

# Bacterial Respiratory Infection (3<sup>rd</sup> Year Medicine)

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# Introduction

- The respiratory tract is the most common site of body acquired infection by **pathogens and opportunistic pathogens.**
- This site becomes infected frequently because it comes into direct contact with the physical environment and is exposed continuously to many **microorganisms in the air.**
- The human respiratory tract is exposed to many potential pathogens via close contact with human healthy carriers via **air droplets, hand & mouth contacts, smoke and dust particles.**
- It has been calculated that the average individual inhaled & ingests at least to **8 microbial cells** per minute or **10,000 per day.**

- 2/
- Before a **Respiratory Disease** is developed **via exogenous source**, the following conditions need to be met:
  - There must be a sufficient cell numbers "dose" of infectious agent inhaled.
  - The infectious particles must be airborne.
  - The infectious organism must remain alive and viable while in the air.
  - The organism must be deposited on susceptible tissue in the host & attached.
  - The patients can't resist the infection process by his immune system.. **The role of respiratory normal flora in preventing infection**

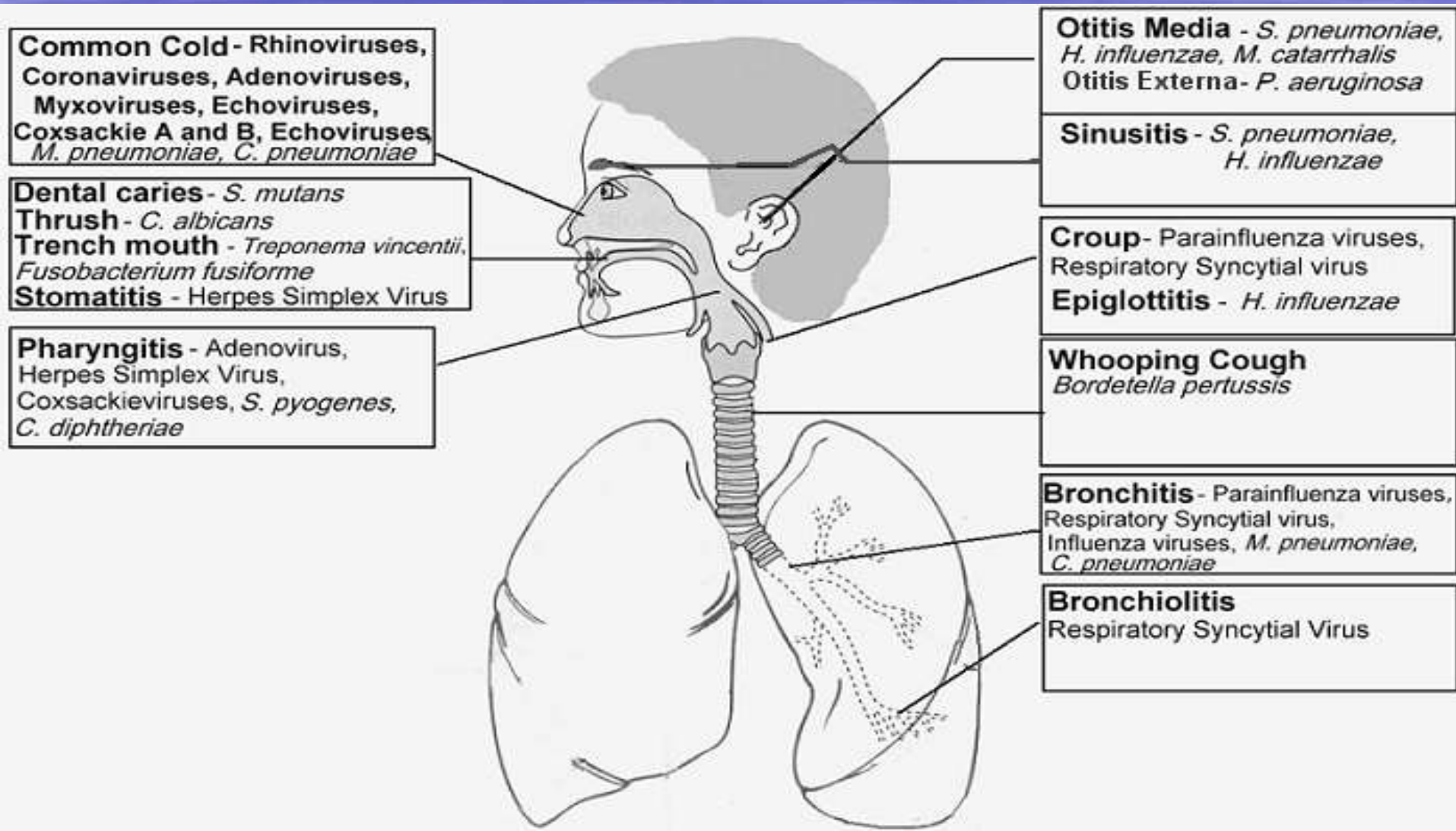


# Normal Bacterial Respiratory Flora

- Most of the surfaces of the upper respiratory tract (including nasal and oral passages, **nasopharynx, oropharynx, and trachea**) are colonized by normal flora. These organisms are usually normal inhabitants of these surfaces and rarely cause disease (Fig.1):
- **Common bacteria >10%:** *Viridans Streptococci* ( *S. mutans*, *S. mitis*), *Neisseria* (*N. flava*, *N. sicca*), *Haemophilus -Parahaemophilus*, *Corynebacteria spp.*, Anaerobic Bacteria (*Bacteroides fragilis*, *Spirochities*)..
- **Less Common <10:** *Group A streptococci* & others, *H. influenzae*, *S. pneumoniae*, *N. meningitidis*..  
*Candida* Various Gram-ve bacilli

