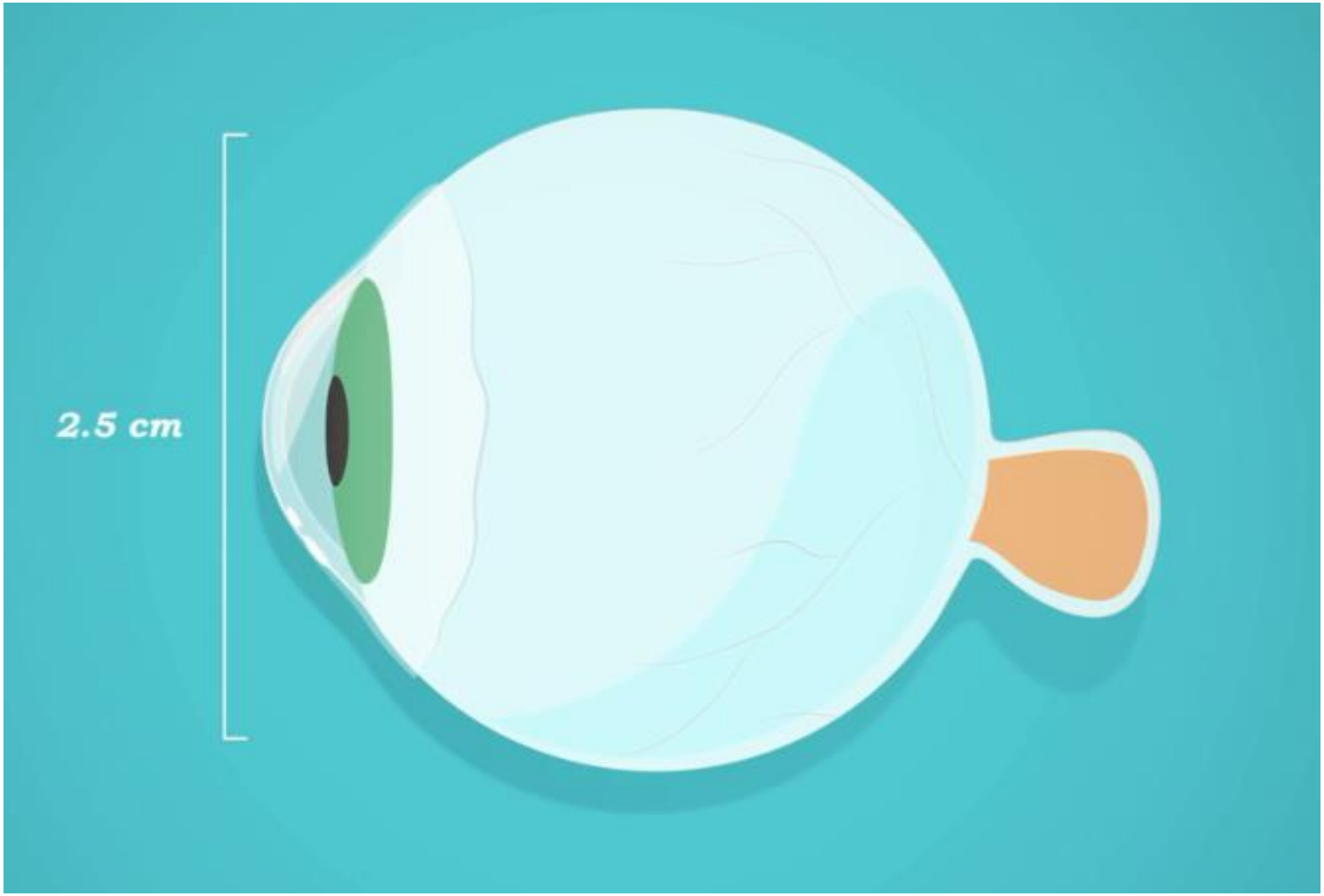
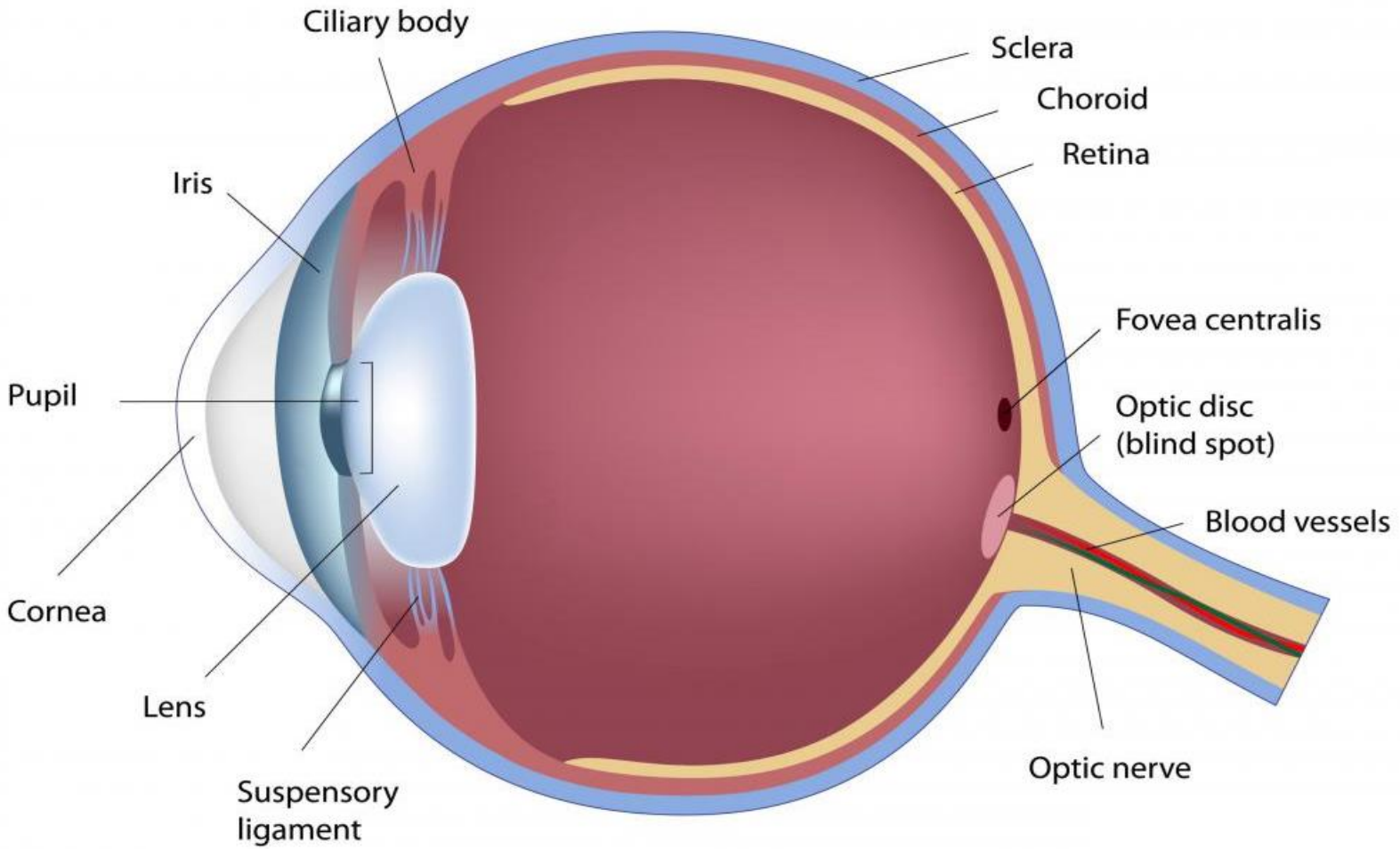
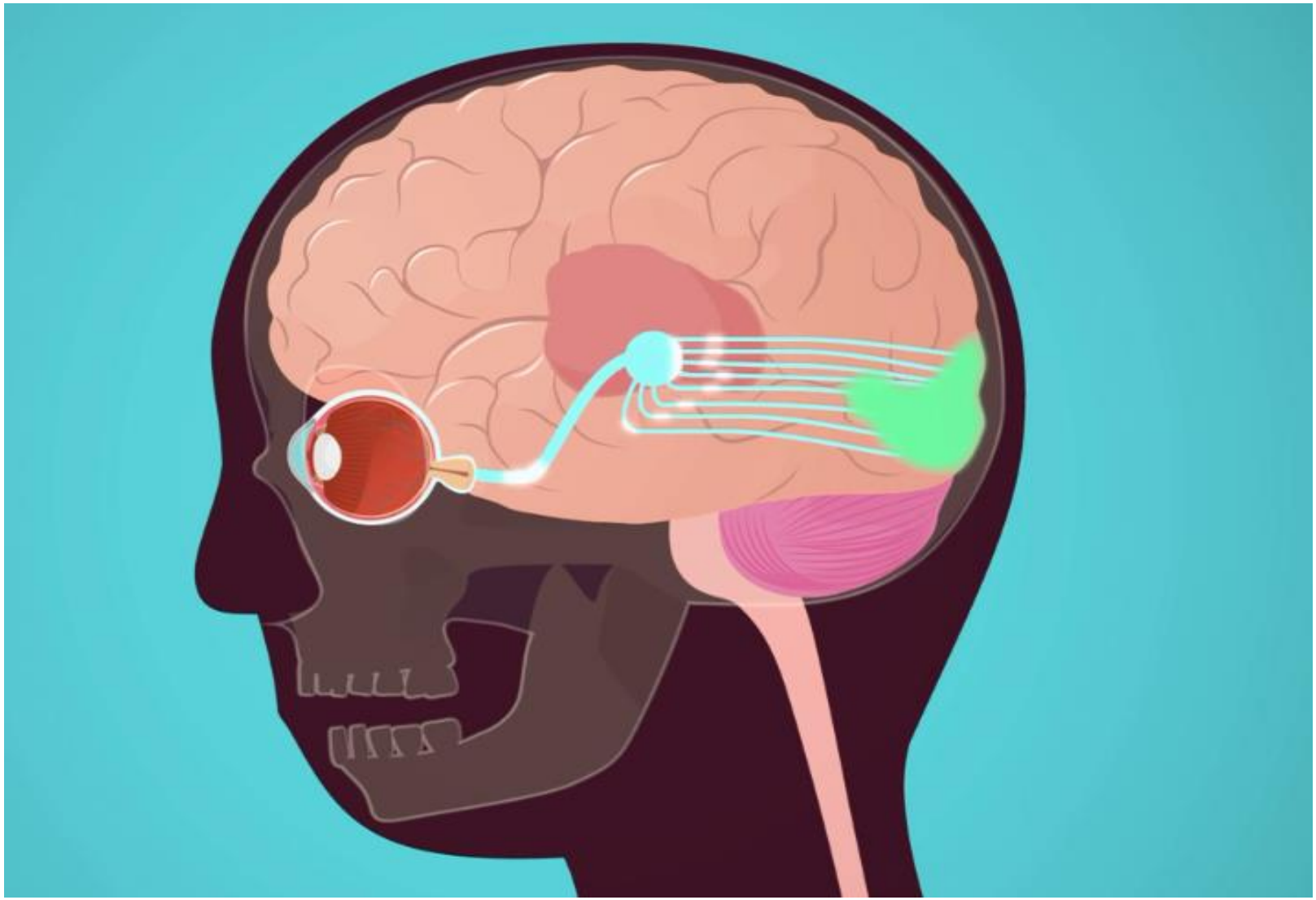


# Vision and The EYE

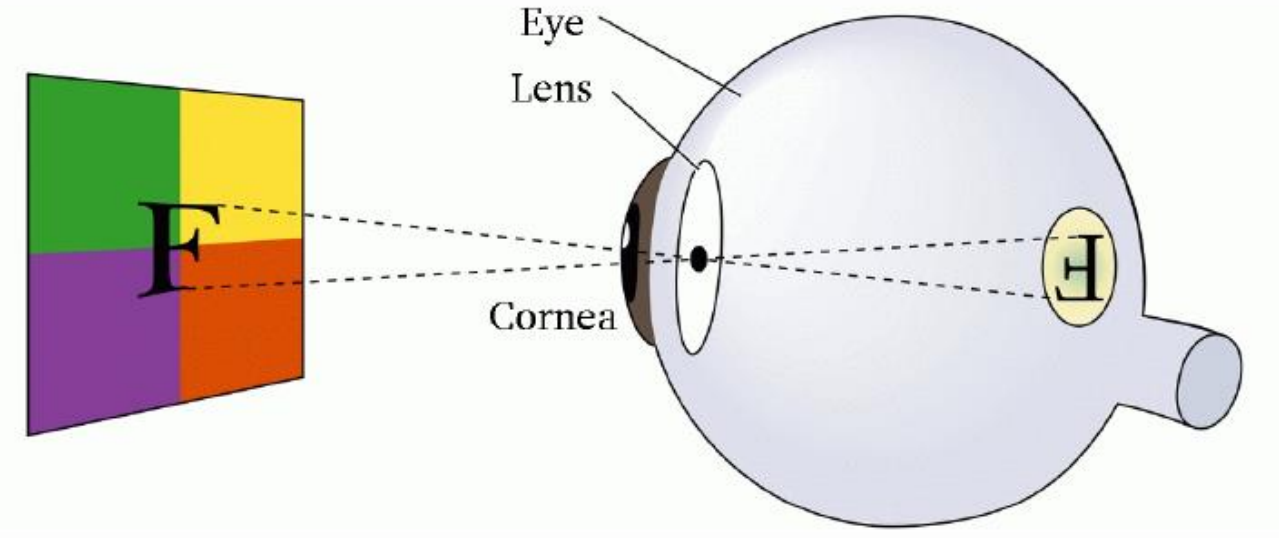


# Vision and The EYE



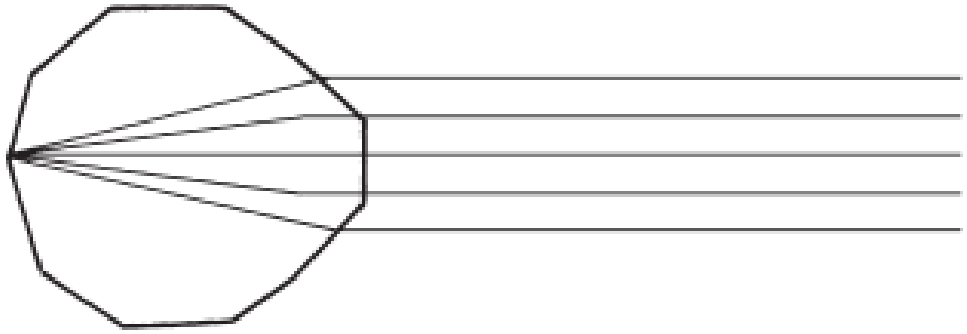
# Vision and The EYE

- *Good lighting increases the depth of field* of the eye. When the pupil is very small, the eye acts like a pinhole camera – all objects are focused on the retina irrespective of viewing distance.
- Increased depth of field reduces the need for optical adjustment by the lens. It is in this sense that it can be said that good lighting reduces the load on the visual system.



