

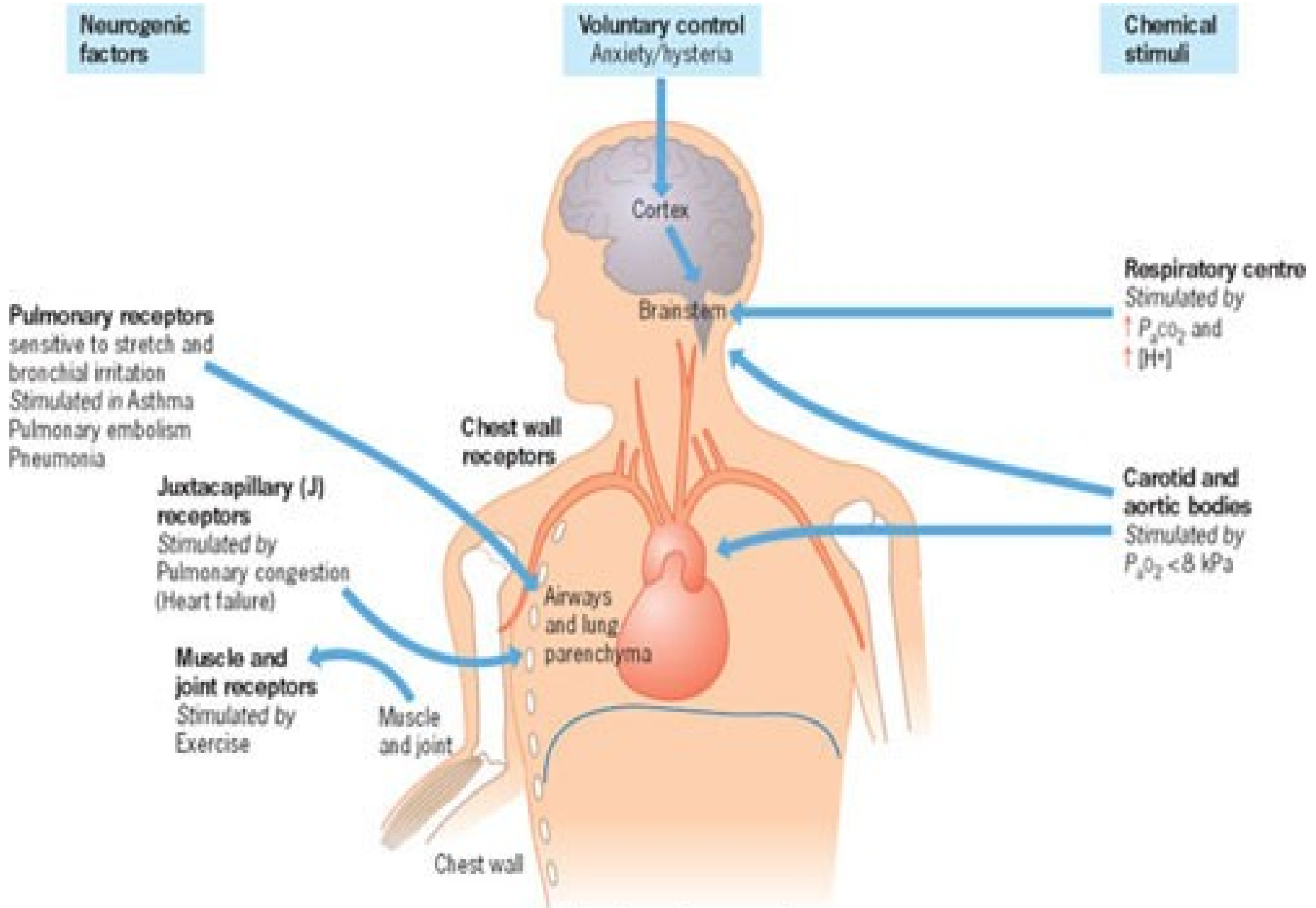
Respiratory system & Lung diseases

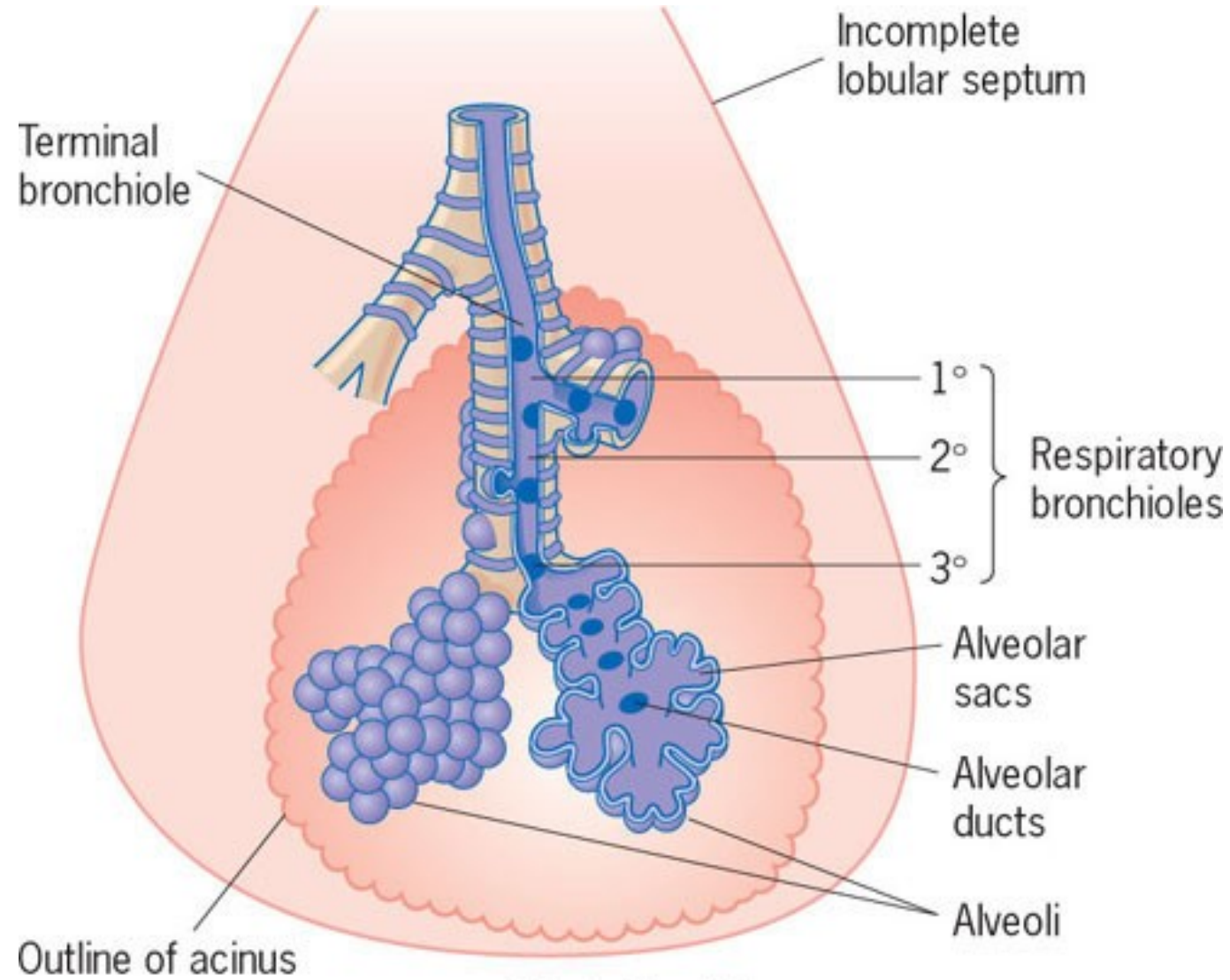
Points

- **Ventilation**
- **Diffusion**
- **Perfusion**

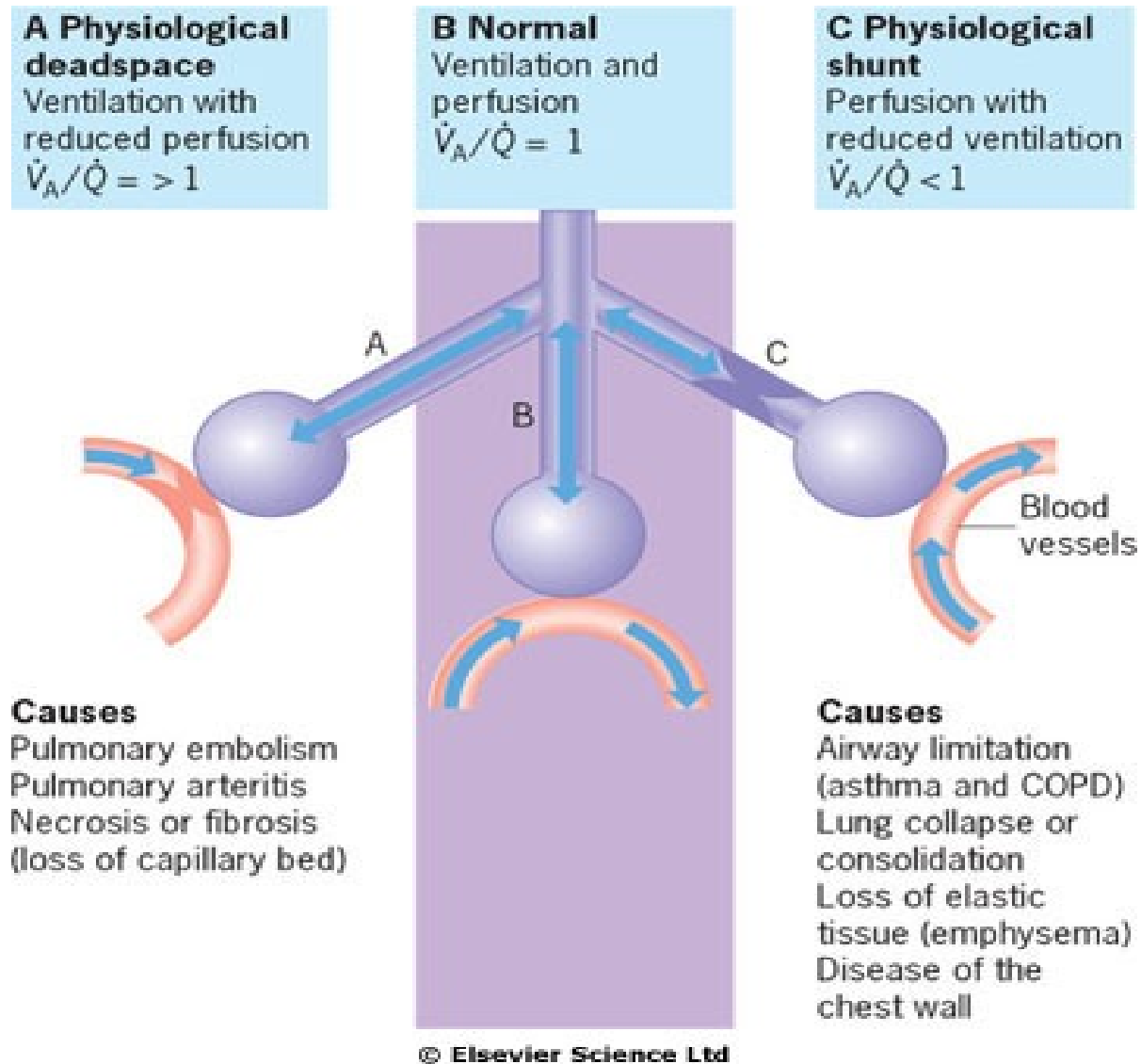
Breathing

- Lung ventilation can be considered in two parts:
- the mechanical process of inspiration and expiration
- the control of respiration to a level appropriate for the metabolic needs.





