Bacterial infections of the skin

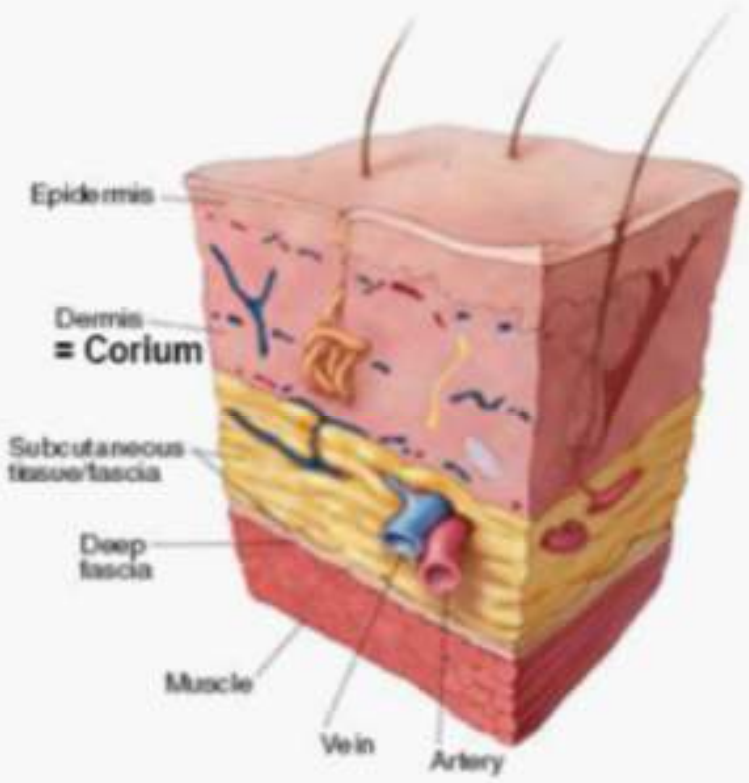
Mircea Betiu

General aspects

- Pyodermas are one of the commonest clinical conditions encountered in dermatological practices especially in the paediatric age group.
- Various factors like poverty, malnutrition, overcrowding and poor hygiene have been stated to be responsible for its higher incidence in the lower socio-economic strata.
- Climatic conditions also play a role with the hot and rainy seasons being the period of maximum occurrence.

Skin – bacterial flora

majority gram-pos Bacteria, different density



Transient flora

(‚airborne flora') – contaminate the normal skin, but rarely multiply on it

- *Staphylococcus aureus*
- *Streptococcus pyogenes*

Resident flora (10^2 to $10^6/cm^2$)

Permanently colonize the skin

- *Corynebacteria* spp
- Propionibacteria
- Coagulase.neg. staphyloc.
- gram+ bacteria
- In skin folds also gram- bact

Temporary resident flora

Contaminate the skin, stay there only for a while

Spectrum of bacterial skin infections Dept. Dermatovenereology Frankfurt

Prospective collection of swabs from infected skin lesions

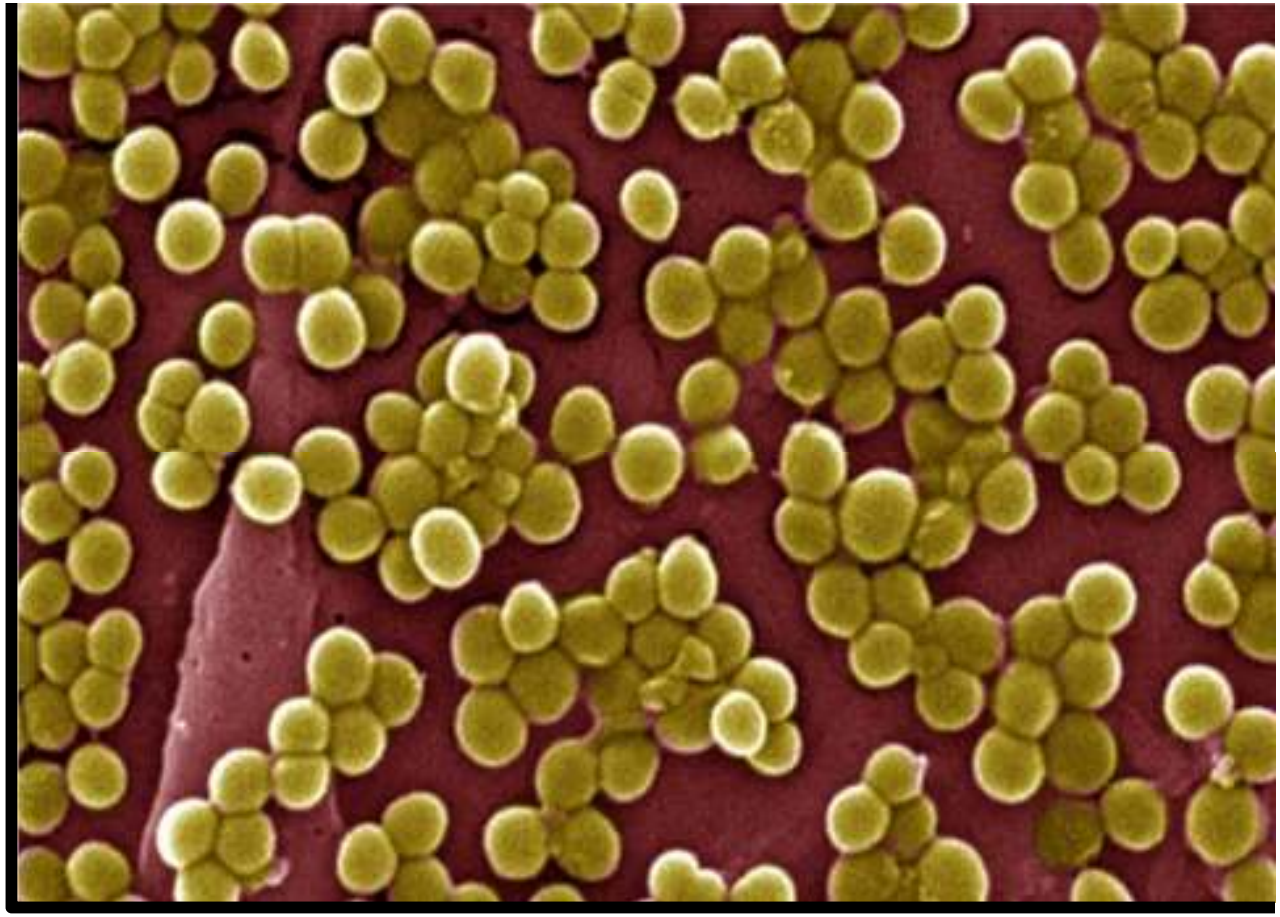
(4 months; 385 isolates out-pts., 175 in-pts)