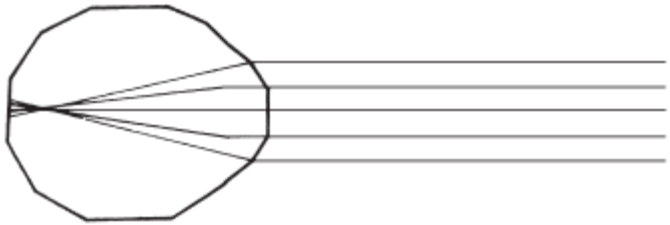
# Visual Defects

- In a normal or *emmetropic* eye, there is a correct relationship between the axial dimensions of the eye and the power of its refractive system. Parallel light rays are focused sharply on the retina.



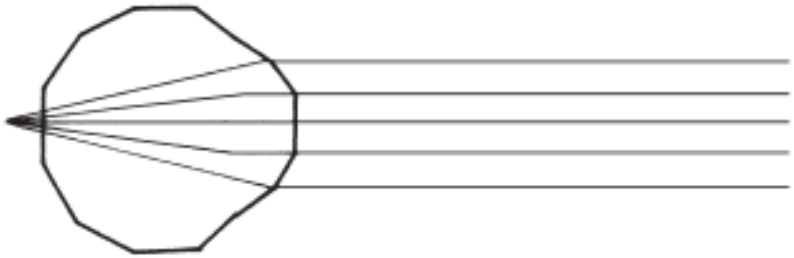
# Visual Defects

- In **myopia**, light rays entering parallel to the optic axis are bought into focus at a point some distance in front of the retina.
- Myopia is sometimes referred to as ‘nearsightedness’ because the near point is closer to the eye in myopic people than it is to a healthy eye.
- Myopic individuals cannot bring distant objects into focus. Myopic individuals can often carry out close tasks such as VDU work or sewing with ease but experience difficulties with tasks such as driving when target objects are more than 5–10 metres away.



# Visual Defects

- In **hypermetropia**, light rays entering parallel to the optic axis are bought into focus behind the retina. This can be caused by the eye being too short antero-posteriorly or by insufficient curvature of the refractive surfaces of the eye.
- Hypermetropia is sometimes referred to as ‘farsightedness’ because the near point is farther away from the eye (for an equal amount of accommodation) than it is in a healthy eye.
- Hypermetropic individuals can be said to lack refractive power and may tire quickly when carrying out work in which the viewing distance is short (such as using a VDU).

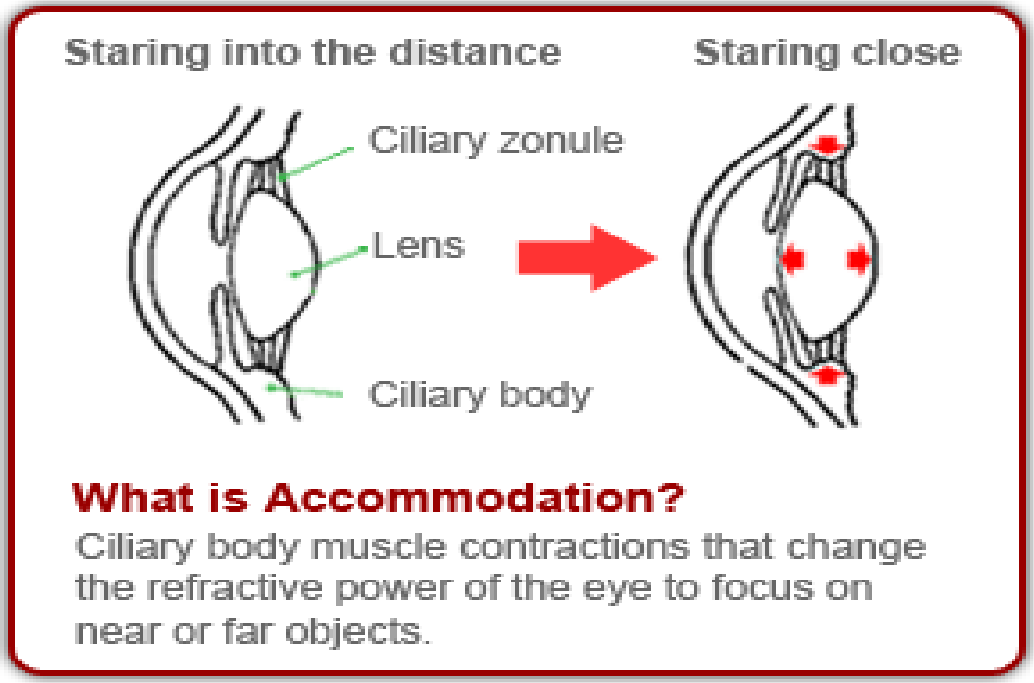


# Visual Defects

- In **astigmatism**, there is an unequal curvature of the refractive surfaces of the eye such that the refractive power is not the same in one plane as in another. When an object of complex shape is viewed, the retinal image may be out of focus in one plane but not in others.

# Visual Defects

- **Asthenopia** is diminished visual acuity associated with eyestrain, pain in the eyes and headache. It is common in people who carry out near visual work for long periods and naturally reverses shortly after the cessation of close visual work.

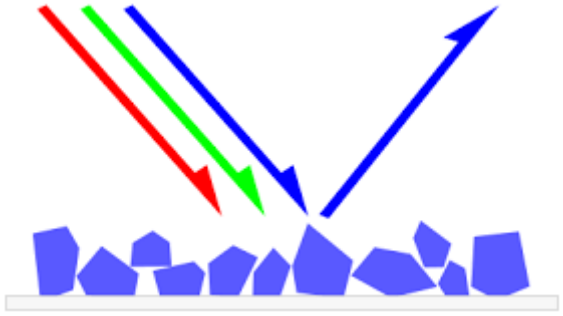


# Photometry

**Reflectance**

It is the percentage of light reflected by a surface.

| Entity | Reflectance (%) |
|---|---|
| White Paper | 95 |
| White Cloth | 65 |
| Newspaper | 55 |
| Plain Wood | 45 |



# Improving Visibility

- One can improve visibility in several ways:
  - Increase source intensity (increase wattage, change to more efficient type: fluorescent, halogen)
  - Bring target closer to viewer
  - Bring target closer to light source
  - Increase *contrast, choose colors* carefully
  - Increase *target size* (big printed books)

# Guidelines for Color Selection

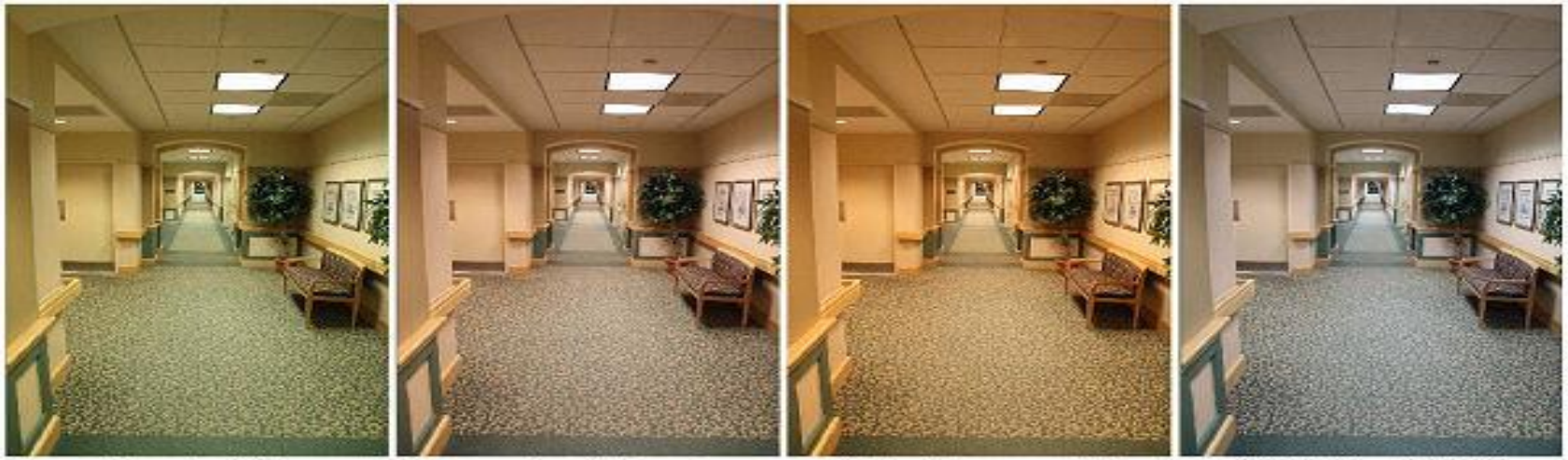
- Choose compatible color combinations. Avoid red/green, blue/yellow, green/blue, red/blue pairs.
- Use high color contrast for character/ background pairs
- Luminosity diminishes in the order white, yellow, cyan, green, magenta, red, blue.
- Use white, yellow, cyan or green against a dark background.

| | | | |
|---|---|---|---|
| Yellow | Green | Blue | Red |
| White | Black | Yellow | Cyan |

# Guidelines for Color Selection

**Color Rendition**

- Light sources vary in their ability to accurately reflect the true colors.
- The color rendering index (CRI) scale is used to compare the effect of a light source on the color appearance of its surroundings.
- A scale of 0 to 100 defines the CRI.
- CRIs in the range of 75-100 are considered excellent, while 65-75 are good. The range of 55-65 is fair, and 0-55 is poor.



# Lighting Design Considerations

- For visual comfort and to meet visual demands the following should be considered (Grandjean, 1980):
  - A suitable level of illumination
  - A balance of surface luminance
  - Avoidance of glare
  - Uniformity of lighting

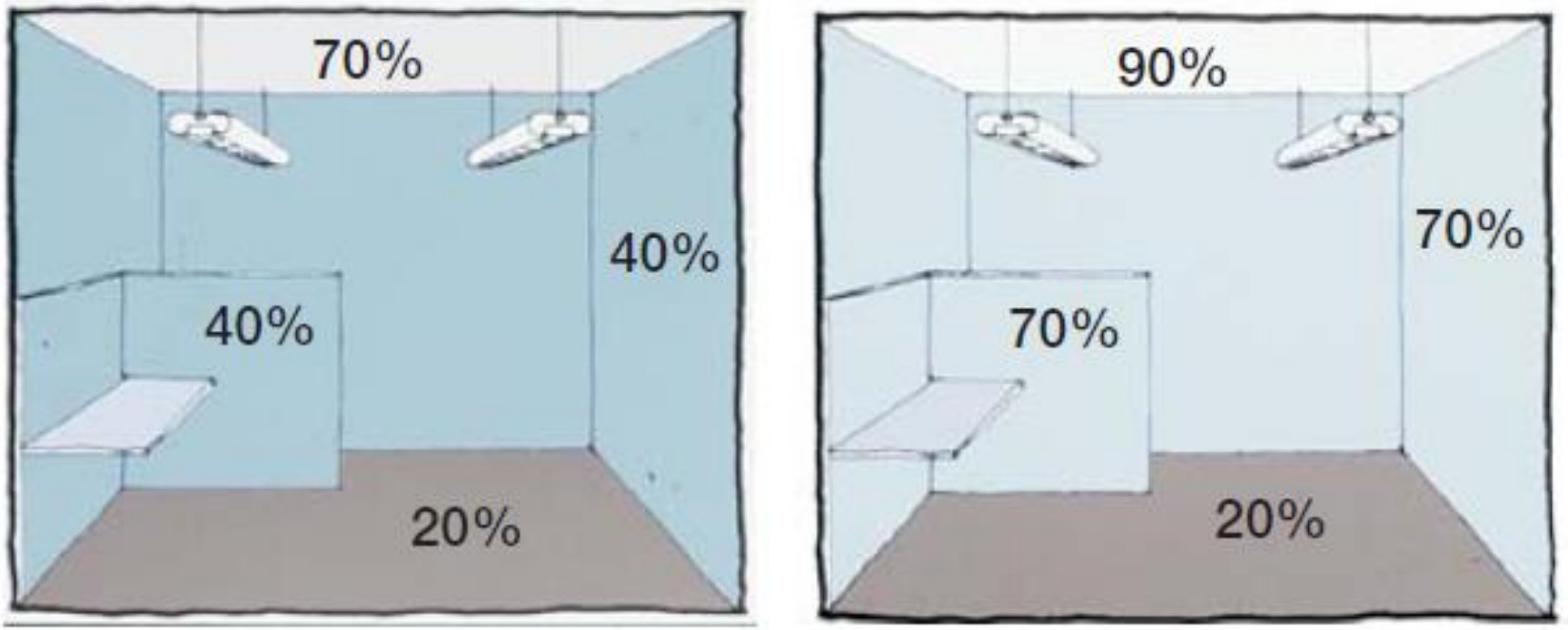
# Illumination Level

- The amount of light needed is a function of:
  - The nature of the *task*
  - The *worker* (age and visual health),
  - The reflectance of the task *background*.

