Pulmonary Diseases: Structure-Function Correlation I

Review of Histology/Histopathology and Airway Diseases (Obstructive)

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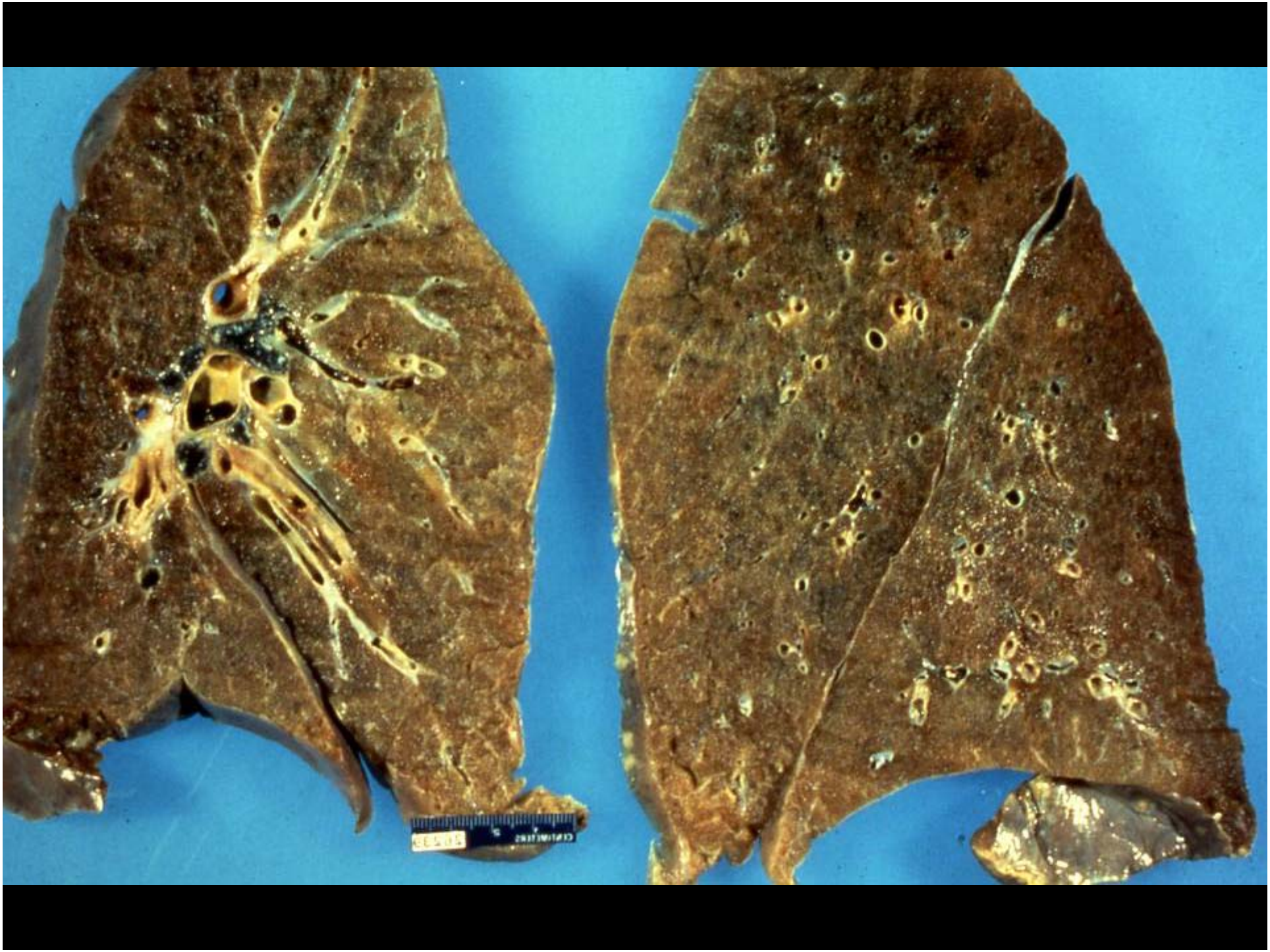
Pulmonary Diseases: Structure-Function Correlation I

- Overview
  - Two lectures will follow the structure/function section of the syllabus:
    - Lecture 1 - Histology/histopathology review and Airways disease.
    - Lecture 2 - Interstitial and parenchymal disease, and vascular disease.

Pulmonary Diseases: Structure-Function Correlation I

Goals:

- **To review microanatomy/histology of normal lung and compare to pathologic alterations within those elements**
- **To observe the relationship between structural/morphologic manifestation of diseases to measurable functional parameters using prototypical diseases of the airways**
- **To describe the pathology, Gross and microscopic, of these pulmonary diseases.**

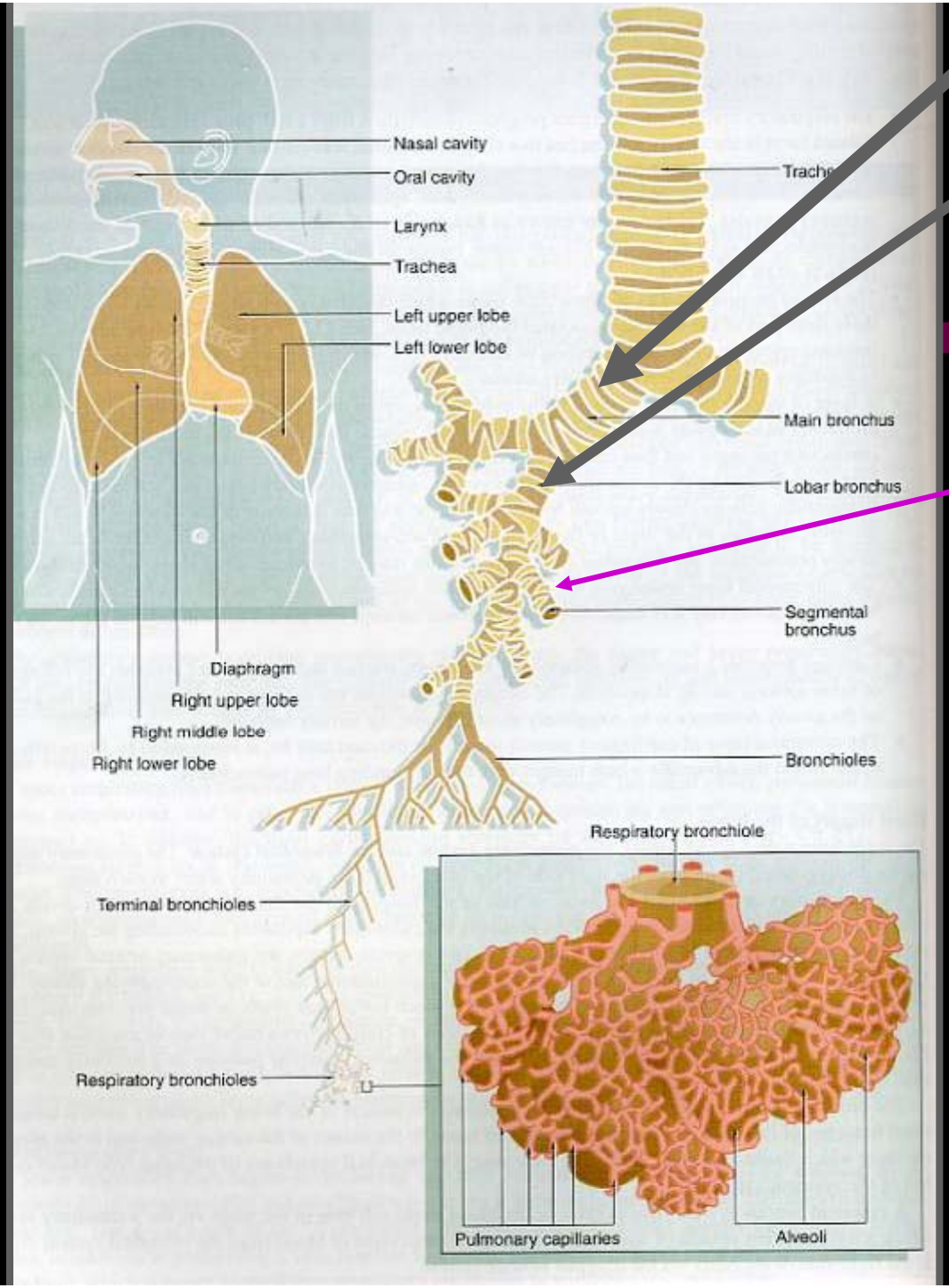


Pulmonary Diseases: Structure-Function Correlation I

- Cast of Characters
  - Airways
    - Conducting
    - Respiratory
  - Vessels
    - Arteries, arterioles - pulmonary and bronchial
    - Capillaries
    - Veins/Venules and Lymphatics
  - Pleura- visceral and parietal

Pulmonary Diseases: Structure-Function Correlation I

- Airways Conducting Zone
  - Trachea
  - Bronchi - ciliated and goblet cells, elastic tissue, smooth muscle, glands, cartilage
  - Bronchioles - (1 mm) - No cartilage or bronchial glands, ciliated lining,no goblet cells, smooth muscle
- Cell types
  - **CILIATED CELL** - beating of cilia contribute to mucociliary elevator
  - **GOBLET CELL** - Mucus secretion
  - **BASAL CELL** - reserve cell
  - **KULCHITSKY CELL** - neuroendocrine cells.



Main stem bronchus

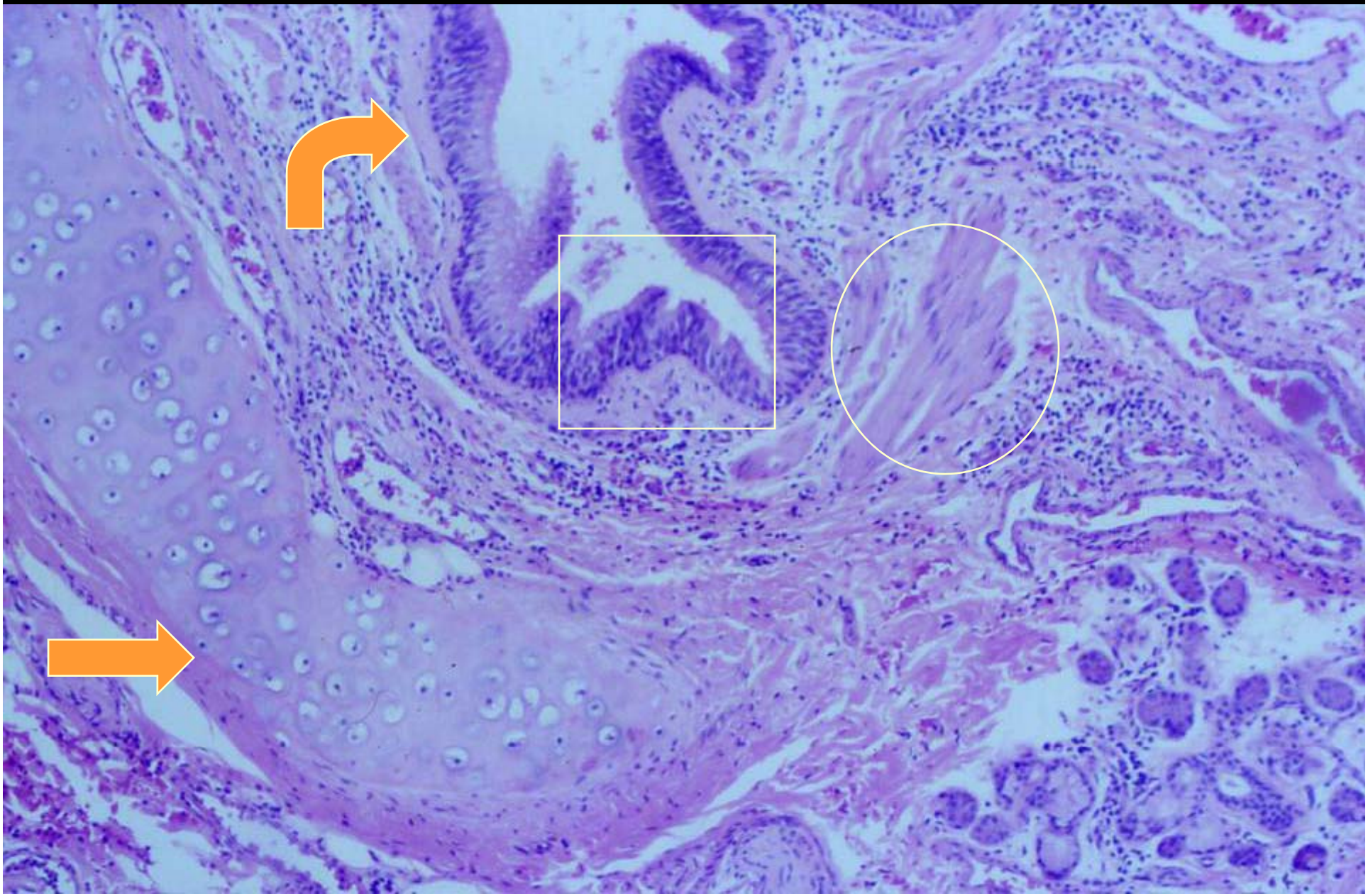
Lobar bronchus (5 lung lobes)

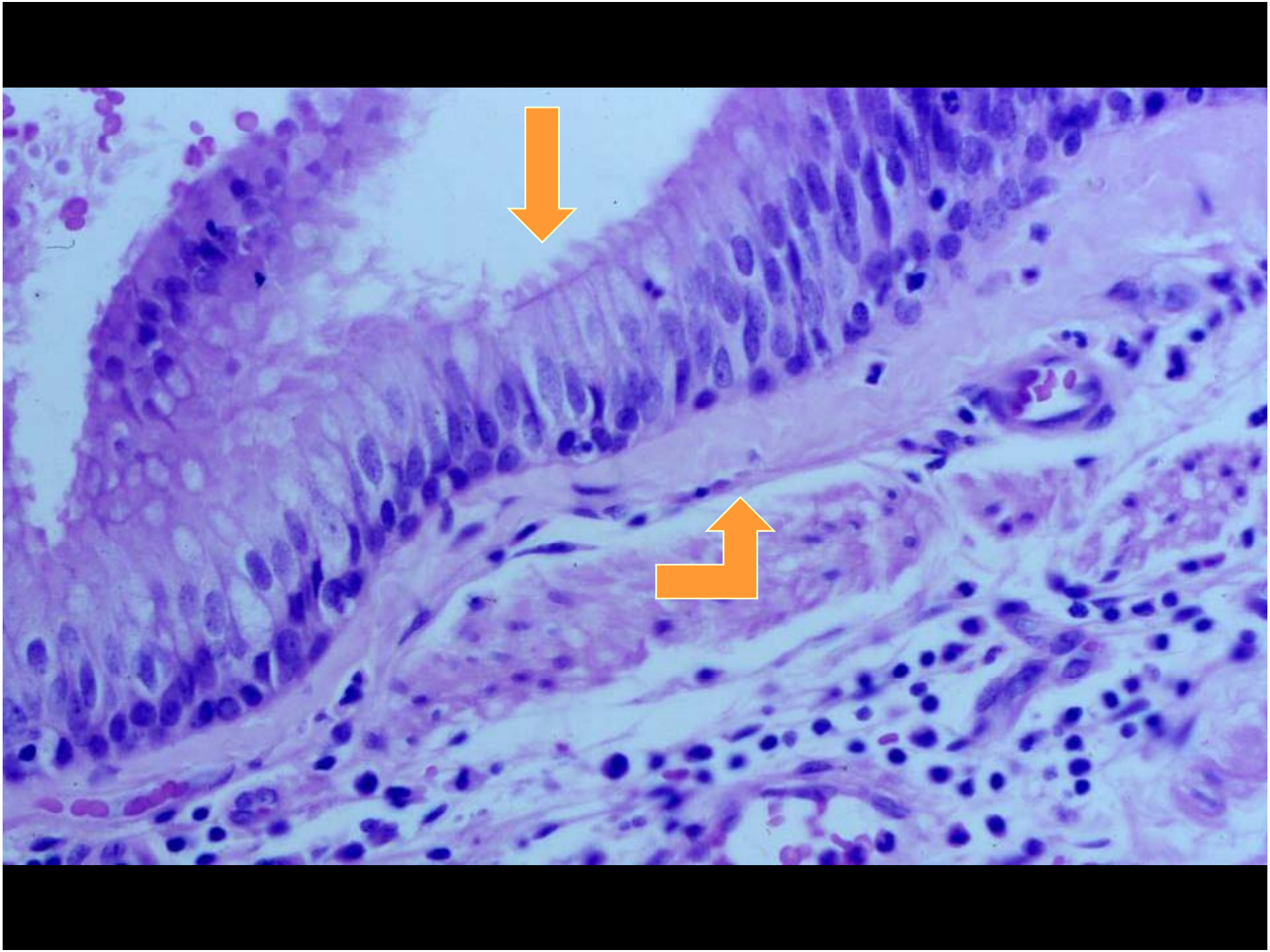
Segmental bronchus (10 bronchopulmonary segments on right, 9 on left