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Lung Volume Patterns

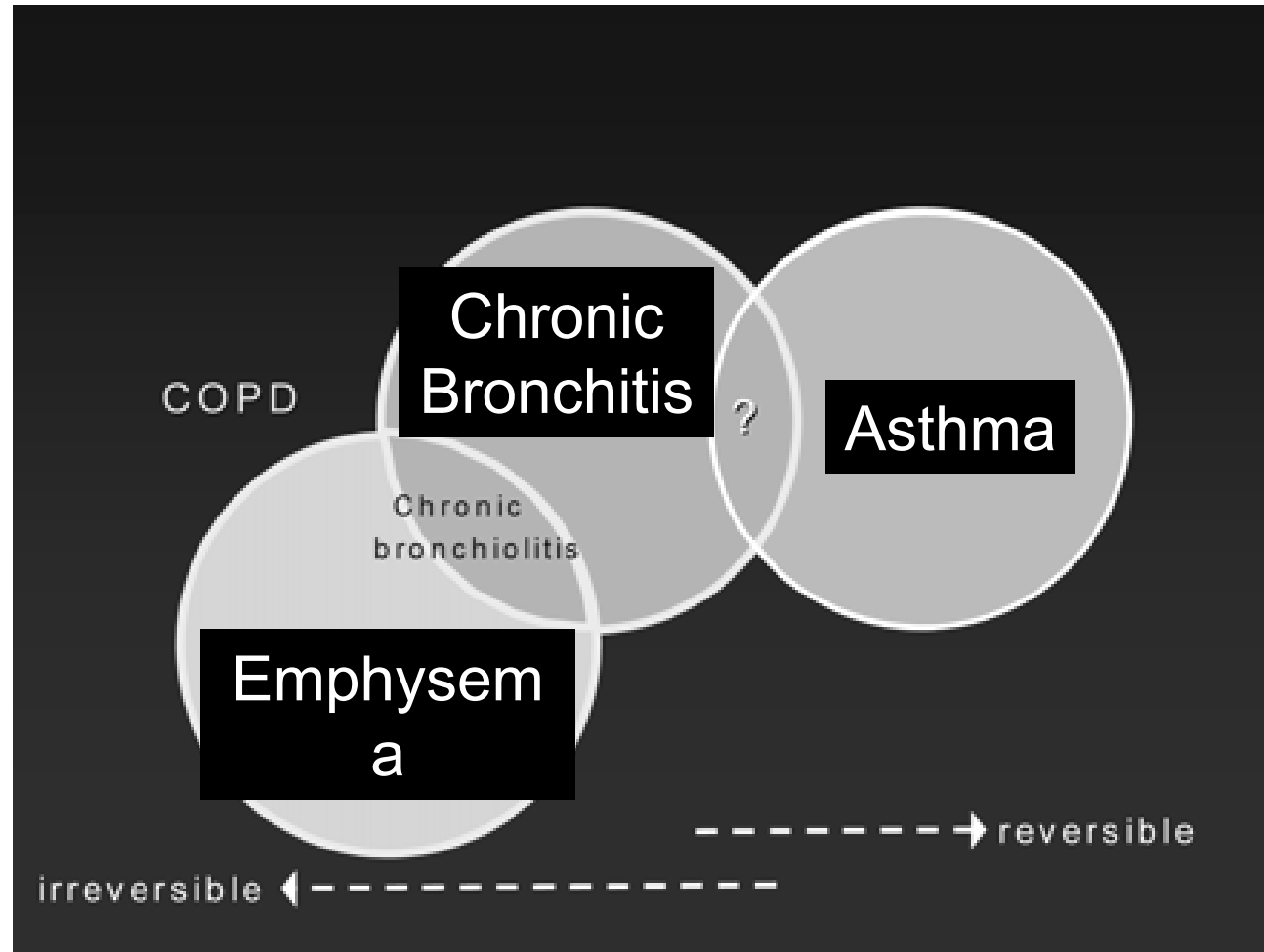
- **Obstructive Disease:** Characterized by hyperinflation and gas trapping (increased TLC and RV/TLC)
 - asthma, chronic COPD (bronchitis, emphysema)
- **Restrictive Disease:** Characterized by generalized reduction in lung volume (decreased TLC, RV and FRC)
 - interstitial lung diseases (pulmonary fibrosis, sarcoidosis), pneumothorax, lung resection

Obstructive pulmonary diseases

- They are characterized by airway obstruction that is worse with expiration.
- Either more force (i.e., use of accessory muscles of expiration) is required to expire a given volume of air or emptying of the lungs is slowed or both.
- The unifying symptom of obstructive disease is **dyspnea**, the unifying sign is **wheezing**.

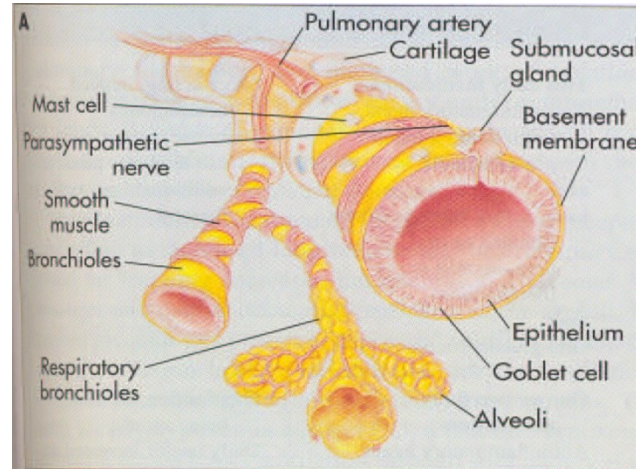
- The most common obstructive diseases are **asthma**, **chronic bronchitis** and **emphysema**.
- Because many individuals have both bronchitis and emphysema, they are often called **COPD**

