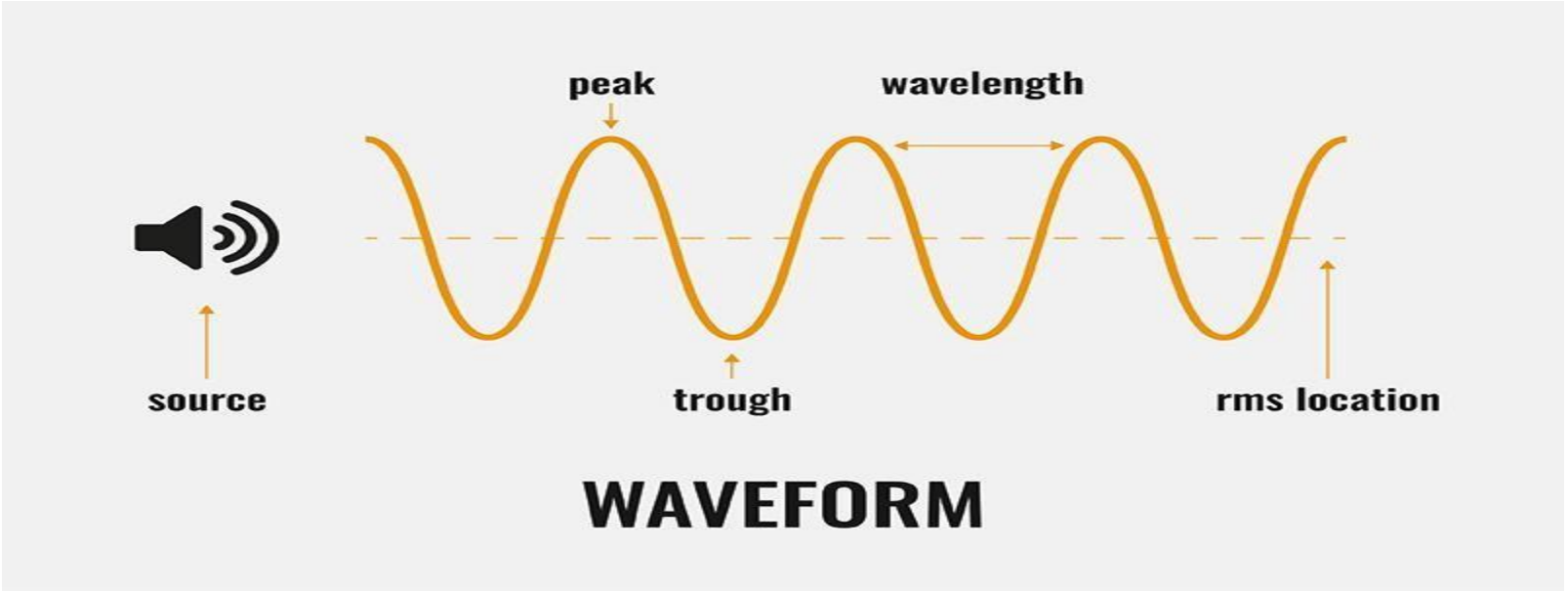
UNIT 5

Measurement of sound: Noise exposure and hearing loss, Hearing protectors, Analysis and reduction of noise, Effects of noise, Performance annoyance of noise and interface with communication, Sources of vibration and performance effect of vibration.

Sound

- Sound is a **form of energy** that travels in waves through a medium, such as air, water, or solids.
- When an **object vibrates**, it creates pressure waves that propagate through the surrounding medium, causing it to vibrate in turn.
- These **vibrations are detected by our ears**, which convert them into electrical signals that our brains interpret as sound.
- The characteristics of sound waves include frequency, wavelength, amplitude, and speed.

The human ear is sensitive to frequencies in the range of 20 to 20,000 Hz



Characteristics of sound wave

- **Amplitude**: The amplitude of a sound wave refers to the height of the wave, or the amount of energy it carries. This determines the loudness of the sound, with higher amplitude waves producing louder sounds.

- **Frequency:** The frequency of a sound wave refers to the number of vibrations per second, measured in Hertz (Hz). This determines the pitch of the sound, with higher frequency waves producing higher pitched sounds.

- **Wavelength:** The wavelength of a sound wave refers to the distance between two consecutive peaks or troughs in the wave. This is related to the frequency of the wave, with higher frequency waves having shorter wavelengths

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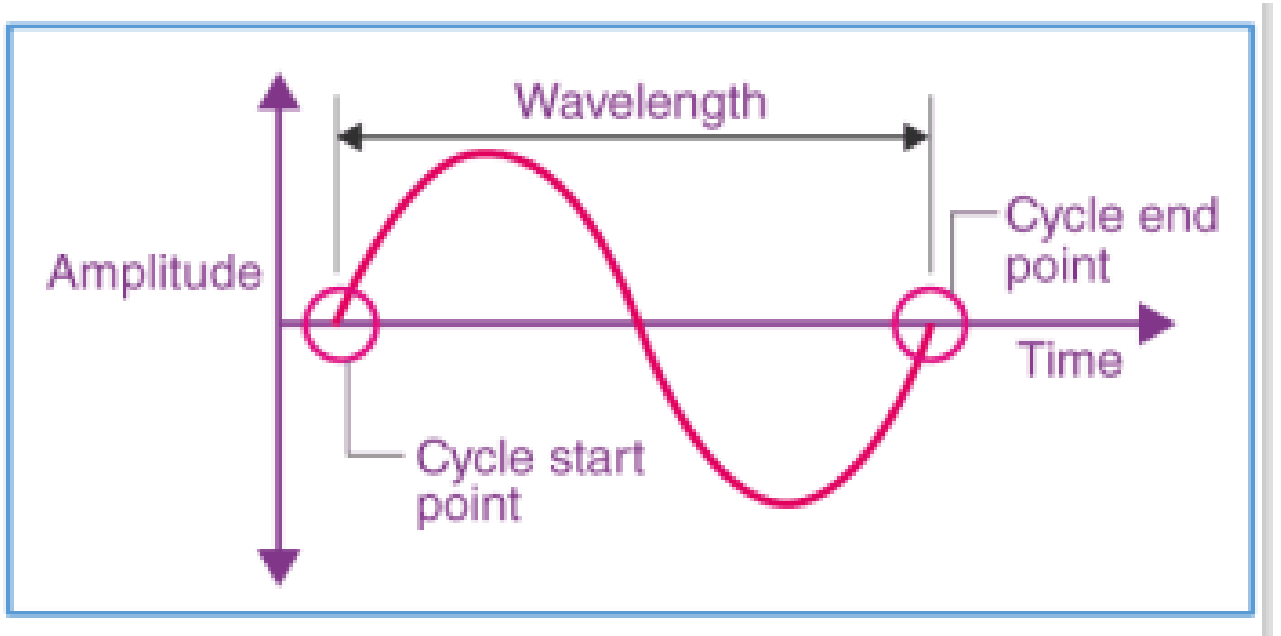
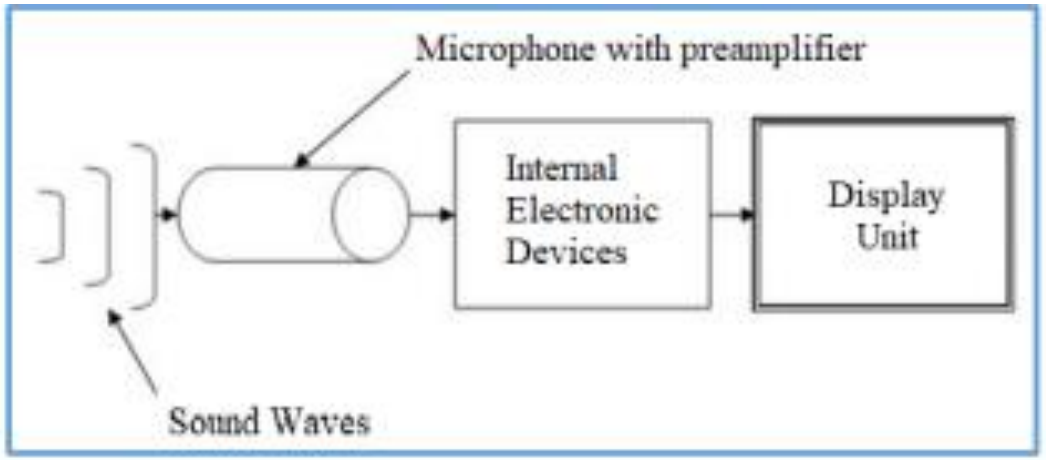
- **Speed:** The speed of a sound wave depends on the medium through which it is traveling, and is generally slower in denser mediums. In air at room temperature and pressure, sound travels at a speed of approximately 343 meters per second.