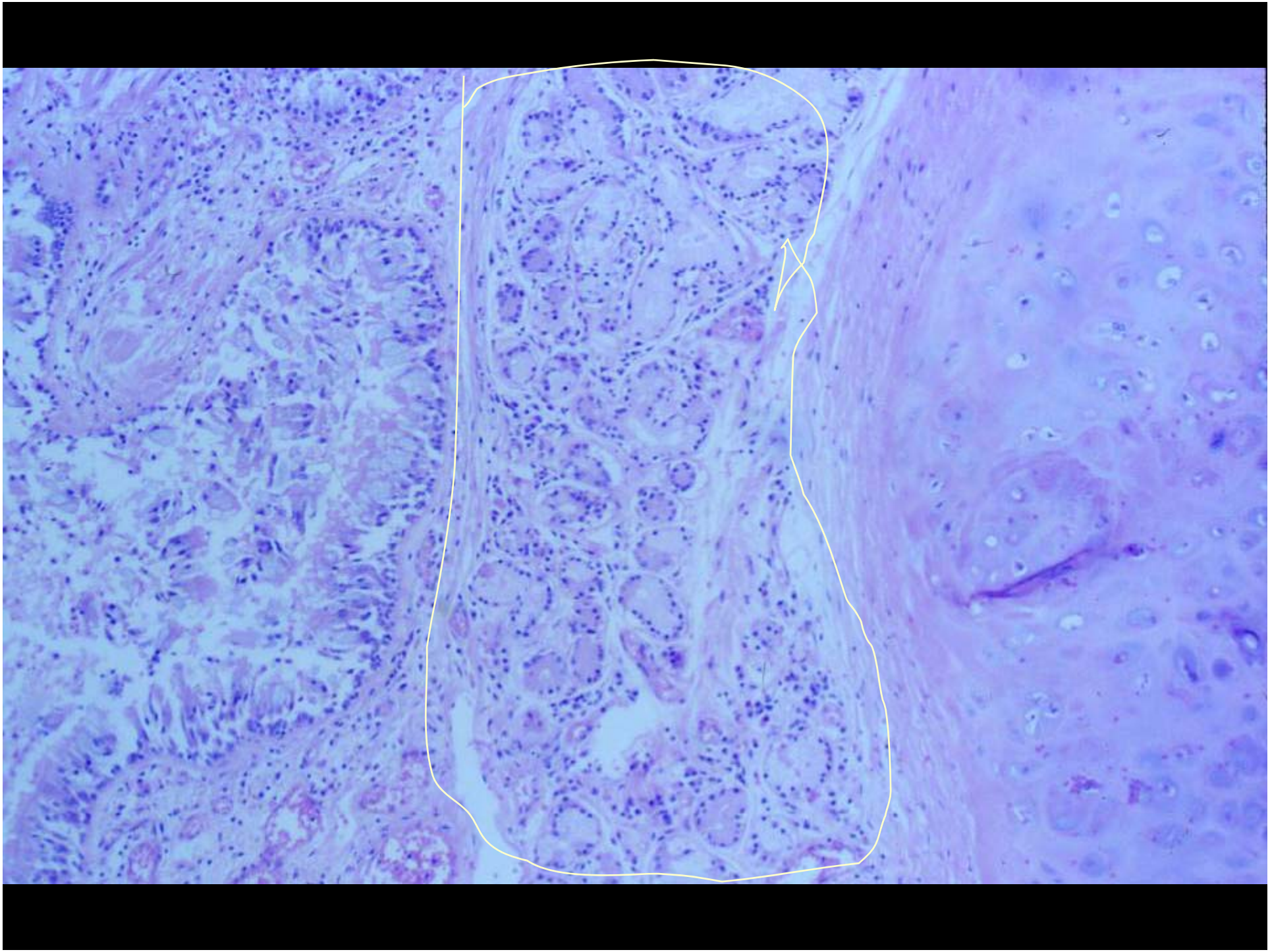
Branching continues as airways become bronchioles, then at terminal bronchioles airways transition into respiratory bronchioles