Bacteria	out-pts	in-pts
Staphylococcus.aureus	67%	61%
Streptococci A,B	27%	25%
Pseudomonas aerug.	5%	20%
Enterobacter spp.	22%	28%
Others	<5%	<5%

- Dermat. infections are primarily caused by virulent pathogens, mainly staphylococci and streptococci, are called pyodermas
- Bacterial infection can affect the epidermis, skin appendages, or cutaneous / subcutaneous tissues

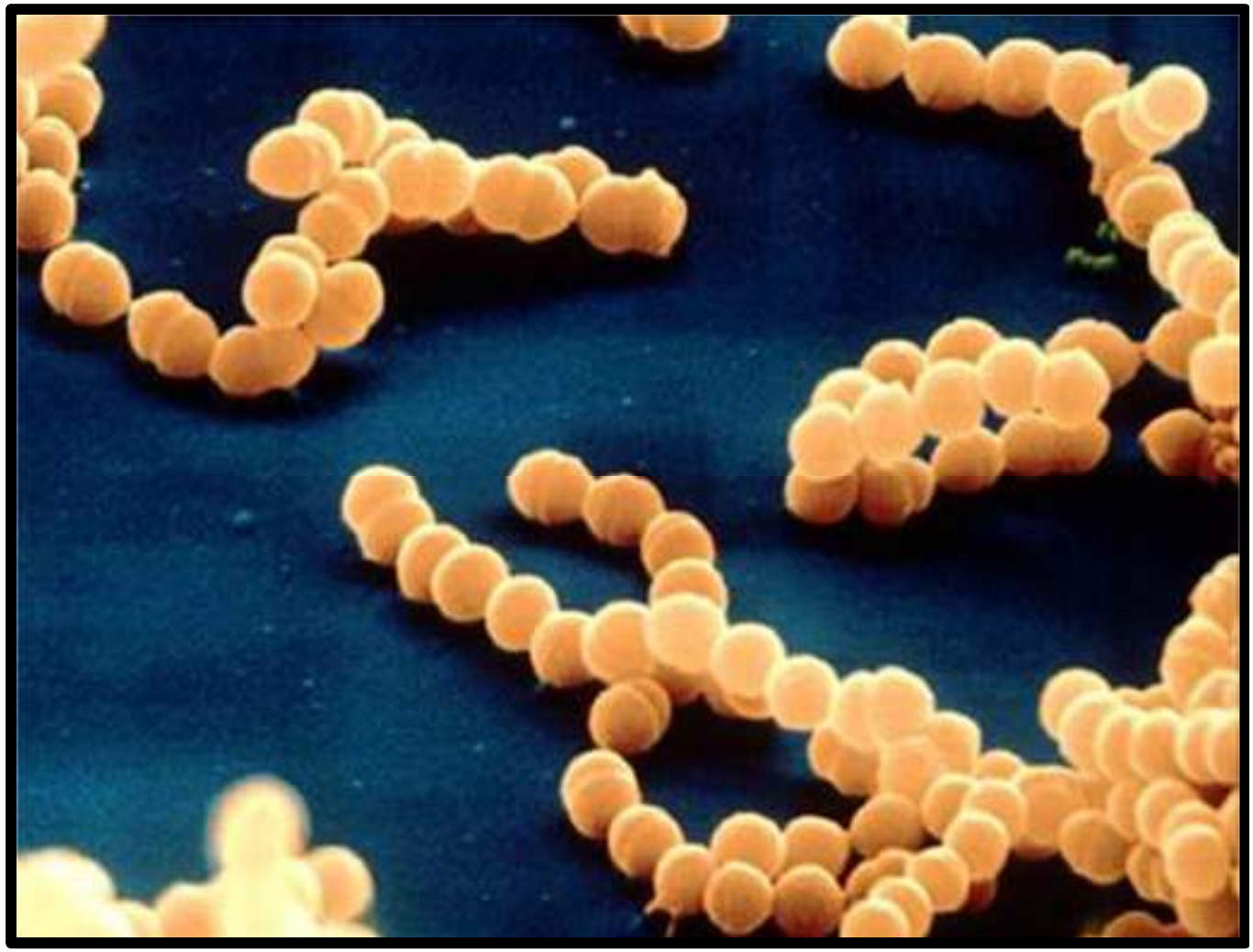
Ochsendorf et al, Hautarzt,51:319-326

ETIOLOGY
Staphylococcus



- Staph. aureus, coagulase- positive, pathogen (90%)
- Staph.epidermidis, coagulase-negative, potentially pathogen (10%)
- Staphylococcus albus, coagulase-negative, saprophite

ETIOLOGY
Streptococcus



Streptococcus is catalase-negative

- beta-hemolitic,
- alpha-hemolitic
- non-hemolitic

Lancefield 18 groupes (A-R): Groupe A ***Streptococcus pyogenes*** (β-hemolitic, type 3, 13, 12, 8, 49 and 57) */GAS/;* Groupe B *Streptococcus agalactiae, etc.*