- **Direction:** Sound waves travel in all directions from their source, and can be reflected, refracted, or absorbed by different materials and surfaces



Measurement of sound

- The measurement of sound is typically done using a unit called the **decibel (dB)**, which is a logarithmic scale that expresses the intensity or loudness of a sound relative to a reference level.
- The **reference level** used for sound measurements is usually the threshold of human hearing, which is considered to be 0 decibels (dB).
- The intensity of sound is typically measured using a sound level meter, which consists of a **microphone** that **detects sound waves** and an **electronic circuit** that converts the sound pressure level into a corresponding decibel value



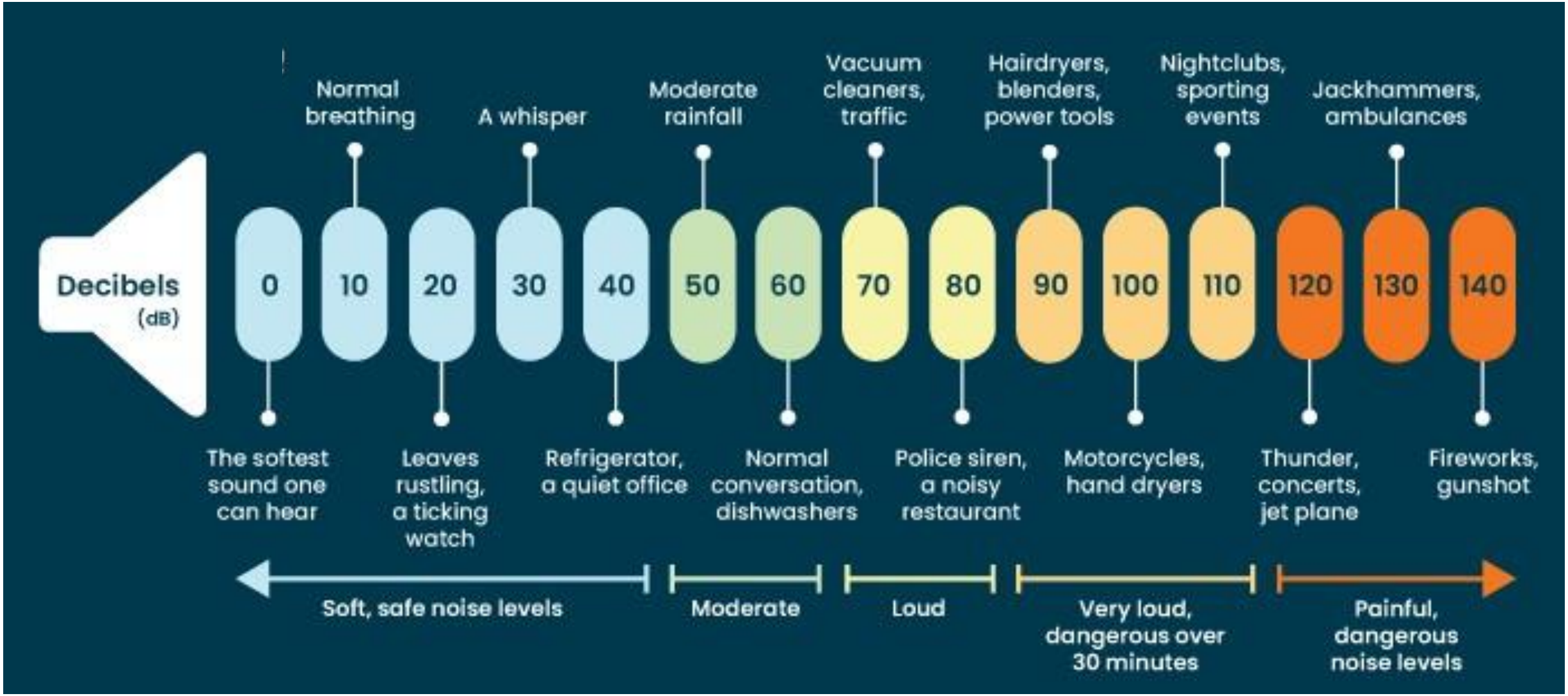


Figure: Some common sound values in decibels

Decibel scale (dBA)

130	threshold of pain
120	aircraft on take off
110	rock band
100	jackhammer
90	truck
80	telephone ringing
70	passenger car
	Unhealthy
60	conversation
	WHO Europe IT-1 for noise (55)
50	rain
40	quiet living room
30	whisper
20	ticking of a watch
10	rustling leaves
0	threshold of hearimg

