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Characteristics of Light




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Contents

- What is light and what are its properties?
- How a laser works
- How an IPL source works
- What are the differences between the two?
- Why do we use pulsed light?
- The effects of spot size




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Terminology

Oxford English Dictionary:
/términólleji/ n. (pl. -ies) **the system of terms in a particular subject**



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Wavelength

- What is oscillating up and down?
- Light travels as a wave of electric and magnetic fields
- The **wavelength** (λ) is the distance between two points on the wave which are separated by one complete cycle, we use λ
- We can also count the number of peaks passing per second to get frequency
- Wavelength of visible light is measured in nanometres (nm)
 - 1nm = 1 billionth of a metre
- Wavelength determines the **colour** of the beam and how it will **interact with tissue**

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Colour and Wavelength

Deep (4mm)

Red

Green

Blue

Shallow

Skin penetration depth

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Light is part of the Electromagnetic Spectrum

gamma rays X-rays ultraviolet rays infrared rays radar FM TV shortwave AM

10⁻¹⁴ 10⁻¹² 10⁻¹⁰ 10⁻⁸ 10⁻⁶ 10⁻⁴ 10⁻² 1 10² 10⁴

Wavelength (meters)

Visible Light

400 500 600 700

Wavelength (nanometers)

- Optical radiation: UV/VISIBLE/IR
- UV (A,B,C): 100-400nm
- Visible: 400-750nm
- IR: 750 – 1mm (Near IR: 750 – 1400nm)

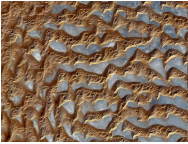
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Light as Photons

- Light is lumpy!
- Extremely small individual energy packets called photons
 - this laser pointer produces 10,000,000,000,000,000 photons
 - like grains in a sand dune



Rub' al Khali, Arabia from earth orbit
www.nasa.gov/multimedia/imagegallery/image_feature_1200.html

- The energy of each photon depends on λ
 - smaller λ = higher energy

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Ionising Radiation

- Light of any λ burns if enough is absorbed by tissue
- Short λ light (e.g. UV, X-rays) is dangerous even at low power because it can cause chemical changes in our bodies
- Classed as ionizing radiation (the energy of a single pulse is great enough to strip off an electron)
- Lasers/IPL for skin treatments are specifically designed not to emit ionizing radiation by filtering out low wavelengths

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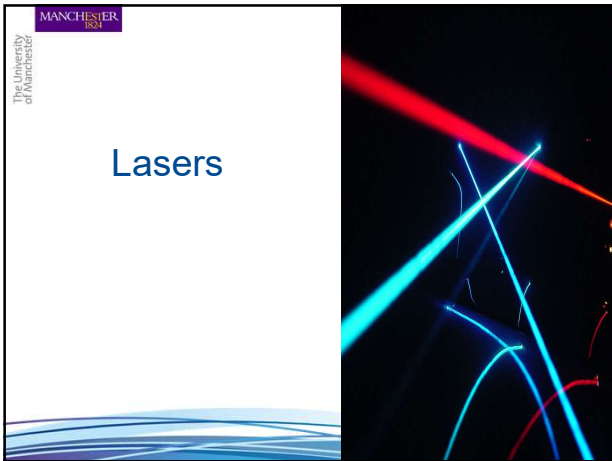
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Laser and Light Sources

- Many applications in aesthetic photomedicine use lasers, developed in 1960's
- Since 1995, filtered broad-band (IPL) light sources have been used for some of these applications
- What's the difference between laser and light sources?

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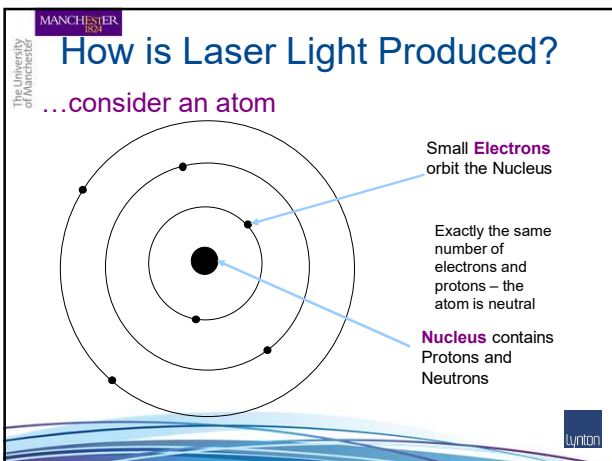
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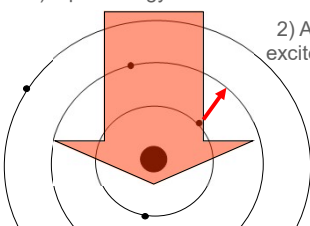
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Spontaneous Emission

1) Input Energy



2) An electron is excited to a higher state

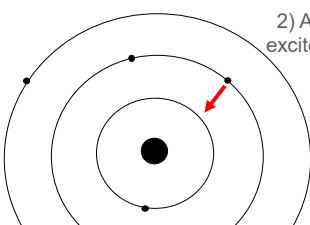
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Spontaneous Emission



2) An electron is excited to a higher state

3) The electron spontaneously returns to the lower state and emits a photon

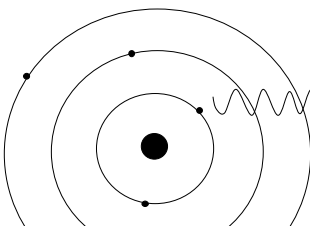
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Spontaneous Emission



3) The electron spontaneously returns to the lower state and emits a photon

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Stimulated Emission

1) Input Energy

2) An electron is excited to a higher state

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Stimulated Emission

2) An electron is excited to a higher state

3) A photon passing by stimulates the electron to return to the lower state and emit an identical photon

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Stimulated Emission

3) A photon stimulates the electron to return to the lower state and emit an identical photon

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Light Amplification

Light Amplification by Stimulated Emission of Radiation

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Properties of Laser Light

- **Monochromatic**
 - Only a single narrow band of wavelengths is emitted
- **Coherent**
 - The light waves are 'in-step'
- **Directional**
 - Lasers tend to be non-divergent

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Anatomy of a Laser

Principal components:

1. 'Gain medium'
2. Source of energy - usually either electric current or another light source
3. Highly reflective mirror
4. Output coupler (partially reflective mirror)
5. Output beam

image from <http://en.wikipedia.org/wiki/Laser>

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The Gain Medium

Solid
e.g. Nd:YAG

Liquid
e.g. pulsed dye

Gas
e.g. CO₂

Choice of gain medium determines laser wavelength

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Frequency Doubling

- Laser light passing through a 'nonlinear crystal' generates a harmonic at twice the frequency (i.e. half the λ)
- E.g. A KTP crystal is used to convert the infrared output of a Nd:YAG laser into green light

Nd:YAG laser

Infrared laser beam

KTP[§] nonlinear crystal

Green & residual infrared laser beam

Filter

Green laser beam

[§] KTP = Potassium Titanyl Phosphate

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Medical Lasers

Excimer

Argon

KTP

Pulsed Dye

Alexandrite

Ruby

Diode

Near Infrared

Nd:YAG

Er:Fiber

Cr:Er:YSSG

Er:YAG

Ho:YAG

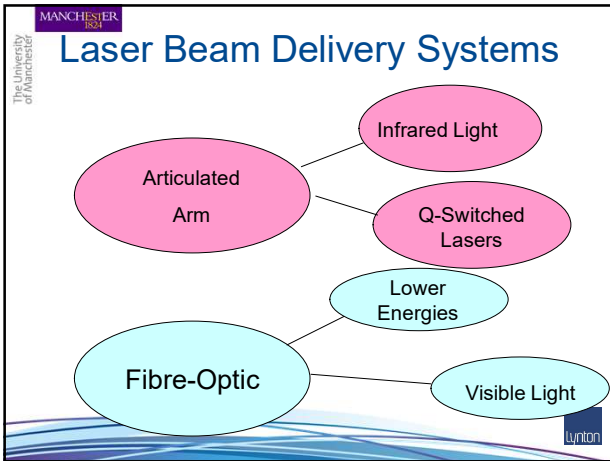
CO₂

Wavelength (nm)

shorelaser.com

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Activity

- Name two properties of laser light

- Which colour of visible light has the shortest wavelength? _____
- Give an example of a solid state laser

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Intense Pulsed Light (IPL) sources

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Intense Pulsed Light Sources

An electrical current is passed through the gas in the lamp. When the current is increased a intense pulse of light is emitted.

- Light emitted in all directions
- Many different wavelengths emitted (**white light**)

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IPL Handpiece

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White Light

- White Light is a mixture of many different wavelengths (colours)
- Light bulbs, the sun & IPLs emit white light
- Most IPLs use wavelengths of approx 550 - 1100 nm (yellow/orange/red light)

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'Ordinary' Light Characteristics (including IPLs)


- Non-coherent
- Contains many wavelengths
- Emitted in all directions (divergent)

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Why do we use pulsed light?



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Energy & Power

Power and energy affect the consequences of LASER exposure

POWER
Measured in Watts (W)
What do you pay for when you buy electricity – what are the units? kWh or kilowatt-hours – this is Energy

ENERGY
Measured in Joules (J)
Energy = Power x Time, $J = W \times s$, or Power = Energy/time
How many Joules in a Mars Bar? 300 kcal = 1.2 million J
You could lift a 1 tonne car 100 m above the ground with the energy in a Mars bar!

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Modes of Operation

CW (continuous wave)
Light is constantly emitted with no interruptions

Pulsed
The light is "released" in one or more short bursts, light then nothing then light etc.

Repetition-Rate (or Rep-rate)
If the pulses come regularly then the number of pulses given in one second is called the rep-rate and is measured in Hertz (Hz).

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Types of pulses

- IPLs and long-pulsed lasers have **millisecond pulses** (a single pulse lasts a thousandth of a sec, $t_p \sim 1\text{ms}$).
- A **Q-Switch** is a device that produces a very short, **very high energy** pulse
- Q-Switched lasers have **nano-second** pulses (billionth of a second, $t_p \sim 1\text{ns}$).

How many nanoseconds are there in 1 millisecond?
1 million

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Measuring Pulses

- We can measure the energy of a single pulse (in Joules, typically a few 10's)
- We can also measure the peak power (in Watts, $P_p = E_p/t_p$)
- The peak power in a Q-switch pulse is about a million times higher than in a long pulse of the same energy.
- If the pulses come regularly we can also measure the average power (again in Watts, $P_{av} = E_p \times \text{rep-rate}$)

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Peak Power & Average Power

- Peak power, P_P
 - maximum power during a pulse
- Average power, P_A
 - Amount of energy per second

$t = 1s$

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Long Pulses vs. Q-Switches

<p>Long Pulsed Lasers</p> <ul style="list-style-type: none"> • Most dermatology lasers and all IPLs deliver long-pulses • Light is emitted over a time period of milliseconds (ms) • This creates a photothermal effect in the skin • Used for treatment of Hair, Vessels, certain pigment, Photorejuvenation etc 	<p>Q-Switch Lasers</p> <ul style="list-style-type: none"> • A device inserted into a laser to produce a very short, high energy laser pulse • Typically have nano-second (ns) pulses (i.e. a million times faster than long-pulse systems) • This creates a photomechanical effect in the skin • Used for treatment of Tattoos and Pigment
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Active vs. Passive Q-Switches

Not all Q-Switched lasers are the same!

- **Passive** and **Active** Laser systems generate the pulses very differently
- They have **very** different power outputs and clinical outcomes
- Passive Q-Switches can offer good fading, but **active Q-Switch systems are gold standard** for tattoo removal


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Passive & Active Q-Switches

- **Active**
 - Pulses triggered by an outside signal
 - Larger peak powers & pulse energies
 - Gives best tattoo removal results
- **Passive**
 - Pulses emitted without external trigger
 - Smaller peak powers & pulse energies
 - Cheaper and more compact than traditional active Q-switch lasers



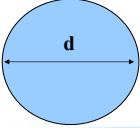
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Spot size

When a laser beam falls onto a surface (for example the patients skin) then a small dot of light is seen. The **diameter** of this spot can be measured in **millimetres** and this is called the **spot size**

Diameter (**d**) measured in mm is the spot size



A circular 5mm spot size actually covers an area of only 0.2 cm²



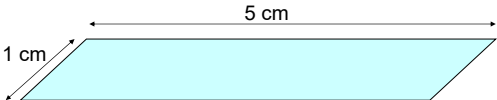
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Treatment Area

Most IPLs use a rectangular light guide to deliver the light to the skin.