# Fig.1 Upper Respiratory Tract Infection

## Most infections are mixed Viruses plus Bacteria





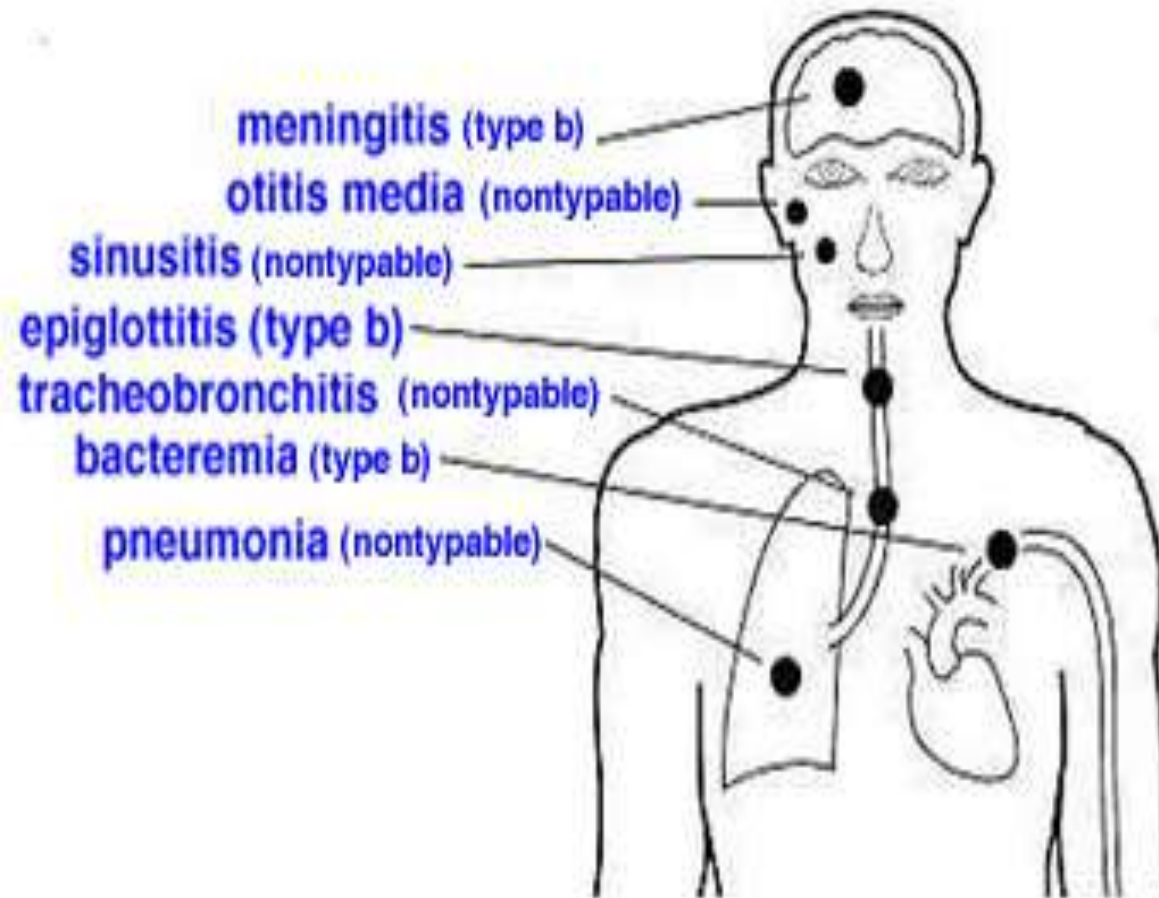
# Common Bacteria Agents cause of Upper Respiratory Infections

- **Haemophilus influenzae type b**.. Capsule.. Lipooligosaccharides.. invasive ..Highly susceptible to cold & room and high temperatures .. Autolysis rapidly.  
**Clinical Features**: Rare Sore Throat.. Common Otitis – Sinusitis.. Conjunctivitis.. Blood sepsis/ Meningitis.. Children (6 months-5 years)..Less Adults
- **Hib-vaccine** polysaccharide-protein conjugate vaccine.. combined with diphtheria-tetanus-pertussis vaccine.. starting after the age of 6 weeks.
- **Staphylococcus aureus** : Gr-positive cocci .. Infect All ages..Sinusitis, Pneumonia, Conjunctivitis, Rare Sore Throat.. Blood sepsis.. Rare Meningitis.. Staphylococcal pneumonia is a frequent complication following influenza infection..Infants, Elderly patients, immunosuppressed.