Table 1 **Bacterial diseases of the skin**

Organism	Infection
Commensals	Erythrasma, pitted keratolysis, trichomycosis axillaris
Staphylococcal	Impetigo, ecthyma, folliculitis, secondary infection
Streptococcal	Erysipelas, cellulitis, impetigo, ecthyma, necrotizing fasciitis
Gram-negative	Secondary infection, folliculitis, cellulitis
Mycobacterial	TB (lupus vulgaris, warty tuberculosis, scrofuloderma), fish tank granuloma, Buruli ulcer, leprosy
Spirochaetal	Syphilis (e.g. primary, secondary), Lyme disease (erythema chronicum migrans)
Neisseria	Gonorrhoea (pustules), meningococcaemia (purpura)
Others	Anthrax (pustule), erysipeloid (pustule)

The most common bacteria to cause skin infections are:

- ***Staphylococcus aureus***
  - Folliculitis
  - Furunculosis (boils)
  - Impetigo (school sores)
  - Methicillin (meticillin) resistant Staph. aureus
  - Staphylococcal scalded skin syndrome
  - Toxic shock syndrome
- ***Streptococcus pyogenes***
  - Cellulitis
  - Erysipelas
  - Impetigo
  - Necrotising fasciitis
  - Scarlet fever
- **Overgrowth of *Corynebacterium* spp:** erythrasma, pitted keratolysis & trichomycosis axillaris)

Other less common skin bacterial infections

- **Gonorrhoea** - pustules
- **Meningococcal disease** - pustules
- **Erysipelothrix insidiosa**, cause of erysipeloid (usually an animal infection)
- **Haemophilus ducreyi**, cause of chancroid
- **Haemophilus**, cause of cellulitis in young children
- **Klebsiella rhinoscleromatis**, cause of rhinoscleroma
- **Pseudomonas aeruginosa** causes wound infections, athlete's foot, gram negative folliculitis, chronic paronychia, spa pool folliculitis and ecthyma gangrenosum
- **Calymmatobacterium granulomatis**, cause of granuloma inguinale
- **Bacillus anthracis**, cause of anthrax
- **Clostridium perfringens** and other species cause gas gangrene
- **Treponema** species cause syphilis, yaws and pinta
- **Borrelia species** cause Lyme disease
- **Bartonella species** cause cat scratch fever, bacillary angiomatosis and bartonellosis
- **Mycobacterium species** cause tuberculosis, leprosy and atypical mycobacterial infections
- ***Serratia marcescens*** is a facultative anaerobic gram-negative bacillus that may rarely cause skin infections such as cellulitis, abscesses and ulcers.

Other skin conditions sometimes caused by bacterial infection

- Kawasaki disease (mucocutaneous lymph node syndrome)
- Pseudofolliculitis barbae (shaving bumps)
- Sarcoidosis
- Scalp folliculitis
- Osler nodes and Janeway lesions (bacterial endocarditis)
- Bacterial vaginosis is one cause of vaginal discharge, in which lactobacilli are replaced by gram positive cocci.

Staphylococcal skin infections

- Staphylococci ('staph') are a common type of bacteria that live on the skin and mucous membranes (eg. in nose) of humans. *Staphylococcus aureus* (*S. aureus*) is the most important of these bacteria in human diseases. Other staphylococci, including *S. epidermidis*, are considered commensals, or normal inhabitants of the skin surface.
- About 15-40 per cent of healthy humans are carriers of *S. aureus*, that is, they have the bacteria on their skin without any active infection or disease (colonisation). The carrier sites are usually the nostrils and fexures, where the bacteria may be found intermittently or every time they are looked for.

What causes Staph. infections?

- Frequent skin injury, particularly if the skin is dry.
- Pre-pubertal children and certain occupational groups such as healthcare workers.
- Underlying illness and certain skin diseases increase the risk of infection:
  - Severe atopic dermatitis
  - Poorly controlled diabetes
  - Kidney failure, especially those on dialysis
  - Blood disorders such as leukaemia and lymphoma
  - Malnutrition
  - Low serum iron
  - Alcoholism
  - Intravenous drug users
  - Medication with systemic steroids, retinoids, cytotoxics or immunosuppressives
  - Immunoglobulin M deficiency
  - Chronic granumomatous disease
  - Chediak-Higashi syndrome
  - Job's and Wiskott Aldrich syndromes (associations of severe Staphylococcal infection with eczema, raised immunoglobulin E and abnormal white cell function)