The treatment area is measured in centimetres squared (cm²).



Some IPLs can treat an area 5 cm² which is approximately 25 times bigger than the area covered by a 5.0 mm laser spot.



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Energy Density or FLUENCE


We know from experience that concentrating the light into a smaller area increases the intensity of the interaction

The **fluence** is the energy per area, measured in J/cm²

$$\text{Fluence}(\text{J}/\text{cm}^2) = \frac{\text{Energy}}{\text{Area}}$$

For example if 20 J is delivered in a spot size of 5 mm, (which gives a treatment area of 0.2 cm²) the fluence is 100 J/cm²

If you **increase** the spot size, you **decrease** the fluence

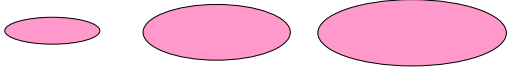


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Fluence and Spot Size


Consider a 1J laser beam being delivered to the skin



3mm spot 5mm spot 7mm spot

Fluence = 14J/cm² Fluence = 5J/cm² Fluence = 3J/cm²

If you increase the spot size, you decrease the fluence




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Activity


- What is the typical pulse duration of a Q-Switch laser? _____
- If you want to destroy a hair follicle by heating it, should you use a long-pulse laser or a Q-Switch laser? _____
- Will a laser giving out 1J of energy have a higher fluence with a 8mm or 3mm spot size? _____



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Any Questions?



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Safety Issues & Equipment Management

Dr Mark Dickinson



**Warning
Laser beam**

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Classes of Lasers

- **Class 1 – No risk to eyes or skin**
 - Safe under standard conditions
 - Also includes embedded products such as CD players, printers
 - No warning labels
- **Class 1M – Low risk to eyes, no risk to skin**
 - Safe under standard conditions, unless using optics
 - Warning label: DO NOT VIEW DIRECTLY WITH OPTICAL INSTRUMENTS

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Class 1C

- For contact application to the skin, or non-ocular use.
- Mainly for home hair removal products.
- Exceed MPE for skin.
- Engineered to prevent accidental ocular exposure.

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Classes of Lasers

- **Class 2 - Low risk to eyes, no risk to skin**
 - Visible wavelengths, blink reflex controls exposure. These lasers present a dazzle hazard
 - E.g., Barcode readers, laser pens
 - Warning Label: DO NOT STARE INTO BEAM
- **Class 2M - Low risk to eyes, no risk to skin**
 - Blink reflex prevents damage unless optics used
 - Warning Label: DO NOT STARE INTO BEAM OR VIEW DIRECTLY WITH OPTICAL INSTRUMENTS

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Classes of Lasers

- **Class 3R – Low risk to eyes. Low risk to skin**
 - Risk of eye injury still low, but includes some invisible wavelengths
 - Warning Label: AVOID DIRECT EYE EXPOSURE (for wavelengths 400-1400nm). For other wavelengths: AVOID EXPOSURE TO THE BEAM

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Classes of Lasers

- **Class 3B– Medium risk to eyes. Low risk to skin**
 - Direct exposure is hazardous, but scattered light is safe
 - Skin hazard avoided through aversion to localised heating
 - E.g. IPLs
 - Warning Label: AVOID EXPOSURE TO THE BEAM



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Classes of Lasers

- **Class 4 – High risk to eyes and skin**
 - Can cause skin injury / fire hazard
 - Direct exposure is hazardous to eye and skin.
 - Scattered light also hazardous to eyes
 - E.g. Most skin laser systems
 - Warning Label: AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION




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MPE

- **Maximum Permissible Exposure** – level of radiation to eye or skin where no adverse effects caused
- Depends on the wavelength, pulse duration/exposure time, tissue type, retinal risk
- **All medical lasers exceed MPE limits!**
- MPE determines what goggles should be used for lasers, there are other types for IPL
- Codes on goggles show optical safety range



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Nominal Ocular Hazard Distance

- Laser beams diverge to some extent
- Light from an IPL definitely diverges
- The spot size gets bigger with distance
- The fluence (energy/area) reduces with distance
- The distance at which the fluence = MPE is the NOHD
- At distances greater than the NOHD there is no hazard
- NOHD >100m for lasers
- <1m for IPL

monochromatic light source

laser light source

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Activity

- Which laser class presents the greatest hazard, class 4 or class 1? _____
- A 790nm diode laser has been classified as class 2, can this be correct _____
- Is there an optical hazard from a laser or IPL source if you are at a distance greater than the NOHD? _____

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Optical Density (OD)

- The OD is a number that describes the amount of light passing through (anything)
- The higher the OD, the less light passes
- The scale is logarithmic (as is the eye's response)
- For example:
- Used for eyewear

% transmission	Optical Density
0.01	4
0.1	3
1	2
10	1
100	0

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Understanding Eyewear

- Should reduce the amount of light reaching the eye to less than the MPE via an appropriate OD
- Designed for particular wavelengths (often multiple)
- The OD is often given as an “L” value (not strictly true!)
- MUST be CE marked
- Need enough for patients and clinicians
- Must be disinfected between users

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Eyewear Considerations

- Prescription eyewear available – but very expensive
- Consider degradation/ventilation
- IPL standards derived from US ANSI welding standards
 - Shade 3 give 14% luminous transmission
 - Shade 5 give 2% luminous transmission
- Maximise room illumination to minimises risk & eye-strain – why?
- Use your own marking system to easily identify

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Laser Eyewear

- Markings
 - D – cw for 10 seconds, once
 - I – pulsed (10^{-4} - 10^{-1} s), 100 pulses
 - R – giant pulse (10^{-9} – 10^{-7} s), 100 pulses
 - M – mode coupled pulses ($<10^{-9}$ s), 100 pulses
- Example
 - DIR 800-1080 L5

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IPL Eyewear

- Three possibilities:
 - Use green 'shade' eyewear
 - Use "LightSpeed" glasses
 - Use blackout goggles for the patient





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Laser Plume

- Smoke and vapour (plume) may be released during a procedure (e.g. hair and tattoo removal)
- Evidence that inhaled cellular and viral debris can have an adverse effect
- Consider:
 - Masks
 - Smoke evacuators



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Fire and burn hazards

- Need heat, oxygen and fuel
 - Drapes, towels, gauze, clothing hair etc
- Class 4 laser beams can cause fires directly!
- Fibre tips may get hot and remain hot
- IPL applicators may get hot and remain hot
- Power supplies may present a fire hazard under some failure conditions