Spectrum of Obstructive Lung Disease Syndromes

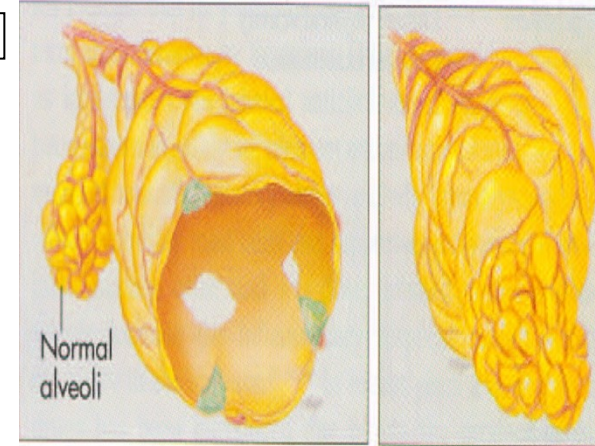


Airway obstruction caused by emphysema, chronic bronchitis, and asthma

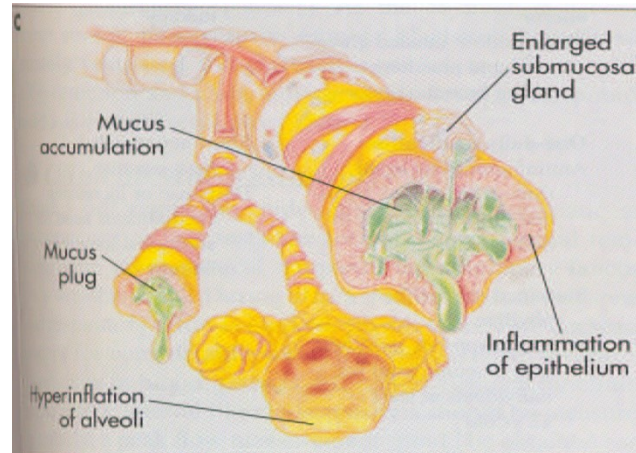
Normal lung



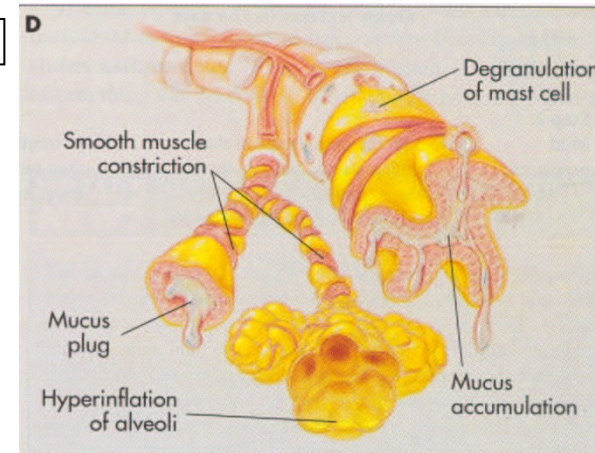
Emphysema



Bronchitis



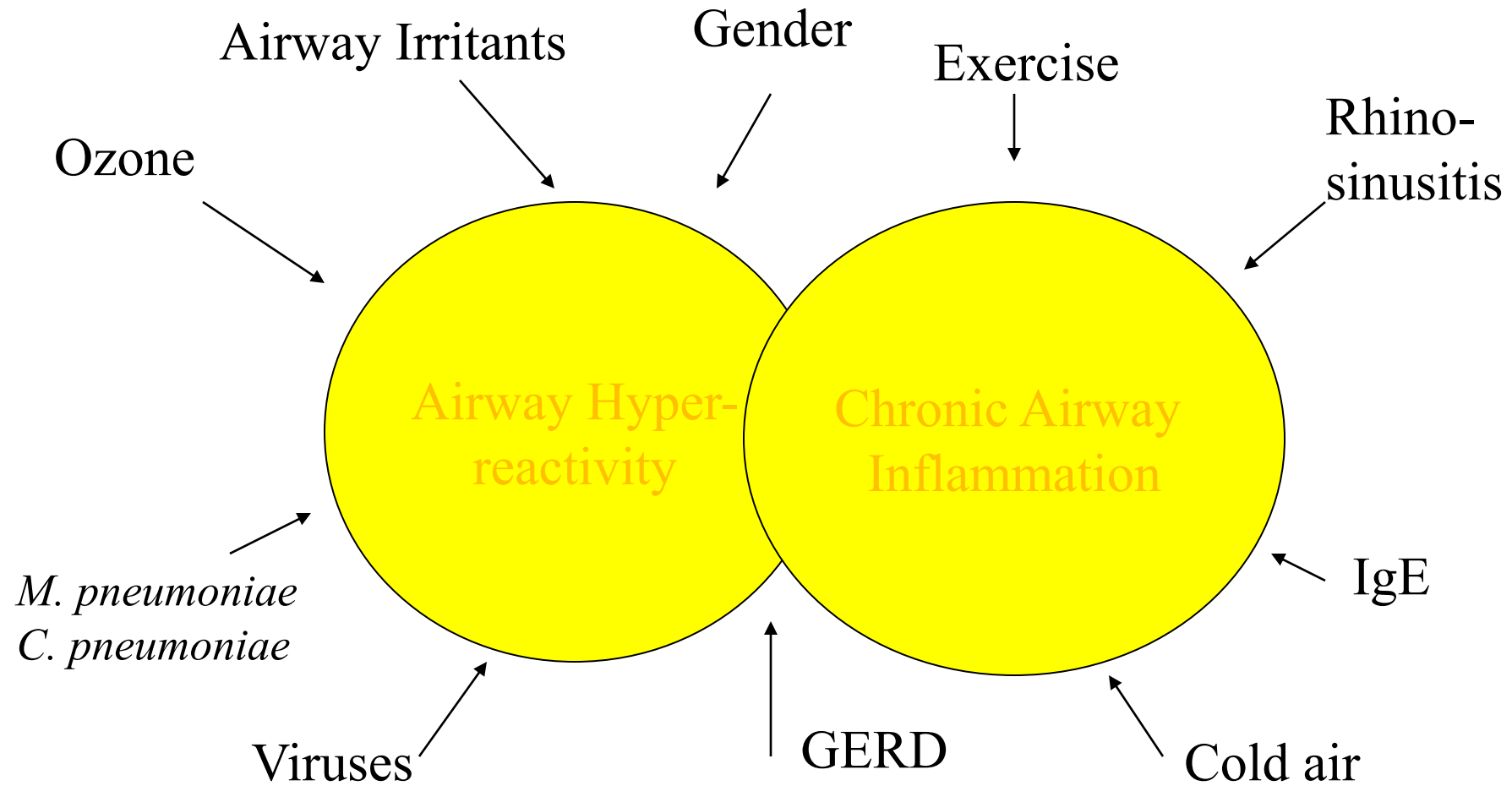
Asthma



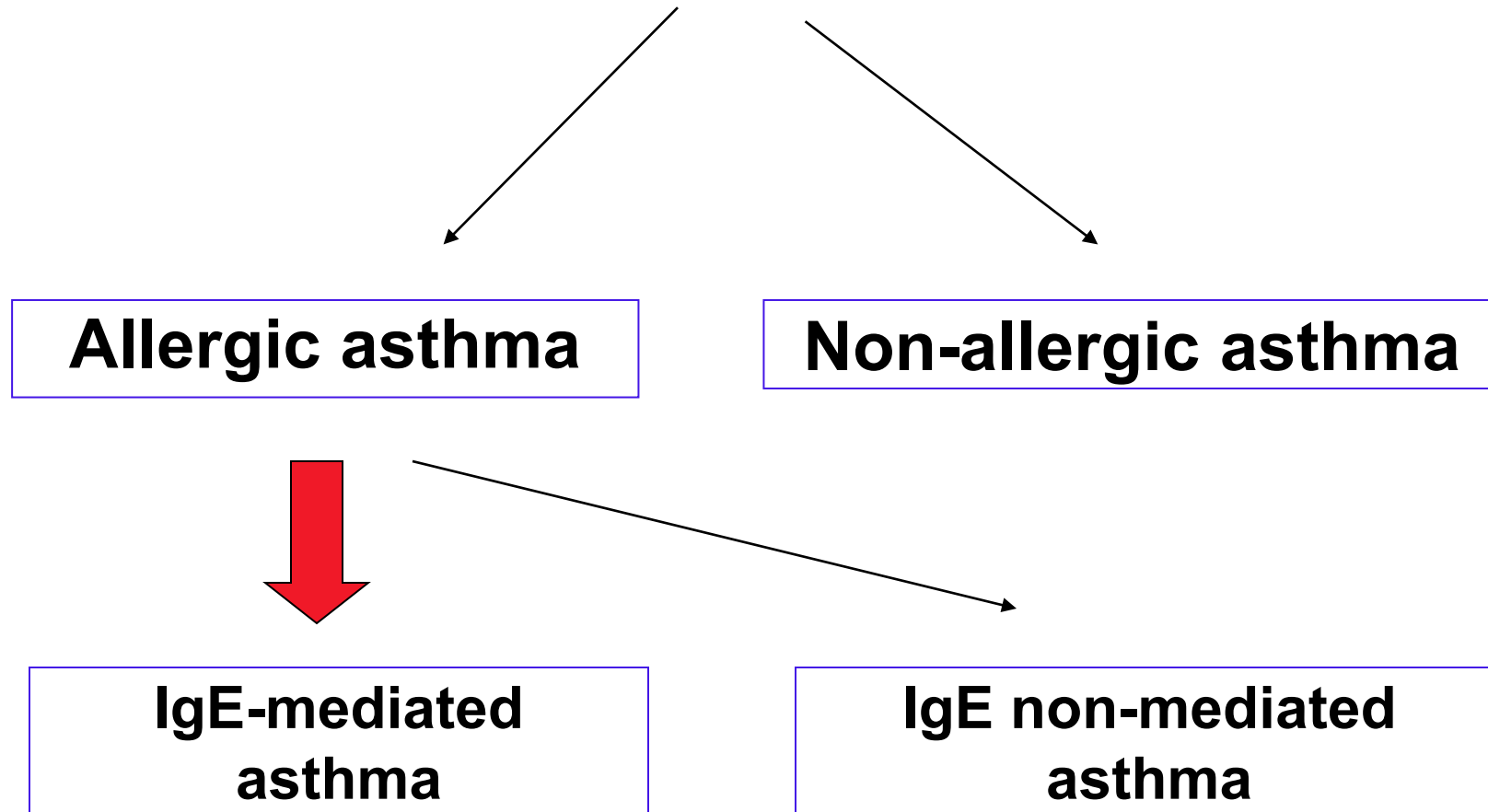
Asthma bronchiale

- **Asthma is a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role.**
- **The chronic inflammation causes an associated increase in airway hyperresponsiveness that leads to recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night or in the early morning.**
- **These episodes are usually associated with widespread but variable airway obstruction that is often reversible either spontaneously or with treatment.**

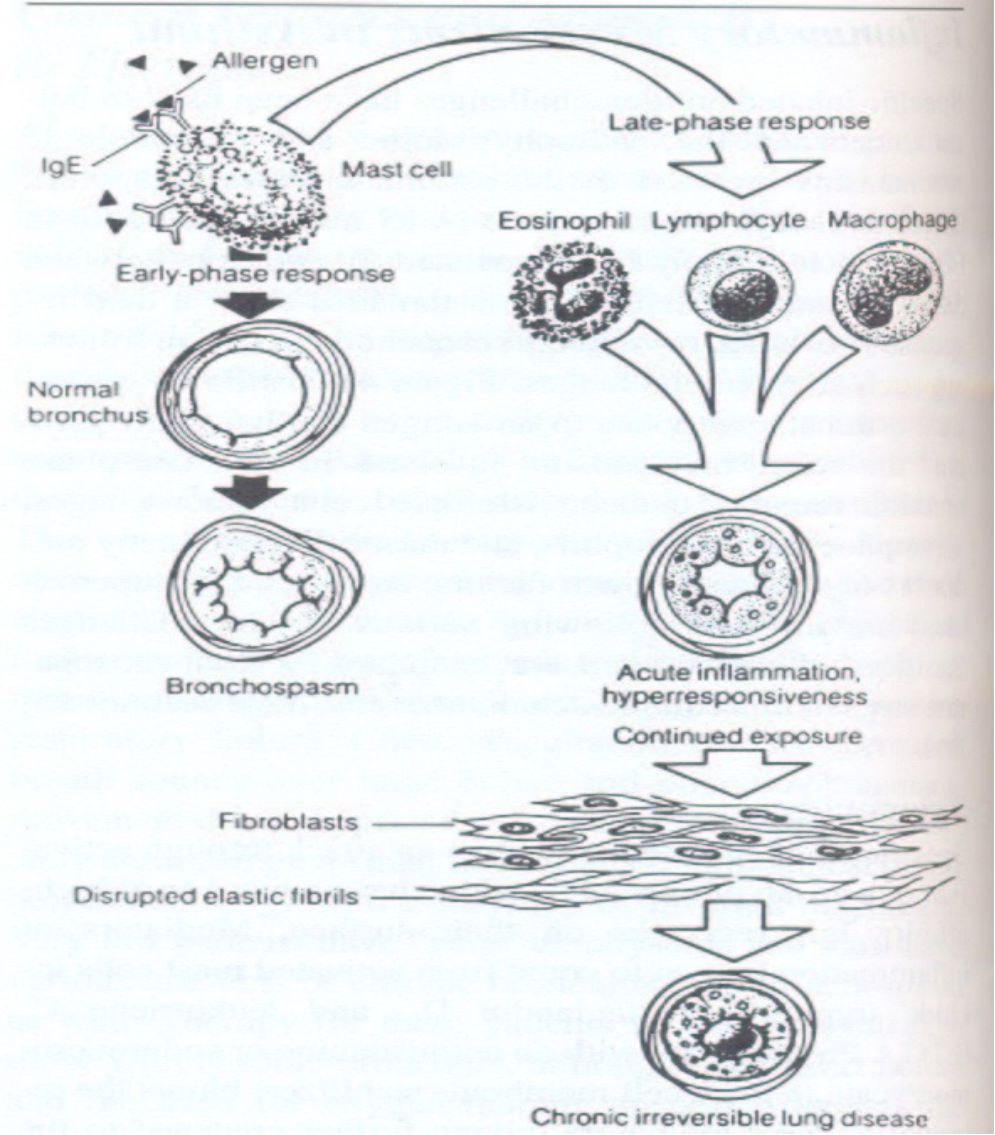
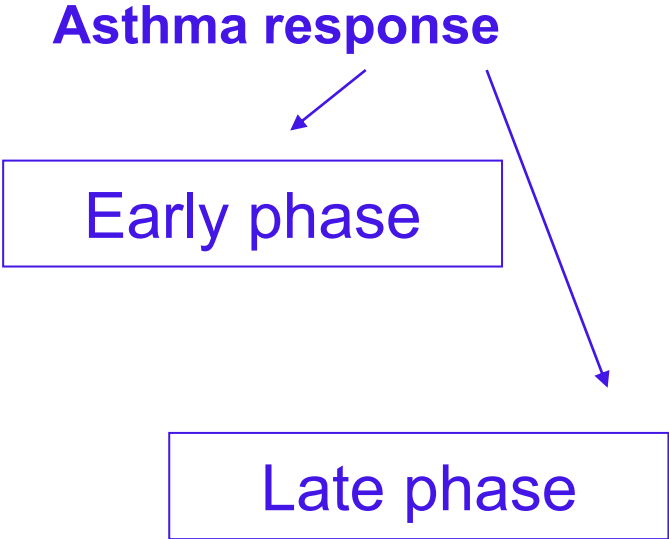
Asthma Pathogenesis

