CHAPTER 2

ANATOMY & PHYSIOLOGY OF THE SKIN AND HAIR

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- The Skin
- The Epidermis, Dermis and Hypodermis
- Sebaceous Gland
- Epidermal Protection
- Skin Diseases and Conditions

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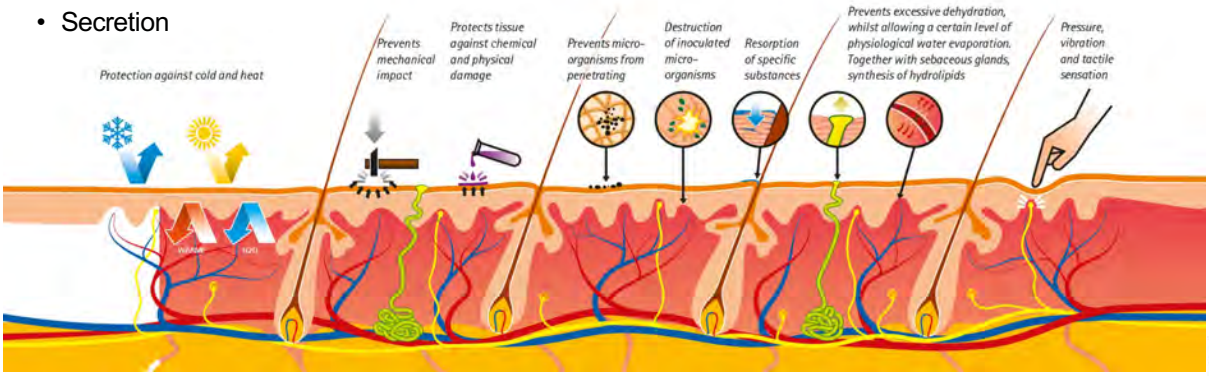
Anatomy of Physiology of the Skin

The Skin is the largest sensory organ and has multiple functions including:

- Protection
- Heat Regulation
- Excretion
- Secretion
- Absorption
- Sensation
- Synthesis of Vitamin D

The layers of The Skin:

- Epidermis
- Dermis
- Hypodermis or Subcutaneous



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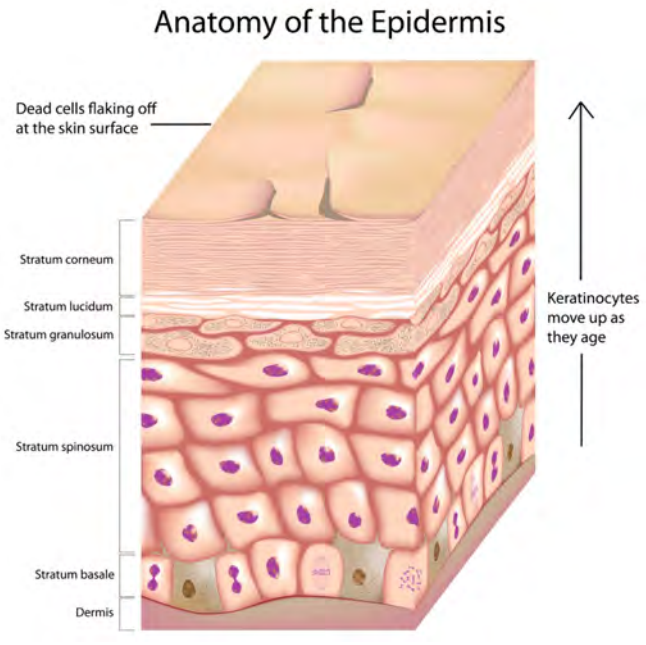
The Epidermis

The epidermis is made up of these layers:

1. Stratum corneum
2. Stratum lucidum
3. Stratum granulosum
4. Stratum germinativum
5. Basal layer (melanocytes located in or near here)

It is thickest on the palms of the hands and soles of the feet and thinnest on the eyelids.



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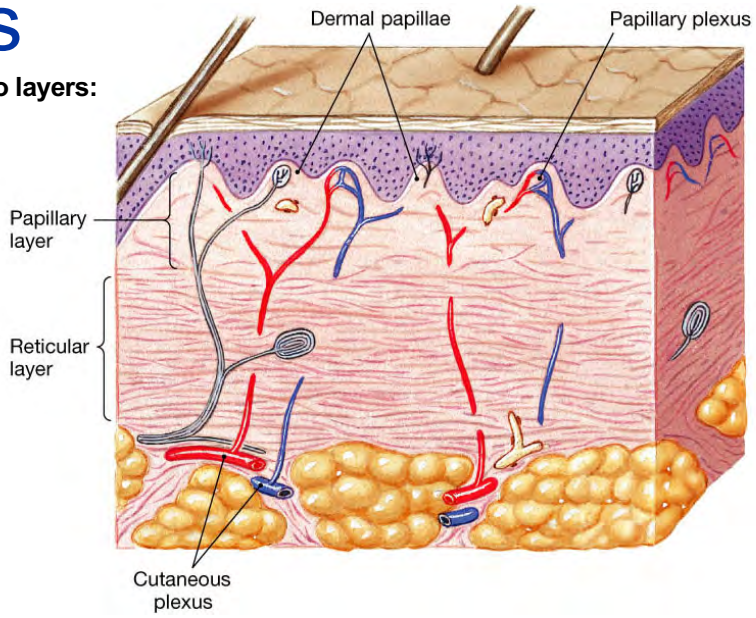
The Dermis

The Dermis is divided into two layers:

- The Papillary
- Reticular Layer

Did you know?
The skin is not much thicker than a few sheets of paper!