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Electrical Hazards

- Make sure all equipment has a current PAT sticker
- Check for loose wiring
- Check for damaged wires and plugs
- Check for water leaks
- Remove from supply when not in use

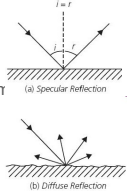
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Reflection Hazards

- Two types of reflection:
 - **Specular** - from mirror-like surface
 - Hazard present for class 3B and 4 laser beam
 - **Diffuse** – from optically rough surface
 - Hazard present for class 4 laser beams
- IPL source should present little haza reflections
- Avoid reflective materials in treatment area, e.g. jewellery, watches, mirrors, pens etc



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Equipment Management

- Make an **Inspection Check List**, e.g.
 - Ensure light guides kept spotless (both ends)
 - Keep handpiece in case when not in use
 - Check IPL filters
 - Check quality of laser beam using burn paper
 - Check goggles for damage, fit etc
 - Check emergency stops
 - Check switches / umbilical / fibre optic for signs of wear

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Non-Beam Hazards

- **Electrical Hazards**
 - Check for cable damage, water leaks etc. Do not remove protective casing on lasers/IPL
- **Mechanical Hazards**
 - Include slip/trip, RSI, handling, noise etc
- **Fire Hazards**
 - Anaesthetic gases, ET tubes etc
- **Chemical Hazards**
 - E.g. Solvents, laser dyes, plume hazards

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Activity

- Which “L” value lets through most light, L1 or L4? _____
- What three things are required for fire?

- Why does an IPL source present little hazard from stray reflections? _____

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Introduction to Risk Assessment

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“Some bloke wants to know if we’ve carried out a thorough risk assessment?”

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Principles of Risk Assessment (RA)

- RA is not unique to lasers/IPL!
- Need to identify hazards and weigh-up risk
 - The HSE 5 Steps to Risk Assessment
 - 1 - Look for Hazards
 - 2 - Decide who might be harmed and how
 - 3 - Evaluate the risks and consider existing precautions
 - 4 - Record your findings
 - 5 - Review and Revise

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Good Housekeeping



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Spotting Hazards - some are easy!



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Risk Assessment

- Advice & guidelines provided by the LPA
- Upheld by LPS day to day
- If a hazard exists, it needs to be controlled
- There is a well-established order
 - Engineering Controls
 - Administrative Controls
 - Personal Protective Equipment

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Engineering Controls

- These protect by design of equipment. For example
 - Covers and panels enclosing power supply
 - Key control
 - Footswitches
 - Aiming beams
 - Door Interlocks

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Administrative Controls

- Administration of safety procedures. Very dependant on users
 - Training (like this!!)
 - Appoint LPS and have list of authorised users
 - Warning signs
 - Laser controlled areas (e.g. no mirrors, sufficient working space etc)

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Personal Control Measures

- Only protects the person using it, so avoid heavy reliance on this.
 - »Goggles
 - »Laser masks (charcoal masks only work for about 30 minutes)

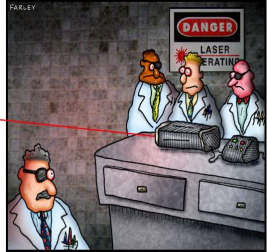
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Laser/IPL Safety Management

- Identification of responsibilities – LPA / LPS
- Register of authorised users
- Nominated key holders & their responsibilities
- Operators responsibilities (house-keeping and pre-use safety checks)
- Appropriate training (evidence)



Peer pressure in the laser lab

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Responsible Individuals


• Employer	Has ultimate responsibility for Health and Safety Issues for all staff, clients, visitors
• Laser Protection Advisor (LPA)	Gives advice on laser safety to the employer
• Laser Protection Supervisor (LPS)	Responsible for day to day supervision of safely aspects
• Nominated Users	Should be trained to use specific laser and read and sign local rules

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Any Questions?




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Light - Tissue Interactions

Dr Sam Hills



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Overview

- The Skin
- Light-Tissue Interactions
- Selective Photothermolysis
- Skin Hazards
- Dealing with an Adverse Skin Reaction
- Eye Hazards

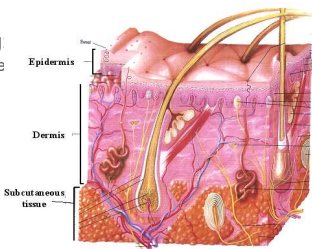
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The Skin

- Our largest organ, has **many functions** including
 - Protection against pathogen and water loss
 - Sensation
 - Temperature regulation
 - Insulation
 - Synthesis of Vitamin D
 - Aesthetics and communication
- Three major layers: **epidermis, dermis and subcutaneous tissue**



The diagram shows a cross-section of the skin. The top layer is the Epidermis, which contains hair follicles and sweat glands. Below it is the Dermis, containing blood vessels, nerves, and more sweat glands. The bottom layer is the Subcutaneous tissue, which is primarily composed of fat. Labels on the left side of the diagram identify the Epidermis, Dermis, and Subcutaneous tissue.


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Epidermis

- **Outermost** layer of skin – main role is of **protection** (against UV, penetration, micro-organisms etc)
- Is stratified, continually renewing epithelium tissue
- There are **no blood vessels** (nourished by diffusion from dermis)
- Thickness varies from 0.05 – 1.55mm



The image shows a microscopic view of the epidermis, highlighting the multiple layers of stratified epithelial cells. The cells are arranged in a brick-like pattern, with the outermost layer being the most densely packed.

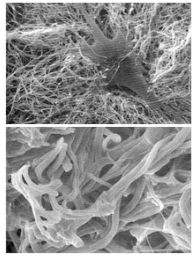
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Dermis

- Lies directly **beneath the epidermis**
- Is a tough and flexible foundation
- Consists mainly of **connective tissue** (collagen and elastin)
- Also houses muscles, nerves, lymph vessels and extensive **blood supply**



The image shows a microscopic view of the dermis, illustrating the dense network of collagen and elastin fibers that form the connective tissue. The fibers are arranged in a complex, interwoven pattern, providing strength and flexibility to the skin.