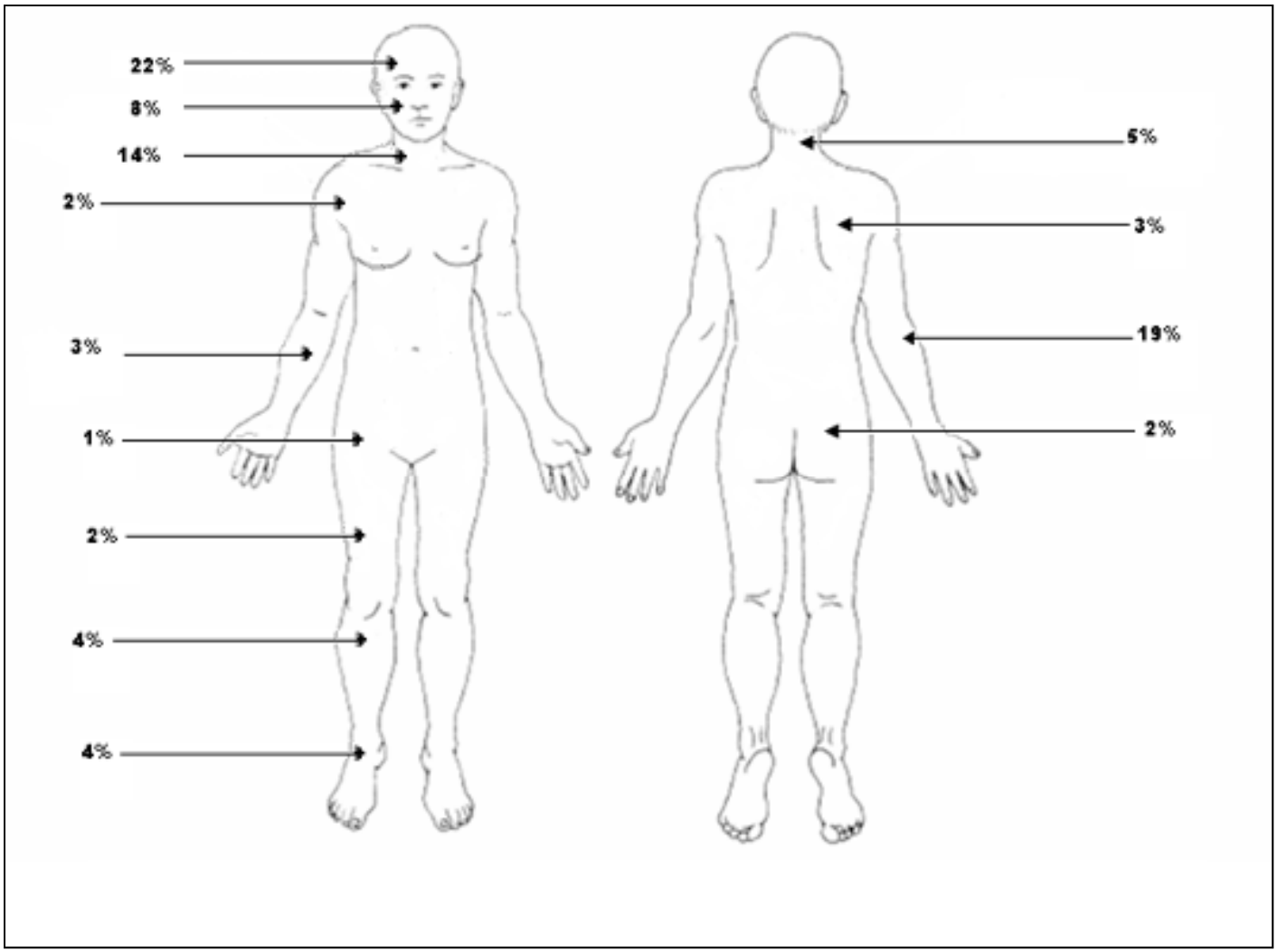
Bacteriology

- *Staphylococcal aureus* – Gram-positive cocci
- Usually facultative anaerobes, capable of surviving at various levels of oxygenation, and are generally very hardy organisms.
- Are only able to invade via broken skin or mucous membranes
- Ways to avoid host defence:
  - Hide their antigens to avoid an immune response
  - Kill infection-fighting cells (phagocytes)
  - Survive within host infection-fighting cells.
  - Develop resistance to antibiotics
  - Release toxins (intoxication) – these do not require the presence of live bacteria to have an effect.

CLASSIFICATION OF STAF. INFECTIONS OF THE SKIN

SUPERFICIAL FOLLICULITIS	▪ Impetigo, osteofolliculitis (Bockhardt)
DEEP FOLLICULITIS	▪ Sicozis vulgaris ▪ Folliculitis profunda
PERI-FOLLICULITIS	▪ Furuncle ▪ Carbuncle (antracoid furuncle)
SWEAT GLANDS INFECTIONS	▪ Hidrosadenitis (apocrine) ▪ Pseudofurunculosis of Finger (eccrine)
STAPH. INFECTIONS OF GLABROUS SKIN	▪ Impetigo bulosa, pemfigus neonatorum epidemicus ▪ Exfoliative dermatitis of Ritter von Rittersheim
DEEP STAPH. INFECTIONS	▪ Ecthyma, Cellulitis
DISEASES PRODUCED TO STAPH TOXINS	▪ SSSS, TSS, Scarlet fever, food poisoning

DISTRIBUTION OF STAPH. INFECTIONS (Roodyn)



Types of skin disease

Staphylococcal skin infections include:

- **Impetigo** (school sores)
- **Ecthyma** (crusted ulcers)
- **Cellulitis** (more often due to streptococcus)
- Hair follicle infections including staphylococcal **folliculitis**, boils (**furuncles & carbuncles**) and **sycosis** (beard infection)
- Secondary skin infection of wounds, dermatitis, scabies, diabetic ulcers etc.
- Staphylococcal hypersensitivity reactions such as folliculitis decalvans (a cause of scarring hair loss)
- Diseases produced to Staph toxins: SSSS, TSS, Scarlet fever, food poisoning

Staph. Impetigo (ostiofolliculitis)

- **Impetigo** is a bacterial skin infection, called **school sores** because it most often affects children, it is **quite contagious**.
- ***Streptococcus pyogenes*** and/or ***Staphylococcus aureus*** are the micro-organisms responsible for impetigo.
- Impetigo may be caught from someone else with impetigo or boils.
- It often starts at the site of a **minor skin injury** such as a graze, an insect bite, or scratched eczema.

Impetigo (ostiofolliculitis)

Impetigo

Folliculitis – follicular pustula

- **Folliculitis** is the name given to a group of skin conditions in which there are **inflamed hair follicles -** a tender red spot at the beginning, often with a surface follicular pustule.
- **Hair centered pustule**.
- Folliculitis can be due to infection, occlusion, irritation and specific skin diseases.

Folliculitis

Folliculitis

Folliculitis

Folliculitis

Boils = Furuncles

- A **deep form** of bacterial folliculitis;
- Present as one or more tender **red spots, lumps or pustules, centred on a hair follicle**.
- **Necrotic** core (head)
- ***Staphylococcus aureus***
- If there are multiple heads, the lesion is called a '**carbuncle**'.
- Large boils form **abscesses**, defined as an accumulation of pus within a cavity.
- **Cellulitis** may also occur, i.e. infection of the surrounding tissues, and this may cause fever and illness.

Why do boils occur?