About 20 branch generations from beginning to end

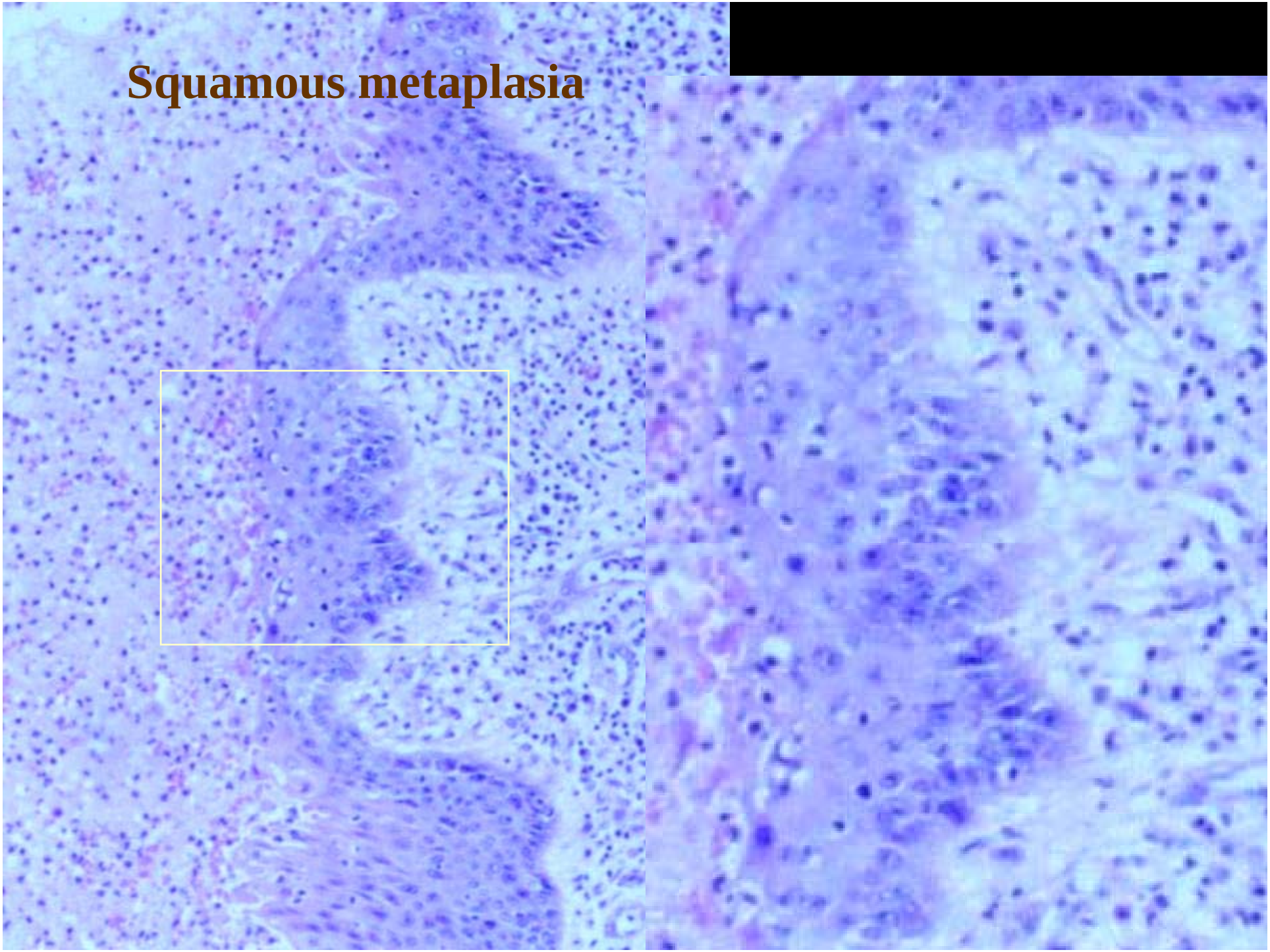
Normal airway







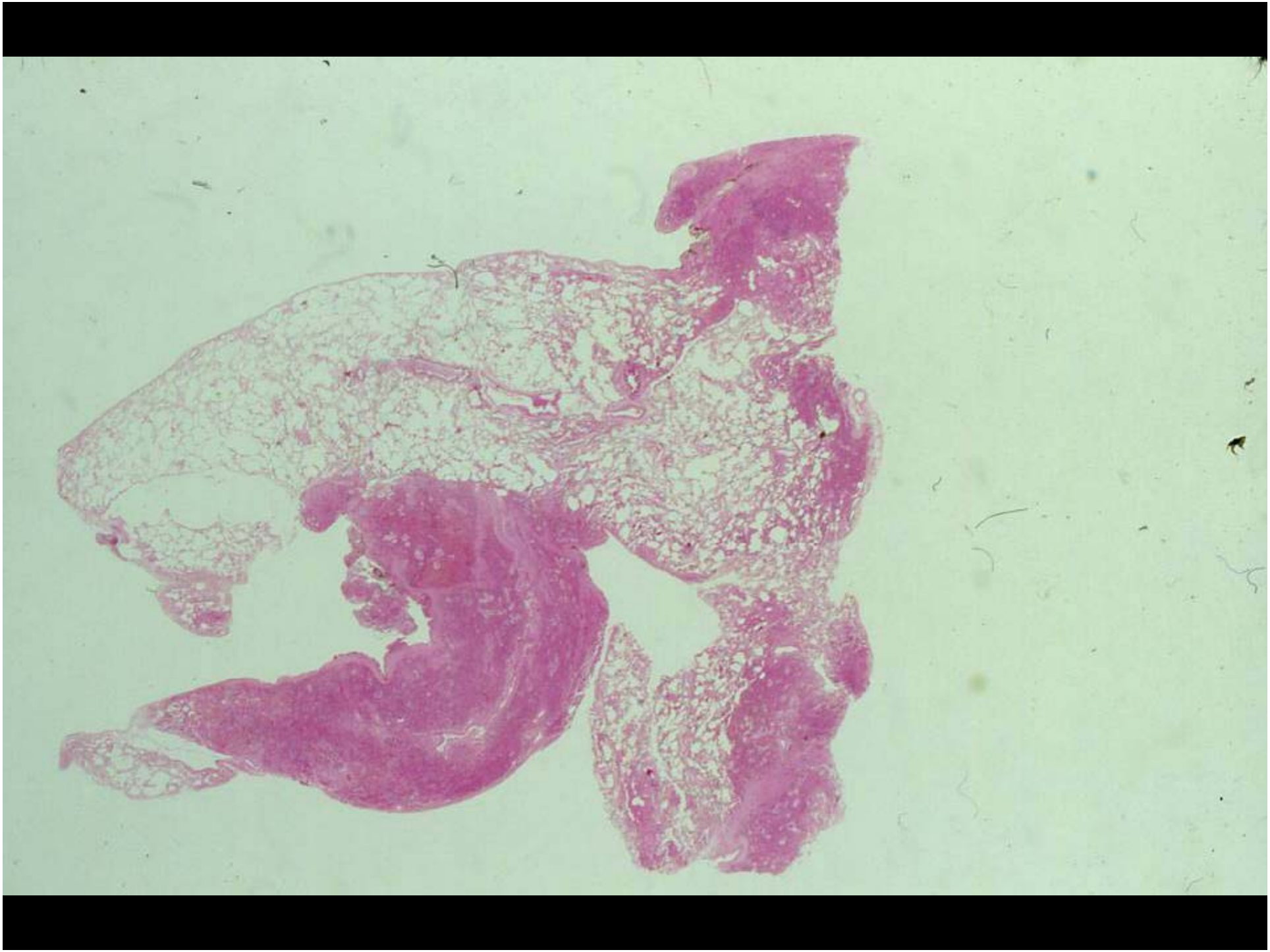
Squamous metaplasia

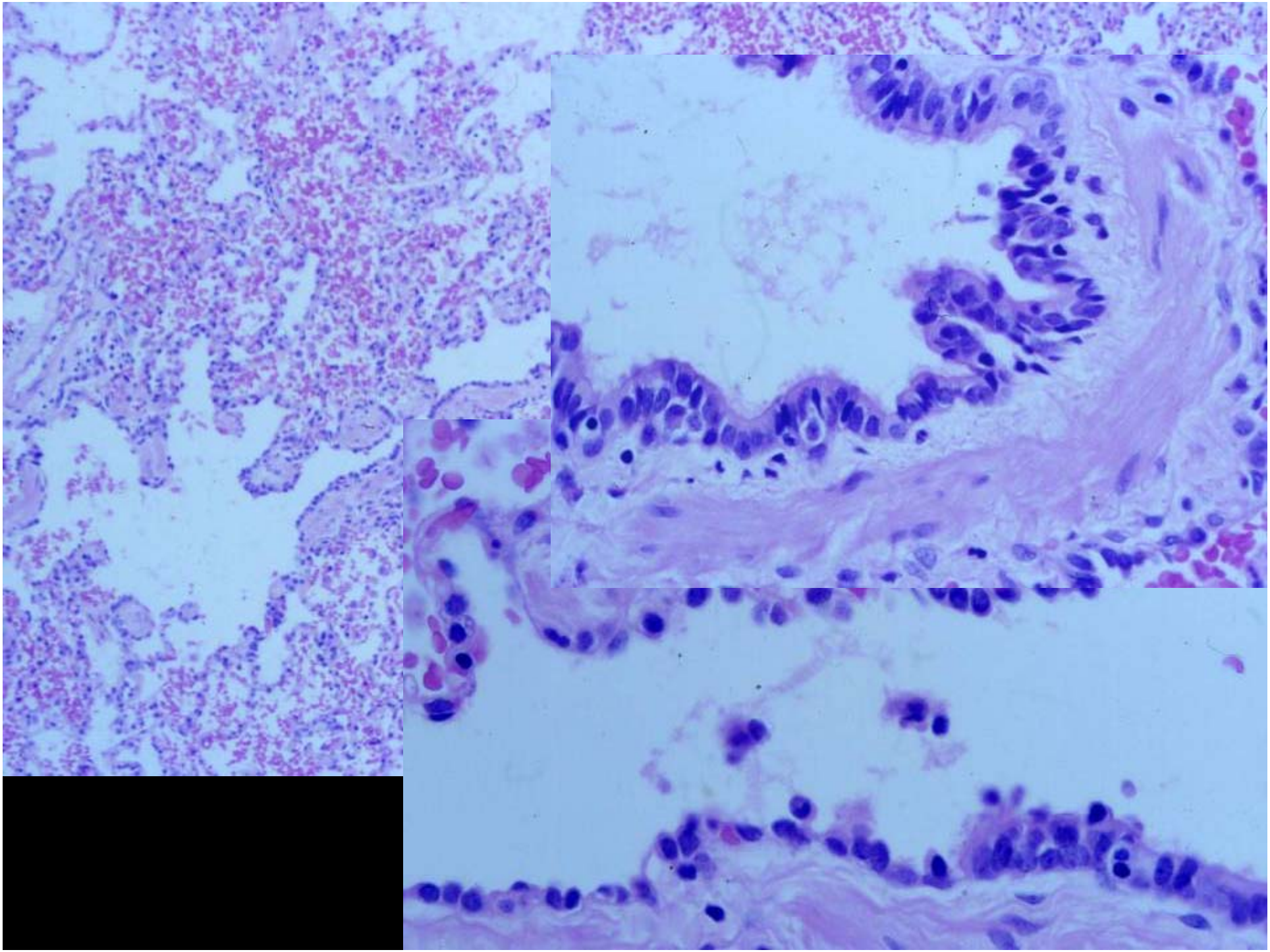


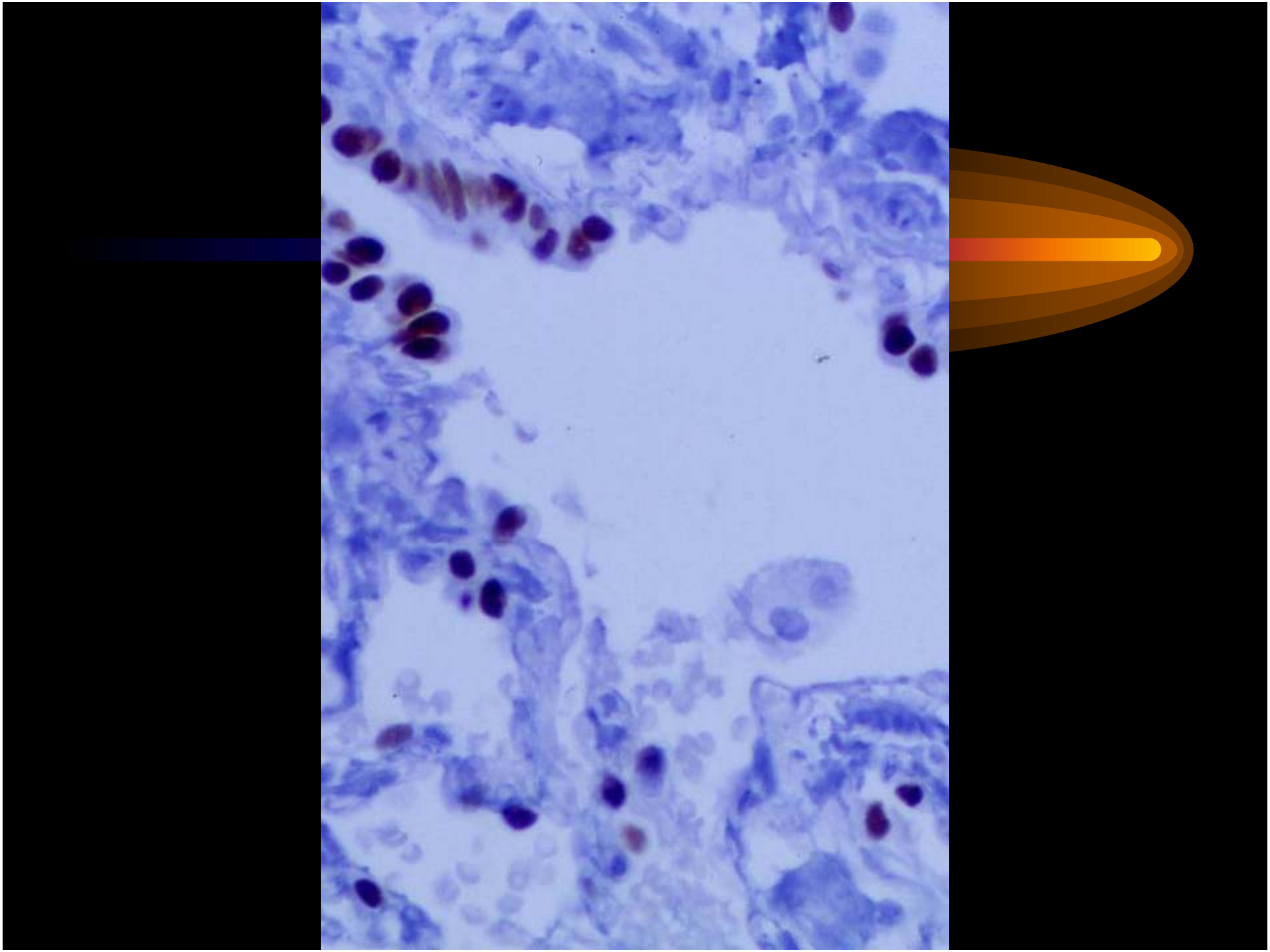
Pulmonary Diseases: Structure-Function Correlation I

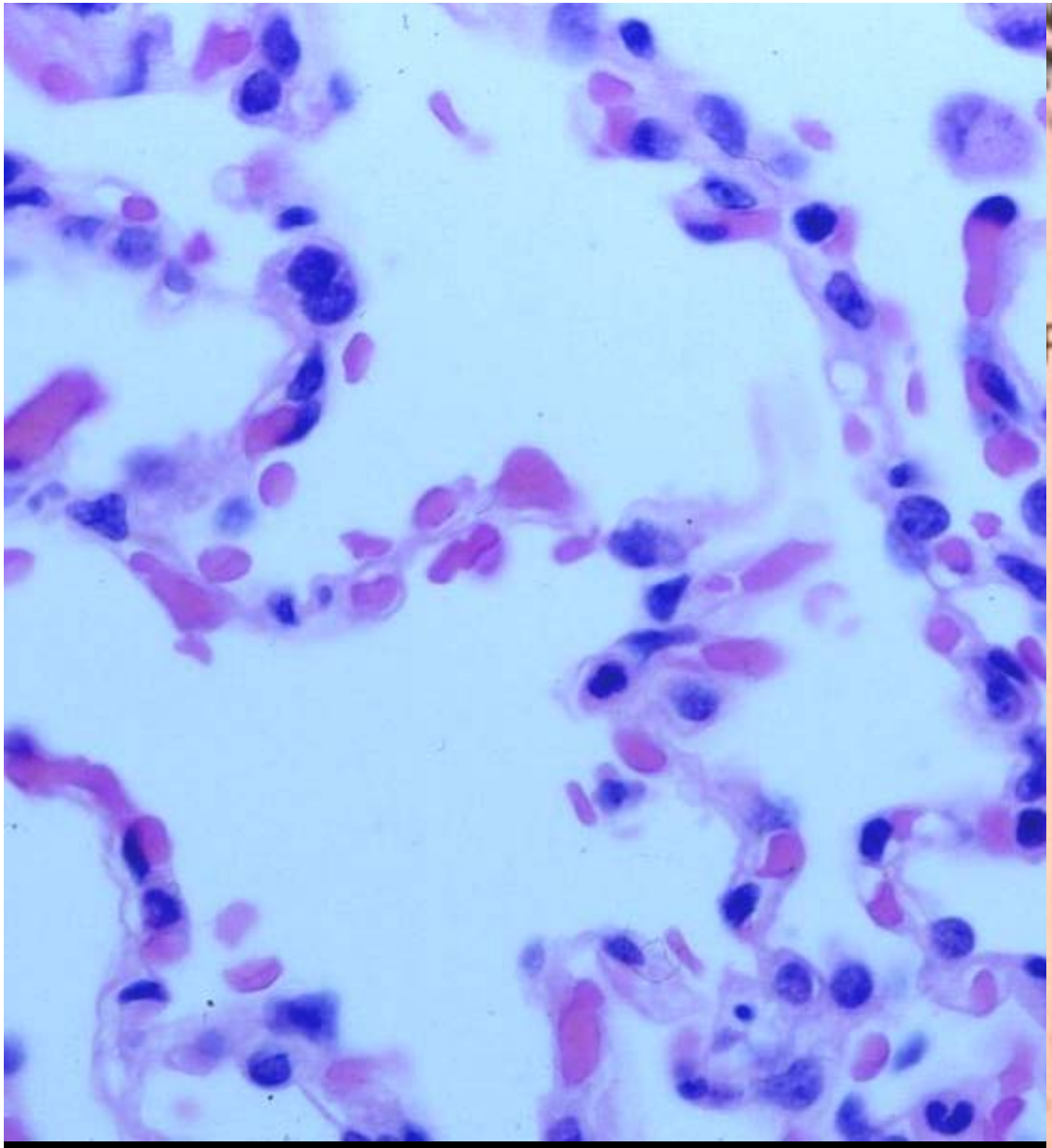
- Airways Respiratory Zone
  - Respiratory bronchiole - lined by ciliated cells and **CLARA CELLS**
  - Alveolar ducts/sacs
    - **Type I cells** 90% of alveolar surface
    - **Type II cells**

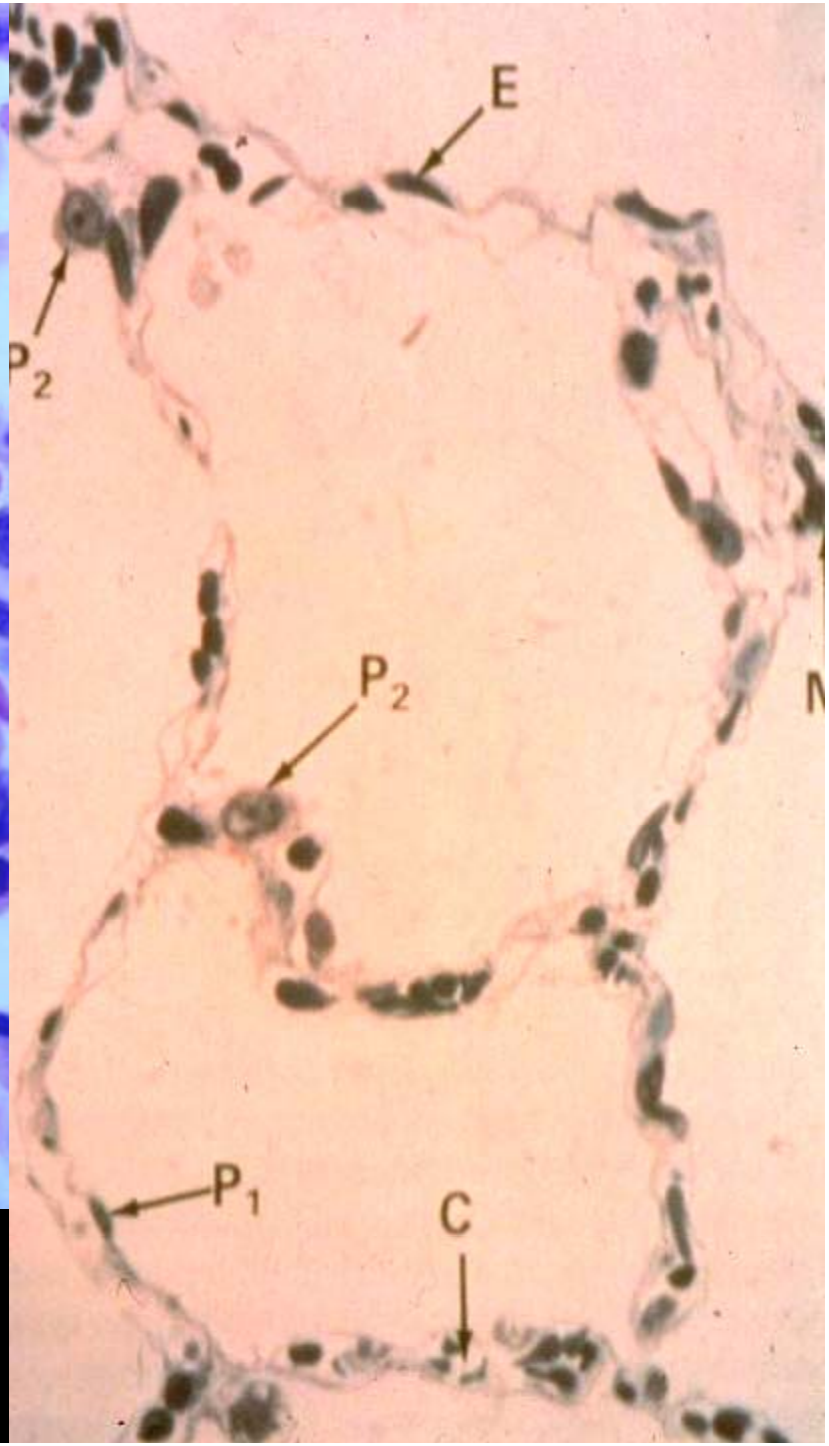
- Cell types
  - **CLARA CELLS** - produce a component of surfactant and are the bronchiolar reserve cell
  - **TYPE I CELLS** - Thin lining cell for gas exchange
  - **TYPE II CELLS** - surfactant and alveolar reserve cell