# Fig.2 Haemophilus influenzae

Gram-stain: G-ve coccobacilli + fimentes

## *Haemophilus influenzae* infections





# Streptococcus infections

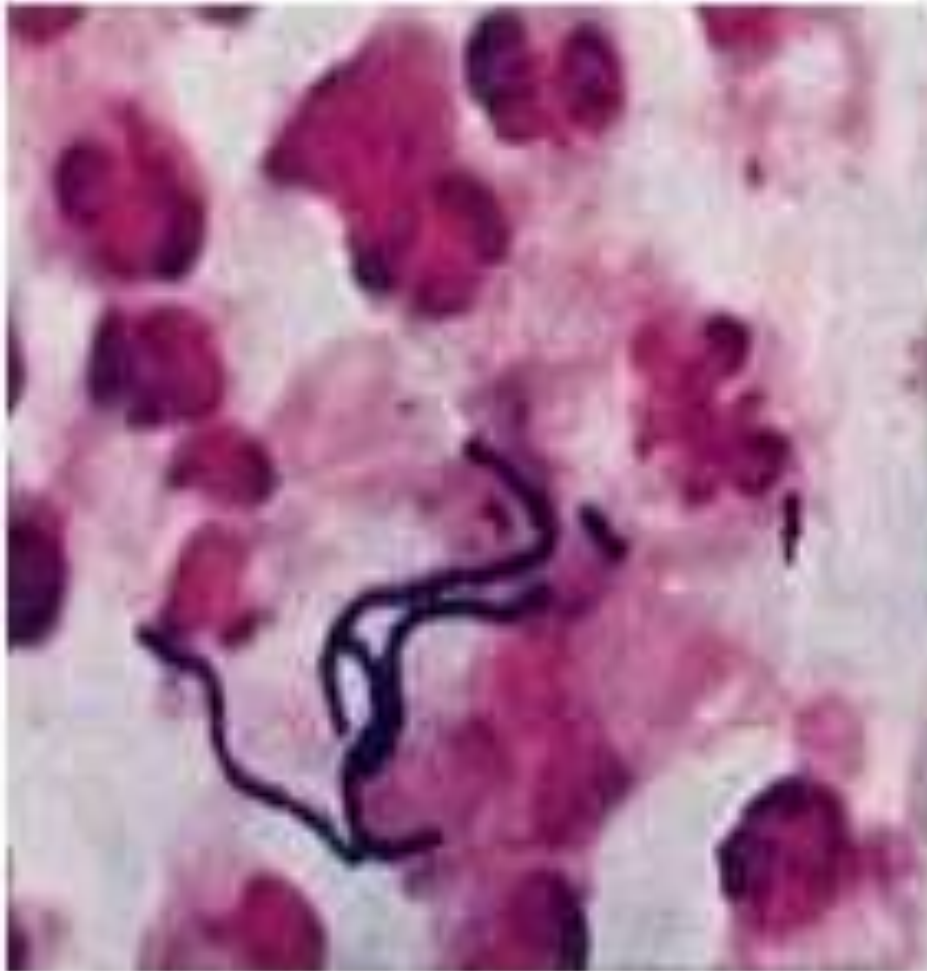
- The genus **Streptococcus** consists of gram-positive cocci.. Human commensals & opportunistic pathogens  
Respiratory Tract.. **Beta-H-streptococci group**,  
**Viridans Streptococci group**
- Definitive identification of **hemolytic pyogenic streptococci** based on the serologic reactivity of cell wall polysaccharide antigens (**Lancefield groups**).
- The most important groups are A, B,C D, G, F.
- **Groups A & B streptococci** are common human commensals & opportunistic pathogens.. always produce beta hemolytic reaction.. on blood agar in vitro.



# *S. pyogenes* (Group A Hemolytic Streptococcus)-1

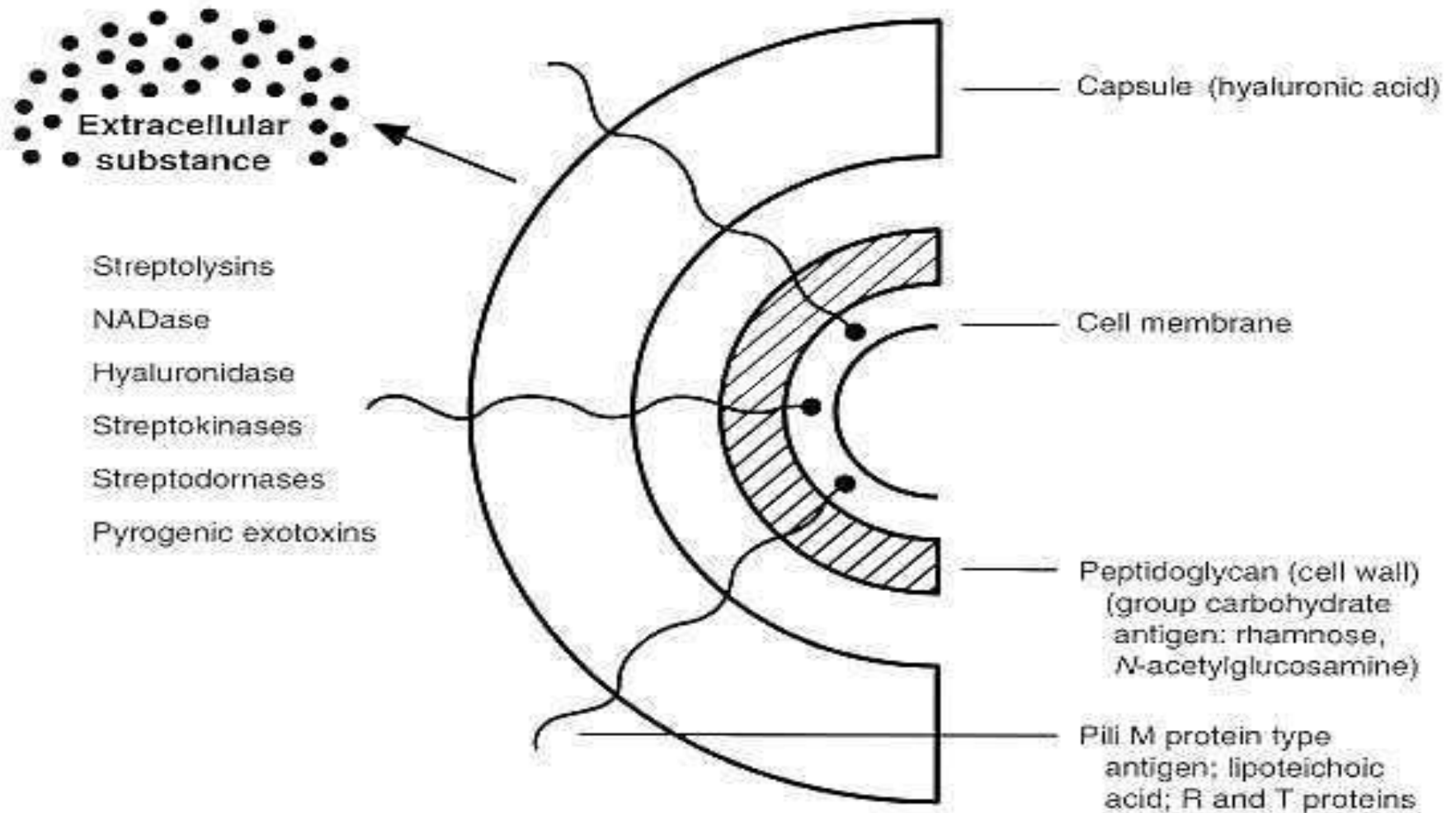
- **Group A Hemolytic Streptococcus** causes in 10-30% Pharyngitis-Tonsillitis/Sore Throat less Otitis–Sinusitis, Skin in all Children..Virulence factors
- **Complication:** Post-streptococcal diseases
- Group A is one of the most frequent pathogens of humans. It is estimated that between 5-15% of normal individuals carry this bacterium, usually in the respiratory tract, without signs of disease as normal flora.. **Healthy Carriers**
- Endogenous Infection occurs when the organism is able to penetrate the host defenses..mostly children
- Causes localized or systemic infections.. Its virulence is related to cell structures, enzymes & toxins