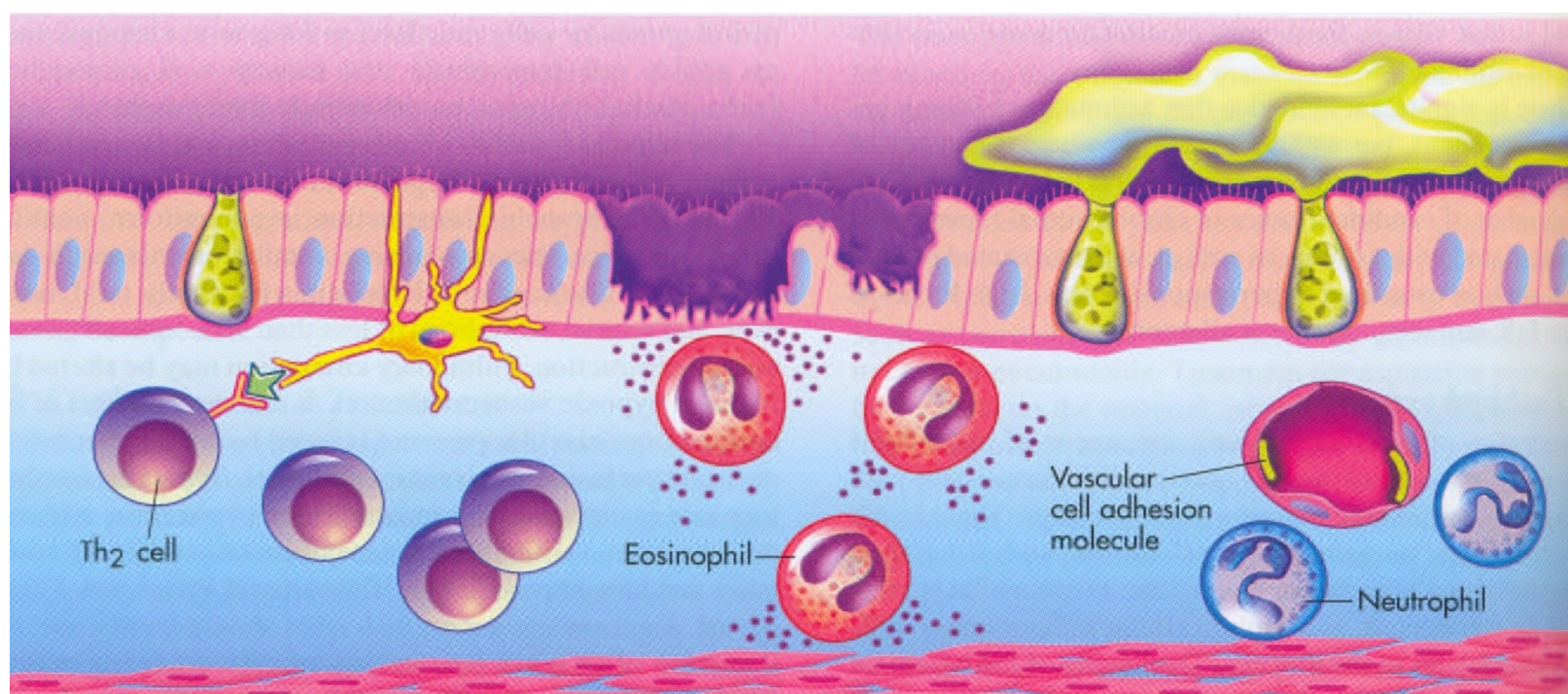
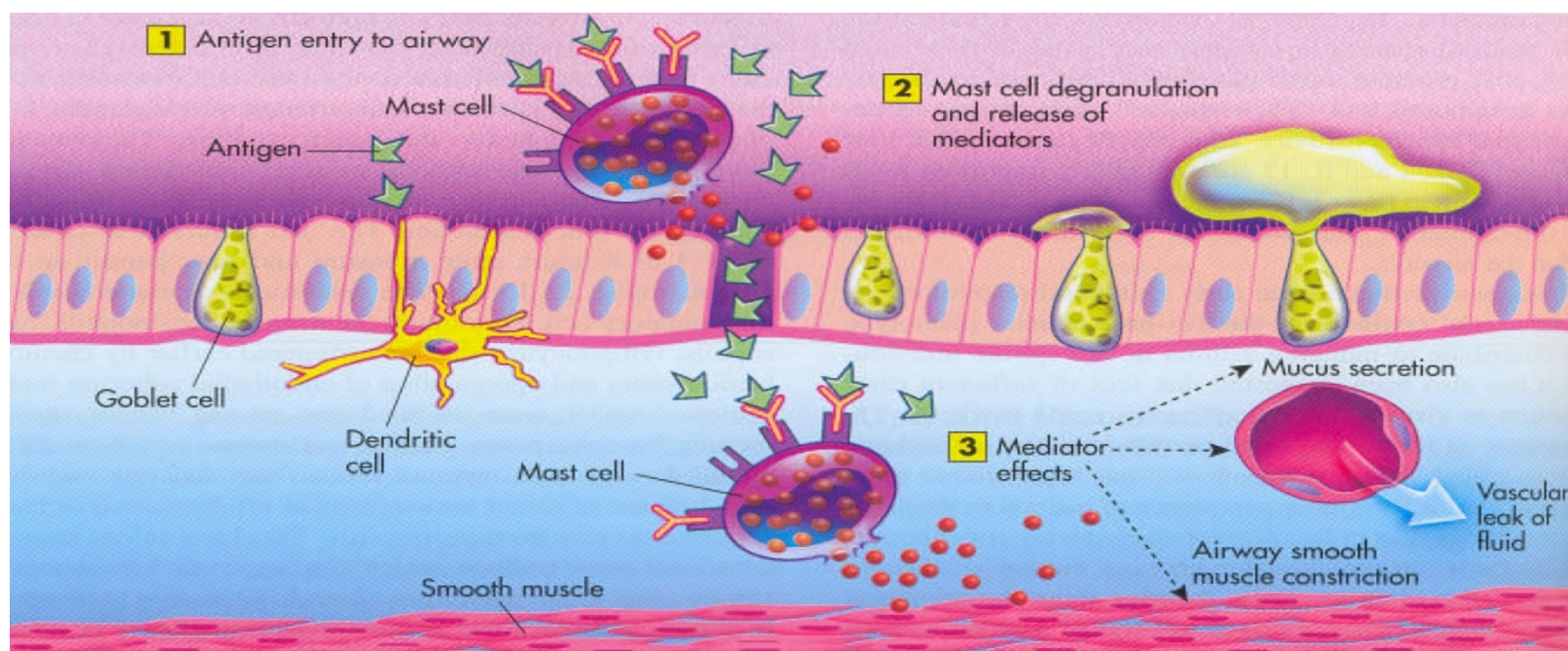


Types of asthma



Allergic asthma





Asthma classification based on severity

- Mild intermittent
- Mild persistent
- Moderate persistent
- Severe persistent

Determining Asthma Severity

	Symptoms Daytime	Symptoms Nocturnal	<u>FEV₁</u> PEFR Variability
Severe Persistent	Continuous	> 2 nights/wk	<u><60% pred</u> >30%
Moderate Persistent	Daily	1 or 2 nights/wk	<u>60-80% pred</u> >30%
Mild Persistent	>2 days/wk	> 2 nights/mo	<u>>80% pred</u> 20-30%
Mild Intermittent	<2 days/wk	< 2 nights/mo	<u>>80 % pred</u> <20 %

Asthma – clinical manifestations

During full remission

- Individuals are asymptomatic and pulmonary function tests are normal.

During partial remission

There are no clinical symptoms but pulmonary function tests are abnormal

During attacks

- Individuals are dyspneic and respiratory effort is marked
- Breath sounds are decreased except for considerable wheezing, dyspnea, non-productive coughing, tachycardia and tachypnea occur

Asthma - pulmonary function

- Spirometry shows decreases in expiratory flow rate, forced expiratory volume (FEV), and forced vital capacity (FVC)
- FRC and total lung capacity (TLC) are increased.
- Blood gas analysis shows hypoxemia with early respiratory alkalosis or late respiratory acidosis.

Treatment

Goals:

- To reverse of acute attacks
- To control recurrent attacks
- To reduce bronchial inflammation and the associated hyperreactivity
- + elimination of allergens (if it is possible)

Drugs:

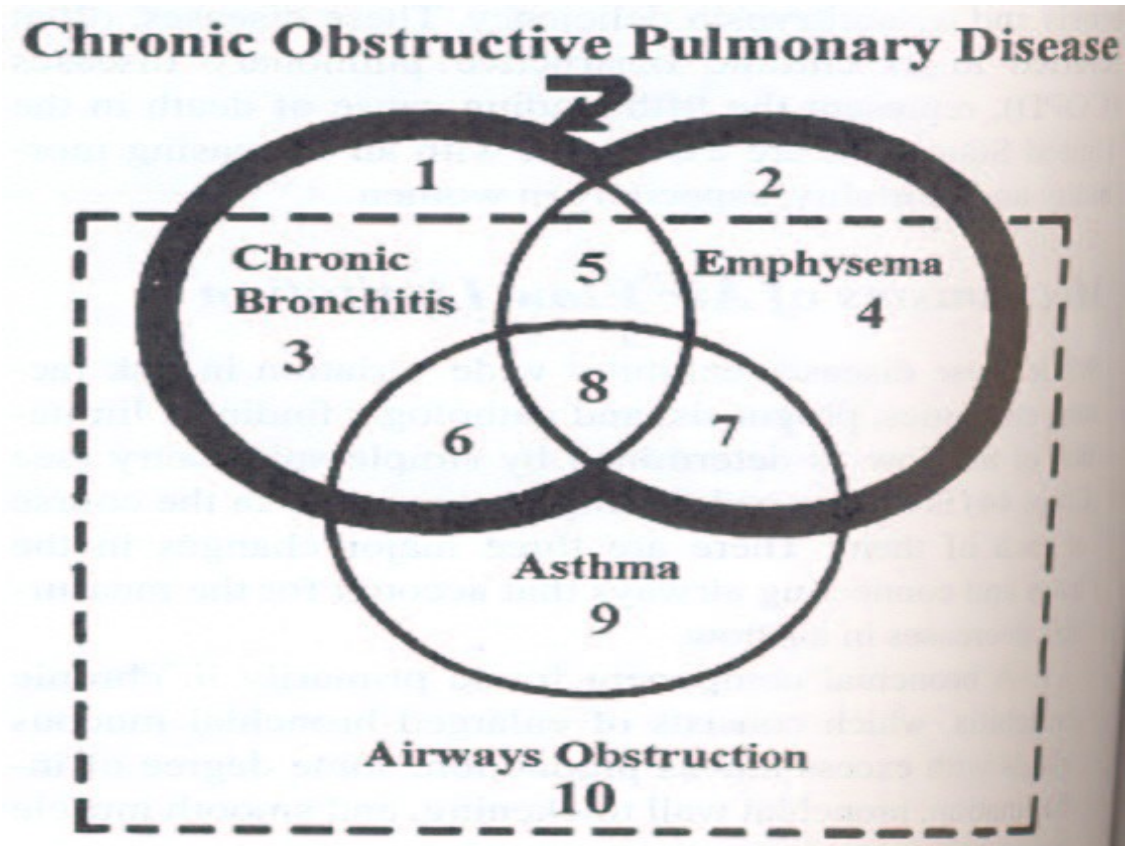
- Allergen's immunotherapy
- Bronchodilator (Beta agonists, Anticholinergic agents, Theophylline)
- Immunosuppressant (corticosteroids)
- Others (Leukotriene modifiers, antihistamine, e.g.)