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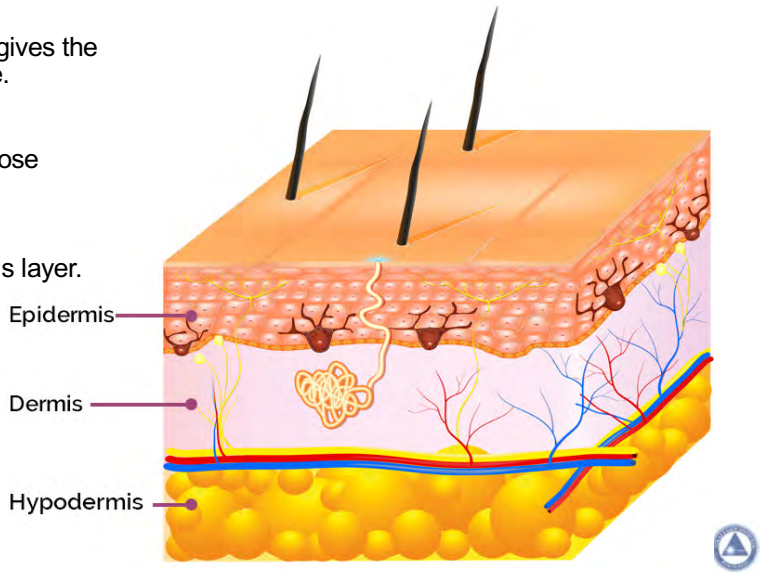
The Hypodermis / Subcutaneous Tissue

- The fatty layer beneath the dermis that gives the body the smooth contoured appearance.
- Subcutaneous tissue is also called adipose tissue.
- Cellulite or fat pockets accumulate in this layer.



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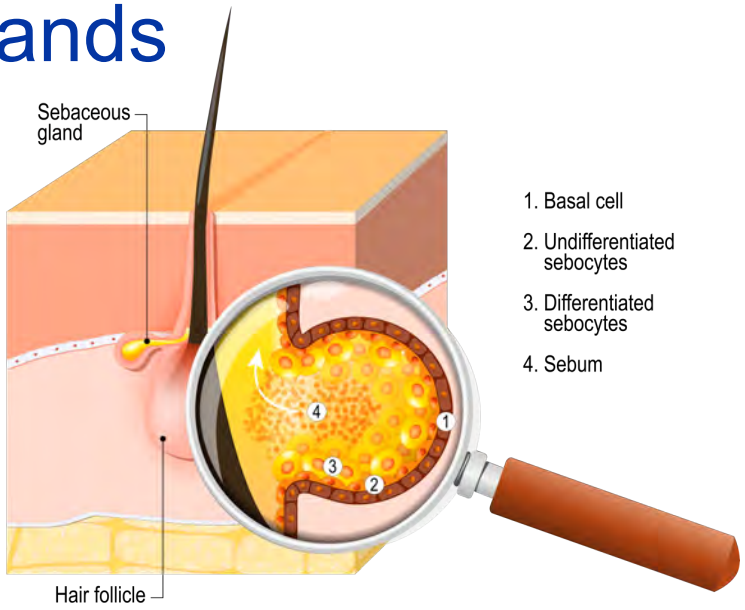
Sebaceous Glands

- Sebaceous glands are found all over the skin.
- Appendages to the hair follicles.
- Found in greater numbers on the scalp, T-zone and cheeks.
- Produce a waxy oily substance called sebum.
- The endocrine system influences these glands, which are most active during puberty.



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Epidermal Protection I

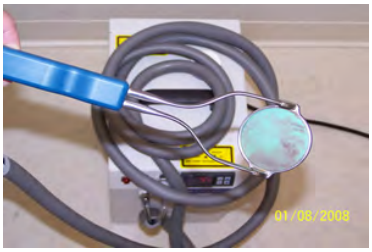
Epidermal temperature is normally ~30-35˚ C. 45˚ C threshold of blistering, 65° C denaturation of collagen

Causes:

- Direct heating from incident beam
- Backscattering or direct conduction from deeper layers

Epidermis can be protected by:

- Cooling
- Decreasing fluence
- Elongated pulse width
- A combination



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Epidermal Protection II: Spot Size

- A larger spot size delivers a higher effective fluence at a given depth
- Scattered photons stay in the target area
- At 4.5 mm depth, 20 J/sq.cm @ 12mm spot = 20 x 78%=17 J/sq.cm @ 18mm spot
- At 4.5 mm depth, 17 J/sq.cm @ 18mm spot = 37 J /sq.cm @ 7mm spot

Spot size vs. % of energy delivered at depth

Depth	18 mm	15 mm	12 mm	10 mm	7 mm
0.1 mm	100%	98%	95%	92%	84%
0.5 mm	100%	98%	94%	91%	81%
1.0 mm	100%	98%	93%	88%	74%
1.5 mm	100%	96%	91%	85%	69%
2.5 mm	100%	96%	88%	79%	59%
3.5 mm	100%	94%	83%	74%	52%
4.5 mm	100%	92%	78%	67%	46%

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Skin Diseases and Conditions

- **Acne**
- **Boils**
- **Cellulitis**
- **Folliculitis**
- **MRSA**
- **Fungal Diseases**
- **Eczema**
- **Keratosis Pilaris**
- **Rosacea**
- **Herpes Simplex Virus**
- **Herpes Zoster**

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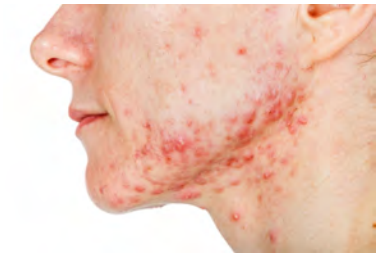
Skin Diseases & Conditions I

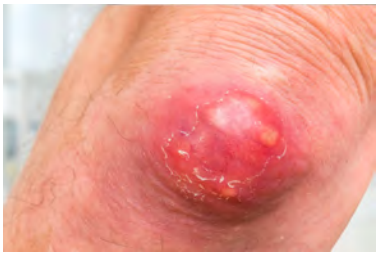
Acne

- Acne is a common skin disease affecting the face and body with the densest population of sebaceous follicles. The skin affected will have blackheads, whiteheads, pustules, papules or nodules and possibly scarring.
- The lesions are caused by changes in pilosebaceous units, skin structures consisting of a hair follicle and its associated sebaceous gland.
- The most common type is acne vulgaris, “common acne”.



Boils

- A boil, also called a furuncle, is a deep folliculitis infection of the hair follicle.
- It is most commonly cause by the bacterium Staphylococcus aureus.
- Boils can range from pea-sized to golf ball sized.
- Individual boils clustered together are called carbuncles.



