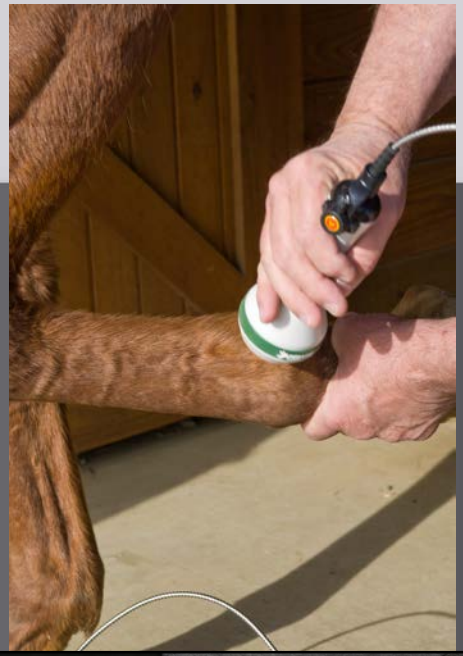
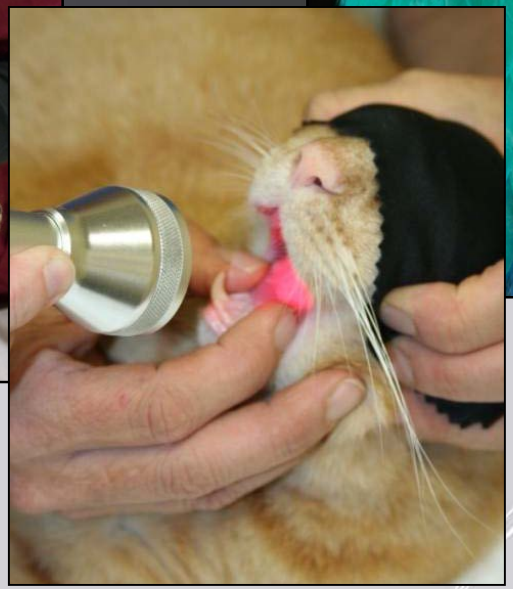
Laser Therapy: A New Paradigm in Veterinary Practice

Ronald J. Riegel D.V.M., FASLMS, VMSO





“Thank you”

The American Institute of Medical Laser Applications

AIMLA

www.aimla.org

Email: aimladvm@aol.com

COMPANION THERAPY LASER®

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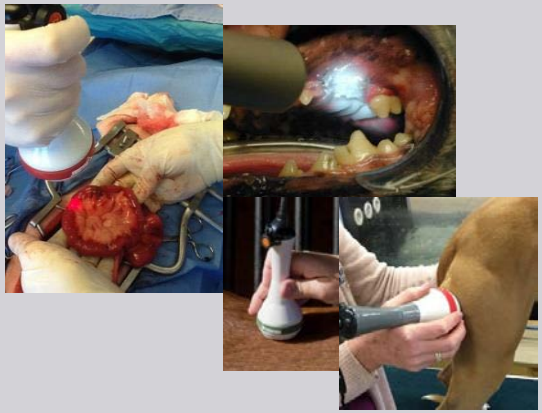
Resource information

Laser Therapy in Veterinary Medicine: *Photobiomodulation*



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John C. Godbold, Jr., DVM

John Wiley & Sons Inc.

Publication: Late2016/Early 2017
43 Chapters
37 Contributing Authors

Websites:

www.aimla.org
www.pubmed.gov
www.research.gov.

Atlas of Class IV Laser Therapy
Small Animal
John C. Godbold, Jr. DVM
CD ROM Edition

Syllabus:

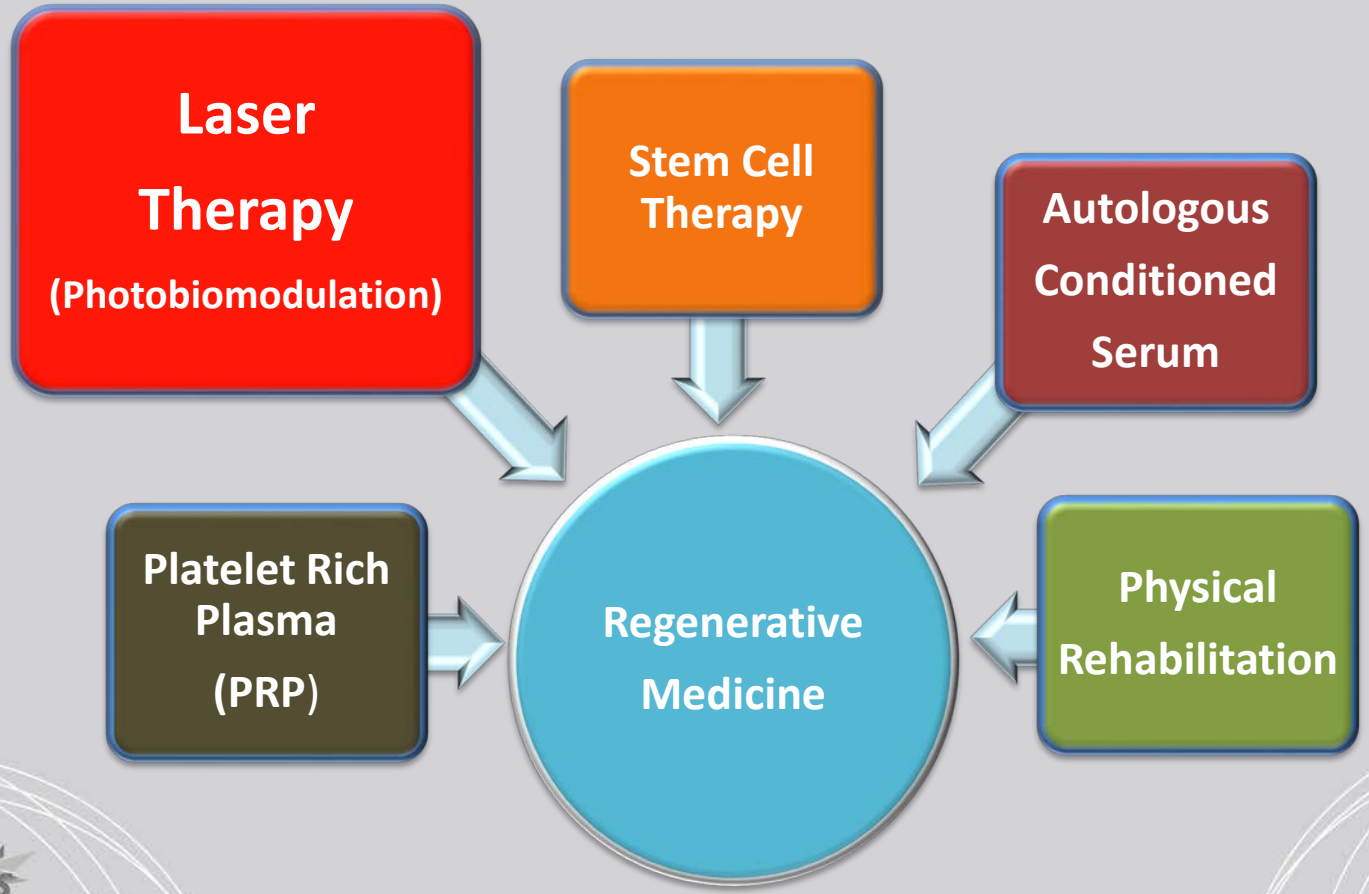
8:00 – 9:00 Fundamental information
Science, laser-tissue interaction, research evidence

9:30 – 10:30 Clinical Applications
Application techniques, common and uncommon applications.

10:45 – 11:45 Interactive session on treatment of specific disorders and anatomical areas.

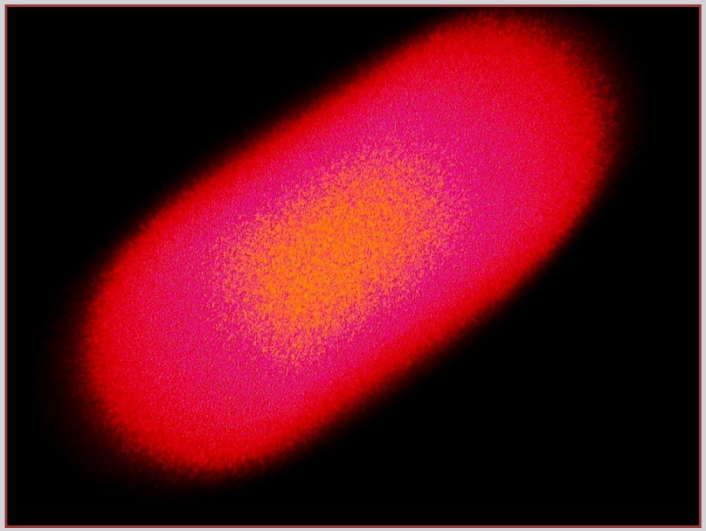
New technology

Regenerative medicine



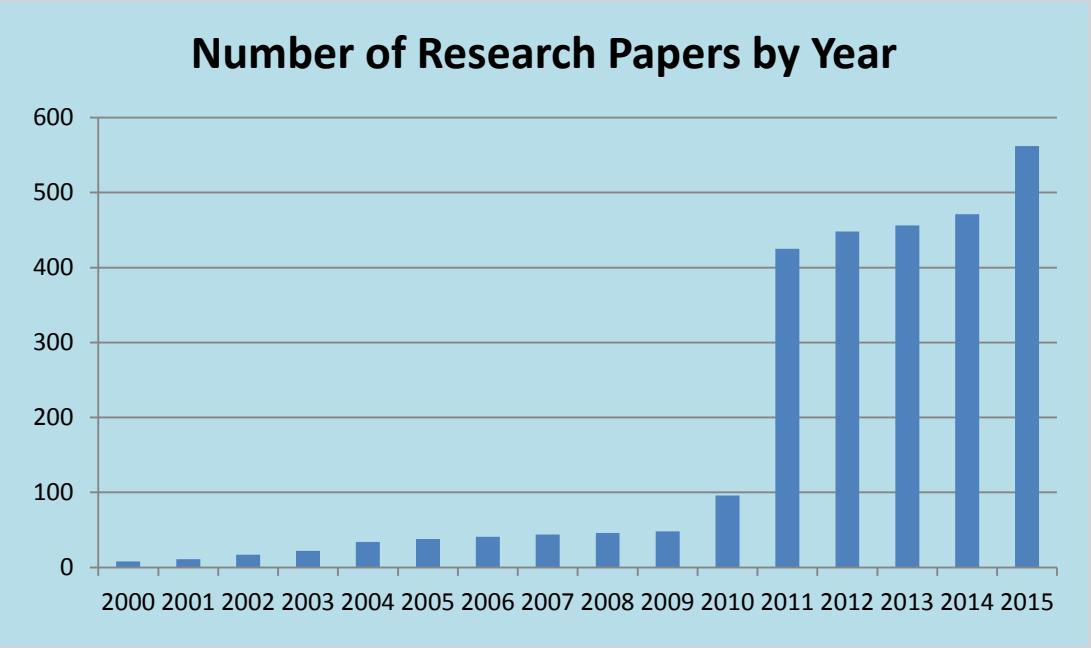
What does laser therapy actually accomplish?

1. Relieves pain
2. Modulation of the inflammatory response
3. Increases microcirculation



Therefore an acceleration of the healing process

Scientific Evidenced Based Medicine



Low Level Laser Therapy: 4,463 articles (increase of ~300 in 6 months time!)

Cold Laser Therapy: 4,540 articles

LLLT: 4,127 articles

Photobiomodulation: 186 articles

www.pubmed.com

Since Jan. 1st 2016 till 4/10/16: 86 papers on photobiomodulation

Research evidence and clinical evidence is:

<u>Evidence Based Healthcare</u>

Part One: Fundamental Information

Current nomenclature

Low Level Laser Therapy …

Cold Laser … Laser Therapy … Light Therapy … High Intensity Laser Therapy … LED Therapy …

LLLT… LEDT… HILT…

Photobioregeneration

Stem cells and PRP

Laser classification

Lasers are classified by potential danger to the eye

Class 1

Safe

Class 1M

Safe provided optical instruments are not used**

***Optical instruments - binoculars, telescopes, microscopes, magnifying glasses (but not prescription glasses)*

Class 2

These are visible lasers. This class is safe for accidental viewing under all operating conditions. However, it may not be safe for a person who deliberately stares into the laser beam for longer than 0.25 s, by overcoming their natural aversion response to the very bright light.

