Understand or Know:

1. The basic mechanisms of light interaction with tissue.
2. The basic technical terms related to laser irradiation of tissue.
3. The 4 things that will influence the outcome of a laser application to tissue.
4. The principles of fluence distribution in tissue that would allow the prediction of adequate or inadequate irradiance of a tumor undergoing photodynamic therapy.

Light Amplification by the Stimulated Emission of Radiation
Laser Applications in Veterinary Medicine and Surgery
George M. Peavy, DVM, DABVP  gpeavy@uci.edu

Gas Lasers
Solid State Lasers
Diode Lasers
Fiber Lasers

<table>
<thead>
<tr>
<th>Type</th>
<th>Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argon</td>
<td>488; 514 nm</td>
</tr>
<tr>
<td>KTP</td>
<td>532 nm</td>
</tr>
<tr>
<td>Krypton</td>
<td>531; 568 nm</td>
</tr>
<tr>
<td>Dye and Diode</td>
<td>577-780 nm</td>
</tr>
<tr>
<td>Helium Neon</td>
<td>630 nm</td>
</tr>
<tr>
<td>Gold Vapor</td>
<td>630 nm</td>
</tr>
<tr>
<td>Ruby</td>
<td>694 nm</td>
</tr>
<tr>
<td>Near IR Diode</td>
<td>810 - 980 nm</td>
</tr>
<tr>
<td>Nd:YAG</td>
<td>1,064 nm</td>
</tr>
<tr>
<td>Ho:YAG</td>
<td>2,120 nm</td>
</tr>
<tr>
<td>Er:YAG</td>
<td>2,940 nm</td>
</tr>
<tr>
<td>CO₂</td>
<td>10,600 nm</td>
</tr>
</tbody>
</table>

Wavelength Selection
Energy (Joules) is a Measure of Work

Power (Joules/second = Watts) is the Rate of Work

Energy Density (Joules/cm²)

Fluence

Power Density (Watts/cm²)

Irradiance
Laser Applications in Veterinary Medicine and Surgery
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- Vaporization Crater - Temp > 100 °C
- Char Formation
- Zone of Thermal Necrosis - Protein Denaturation - Temp 60 - 100 °C
- Zone of Thermal Injury - Temp < 60 °C

Beam Intensity
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**Energy (Joules) – Measure of Work**

**Power (Joules/second = Watts) – Rate of Work**

**Energy Density (Joules/cm²)**

- **Fluence**
- **Power Density (Watts/cm²)**

**Irradiance**

---

**Power Density vs. Spot Size**

<table>
<thead>
<tr>
<th>Spot Size (mm)</th>
<th>0.2</th>
<th>0.4</th>
<th>0.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power (W)</td>
<td>5</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Power Density</td>
<td>160</td>
<td>320</td>
<td>640</td>
</tr>
<tr>
<td>(Watts/cm²)</td>
<td>480</td>
<td>960</td>
<td>1,920</td>
</tr>
</tbody>
</table>

*Calculation based on the heat of vaporization of water (2500 J/cm³), the absorption coefficient of water at 10,600 nm (794/cm) and the thermal relaxation time of soft tissue for 10,600 nm (694 µs)*

---

**Focal Point**

<table>
<thead>
<tr>
<th>Spot Size (mm)</th>
<th>0.2</th>
<th>0.4</th>
<th>0.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Density (W/cm²)</td>
<td>32,000</td>
<td>8,000</td>
<td>2,000</td>
</tr>
</tbody>
</table>

---

**Defocused**

---
Time Domain of Delivery

Pulse Duration shorter than Thermal Relaxation Time of the tissue
Thermal energy confined to area of beam exposure

Pulse Duration longer than Thermal Relaxation Time of the tissue
Thermal energy diffuses to surrounding tissue before ablation
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- Power
  - Continuous Wave
    - Peak Power = Average Power
  - Pulse
    - Pulse Interval
    - Peak Power = Average Power
  - Superpulsed
    - Continuously Released
      - Peak Power = Average Power
  - Superpulsed
    - Pulsed Release
      - Micro-pulse
      - Macro-pulse
  - Continuous Release
  - Pulsed Release
  - Micro-pulse
  - Macro-pulse
- Power vs. Time
- Vaporization Crater - Temp > 100°C
- Char Formation
- Zone of Thermal Necrosis - Protein Denaturation - Temp 60-100°C
- Zone of Thermal Injury - Temp < 60°C
Factors that Influence Tissue Response