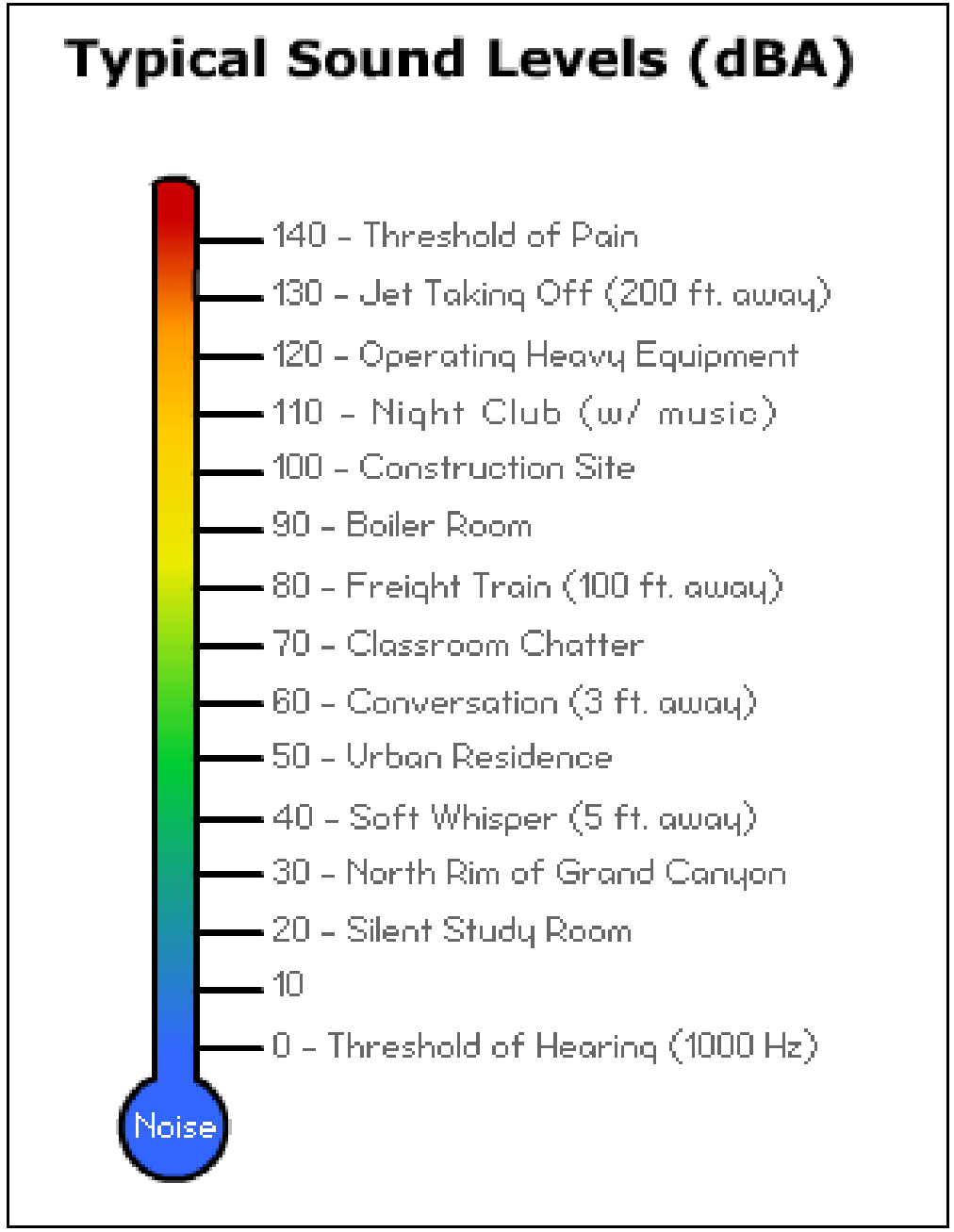
Noise

- Noise is a type of **unwanted or disturbing sound** that is typically characterized by its intensity, frequency, and duration.
- It can be caused by a **variety of sources**, including **transportation** (such as traffic or airplanes), **industrial processes, construction activities**, and **human activities** (such as music, talking, or shouting).
- Excessive exposure to noise can have **negative effects on human health**, including hearing loss, tinnitus, cardiovascular disease, and sleep disturbance.
- Noise pollution can also have **negative impacts on the environment,** including disruption of animal communication and behavior, and interference with natural soundscapes

Noise Exposure

WHAT DO NOISE LEVELS LOOK LIKE?

dBA	Permissible Exposure in 24 hours
85	8 hours
88	4 hours
91	2 hours
94	1 hour
97	30 minutes
100	15 minutes
103	7 minutes 30 seconds
106	3 minutes 45 seconds



Approximation of decibels (dB)

Can cause immediate and permanent hearing loss after just one close-range exposure.

shotgun **160**

jet engine taking off **140**

siren **120**

Regular prolonged exposure to these sounds can lead to noise-induced hearing loss over time.

rock concert **110**

motorcycle **100**

power tools **90**

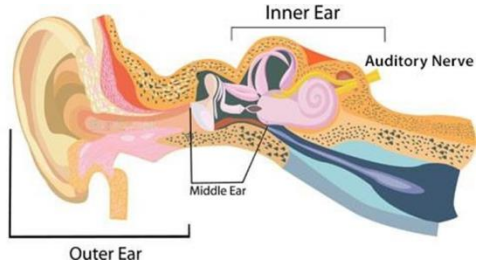
heavy traffic **80-90**

Hearing loss due to noise exposure

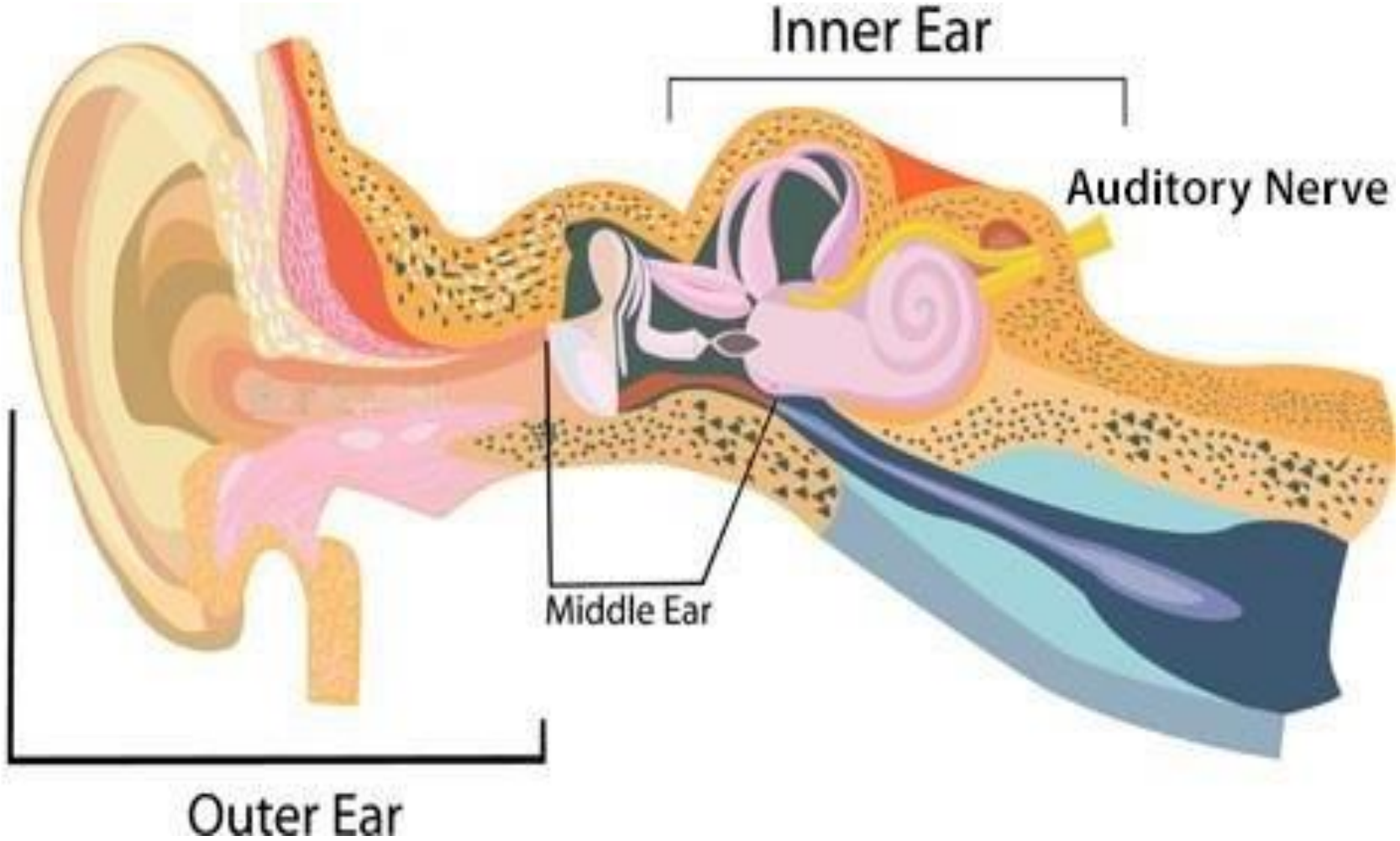
- **Excessive noise** over a **prolonged period of time** can cause damage to the sensitive cells in the inner ear, which are responsible for converting sound waves into electrical signals that **the brain can interpret as sound**.

- Hearing loss due to noise exposure typically affects the ability to hear high- pitched sounds, such as **speech consonants**, which can make it **difficult to** understand speech and communicate effectively.

- The severity of hearing loss depends on several factors, including the **intensity, frequency, and duration of the noise exposure**, as well as the individual's age, genetics, and other factors.