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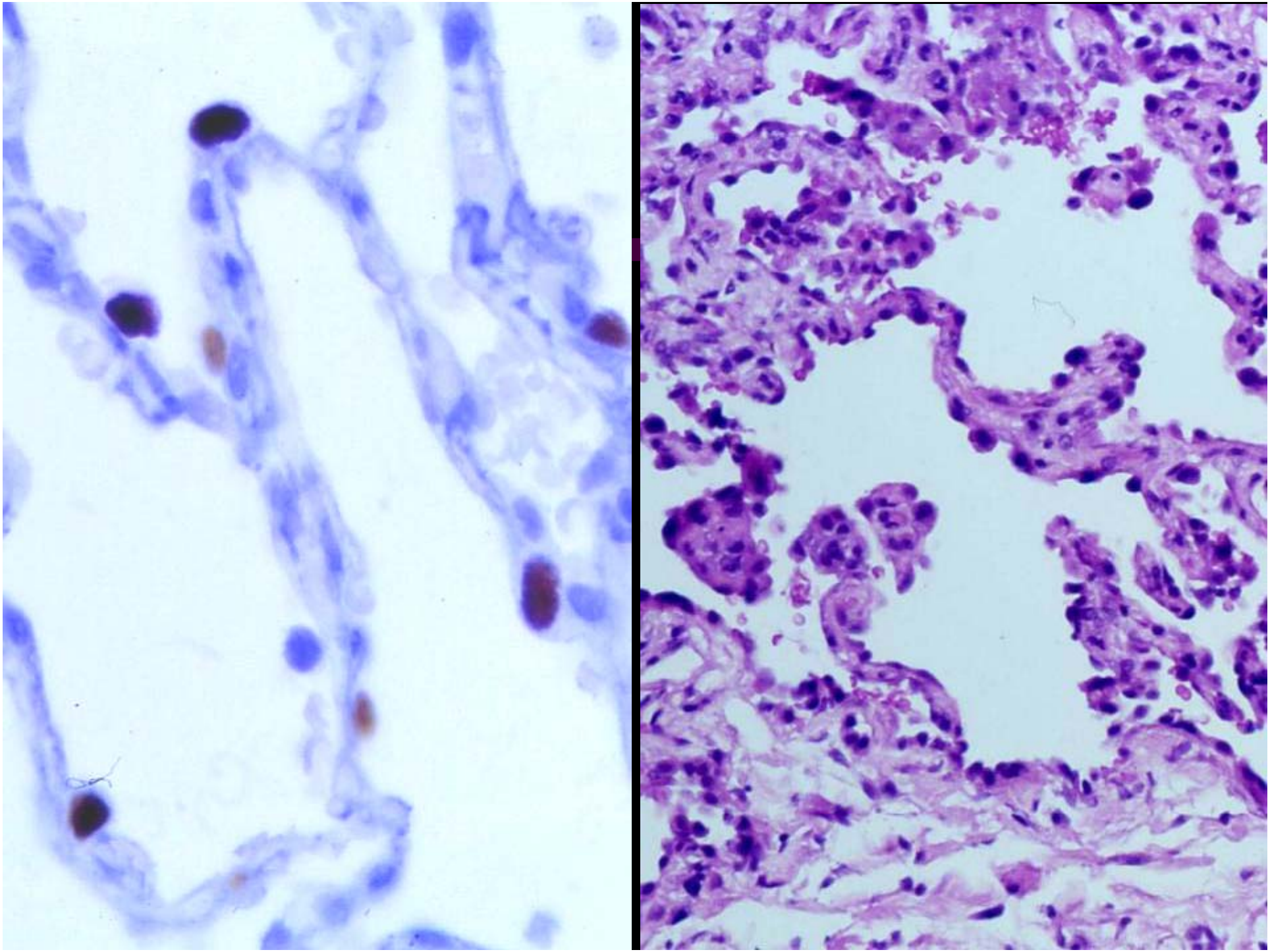
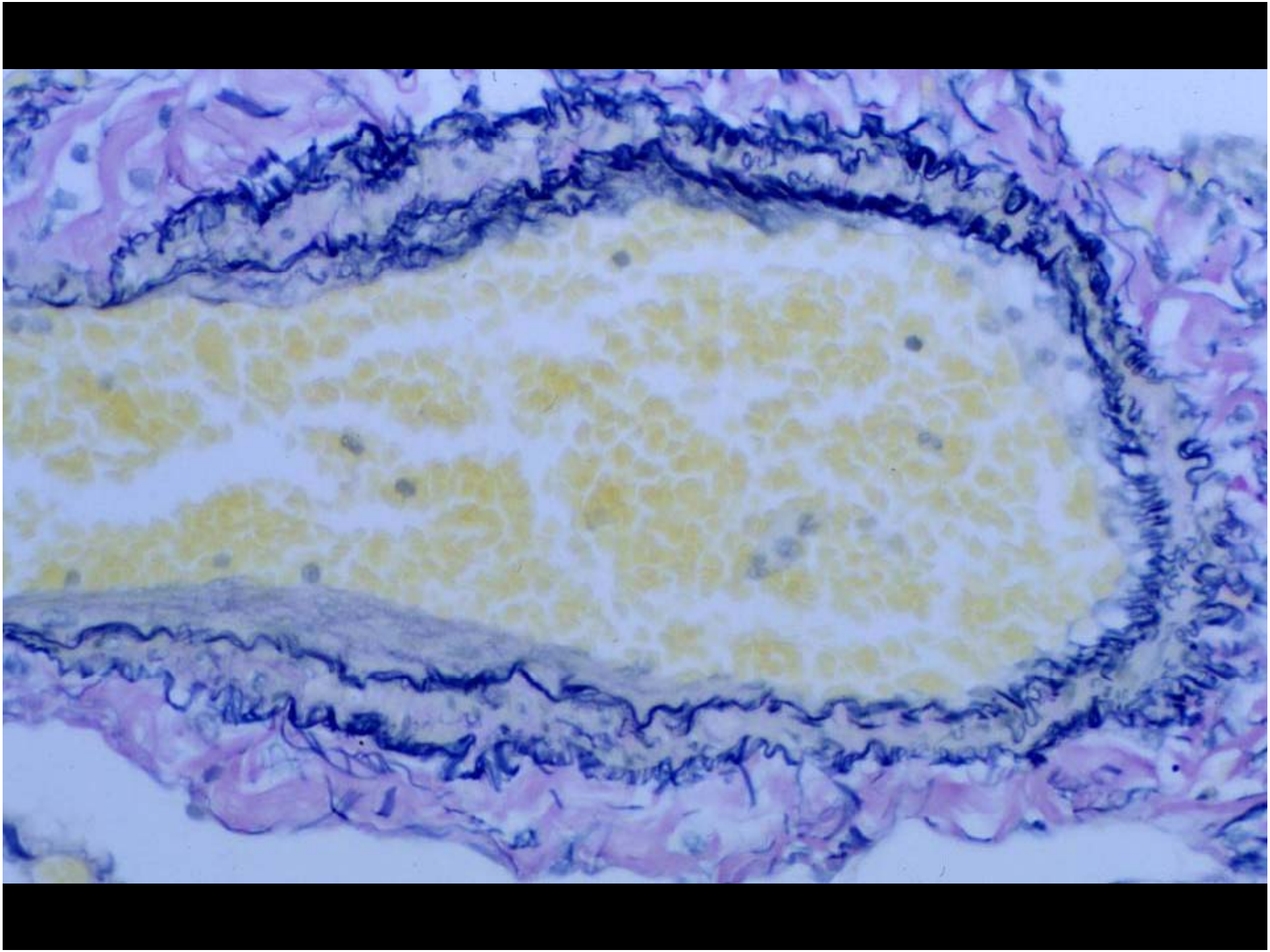
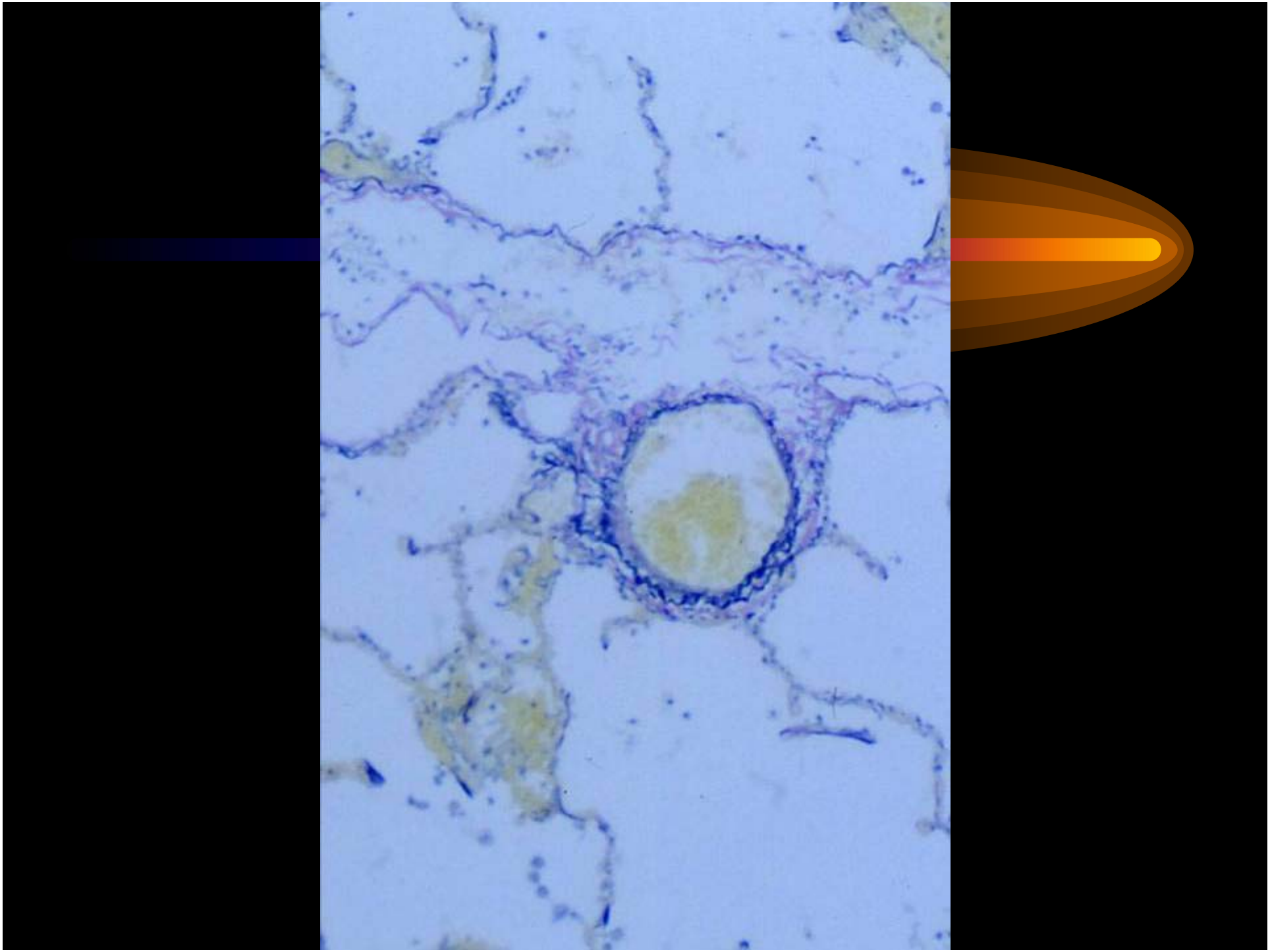


Pulmonary Diseases: Structure-Function Correlation I

- Vessels - Pulmonary
  - –Arteries/arterioles - travel and divide with bronchi and bronchioles
  - – Produce capillary bed in alveoli for gas exchange
  - –Venules collect capillary blood into lobular septa, forming veins and joining at the hilum.
- Vessels - Bronchial
  - – Artery from aorta
  - – Supplies bronchial tree up to respiratory bronchiole
  - – Venous drainage to azygous/hemiazygous



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Pulmonary Diseases: Structure-Function Correlation I

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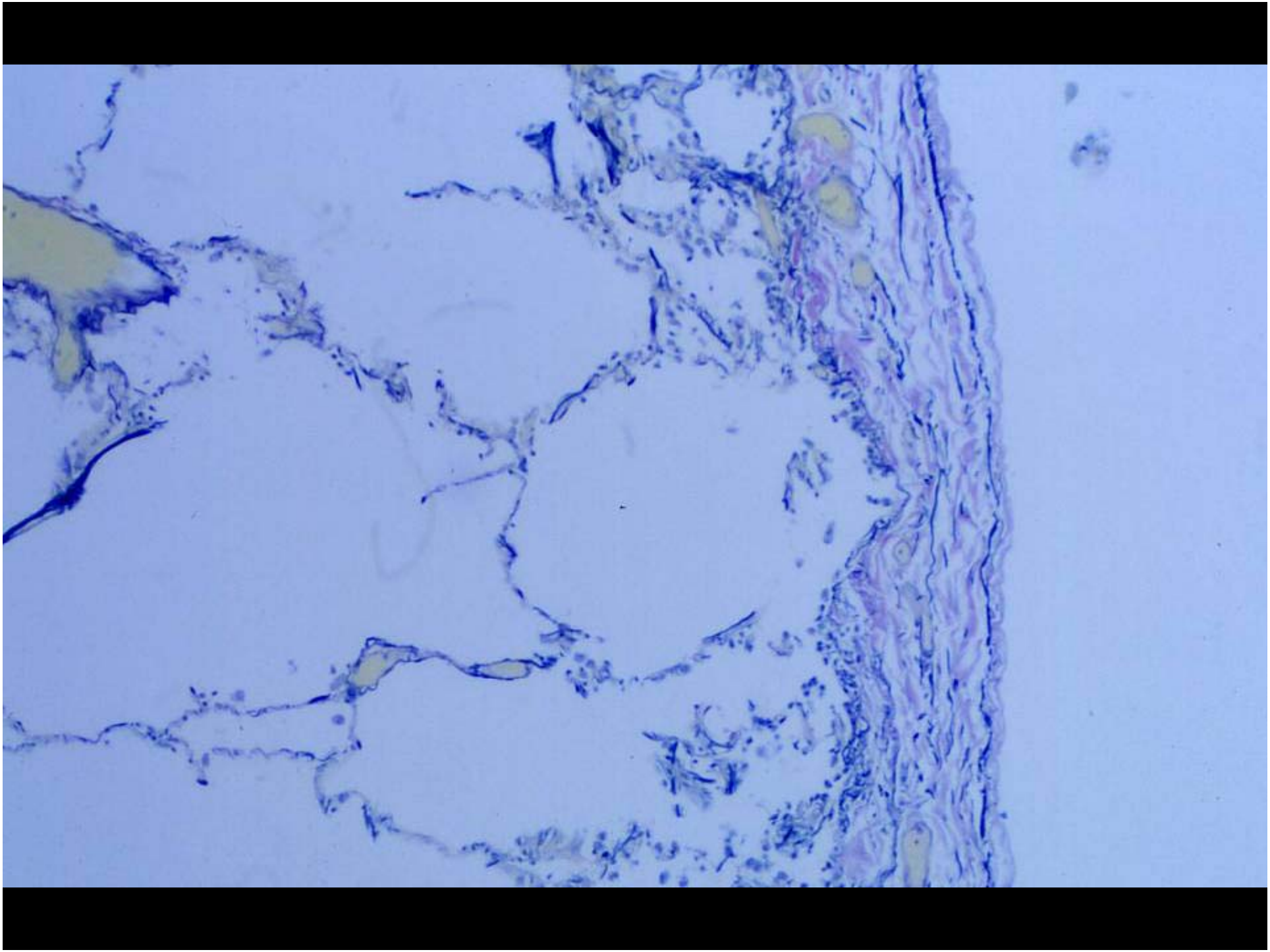

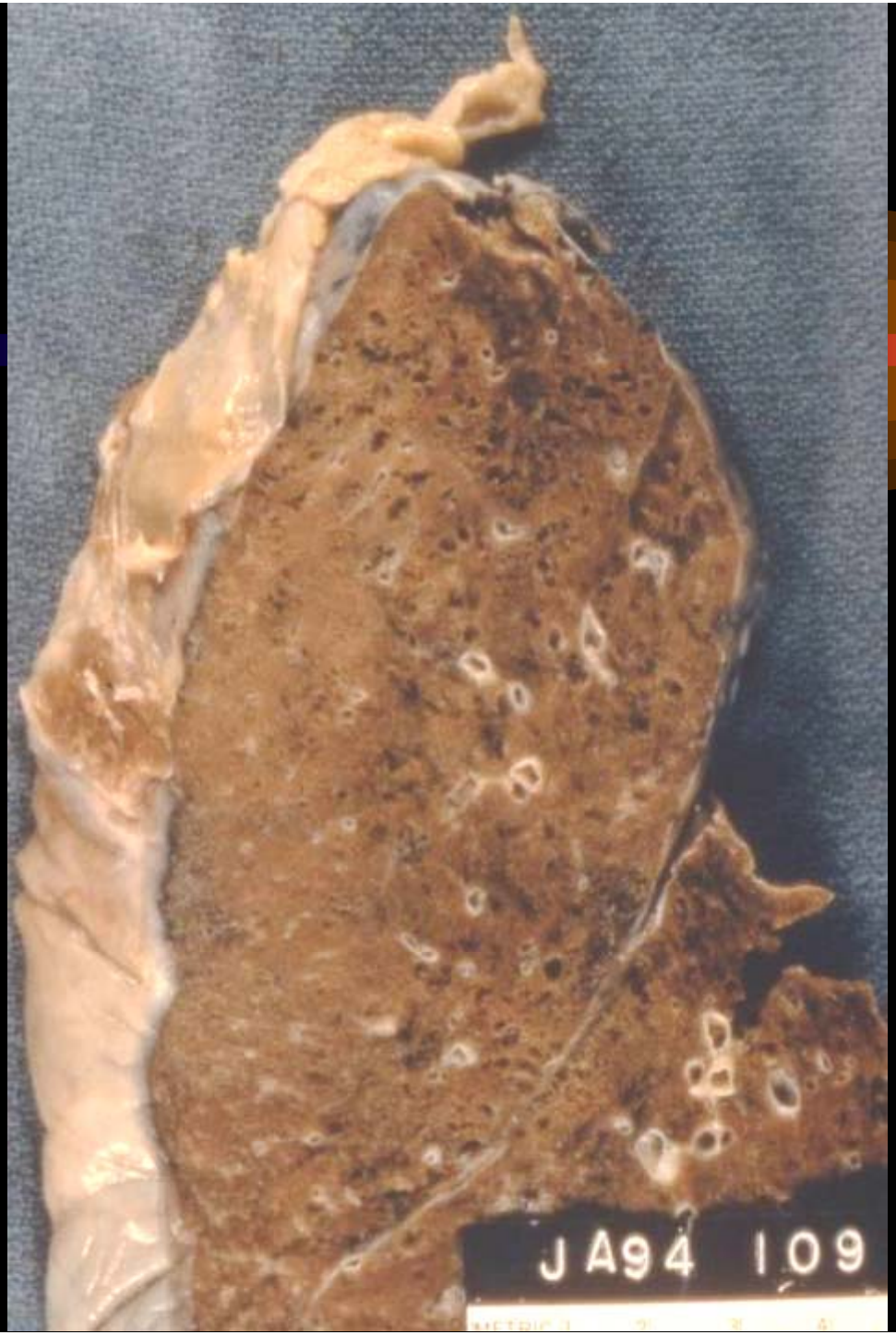
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Pulmonary Diseases: Structure-Function Correlation I