Class 2M

Hazardous (even for accidental viewing) when viewed with the aid of optical instruments

Laser pointer

Class 3R

(1 - 5mW)

Radiation in this class is considered low risk, but potentially hazardous

OSHA requires <u>all</u> Class 3 and Class 4 therapeutic lasers users to wear protective eyewear

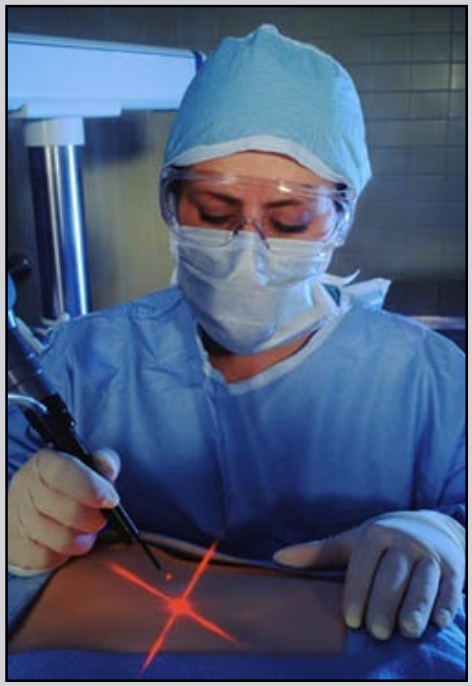
Class 3
(1 mw – 500 mw)

Class 3B

(5 - 500mW)

Radiation in this class is very likely to be dangerous

Class 4
(500 mW>)



Surgical
(CO_2 and diode)

Therapeutic lasers

Radiation in this class is hazardous, and viewing of the diffuse reflection may be dangerous.

Protective eyewear required

Penetration

How deep does a therapeutic dose penetrate?

Radiative Transfer Equation

--fully describes the energy flow of light in tissue

$$-\nabla \cdot \kappa(r)\nabla\phi(r,t) + \mu_a\phi(r,t) + \frac{1}{c}\frac{\partial \mu_a \phi(r,t)}{\partial t} = qo(r,t)^{(1)}$$

Where:

ϕ – ***The Photon Density, is given by:***

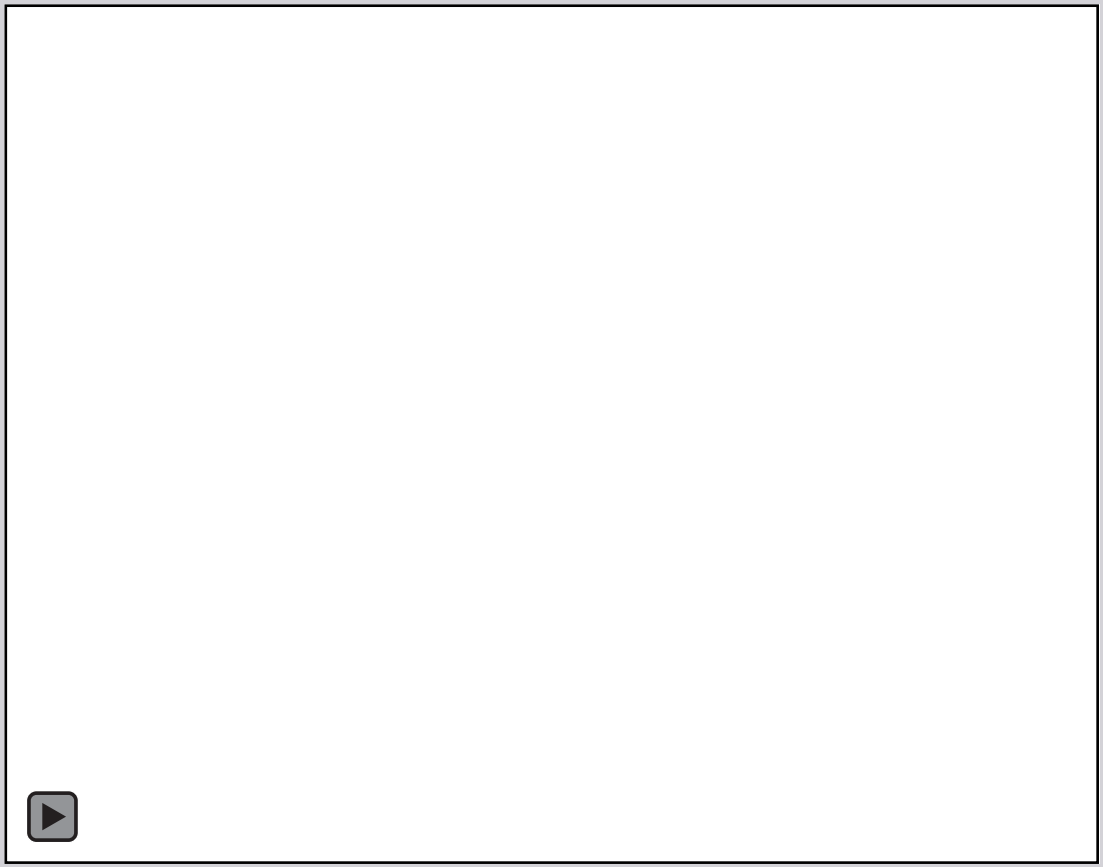
$$\phi(r,t) = \int_{S^{n-1}} \varphi(r,\hat{s},t)\, \partial\hat{s}'$$

κ – ***The Diffusion Coefficient, is given by:***

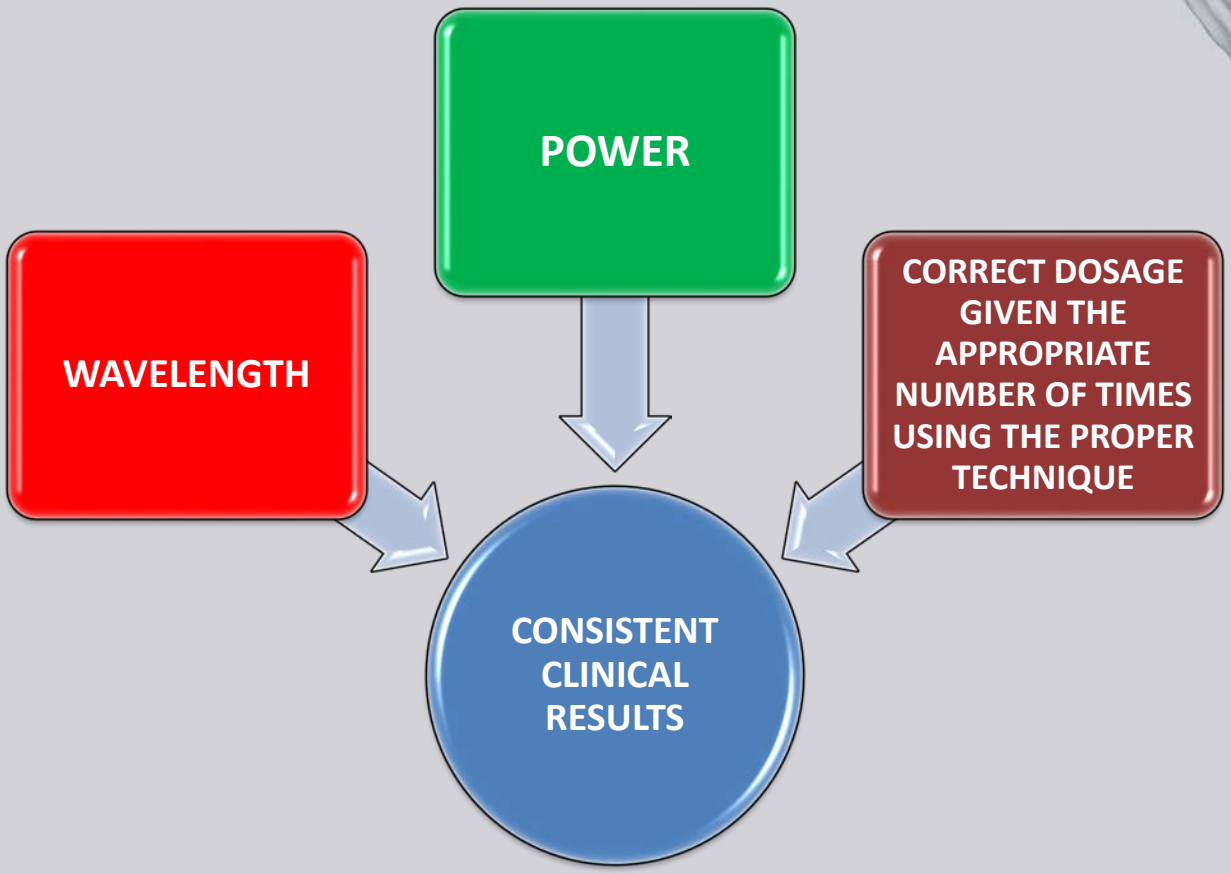
$$\kappa = \frac{1}{3}(\mu_a + \mu_s')$$

(1) *Diffusion Approximation to the RTE: $\mu_s >> \mu_a$ and tissue thickness >> λ*

Light doesn't suddenly stop "penetrating tissue"



Penetration parameters



WAVELENGTH

- Penetration depth.
- Absorption.
- The most important factor

POWER

- The number of photons at that depth to saturate the tissues.

DOSAGE

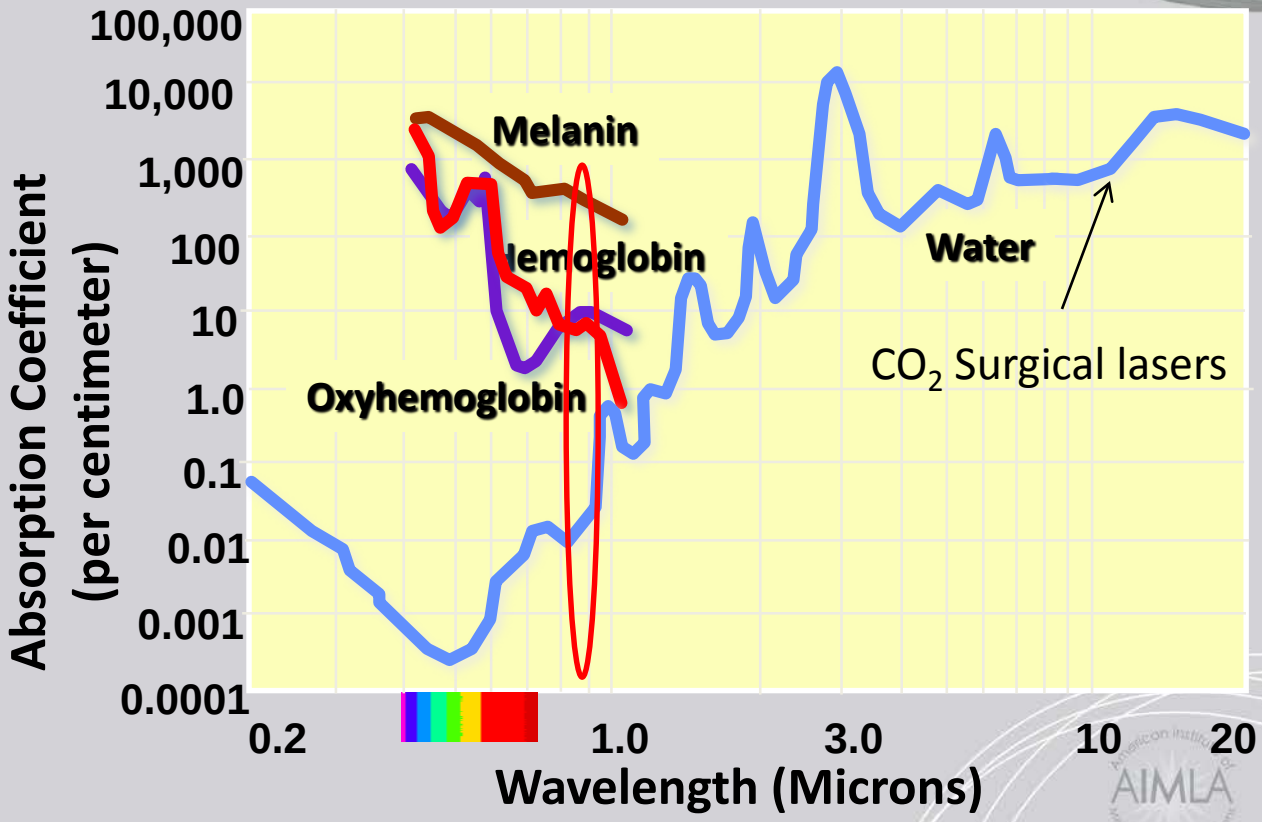
- Joules/$cm^{2.}$
- Appropriate number of treatments .
- Proper application technique.