Hearing loss due to noise exposure



Symptoms of noise-induced hearing loss

- Day to day, a person may struggle to hear speech, especially words with **"s," "f," "sh" and "th" sounds** in them.
- For example, the words "shell" "sell" and "fell" are hard to distinguish
- You have **pain in your ears** following loud noise exposure.
- Other people comment that you're talking loudly or shouting.
- You have tinnitus—ringing, whooshing, roaring or buzzing sounds in your ears.
- You may experience diplacusis, or "double hearing," though this is rare.
- You may have **hearing loss in both ears**, but one ear is far worse.

Hearing protectors

- **Hearing protectors** are devices designed to reduce the level of noise that reaches the ears and protect them from damage due to exposure to excessive noise.

Earplugs: These are small, disposable or reusable devices that are inserted into the ear canal to block noise.

Earplugs can be made of foam, silicone, or other materials, and come in various shapes and sizes to fit different ear sizes and shapes

<u>Earmuffs:</u> These are **over-the-ear devices** that consist of two ear cups connected by a headband.

Earmuffs create **a seal around the ears** to reduce the amount of noise that reaches the ear. They are typically made of plastic or metal with foam or other sound-absorbing materials inside the ear cups

<u>Semi-insert earplugs:</u> These are earplugs that are attached to a headband or other device that **fits over the head**, leaving the ear canal open.

They provide lower attenuation than earplugs or earmuffs but can be more comfortable for extended use.

Active noise-cancelling headphones:
These headphones use noise-cancelling technology to reduce ambient noise levels.

They are typically used in environments where there is a constant low-frequency noise, such as airplane cabins or in factories.

- It is also important to **ensure that the hearing protectors are properly fitted and worn correctly** to provide maximum protection.

- **Regular hearing checks** should be conducted to monitor hearing and **ensure** that the hearing protectors are providing adequate protection

Noise Analysis

- Noise analysis is focused on understanding and managing unwanted sound or noise in a given environment.
- This can include sources of noise such as traffic, industrial equipment, or HVAC systems.
- Noise analysis involves measuring and evaluating the characteristics of noise, including its frequency, intensity, and duration.
- This information can be used to develop strategies for mitigating or reducing noise levels in a given environment, such as through the use of sound barriers, noise-reducing materials, or changes in equipment or processes.
- Understanding the properties and characteristics of sound and noise, researchers and practitioners can develop strategies for optimizing acoustic environments and minimizing the impact of noise on human health and well-being

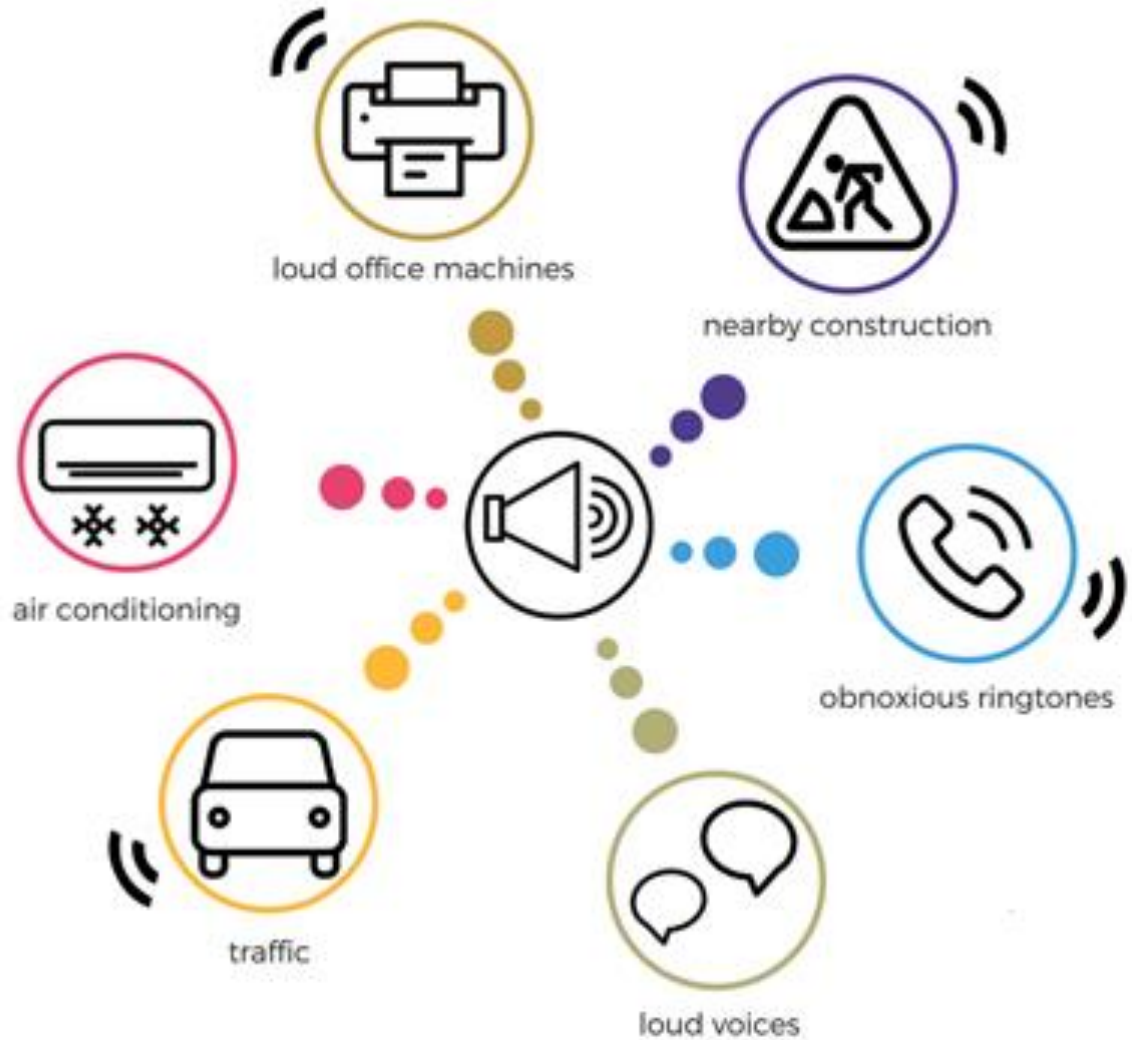
Analysis and reduction of noise

The analysis and reduction of noise is an important consideration in designing work environments that promote productivity, safety, and comfort for workers. There are several factors that need to be taken into account in this process:

- **Identify sources of noise**: The first step in analyzing noise in a work environment is to identify the sources of the noise. This may involve measuring the decibel levels of various sources of noise, such as machinery, equipment, or traffic.

- **Assess the impact of noise on workers**: The next step is to assess the impact of noise on workers. High levels of noise can lead to hearing loss, stress, fatigue, and reduced productivity. Workers in noisy environments may also experience communication difficulties and be more prone to accidents.

Noise pollution in the workplace



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Reduce noise at the source: One way to reduce noise is to design equipment and machinery that produce less noise. This can be achieved by using quieter motors or engines, or by installing noise-reducing components such as mufflers or silencers.

Use sound-absorbing materials: Another way to reduce noise is to use sound-absorbing materials such as acoustic panels, curtains, or foam tiles. These materials help to absorb sound waves and prevent them from bouncing off surfaces and creating echoes.

Implement administrative controls: Administrative controls such as scheduling noisy work during off-hours or providing hearing protection devices can also be effective in reducing noise exposure.