*General lighting throughout room
† Illumination on tasks
‡ Illumination on tasks obtained by combination of general and local lighting

| Category | Range of Illuminance lx, (fc) | Type of Activity |
|---|---|---|
| A | 20-30-50*, (2-3-5)* | Public Areas with dark surroundings |
| B | 50-75-100*, (5-7.5-10)* | Simple orientation for short temporary visits |
| C | 100-150-200*, (10-15-20)* | Working spaces where visual tasks are performed only occasionally |
| D | 200-300-500†, (20-30-50)† | Performance of visual task of high contrast e.g. reading books |
| E | 500-750-1000†, (50-75-100)† | Performance of visual task of medium contrast e.g. poorly printed materials |
| F | 1000-1500-2000† | Performance of visual task of low contrast e.g. difficult inspection |
| G | 2000-3000-5000‡ | Performance of visual task of low contrast over prolonged period |
| H | 5000-7500-10000‡ | Performance of visual task of low contrast over prolonged period, small size |
| I | 10000-15000-20000‡ | Performance of visual task of extremly low contrast over prolonged period, small size |

# Balance of Surface Luminance




A small increase in room reflectances produces a big improvement in efficiency. The lighter room provides 55% more light on the work surface for the same energy or uses 70% less energy to provide equivalent brightness. The lighter room also provides better brightness ratios, comfort and daylight distribution.

# Avoidance of Glare

**Glare**

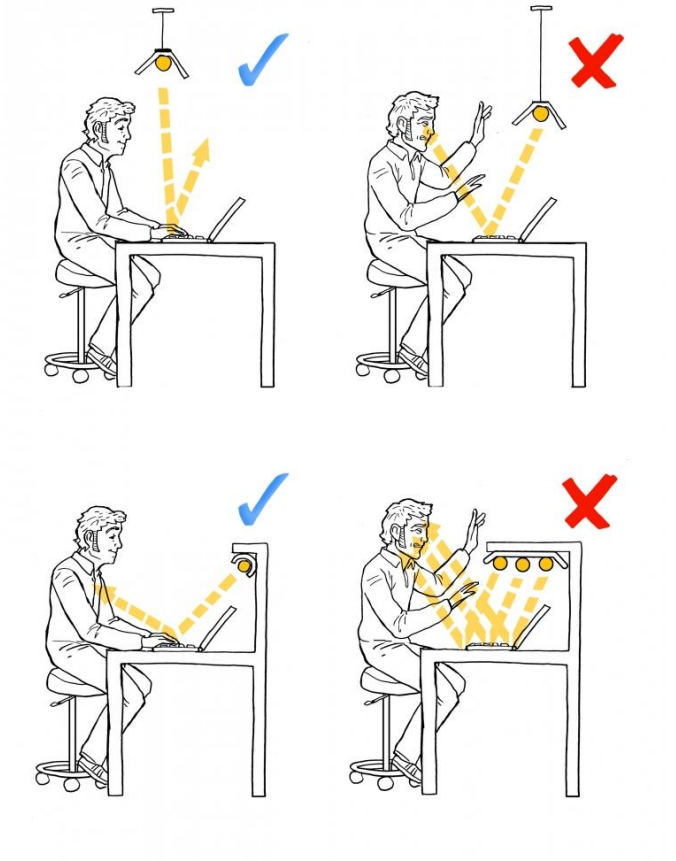
- Glare is a sensation caused by luminance in the visual field that are too bright. Discomfort, annoyance, or reduced productivity can result. A bright object in front of a dark background (too much contrast ) usually causes glare.

# Avoidance of Glare

- Glare can be reduced by choosing a suitable combination of direct and indirect lighting.
- With direct lighting, most of the light is directed towards the target in the form of a cone. This produces hard shadows and sharp contrasts between illuminated and non-illuminated areas.
- Indirect lighting is reflected off other surfaces in a room and produces a smoother transition between surface luminances and reduces shadows.

# Avoidance of Glare

- All lamps should have glare shields or shades and the line of sight from the eye to the lamp should have an angle greater than 30 degrees to the horizontal.
- Overhead lamps should not reflect off desktops or work surfaces into the operator's eyes

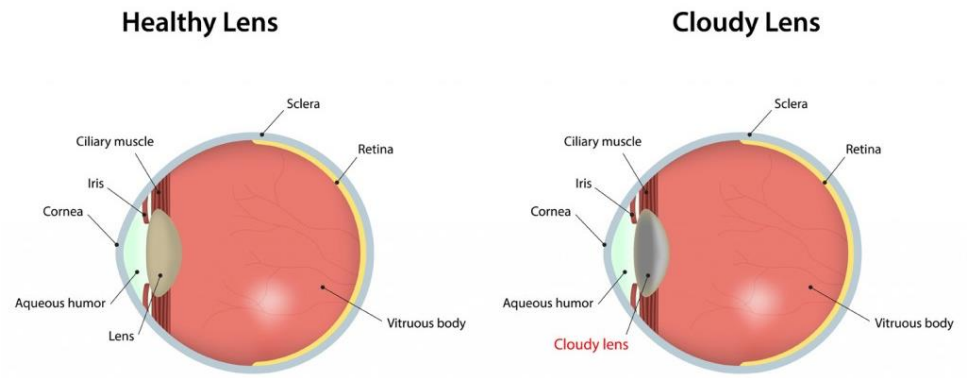


# Uniformity of Lighting

- Fluctuating luminances can be more disturbing than static contrasts.
- Incandescent bulbs radiate light fairly uniformly over time, whereas fluorescent lamps are known to flicker.
- Fluorescent lamps work by passing an electric current through a gas in a glass tube.
- The gas emits visible (almost monochromatic) light and ultraviolet radiation periodically in accordance with the mains frequency.

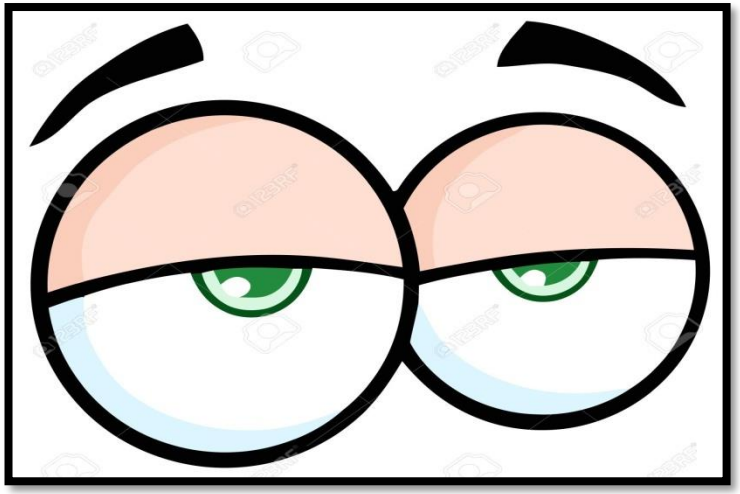
# Visual Discomfort: Complaints

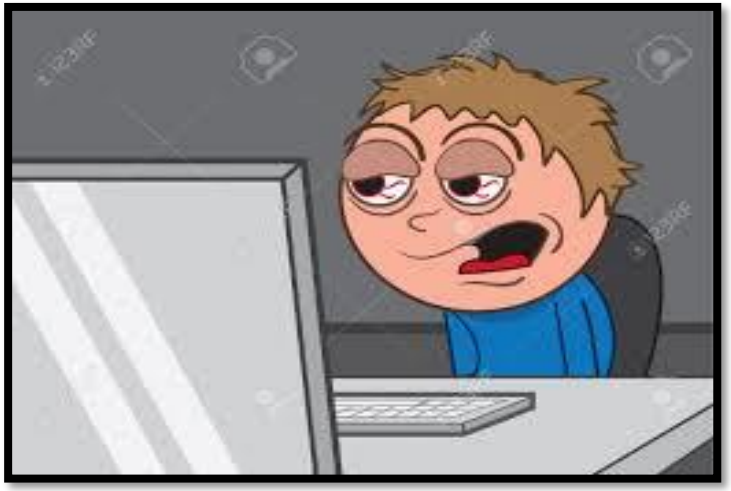
- Eye Strain - Largest Single Complaint
- Burning / Itching Eyes
- Headaches
- Cataracts



# Visual Discomfort: Causes

- Eye Muscle Strain / Fatigue
- Dry Eyes
- Uncorrected Vision Problems
- Vision Correcting Eyewear - Focusing Difficulties





# Visual Discomfort: Consensus

- No Evidence That VDT Work Leads  to Visual Damage
- No Proven Correlation Between VDT Usage and Cataracts
- Eye Muscle Strain / Fatigue
  - Lighting / Glare
  - Monitor Height & Distance to Eyes
  - Visual Concentration on Monitor
- Dry Eyes
  - VDT Environment Less Humid
  - Eye Blink Rate:  3. 6 / Min VDT vs. 18. 4 / Min Normal

# Visual Discomfort: Control Measure

**Lighting / Glare**

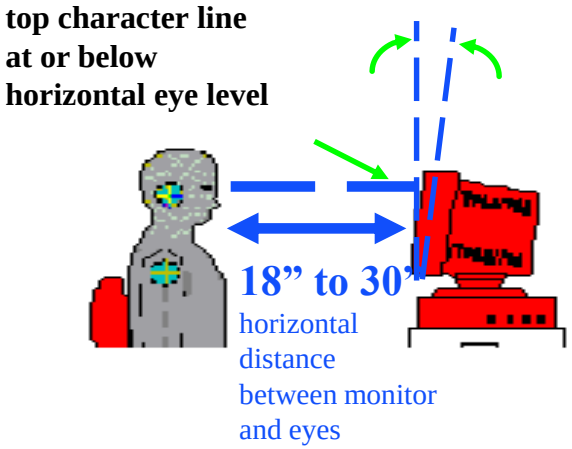
- VDT: 50 fc / 500 Lux Optimum Light Level
- Office: 100 fc / 1,000 Lux Optimum Light Level
- Don’t Place VDT Directly Under Bright Overhead Lights
- Provide Indirect Lighting and Supplement With Task Lighting
- Low Reflective Walls / Work Surfaces
- Anti-Glare Screens: Last Resort Only