Wavelength

- For effective penetration, the wavelength needs to avoid *scattering, surface absorption and absorption by unwanted chromophores.*

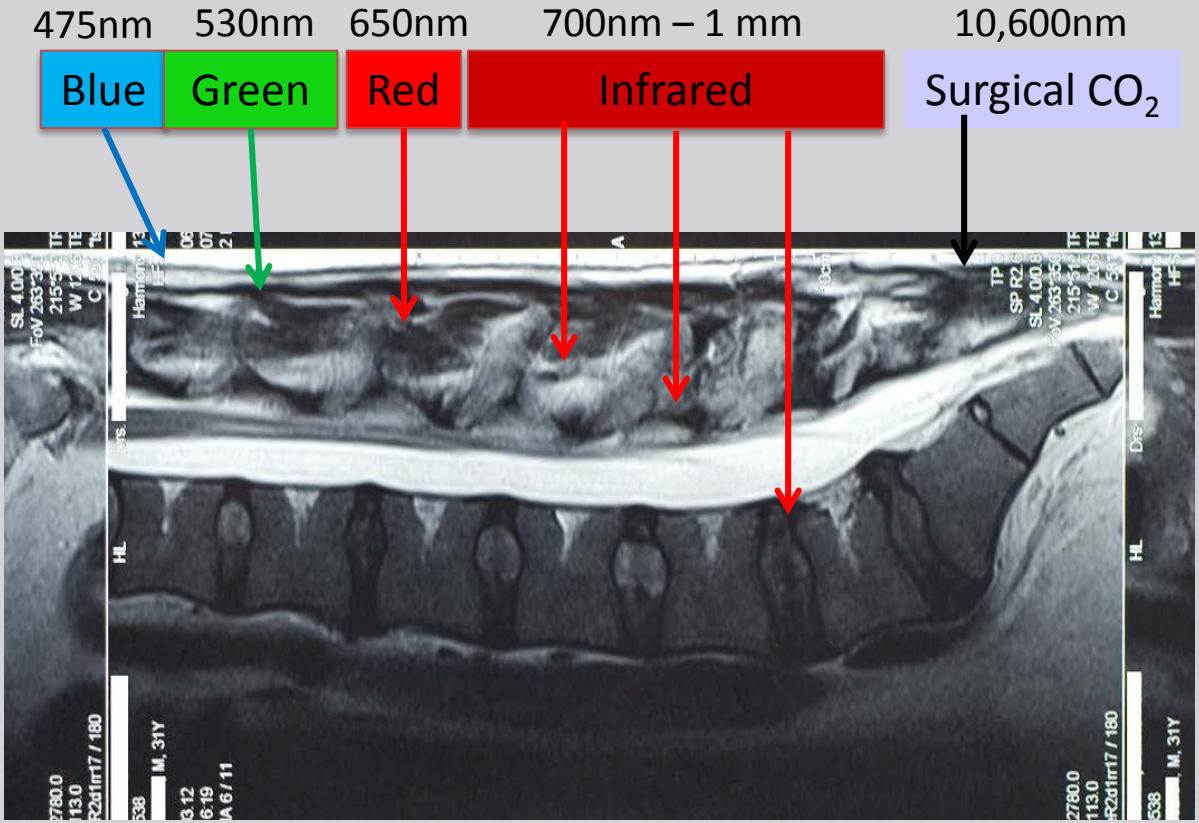
- This is called the therapeutic window

Examples:
Hemoglobin
Melanin
Water



540nm

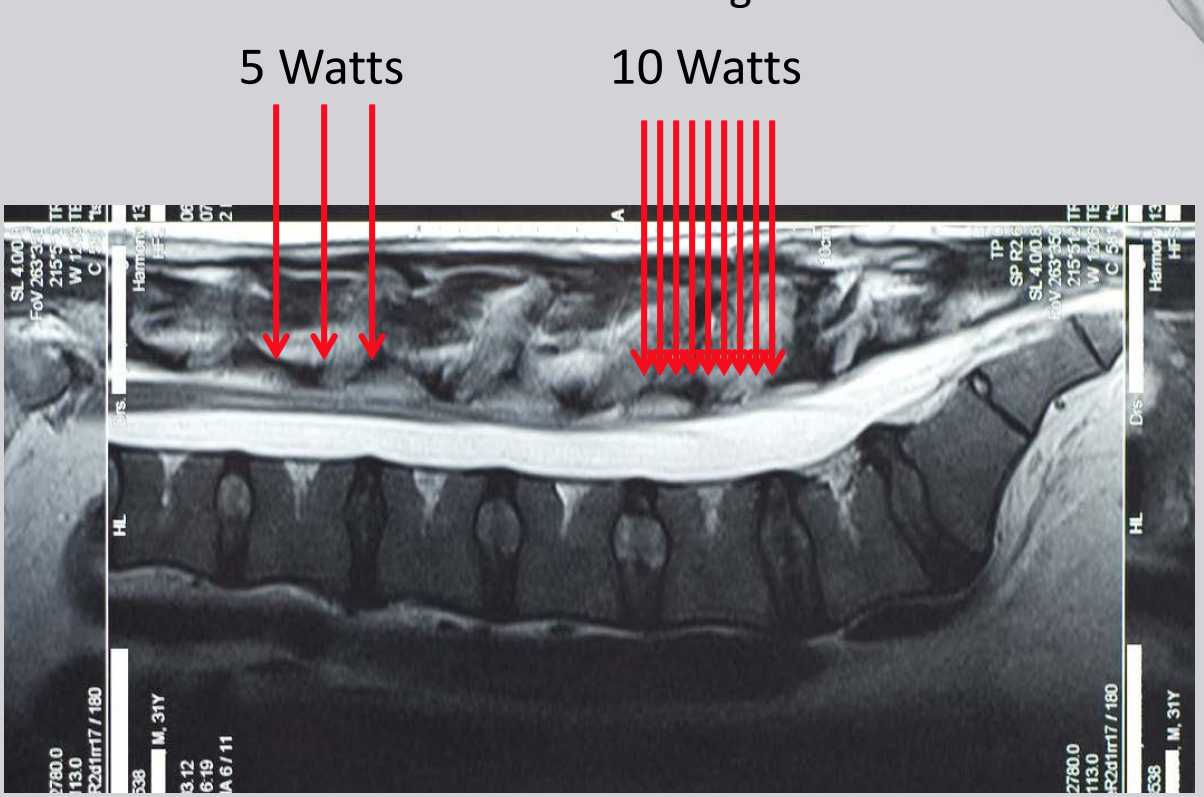
630nm



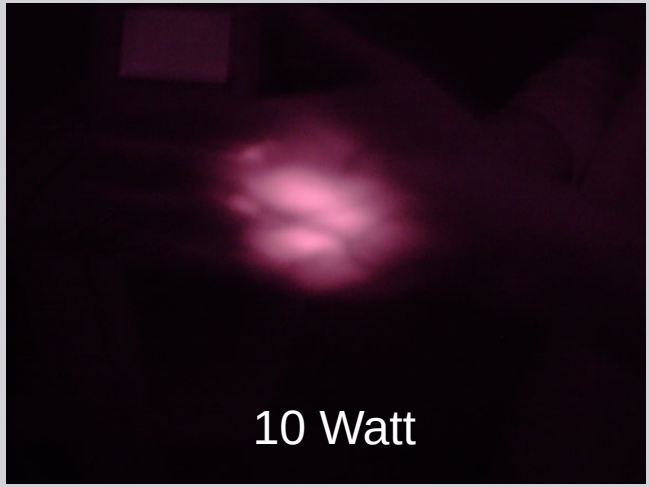
Depth of penetration is determined by the length of the wavelength

Power

Both at 980nm wavelength

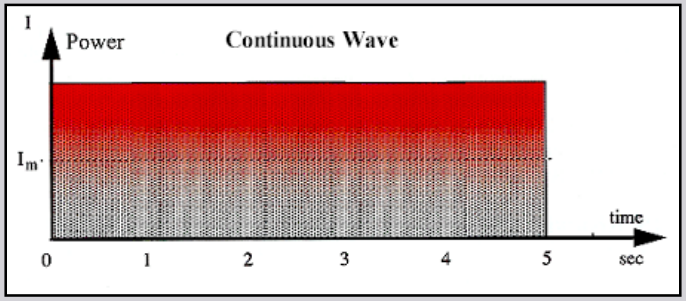


Power determines the number of photons at that depth.

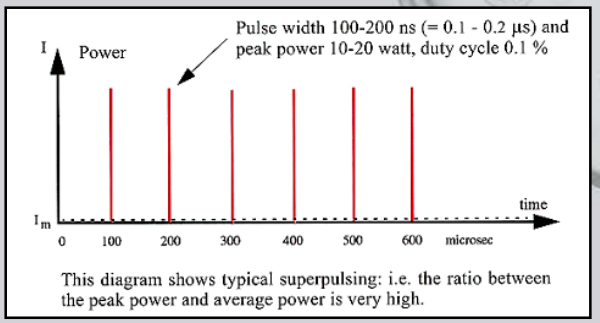


Wavelength 980nm

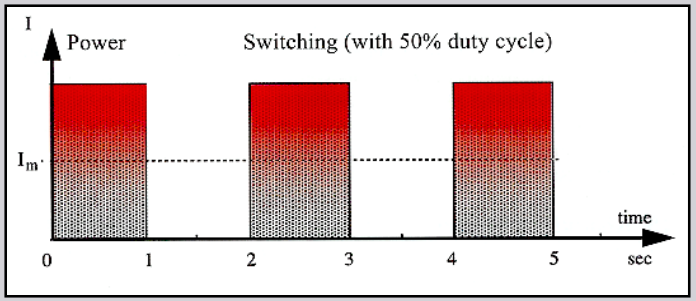
Emission



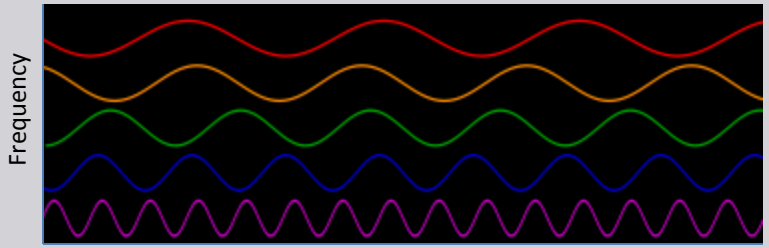
Continuous wave (CW)



Super pulsing



Modulated continuous wave



Frequency is expressed in Hertz (Hz)

The number of cycles per second that a waveform repeats

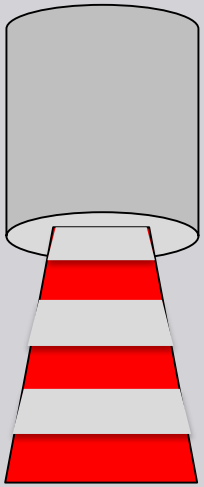
5 cycles per second = 5Hz

The terms pulsing and frequency are used interchangeably to describe the same concept.

Pulsing/frequency

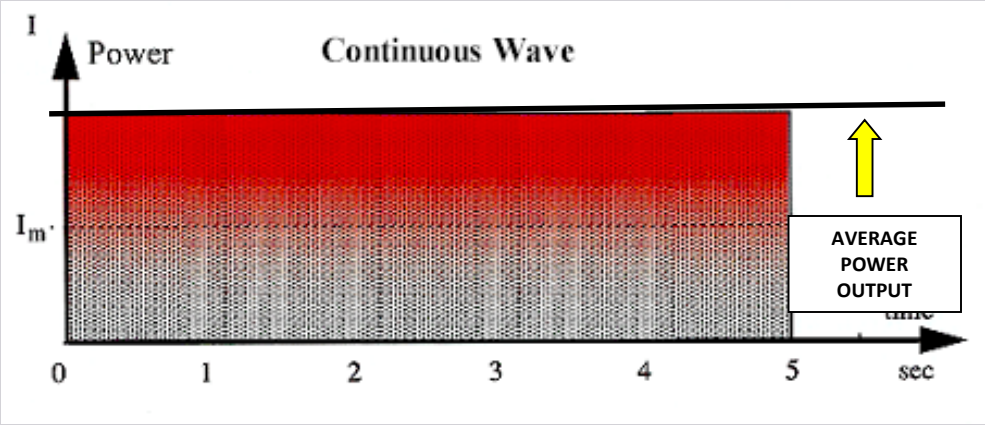
Pulsing mode = “X” Hz

Laser is emitting only 50% of the time.

