The Science of Therapeutic Modalities

Chapter 1

Objectives

- Define the electromagnetic and acoustic spectra
- Identify the therapeutic modalities classified within the electromagnetic and acoustic spectra
- Discuss the relationship between wavelength and frequency
- Apply the laws that govern the effects of electromagnetic and acoustic energy to therapeutic modalities

Forms of Energy Utilized by Therapeutic Modalities

- Generally classified into one of two spectra
  - Electromagnetic Spectrum
  - Acoustic Spectrum

Electromagnetic Spectrum

- Electrical stimulating currents
- Shortwave diathermy
- Microwave diathermy
- Infrared
  - Cold packs
  - Cold whirlpool
  - Hot whirlpool
  - Paraffin
  - Hydrocollator
- Red (visible light – laser)
- Ultraviolet

Electromagnetic Spectrum

- All radiant energy travels at a constant velocity (300 million meters per second)
- Velocity = wavelength x frequency
Electromagnetic Spectrum

- **Wavelength** – distance between the peak of one wave and the peak of the next wave
- **Frequency** – the number of waves occurring in 1 second (measured in Hz – hertz)

- Velocity = wavelength x frequency
- Inverse relationship between wavelength and frequency

---

Electromagnetic Spectrum

- **Electrical stimulating currents**
- **Shortwave diathermy**
- **Microwave diathermy**
- **Infrared**
  - Cold packs
  - Hot whirlpool
  - Paraffin
  - Hydrocollator
- **Red (visible light – laser)**
- **Ultraviolet**

<table>
<thead>
<tr>
<th>Therapeutic Modalities</th>
<th>Wavelength</th>
<th>Frequency</th>
<th>Depth of penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical stimulating currents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shortwave diathermy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microwave diathermy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrared</td>
<td>longest</td>
<td>lowest</td>
<td>greatest</td>
</tr>
<tr>
<td>Red (visible light – laser)</td>
<td>shortest</td>
<td>highest</td>
<td>least</td>
</tr>
<tr>
<td>Ultraviolet</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Therapeutic Modalities</th>
<th>Wavelength</th>
<th>Frequency</th>
<th>Depth of penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Therapeutic Modalities</th>
<th>Wavelength</th>
<th>Frequency</th>
<th>Depth of penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflected</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refracted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absorbed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Laws Governing the Effects of Electromagnetic Radiations

- Generally, radiations with the longest wavelengths will have the greatest depth of penetrations, regardless of the frequency.
- A variety of factors influence depth of penetration – these will be discussed later as we study each modality.

- **Arndt-Schultz Principle**
  - No reactions or physiological changes will occur within the tissues if insufficient energy is absorbed to stimulate the absorbing tissues (target tissues).
Laws Governing the Effects of Electromagnetic Radiations

**Arndt-Schultz Principle**

**Application 1** — to achieve numbness or a decrease in muscle spasm from an ice bag application, the ice bag must be left on long enough for the target tissues to be cooled — longer for deeper tissues — less time for more superficial tissues.

**Arndt-Schultz Principle**

**Application 2** — to produce a muscle contraction using electrical muscle stimulation, the current must be increased until enough energy is absorbed to depolarize the motor nerve.

Laws Governing the Effects of Electromagnetic Radiations

**Law of Grothus-Draper**

- Describes the inverse relationship between energy absorption and penetration to deeper tissues.
- If the energy is not absorbed by the superficial tissues, it will penetrate to deeper tissues.

![Diagram of energy absorption and penetration](image)

**Cosine Law**

- Radiant energy is more likely to be transmitted to deeper tissues if the radiation is applied at a right angle to the area being treated.

![Energy Source Diagram](image)

**Inverse Square Law**

- Intensity of radiation is inversely related to the square of the distance from the energy source.
- Example:
  - When using an infrared lamp to heat the low back:
    - the closer the lamp is to the skin (shorter distance), the greater the heat intensity
    - The greater the distance between the skin and lamp, the less heat intensity is applied

Acoustical Spectrum

- The range of frequencies and wavelengths of sound waves.
- Ultrasound is the only modality classified in the acoustical spectrum.
- Ultrasound produces heat through mechanical vibrations.
Acoustical Energy
- The human ear can detect acoustical frequencies up to 20,000 Hz
- Therapeutic ultrasound utilizes frequencies from 1 to 3 MHz (megahertz)
- At 1 MHz, 50% of the ultrasound energy will penetrate to a depth of 5 cm

Therapeutic Ultrasound
- Classified as a “deep-heating” modality because of its ability to penetrate to deeper tissues than most electromagnetic modalities
- Other “deep-heating” modalities
  - Shortwave diathermy
  - Microwave diathermy

Therapeutic Ultrasound
- The denser the tissue, the greater the velocity of energy transmission
  - Speed of transmission greater in bone than fat tissue (bone is denser than fat tissue)

Objectives
- Define the electromagnetic and acoustic spectra
- Identify the therapeutic modalities classified within the electromagnetic and acoustic spectra
- Discuss the relationship between wavelength and frequency
- Apply the laws that govern the effects of electromagnetic and acoustic energy to therapeutic modalities

What questions do you have?

What’s Next?
Prior to class on Tuesday:
Read Chapter 2 – The Healing Process