- Disease of the acini and interstitium
  1) Replacement of air with fluid, inflammatory cells or cellular debris
  2) Thickening of alveolar walls and interstitium
  3) Destruction of acinar walls
- Disease of the conducting airways
- Disease of the pulmonary vasculature

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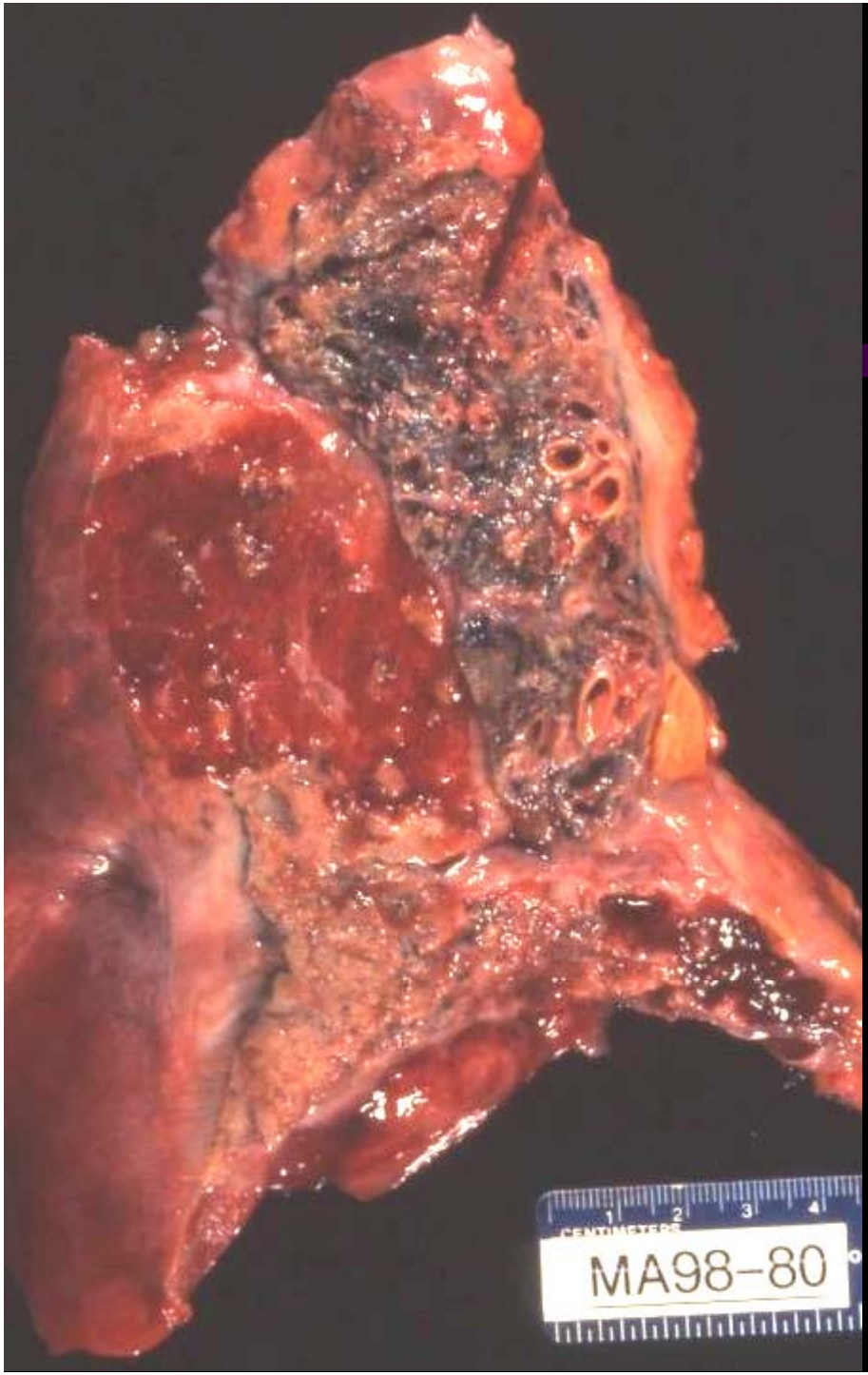
Pulmonary Diseases: Structure-Function Correlation I

- Disease of the conducting airways
  - Asthma
  - Chronic bronchitis
  - Bronchiectasis
    - Permanent dilation of bronchi and bronchioles, due to destruction of elastic tissue and muscle.

Disease of the conducting airways - Bronchiectasis

- **Dilatation of bronchi and bronchioles, usually due to necrosis of wall and obstruction**
  - **Foreign body**
  - **Mucoid impaction**
    - **Aspergillus**
  - **Cystic fibrosis**
  - **Immotile cilia**
  - **Chronic bronchitis and infection**
- **Gross Pathol. - Dilated bronchi, filled with mucus or pus, lower lobes.**
- **Microscopic -**
  - **Can have acute and chronic inflammation**
  - **Varying degrees of fibrosis**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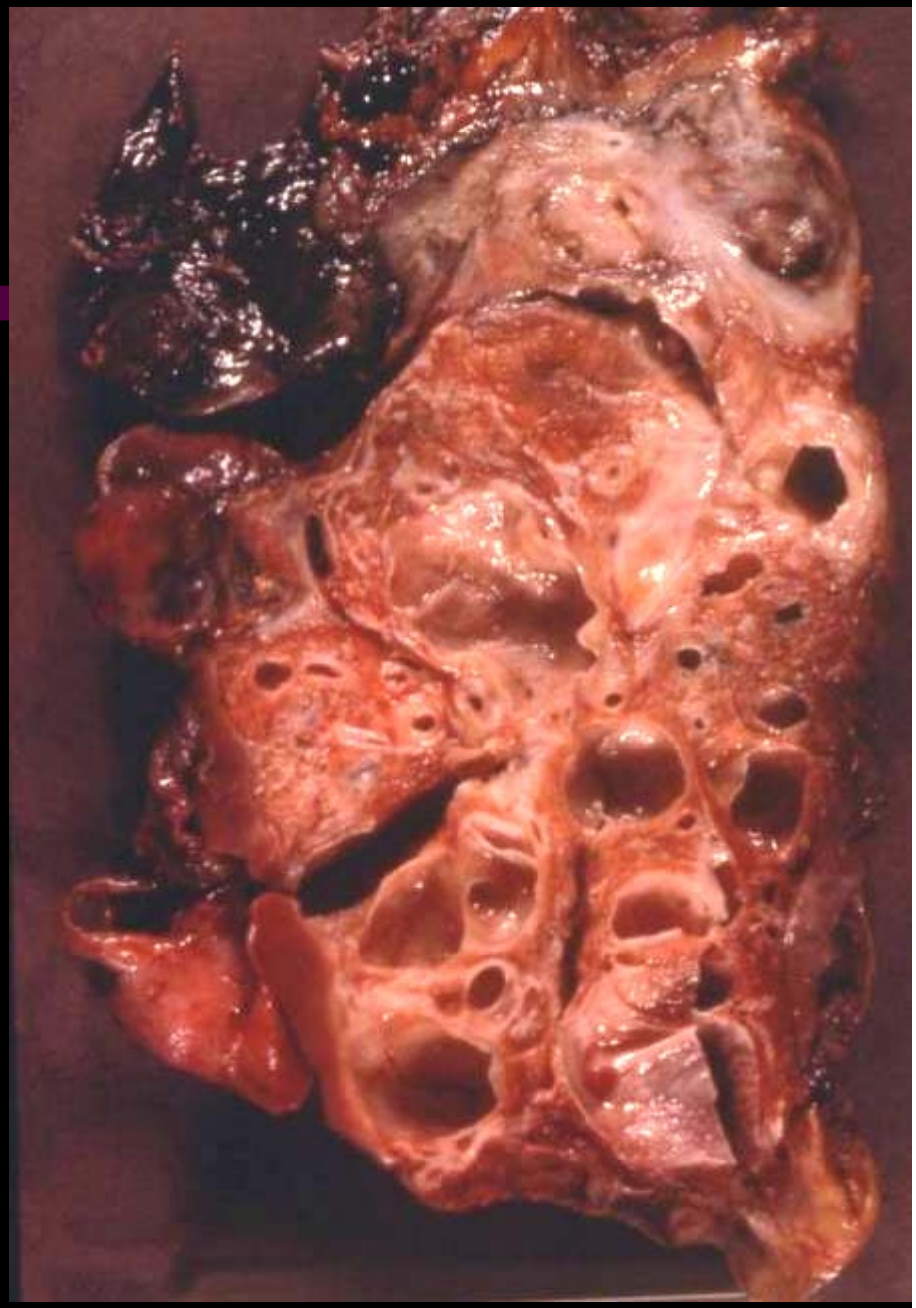
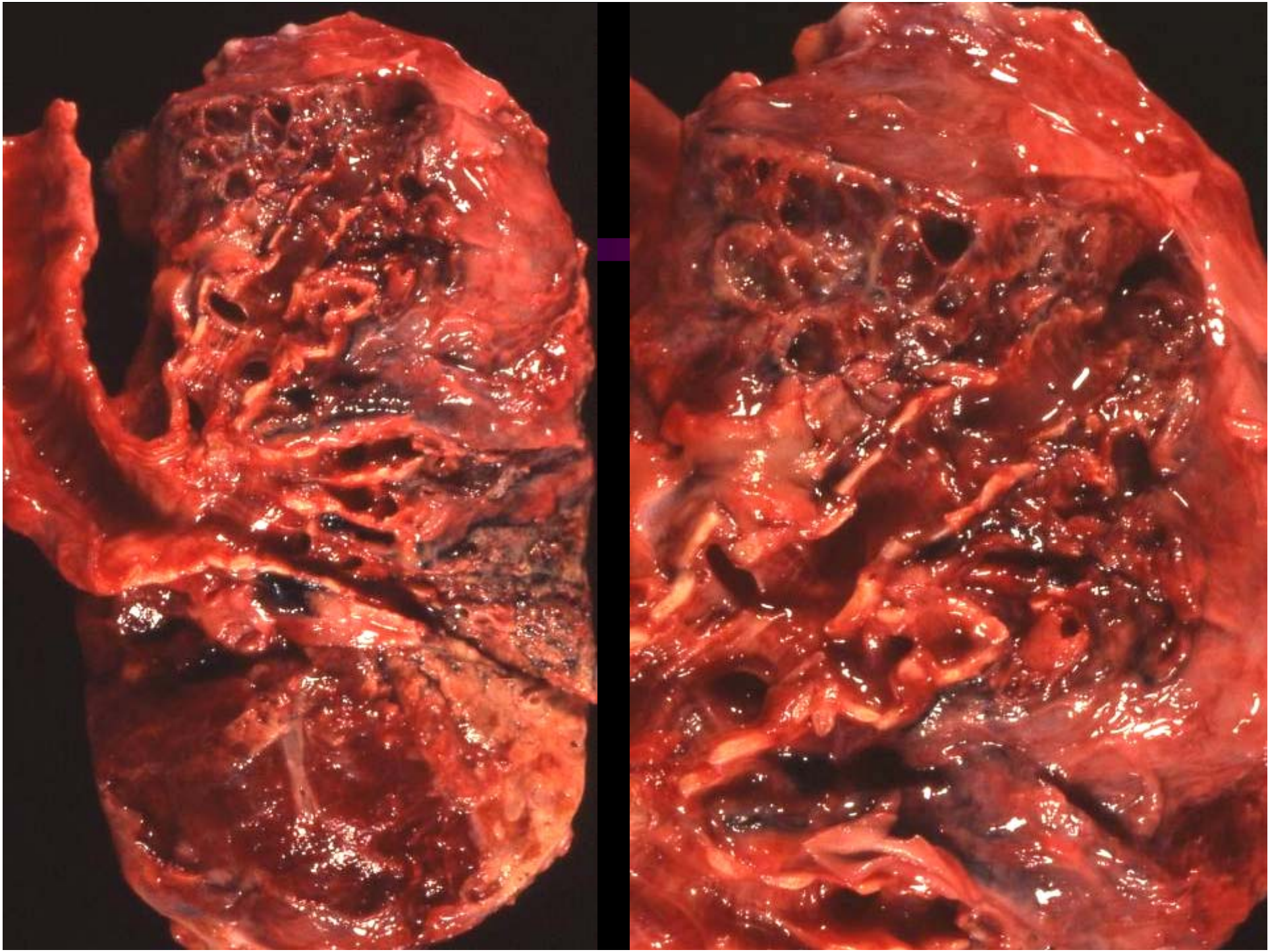
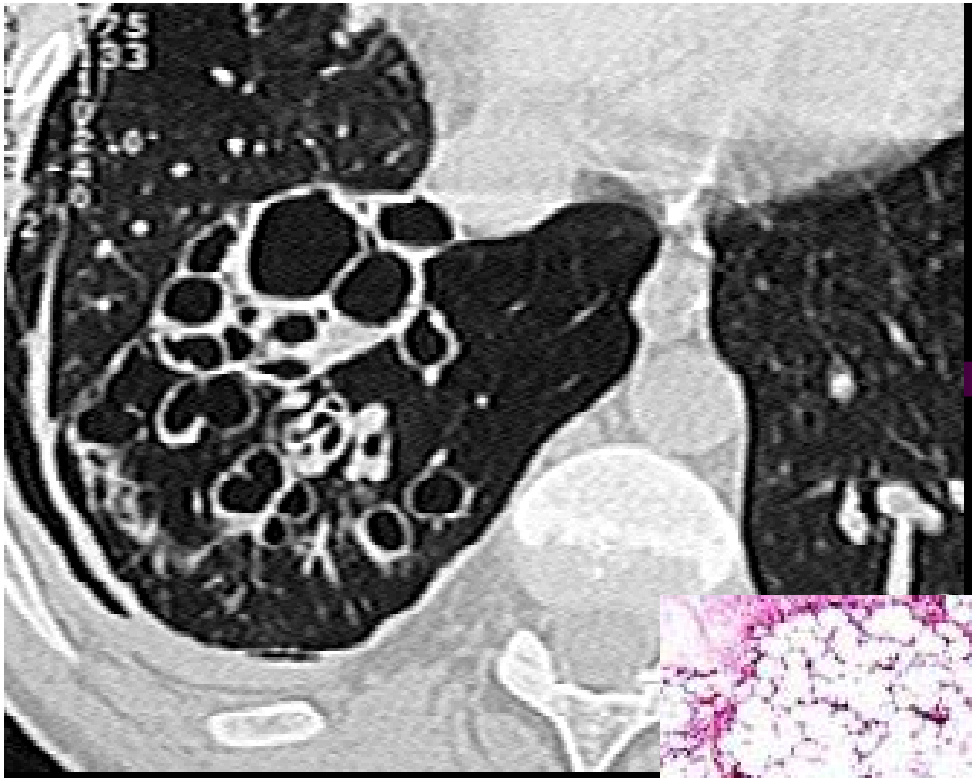
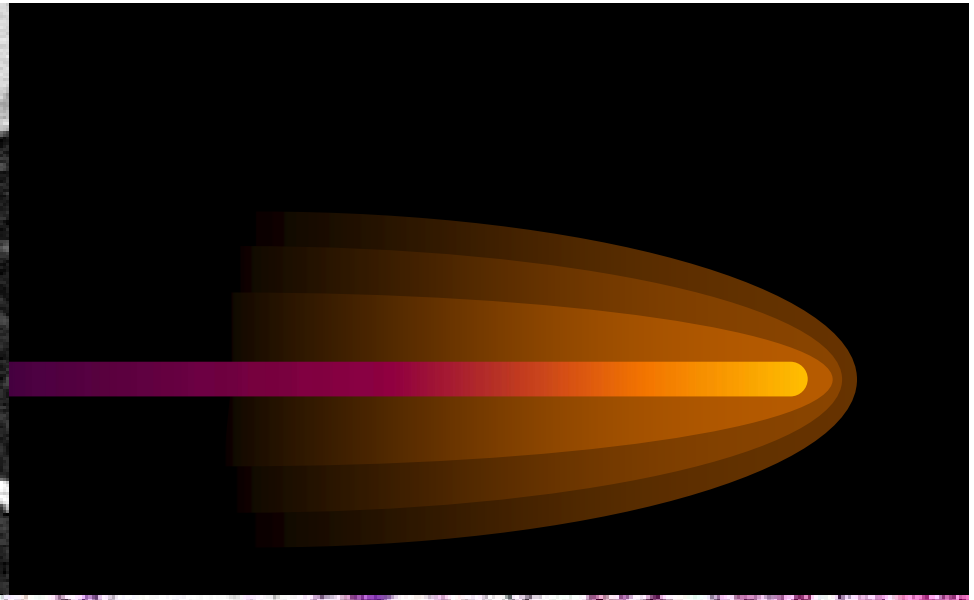
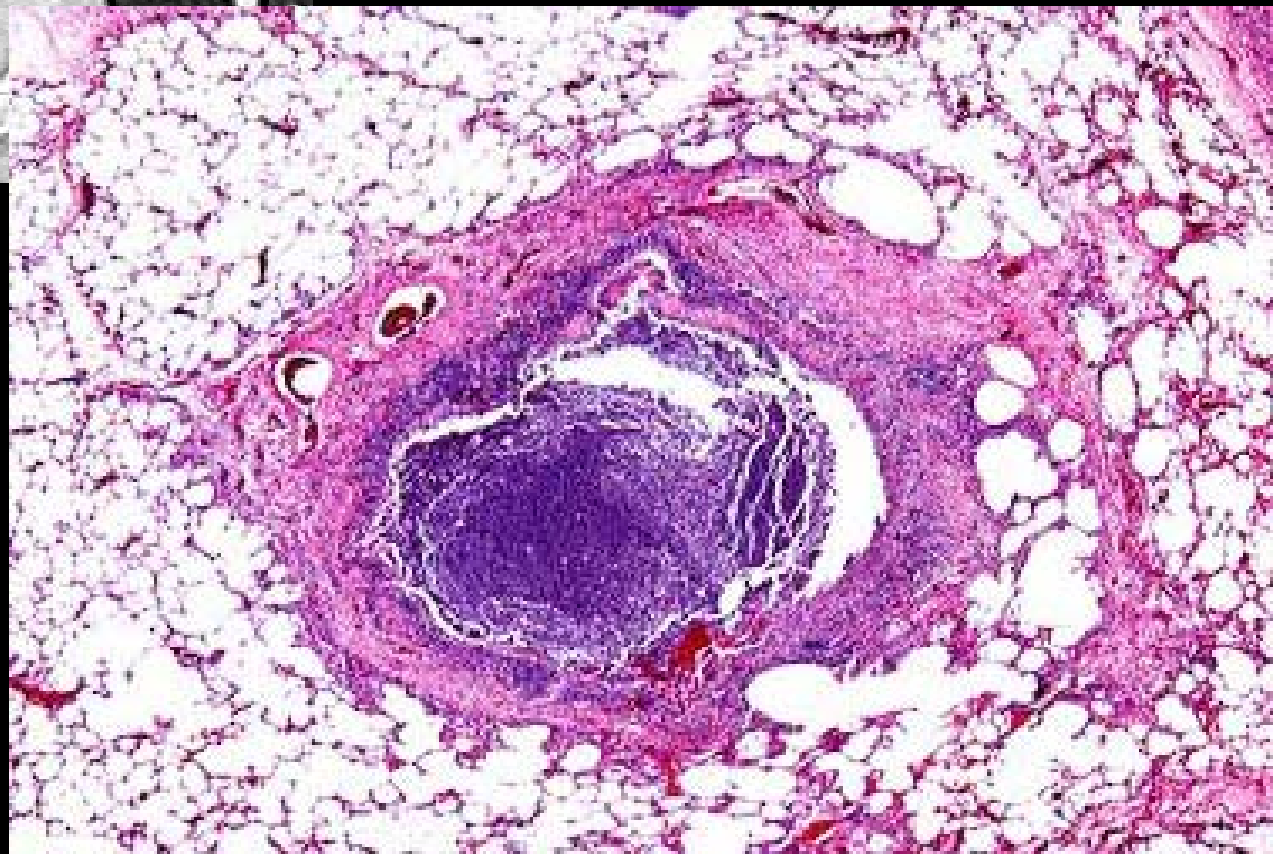
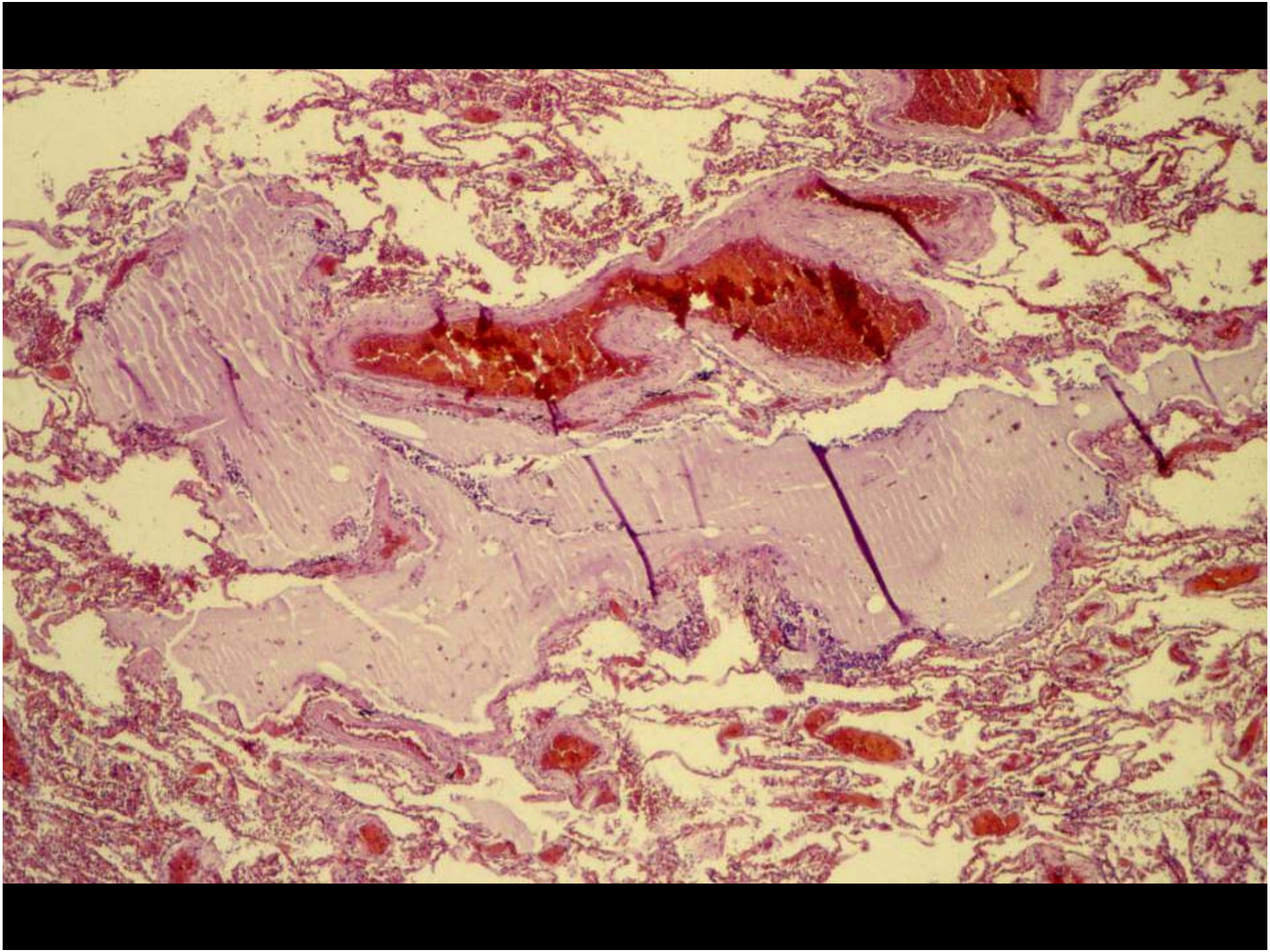