Wavelength Selection
Beam Intensity
  Power Output of the Laser
  Focal Point Diameter
  Distance from Tissue (Focused vs. Defocused)
  Angle of Incidence of Beam to Tissue
Time Domain of Delivery
  Hand Speed of Surgeon
  Laser Mode: CW or Pulsed and Pulse Parameters
Tissue Handling
  Tissue Tension
  Remove Char

Benefits Promoted by Industry

- Hemostasis
- Less Pain
- Reduced Swelling
- Rapid Healing

Benefits as Seen by Me

- Hemostasis
- Precision of Tissue Removal
- Access to Difficult to Access Locations
- Reduced Patient Suffering
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- Hemostasis
- Precision of Tissue Removal
- Access to Difficult to Access Locations
- Reduced Patient Suffering

Meibomian Gland Tumor
(Sebaceous adenoma of the eyelid)

10 Days Post Surgery
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6 Weeks Post Surgery

- Hemostasis
- Precision of Tissue Removal
- Access to Difficult to Access Locations
- Reduced Patient Suffering
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- Hemostasis
- Precision of Tissue Removal
- Access to Difficult-to-Access Locations
- Reduced Patient Suffering

Chronic Recurring Draining Tract
- 8 year old, M, Bouvier des Flandres
- Multiple draining tracts all 4 paws
- Recurrent after surgical debridement and antibiotic therapy

CO₂ Laser
- 10 W
- Articulated arm delivery
- 0.2 mm spot size, focused and defocused
- Antibiotics orally
• 8 weeks post surgery
• No recurrence

Plasma Cell Tumor
Re-excision for Wider Margins

Gingival hyperplasia – 3 to 5 mm pockets throughout mouth
Immediately post laser gingivectomy
Elongated Soft Palate Excision

- Hemostasis
- Precision of Tissue Removal
- Access to Difficult to Access Locations
- Reduced Patient Suffering

Photographs Courtesy of Dr. Ray Arza DVM

CO\textsubscript{2} Laser Soft Palate Excision

Photographs Courtesy of Dr. Barbara Gores DVM, DACVS
Stenotic Nares

- Complications of Untreated Stenotic Nares:
  - Eversion of laryngeal sacculae
  - Laryngeal edema
  - Laryngeal collapse
  - Noncardiogenic pulmonary edema

- Other Conditions Frequently associated with Stenotic Nares:
  - Elongated Soft Palate
  - Hypoplastic Trachea

Stenotic Nares Correction

Wedge Resection

Case Courtesy of Dr. Barbara Gores DVM, DACVS
Southwest Veterinary Specialty Center
Tucson, AZ
Laser Applications in Veterinary Medicine and Surgery
George M. Peavy, DVM, DABVP  gpeavy@uci.edu

Vetscope Probe & 0.8 mm Laser Tip

Cerumen Gland Adenoma

Photograph Courtesy of Dr. Lou Gotthelf

CO₂ Laser Assisted Myringotomy

Photographs Courtesy of Dr. Lou Gotthelf
Feline Polyp

Photograph Courtesy of Dr. Lou Gotthelf

Equine Epiglottal Entrapment
Selective Photothermolysis

Angiomatosis (vascular proliferation)
Distichiasis (extra eyelashes)
Cyclophotocoagulation (treatment for glaucoma)

Angiomatosis

Pre-treatment
Immediate post-treatment
6 treatments over 2 years

PDT
Photodynamic Therapy
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Photodynamic Therapy of Cancer
(laser + photosensitizer)

Drug Selectively absorbed by cancer cells

Administer Photosensitizer

Fiber optic bundle

Argon laser
Dye laser

Treatment

514 nm - 488 nm  
(blue-green light)

630 nm - 700 nm  
(red light)

1 or 3 O2

Kills Cells

Conditions Necessary for Successful PDT

♦ Adequate amount of photosensitizer in target tissue with little photosensitizer in surrounding normal tissue

♦ Enough light energy of the appropriate wavelength to activate the photosensitizer

Optical Penetration Depth (δ) - Depth into tissue where the incident irradiance is decreased by 63%

In non-melanin containing tissue ≈ approximates the absorption spectrum of blood:

Blue-yellow wavelengths: δ ≈ 0.5 - 1.5 mm

Red wavelengths: δ ≈ 2 - 4 mm

nearIR: δ ≈ 3 - 4.5 mm
Fluence Distribution

Threshold – the minimum fluence that must be absorbed by the photosensitizer per unit volume to produce tissue necrosis.

PDT - Feline Actinic Keratosis

Pre-treatment  Laser Irradiation  6 days post-treatment