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Epidermal Appendages

- Common skin appendages are:
 - Hairs
 - Erector pili
 - Sebaceous glands
 - Sweat glands
 - Nails
- Structures grow into dermis but are epidermal
- Following injury, epidermis is regenerated via the appendages

<http://anatomy.lupui.edu>

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Fitzpatrick Skin Types

Type 1	White: Always burns, never tans
Type 2	White: Usually burns, difficulty in tanning
Type 3	White: Sometimes burns, average tan
Type 4	Moderate Brown: Rarely burns, tans with ease
Type 5	Dark Brown: Very rarely burns, tans very easily
Type 6	Black: Does not burn, tans very easily

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Light/Tissue Interactions

- Photo-chemical
- Photo-thermal
- Photo-mechanical
- Photo-ablative


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Photo-Chemical Effect

- Long term exposure to low energy light
- Chemical reaction with no temperature increase
- Examples include Photo Dynamic Therapy, vision, sun-tanning




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Photo-Thermal Effect

- Tissue heating through absorption of light.
- Depends on wavelength, energy and duration.
- Increasing temperature of tissue above 55°C leads to coagulation/protein de-naturation
- Effect described in Selective Photothermolysis for hair removal/vascular treatments etc




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Photo-Mechanical Effect

- This effect occurs when tissue is rapidly heated using very high peak powers, causing thermal expansion of tissue and shock waves
- Q-Switched lasers are needed
- This effect is used in tattoo removal




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Photo-Ablative Effect

- High energy UV lasers can break molecular bonds in target. Can etch material from a surface with no thermal effect. e.g. UV lasers in refractive corneal surgery



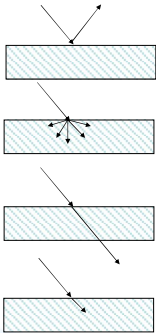
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Laser Beam Interactions

- **Reflection**
 - Can be specular or diffuse
- **Scattering**
 - Light bounces of skin structures until it is absorbed or exits skin surface
- **Transmission**
 - Light passes straight through material with no interaction
- **Absorption**
 - When absorption occurs, heat energy is produced



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Activity

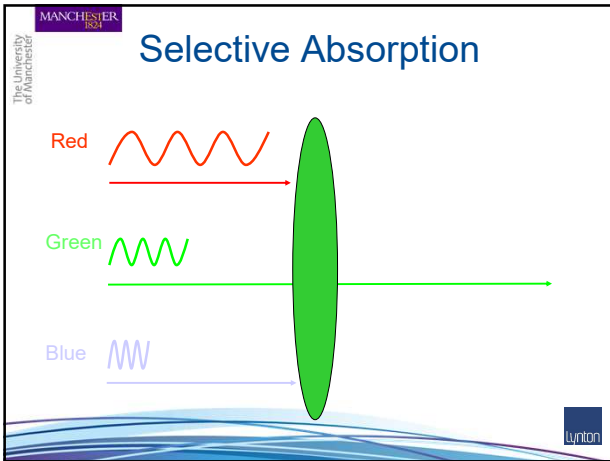
- Which skin-laser interaction is used in hair removal?

- Which skin-laser interaction is used in tattoo removal?

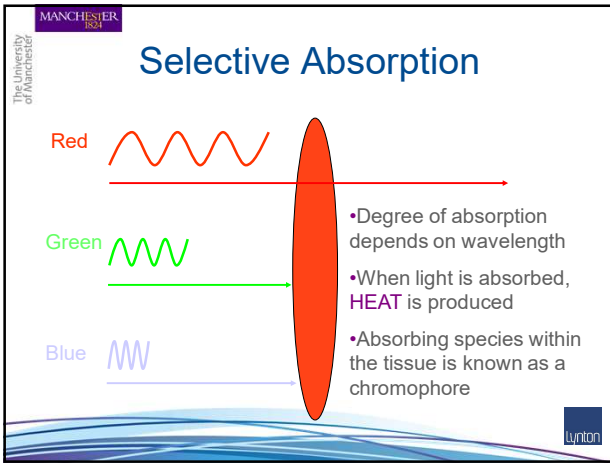
- Which light-tissue interaction causes tissue heating? _____

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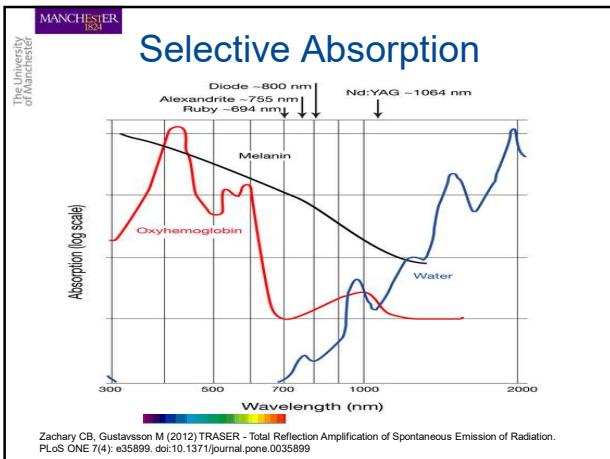
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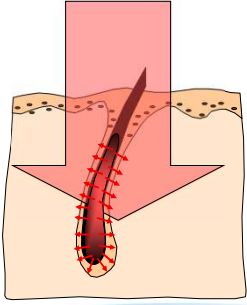
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Selective Photothermolysis



'The specific absorption of light by a target tissue in order to eliminate the target without damaging the surrounding tissue'

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Selective Photothermolysis

- Choose a wavelength that will be **preferentially absorbed** by the target (required to be destroyed) but NOT well absorbed by other chromophores in the skin.
- The irradiating pulse duration should match the **thermal relaxation time** of the target.
- The Fluence should be high enough to cause selective damage to the target

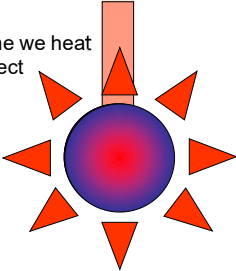
Reference:- Anderson R & Parrish JA. "Microvasculature can be Selectively Damaged using Dye Lasers: A Basic Theory and Experimental Evidence in Human Skin". Lasers in Surgery and Medicine 1: 263 – 276 (1981).