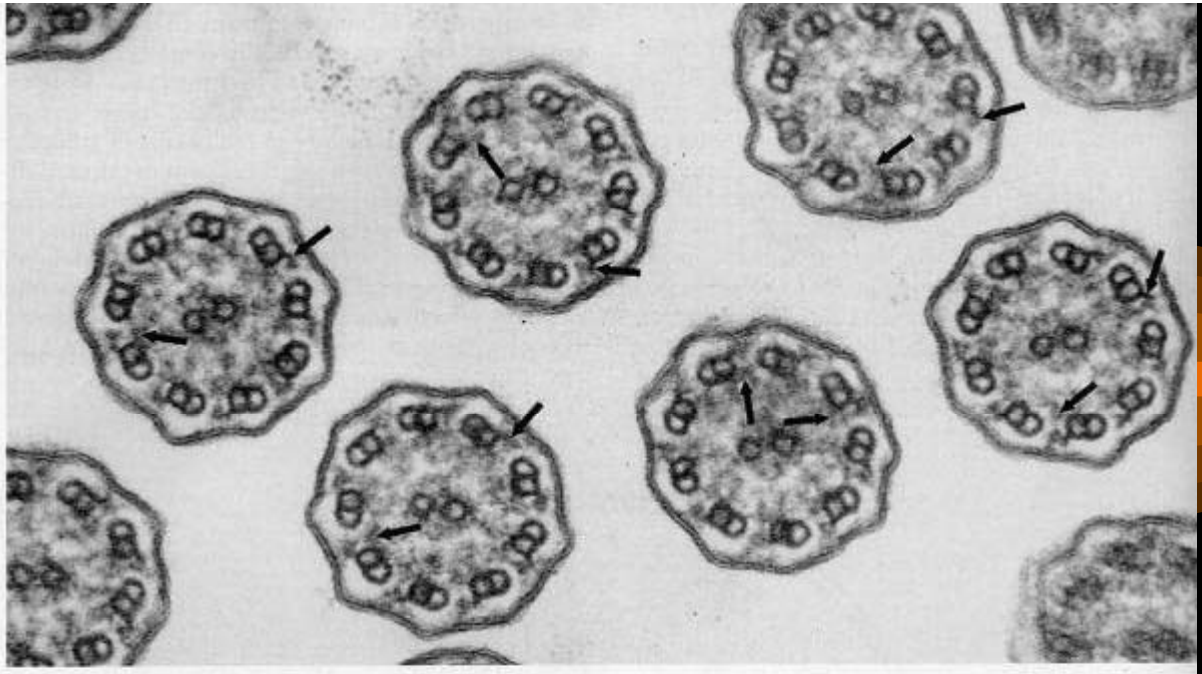
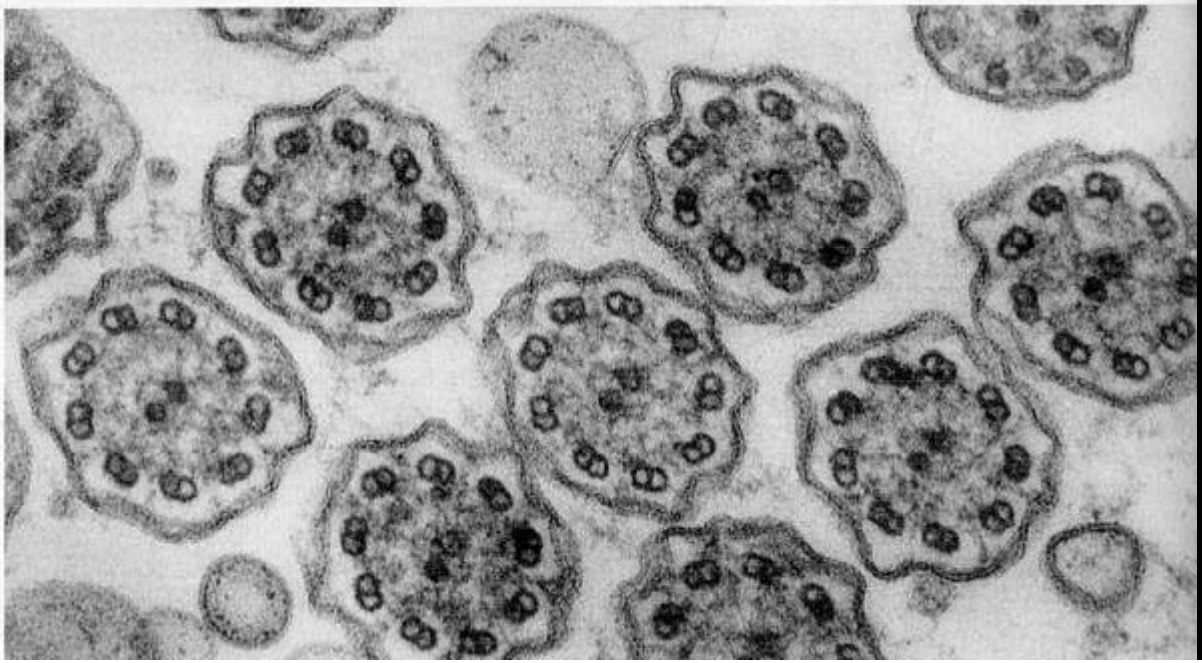


Figure 11.59. Normal cilia (nasal mucosa). Outer and inner dynein arms (*arrows*) are apparent in these cilia. Inn
arms are usually blurred and less distinct than outer arms. (× 150,000)