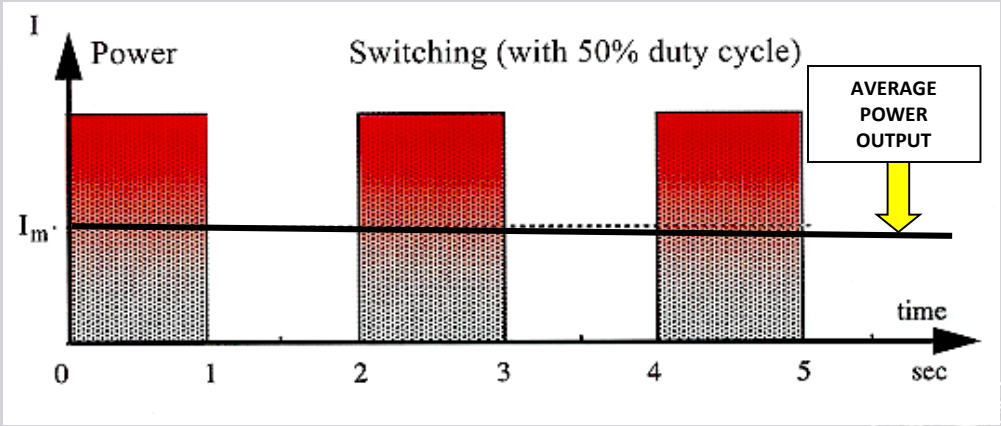


Where is the scientific evidence that specific cells respond to a blinking light?

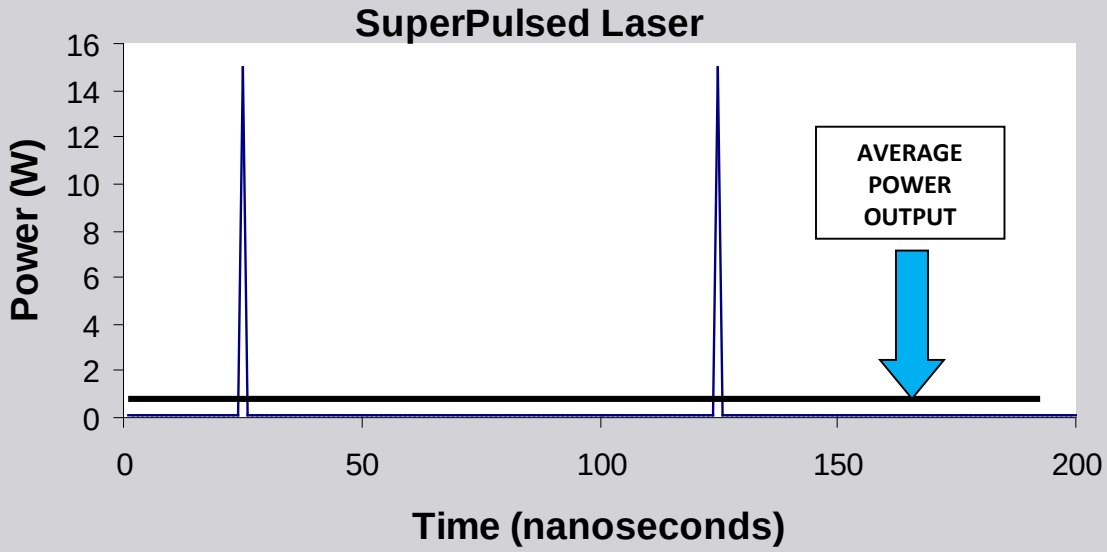
Average power output



Laser emitting at 10W = 10 Joules/sec.
= 600 Joules/min



Laser emitting at 10W:50%Duty cycle =
5 Joules/sec. =
300 Joules/min.



- Average Power Output: ~70mW
- Energy delivered per minute: ~ 4.2J
- Laser Classification: 1 to 3B
- Only feasible for the treatment of small areas
- Peak (instant power): ~25W

Claims of deeper penetration and only way to accomplish analgesia.

Garden hose analogy is erroneous: you can't pressurize photonic energy!

Comparison of time to deliver 3,000 Joules

Treatment Area: 300 cm^2
Dosage:10 J/cm^2
Total energy delivered: 3,000 J

Continuous wave emission

5mW laser
10,000 minutes
166.7 hours

500mW laser
100 minutes
1 hour 40 minutes

3W laser
16.7 minutes

10W laser
5 minutes

Laser emitting at 10W:

50% Duty cycle:

5 Joules/sec. = 300 Joules/min.

Therapy time = 10 minutes

Laser emitting at 25W in a super pulsed mode:

4.2 Joules/minute

Therapy time = 714.28 minutes

Therapy time = 11.9 hours

.....

Laser/Tissue Interaction

Laser/tissue interaction

Photothermal

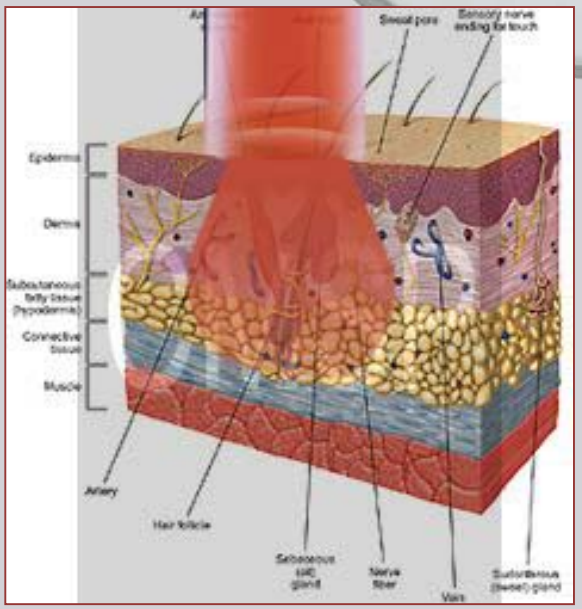
long pulses, biological effect due to heating - hair removal, surgical lasers

Photomechanical *(Photoacoustic)*

short pulsed (q-switched) lasers cause ablation - tattoo removal, photorefractive keratectomy

Photobiochemical

laser causes biochemical change or response - pain reduction, photodynamic therapy (PDT)



Cellular attraction to infrared light

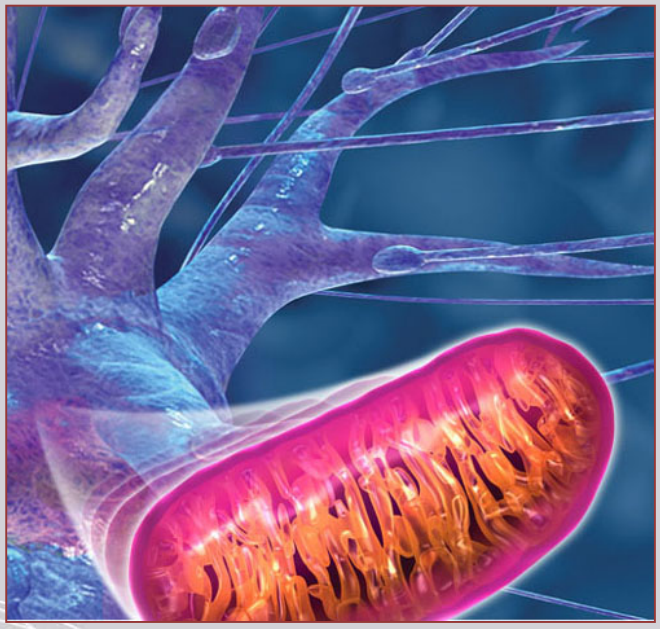
Fibroblasts 3T3 cell cultures
800 – 900 nm 47%
immediately migrated

Guenter Albrecht-Buehler, Ph.D.
Fellow, European Academy of Sciences, Brussels
Fellow, Institute for Advanced Studies, Berlin
Robert Laughlin Rea Professor Emeritus of Cell Biology
Northwestern University Medical School, Chicago

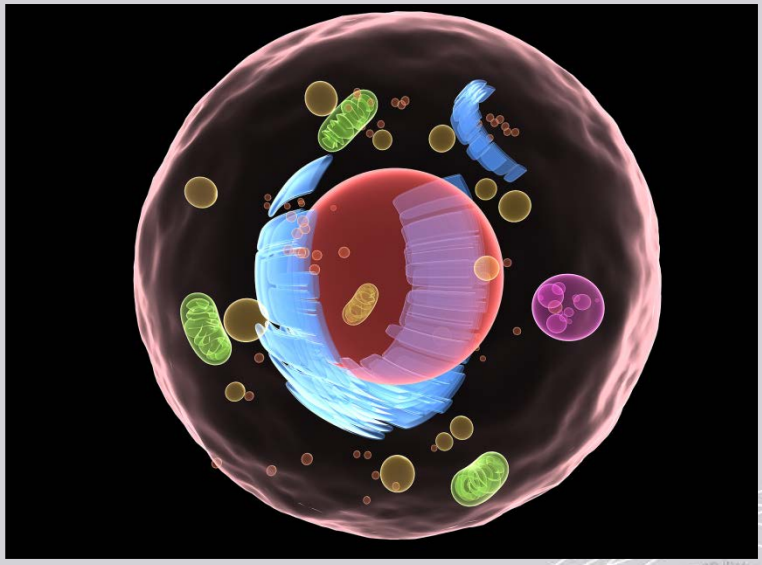
Mechanism of action at the cellular level

Chromophores

are components of various cells and sub-cellular organelles which absorb light.



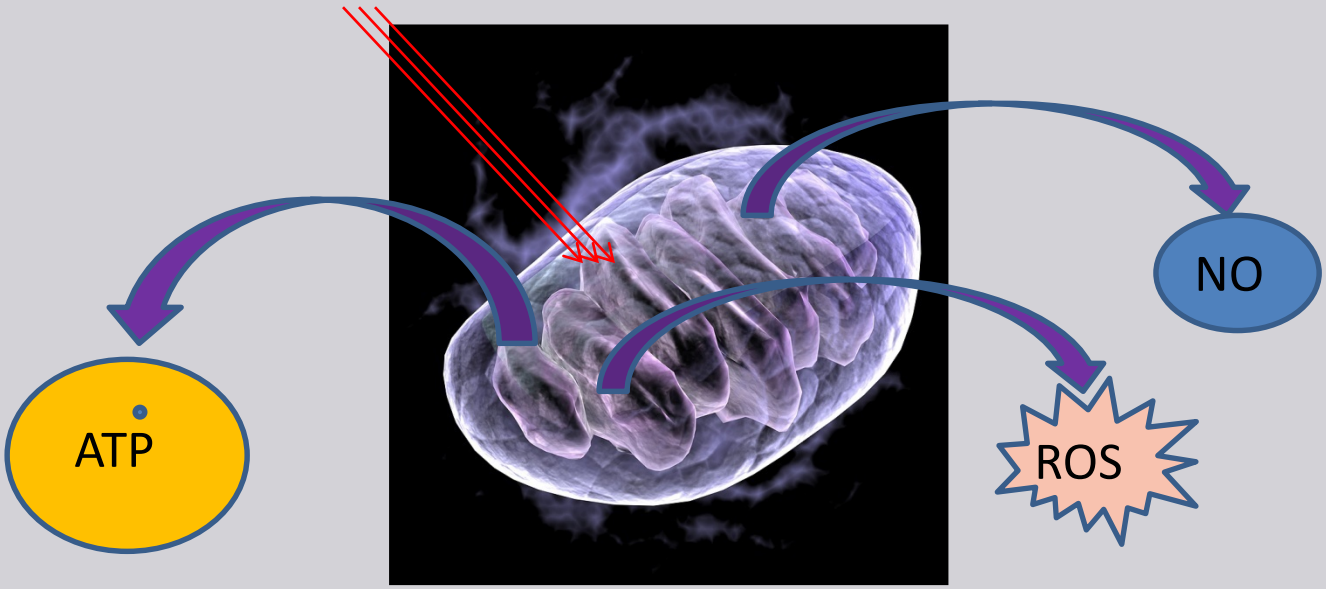
Mitochondria



Cell membrane

Photonic energy stimulates the photoreceptor on the mitochondria to decrease the reaction time for cytochrome c to become cytochrome c oxidase. This facilitates increase in the cellular respiration rate.