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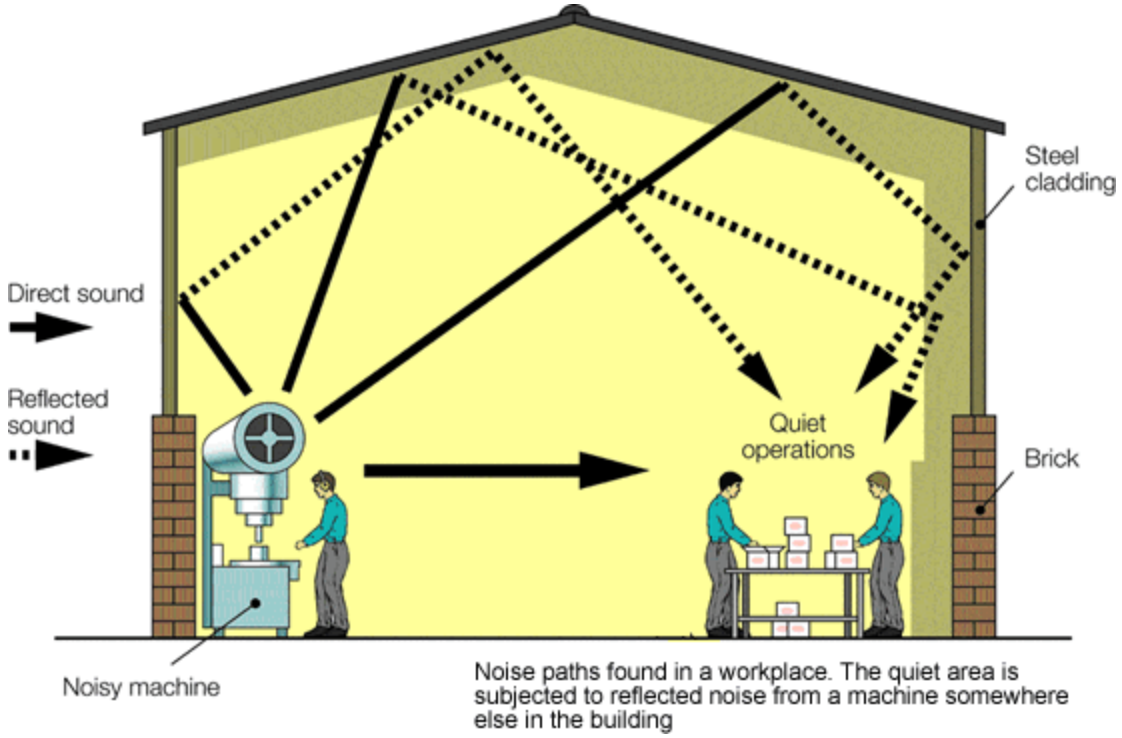
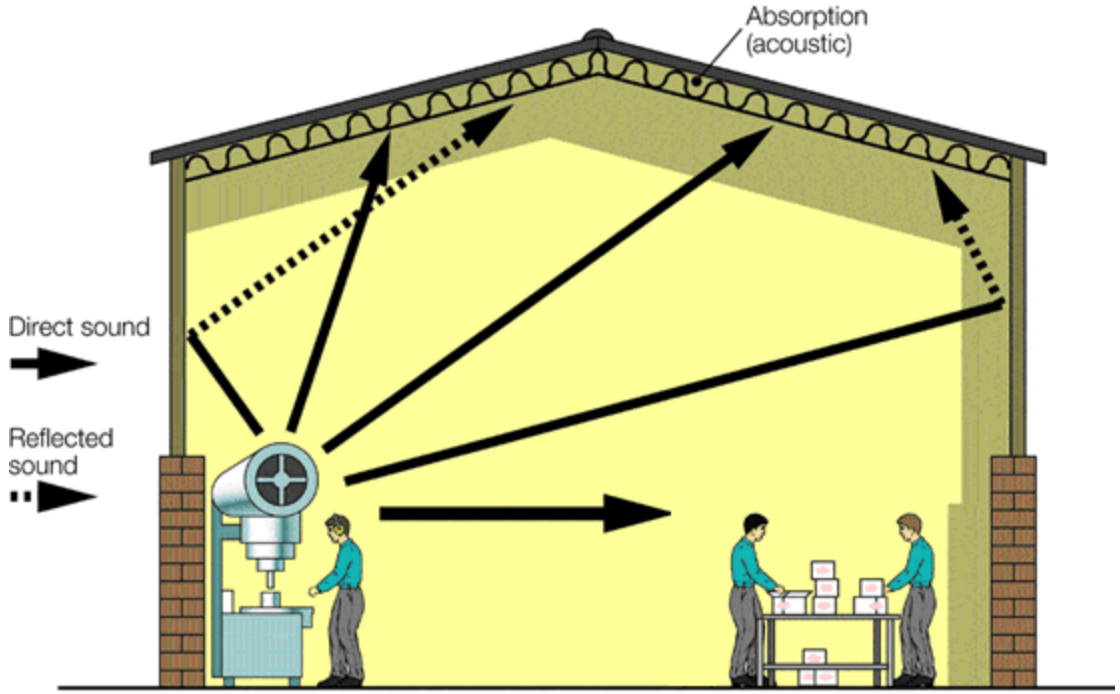
Reduce noise at the source



Noise paths found in a workplace. The quiet area is subjected to reflected noise from a machine somewhere else in the building



Added absorption to roof 'soaks' up reflected noise

The correct use of absorption in the roof will reduce the reflected noise reaching the quiet area

Noise paths found in a workplace

Use of absorption

Types of sound absorbing materials

According to their trade name and availability in market,

- HAIRFELT,
- ACOUSTIC PLASTER,
- ACOUSTICAL TILES,
- STRAWBOARD,
- PULP BOARDS,
- COMPRESSED FIBREBOARDS,
- COMPRESSED WOOD PARTICLE BOARDS,
- PERFORATED PLYWOOD,
- WOOD WOOL BOARD,
- QUILTS AND MATS.

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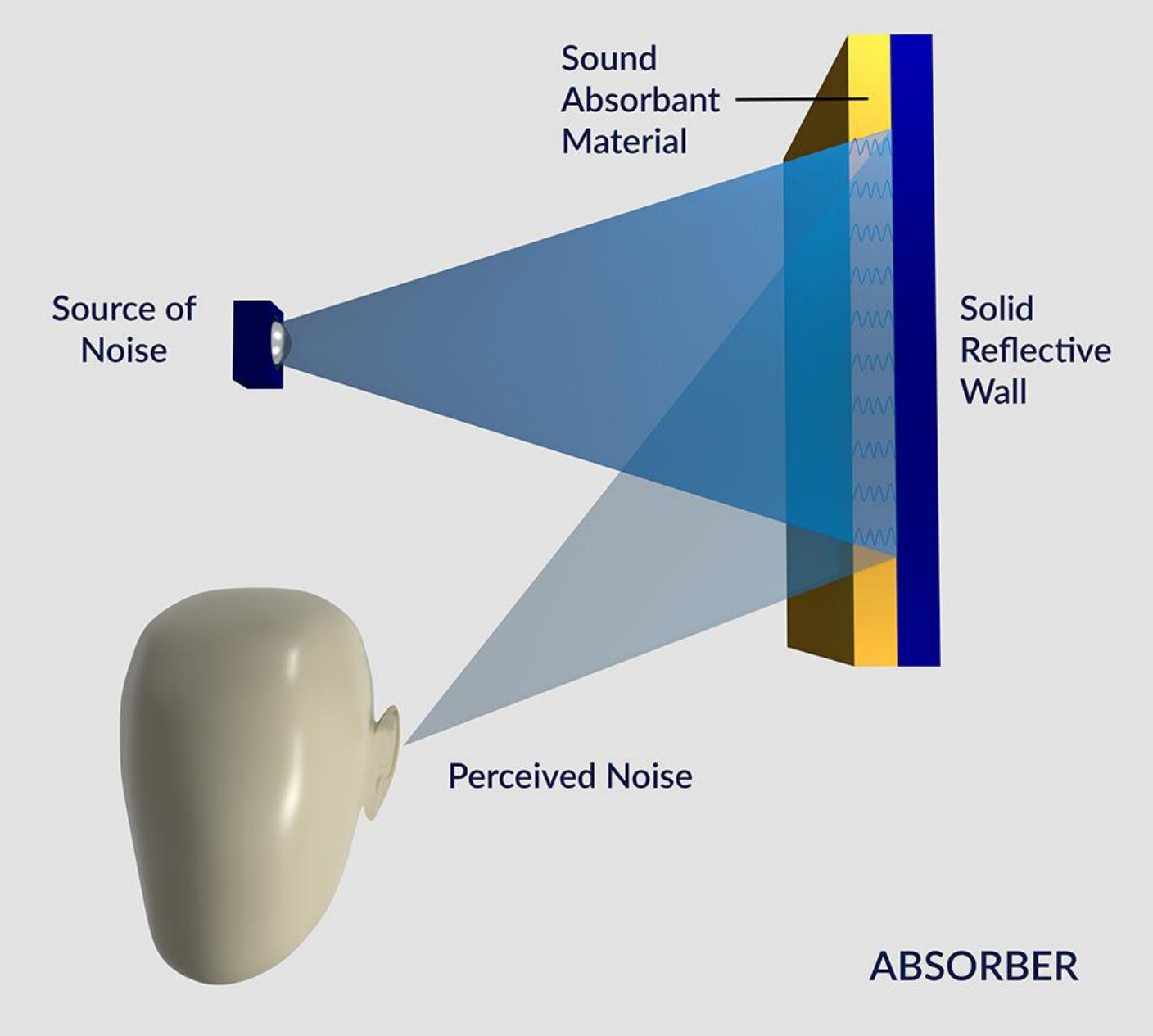
Sound
Absorbant
Material
Source of
Noise
Solid
Reflective
Wall
Perceived Noise
ABSORBER