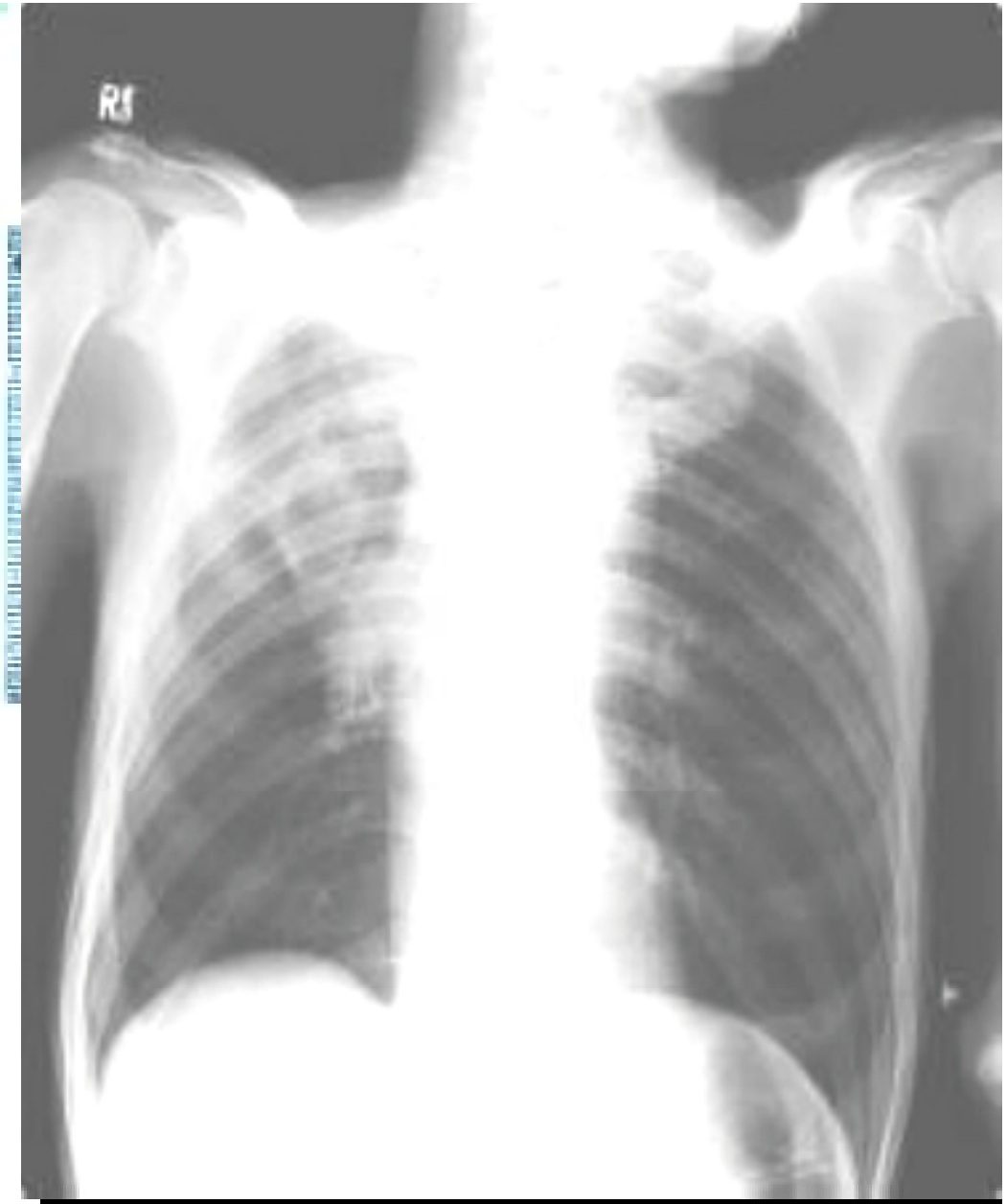
Pulmonary Diseases: Structure-Function Correlation I

- Disease of the conducting airways
  - Asthma
  - Chronic bronchitis
  - Bronchiectasis

Disease of the conducting airways - ASTHMA

- **Bronchospasm, usually reversible**
  - **Allergic trigger**
  - **non-allergic airway hyperresponsiveness**
    - e.g. after infection, triggered by medications, chemical (formalin) or exercise induced
- **Anatomic targets – bronchial epithelium and smooth muscle.**
- **Inflammation**
- **Obstructive disease**

- Gross pathology
  - **hyperinflation, severe if status asthmaticus**
  - **Mucus plugging**
- Microscopic
  - **Smooth muscle hypertrophy**
  - **Inflammation, eosinophils**
  - **Basement membrane thickening**
  - **edema**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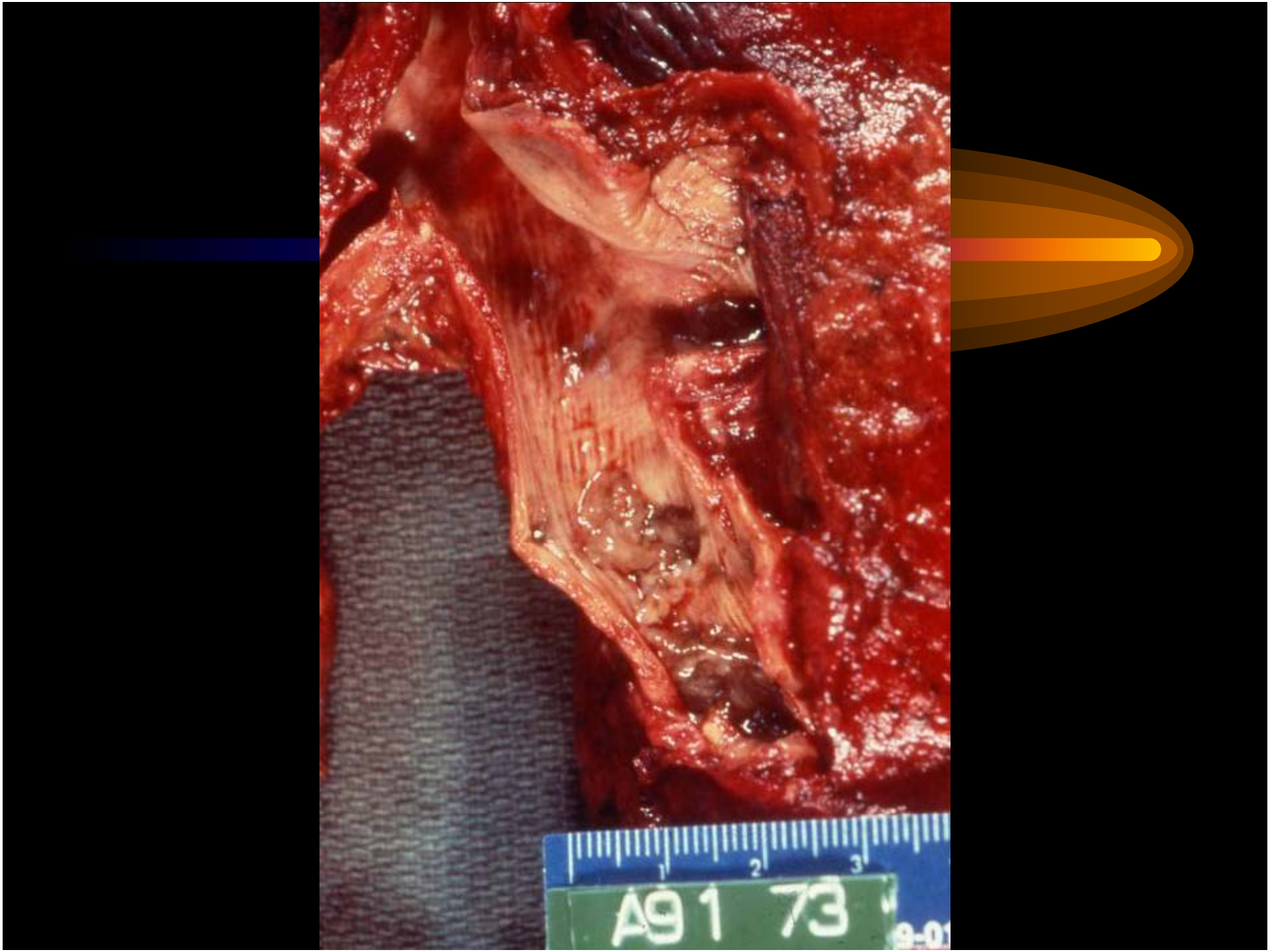
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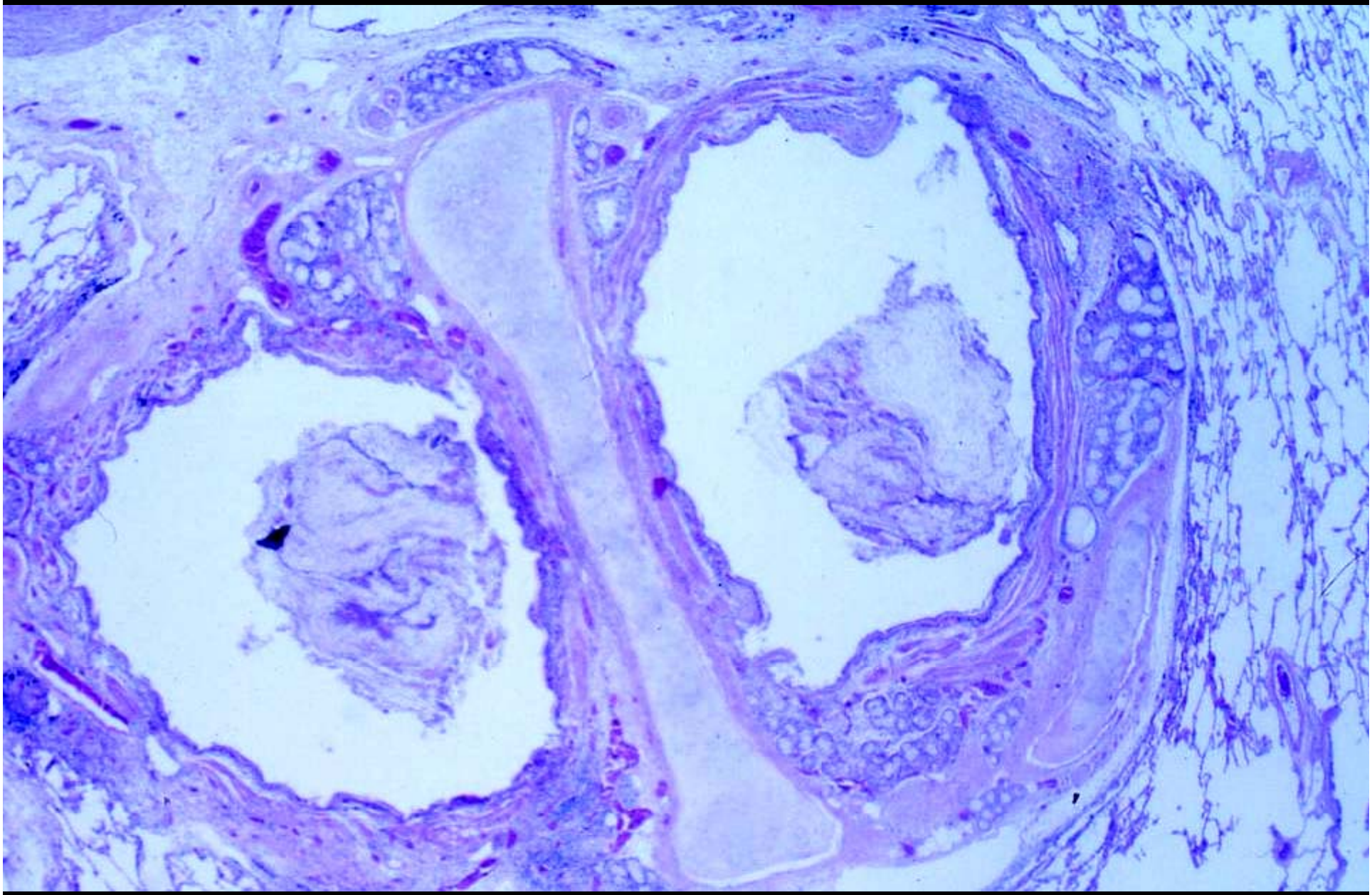
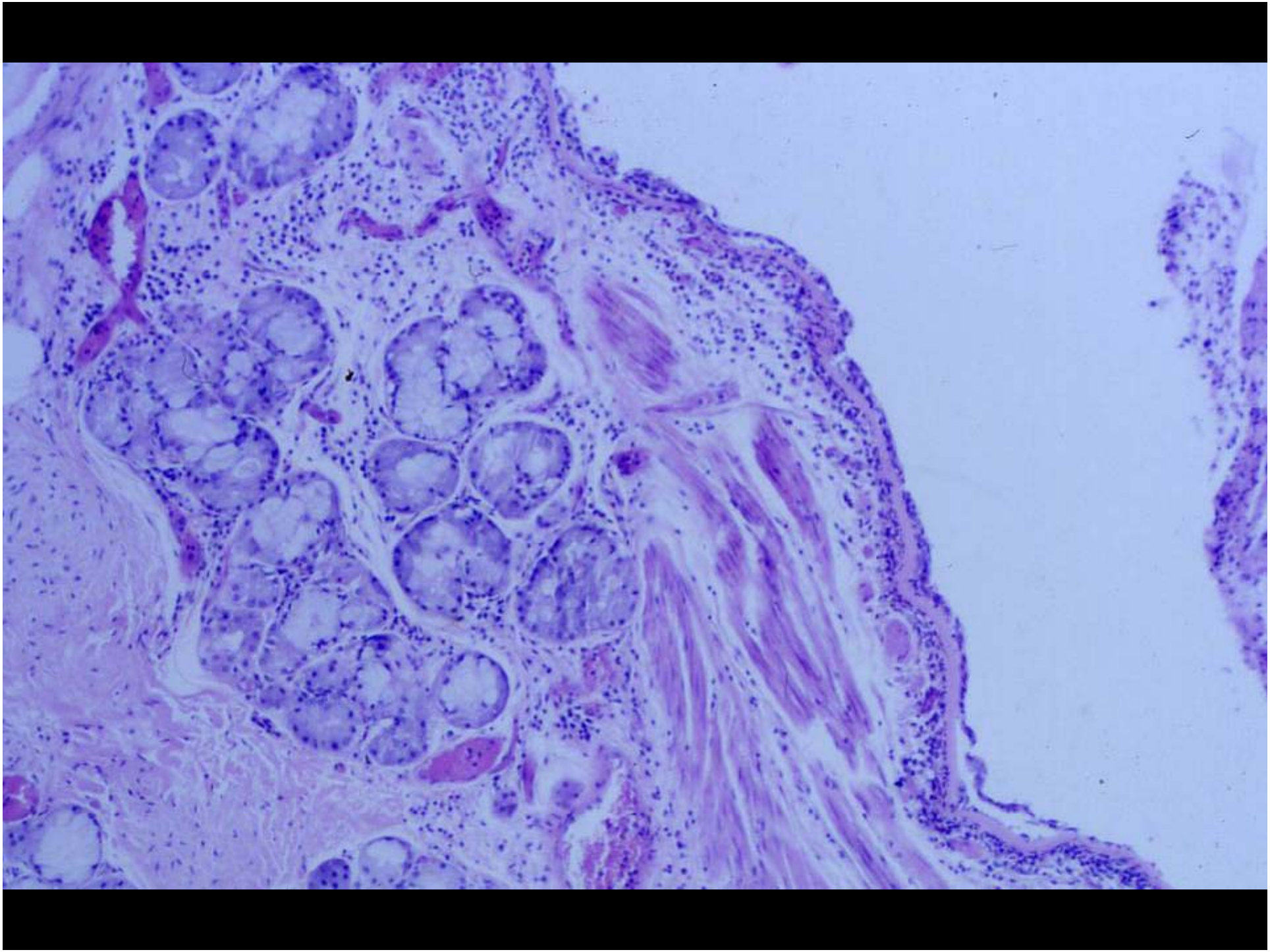
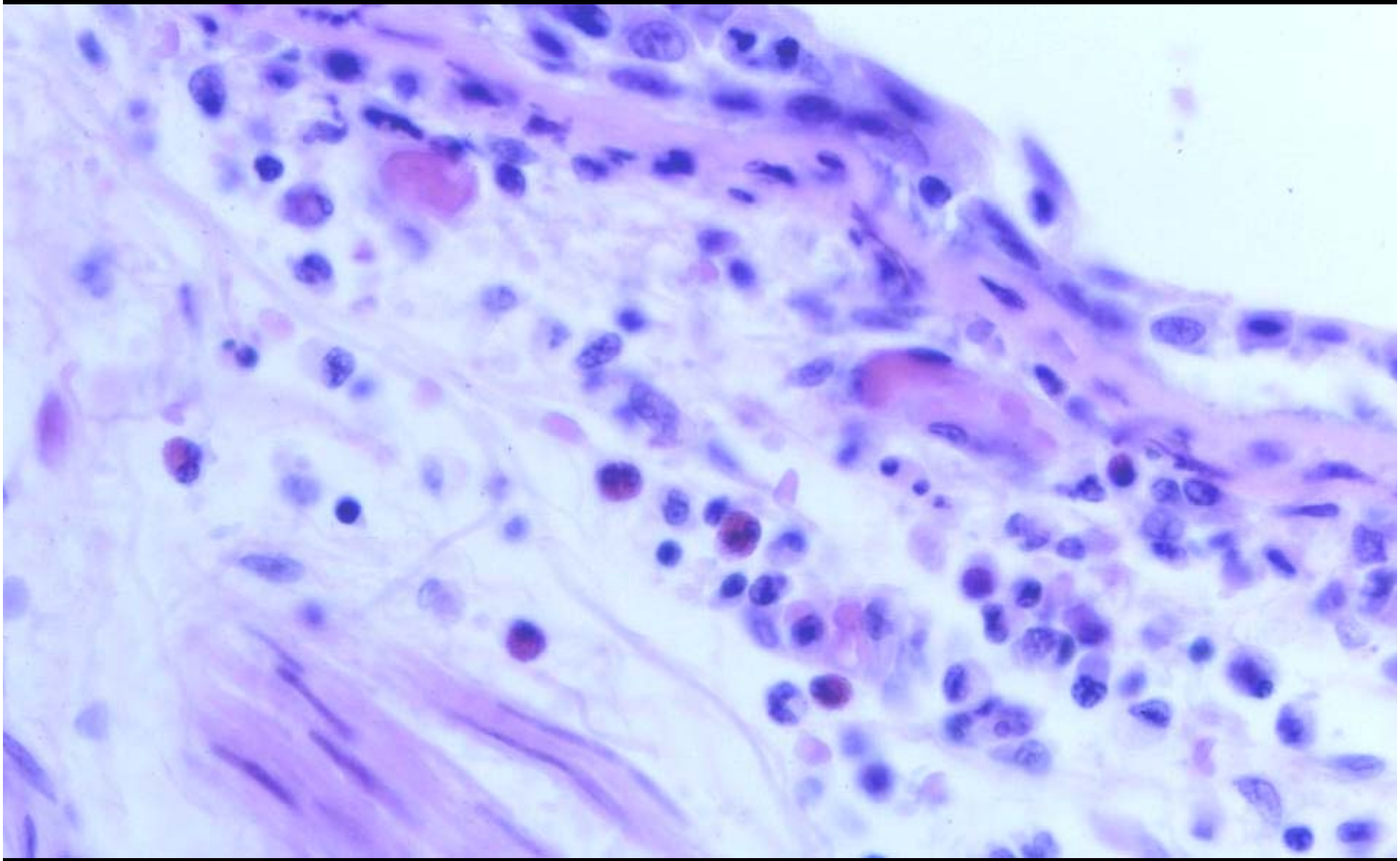
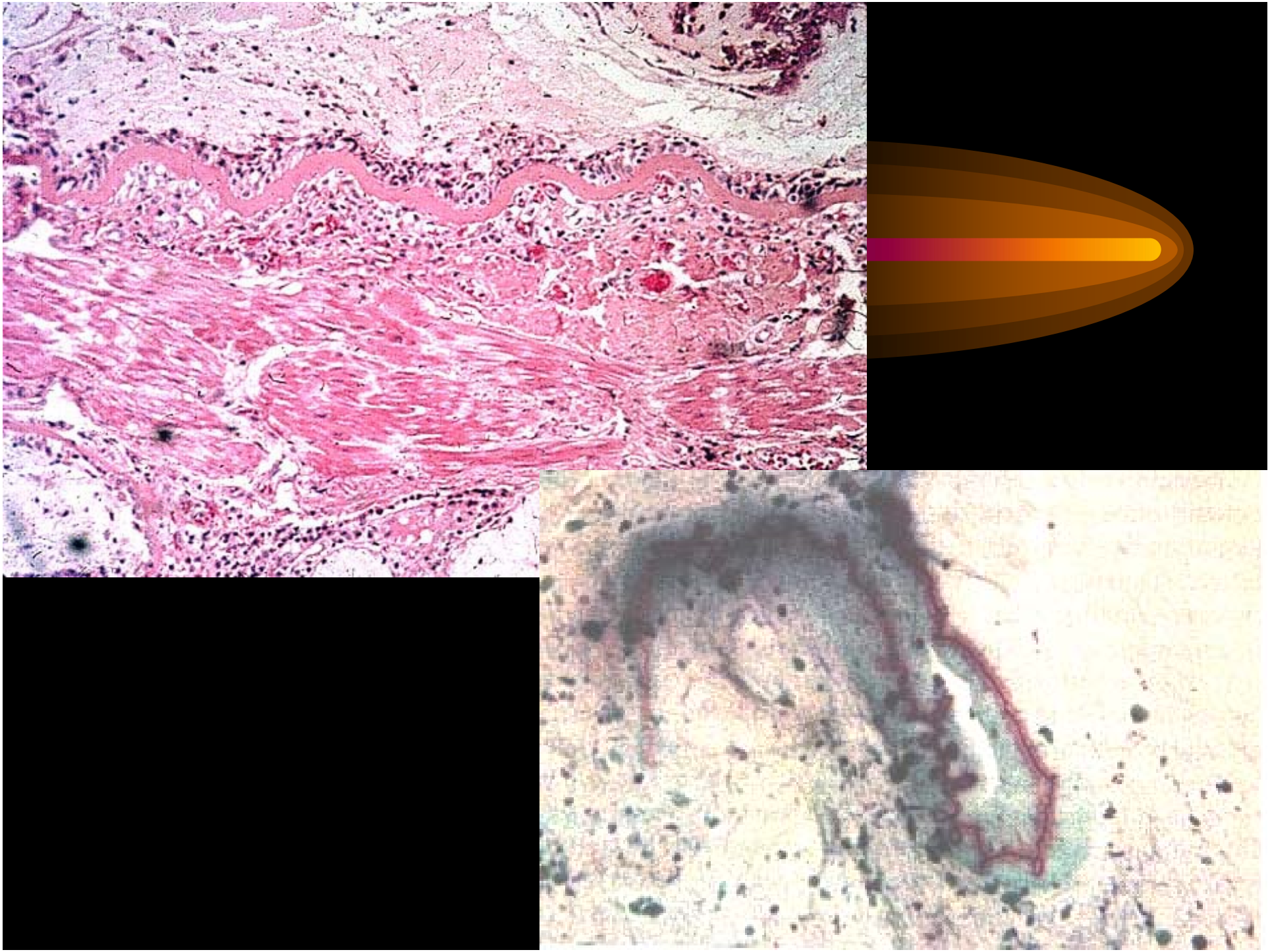