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Thermal Relaxation Time



Assume we heat an object

The object is heated to 100 degrees C (say)

The object then cools until the temperature is half of the original temperature, ie 50°C

The time taken is the **thermal relaxation time (t)**

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Skin Penetration

- Lasers heavily absorbed by water have very limited skin penetration
- The relatively low melanin absorption at 1064nm means it has deep skin penetration depths (up to 4mm).
- For superficial threadveins (such as those on the face and for PWS), lasers or IPLs emitting wavelengths of 500-600nm are preferable. For leg veins, 1064nm is optimal.

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Wavelength & Penetration

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Skin Penetration

- Wavelength is the predominant factor in skin penetration
- Spot size also plays a minor role
- Larger spot sizes show less scattering, so effectively show greater penetration

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Activity

- What skin type is the darkest? _____
- Which commonly used medical laser shows the deepest skin penetration? _____
- Name 2 commonly used vascular lasers

- Name 2 commonly used hair removal lasers

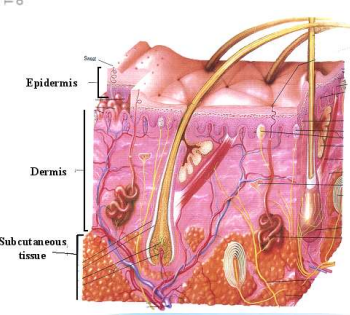
- Name a laser used for ablative resurfacing (i.e. targets water)? _____

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Skin Hazards



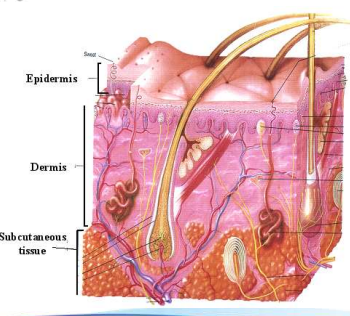
- UV Light (180-400nm) will target the **epidermis** resulting in sunburn, skin aging, increased skin pigmentation and possible malignant changes

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Skin Hazards



- Visible Light (400-700nm) will target the **basal layer and upper dermis**. Can cause thermal damage and pigmentation changes

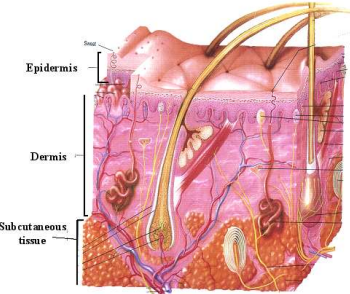
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Skin Hazards



The diagram shows a cross-section of human skin with three layers: Epidermis, Dermis, and Subcutaneous tissue. IR-A light is shown as yellow beams entering from the surface and penetrating into the dermal layer. Labels include 'Sweat' at the surface and 'Lymph' in the dermis.

- IR-A Light (700-1400nm) will target the dermal layer, 1-2mm into the skin. May result in thermal damage to melanin in pigmented lesions and hair follicles.

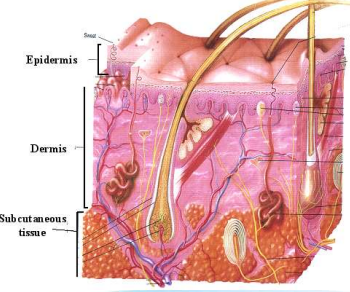
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Skin Hazards



The diagram shows a cross-section of human skin with three layers: Epidermis, Dermis, and Subcutaneous tissue. IR-B & IR-C light is shown as yellow beams entering from the surface and being absorbed in the epidermal layer. Labels include 'Sweat' at the surface and 'Lymph' in the dermis.

- IR-B & IR-C (1400nm-1mm) is absorbed by water in the epidermis. May result in skin burns and ablation of skin (laser resurfacing)

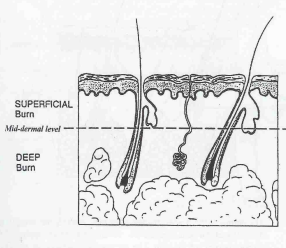
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Depth of Burn



The diagram shows a cross-section of skin with three levels of burn depth: Superficial Burn (1st Degree), Deep Burn (2nd Degree), and Full thickness (3rd Degree). A dashed line indicates the 'Mid-dermal level'. Labels include 'Sweat' at the surface and 'Lymph' in the dermis.

- Erythema
- Partial thickness
 - Superficial (1st Degree)
 - Deep (2nd Degree)
- Full thickness (3rd Degree)

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Assessment of Depth


- Burn surface wet/dry
- Colour red/ pink/ white / charred /mixed
- Capillary refill Blanches or not
- Sensitivity to touch Painful/ insensate

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Erythema



- Red even colour
- Not blistered
- Sensate
- Blanches on pressing
- May be very painful

Eg. Mild sunburn or post laser redness

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Post-Laser Erythema




Baseline Immediately Post Fractional Laser

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Superficial Partial Thickness



- Hallmark is blister
- Underneath blister it is:
 - Even colour
 - Painful
 - Sensate
 - Hair follicles usually intact
 - Blanches on pressing
 - Bleeds on Pinprick


Eg. Severe sunburn, laser burn

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Deep Partial Thickness



- Blister may have burst
- Red/Wet
- Uneven colour
- Does not blanch (fixed staining)
- Painful
- Unevenly Sensate
- Uneven Bleed on pinprick

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Full Thickness



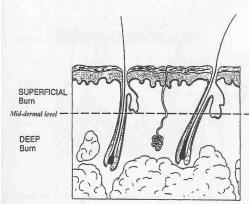
- White to charred
- Leathery feel
- Insensate – may be painful at edges
- Hairless
- Oedema under the burn
- No bleed on pinprick

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Scarring

Burns heal by re-epithelialisation at periphery and from adnexal structures



Superficial Burns
should heal without a scar
temporary skin pigmentation changes occur

Partial Thickness Burns
May leave permanent pigmentation changes (hyper or hypo)

Deep Burns
no adnexal structures
heal by wound contraction
leave scars

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Action to be Taken in Case of an Adverse Incident

- If the IPL/laser is fired directly into the eye, arrange an ophthalmic examination within 24 hrs and supply necessary information on wavelength / fluence etc
- If a burn occurs, immediately cool the affected area, preferably under cool running water. Do not use ice directly on the skin
- If small blisters form, do not break them. If they do burst, cover with a paraffin gauze dressing.
- Do not use creams or lotions
- DO NOT PICK blisters or scabs
- Once the area has healed, apply sunscreen daily