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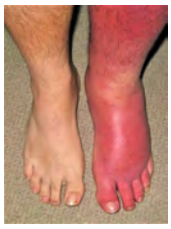
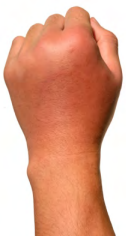
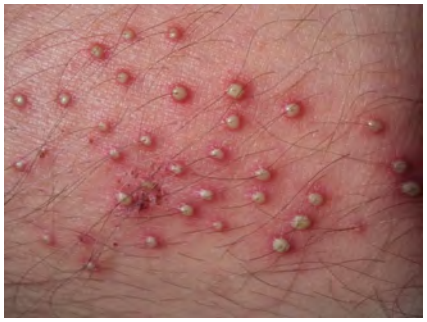
Skin Diseases & Conditions II

- **Cellulitis**
- Cellulitis is a bacterial infection of the skin.
- Staphylococcus and Streptococcus bacteria are the most common causes.
- Bacteria enters through cracked or broken skin.
- Skin is warm, tight, red and inflamed.
- Treated with oral antibiotics.





- **Folliculitis**
- Folliculitis is an infection or inflammation of the hair follicles anywhere on the body.
- Caused when follicles are damaged from friction, shaving or blocked follicle.
- The infection can be either staph bacteria or fungus.
- Treat with antibiotics or anti-fungals.



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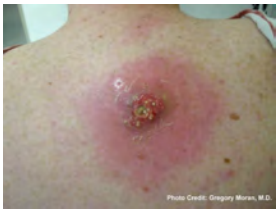
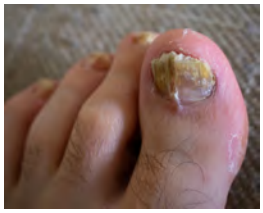
Skin Diseases & Conditions III

Methicillin Resistant Staphlococcus Aureus (MRSA)

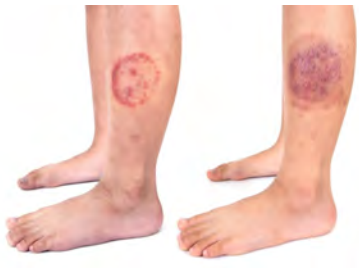
- MRSA is a strain of staph bacteria that's resistant to antibiotics used to treat common staph infections.
- When acquired in a healthcare setting it is called HA-MRSA. when acquired elsewhere it is called CA-MRSA.
- It is spread by skin to skin contact, towels, razors.
- May spread to bones, lungs, heart or brain.





Fungal Diseases of the Skin

- Candida fungus are responsible for yeast infections of the skin and mucous membranes. Candida live on the body, when there is overgrowth this can cause and infection in the mouth (thrush), vaginal, diaper rash or nail infections.
- Ringworm is common affecting all ages and is caused by the Tinea fungus not a worm.
- Tinea barbae (beard), Tinea corporis (body), Tinea pedis (athlete's foot), Tinea cruris (groin, jock itch), Tinea capitis (scalp).



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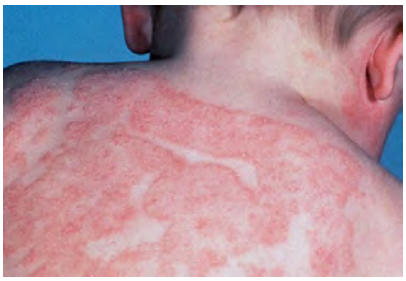
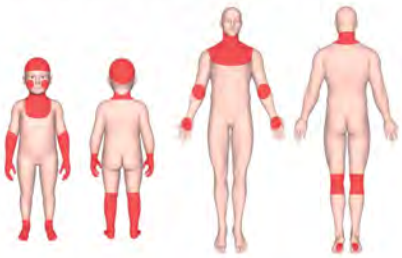
Skin Diseases & Conditions IV

Eczema

- Eczema is term for a group of medical conditions that cause the skin to become inflamed or irritated.
- Atopic dermatitis is due to a hypersensitivity reaction (like an allergy) in the skin, which leads to long-term swelling and redness (inflammation) of the skin. People with atopic dermatitis may lack certain proteins in the skin, which leads to greater sensitivity.
- **Triggers-** Food Allergy, Pollens, Molds, Mites, Dust, Animal Dander, Stress, Detergents
- **Treatments-** Corticosteroids, topical creams and ointments, avoiding triggers



Common Sites of Eczema in Children and Adults



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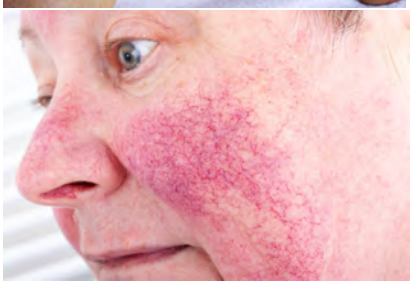
Skin Diseases & Conditions V

Keratosis Pilaris

- A common skin condition where keratin forms hard plugs within hair follicles (the red bumps are rough).
- Harmless, hereditary and common with Eczema.
- Worse in the winter.
- Treat with exfoliants, steroids and moisturizers.

Rosacea

- a chronic skin condition that presents with redness (erythema), flushing, pimples or visible blood vessels.
- Rhinophyma (a thickening of the skin, particularly the nose) may occur in advanced cases.
- **Triggers-** Hot or spicy foods, Alcohol, Sunlight, Emotions such as anger or embarrassment, Extreme temperature changes
- **Treatments-** Laser or IPL treatments, Antibiotics, Avoid triggers



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Skin Diseases & Conditions VI

Psoriasis

- Psoriasis is a chronic disease of the immune system. The Immune system triggers skin cells to speed growth, causing itchy red spots, redness and thick flakey lesions. It affects both the skin and the joints “psoriatic arthritis”
- Psoriasis is not contagious.