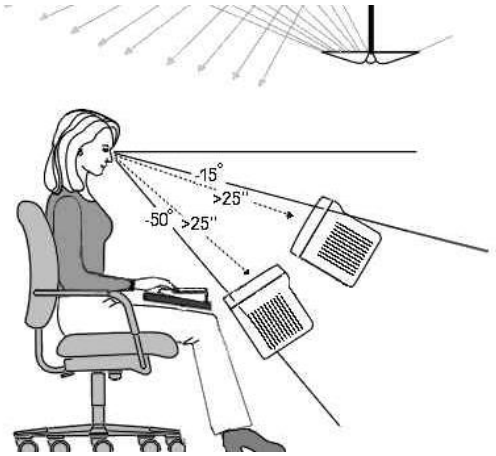
# Visual Discomfort: Control Measure

# Visual Discomfort: Control Measure

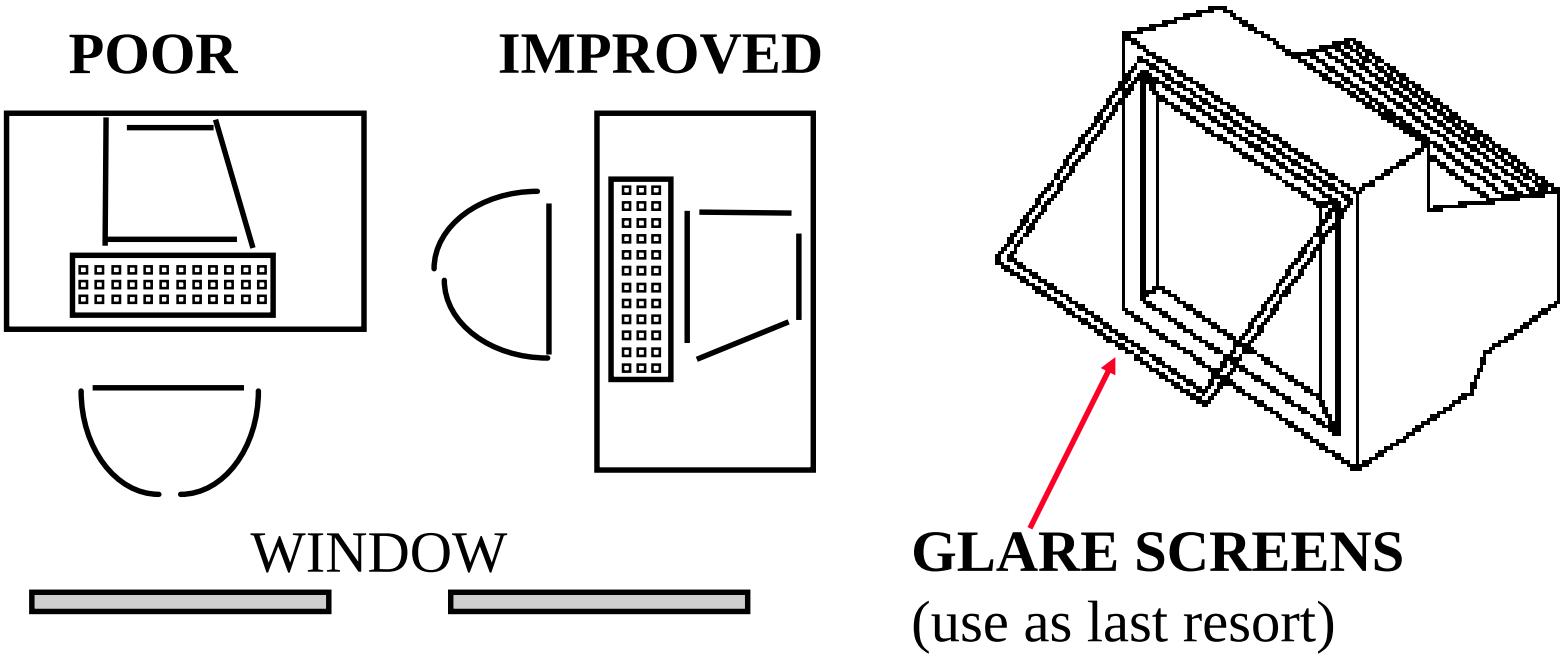
## Lighting / Glare

- Ensure Monitor Display Quality
  - Adjustable Brightness and Contrast
  - High Resolution
- Adjust Monitor Height and Distance
  - Top Character Line on Screen 15 - 20 Degrees below Horizontal Eye Level
  - Eye to Screen Distance 18”- 30”



# Visual Discomfort: Control Measure



# Visual Discomfort: Control Measure

**use correct lighting level for the task performed**

# Visual Discomfort: Control Measure

- Eye: Strain / Fatigue / Dryness
  - Eye Focusing / Muscle Defatigue Exercises
    - 1 Min. Rest / Exercise Break After 15 Min. Continuous VDT Work
  - Remember to Blink Eyes Frequently
  - Contact Lens Wearers Should Supplement Own Tears Via Eye / Rewetting Drops

# Noise

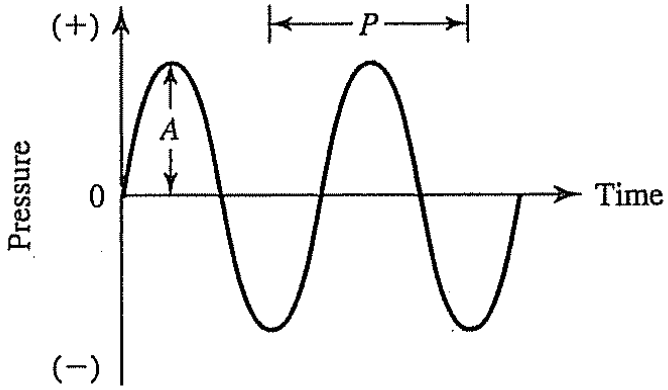
# Sound

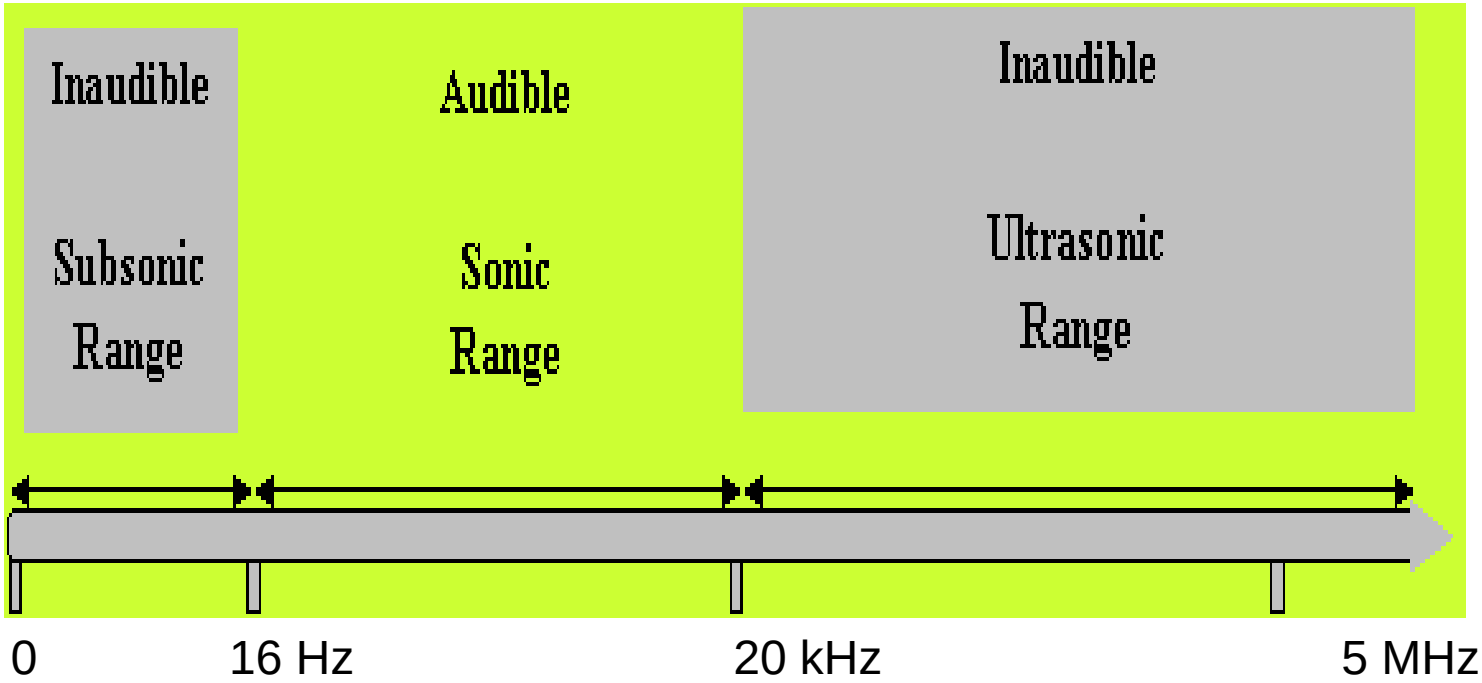
- Sound is a sensation of acoustic waves (disturbance/pressure fluctuations setup in a medium)
- Sound, a manifestation of vibration, travels in wave patterns through solids, liquids and gases.
- Unpleasant, unwanted, disturbing sound is generally treated as Noise and is a highly subjective feeling.

# Amplitude & Frequency

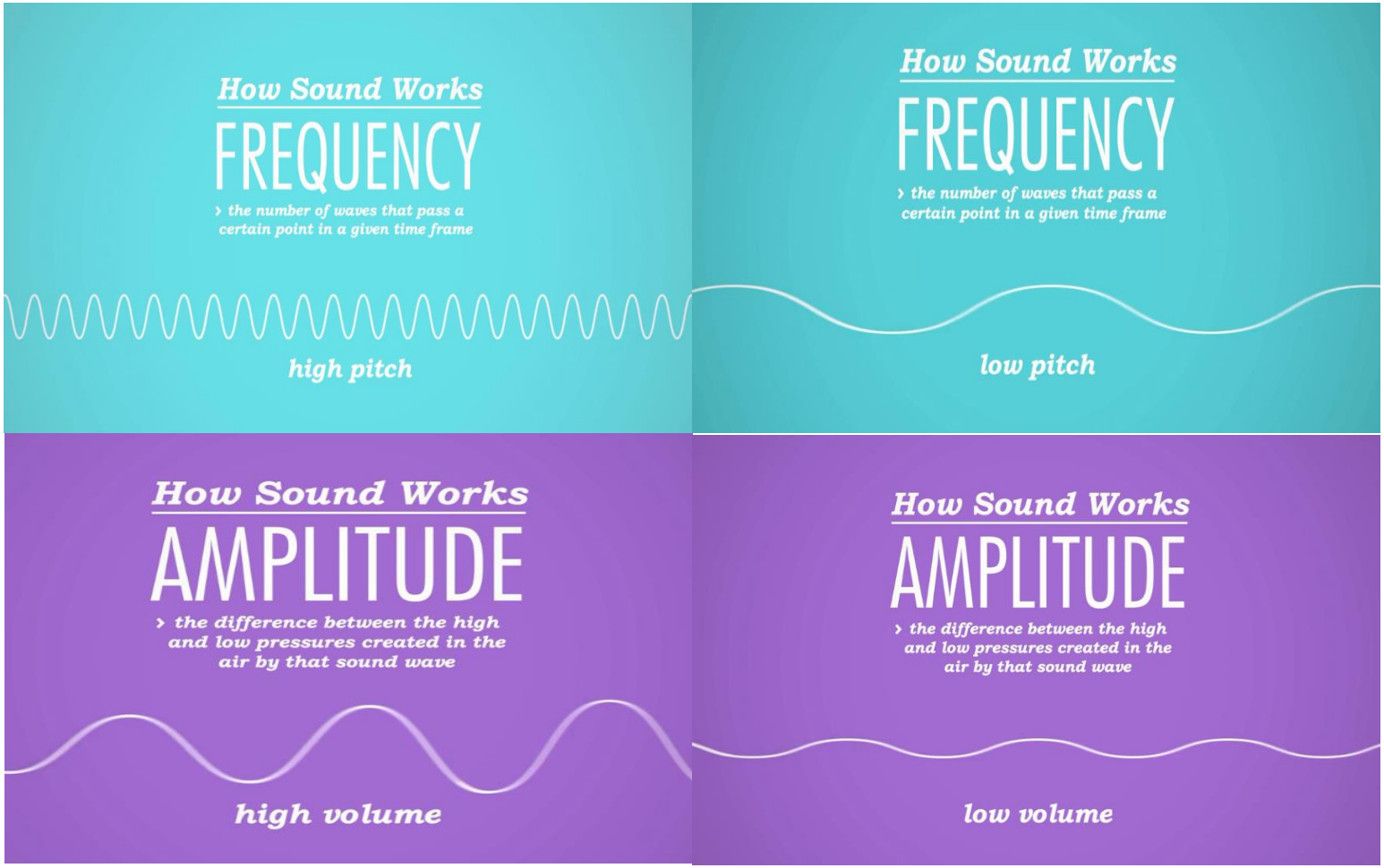
Frequency and amplitude define a pure tone. Their subjective counterparts are pitch and loudness.

A healthy young person can hear sounds in the range 16–20 000 Hz.