# Fig.3-Beta-Hemolytic Streptococci





# Fig.4- Streptococcus pyogenes

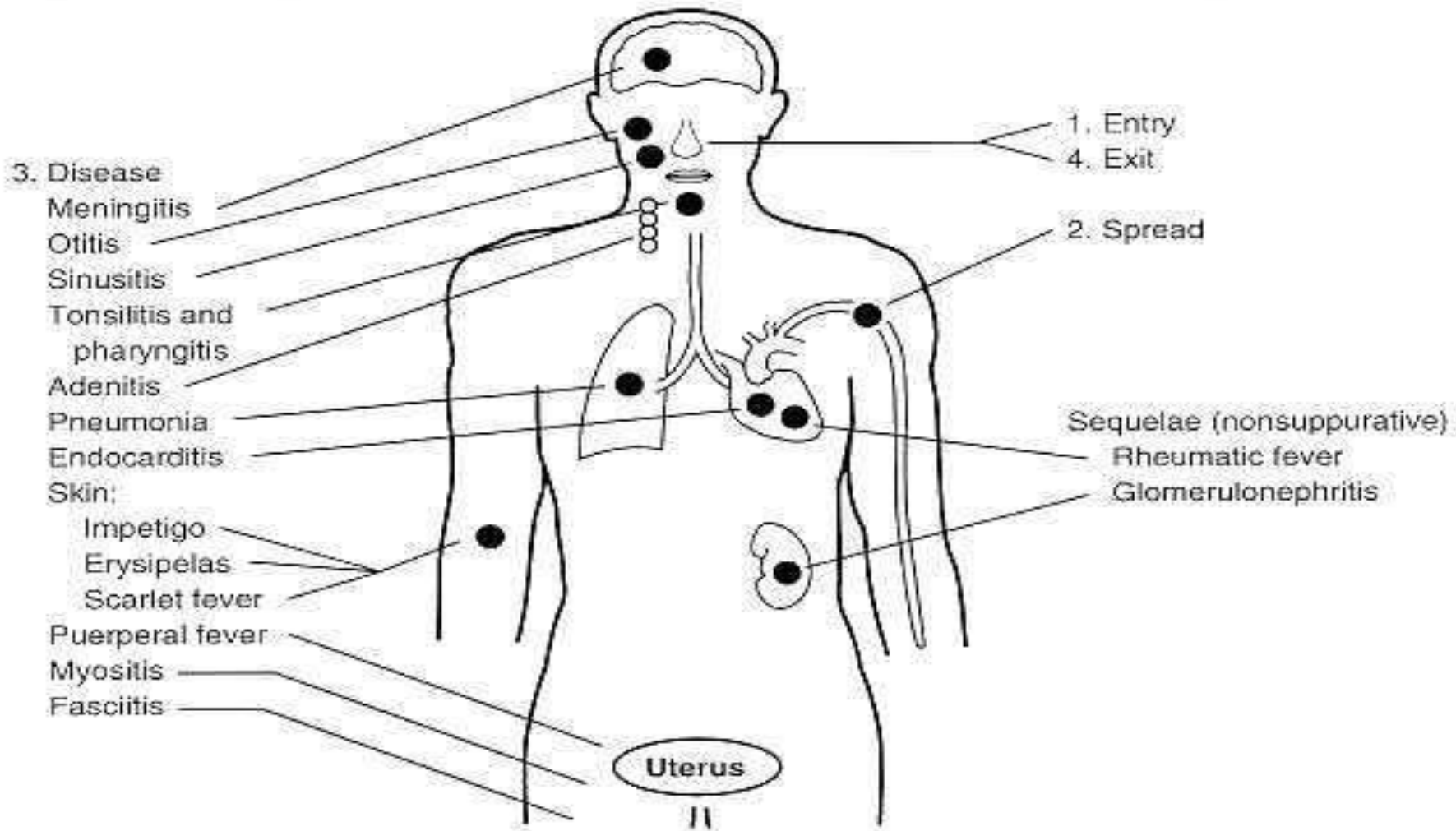


# Pathogenesis of Group A *Streptococcus-2*

- It has ability to colonize and rapidly multiply and spread in its host while resist phagocytosis due to the cell surface T, R, M-proteins.. About 100 serotypes
- Resistance & Immunity to infection developed by presence of specific M-protein antibodies
- Respiratory Infection.. Via droplets.. Mostly occurs in Children < 12 years.. begin as acute Pharyngitis-Tonsillitis.. Repeat Streptococcal Throat infection is common in young children.. each few weeks-months.
- Infection may spread to other body sites.. sinusitis, otitis media, blood sepsis, wound-Skin.. rarely pneumonia & meningitis



# Fig.5-Infections of Streptococcus pyogenes



# Group A *Streptococcus* Skin infection-3

- **Scarlet fever**.. In children.. begins as pharyngitis caused by certain lysogenic *S. pyogenes* Strains producing pyrogenic/erythrogenic exotoxins (A,B,C).. Causes diffuse erythematous rash in oral mucous membranes .. Red Tong & Skin rash.. Infection results in lifelong immunity.
- **Impetigo** manifested as superficial skin blisters associated with massive brawny edema.
- **Cellulitis**.. Skin infection rapidly spread to subcutaneous tissues.. Wound.. highly communicable in children.. may cause glomeronephritis ..but rarely **Rheumatic fever**.
- **Erysipelas**.. Complication of cellulitis involving Lymphatics
- **Streptococcal Toxic Shock Syndrome** are systemic responses to increased circulating **pyrogenic toxins A** ..excreted from some **GAH Streptococcus strains**.. High fever, sepsis, Diarrhea, can be fatal.