Treatments:

- Topical Treatments
  - Corticosteroids
  - Vitamin D
  - Retinoids
  - Salicylic Acid
  - Coal Tar
- UV Light Therapy
- Laser Therapy
  - Excimer
  - Pulsed Dye
- Various oral and injected medications

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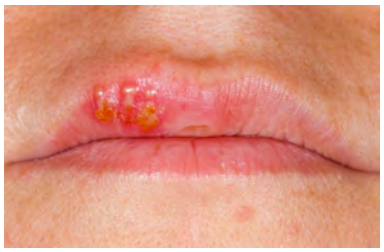
Skin Diseases & Conditions VII

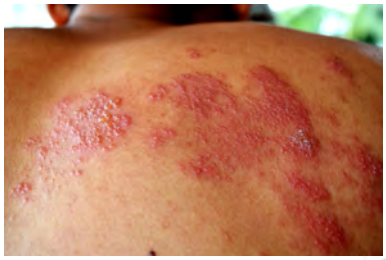
Herpes Simplex Virus (HSV)-

- Affects 85% of the world's population.
- HSV encompass some of the hosts DNA seeming as they are part of the body. HSV-1 presents as cold sores & fever blisters in the perioral region and is transmitted by saliva. HSV-2 is mainly transmitted through sexual contact and presents in the genital or perianal region.
- Treatment is the use of antivirals such as Zovarix (there is no cure).



Herpes Zoster (Shingles)

- Thought to be caused by the reactivation of the varicella virus (chicken pox). Estimates are that 10%-20% of people experience the condition.
- May be an early symptom of AIDS.
- Pre-eruptive tingling, itching or burning may appear first and within days the raised red pus-filled vesicle clusters appear. May present on the body and the eyes.
- Treat with antiviral drugs (there is no cure).



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The Anatomy & Physiology of the Hair

- The Hair Follicle
- Melanin
- Different Types of Hair
- The Hair Growth Cycle
- Hormones and Hair Growth

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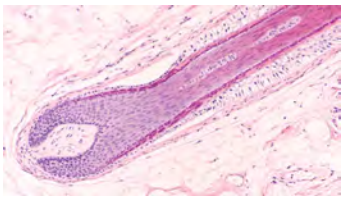
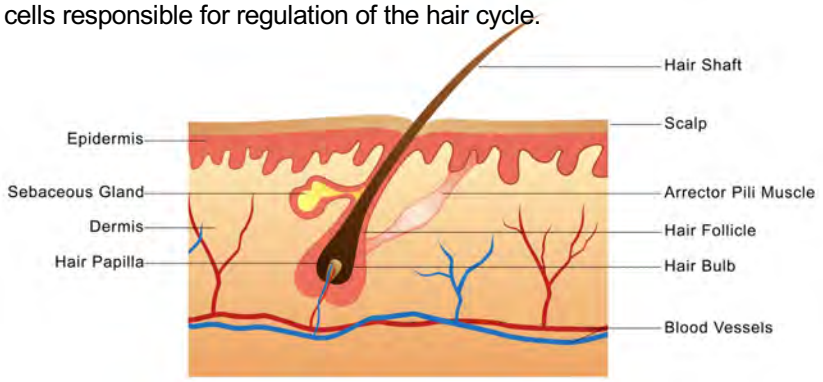
The Hair Follicle

- Hair shaft composed of keratin, produced in the Bulb (lower part of follicle).
- Papilla- neurovascular bundle.
- Inner root sheath encloses the shaft .
- Arrector Pili muscle attaches at the Bulge.
- Bulge contains cells responsible for regulation of the hair cycle.



Hair under a microscope



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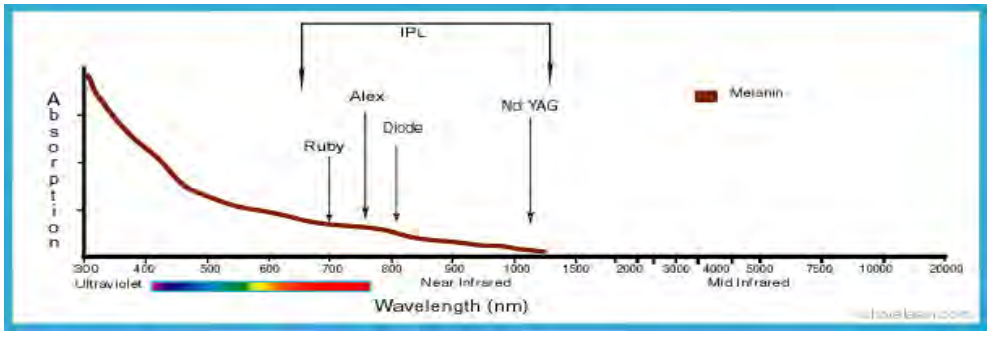
Melanin I

- Melanin pigment -produced in Bulb, possible Bulge.
- Concentrated in upper Bulb and hair shaft.
- Bulb may be as deep as 7mm (scalp), deepest in mid-Anagen, or actively growing hairs.
- Bulb is more superficial in follicles coming out of dormancy.



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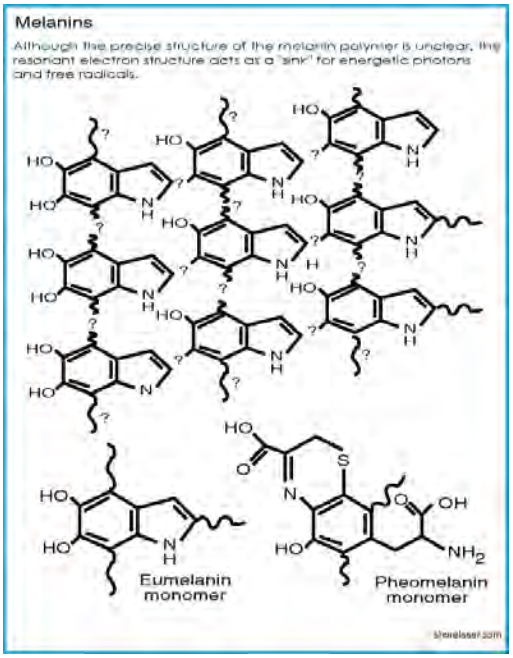
Melanin II

- Produced by melanocytes in the basal layer of epidermis, inner root sheath.
- True or “eumelanin” is black/brown.
- Pheomelanin -reddish yellow, less absorption NIR.
- Light refraction in shaft, and absolute and relative amounts of melanin determine hair color.
- More melanin distributed volumetrically in hair than in skin.