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Recognising Infection

- Acute burns are sterile
- Laser burns should heal within 2 weeks
- Redness around burn is common (erythema)
- Watch out for increasing pain, spreading redness, temperature, swelling over redness, discharge
- Suspected infection requires medical assistance



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Burn Risk-Factors

- TANS TANS TANS!
- Dark skins (treat cautiously due to increased risk of post-inflammatory hyperpigmentation)
- Unshaven hair
- Thin skin (hands, necks, décolleté, the elderly, more susceptible)
- Very concentrated target (very dense hair or threadveins)
- Inadequate cooling
- Aggressive wavelengths (i.e. 585 vs 650 IPL treatment, or 1064nm vs 532nm tattoo removal)

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What to do if Someone has an Adverse Reaction

- Reassure
- Gain as much information as possible on injury, post-treatment compliance etc
- Keep in touch – phone for updates
- Get client to come into clinic for photos and evaluation
- Document everything
- Don't incriminate yourself
- If all else fails, hand over to insurance company

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Light Eye Hazards

- Risk depends on **wavelength, energy, divergence and exposure duration**
- **Low divergence** sources (**Lasers**) will retain power over large distances
- **High divergence** sources (**IPLs**) will do little damage over large distances.
- **Invisible wavelengths** will not trigger blink response and therefore can be **particularly hazardous**

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Eye Hazards

- UVC & UVB (180-315nm) causes inflammation of the **cornea** (photokeratitis – equiv. to sunburn)
- UVA (315-400nm) will target the **lens**, which has UV absorbers to protect the retina (cataracts)

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Eye Hazards

- Visible and IR-A light (400-1400nm) will affect the **retina**, causing burns. Damage to the fovea can cause blindness

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Eye Hazards

- IR-B (1400-3000nm) water abs. can damage the **cornea and aqueous humor**
- IR-C (3000nm-1mm) will target the **surface of the cornea**


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Quote from Wikipedia...

- ...Some people exposed to Nd:YAG laser emitting invisible 1064 nm radiation, may not feel pain or notice immediate damage to their eyesight. *A pop or click noise emanating from the eyeball may be the only indication that retinal damage has occurred* i.e. the retina was heated to over 100°C resulting in localized explosive boiling accompanied by the immediate creation of a permanent blind spot



Big Scary Laser
Do not look Into beam with remaining eye

www.electrictstuff.co.uk


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Activity

- Which wavelengths of light can cause malignant changes to the skin? _____
- Give 3 recommendations for dealing with an adverse reaction



- Which wavelengths of light will target the retina? _____
- What wavelength range is commonly responsible for cataracts? _____



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Any Questions?

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Standards, Regulations and Best Practice

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Standards & Regulations for Manufacturer/Supplier

MANUFACTURERS Equipment Safe & "Fit for Purpose"

- CE-Certification, ideally to Medical Devices Directive or Medical Devices Directive (May 2020)
- Tested to relevant Safety Standards
- Manufacturer must have Medical Spec Quality System

SUPPLIERS Services Safe & "Fit for Purpose"

- Suppliers ideally have Medical Spec Quality System

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Standards & Regulations for Clinic/Salon Operators

CLINIC/SALON OPERATORS – Patient Safety

- Training
- Suitability of Premises
- Suitability of Equipment (previous slide)
- Good Management
- Quality of Care

↓

External (Government?) Regulation

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Regulatory History (Part 1)

- Registered Homes Act (up to 2000)
Enforced by : Local Councils
- Care Standards Act 2000
Private & Voluntary Health Care Regulations 2001
National Minimum Standards
Enforced by :
 - 2000 – National Care Standards Commission (NCSC)
 - 2004 – Healthcare Commission (HCC)
 - 2009 – Care Quality Commission (CQC)

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Regulatory History (Part 2)

- Health & Social Care Act 2008
Enforced by : Care Quality Commission (CQC)

But:
Only applies to certain types of individual carrying out certain types of procedures.

Thus:

DEREGULATION
IN OCTOBER 2010 - FOR MOST PEOPLE

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Current Situation Summary

- Since "Deregulation", most clinics and salons no longer regulated by CQC.
- Some Local Councils stepping in and using existing regulations (Special Treatment Licences, Health & Safety in the Workplace, etc).
- The Joint Council of Cosmetic Practitioners (JCCP) are currently trying to implement a Voluntary Register
- Certain establishments still fall under CQC regulation as a result of the new [Health & Social Care Act 2008](#).

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Current CQC Registration System



- Implemented from 1st October 2010 :- **The Health and Social Care Act 2008 (Regulated Activities) Regulations 2010 and The Care Quality Commission (Registration) Regulations 2009**

An establishment will continue to be regulated by the CQC (and must register) if:

- Treatments are being carried out by, or under the supervision of, a **healthcare professional**

AND

- They are Carrying out "Regulated Activities", e.g. Treating **'diseases, disorder or injury'**, Surgical Procedures, Diagnostic & Screening







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Regulated Activities?

- Still not clear exactly which treatments fall under the definition of 'disease, disorder or injury' – case by case scenarios
- E.g. Acne is considered a disorder, excess female facial hair is (probably!) not
- Invasive procedures (such as 'Smart Lipo') remain under registration- Surgical







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CQC Registration & Monitoring

- Registration (Now F.O.C.)
 - DBS Checks
 - Registered Manager?
 - Statement of Purpose
- Initial Site Inspection & Interview
- Regular Site Re-inspection (un-announced)
- Annual Fee (£1,500)
- A report is produced, which is published online.

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Monitoring : What is monitored?

- Respecting and involving people who use services
- Consent to care and treatment
- Care and welfare of people who use services
- Co-operation with other providers
- Safeguarding people who use services from abuse
- Cleanliness and infection control
- Management of medicines
- Safety and suitability of premises
- Safety, availability and suitability of equipment
- Requirements relating to workers
- Supporting workers
- Assessing and monitoring the quality of service provision
- Complaints
- Records

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For the rest of us not under the CQC : Best Practice / Local Council Regs

General Conditions for all Establishments

- E.g. Licence, Insurance, Staff & Training, Records.
- E.g. Structure & Condition of premises, Sanitation.

Additional Conditions for Treatment Rooms

- E.g. Cleanliness of Furniture, Fittings, Equipment.
- E.g. Ventilation, Heating, Electrical Installation.

Additional Conditions for Lasers & IPLs?