Mrowiec, J., et al. 1997



Physiological effects

Photobiomodulation initiates a biochemical cascade of events that results in:

1. A reduction in pain
2. A reduction in inflammation
3. An increase in microcirculation

Therefore there is an acceleration in tissue repair and wound healing

Establishment of an Effective Photobiomodulation Treatment Protocol in an Animal Model of Persistent Neuropathic Pain

Ketz, A. *et al* (2015). American Society of Lasers in Medicine and Surgery.

The sciatic nerve, sural, common peroneal and tibial nerves were cut.
60 rats divided into a sham surgery group and a PBM + surgery group.

After just two treatments the PBM group began recovery.
At day 26, this group reached baseline levels of sensitivity to mechanical stimulus.

Phototbiomodulation of the dorsal root ganglion for the treatment of low back pain: A pilot study

Holanda, V.M. *et al* (2016). Lasers Surg Med.

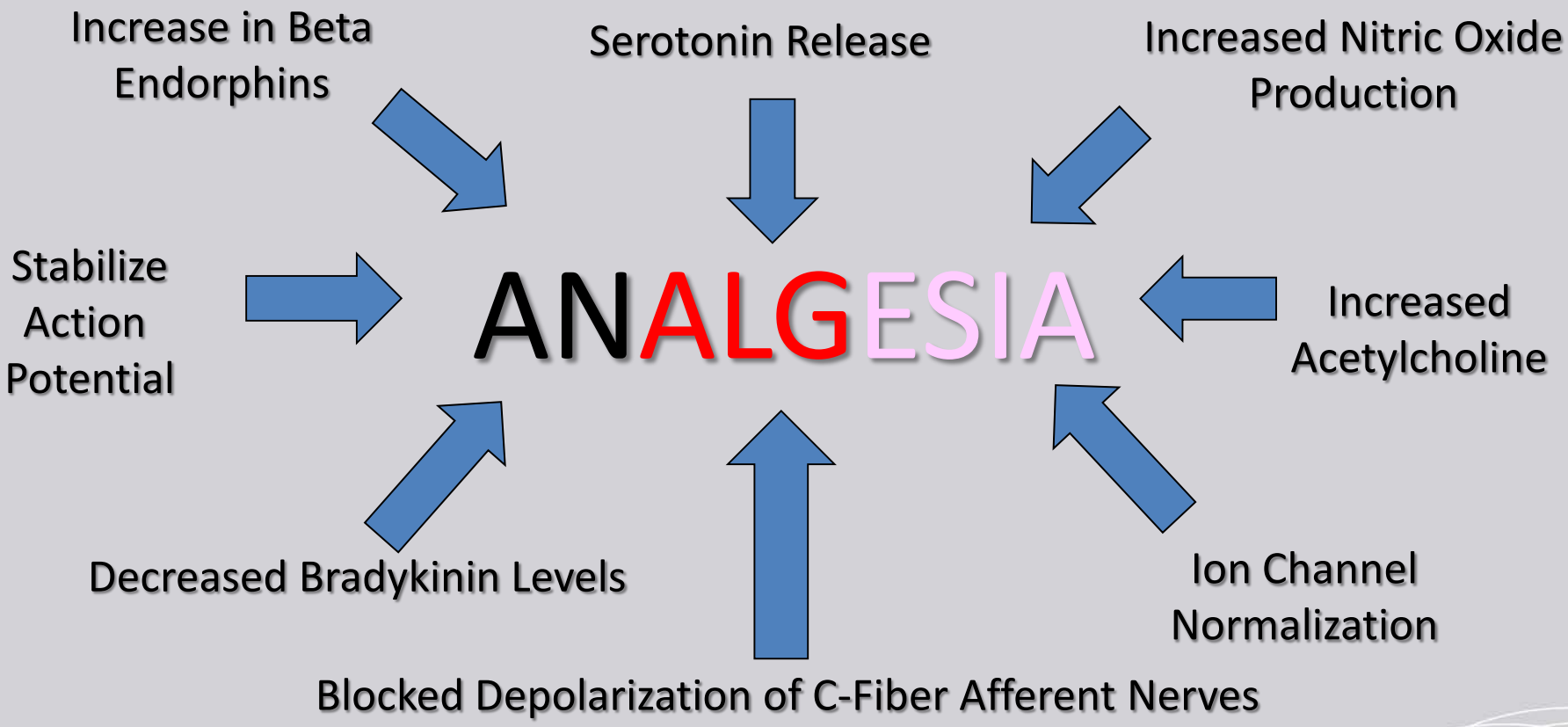
Three groups: lidocaine injection, radiofrequency, or laser therapy

Laser irradiation caused an immediate decrease in low back pain similar to pain reduction cause by lidocaine injection

Mechanism of Action: Analgesia

- Increased nitric oxide production
  Uozumi et al, August 2010 Farvier *et al* 2014
- Increase in beta endorphins
  Cidral-Filho *et al.* 2014
- Decreased bradykinin levels
  Chow, R.T. and Barnsley, L. 2005
- Ion channel normalization
  Rosenbaum, T,PhD, Simon, S, PhD, Islas, L, PhD 2007
- Stabilizes the action potential
  Rochkind S, et al. 2000.
- Increase serotonin release
  Magalhaes, M. et al. 2015
- Increased release of acetylcholine
  Nicolau, R.A., Martinez, M.S., Rigau, J. and Tomás, J. 2004; Rochkind, S. & Shainberg, A. 2013
- Blocked depolarization of C-fiber afferent nerves
  Ohno T. 1997. Tsuchiya K et al. 1993. Wakabayashi, H., et al. 1993

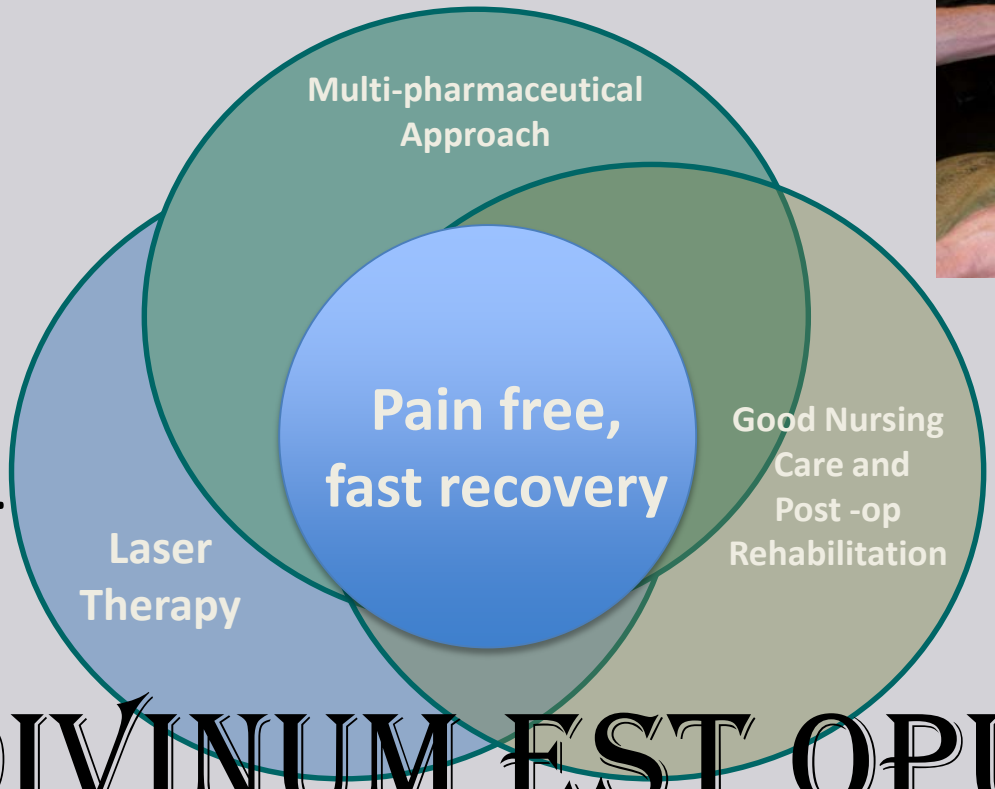
Biochemical/Physiological Cascade of Events Resulting in Analgesia



Integration into Pain Management Protocols

Acute pain:
Trauma.
Burns.
Otitis.
Dental

Chronic pain: OA.
Post surgical:
Routine and orthopedic.



Dermatological
Abdominal
Respiratory

"DIVINUM EST OPUS SEDARE DOLOREM"

Divine is the work to subdue pain
--Hippocrates

Common Pain Management Applications in Practice

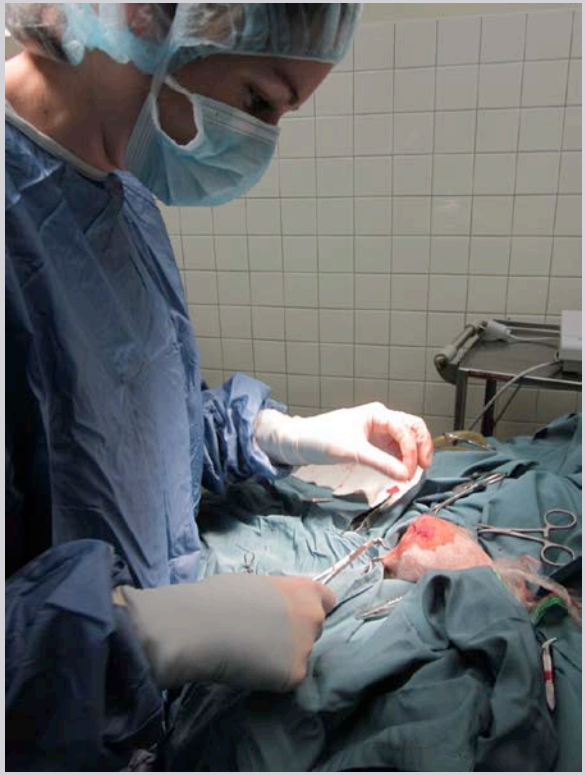
Acute Pain Management

1. Post surgery
2. Dental procedures
3. Burns
4. Otitis
5. Urinary disorders
6. Gastrointestinal disorders

Chronic Pain Management

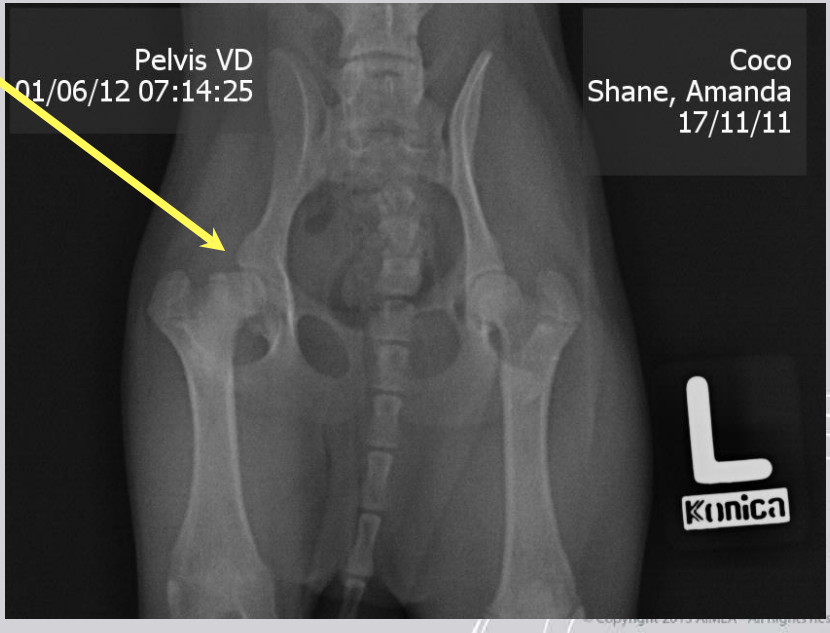
1. Osteoarthritis
2. Geriatrics
3. Dermatologic disorders
4. Respiratory disorders
   e.g. Feline asthma

Clinical Case: Post-op Pain



- 9 mo. old female spayed Chihuahua
- Avascular necrosis - femoral head and neck excision
- Sx June 4, 2012
- CRI morphine, ketamine, medetomadine, IA bupivicaine
- Post-op laser therapy