Chronic obstructive pulmonary disease (COPD)

- ❑ **COPD is defined as pathologic lung changes consistent with emphysema or chronic bronchitis.**
- ❑ **It is syndrome characterized by abnormal tests of expiratory airflow that do not change markedly over time, and without a reversible response to pharmacological agents.**

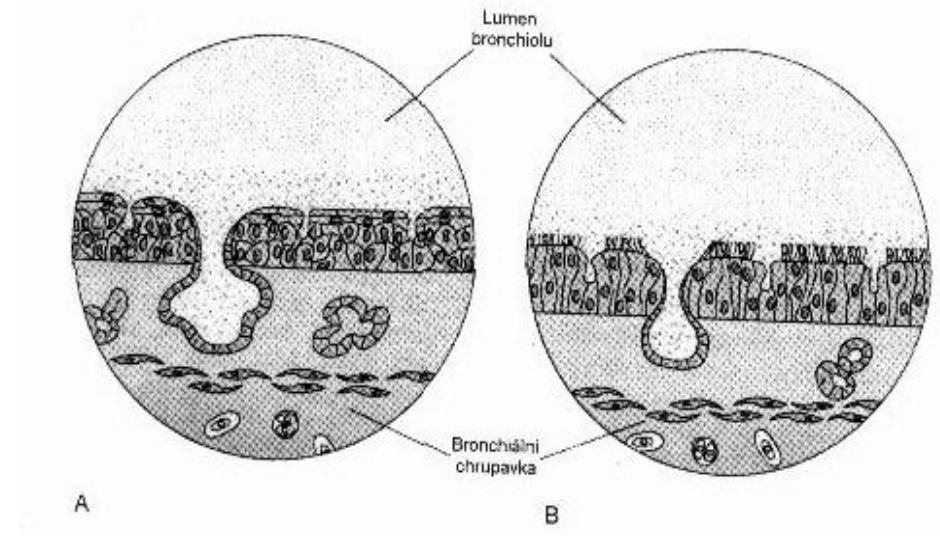
- ❑ **5-20% adult population**
- ❑ **Most frequently in men**
- ❑ **The fifth leading cause of death**

The complex, heterogenous overlapping of the three primary diagnoses include under diseases of air flow limitation is present on the next picture:



1. Chronic bronchitis

- ❑ **Chronic bronchitis is defined as hypersecretion of mucus and chronic productive cough that continues for at least 3 months of years for at least 2 consecutive years.**
- ❑ **Incidence is increased in smokers (up to twentyfold) and even more so in workers exposed to air pollution.**
- ❑ **It is a major health problem for the elderly population. Repeated infections are common.**



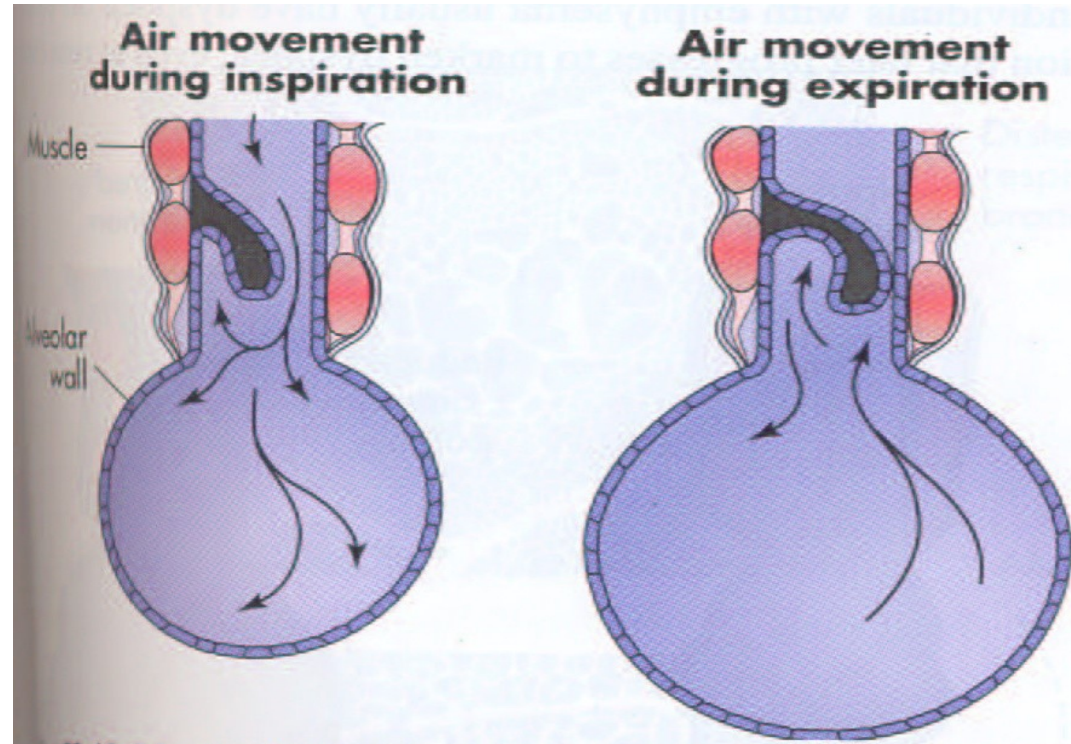
Chronic bronchitis - etiology

- It is primarily caused by **cigarette smoke**, both active and passive smoking have been implicated
- Other risk factors:
 - **profesional exposition**
 - **air pollution**
 - **repeated infections of airways**
 - **genetics**

Chronic bronchitis - morphology

- **Inspired irritants not only increase mucus production but also increase the size and number of mucous glands and goblet cells in airway epithelium**
- **The mucus produced is thicker and more tenacious than normal. This sticky mucus coating makes it much more likely that bacteria, such as H. influenzae and S. pneumoniae, will become embedded in the airway secretions, there they reproduce rapidly.**
- **Ciliary function is impaired, reducing mucus clearance further. The lung's defense mechanisms are therefore compromised, increasing susceptibility to pulmonary infection and injury.**
- **The bronchial walls become inflamed and thickened from edema and accumulation of inflammatory cells.**

- Initially chronic bronchitis affects only the larger bronchi, but eventually all airways are involved.
- The thick mucus and hypertrophied bronchial smooth muscle obstruct the airways and lead to closure, particularly during expiration, when the airways are narrowed.
- The airways collapse early in expiration, trapping gas in the distal portions of the lung.
- Obstruction eventually leads to ventilation-perfusion mismatch, hypoventilation (increased PaCO₂) and hypoxemia.



Chronic bronchitis – clinical manifestations

- Individuals usually have a productive cough („smoker’s cough“) and evidence of airway obstruction is shown by spirometry
- **Bronchitis patients** are often described as „**blue bloaters**“ due to their tendency to exhibit both hypoxemia and right heart failure with peripheral edema in spite of only moderate obstructive changes on pulmonary functional tests.
- **Acute episodes** (e.g. after infection) result in marked hypoxemia that leads to **polycythemia and cyanosis (blueness)** associated with an increase in pulmonary artery pressure, impairing right ventricular function, and significant jugular venous distension and ankle edema (bloating)

Table 32-4**Clinical Manifestations of Chronic Obstructive Lung Disease**

Clinical Manifestations	Bronchitis	Emphysema
Productive cough	Classic sign	Late in course with infection
Dyspnea	Late in course	Common
Wheezing	Intermittent	Minimal
History of smoking	Common	Common
Barrel chest	Occasionally	Classic
Prolonged expiration	Always present	Always present
Cyanosis	Common	Uncommon
Chronic hypoventilation	Common	Late in course
Polycythemia	Common	Late in course
Cor pulmonale	Common	Late in course

Chronic bronchitis – evaluation and treatment

- Diagnosis is made on the basis of physical examination, chest radiograph, pulmonary function tests and blood gas analyses.
- The **best „treatment“** is **prevention**, because pathological changes are not reversible.
- If the individuals **stops smoking**, disease progression can be halted
- **Therapy:**
 - bronchodilators
 - expectorans
 - chest physical therapy
 - steroids
 - antibiotics

Chronic bronchitis: low-flow oxygen therapy

- It is administered with care to individuals with severe hypoxemia and CO₂ retention
- Because of the chronic elevation of PaCO₂, the central chemoreceptors no longer act as the primary stimulus for breathing.
- This role is taken over by the peripheral chemoreceptors, which are sensitive to changes in PaO₂.
- Peripheral chemoreceptors do not stimulate breathing if the PaO₂ is much more than 60 mmHg.
- Therefore, if oxygen therapy causes PaO₂ to exceed 60 mmHg, the stimulus to breathe is lost, PaCO₂ increases, and apnea results.
- If inadequate oxygenation cannot be achieved without resulting in respiratory depression, the individual must be mechanically ventilated)

2. Emphysema

- It is abnormal permanent enlargement of gas-exchange airways (acini) accompanied by destruction of alveolar walls and without obvious fibrosis.
- In emphysema, obstruction results from changes in lung tissues, rather than mucus production and inflammation, as in chronic bronchitis.
- The major mechanism of airflow limitation is loss of elastic recoil.