- **Staph. carrier state**: 10-20% of the population
- *Staph. aureus* is most commonly carried in the nostrils, armpits, between the legs and in the cleft between the buttocks.
- **Tiny nicks or grazes** or something rubbing against the skin **can innoculate the Staph**. germ into the wall of a hair follicle which is a ‘weak point’ in the skin's defences.
- **Once innoculated**, the bacteria cause a boil which goes on to run its usual course of **about 10 days.**
- Boils are sometimes related to **immune deficiency, anaemia, diabetes or iron deficiency.**

Furuncle (Boil)

Furuncle (Boil)

Furuncle “malignant”

Carbuncle

Carbuncle (watering pot sign)

Abscess

SICOSIS VULGARIS

SICOSIS VULGARIS

Wound infection

Hidrosadenitis

Hidrosadenitis

Hidrosadenitis

PSEUDOFURUNCULOSIS
of Finger

PSEUDOFURUNCULOSIS of Finger

Impetigo bulosa

PEMFIGUS NEONATORUM EPIDEMIC
(impetigo bulosa)

Dermititis exfoliativa neonatorum Ritter von Rittersheim

Dermititis exfoliativa neonatorum Ritter von Rittersheim

Folliculitis decalvans

- Form of **alopecia** (hair loss) that involves **scarring**.
- Redness and swelling and **pustules around the hair follicle** (folliculitis) that leads to destruction of the follicle and consequent permanent hair loss.
- Is one cause of **cicatricial alopecia** (baldness with scarring) and is sometimes known as **tufted folliculitis**.
- Affects both men and women and may start first during adolescence or at any time in adult life.
- In most cases ***Staphylococcus aureus*** can be isolated from the pustules.

Folliculitis decalvans

Folliculitis decalvans

Skin disease due to toxins produced by the bacteria include:

- Staphylococcal scalded skin syndrome (SSSS), which usually affects children less than five years old or rarely, adults with kidney failure.
- **Toxic shock syndrome**. This is a relatively uncommon illness usually resulting from the release of Toxic Shock Syndrome Toxin-1 (**TSST-1**) or enterotoxin B – **superantigens capable of generating a massive inflammatory response**.
- Staphylococcal scarlatina (scarlet fever).
- Staphylococcal toxins can also cause food poisoning.

Staphylococcal scalded skin syndrome

- Staphylococcal scalded skin syndrome (SSSS) - **red blistering** skin that looks like a burn or scald, hence its name staphylococcal scalded skin syndrome.
- SSSS is caused by the release of **two exotoxins (epidermolytic toxins A and B)** from toxigenic strains of the bacteria ***Staphylococcus aureus***.
- The toxins bind to a molecule within the **desmosome called Desmoglein 1** and break it up so the skin cells become unstuck.
- SSSS has also been called **Ritter's disease or Lyell's disease** when it appears in newborns or young infants.

What are the signs and symptoms of staphylococcal scalded skin syndrome?

- SSSS usually **starts with fever**, irritability and widespread redness of the skin. Within 24-48 hours **fluid-filled blisters** form. These rupture easily, leaving an area that looks like a burn.

Characteristics of the rash include:

- **Tissue paper-like wrinkling** of the skin is followed by the appearance of large fluid-filled **blisters (bullae)** in the armpits, groin and body orifices such as the nose and ears.
- Rash **spreads to other parts** of the body including the arms, legs and trunk. In newborns, lesions are often found in the diaper area or around the umbilical cord.
- Top layer of skin begins **peeling off in sheets**, leaving exposed a moist, red and tender area.
- Other symptoms may include **tender and painful areas** around the infection site, weakness, and **dehydration**.

Scalded skin syndrome

Scalded skin syndrome

Diagnosis

- The diagnosis of staphylococcal skin infections should be confirmed by a **positive laboratory culture of a swab** from the infected site or **blood culture**.
- In staphylococcal intoxications there may be no viable bacteria to culture and the diagnosis may be made retrospectively on the basis of a blood test demonstrating an **immune response (seroconversion) to toxins** following a compatible illness.

Treatment

- Appropriate antibiotics (penicillinase-resistant – **vancomycin, mupiricin**)
- Drainage of pus collections
- Surgical removal (debridement) of dead tissue (necrosis)
- Removal of foreign bodies (eg. stitches) that may be a focus of persisting infection
- Treating the underlying skin disease (e.g. atopic eczema)
- Due to widespread antibiotic resistance, it is better to prevent staphylococcal infections where possible. The most effective way is to wash hands before touching broken skin.
- It is also important to clear bacteria **colonising the nostrils** and under the fingernails with either antibiotic ointment (eg. fusidic acid or mupirocin) or petroleum jelly several times daily for one week of each month.

Antibiotic Resistance

- Staphylococci are becoming increasingly **resistant** to many commonly used antibiotics including penicillins, macrolides such as **erythromycin, tetracyclines and aminoglycosides.**
- Penicillin resistance in *S. aureus* is due to production of an enzyme called beta-lactamase or penicillinase. Unfortunately there is now increasing methicillin resistance (**MRSA**).
- Penicillins with a beta-lactamase-inhibitor such as **amoxicillin + clavulanic acid** may be used to treat *S. aureus*.
- Macrolide resistance is also high among *S. aureus* but macrolides may be taken by mouth whereas vancomycin requires intravenous administration. **Other** options include **clindamycin and rifampicin**.

Streptococcal skin infections

Streptococci (strep) are bacteria that are commonly found harmlessly living in the human respiratory, gut and genitourinary systems.

Skin diseases due to direct infection with streptococcus include:

- Impetigo
- Ecthyma
- Cellulitis
- Erysipelas
- Necrotising fasciitis
- Secondary skin infection of wounds, dermatitis, scabies, diabetic ulcers etc.
- Tropical ulcers
- Blistering distal dactylitis
- Streptococcal perianal and/or vulval dermatitis

Bacteriology

- **Streptococci** are classified as **Gram-positive cocci** based on their appearance under a microscope. They are spherical or ovoid in shape and tend to forms chains with each other.
- Streptococci that cause human disease are usually facultative anaerobes, that is, they prefer lower levels of oxygen in their environment.
- Streptococci are further classified into subtypes based on sugar chains expressed on their outer shell **(Lancefield group)** and their behaviour when grown in the laboratory (alpha- or beta-haemolysis).
- Most streptococci important in skin infections belong to the **Lancefield groups A, C and G, and are beta-haemolytic**.
- ***Streptococci pneumoniae*** **(pneumococci)** are bacteria important in **pneumonia and meningitis** but rarely cause skin disease; pneumococci are alpha-haemolytic and do not belong to the Lancefield group.