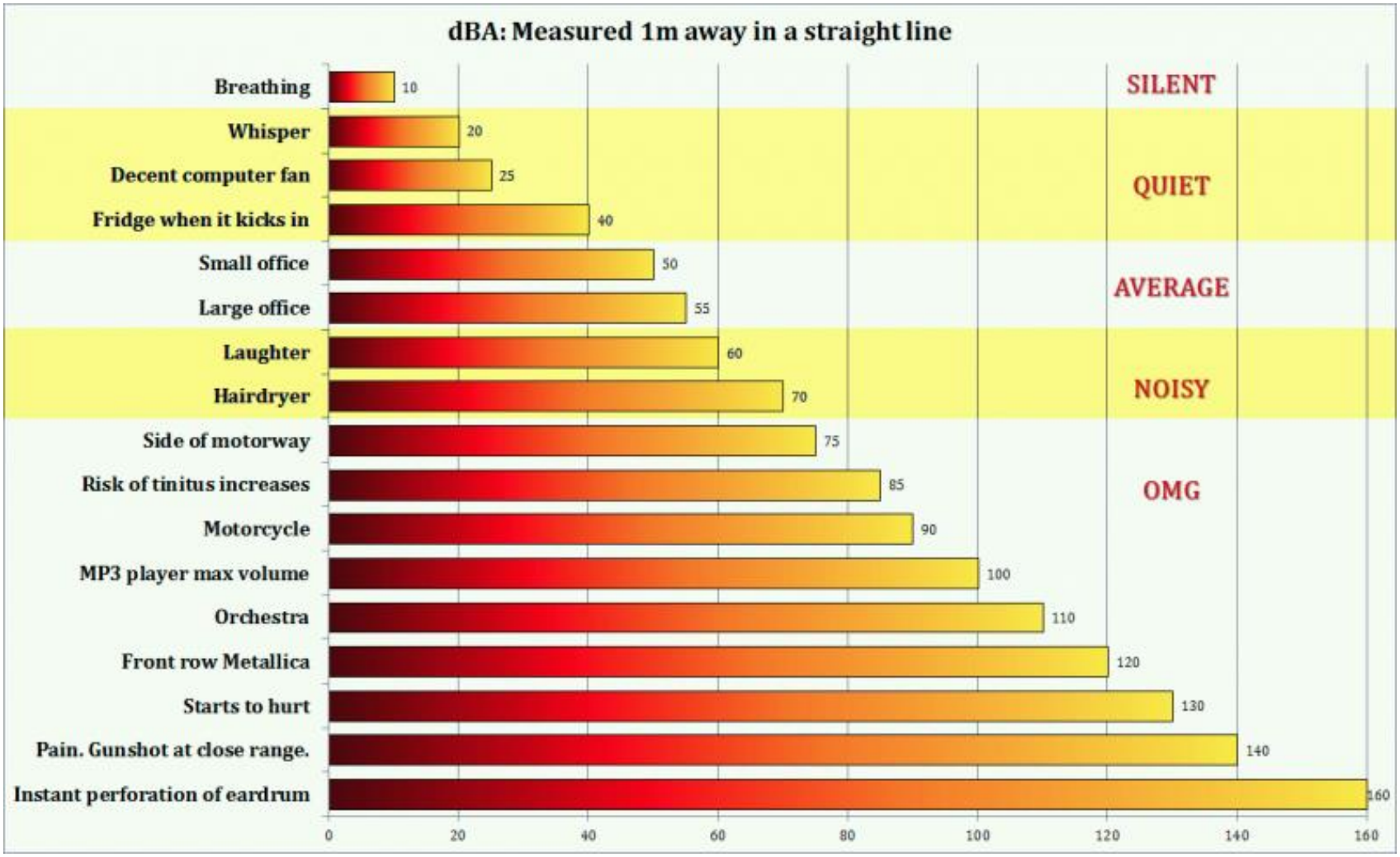
# Amplitude & Frequency



# Levels and Decibels

- The amplitude of sound is evaluated by measuring the sound pressure level (SPL).
- The range of SPLs to which the human ear is sensitive is so wide (0.00002 to 20 N/m2) that linear scaling would present a problem.
- For this reason a logarithmic scale – the decibel scale – is used.
- The smallest noticeable difference in intensity between two sounds is about 1 decibel.

# Levels and Decibels



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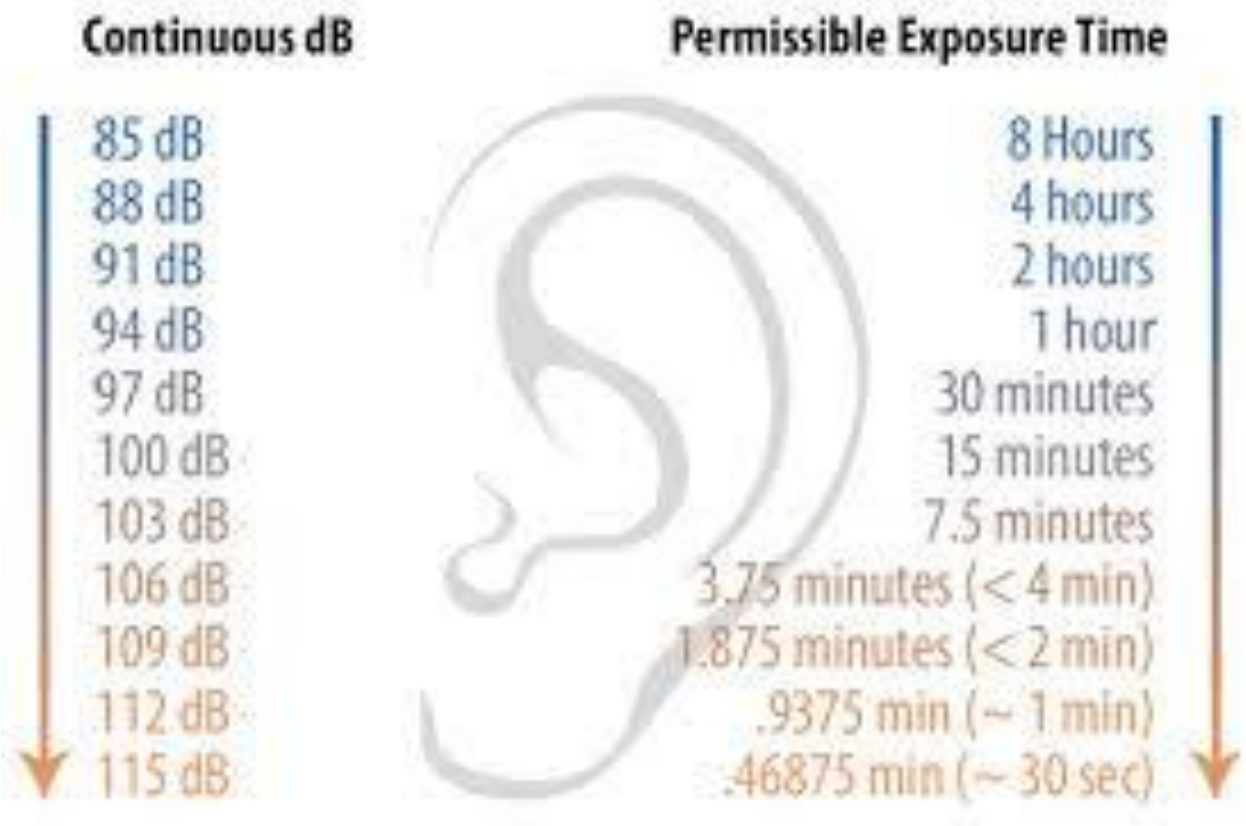


# Levels and Decibels

$$L_p = 20 \log_{10}\left(\frac{p}{p_r}\right) \quad \text{dB}$$

where

$L_p$ = sound pressure level in decibels
$p$ = sound pressure in newtons per square metre
$p_r$ = reference sound pressure level (0.00002 N/m$^2$)

For example, if the rms SPL is 2 N/m$^2$, then

$$\log_{10}\left(\frac{p}{p_r}\right) = \log_{10}(2/0.00002)$$
$$= \log_{10} 100\,000$$
$$= 5$$

and

$$L_p = 100 \text{ dB}$$

# Levels and Decibels

The formula for the sum level of sound pressures of $n$ incoherent radiating sources is

$$L_\Sigma = 10 \cdot \log_{10}\left(\frac{p_1^2 + p_2^2 + \cdots + p_n^2}{p_0^2}\right) = 10 \cdot \log_{10}\left(\left(\frac{p_1}{p_0}\right)^2 + \left(\frac{p_2}{p_0}\right)^2 + \cdots + \left(\frac{p_n}{p_0}\right)^2\right)$$

The reference sound pressure $p_0$ is 20 µPa = 0.00002 Pa = 2 × $10^{-5}$ Pa (RMS) ≡ 0 dB.

From the formula of the sound pressure level we find

$$\left(\frac{p_i}{p_0}\right)^2 = 10^{\frac{L_i}{10}}, \qquad i = 1, 2, \cdots, n$$

This inserted in the formula for the sound pressure level to calculate the sum level shows

$$L_\Sigma = 10 \cdot \log_{10}\left(10^{\frac{L_1}{10}} + 10^{\frac{L_2}{10}} + \cdots + 10^{\frac{L_n}{10}}\right) \text{ dB}$$

$L_\Sigma$ = Total level and $L_1$, $L_2$, ... $L_n$ = sound pressure level of the separate sources in dBSPL.

Incoherent means: lacking cohesion, connection, or harmony. It is not coherent.

For example, adding of threedecibel values, that means levels 94.0 + 96.0 + 98.0:

$L = 10 \log_{10}(10^{9.4} + 10^{9.6} + 10^{9.8}) = 101.1$ dB

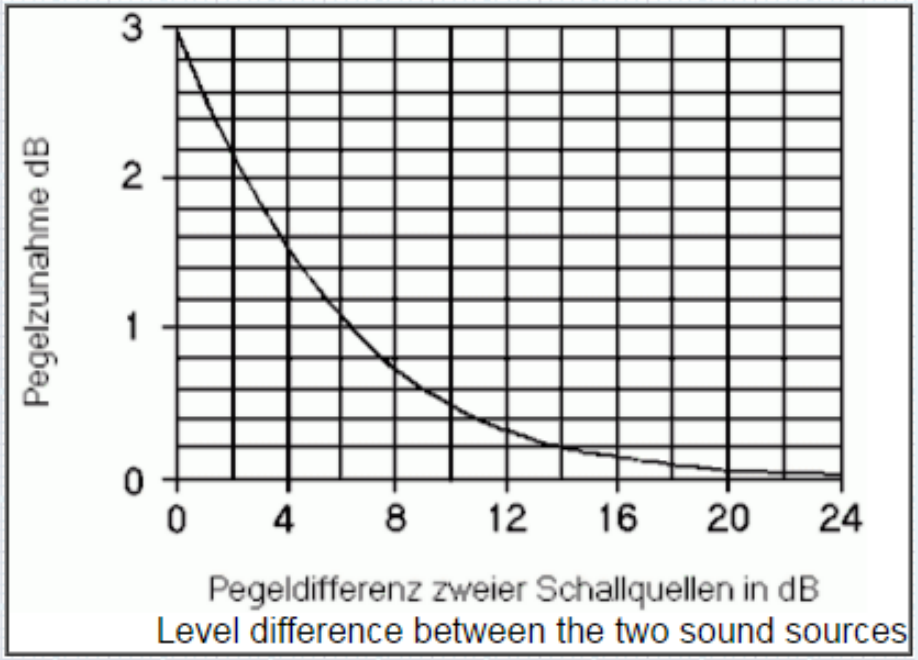
# Levels and Decibels

**Table for combining decibel levels**

**Difference between the two levels to be added in dB**

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.01 | 2.54 | 2.12 | 1.76 | 1.46 | 1.19 | 0.97 | 0.79 | 0.64 | 0.51 | 0.41 |

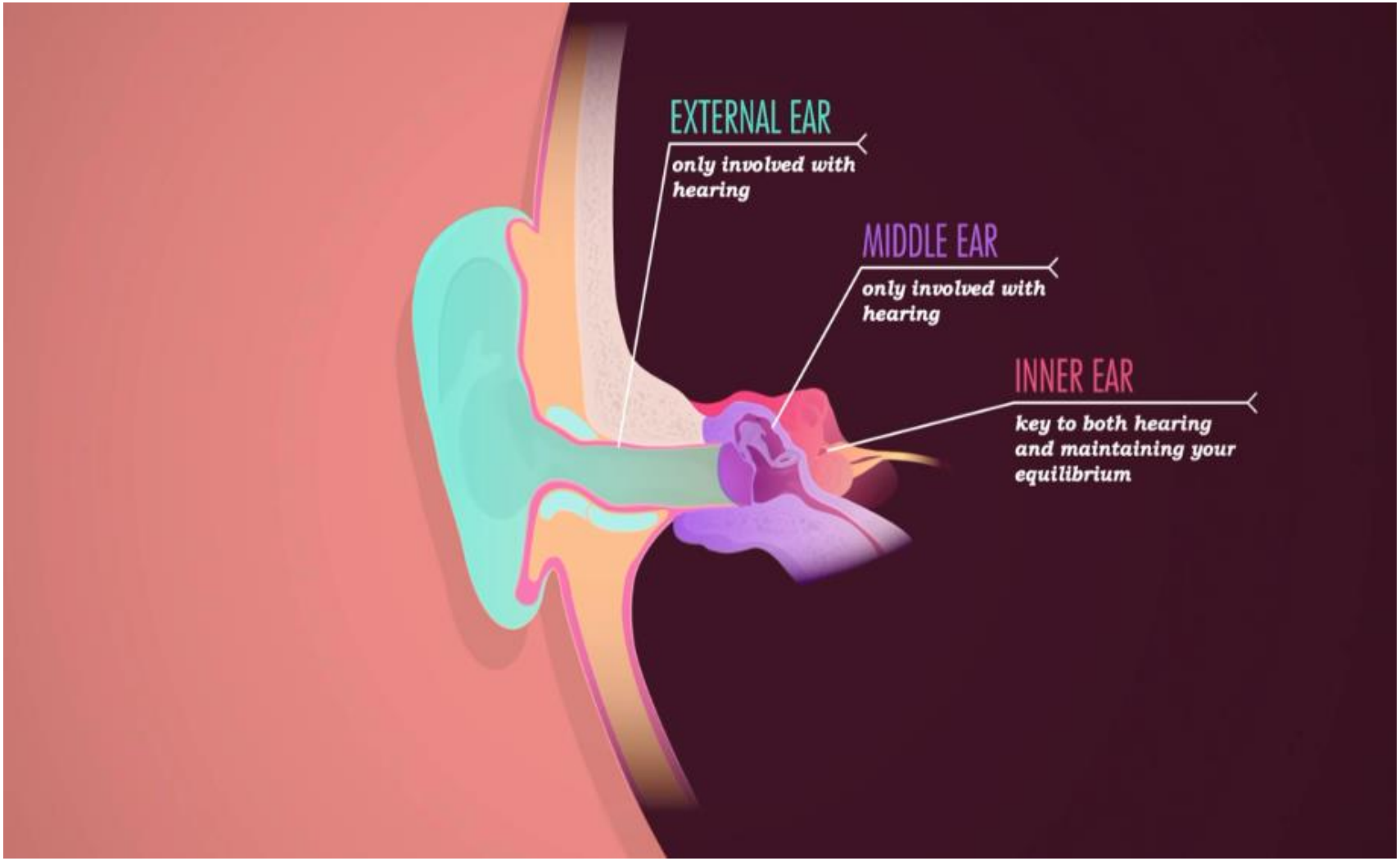
**Difference between the two levels to be added in dB**



# Hearing & The EAR

- The ear converts sound waves in air into nerve impulses, which travel along the auditory nerve to the brain.
- Further processing in the brain results in the perception of sound and the recognition of auditory patterns.