Cont..

Educate workers: It's important to educate workers about the risks of noise exposure and the steps they can take to protect themselves. This may include providing training on the proper use of hearing protection devices and encouraging workers to take breaks in quiet areas.

In summary, the analysis and reduction of noise in human factors engineering requires a multi-faceted approach that considers the sources of noise, the impact on workers, and a range of strategies to minimize noise exposure. By implementing these strategies, work environments can be designed to promote safety, productivity, and well-being.

Reducing the Risk of Occupational Noise

Reducing the Risk of Occupational Noise:

- Using low-noise tools and machinery
- Maintaining machines properly so they operate quietly
- Isolating and enclosing noise sources
- Identifying and constantly monitoring noise levels through noise risk assessments
- Creating barriers between the noise and your employees
- Training employees to recognize and avoid hazardous noise (above 85 dB) exposure
- Requiring employees to wear PPE when there's a risk of noise exposure

EFFECTS OF NOISE

Exposure to noise can have a range of negative effects on physical and mental health. Here are some common effects of noise:

- **Hearing damage**: Workers who are exposed to high levels of noise over a prolonged period can experience permanent hearing loss, which can be a significant safety risk in some industries.

- **Communication difficulties**: Noise can make it difficult for workers to communicate effectively, leading to misunderstandings, errors, and decreased productivity.

Stress and anxiety: Exposure to noise can cause stress and anxiety, leading to decreased job satisfaction, decreased productivity, and increased absenteeism.

Cognitive impairment: Exposure to noise has been linked to cognitive impairment, including decreased attention span, reduced memory function, and impaired decision-making ability. This can be particularly problematic in jobs that require high levels of concentration and attention to detail.

Fatigue: Noise can disrupt sleep patterns, leading to fatigue and decreased productivity during the day. Chronic sleep deprivation can also have negative effects on physical and mental health.

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Safety risks: In some industries, exposure to noise can be a significant safety risk, as workers may not be able to hear warning signals or communicate effectively in emergency situations.

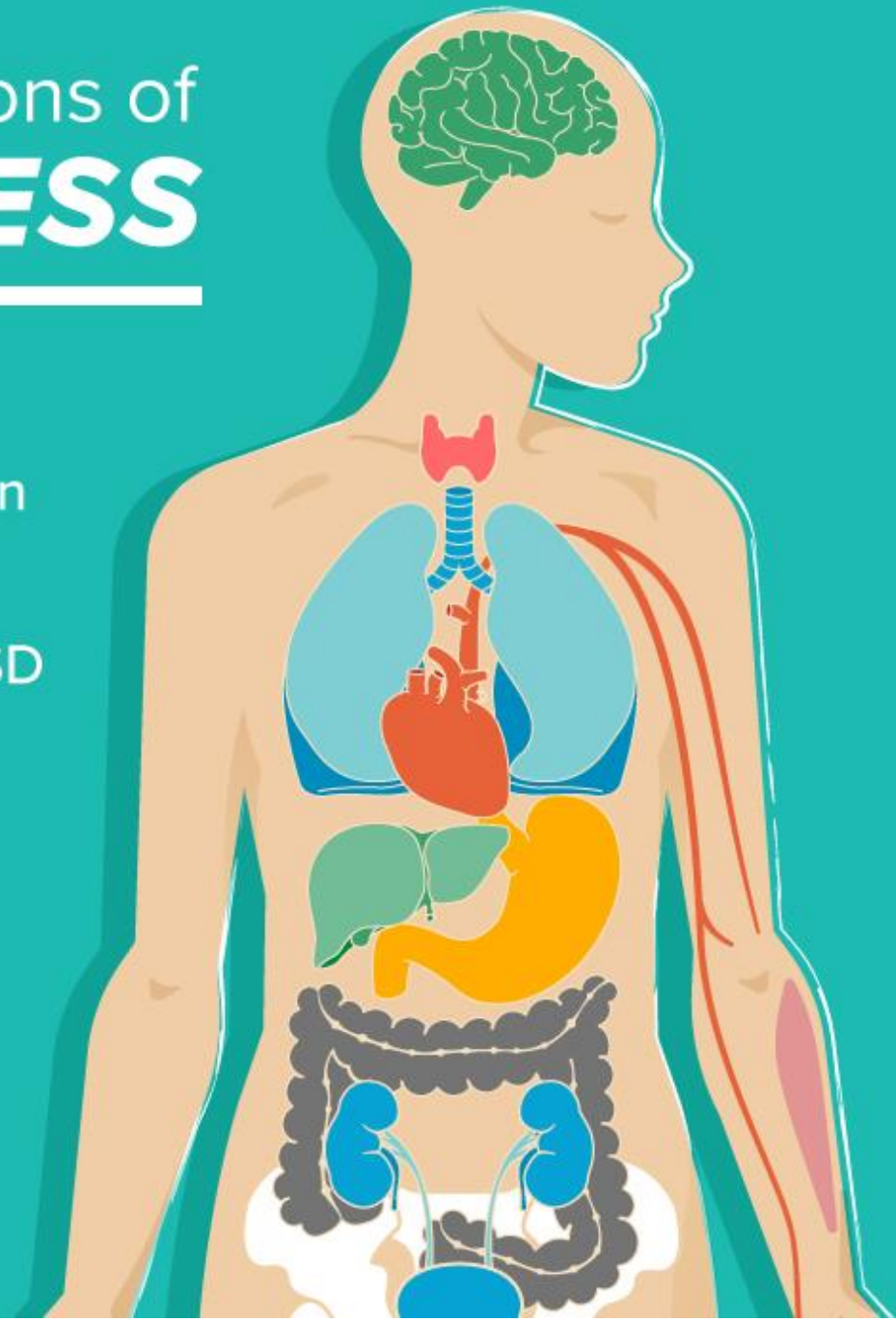
Hypertension : Loud noise can increase blood pressure and induce hypertension in many people.

Behavioural Changes : Constant exposure to loud noise makes a person short-tempered, impatient and irritable.