# Scarlet Fever



# Group A *Streptococcus*-4

- **Necrotizing fasciitis** .. Wound infections .... Rapid and extensive necrosis subcutaneous tissues & fascia.. associated with Bacteremia, Endocarditis, Heart failure.. High fatality without antibiotics treatment.
- Blood sepsis.. meningitis .. endocarditis.. Rare Puerperal fever.. infected uterus after delivery.. blood sepsis
- Post streptococcal diseases:
- Rheumatic fever & Glomerulonephritis, followed repeat infection with Group A streptococcus.. Mostly Sore Throat .. developed in 1-3% of untreated infections.
- Both diseases and their pathology are not due to dissemination of bacteria, but to immunological reactions to **Group A streptococcal antigens**.. mainly Cell wall antigens & M-protein.



# Diagnosis & Treatment

- Lab Diagnosis: Culture.. Throat, Nose, Blood, Vagina, CSF. Definitive identification type of Hemolytic Strept. accomplished by using specific **antistreptococcal sera** by slide agglutination test.
- Detection Specific Antibodies: 2-4 weeks after throat or skin infection.. **Antistreptolysin O (ASO)** titer: > 240 IU, **positive Streptokinase** , **Anti-M Protein**
- Treatment: Clinical cases .. healthy Carrier.. Penicillin G / V.. Monthly injection in repeat infection
- Group A is still highly susceptible to Penicillins.. Less to Cephalosporins & Macrolides and other antibiotics
- No Vaccine is available

## *Corynebacterium diphtheriae*

- Sore Throat.. Intensive inflammation pharyngeal mucosa, Gray Pseudomembranous.. Release Diphtheria Exotoxin.. Spread to Heart muscle.. Myocarditis.. Peripheral nervous system/ Neuritis, Adrenal glands.. Laryngeal obstruction, Respiratory, Heart Failure.. Permanent Immunity by Vaccination.. Rapid diagnosis .. antibiotic treatment + Diphtheria Antitoxin
- Lab Diagnosis: Throat swab , Direct Smear not significant, Culture for *C. diphtheria*.. selective Tellurite Blood agar+ blood agar..Toxigenesity test
- **Vincet Angina / Trench Mouth**: Mixed infection.. Oral Normal flora..**Borrelia /Treponema vincenti/ Fusobacterium** ..Oral mucosa Lesions/Gingivitis.. Rare Throat-gingival ulceration....Swelling & Inflammation of Gum/Gingival mucosa.



# Gingivitis





# Neisseria meningitidis

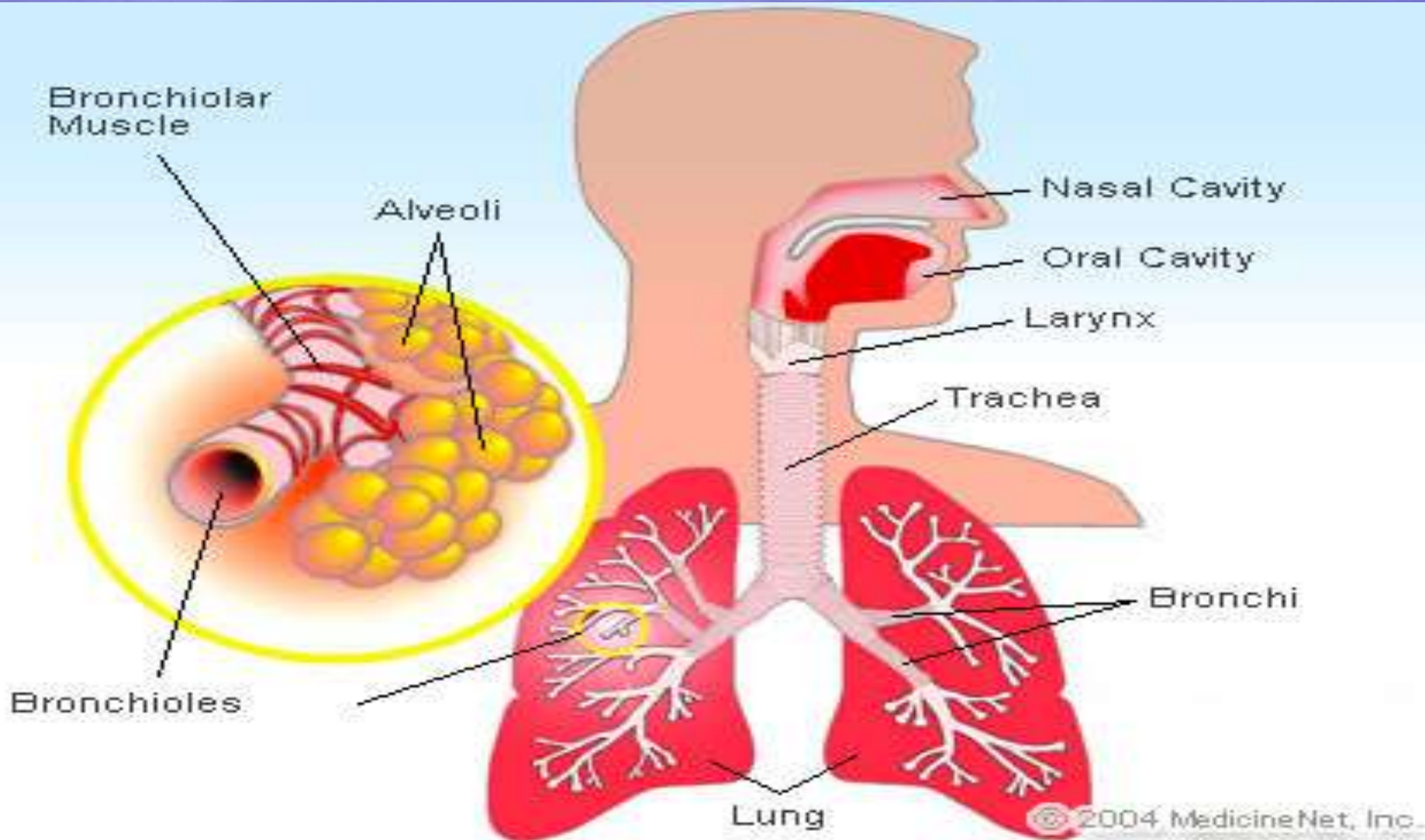
- Colonize only human nasopharynx mucosa.. Serotype A, B, C W-135, Endotoxin / Lipo-oligopolysaccharides.. **Epidemic meningitis**.. Mild Sore Throat, Meningococcal sepsis, Severe headaches, high fever, pain , stiffness of the neck, nausea, Haemorrhagic skin rash-lesions, Sever organ dysfunction, shock and diffuse intravascular coagulation .. Waterhouse-Friderichsen syndrome ..Haemorrhic adrenal glands..High mortality.. Specific Serotype Immunity.. Vaccine.
- Prompt diagnosis + antibiotic treatment..Contacts Prophylaxis
- Lab Diagnosis: 1-Direct gram-negative CSF.. Culture Throat swabs, blood, CSF.. Blood + Chocolate agar.  
2- Biochemical + Haematological investigation of CSF.. increased protein-decreased sugar levels.. numerous neutrophiles  
3- Detection *N. meningitidis* antigens in CSF