Lancefield Group A

- This group consists of a single type of streptococcus called ***Streptococcus pyogenes***.
- Up to one-fifth of the healthy population can carry *Strep. pyogenes* in the throat.
- *Strep. pyogenes* produces many toxins and enzymes that aid it in establishing infection.
- It is an important cause **of pharyngitis, impetigo, cellulitis and necrotising fasciitis**.
- It is capable of inducing **scarlet fever, post-infectious glomerulonephritis (kidney disease) and rheumatic fever (heart disease).**

CLASIFICATION OF STREP.INFECTIONS OF THE SKIN

VESICULO-BULLOUS	▪ Impetigo Tilbury-Fox ▪ Turniola (paronychia streptococica) ▪ Cheilitis angularis
EROSIVE AND ULCERATIVE	▪ Intertrigo ▪ Papulo-erosive ▪ Ecthyma ▪ Necrotising fasciitis
ERYTHEMATOUS	▪ Erysipelas
SCUAMOUS	▪ Pityriasis alba

Strep. Impetigo – non-follicular pustule

- **Strep. impetigo** presents with **non-follicular pustules** and round, oozing patches which grow larger day by day.
- There may be clear blisters (**bullous impetigo**) or **golden yellow crusts**.
- It most often occurs on exposed areas such as the **hands and face**, **or in skin folds** particularly the armpits.

Impetigo

Impetigo

Impetigo

Impetigo

Impetigo

TURNIOLA (distal dactylitis)

ANGULAR CHEILITIS

Intertrigo

Ecthyma

- **Ecthyma** is a skin infection characterised by **crusted sores beneath which ulcers form**. It is a **deep form of impetigo** as the same bacteria causing the infection are involved but ecthyma causes ulcers (not erosions) of the skin.
- Ecthyma lesion usually **begins as a vesicle** (small blister) or pustule on an inflamed area of skin. A **hard crust** that is harder and thicker than the crust of impetigo soon covers this. With difficulty, the crust can be removed to reveal an indurated ulcer that may be red, swollen and oozing with pus.
- The areas most affected are the **buttocks, thighs, legs, ankle and feet.** Occasionally, the local lymph nodes become swollen and painful.

Ecthyma

Ecthyma

Ecthyma

Ecthyma

Cellulitis

- **Cellulitis** is a common bacterial infection of the hypodermis, which can affect all ages. It usually affects a **limb** but can occur anywhere on the body.
- Symptoms and signs are usually **localised to the affected area** but patients can become generally unwell with fevers, chills and shakes (bacteraemia).
- Severe or rapidly progressive cellulitis may lead to **septicaemia** (blood poisoning), **necrotising fasciitis** (a more serious soft tissue infection), or **endocarditis** (heart valve infection).

Clinical features

- Some or all of the following features may be seen over the affected skin.
- Redness
- Swelling
- Increased warmth
- Tenderness
- Blistering
- Abscess
- Erosions and ulceration
- If there is no increased warmth over the skin it is unlikely to be cellulitis.
- Lymphangitis is a red line originating from the cellulitis and leading to tender swollen lymph glands draining the affected area (e.g. in the groin with a leg cellulitis). It is caused by infection within the lymph vessels.
- After successful treatment, the skin may flake or peel off as it heals.

Cellulitis

Cellulitis

Erysipelas

- **Erysipelas is a superficial form of cellulitis**, a potentially serious bacterial infection affecting the skin.
- Erysipelas most often affects infants and the elderly, but can affect any age group.
- Risk factors are similar to those for other forms of cellulitis. However, unlike cellulitis, almost all erysipelas is caused by Group A beta haemolytic streptococci (***Streptococcus pyogenes***)

Clinical Features

- Erysipelas predominantly affects the skin of **the lower limbs,** but when it involves **the face** it can have a characteristic butterfly distribution on the cheeks and bridge of the nose.
- Symptoms and signs of erysipelas are usually **abrupt in onset** and often accompanied by **general illness** in the form of fevers, chills and shivering.
- Affected skin **is distinguished** from other forms of cellulitis **by a well-defined, raised border**. The affected skin is red, swollen and may be finely dimpled (like an orange skin). It **may be blistered**. Bleeding into the skin may cause purpura (purple patches).
- **Cellulitis does not usually exhibit such marked swelling** but shares other features with erysipelas such as pain and increased warmth of affected skin.