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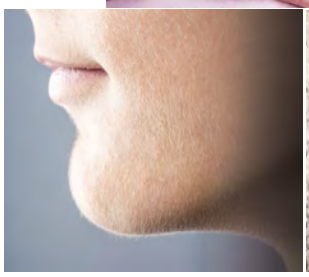
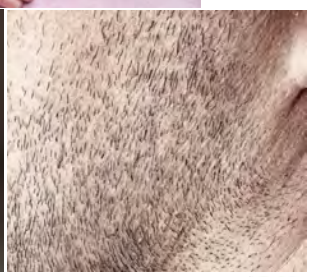
Different Types of Hair

There are three main types of hair found on the human body at one time or another:

- **Lanugo** - soft downy hair that covers the hair of fetuses in utero and infants. Usually sheds a few weeks after birth.
- **Vellus-** Fine short hair, often called “peach fuzz”. Women have more vellus hair than men.
- **Terminal** – Longer, courser, pigmented hair that covers the scalp, arms and legs. Develops on the axillae and groin area at puberty.





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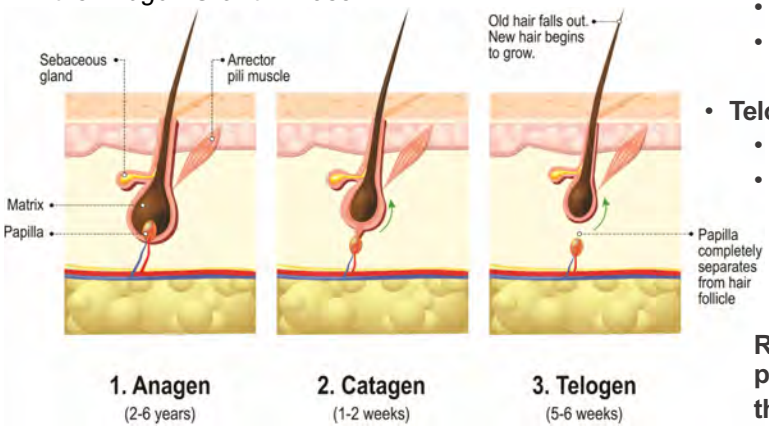
The Hair Growth Cycle I

- Hair growth is characterized by cycles of growth, regression, rest, and regrowth.
- Laser Hair Reduction is most effective with hair in the *Anagen* Growth Phase.



- **Anagen** – Active
  - Growth phase, determines length of hair.
- **Catagen** – Transitional
  - In between Anagen &Telogen.
  - Regression, follicle shrinks, papilla involutes.
- **Telogen** – Resting
  - Dormant phase.
  - Resting phase, terminates with shedding of the shaft.

Remember the order of the Growth phases by using the acronym ACT

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The Hair Growth Cycle II

- Each follicle cycles independently of adjacent follicles.
- Variations between body areas-length of anagen determines length of hair.

Properties of hair for frequently treated body areas

Body Site	% Anagen	%Telogen	Duration of Telogen	Follicle Density	Follicle Depth
Scalp	85%	15%	3 months	350/sq.cm	5-7 mm
Beard	70%	30%	3 months	500/sq.cm.	2-4 mm
Upper Lip	65%	35%	6 weeks	500/sq.cm.	1-2.5 mm
Axilla	30%	70%	3 months	65/sq.cm.	4-5 mm
Chest/Back	25%	75%	9 months	70/sq.cm	2-5 mm
Breasts	30%	70%	4 months	70/sq.cm	2-4 mm
Arms	20%	80%	6 months	80/sq.cm	2-4 mm
Legs	20%	80%	9 months	60/sq.cm.	1-2.5 mm
Bikini/Pubic	30%	70%	3 months	70/sq.cm.	4-5 mm

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Hormones & Hair Growth

Hair Growth is stimulated by certain glands in the endocrine system. There are several conditions and syndromes that have excessive hair growth as a symptom:

- Hirsutism
- Hypertrichosis
- Polycystic Ovary Syndrome (PCOS)

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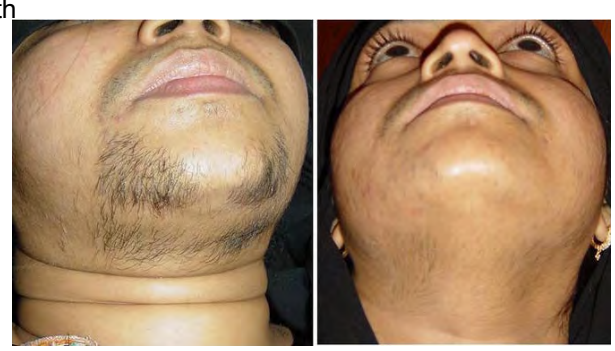
Hirsutism

- Hirsutism is the definition for terminal hair growth in women that is caused by excessive male androgens.
- The typical areas of excessive growth are the face, chest, buttocks and groin.
- Some drugs that affect the endocrine system may increase the percentage of male androgens.
- In the U.S. hirsutism effects 1 in 20 women.



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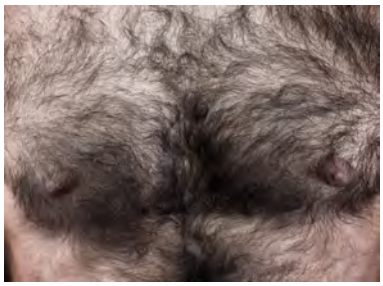
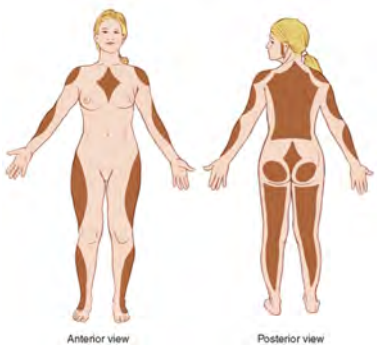
Hypertrichosis

- Hypertrichosis means an overabundance of hair and stems from the Greek hyper, meaning “over” and trichosis, meaning “hair”.
- Hypertrichosis is excessive abnormal hair growth on any part of the body.
- The exact cause is unknown.
- Result of some cancer treatments.
- Reaction to some prescription medications, especially steroids.