# Hearing & The EAR



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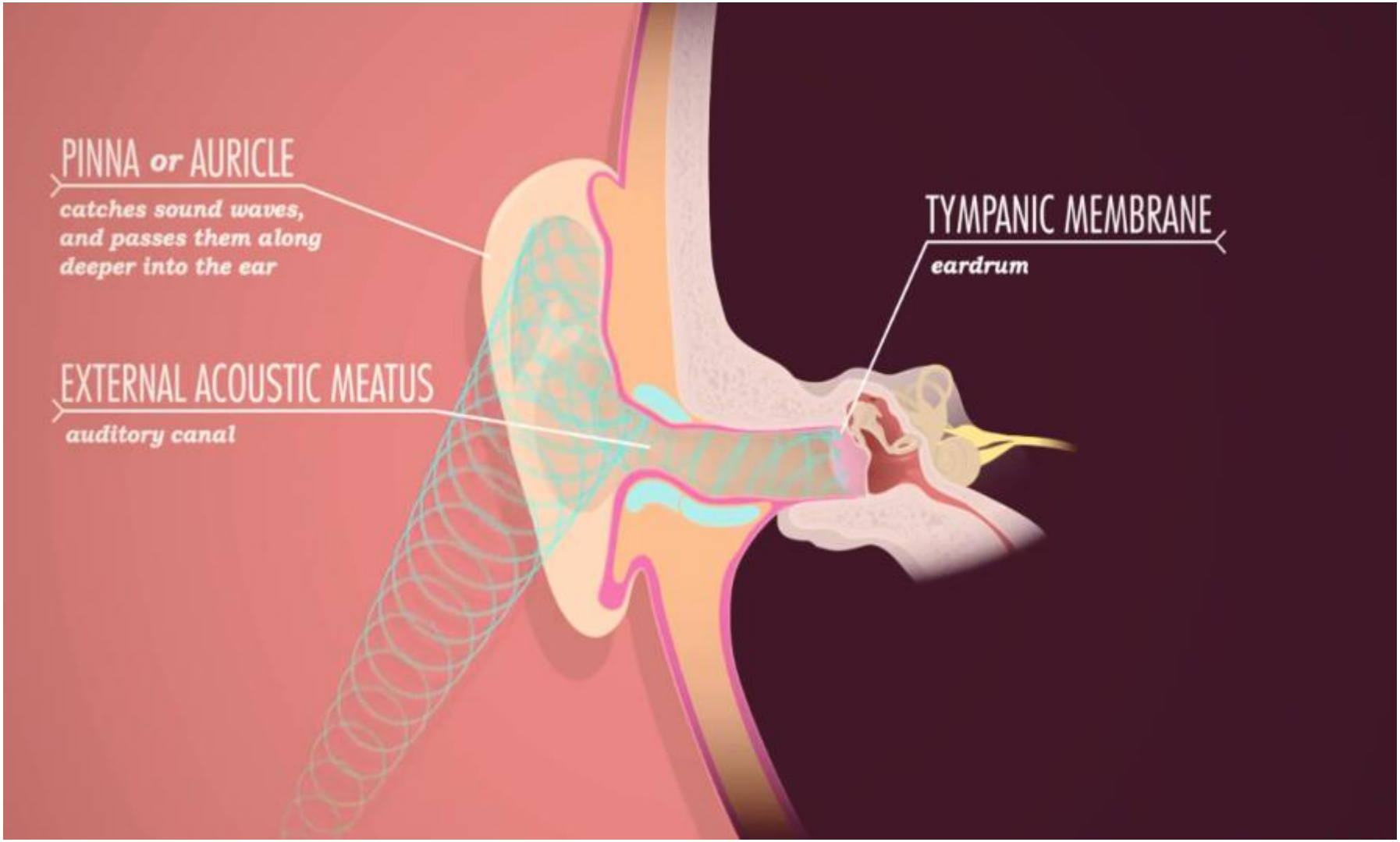
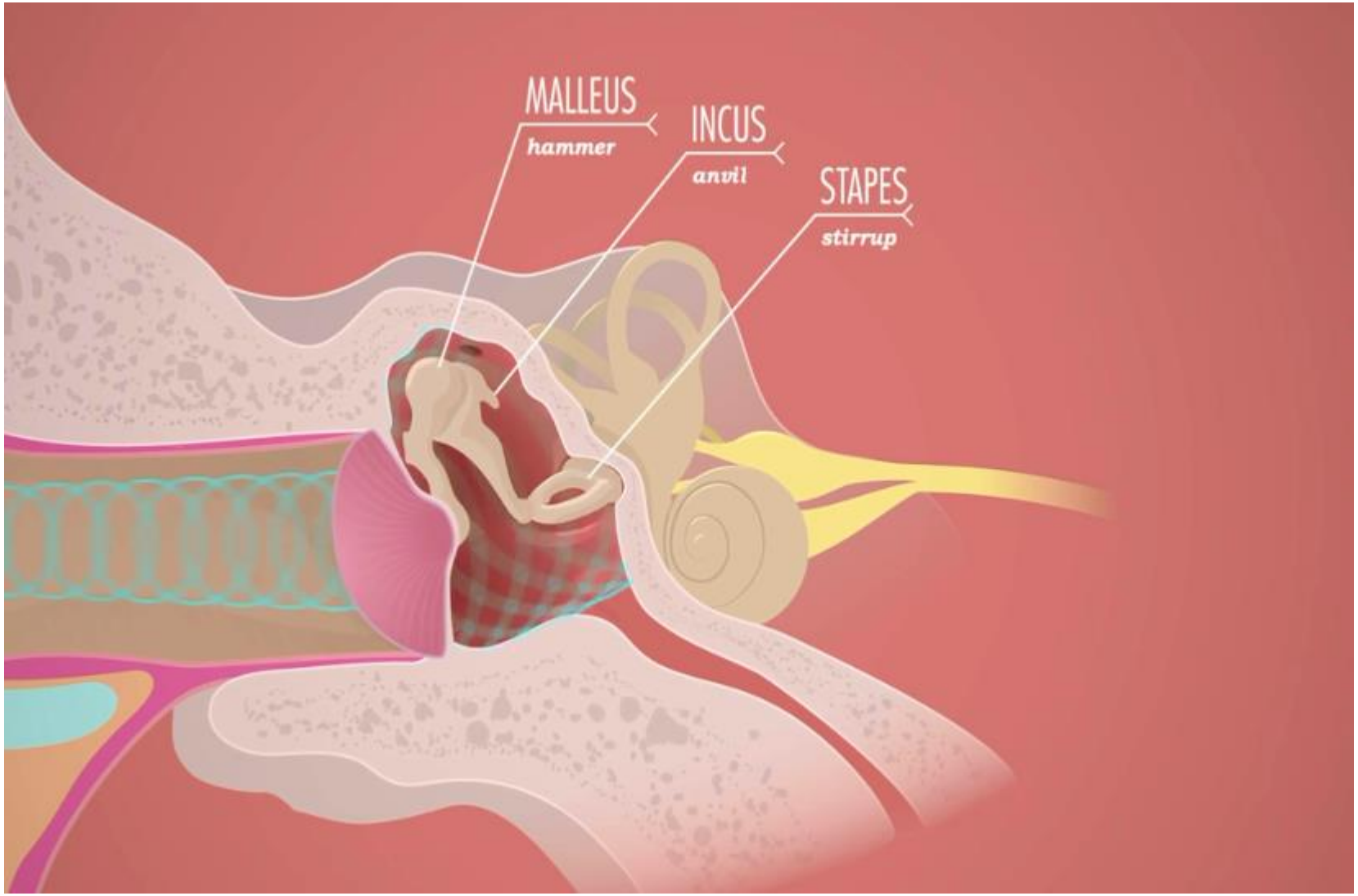


# Hearing & The EAR



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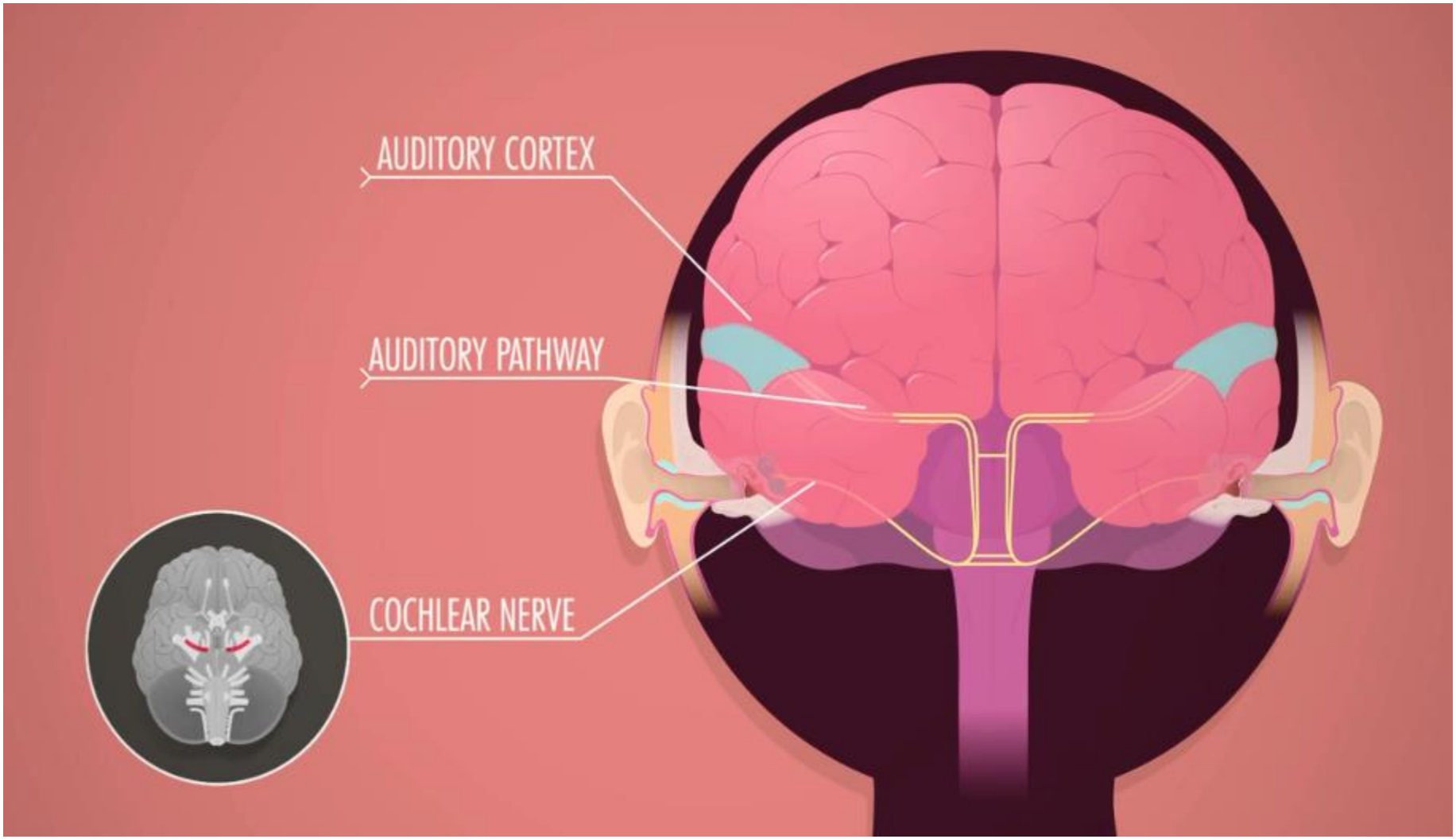


# Hearing & The EAR

Hearing requires three main steps. In each, energy is converted from one form to another:

**Step-1**

Pressure variations due to longitudinal waves in the environment are guided into the external auditory meatus where they cause a mechanical vibration of the tympanic membrane (eardrum). The tympanic membrane is connected to three small bones (ossicles) in the middle ear which, in turn, are caused to vibrate

**Step-2**

Mechanical vibration of the auditory ossicles is converted to wave motion in the cochlear fluid at the oval window.

**Step-3**

Wave motion in the cochlear fluid is converted to nerve impulses in the auditory nerve by hair cells in the cochlea.