Types of emphysema

□ Three distinctive types of alveolar destruction have been described, according to the portion of the acinus first involved with disease:

1) Centrilobular (centriacinar):

- septal destruction occurs in the respiratory bronchioles and alveolar ducts, usually in the upper lobes of the lung. The alveolar sac (alveoli distal to the respiratory bronchiole) remains intact. It tends to occur in smokers with chronic bronchitis.

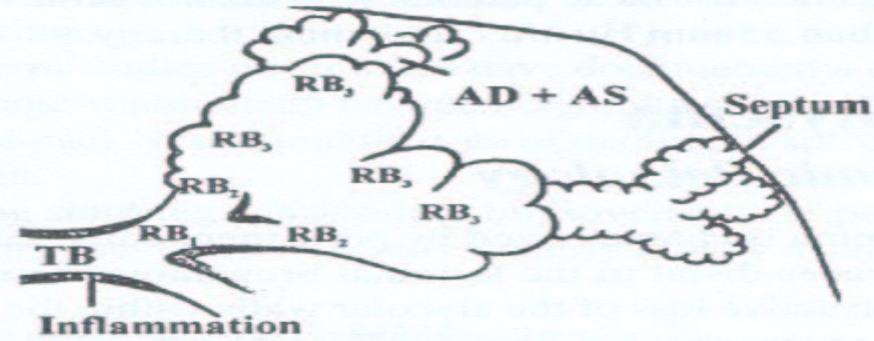
2) Panacinar (panlobular):

- It involves the entire acinus with damage more randomly distributed and involving the lower lobes of the lung. It tends to occur in patients with α 1-antitrypsin deficiency.

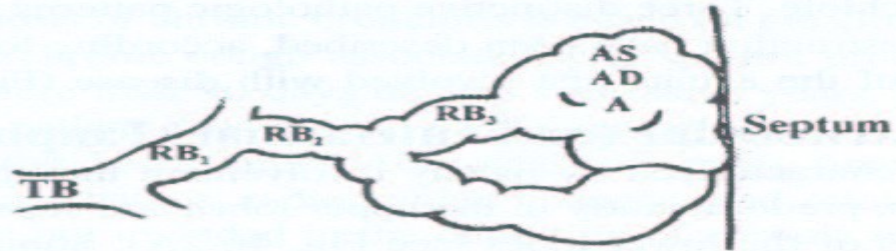
3) Distal acinar (subpleural):

- It is typically seen in a young adult with a history of a spontaneous pneumothorax.

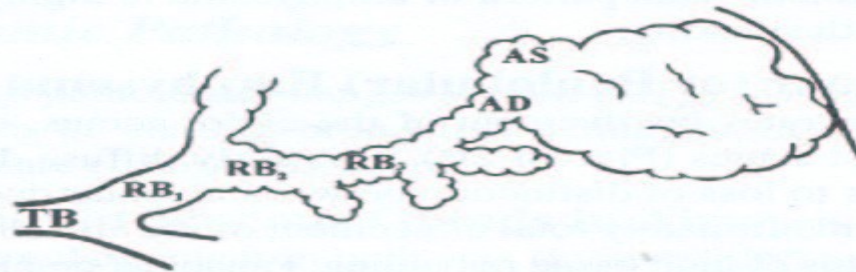
A. Centrilobular Emphysema



B. Panacinar Emphysema



C. Distal Acinar Emphysema



Types of emphysema

– Primary emphysema:

- it is commonly linked to an inherited **deficiency of the enzyme α 1-antitrypsin** that is a major component of α 1-globulin, a plasma protein.
- Normally it inhibits the action of many proteolytic enzymes.
- Individuals with deficiency of this enzyme (AR) have an increased likelihood of developing emphysema because proteolysis in lung tissues is not inhibited.

– Secondary emphysema:

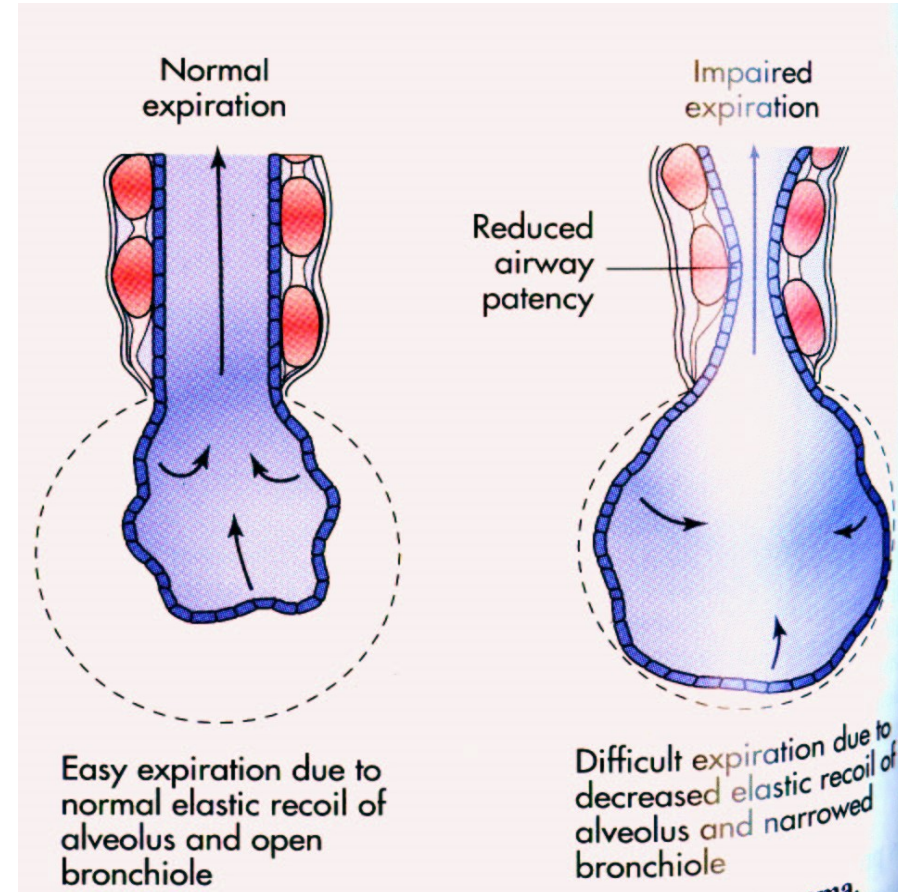
- It is also caused by an inability of the body to inhibit proteolytic enzymes in the lung. It results from an insult to the lungs from **inhaled toxins**, such as **cigarette smoke** and **air pollution**.

Pathophysiology of emphysema

- Emphysema begins with **destruction of alveolar septa**
- It is postulated that inhaled oxidants, such as those in cigarette smoke and air pollution, tip the normal balance of elastases (proteolytic enzymes) and antielastases (such as α 1-antitrypsin) such that elastin is destroyed at an increased rate
- **Expiration becomes difficult** because loss of elastic recoil reduces the volume of air that can be expired passively.
- **Hyperinflation of alveoli** causes large air spaces (bullae) and air spaces adjacent to pleura (blebs) to develop.
- The combination of increased RV in the alveoli and diminished caliber of the bronchioles causes part of each inspiration to be trapped in the acinus.

Mechanisms of air trapping in emphysema

Damaged or destroyed alveolar walls no longer support and hold open the airways, and alveoli lose their property of passive elastic recoil. Both of these factors contribute to collapse during expiration.



Emphysema – clinical manifestations

- Patients with emphysema are able to maintain a higher alveolar minute ventilation than those with chronic bronchitis. Thus they tend to have a higher PaO₂ and lower PaCO₂ and have classically been referred to as „pink puffers“
- Physical examination often reveals a thin, tachypneic patient using accessory muscles and pursed lips to facilitate respiration. The thorax is barrel-shaped due to hyperinflation.
- There is little cough and very little sputum production (in „pure“ emphysema)

Table 32-4**Clinical Manifestations of Chronic Obstructive Lung Disease**

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Polycythemia	Common	Late in course
Cor pulmonale	Common	Late in course

Emphysema – evaluation

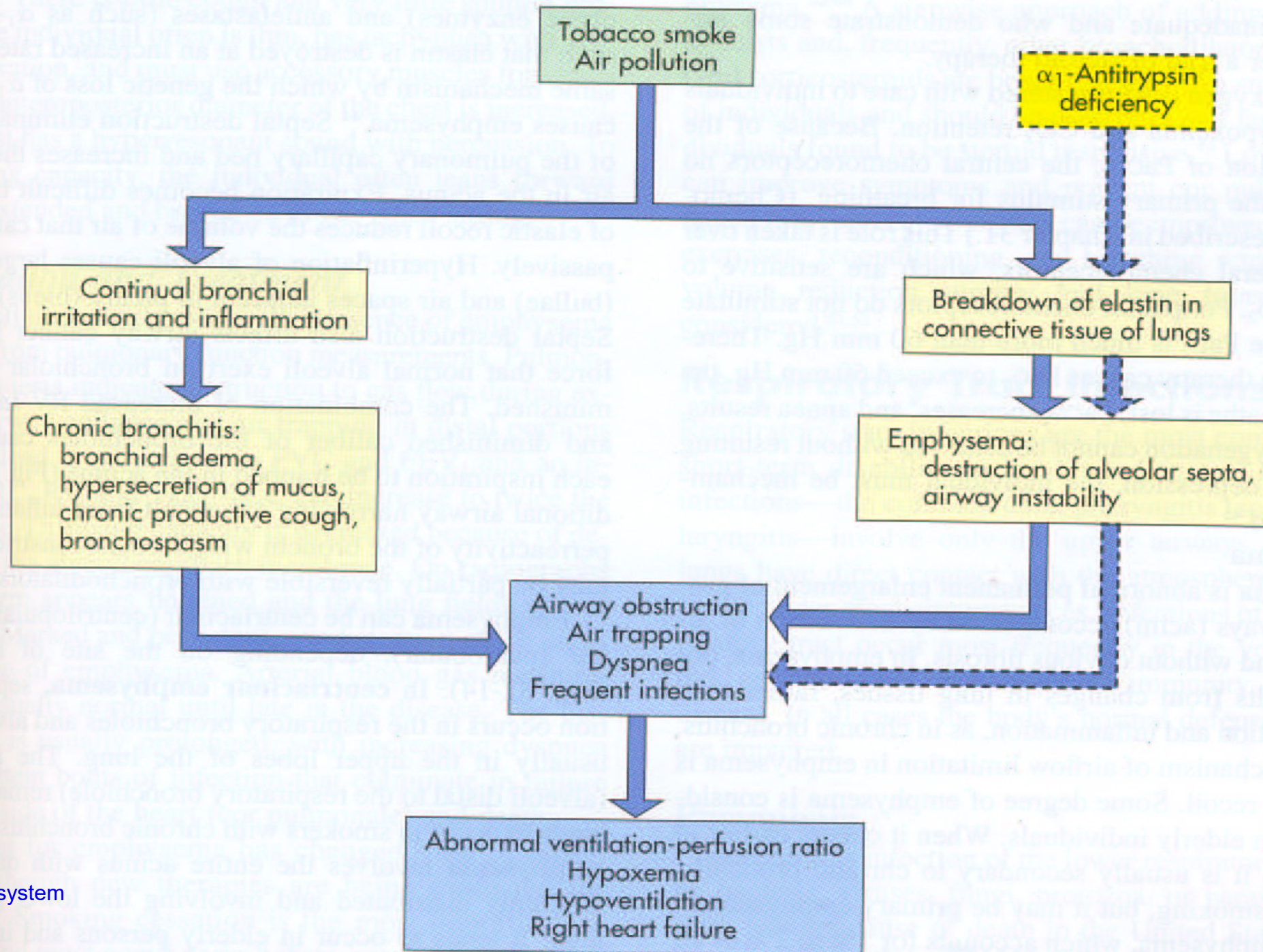
– Pulmonary function tests:

- indicate **obstruction to gas flow during expiration**
- airway collapse and air trapping lead to a **decrease in FVC and FEV1** and an **increase in FRC, RV, and TLC.**
- **diffusing capacity is decreased** because destruction of the **alveolocapillary membrane**

– **Arterial blood gas measurements are usually normal** until late in the disease

Emphysema – approach to therapy

- **Smoking cessation is the most important intervention**
- **Inhaled anticholinergic agents**
- **β 2-adrenergic agonists**
- **Steroids**
- **Low-flow oxygen therapy in selected individuals**
- **Lung transplant can be considered**



Interstitial lung diseases

- There are a large number of diseases that affect the interstitium of the lung



it is connective tissue present between the alveolar epithelium and capillary endothelium

- Some of these diseases have known etiology, e.g. **occupational diseases**
- Others are **diseases of unknown etiology**
 - most frequent of these are idiopathic pulmonary fibrosis (diffuse interstitial fibrosis), pulmonary fibrosis associated with collagen-vascular diseases, and sarcoidosis.

Nozological units

Idiopathic pulmonary fibrosis

- Diseases unknown etiology, non-specific fibrotic change in lung. The diagnosis is to some extent one of exclusion.

Sarcoidosis

- One of the most common. It is multi-system granulomatous disease that involves lung, lymph nodes, salivary glands, and liver. Specific type is called erythema nodosum

Occupational interstitial diseases

- Exposure to occupational and environmental inhalants for a long time can lead to develop lung disease. Workers in industries with heavy exposure to silica dust, asbestos particles, and welding fumes are generally aware of the risk of their occupation.

Occupational diseases

Diseases

Azbestosis
Aspergilosis
Berryliosis
Lung of breeder of birds
Pneumoconiosis
Farmer's lung
Silicosis
Welder's lung

Cause

Azbestos particles
Mould - *Aspergillus*
Beryllium's compounds
Birds' antigens
Coal
Grain's mould
Silica dust
Welding fumes

Clinical manifestations

Subjective symptoms

- dyspnoea
- cough

Objective signs

- tachypnoea
- crackles
- clubbing
- cyanosis
- cor pulmonale

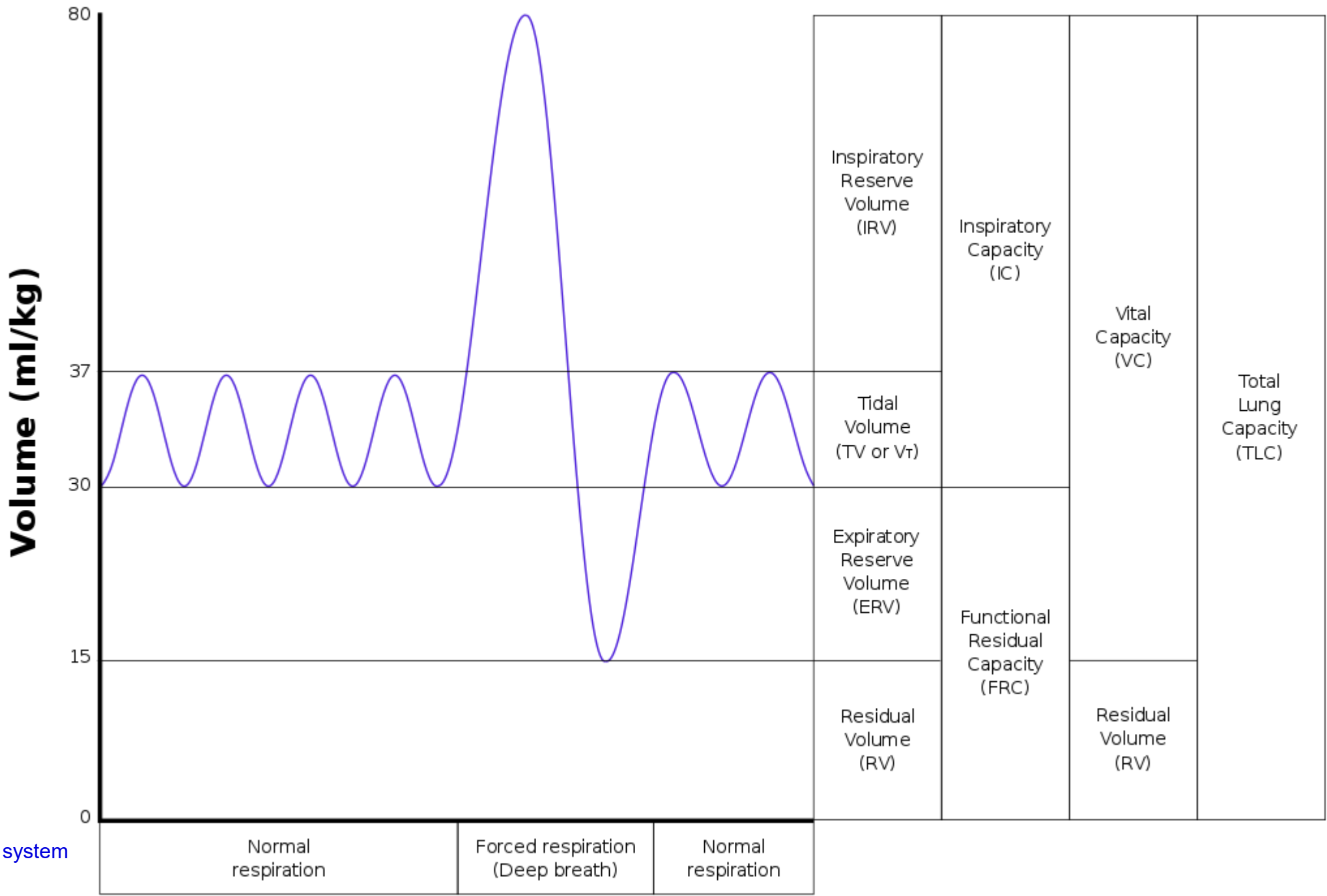
Laboratory findings

- Decrease PaO_2
- normal PaCO_2
- ECG- cor pulmonale
- Spirometry - restrictive pattern (VC, normal ratio FEV_1/FVC)
- Decrease diffusion capacity of the lung for carbon monoxide

Therapy

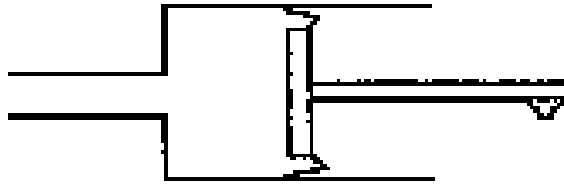
- It depends on etiology (if it is known)
- Stopping the occupational exposure
- Antibiotics
- Diseases of unknown etiology (sarcoidosis, idiop. pulmonary fibrosis) corticosteroids
- Oxygen therapy