Cardiac Diseases : Noise pollution increases blood pressure, which leads to cardiac diseases.

Physical Manifestations of **NOISE STRESS**

- Delayed cognitive development in children
- Psychological triggers for individuals with PTSD
- Lower threshold for noise resulting in sleep disturbance
- Increased heartrate
- Changes in immune system



- Anxiety
- Annoyance, mood shifts
- Elevation of cortisol production
- Hypertension
- Myocardial infarction
- Vasoconstriction
- Elevated blood pressure
- Elevated adrenaline levels

Performance annoyance of noise and interface with communication

- Performance annoyance of noise refers to the negative effect of noise on a person's ability to perform a task, and it can be particularly problematic in work environments that require high levels of concentration and attention to detail.

- When workers are exposed to high levels of noise, their ability to communicate effectively can also be affected, leading to decreased productivity and safety risks.

- Noise can interfere with communication in several ways. First, it can make it difficult for workers to hear and understand each other, particularly in noisy work environments where there is a lot of background noise. This can lead to misunderstandings, errors, and decreased productivity.

Relation between Noise levels and Perceived annoyance Levels

Level dbA	50	60	70	80	90	100
Annoyance	0.49 below tested range	1.55 barely annoying	2.61 almost moderately annoying	3.67 nearly quite annoying	4.72 almost extremely annoying	5.78 above extremely annoying

1-Not annoying
2- Lightly annoying
3- Moderately annoying
4- Quite annoying
5-Extremely annoying

The relationship between the annoyance ratings and noise level was determined by regression analysis to be:

Annoyance rating = -4.798 + 0.106 dBA

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- Noise can also interfere with communication by reducing the ability of workers to hear warning signals or alarms. In some industries, such as aviation or manufacturing, failure to hear a warning signal can be a significant safety risk.

- In addition, noise can interfere with communication by making it difficult for workers to use communication technologies effectively. For example, background noise can interfere with phone or video conferencing, making it difficult to hear or understand what is being said.

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Overall, the negative effects of noise on communication can lead to decreased productivity, safety risks, and job dissatisfaction. It is important to design work environments that minimize noise exposure and promote effective communication to ensure that workers can perform their tasks safely and effectively.

This may involve using noise-reducing technologies, providing hearing protection, or scheduling noisy work during off-hours.

Sources of vibration

There are many sources of vibrations in the workplace. Some of the most common sources of vibrations in the workplace include:

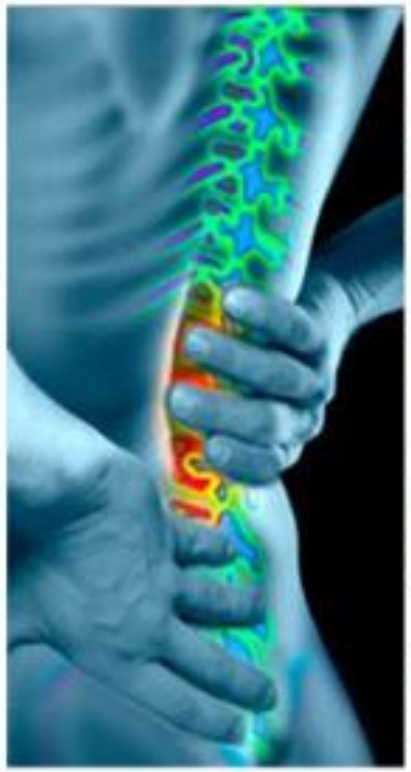
Industrial machinery: Industrial machinery, such as mills, lathes, and presses, can generate significant amounts of vibration as they operate.

Vehicles: Vehicles used in the workplace, such as forklifts and heavy equipment, can generate vibrations as they move and operate.

Power tools: Power tools, such as drills, saws, and grinders, can generate vibrations as they are used.

Sources of vibration

Sources of vibration



Whole Body Vibration and Musculoskeletal Health
Among Moving Vehicle Operators

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Pneumatic tools: Pneumatic tools, such as air hammers and impact wrenches, can generate vibrations as compressed air is used to power the tool.

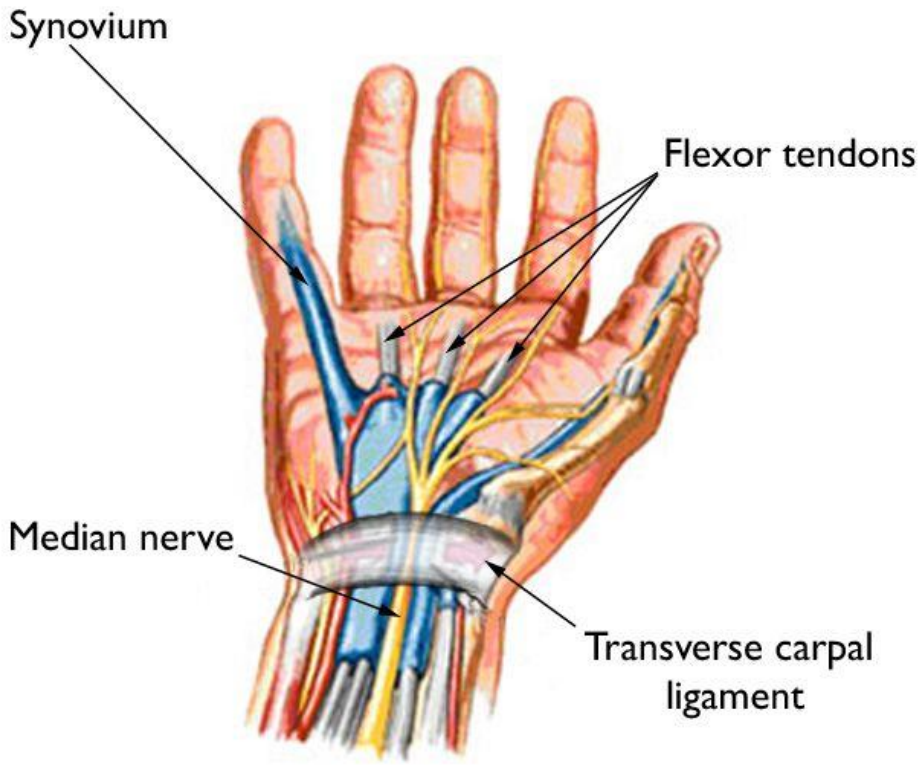
Work surfaces: Vibrations can also be transmitted through work surfaces, such as assembly line conveyor belts, and cause discomfort or injury to workers.

Building structures: Buildings and structures can also generate vibrations from external sources such as road traffic, nearby construction or demolition activities, and earthquakes.

Human activity: Human activities such as walking, running, jumping, and even typing on a keyboard can generate vibrations.

Performance effect of vibration

Occupational injuries: Exposure to excessive vibration can cause occupational injuries, such as carpal tunnel syndrome, hand-arm vibration syndrome, and back injuries.



Carpal tunnel syndrome is caused by **pressure on the median nerve** as it travels through the carpal tunnel.