- CRI morphine, ketamine, medetomadine, IA bupivicaine
- Post-op laser therapy



Post FHO Sx laser therapy protocol

- Incision: 2 Joules/cm^2
- Periarticular muscles:

  Day 1 and 2: 8 Joules/cm^2
- Periarticular muscles, back and thigh: 6 Joules/cm^2 on day 3 then alternate days

Dosage: 2-4 J/cm^2

Burn

Foot pad meets stove top

Dosage:

1 – 2 J/cm^2

Otitis

Dosages:

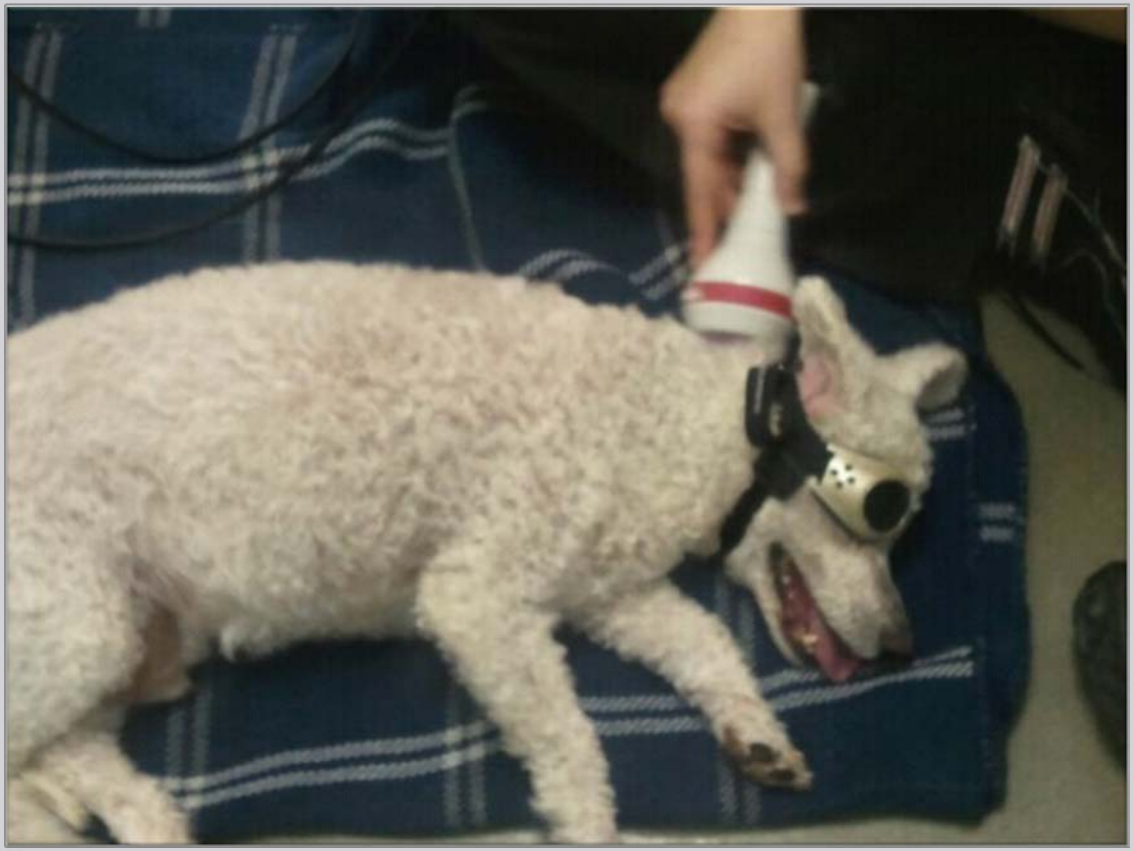
Pinna and external structures:

2 – 4 J/cm^2

Ear canal:

6 – 8 J/cm^2

Cervical disc pain



Dosage:

8 – 10 J/cm^2

Urinary tract pain

Uroliths ~ FUS ~ Interstitial Cystitis

Pyelonephritis ~ Urethral Obstruction

Dosage: 10 -12 J/cm^2
Positioning the patient very important

Gastrointestinal pain

Pancreatitis ~ Parvovirus ~ GI Surgery ~

Dosage:

10 – 12 J/cm^2; lateral recumb. both sides and ventrally.

Increase dosage for larger patients >60 lbs.

Intestinal resection and anastomosis: Stick and Plastic Body

Dosage:

- 2 – 3 J/cm^2 during surgery and before closing incision then 1 – 2 J/cm^2 after closure.
- Incision (1 – 2 J/cm^2) and abdomen (10 – 12J/cm^2) for three consecutive days.

Chronic pain management

- Chronic pain serves no purpose.
- Stimulus may be persistent – OA.
- Lasts longer that 1 month.
- Stimulus may be absent.
  - CNS malfunctioning
  - Wind up- central neuronal hyperexcitability

Chronic dermatologic condition

Chronic otitis:

Dosages:

Pina:

2 – 4 J/cm^2

Ear canal:

10 – 12 J/cm^2

Frequency:

Daily X 3

then EOD for two weeks

then maintenance to maintain.

Stomatitis

6 treatments over 2 weeks
Picture taken 1 month later

Chronic respiratory pain management

Feline asthma

PBMT will provide:

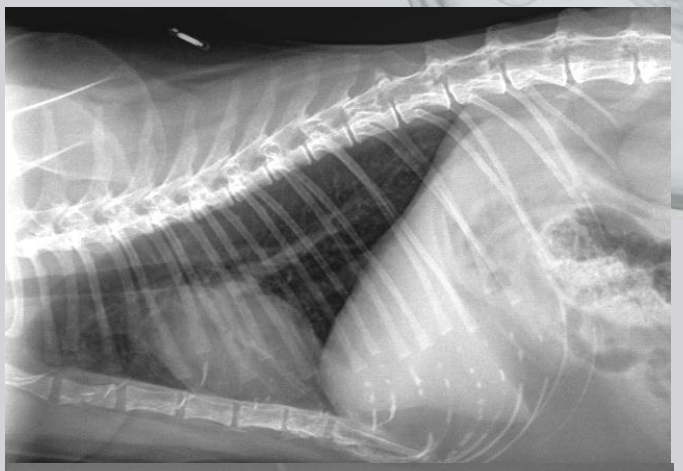
- pain relief
- reduction in inflammation
- improved quality of life

Dosage: 6 – 8 J/cm^2

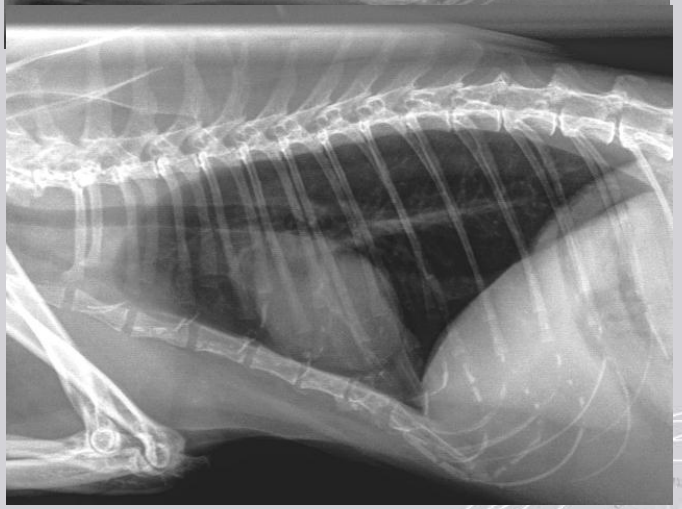
Frequency of therapy: three out of first four days then three times per week then once a week till managed.

Will respond by 6 – 8 treatments

Before



After



Case Study Provided By:
Hege Thorsen, BVSc, MRCvS
Troll Veterinærklinikk AS
Kleppestø, Askøy Norway

PBMT modulates the inflammatory reaction

Inflammation: *īnflammō;* "I ignite, set alight."

The fundamental acute inflammatory reaction to any form of trauma is ubiquitous regardless of the inciting cause; surgical, pathogenic or physical trauma.

A study of the effects of LLLT using red and NIR wavelengths on acute inflammation in the rodent model.

Raymond J Lanzafame, MD PLLC;Rochester General Hospital, Rochester NY
American Society for Laser Medicine and Surgery Proceedings 2014.

LLLT significantly reduced acute inflammation.

Comparative analysis of two low-level laser doses on the expression of inflammatory mediators and on neutrophils and macrophages in acute joint inflammation.

Santos, S.; Alves, A.;Leal-Junior, E.;Albertini,R; Vieira, R.;Ligeiro,A.; Silva, J.; Carvalho,P.
Lasers Med Sci. 2013 Oct; DOI: 10.1007/s10103-013-1467-2

Reductions in IL-1β, IL-6 and TNF-α and inhibition of inflammatory cells.

Biochemical Mechanisms Resulting in a Reduction of Inflammation

Inhibits the synthesis and secretion of inflammatory prostaglandin yet stimulates prostaglandins that have a vasodilatory and anti-inflammatory action.

Assis, L, Moretti, A.I.S, Abrahão, T.B., Cury, V., Souza, H.P., Hamblin, M.R., and Parizotto, N.A.
Lasers Surg Med. Oct 2012

Stabilization of the cellular membrane

Quast RB, kortt O, Henkel J, Dondapati SK, Qustenhagen DA, Stech M, Kubrick S.
J Biotechnol. 2015 Jun 10;203:45-53.

Enhancement of ATP production and synthesis

Farivar S, Malekshahabi T, Shiari R
Biological effects of low level laser therapy. *Lasers Med Sci*. 2014 Spring;5(2):58-62.

Stimulation of vasodilatation

Acceleration of leukocytic activity

Kelly A. Larkin, MS, CAT(C); Jeffrey S. Martin, PhD; Elizabeth H. Zeanah, MS; Jerry M. True, DC, FIACN; Randy W. Braith, PhD; Paul A. Borsa, PhD, ATC, FACSM. *J. Athl. Trainer, 47(2)178-183.2012*

Reduction in interleukin 1

Alves AC, Vieira R, Leal-Junior E, dos Santos S, Ligeiro AP, Albertini R, Junior J, de Carvalho P *Effect of low-level laser therapy on the expression of inflammatory mediators and on neutrophils and macrophages in acute joint inflammation.* Arthritis Res Ther. 2013;15(5):R116

Stimulation of vasodilatation

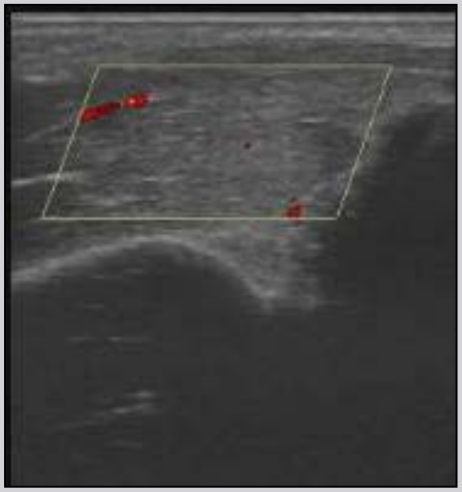
An increase in:

- Nitric oxide
- Serotonin
- ROS

Honmura A, Ishii A, Yanase M, et al. 1993 Mizokami, T., Aoki K., Iwabuchi, S. et al. 1993

Houreld, N.N., Sekhejane, P.R. and Abrahamse, H.;Lasers Surg. and Med. 42:494-502, 2010