Erysipelas

Erysipelas

Erysipelas

Pityriasis alba

Pityriasis alba

Necrotising fasciitis

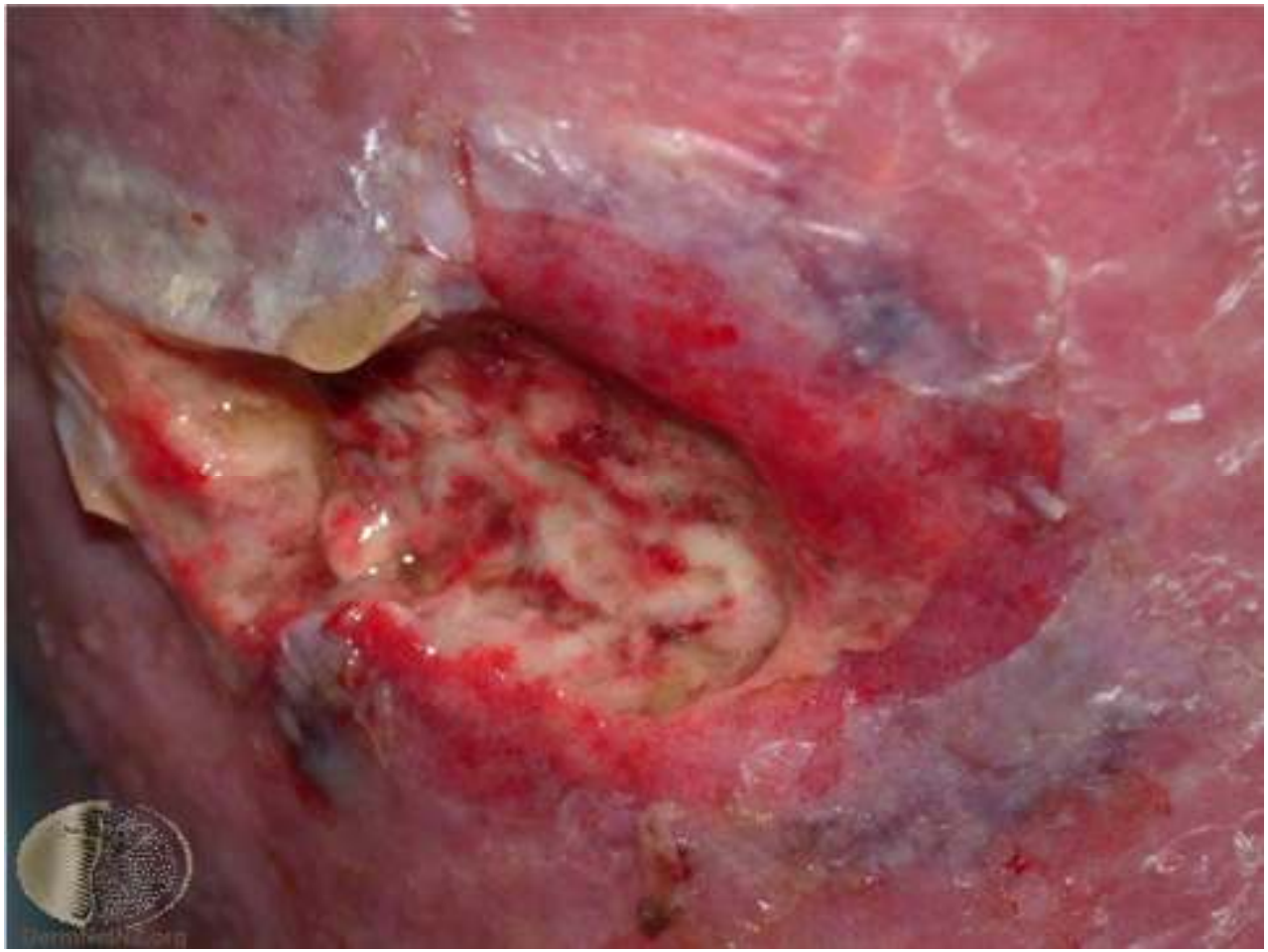
- **Necrotising fasciitis** is a very serious bacterial **infection of the soft tissue and fascia** (a sheath of tissue covering the muscle). The bacteria multiply and release toxins and enzymes that result in thrombosis (clotting) in the blood vessels. The result is destruction of the soft tissues and fascia.
- There are **three main types** of necrotising fasciitis:
  - Type I (polymicrobial i.e. more than one bacteria involved)
  - Type II (due to haemolytic group A streptococcus)
  - Type III (gas gangrene)
- Bacteria causing type 1 necrotising fasciitis include ***Staphylococcus aureus***, *Haemophilus*, *Vibrio* and several other aerobic and anaerobic strains. It usually follows significant injury or surgery.
- Type II necrotising fasciitis has recently been sensationalised in the media and is commonly referred to **as flesh-eating disease**.
- Type III is caused by ***Clostridia perfringens*** or less commonly *Clostridia septicum*. It usually follows significant injury or surgery and results in gas under the skin: this makes a crackling sound called **crepitus.**

Signs and symptoms

- Symptoms appearing **usually within 24 hours** of a minor injury
- **Pain** in the general area of the injury and worsening over time
- **Flu-like symptoms** such as nausea, fever, diarrhoea, dizziness and general malaise
- **Intense thirst** as body becomes dehydrated
- Within 3-4 days of the initial symptoms the following may occur:
  - Affected area starts to swell and may show a purplish rash
  - Large dark marks form that turn into blisters filled with dark fluid
  - Wound starts to die and area becomes blackened (necrosis)
  - Severe pain
- By about **days 4-5**, the patient is very ill with dangerously low blood pressure and high temperature. The infection has spread into the bloodstream and the body goes **into toxic shock**. The patient may have altered levels of consciousness or become totally unconscious.

Necrotising fasciitis

Necrotising fasciitis



In addition

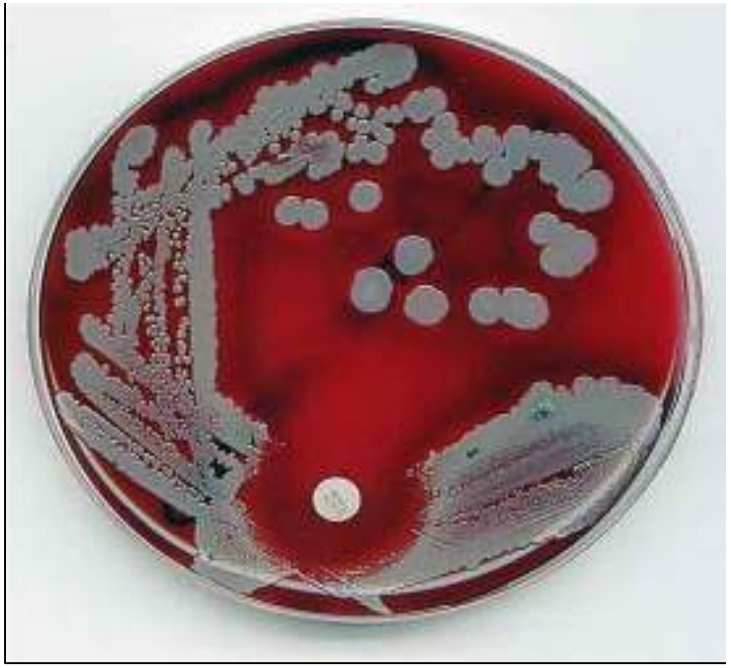
Streptococci are capable of causing skin disease through means other than direct infection of the skin. For example:

- **Scarlet fever** is a reaction to a circulating toxin that is produced by some strains of streptococcus
- Streptococcal **toxic shock-like syndrome** (STSS)
- Allergic hypersensitivity to streptococcal bacteria may result in **erythema nodosum** or **vasculitis**.
- **Psoriasis**, especially **guttate** forms, may be provoked or aggravated by streptococcal infection.
- **Pustulosis acuta generalisata**: scattered sterile pustules on hands, feet and elsewhere following an streptococcal upper respiratory tract infection; may be associated with painful joints.