# Noise Pollution

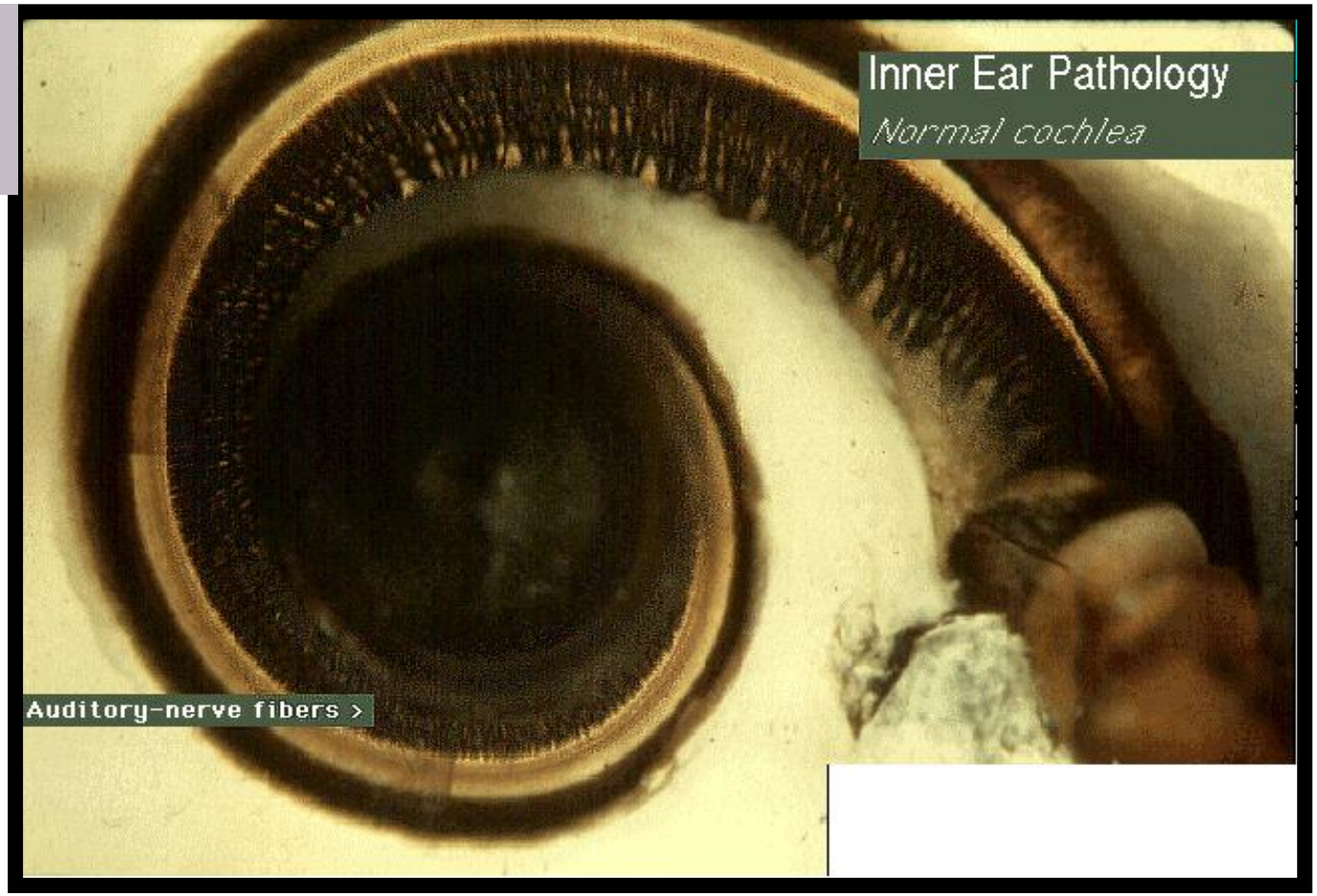
- **Noise pollution** is displeasing human, animal or machine-created sound that disrupts the activity or balance of human or animal life.
- The source of most outdoor noise worldwide is mainly construction and transportation systems, including motor vehicle noise, aircraft noise and rail noise. Poor urban planning may give rise to noise pollution, since side-by-side industrial and residential buildings can result in noise pollution in the residential area.

# Health Effects of Excessive Noise

- **Noise Induced Hearing Loss (NIHL) -** a cumulative effect from repeated exposure and it is due to damage to the hair cells of the cochlea in the inner ear.
- **Tinnitus** - Noise heard in the ear without external cause, frequently accompanies deafness.
- **Temporary Threshold Shift (TTS)** - Damage to the hair cells of the inner ear which can impair hearing temporarily, resulting from exposure to high noise levels.

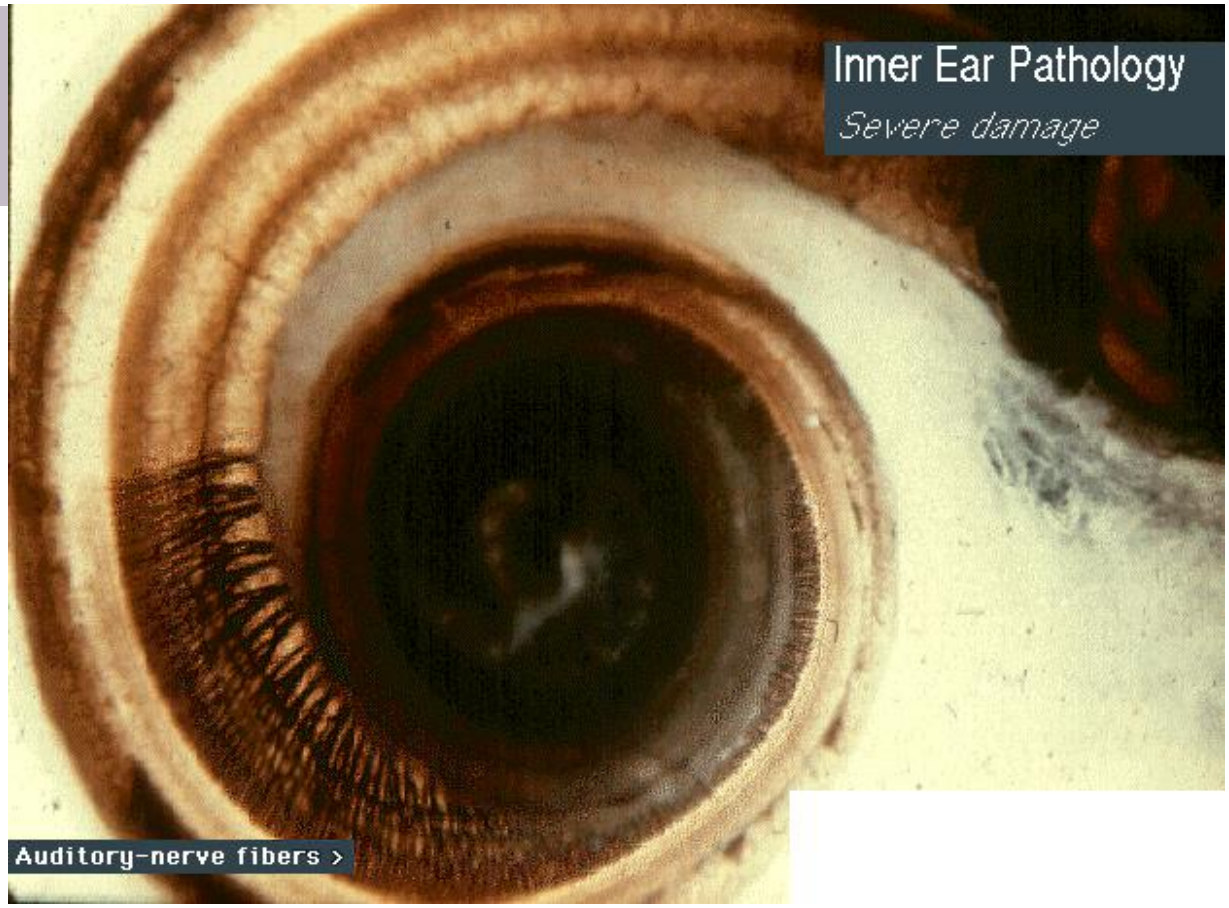
# Health Effects of Excessive Noise

Healthy Cochlea



# Health Effects of Excessive Noise

Damaged Cochlea



# Health Effects of Excessive Noise

- **Physical damage** - to the eardrum and ossicles induced by excessively high noises e.g. explosions.

- **Annoyance/stress** - which is difficult to measure and quantify, but may cause psychological effects such as poor concentration, irritability and stress.

# Control Measure for Noise Hazard

**Engineering controls** that reduce sound exposure levels are available and technologically feasible for most noise sources. Engineering controls involve modifying or replacing equipment, or making related physical changes at the noise source or along the transmission path to reduce the noise level at the worker's ear.

Examples of inexpensive, effective engineering controls include some of the following:

- Choose low-noise tools and machinery.
- Maintain and lubricate machinery and equipment (e.g., oil bearings).
- Place a barrier between the noise source and employee (e.g., sound walls or curtains).
- Enclose or isolate the noise source.

# Control Measure for Noise Hazard

**Administrative controls** are changes in the workplace that reduce or eliminate the worker exposure to noise. Examples include:

- Operating noisy machines during shifts when fewer people are exposed.
- Limiting the amount of time a person spends at a noise source.
- Providing quiet areas where workers can gain relief from hazardous noise sources (e.g., construct a sound proof room where workers' hearing can recover).
- Restricting worker presence to a suitable distance away from noisy equipment.
- Controlling noise exposure through distance is often an effective, yet simple and inexpensive administrative control. This control may be applicable when workers are present but are not actually working with a noise source or equipment. Increasing the distance between the noise source and the worker, reduces their exposure.

# Control Measure for Noise Hazard

**Hearing protection devices (HPDs)**, such as earmuffs and plugs, are considered an acceptable but less desirable option to control exposures to noise.




# Control Measure for Noise Hazard

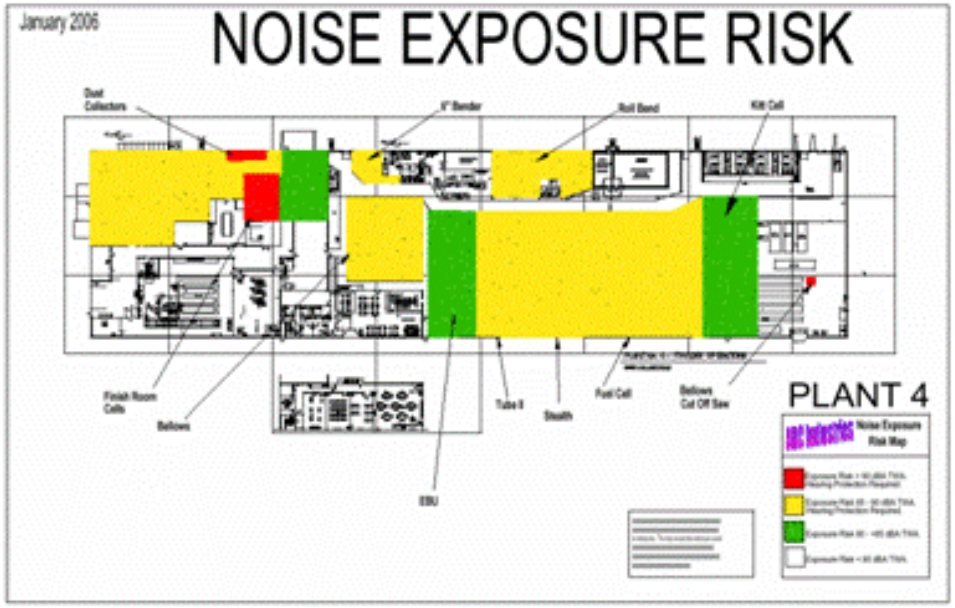
## Ear Plugs Vs Ear Muffs

| Earplugs | Earmuffs |
| --- | --- |
| **Advantages**<br>Small & easily carried, convenient to use with other PPE, more comfortable in hot, humid work areas and convenient for use in confined work areas. | **Advantages**<br>Less attenuation variably among users, designed so that one size fits most hat sizes, may be worn with minor ear infections and not easily misplaced or lost. |
| **Disadvantages**<br>Require more time to fit, difficult to insert or remove, may irritate the ear canal, easily misplace, more difficult to see and monitor use, get dirty when your hands are dirty. | **Disadvantages**<br>Heavier, less portable, inconvenient for use with other PPE, uncomfortable in hot humid work areas, inconvenient for use in confined areas. |

# Control Measure for Noise Hazard

An **effective hearing conservation program** must be implemented by employers in general industry. This program strives to –

- prevent initial occupational hearing loss,
- preserve and protect remaining hearing, and
- equip workers with the knowledge and hearing protection devices necessary to protect them.



# Control Measure for Noise Hazard

Key elements of an **effective hearing conservation program** include:

- Workplace noise sampling including personal noise monitoring.
- Informing workers at risk from hazardous levels of noise exposure of the results of their noise monitoring.
- Implementing comprehensive hearing protection follow-up procedures for workers who show a loss of hearing (standard threshold shift) after completing baseline (first) and yearly audiometric testing.
- Proper selection of hearing protection based upon individual fit and manufacturer's quality testing indicating the likely protection that they will provide to a properly trained wearer.
- Training and information that ensures the workers are aware of the hazard from excessive noise exposures and how to properly use the protective equipment that has been provided.