Areas prone to Hypertrichosis



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Stein – Leventhal Syndrome or Polycystic Ovary Syndrome (PCOS)

- Can cause excessive hair growth on face, neck, chest and thighs.
- Many women with PCOS will have course facial hair.
- Characterized by high levels of the male hormone androgen.
- Lack of menstruation.
- Cysts on the ovaries.
- Obesity in some cases.
- Small breasts.

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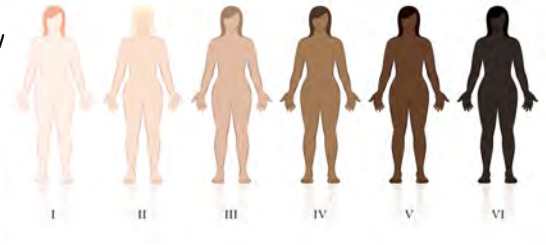
Pre-Treatment Considerations I

- The best candidate for LHR is a patient with light skin and dark hair.
- Blond, red, grey and white hair (pheomelanin) does not respond to LHR treatments.
- Multiple treatments are necessary for a gradual reduction in the amount of visible hair.
- The melanin content of the skin and hair follicle determines the amount of energy that can be safely used.
- Lighter skinned patients (Type I-III) may be treated w any wavelength
- Darker skinned patients (Type IV-VI) may be treated with longer wavelengths

Fitzpatrick Skin Phototypes

Skin Type	Skin Color	Tanning History
I	Very fair, "transparent"	Always burns, never tans
II	Fair	Always burns, tans with difficulty
III	Fair to light olive	Burns mildly, tans slowly
IV	Olive to brown	Rarely burns, tans easily
V	Dark brown	Very rarely burns, tans very easily
VI	Black	Never burns, tans very easily



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Pre-Treatment Considerations II

- Tanned patients should wait at least 2-4 weeks (except for Nd:YAG).
- Patients who have waxed or plucked should wait at least 4 weeks .
- Patients who are pregnant should not be treated.
- Herpes Labialis (fever blisters) should be treated prophylactically (Valcyclovir 500mg BID X 3 days).
- Patients on oral retinoids (Accutane) should not be treated for 6 months after discontinuing the medication .
- Patients on photosensitizing medications should discontinue the medication for 3 days to 3 weeks before treatment.

Photosensitizing Medications include:

- Tetracyclines
- Topical retinoids
- Sulfonamides
- Amiodarone
- ACE inhibitors
- Nifedipine
- Phenothiazines
- Tricyclic antidepressants
- Quinolone antibiotics
- Thiazides
- NSAIDs

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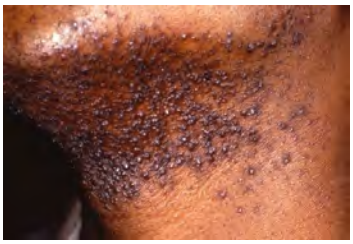
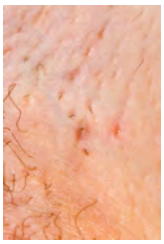
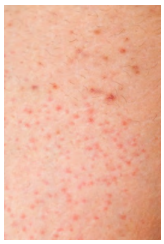
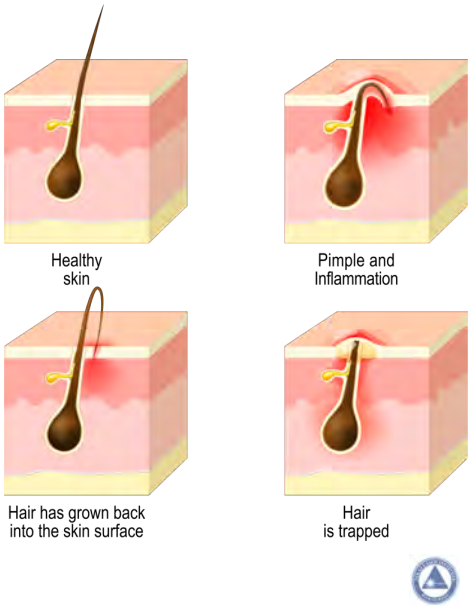
Pre Treatment Considerations III: Pseudofolliculitis Barbae

- "Ingrown hairs" occur when hair shaft grows into skin after shaving.
- Elliptical follicle/hair shaft.
- Irritation, pustules as hair coils in follicle with superinfection.
- Common in neck (especially African-American males), axillae, bikini.
- LHR is treatment of choice.









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LHR Treatment Considerations I: Speed of Treatment

- Depends on device's ability to produce photons.
- Large spot size with high repetition rates are most effective.
- Scanners reduce operator fatigue, but with small spot size and increased patient discomfort.

Avg. Male back = 2500-3000 sq,cm

18mm spot = 2.545 sq.cm

= 1200 pulses

= **20 min** @1 Hz

= **13.3 min**. @1.5 Hz

Spot Size Relative Areas

Spot Size	Area cm^2	%Area 7 mm	%Area 10 mm	%Area 12 mm	%Area 15 mm	%Area 18 mm
7 mm	0.385	**100%**	48%	29%	21%	15%
10 mm	0.810	210%	**100%**	69%	44%	31%
12 mm	1.131	340%	144%	**100%**	64%	44%
15 mm	1.767	459%	225%	156%	**100%**	69%
18 mm	2.545	661%	324%	225%	144%	**100%**

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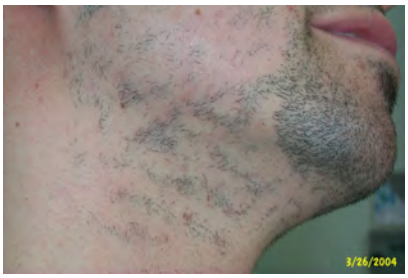
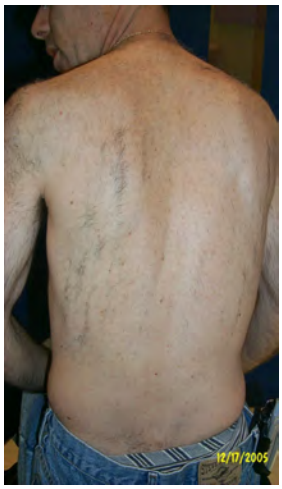
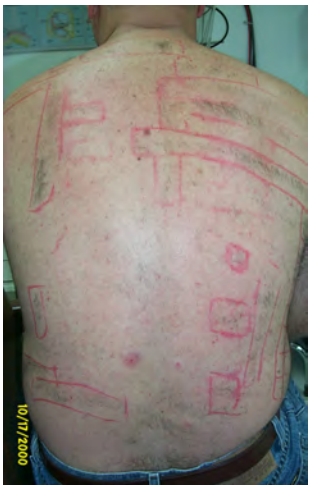
LHR Treatment Considerations II: Adequate Coverage

- Treated area must be covered completely and evenly.
- Divide large areas and treat sections.
- Washable magic markers.
- White eye pencil.
- Track progress in topical gel.
- Touch-up as needed.