Medial head of *Triceps Brachi M*

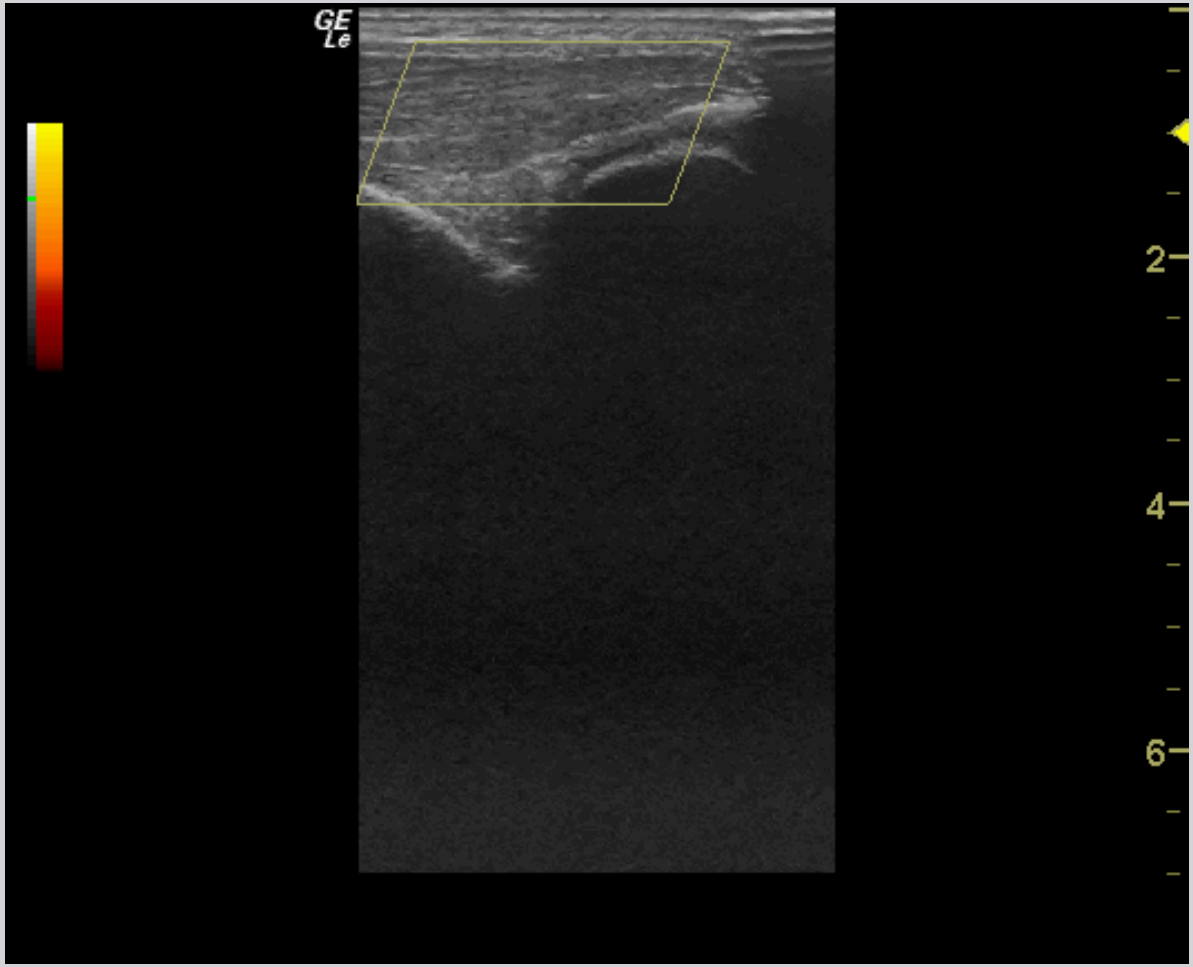


Ten minutes post
Dose: 8 J/cm^2
2400 Joules

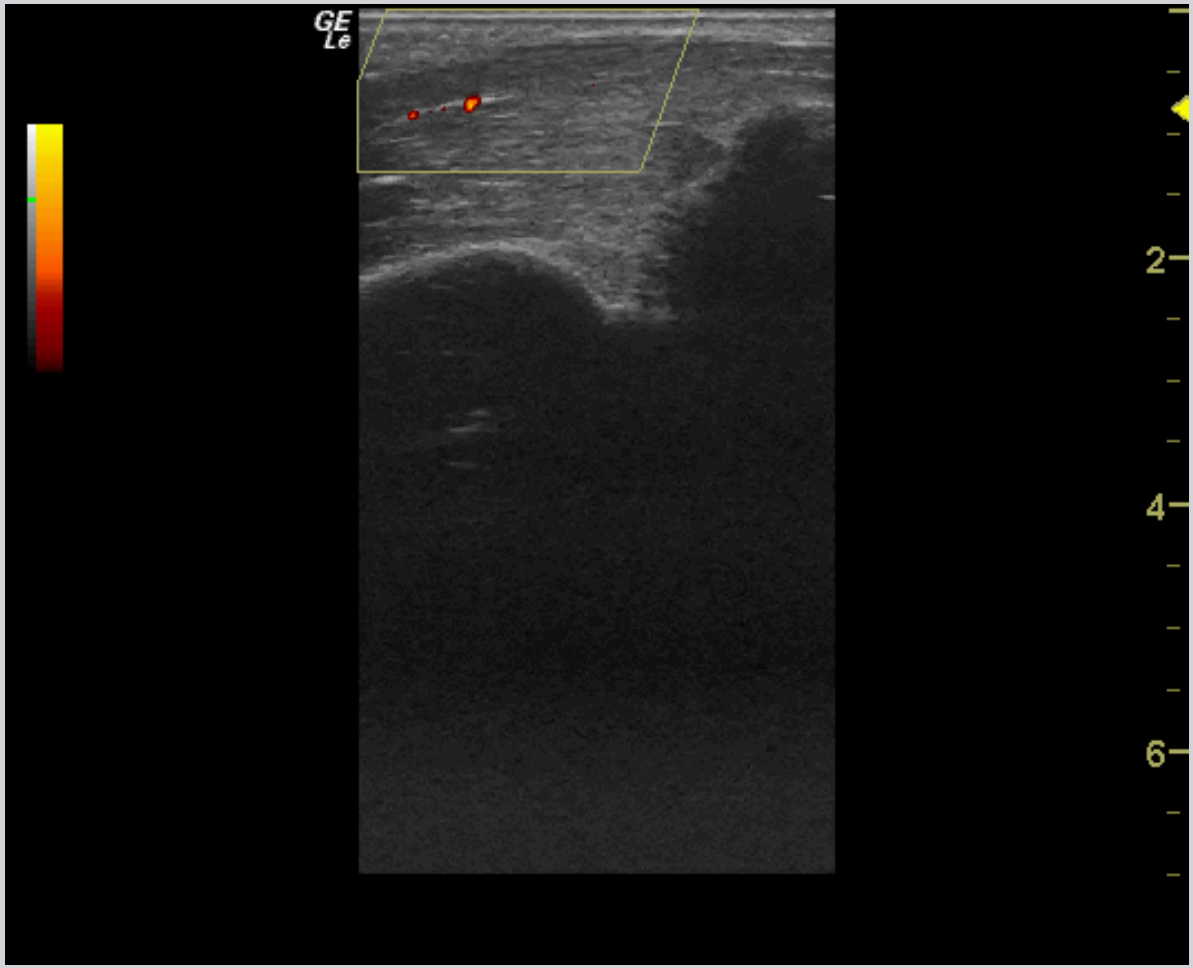
Fifty minutes

Promedica Sports Medicine, Toledo Ohio 2009

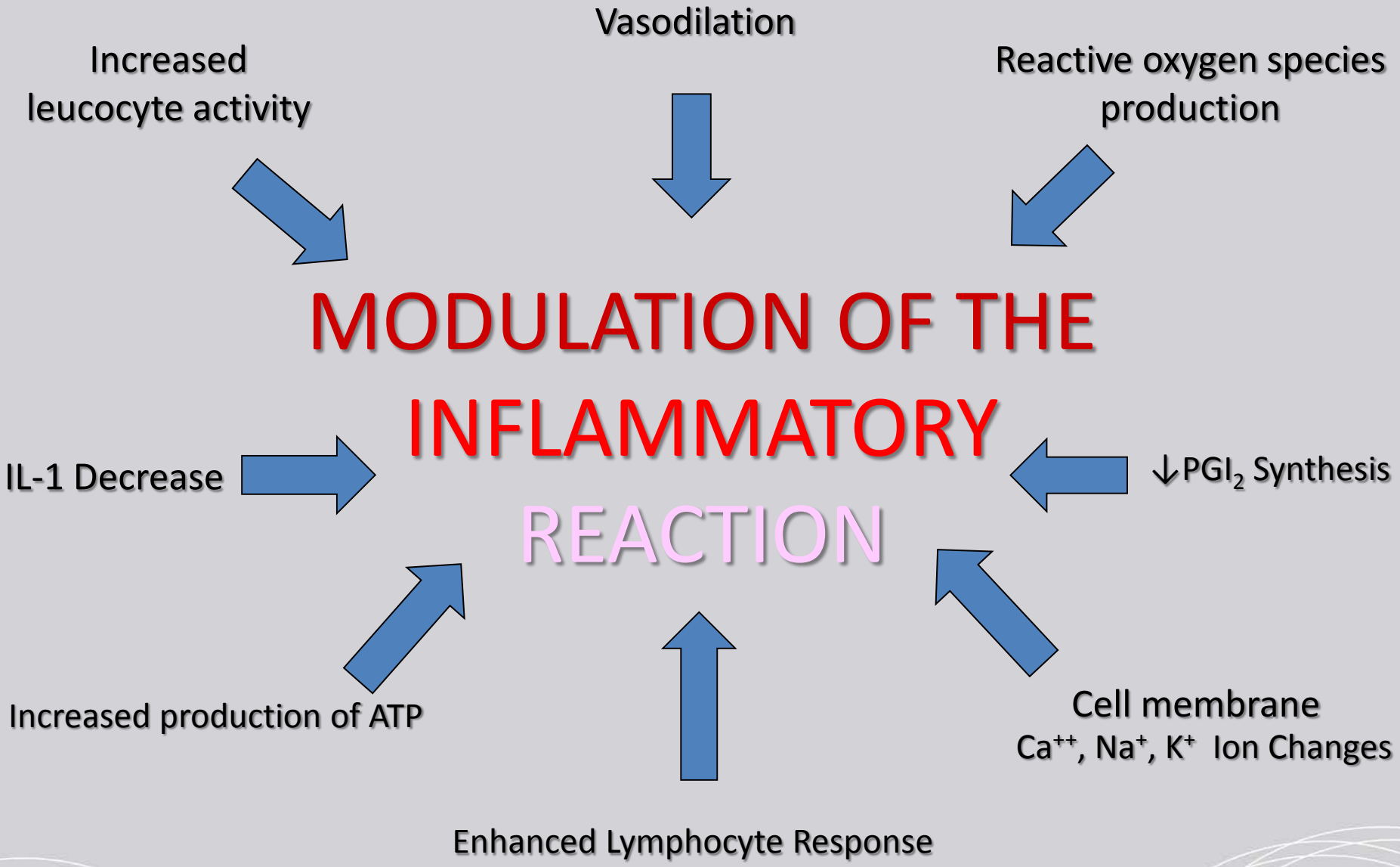
Extensor carpi radialis brevis tendon



Two minutes prior to therapy at 10 J/cm^2



Ten minutes post therapy



Pyotraumatic dermatitis

Three hours post administration

- Dry
- Decreased inflammation

Administration of 5 J/cm^2
Emission of 600 Joules

John C. Godbold, Jr. DVM
Stonehaven Park Veterinary Hospital / Laser Surgery Center
Jackson, Tennessee

How does photobiomodulation accelerate the healing process?

Twenty-Six Days
Dosage: 4 J/cm^2
Ten PBMT sessions

Laser Therapy Facilitates Superficial Wound Healing in Humans: A Triple-Blind, Sham-Controlled Study

Hopkins et al
J Athl Trainer 2013

- Triple-blind, sham-controlled in-vivo human study
  identical skin wounds were created in 22 volunteers
  age = 21 +/- 1 years
- Randomly placed in a control, sham laser or laser treatment group
- 8 J/cm^2, 820 nm laser
- Measured epithelial migration

153% greater wound contraction at day 6 in the laser group

Presented at the 2013 ACSM Annual Conference
June 1, 2013

High Powered Laser Therapy Enhances Muscle Healing

Matthew C. Kostek, Diana C. Delgado-Diaz, Bradley Gordon

- Subjects underwent muscle damage protocol using isokinetic dynamometer
- 48 hours after damage, laser administered to one leg
- 6 hours after laser treatment, muscle biopsies were collected
- C2C12 cells were grown in standard culture conditions and received daily laser treatment

RESULTS: Laser treatment increased markers of muscle repair and enhanced muscle cell proliferation in culture.

CONCLUSIONS: High powered laser treatment is effective in increasing molecular markers of muscle repair after damage.

Photobiomodulation in promoting wound healing: a review.

Kuffler, D.P. 2016. *Regen Med*. 11(1):107-22.

Data suggests multiple wavelengths more efficacious than single wavelength. Focuses on studies of biochemical mechanisms.

Redondo, M.S. (2015) Laser Therapy Approach to Wound Healing in Dogs. [ONLINE] Available at: http://www.vettimes.co.uk/article/laser-therapy-approach-to-wound-healing-in-dogs/. [Accessed 10 February 2016].