# Temperature

# Thermal Balance

*Table 9.1* Basic equation of human thermal balance

$$S = M - E \pm R \pm C - W$$

where

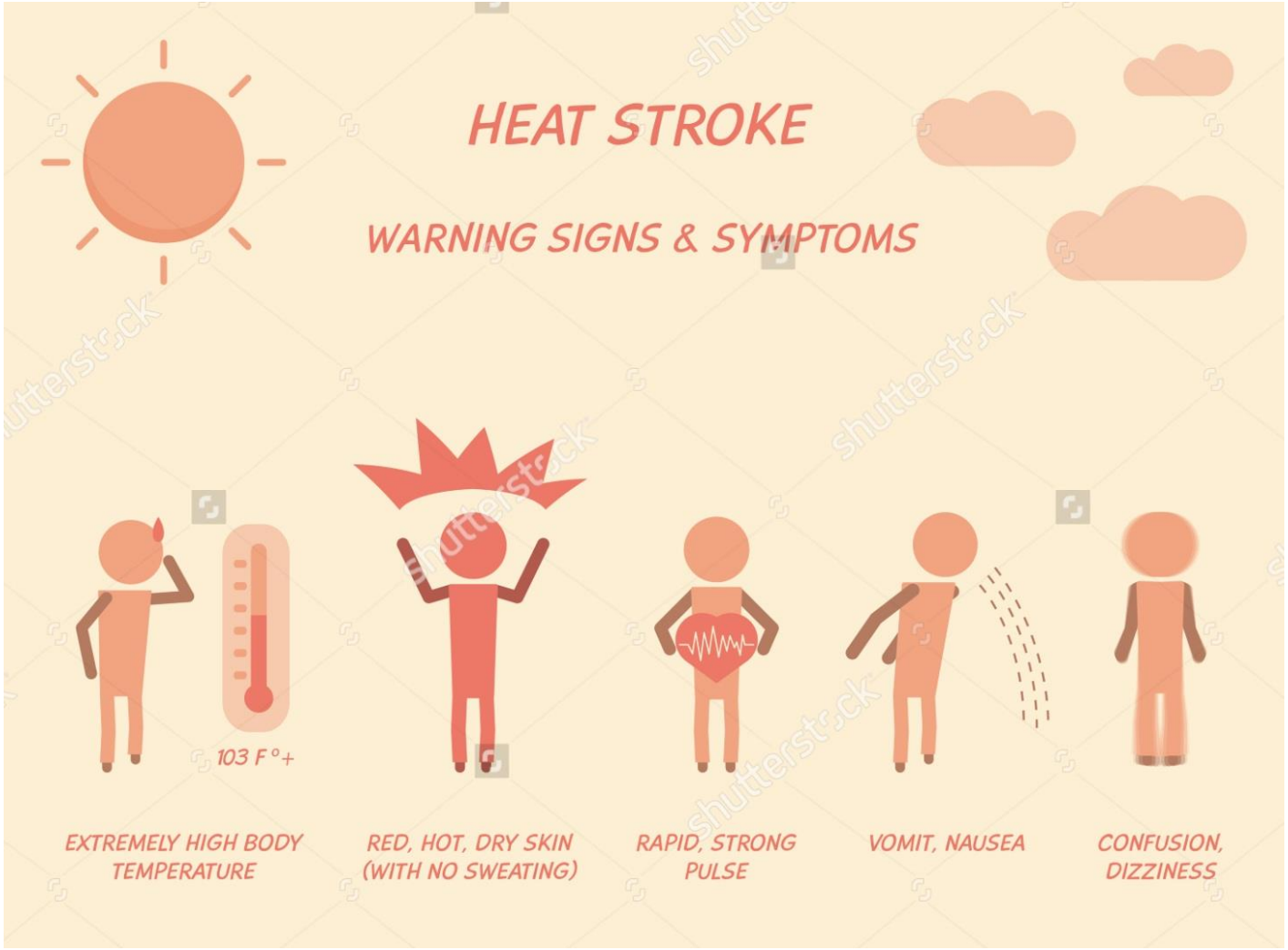
$S$ = Heat gained or lost by the body
$S = 0$ when the body is in thermal balance with the environment
$M$ = Metabolic energy production
$E$ = Heat dissipated through evaporation (sweating)
$R$ = Radiant heat to or from the environment
$C$ = Convection to or from the environment
$W$ = Work accomplished by the worker

# Heat Illness

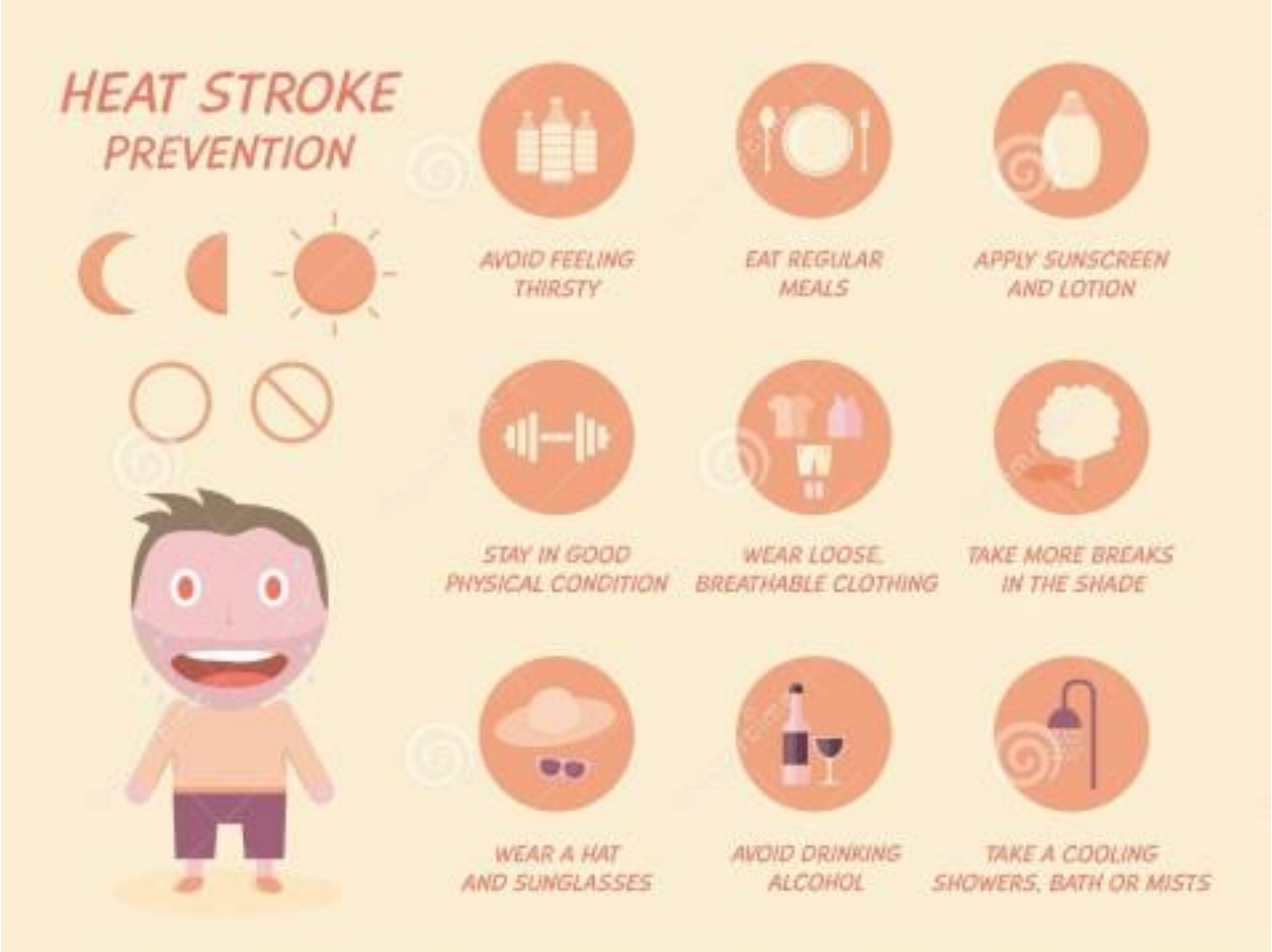
## Heat Hyperpyrexia (Heat Stroke)

- Thermoregulation fails, sometimes suddenly, and core temperature exceeds 41°C.
- The condition may be potentially fatal if untreated. The individual may collapse and will be disorientated. The skin is hot, red and dry.
- Active cooling on rescue from the heat is needed.

# Heat Illness



# Heat Illness



# Heat Illness

## Heat Exhaustion

- When thermoregulatory strain combines with cardiovascular strain, heat exhaustion can occur.
- The person feels weak and may be uncoordinated, breathing may be shallow with a rapid, weak pulse.
- Dehydration contributes to heat exhaustion. Heat stroke can follow if the dehydration is not corrected.
- Removal from the heat, removal of clothing and fanning may restore normal functioning.

# Heat Illness

## Heat Syncope

Fainting due to excessive heat. It is more common in unacclimatised individuals and can be fatal if the sufferer cannot lie down (when working in a confined space, for example).

## Heat Hyperventilation

This can occur when working in the heat while wearing protective clothing. Hyperventilation results in an excessive loss of carbon dioxide. It is treated by making the sufferer breathe into a small bag for a few minutes.

# Heat Illness

## Prickly Heat

- This manifests as a fine, superficial skin rash associated with excessive sweating.
- It often occurs on areas of skin that are covered by clothing or protective equipment.

# Heat Illness

- A worker heading into a heat stroke will no longer realize what's happening to him/her
- It is vital that co-workers be able to recognize what's happening and intervene
- Without quick attention, the co-worker may die!

So, watch out for each other!

# Heat Acclimatization

- ✓ Heat acclimatization is a physiological process of adaptation rather than a psychological adjustment to life in a hot environment.
- ✓ It involves an increase in the capacity to produce sweat and a decrease in the core temperature threshold value for the initiation of sweating.
- ✓ The maximum rate of sweat production can double from 1 liter/hour in an unacclimatized person to 2 liters/hour in an acclimatized person.
- ✓ A state of acclimatization is best achieved by exercising in the heat and drinking plenty of fluid.


# Heat Acclimatization

- ✓ Increased sweat production enhances evaporative cooling of the skin and thus improves heat transfer from the deep body tissues to the periphery.
- ✓ The risk of dehydration and salt depletion is reduced in an acclimatized person owing to expanded blood volume and a reduction in the salt concentration of the sweat.
- ✓ Acclimatization reduces the skin's blood flow requirements, which reduces the cardiovascular load during work in the heat.

# Heat Stress Management

## Some Basic Steps

- Reduce high relative humidity using dehumidifiers.
- Increase air movement using fans or air conditioners.
- Remove heavy clothing; issue loose-fitting overalls.
- Reduce the work rate.
- Include frequent rest pauses.
- Introduce job rotation.

# Heat Stress Management

## Some Basic Steps

- Carry out outdoor work at cooler times of the day (e.g. early morning).
- Allow 2 weeks for acclimatization.
- Enforce rest breaks and provide drinking water or other fluids.
- Provide shade to reduce radiant heat load (plant trees, build awnings, issue wide-brimmed hats).
- In factories, build cool spots and refuges to lower worker exposure.

# Heat Stress Management

## Work Environment Control

- Air movement of less than 0.1 meter per second can lead to stuffy rooms
- Ventilation (need: 300 cubic feet fresh air per person, per hour.)
- A comfortable temperature range for sedentary work is between $21^0$ and $24^0$ C
- The optimum range of relative humidity is 40-50%.
- Relative humidity below 20% can cause dryness of the eyes, nose, throat and build up of static charges.
- Humidity above 80% can cause fatigues.

# Heat Stress Management

## Administrative Control

- Limit time in hot or cold situations,
- Provide rest breaks at appropriate intervals in a temperature controlled environment.

# Cold Injury

## Freezing Cold Injury

- **Frostbite** occurs when the tissues freeze; the damage is caused by high concentrations of electrolytes left in tissue fluids when most of the water turns to ice (Oakley, 2000). The skin is white and hard when frozen and turns red on warming as blood flow returns.

- **Frostnip** is a mild form of frostbite; with frostnip, only the superficial layer is frozen and the tissues recover completely within 30 minutes of re-warming, with the return of sensation to the affected area.

# Cold Injury

## Freezing Cold Injury

- Rewarming is best achieved by placing the affected part against the warm skin of another person.
- Gangrene may develop and re-warming itself may be extremely painful. Re-warming should not be attempted until it is certain that further freezing will not occur.
- **Deep frostbite** is even worse; deep frostbite is rarely seen in occupational settings and has serious medical consequences, including possible amputation of the affected limb.

# Cold Injury

## Non-freezing Cold Injury

- These injuries occur as a result of longer-term exposure to less severe temperatures and are found in military populations (e.g. ‘trench foot’) and in survivors of shipwrecks.
- The cause of the injury is not known but the result is cold sensitization.
- Although the condition may resolve in the years following the exposure, it may worsen as the cold sensitization response makes it more, rather than less, likely that the affected part will be cooled in future.
- In the initial stages, gradual, rather than rapid re-warming is recommended (Oakley, 2000).

# Cold Climate Protection

- The main challenge is to provide a sufficient amount of insulation while allowing moisture, from sweating, to evaporate.
- Garments made of vapor-permeable materials can provide insulation and allow moisture to escape.
- Sweat produced when working, if it collects in the interstices of the garment, will reduce the thermal insulation properties of the garment and may even freeze within the garment when the work stops and metabolic heat production drops. The wearer will rapidly become cold.

# Cold Climate Protection

At temperatures below 0°C, gloves provide inadequate insulation and mittens are needed, resulting in a major reduction in functional manual dexterity.

KEEP
CALM
ITS THE END
OF MY
SLIDESHOW