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LHR Treatment Considerations III: Patient Comfort

- Topical anaesthetics neither necessary nor desirable.
- Discomfort increases with increasing melanin absorption, increasing wavelength.
- Pain should not be from epidermal melanin absorption!!
- Mechanism of discomfort from increasing wavelength not well understood.

- **<u>Control discomfort by:</u>**
- **Increasing pulse width**
- **Decreasing wavelength**
- **Decreasing energy**
- **Decreasing repetition rate**
- **Increasing spot size**
- **Effective epidermal cooling**

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LHR Treatment Considerations IV: Epidermal Cooling

- **Purpose is to protect the epidermis.**
- **Origin of discomfort should be sub-epidermal.**
- Cryogen cooling - convenient, expensive, may be uneven, increased potential for PIH in darker skinned patients.
- Topical gel - messy, inexpensive, does not obscure vision.
- Forced cold air - clean, convenient, expensive.
- Contact cooling – most IPL and Diode lasers have chilled crystal tips that cool the epidermis.
- Ice packs – replaced by forced cold air and spray for the most part.

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Pre-Treatment Considerations

Avoid heat to the area(s) being treated 24-48 hours prior to treatment. This includes but is not limited to hot showers, hot baths, Jacuzzi's, pools, and work outs.

Side Effects & Complications:

- **Erythema (redness)-** a "sunburn" sensation, especially in darker skin types-transient, resolves in minutes .
- **Perifollicular Edema (swelling)-** relatively common, resolves in minutes.
- **Histamine (allergic) reaction-** mild, moderate, severe
  - Mild- moderate: May apply aloe vera or hydrocortisone to affected area. May also take an antihistamine such as Claritin, Zyrtec, Benadryl, Allegra.
  - Severe: Must get prescription from the medical spa .
- **Superficial Epidermal blistering-** typically in dark-skinned, tanned patients. Typically harmless, may see prolonged hypo pigmentation.
- **Hypopigmentation-** typically transient.
- **Hyperpigmentation-** typically resolves, may need product.
- **Activation of HSV-** uncommon, pre-treat to avoid in patients with predisposition.
- **Infection/scarring-** always possible when epidermal barrier has been breached.

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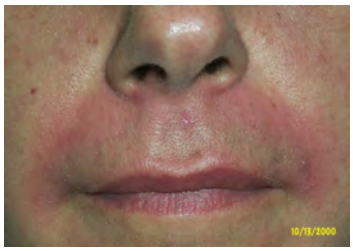
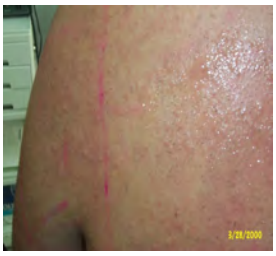
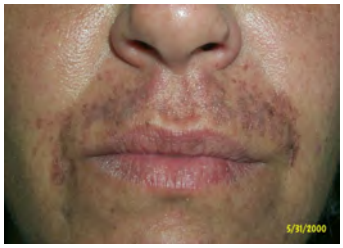
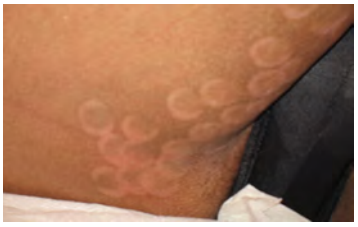
LHR Side Effects and Complications

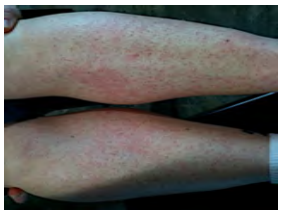

Erythema


Perifollicular Edema


Superficial blistering


Hypopigmentation


IPL burns


Histamine reaction

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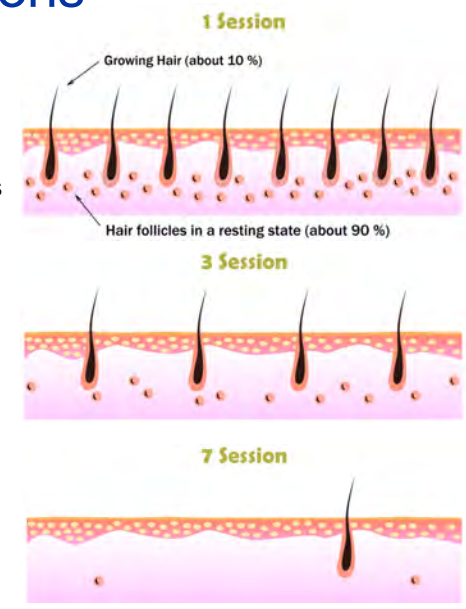
Laser Hair Removal: Limitations

- Not every anagen hair will be affected.
- Response may vary between follicles.
- Response may be temporary for some follicles.
- In most cases telogen follicle will be shocked, and recur as anagen follicles.
- Variability in a given individual's response.
- Variability in treatment parameters and technique (most appropriate vs. available wavelength, adequacy of coverage, etc).
- Ultimate response limited by the % of anagen hair in the treated area.



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Laser Hair Removal: Treatment Interval

- Following treatment, both anagen and telogen hairs are shed.
- The longer the duration of telogen in the treated area, the longer the interval before visible hair reappears.
- A greater percentage of follicles enter anagen synchronously.
- Treatment at this time should result in an improved response.
- Follicles enter anagen before visible hair shafts appear.