# Lower Bacterial Respiratory Infection

- Mostly endogenous source of Infection.. Opportunistic Organisms spread from the upper respiratory tract .. less commonly hematogenous spread to the lung parenchyma.
- A combination of factors ..including virulence of the infecting organism, status of the local defenses, and overall health of the patient may lead to bacterial pneumonia.
- The patient become more susceptible to infection by presence chronic lung disease.. Infant, Old age .. dysfunction of immune defense mechanisms.. Viral Respiratory infection..



# Lung Infections



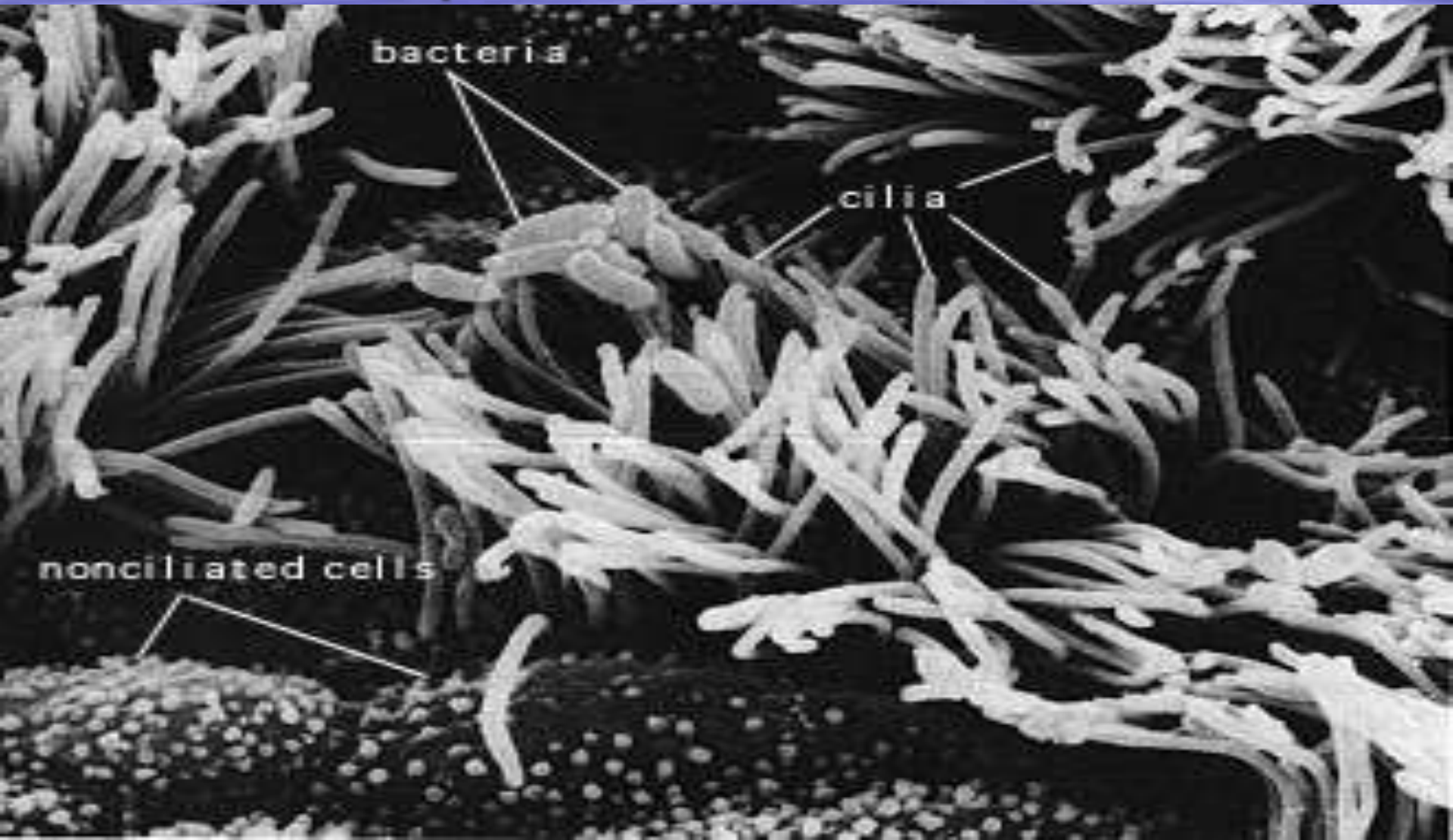


# Whooping cough & Bronchitis

*Bordetella pertussis* /*B. parapertussis*, Gram-negative bacilli, difficult to culture.. Release Endotoxin, Cytotoxins, Obstruction ciliated epithelium small Bronchi.. Pertussis toxin causes Lymphocytosis..

- **Clinical Features:** 1-Catarrhal stage..Mild Cough, Mild inflammation pharynx-Larynx, Low fever.. Few days.. 2-Paroxysmal cough.. Prolonged irritating Cough & mucus secretion, Fever, Cyanosis, Lung collapse, Convulsions, No Blood invasion.. Most infection Young Children.. Rare Adults..Community Outbreaks & single cases .
- Clinical Diagnosis..PCR detection bacterial DNA in nasopharyngeal swab, blood & Urine.. Specific antibodies..Prevention by vaccination.