Carpal tunnel syndrome: Exposure to vibration might also lead to carpal tunnel syndrome. This is a painful nerve disorder that causes **tingling, numbness and weakness in parts of the hand.**

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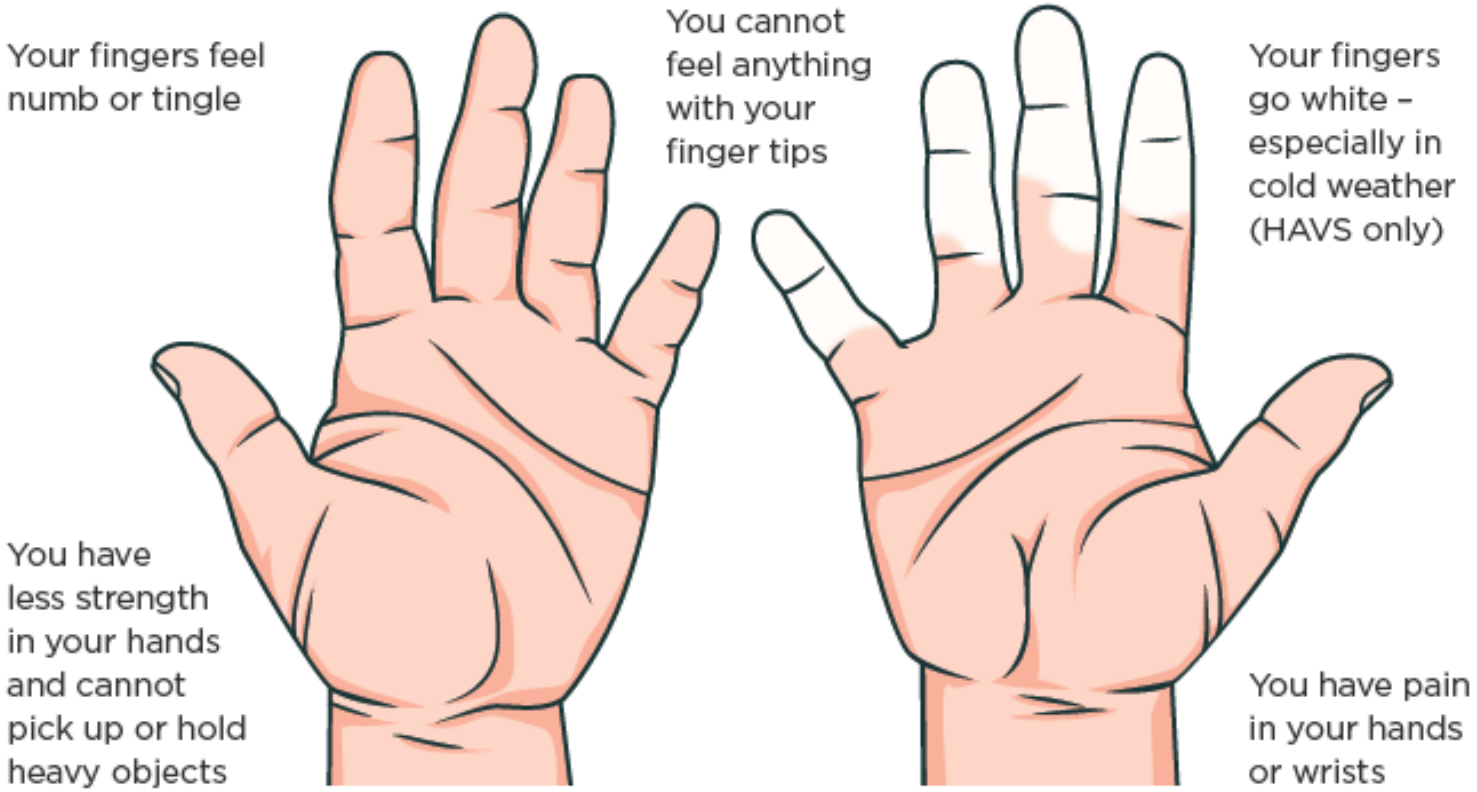

Hand-arm vibration syndrome (HAVS) is a potential health hazard to workers in any occupation involving repetitive use of vibrating tools. HAVS is a collection of sensory, vascular, and musculoskeletal symptoms caused by repetitive trauma from vibration.

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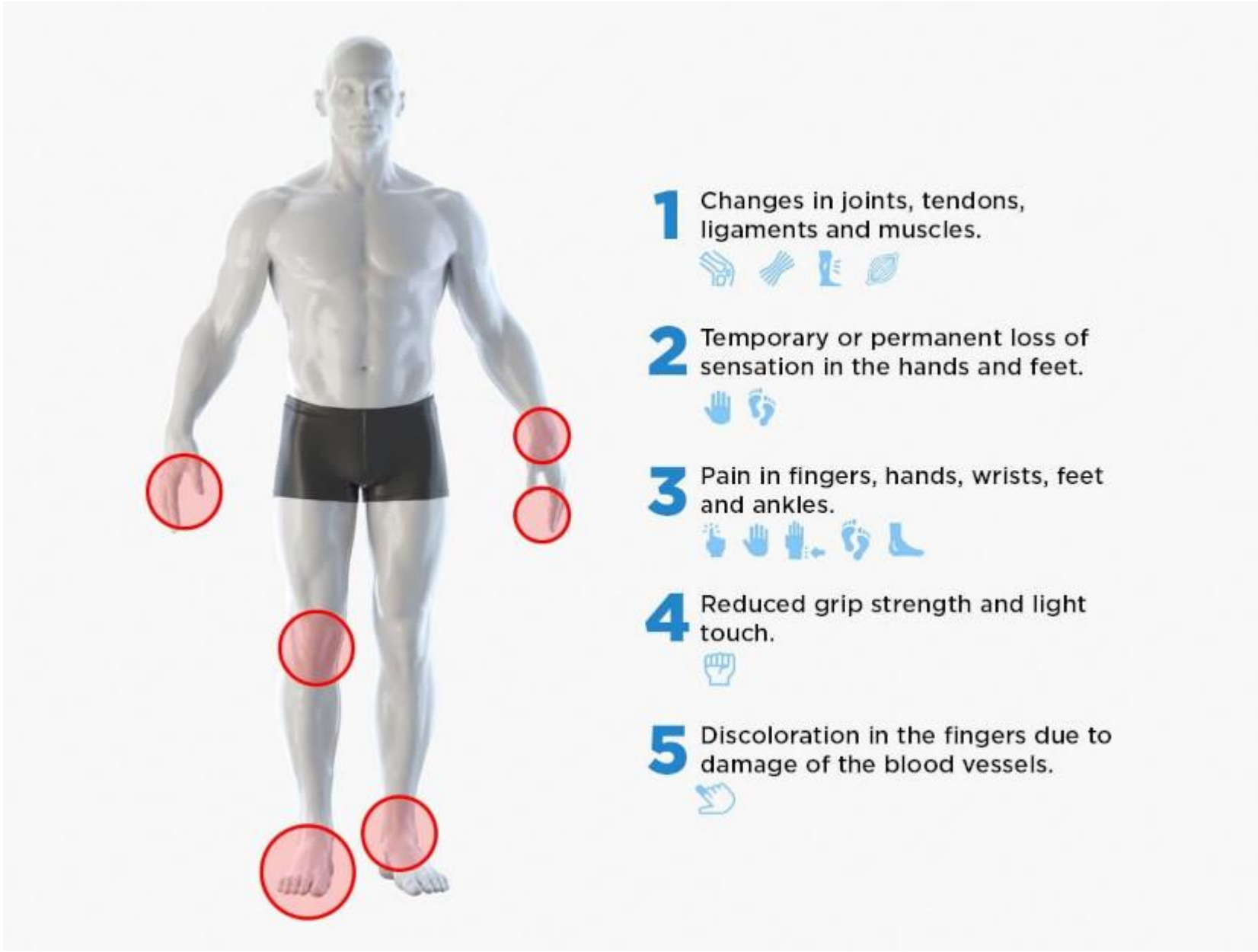

Effects of Vibration on the Human Body

Decreased work productivity: Prolonged exposure to vibrations can lead to decreased work productivity due to fatigue, discomfort, and other symptoms.

Hearing damage: Some vibrations can be transmitted through the air as noise, which can lead to hearing damage or loss.

Damage to equipment: Vibrations can cause damage to machinery and equipment, leading to breakdowns, malfunctions, and increased maintenance costs.

Discomfort: Workers may experience discomfort or pain due to vibrations, which can affect their job satisfaction and morale.