- **Rule of thumb #1:** treat at an interval equal to half the telogen phase; or
- **Rule of thumb #2:** treat when visible hair makes its reappearance-the hair free interval will gradually lengthen.

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Properties of hair for frequently treated body areas

Body Site	% Anagen	%Telogen	Duration of Telogen	Follicle Density	Follicle Depth
Scalp	85%	15%	3 months	350/sq.cm	5-7 mm
Beard	70%	30%	3 months	500/sq.cm.	2-4 mm
Upper Lip	65%	35%	6 weeks	500/sq.cm.	1-2.5 mm
Axilla	30%	70%	3 months	65/sq.cm.	4-5 mm
Chest/Back	25%	75%	9 months	70/sq.cm	2-5 mm
Breasts	30%	70%	4 months	70/sq.cm	2-4 mm
Arms	20%	80%	6 months	80/sq.cm	2-4 mm
Legs	20%	80%	9 months	60/sq.cm.	1-2.5 mm
Bikini/Pubic	30%	70%	3 months	70/sq.cm.	4-5 mm

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Problems, Pitfalls, and Tips I

Dense/thick hair (i.e., scalp, beard) is difficult to treat.

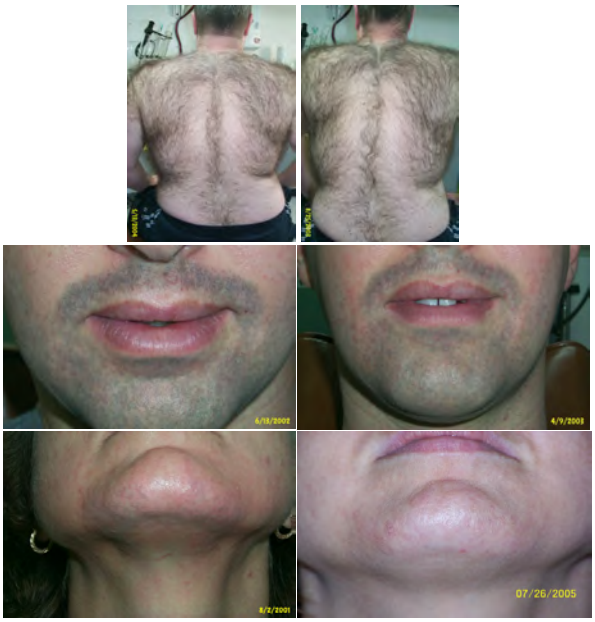
- Large, closely packed follicles absorb enough energy to make high fluences impractical.
- Repeat treatments at tolerable fluence with aggressive cooling.

Male backs Low % anagen hairs with long telogen phase necessitates many treatments over prolonged period.

- High level of dissatisfaction if this is not explained to patient before treatment.

Female faces Even one visible hair is objectionable.

- Humans of both sexes have equal number of hair follicles.
- Male = terminal, Female = vellus



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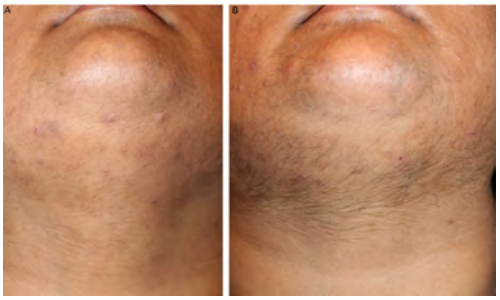
Problems, Pitfalls, and Tips II

Paradoxical Hair Growth:

- Poorly understood.
- Rare, typically occurs at periphery of treated areas in darker skin types.
- May be related to sublethal thermal stimulation and resultant hyperaemia.
- Resolves spontaneously, may be prevented by peripheral cooling, double passes.

Hair Response Tips:

- Paramedian chin hair is most resistant hair on the face.
- Eyebrow hair is the most responsive hair on the face.
- Ear and nose hair responds well to treatment.
- Bikini and axillary is responsive. Back hair is resistant.
- Despite similar kinetics, chest hair responds better than back hair.
- Extremities respond better than chest or back.
- “Mole” hairs, “mutant” hairs respond poorly to treatment.



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Laser Hair Removal: Results I

There are no long term, well controlled prospective studies comparing devices, treatment protocols, or any other variables. It is difficult to scientifically assess results because of the enormous variations in hair and skin color, body site, age, and sex of subjects.

Based on 11 years of experience and review of the literature, one can draw certain conclusions about LHR:

- Approximately 80% of patients will respond predictably to treatment, with progressive reduction in hair growth.
- 5-10% of patients are poor or non-responders.
- 5-10% of patients respond exceptionally well.
- The Alexandrite laser at 755 nm is the preferred device for LHR in a typical mixed population, suitable for 90% of patients.
- IPL or the Nd: YAG laser at 1064 nm is rarely used when practitioners have 755 nm available.
- IPL is inferior to the Alexandrite laser for lase hair removal.
- Currently no U.S. Manufacturer offers a Ruby Laser for laser hair removal.

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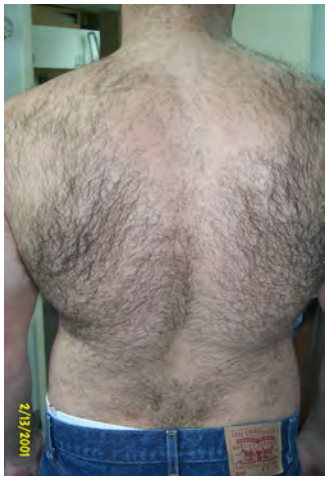
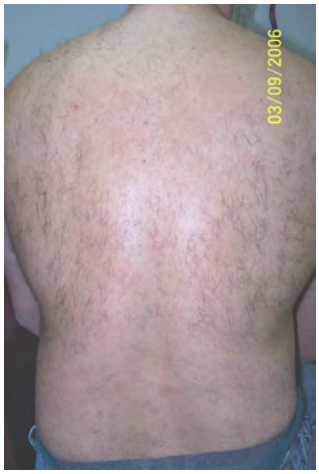
Laser Hair Removal: Results II



- Before



- 5 years post 5th treatment

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