# Bacteria attached to Ciliated epithelium cells





# Acute/Chronic bronchitis

- A clinical syndrome caused by inflammation trachea, swelling & irritation bronchi & bronchioles, Persistent cough.. Few sputum.. often associated with viral respiratory tract infection. Acute bronchitis is rarely a primary bacterial infection in healthy children.
- Adults Chronic bronchitis followed viral infections.. Associated with secondary Strept. pneumoniae, *H. influenzae*, *Group A Strept.*, *S. aureus*.. Complications: Asthma.. Rare Pneumonia



# Pneumonia

- Pneumonia is an inflammation of the lungs..Sputum.. Many different opportunistic organisms including Bacteria, Viruses, Fungi.
- Pneumonia is a common illness that affects millions of people each year worldwide.. Associated with high fatality..Intensive Care..Use Respiratory Equipments.
- The symptoms of pneumonia range **mild severe-fatal**. The severity depends on the type of organism, Patient's Age, Health condition & general immunity.
- Severe pneumonia: Lung Inflammation, fluid buildup, Purulent sputum.. containing pus / blood.. High Fever, Malaise, Nausea, Vomiting, Rapid respiration/ Breath shortness Increased heart beats, Mental confusion.

# Bacterial Causes of Pneumonia

- Pneumonia may be further categorized into community-acquired pneumonia (CAP), or hospital-acquired pneumonia (HAP)..Respiratory Equipment.
- CAP ..caused mostly by Strep. pneumoniae and followed viral infection in children ..Elderly patients
- HAP.. Caused by Gram-ve *P. aeruginosa*, *Klebsiella pneumonia*, ***Acinetobacter baumannii*** ..Less by *Haemophilus influenzae type b*, *Staphylococcus aureus* or others..May associated with blood sepsis.
- Both produce productive bloody or rust-colored sputum.. green sputum.. High fever.. Fatal without antibiotic & Supportive treatment.



# Streptococcus pneumoniae

- 90 Capsular Serotypes.. Common Healthy Carriers.. normally found in the nasopharynx of **5-10% of healthy adults**.. **20-40% of healthy children**
- Several virulence factors: polysaccharide Capsule & Pneumolysins (invasion) .. Both resist phagocytosis & host's immune system.. inhibit activation of complement.. IgA1 .. Proteases destroy mucosa secretory IgA
- **Strept. Pneumoniae** begins as intrapulmonary abscess.. Lung necrosis.. Can be associated with **Empyem** (inflammatory fluid and bacterial debris accumulate in the pleural cavity).
- **Strept. Pneumoniae** often causes blood sepsis, Meningitis, Sinusitis, Otitis Media in young children.



# Strept. pneumoniae & Viridans Streptococci Group



# Lab Dignosis

- *S. pneumoniae* can be differentiated from *S. viridans*, which is also alpha hemolytic, using an Optochin/bile soubility test on Blood agar..Gram-positive diplococcus.
- Up 80% *S. pneumoniae* are R-Penicillin in Jordan & other country.
- Treatment: Amoxycillin-clavulanate, Macrolides (Azithromycin, clarithromycin), Fluoroquinolones (Levofloxacin, ciprofloxacin).. For Bateremia +meningitis..vancomycin,ceftriaxone/cefotaxime
- Prevention: (Pneumovax) Polysaccharide vaccine.. 23-valent strains ..85% protection in those under 55 years of age..five years or longer.. Less for older.. For children there is 7-valent strains vaccine up 80% protection.



# Atypical Pneumonia

- Atypical pneumonia caused by Mycoplasma and Chlamydia, Legionella.. These related to Gram-ve bacteria.. Attached to respiratory mucosa..Not common part of Respiratory flora..Opportunistic pathogens
- Causing mostly milder forms of pneumonia .. characterized by slow development of symptoms unlike other forms of pneumonia which can develop more quickly .. more severe early symptoms.
- M. pneumoniae : The smallest size Bacteria ..Lack Cell Wall.. Lipid bi-layer Membrane.. Aerobic Growth, Respiratory /Urinary Mucosa.. Various Mycoplasma spp. Associated with disease.. Human, Animals, Birds