Spirometry

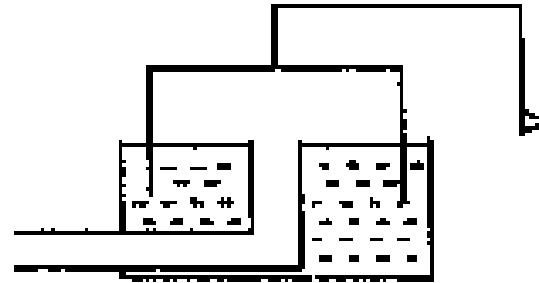


Types of spirometers

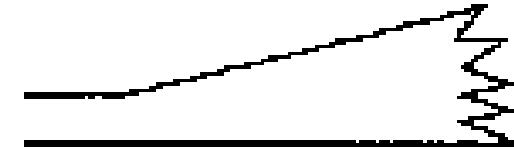
Rolling Seal



Water Sealed

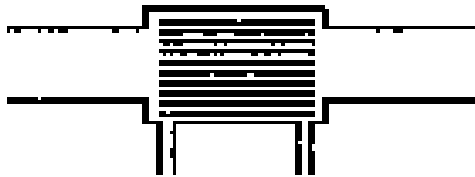


Bellows

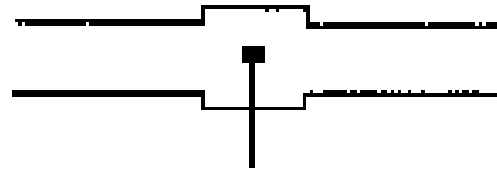


Flow Sensors

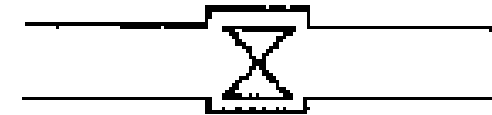
Pneumotach



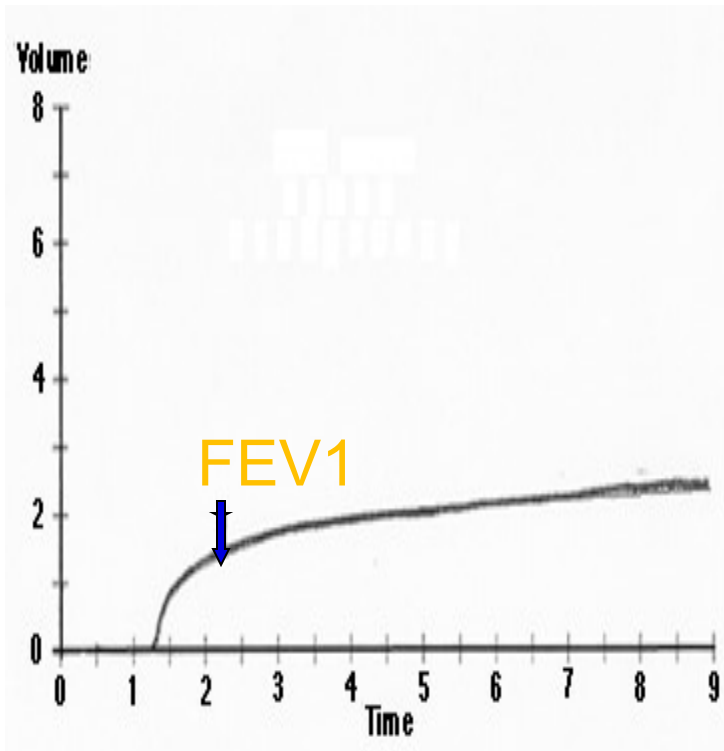
Hot-Wire



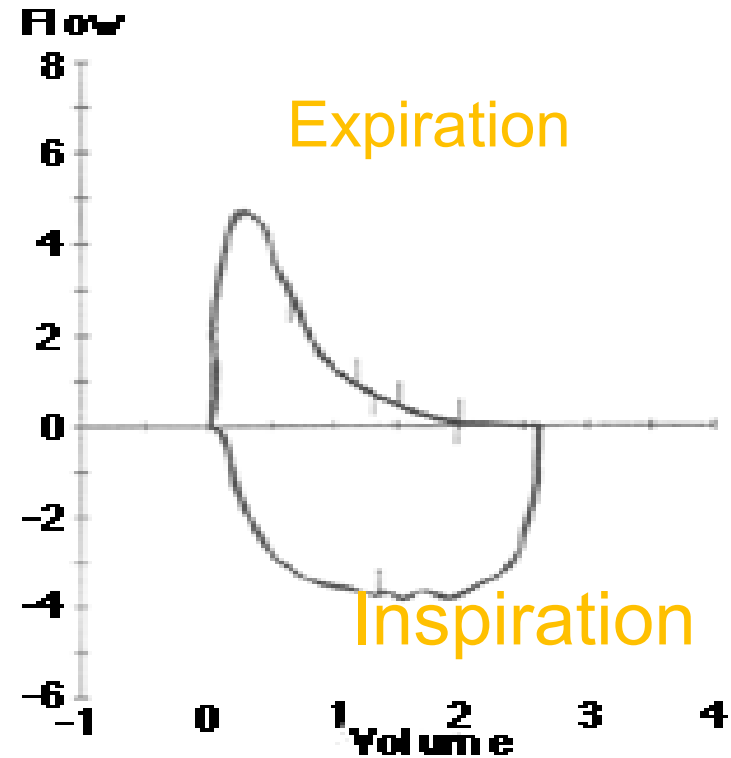
Turbine



Graphs



51 Respiratory system **Volume-time**



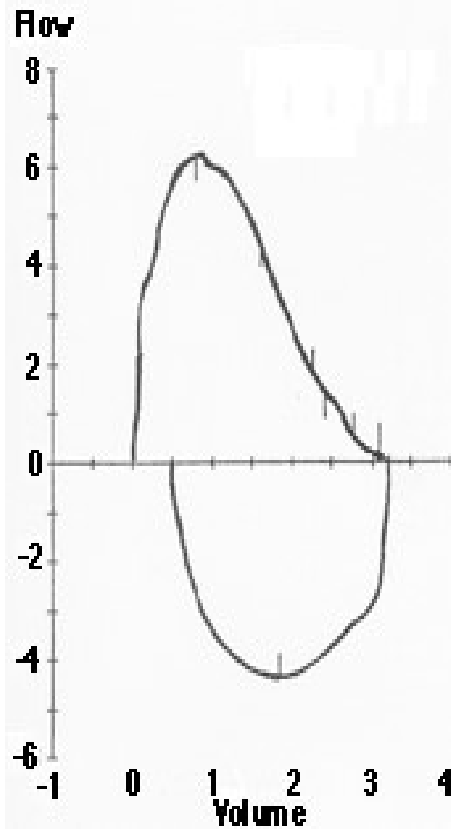
Flow-volume

Lung Volume Patterns

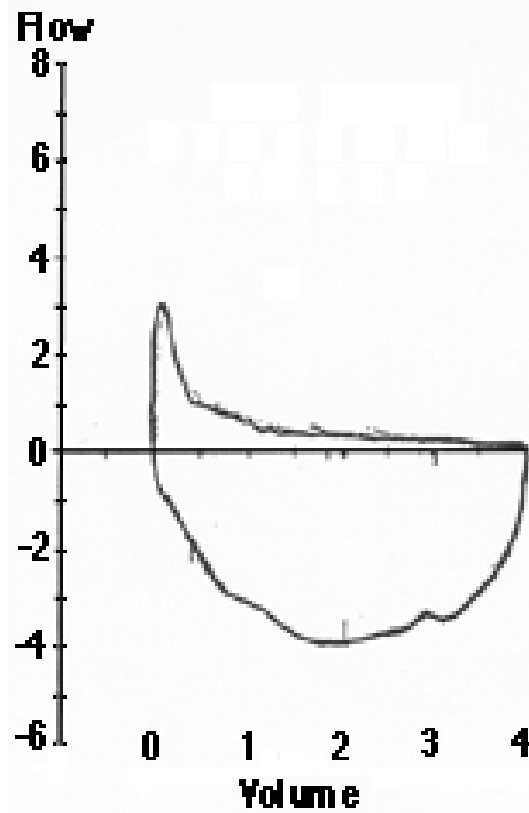
- **Obstructive Disease:** Characterized by hyperinflation and gas trapping (increased TLC and RV/TLC)
- **Restrictive Disease:** Characterized by generalized reduction in lung volume (decreased TLC, RV and FRC)

Flow-volume graphs

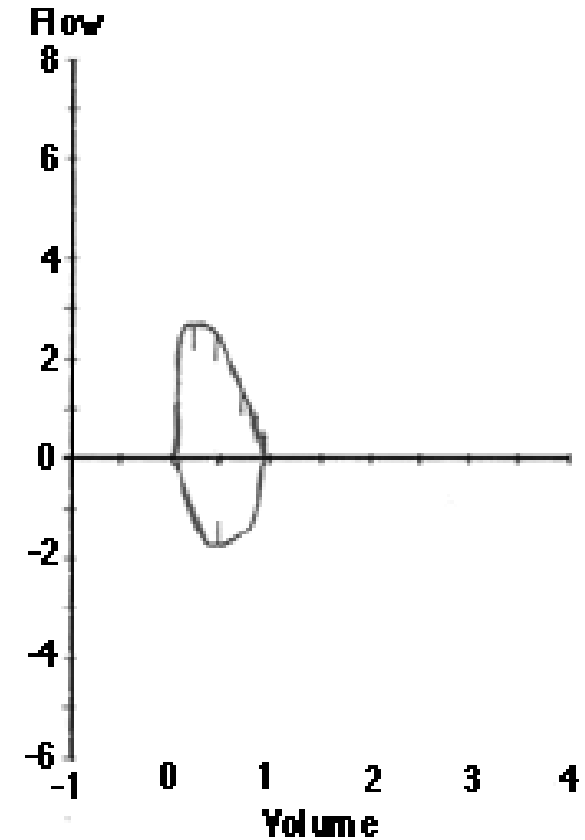
Normal

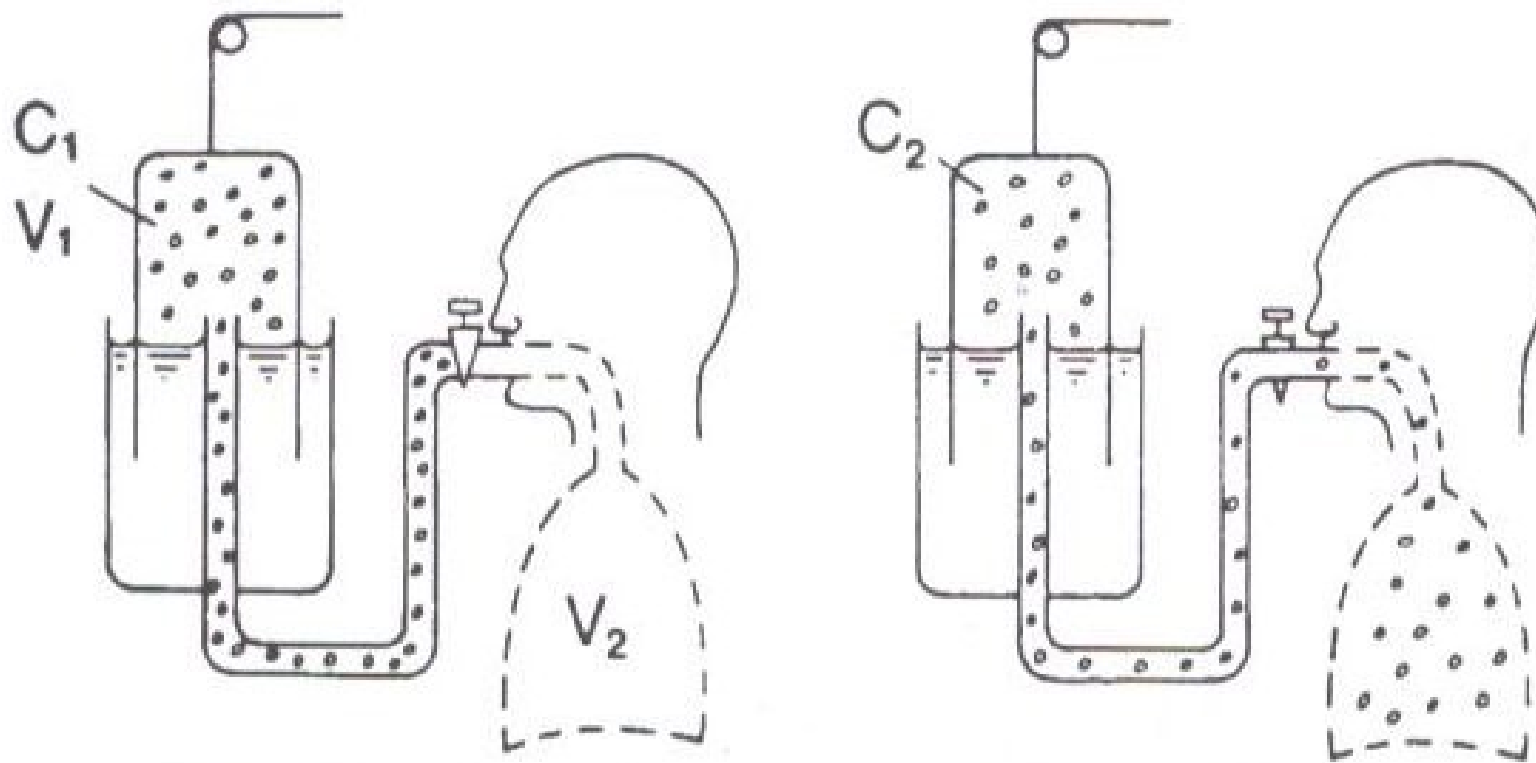


Obstructive



Restrictive





Před ekvilibrací

Po ekvilibraci

$$C_1 * V_1 = C_2 * (V_1 + V_2)$$