- Recommend looking at *BMLA Essential Standards*
- Keep an eye out for further guidelines from Cosmetic Practice Standards Authority (CPSA)

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The BMLA Essential Standards

- BMLA urge all members to adopt these standards
- Local authorities and the JCCP referencing these standards
- They will be maintained and up-dated by the BMLA
- Consist of 3 Essential Standards:
 - P1 Protocols and Procedures
 - P2 Training for Operators
 - P3 Safe Environment

Download the BMLA Essential Standards at www.BMLA.co.uk

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Standard 1: PROCEDURES

Patients/clients will receive treatment using Class 3B and Class 4 Lasers and IPL's in accordance with safe and appropriate procedures

- Arrangements must be in place to ensure **valid written consent** is gained from the client by the laser/IPL operator and medical history, contraindications and skin type should be recorded
- Follow an appropriate **treatment protocol**, produced by an Expert Registered Healthcare Professional (ERHP)
- A Laser/IPL **risk assessment** should be produced by a certified LPA following an on-site visit and should be reviewed annually
- **Local rules** should be produced under the advice of a certified Laser Protection Advisor (LPA) and should be signed by all operators, reviewed annually and be available on-site



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Standard 1: PROCEDURES

Patients/clients will receive treatment using Class 3B and Class 4 Lasers and IPL's in accordance with safe and appropriate procedures

- A person with overall on-site responsibility for lasers and intense lights is appointed (**Laser/IPL Protection Supervisor – LPS**) who should attend a Core of Knowledge course and undertake regular CPD
- All the operators of the Laser/IPL must read and be aware of the local rules and should be **named in a register of authorised operators**.
- A **treatment register** must be completed every time the laser/IPL is used




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Standard 2: TRAINING

Patients/clients will receive treatment from appropriately trained and competent laser/IPL operators

- Operators must have **system specific** and treatment specific training along with attending a recognised **Core of Knowledge** (repeated every 5 years as a minimum)
- Operators must show evidence of **CPD**
- Operators should only use laser/IPL for treatments for which they have received training and are competent
- Compliance with the **Qualification Requirements** published by Health Education England, 2015 would be accepted as fulfilling the **necessary training requirements**



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Standard 3: ENVIRONMENT

The treatment environment in which Class 3B and Class 4 lasers and IPL's are used is safe

- The area around working lasers and IPLs must be **controlled** to protect other persons:
 - Suitable area warning signs displayed on the outside of doors
 - Walls & ceilings in the treatment room shall be decorated in a matt or eggshell finish. Floors in the treatment room shall be of a non reflective finish (*ideally not carpeted*).
 - No mirrors, reflective surfaces or jewellery
 - Locks or interlocks on doors
 - Windows shall be fitted with appropriate opaque blinds.
- While treatment is in progress, the operator is responsible for the safety of anyone within the controlled area



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Standard 3: ENVIRONMENT

The treatment environment in which Class 3B and Class 4 lasers and IPL's are used is safe

- Effective **protective eyewear** must be worn by everyone within the Controlled Area
- Correctly specified and labelled protective eyewear shall be worn by everyone within the **Controlled Area** whenever there is a risk of exposure to laser or IPL radiation.
- The eyewear must match that described in the Local Rules, and therefore be **approved by the LPA**.
- Eyewear shall be cleaned and disinfected between uses



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Standard 3: ENVIRONMENT

The treatment environment in which Class 3B and Class 4 lasers and IPL's are used is safe

- For all laser and IPL sources with a key switch, formal arrangements must exist for the **safe custody of the key**, separate from the equipment. The operating key must not be left unattended with the laser/IPL equipment
- All lasers and IPLs must **comply with current standards** (e.g. BS EN 60601-2-22:2013 for medical lasers and BS EN 60601-2-57:2011 for IPL)
- Lasers and IPLs must be **serviced and maintained** according to the manufacturer's instructions and must have an electrical safety test carried out annually

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Keogh Report

Review of the Regulation of Cosmetic Interventions, April 2013

The Department of Health commissioned a review of the regulation of Cosmetic Surgery in England and generated a report on the matter containing 40 recommendations



Sir Bruce Keogh
NHS Medical Director



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Keogh Report

Review of the Regulation of Cosmetic Interventions

- Predominantly focuses on surgery and injectable fillers, but also includes the regulation of cosmetic laser/IPL treatments.
- Lynton is in favour of most of the recommendations that refer to non-surgical interventions (which includes Laser/IPL)
- A qualification is recommended that must be obtained by either surgical or non-surgical cosmetic practitioners.
- Non-surgical procedures (e.g. Laser/IPL) should be carried out "under the supervision of a qualified clinical professional". EMP?
- Central register for all practitioners. Getting on the register will also depend on suitable premises. All the "Good Practice" we have just looked at will be mandated. LPA required again.



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Keogh Report

Review of the Regulation of Cosmetic Interventions

- Patient consent will have to be done properly. For surgical interventions copies will need to be supplied externally (e.g. the client's GP, certain central bodies, etc.)
- Restrictions on advertising are recommended.
- Aftercare procedures should be mandatory.
- An Ombudsman should be appointed to handle complaints.
- All practitioners should obtain their own insurance, and their insurance status will be recorded on the new central register.
- No recommendation in the report on who should maintain the register, or enforce any new regulations.




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Health Education England

- Following the Keogh Report, Health Education England (HEE) were tasked with outlining the requirements of a Cosmetic Practitioner Qualification for the delivery of Non-Surgical Procedures and Hair Restoration Surgery




NHS
Health Education England

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Functions of the JCCP

- Overseeing the management and development of a **Voluntary Register** to provide guidance to the public on patient safety
- Establishing a set of **entry requirements** for membership
- Publicising and managing the Register which will be **accessible to the general public**
- Accrediting **individual practitioners** and approved **training/education providers** against the agreed standards




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Functions of the CPSA

- Working with the JCCP and advising other regulatory bodies and Councils on **standards and a 'Code of Practice'** with regard to Aesthetic Treatments
- To scan horizons for new treatments informed by the evidence base for those treatments and then sharing with the JCCP to **refresh and develop related educational curricula**
- Collection of activity data**, adverse event data, developing Patient Outcome Measures, Patient Experience Measures



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Still NOT law – everything the JCCP is proposing is essentially a self-regulation framework

Industry standards and practitioner register now up and running and open for applications



Work in progress but Lynton still involved. Follow us on Twitter and Facebook for updates



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Any Questions?



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