# Mycoplasma

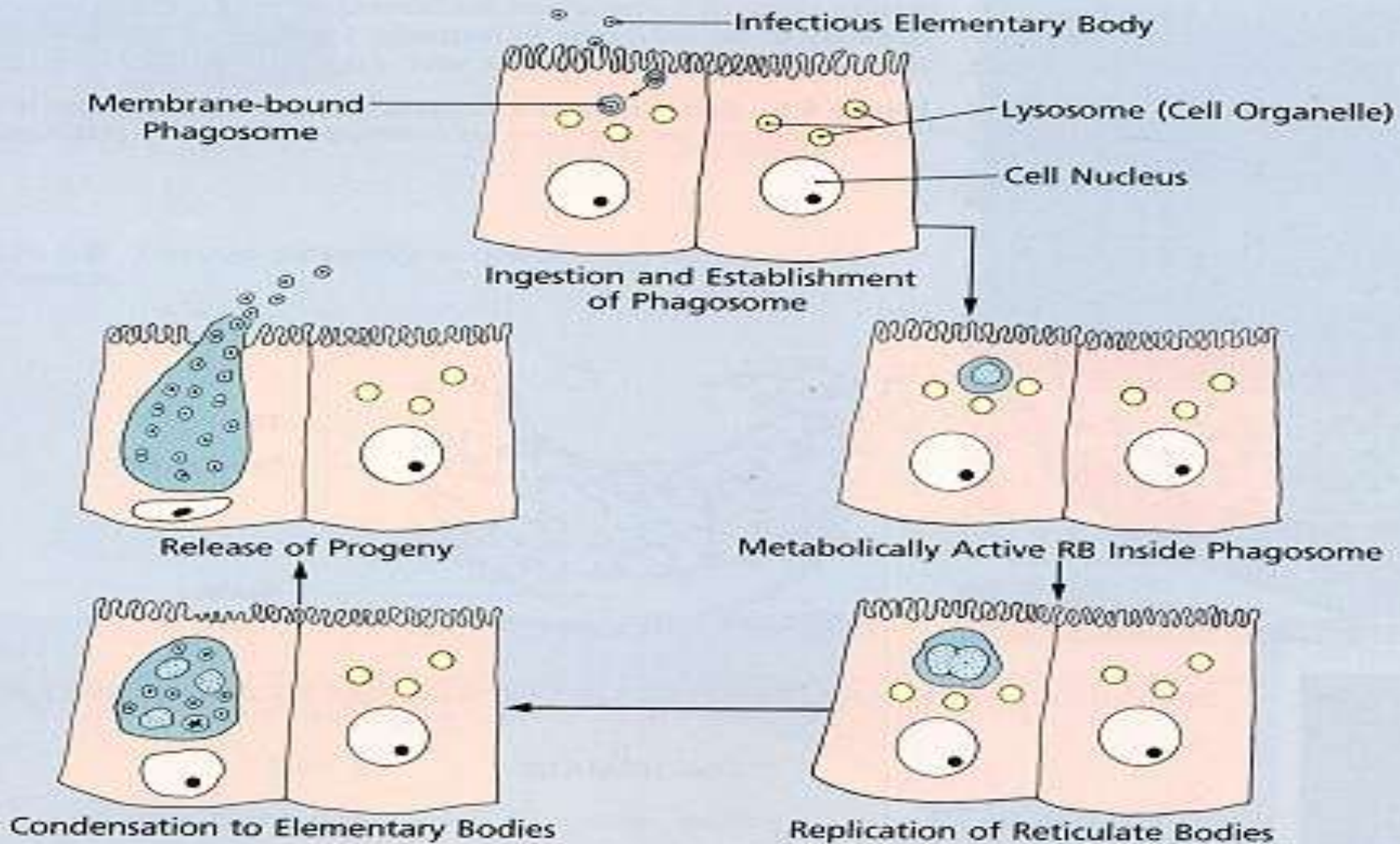
- M. pneumoniae ..spread by droplet infection.. often develop Low fever & dry cough symptoms ..few days-weeks.. anemia, rashes, neurological syndromes..meningitis, encephalitis.
- Acute/ Subacute Pharyngitis.. Bronchitis.. Common Infection in Fall-Winter.. Mostly Old children & Jung Adults.
- Severe forms of M pneumonia have been described in all age groups.
- Lab Diagnosis: Special culture medium.. PCR.. Sputum, Pleural fluid, Blood. Serological Cold-Agglutination Test.. Increased antibody titers.
- Treatment: levofloxacin, moxifloxacin, Macrolides/ Azithromycin.. No Vaccine



# Chlamydia species

- **Chlamydia.. Attached** human mucosal membrane.. ..obligate intracellular.. intracytoplasmic inclusions..Rapidly killed outside body, dryness & high temperature > 4 C.
- **Live cycle:** Infectious elementary bodies attached to the host mucosa and promoting its entry.. Cytoplasm phagosome.. producing reticulate bodies in inclusion.. released elementary bodies..
- **Chlamydia trachomatis..Serotypes C ,K** : Common cause of sexually transmitted disease (STD) Nonspecific urethritis.. mother to newborn babies..maternal fluid.. Atypical pneumonia..Eye infection..**Ophthalmia neonatorum**
- About half of all newborns with Chlamydial pneumonia develop inclusion conjunctivitis.. 1-2 weeks starts mild - severe eyes redness, swollen eyelids, inflammation & yellow thick discharge eyes.
- A & C serotypes of endemic *Ch. trachomatis* cause **Trachoma..** conjunctival scarring, damage eyelids & Cornea.. blindness.

# Chlamydia Life Cycle





# Chlamydial Pneumonia

- C. pneumoniae: droplets infection.. Infants/children often develops gradually.. several weeks mild respiratory symptoms, dry irritating prolonged cough.. nasal congestion.. with/without fever.. Few weeks.. No blood sepsis.
- *C. pneumoniae* infections in adults.. often asymptomatic, mild, May include sore throat, headache, fever, dry cough.
- Clusters of infection have been reported more common in Children than Adults.
- Diagnosis & treatment: Sputum, throat-nasal swab.. MaCoy Cell Culture, ELISA Specific antibodies, PCR.
- Treatment: Tetracyclines, Macrolides, levofloxacin, moxifloxacin .. No Vaccine

# *Chlamydia Psittaci*

- *C. psittaci* causes Zoonotic diseases.. Human infection followed contact with birds (parrots, pigeons, turkeys, and ducks).. A rare human disease called **psittacosis (ornithosis)**.
- Humans respiratory tract can be infected via inhalation bacteria shed from feathers, secretions, and droppings localized inflammation in Bronchi & lung tissues.
- Signs Symptoms: Starts mild..flu-like & ended with severe disease including fatal pneumonia, associated high fever, dry cough, headache.
- Diagnosis & Treatment similar to other Chlamydia.



# Legionella pneumophila

- **Legionella** carry flagella, Pathogenic-Nonpathogenic spp. often found in natural aquatic bodies and wet soil. Facultative Anaerobes Growth in Cold/Hot (4- 80C) Water.. Transmitted, Inhalation via Air Condition, Wet Soil.. Cause outbreak of disease.
- Lung Mucosa..multiply intracellular within the macrophages.. High Fever .. Incub. period 2-10 days .. Nonproductive /Productive dry cough.. Shortness of breath, Chest pain, Muscle aches, Joint pain, Diarrhea, Renal Failure, higher mortality rate. Legionnaires' disease is not contagious
- Risk factors include heavy cigarette smoking, Old age underlying diseases such as **renal failure, cancer, diabetes,** or chronic obstructive pulmonary, suppressed immune systems, corticosteroid.
- Diagnosis & treatment: Special Culture Media, blood/urine specimen for detection Specific antibodies or Antigens by PCR, or EISA .. Macrolides (azithromycin), levofloxacin, moxifloxacin .. No Vaccine.