Pneumococci

- *Strep. pneumoniae* bacteria may live in the throat and nose of healthy people.
- They produce a sticky substance on their outer shell which enables them to attach to the lining of the nose or throat and invade, causing infections in some patients.
- Most infections involve the respiratory tract or meninges but pneumococci occcasionally causes cellulitis.
- **Cellulitis due to pneumococci** usually affects patients with connective tissue disease or **HIV infection.**

LAB



- Gram-stain microscopic examination
- Bacterial cultures (on blood agar)
- **Müller-Hinton agar** is a microbiological growth medium that is commonly used for antibiotic susceptibility testing.
- Testing for antibody response in the patient's blood that aids in detection of recent streptococcal infection (eg. anti-DNAase, anti-streptolysin - **ASLO)**.
- **Rapid-result throat swabs** are also available but are not absolutely reliable and should be interpreted in the clinical context.

Treatment

- It can be difficult to distinguish clinically between skin infection caused by streptococci and other bacteria such as *Staphylococcus aureus*. Antibiotics should therefore be chosen to cover the most likely organisms. **Flucloxacillin** is more appropriate than simple penicillin as it treats both staph. and strep.
- If the laboratory has confirmed **streptococcal infection**, then the most appropriate antibiotic is usually **penicillin**. All streptococci in the Lancefield group are **very sensitive to penicillin**. Those patients with penicillin allergy may be given erythromycin or a cephalosporin (eg. ceftriaxone), which are effective against most streptococci.
- In **very severe *Strep. pyogenes*** infections such as necrotising fasciitis, **clindamycin** may be added to penicillin as very large numbers of bacteria may overwhelm penicillin's mechanism of action.
- Pneumococcal skin infections are generally treated with penicillin, **in more serious infections ceftriaxone or vancomycin** may be more appropriate.

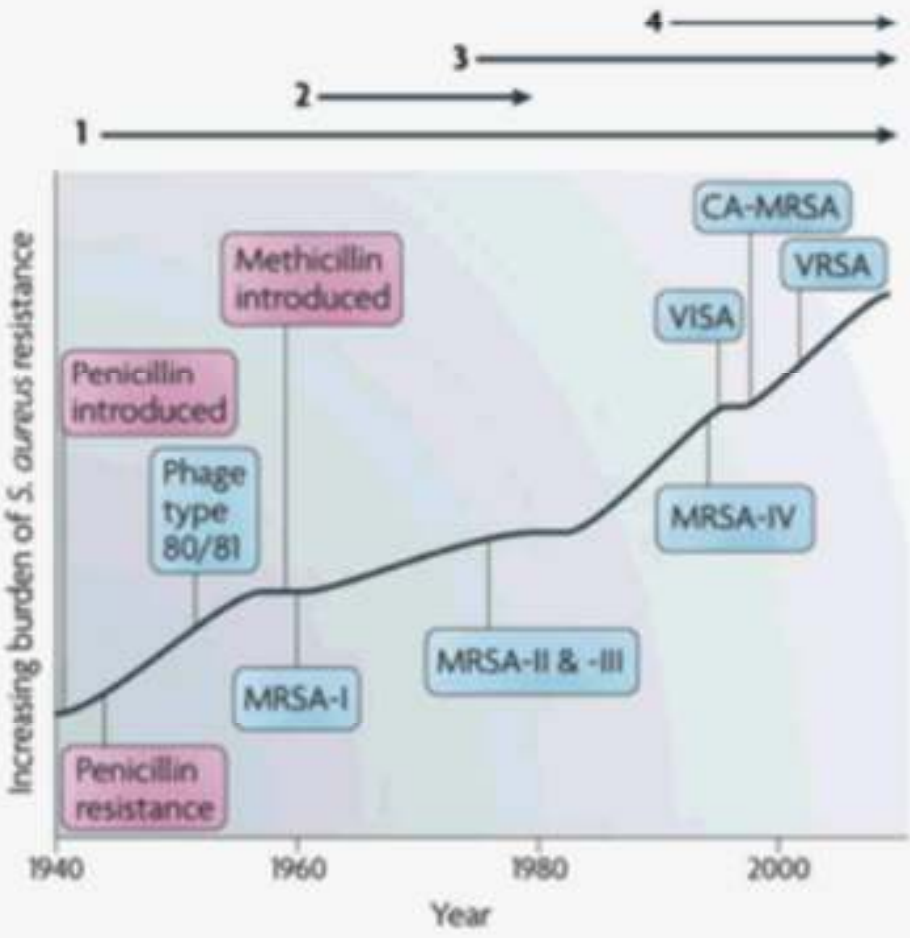
Topical antibiotics and antiseptics

- mupirocin
- fusidic acid
- neomycin
- bacitracin
- neomycin/bacitracin
- canamycine
- chloramphenicol
- chlorhexidine
- aniline dyes (methylene blue, gentian violet)

Waves of resistance: *Staphylococcus aureus* in the antibiotic era Sept 2009

Henry F. Chambers and Frank R. DeLeo**

Nature Rev Microbiology



Methicillin-resistant *S.aureus* (MRSA)
syn. Multidrug-resistant S.aureus
syn. Oxycillin- resistant S.aureus
VISA vancomycin-intermediate S.aureus
Community acquired MRSA (CA-MRSA)

Mueller Hinton agar showing MRSA resistant to oxacillin disk