Peplow, P.V. et al. (2010) Laser photobiomodulation of wound healing: a review of experimental studies in mouse and rat animal models. *Photomed Laser Surg*. 28(3):291-325.

Accelerated tissue repair

Photobiomodulation increases the production of ATP

This increases the energy level of the cell to expedite the uptake of nutrients and speed the elimination of waste by products

Karu T. et al. 2001

Increases the rate of cellular mitosis and collagen synthesis

Wood, et al. Lasers Surg. And Med. 42:559-565, 2010

There is an increase in the leukocytic and macrophage infiltration

Bolton, P., Young, S.R. and Dyson M. 1991

Activates fibroblasts and other tissue repair cell types

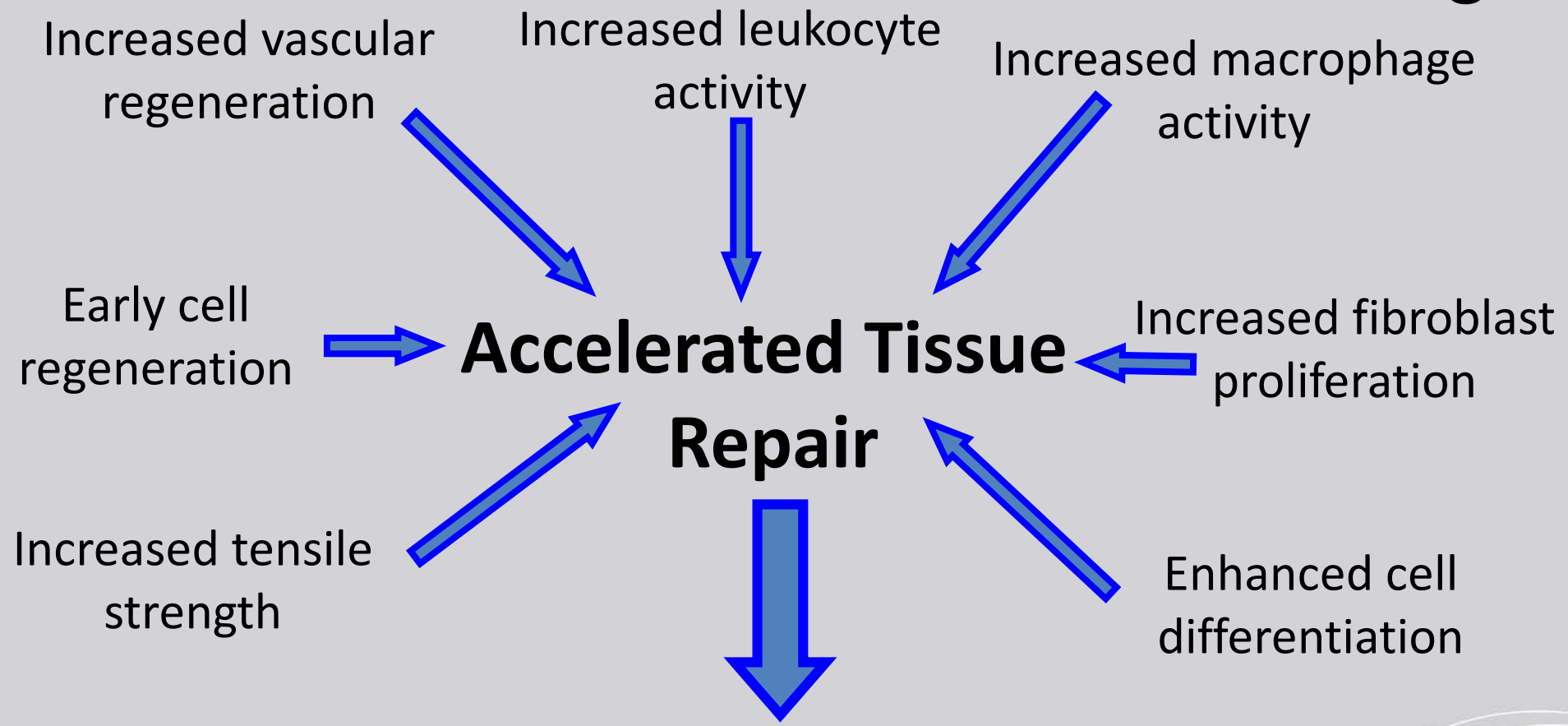
These regenerative cells allow tendons, ligaments, bones and muscles to heal at an accelerated rate

Alexandratou, E., Yova, D., Handris, P., Kletsas, D. and Loukas, S. 2002

Khadra, M., Lyngstadaas, S.P., Haanaes, H.R. and Mustafa, K. 2005

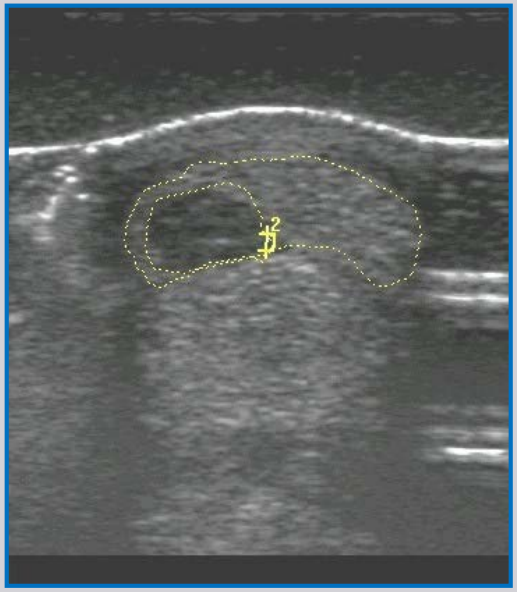
Bjordal *et al. 2007).*

Biochemical/Physiological Cascade of Events Resulting in Accelerated Tissue Healing



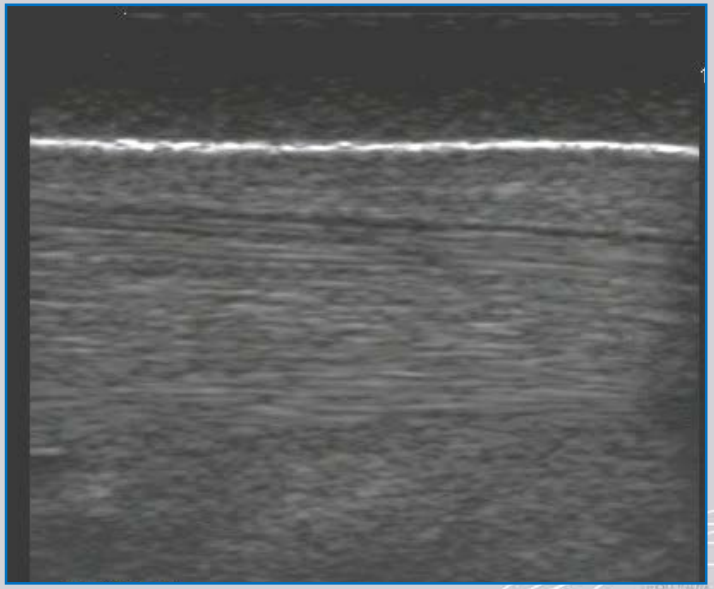
Tendon injury

March 10th, 8-year-old Warmblood show jumper was presented with an acute right forelimb lameness after a competition over a poor surface.



March 10th

Forty five day recheck



Wound Healing: Thermal Injury

History

- 3 year old spayed female English Setter
- Dec 7, 2011- family member spills cup of hot chocolate over her back
- No immediate treatment at home
- Presented Dec 16, 2012 for reluctance to move, foul odor

Laurie Dunbar DVM, CCRP

Treatment Plan:

Cephalosporin antibiotics

Meloxicam

T-shirt to be washed and changed daily

PBMT

EOD

3 treatments only (compliance, results)

24 hours after first laser treatment

Post 3 PBMT sessions

Client did not return for follow up treatments

FRACTURES

Delayed or Non-union

Slow healing

Poor apposition

Routine as part of post surgical protocol

Effect of low-level laser therapy on the fracture healing process.

Kazem Shakouri S1, Soleimanpour J, Salekzamani Y, Oskuie MR.
Lasers Med Sci. 2010 Jan;25(1):73-7. doi: 10.1007/s10103-009-0670-7

Laser enhances callus development in the early stage of the healing process, therefore, laser therapy may be recommended as an additional treatment in non-union fractures in humans.

Low-level laser therapy enhances the expression of osteogenic factors during bone repair in rats

Tim CR1, Pinto KN, Rossi BR, Fernandes K, Matsumoto MA, Parizotto NA, Rennó AC..
Lasers Med Sci. 2014 Jan;29(1):147-56. doi: 10.1007/s10103-013-1302-9

Laser therapy improved bone healing by accelerating the development of newly formed bone and activating the osteogenic factors on tibial defects.

Photobiomodulation of a delayed union fracture

Pug
Two-years-old

Due to economics opted for ext.. fixation:
Meta Splint

Kimberly Juhlin, DVM
Vale Park Animal Hospital
Valparaiso, Indiana

Four weeks fracture site still mobile

Made a window in the Meta splint and therapy applied at all angles

Twice/week for five weeks

Dosage: 8 J/cm^2

After five weeks:
ten therapy sessions.

Resulting angiogenesis and a reduction in edema resulting in a better healing environment.

Bob Marley gets hit by a car!

Bob Marley is a yellow Labrador that was brought in the day after being hit by a car.

He suffered some minor road rash but also suffered degloving injuries to the pads on his feet.

Greg Emmert, D.V.M., CCRP

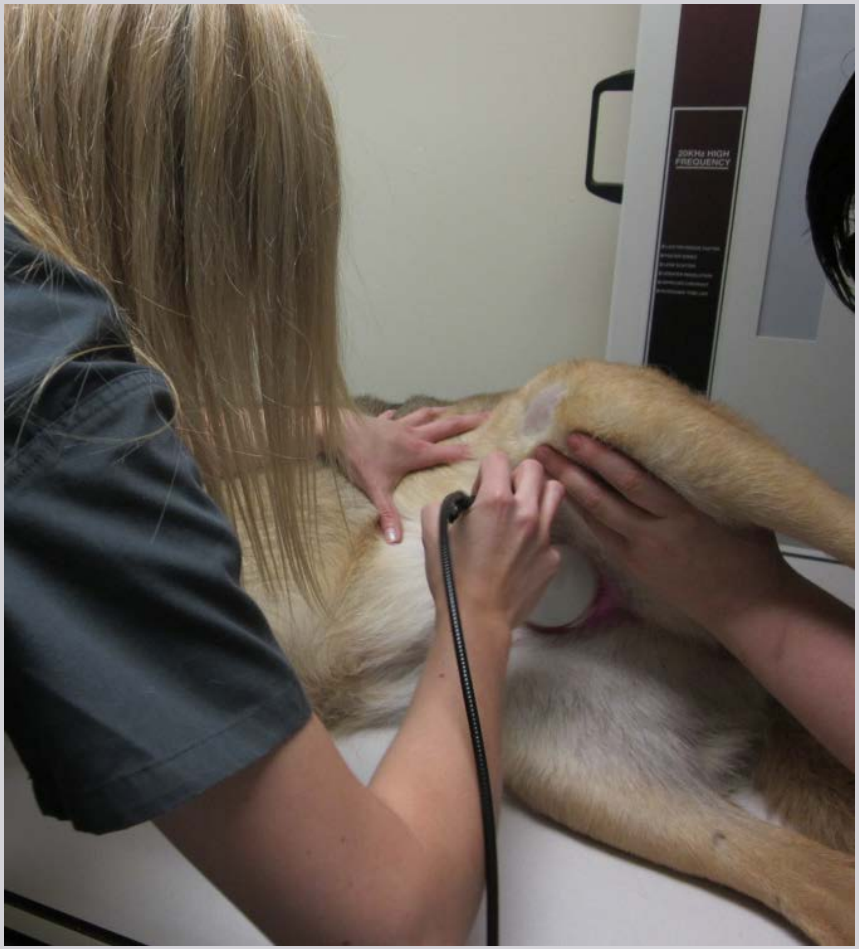
24 Hours

Conclusions:

- ✓ **Scientific and clinical evidenced based medicine.**
- ✓ **Relieves pain.**
- ✓ **Modulates the inflammatory reaction.**
- ✓ **Increases circulation**
- ✓ **Accelerates healing.**

Questions?

Basic Application Techniques



Thank you

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