Disease of the conducting airways - ASTHMA

- Gross pathology
  - **–hyperinflation**
  - **–Mucus plugging**
- Microscopic
  - **–Smooth muscle hypertrophy**
  - **–Inflammation, eosinophils**
  - **–Basement membrane thickening**
  - **–edema**

Functional significance

- **Total lung capacity - increased during attack**
- **Work of breathing increased due to airway resistance**
- **Airway resistance increased, on expiration more than inspiration**

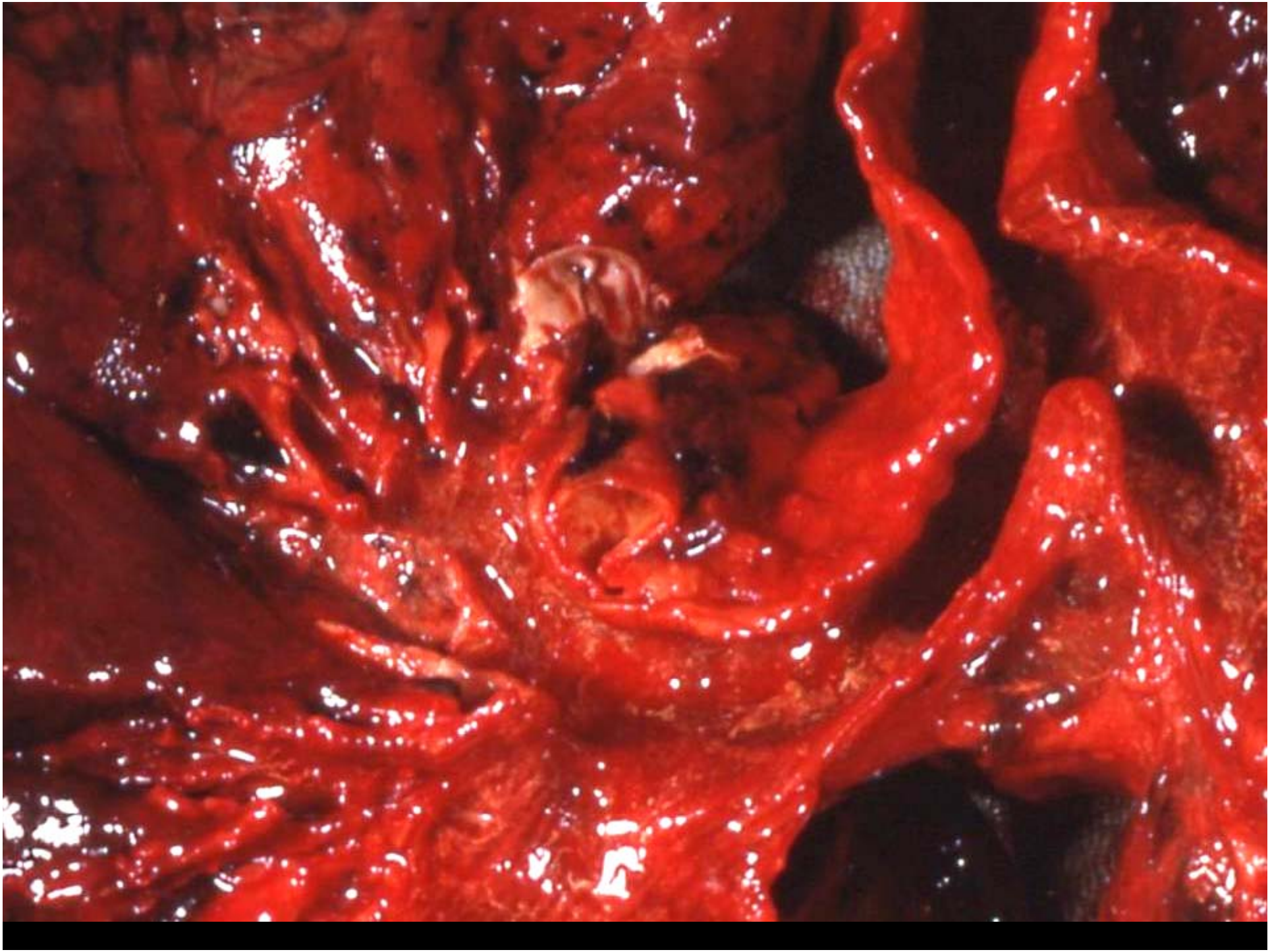
Pulmonary Diseases: Structure-Function Correlation I

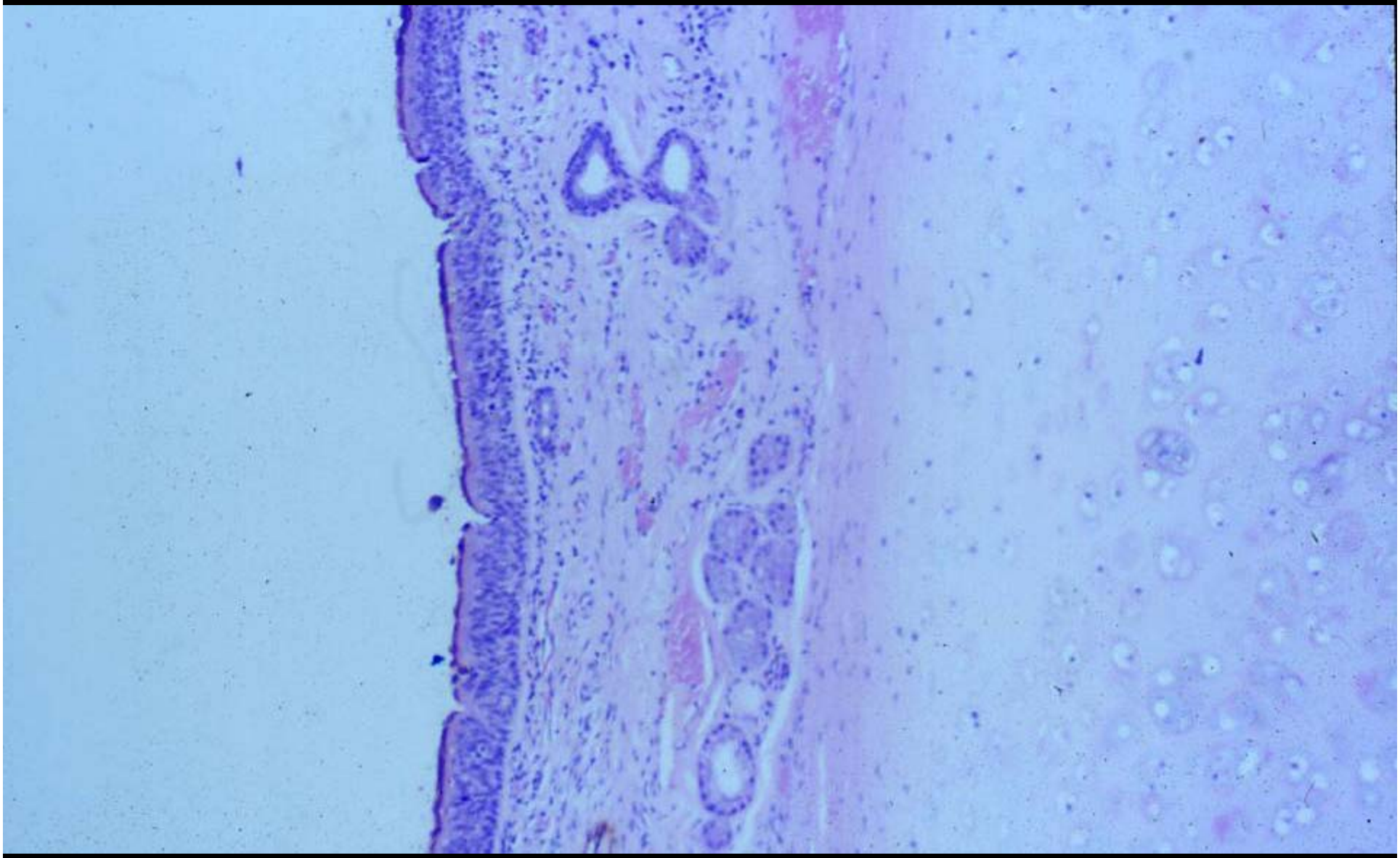
- Disease of the conducting airways
  - Asthma
  - Chronic bronchitis
  - Bronchiectasis

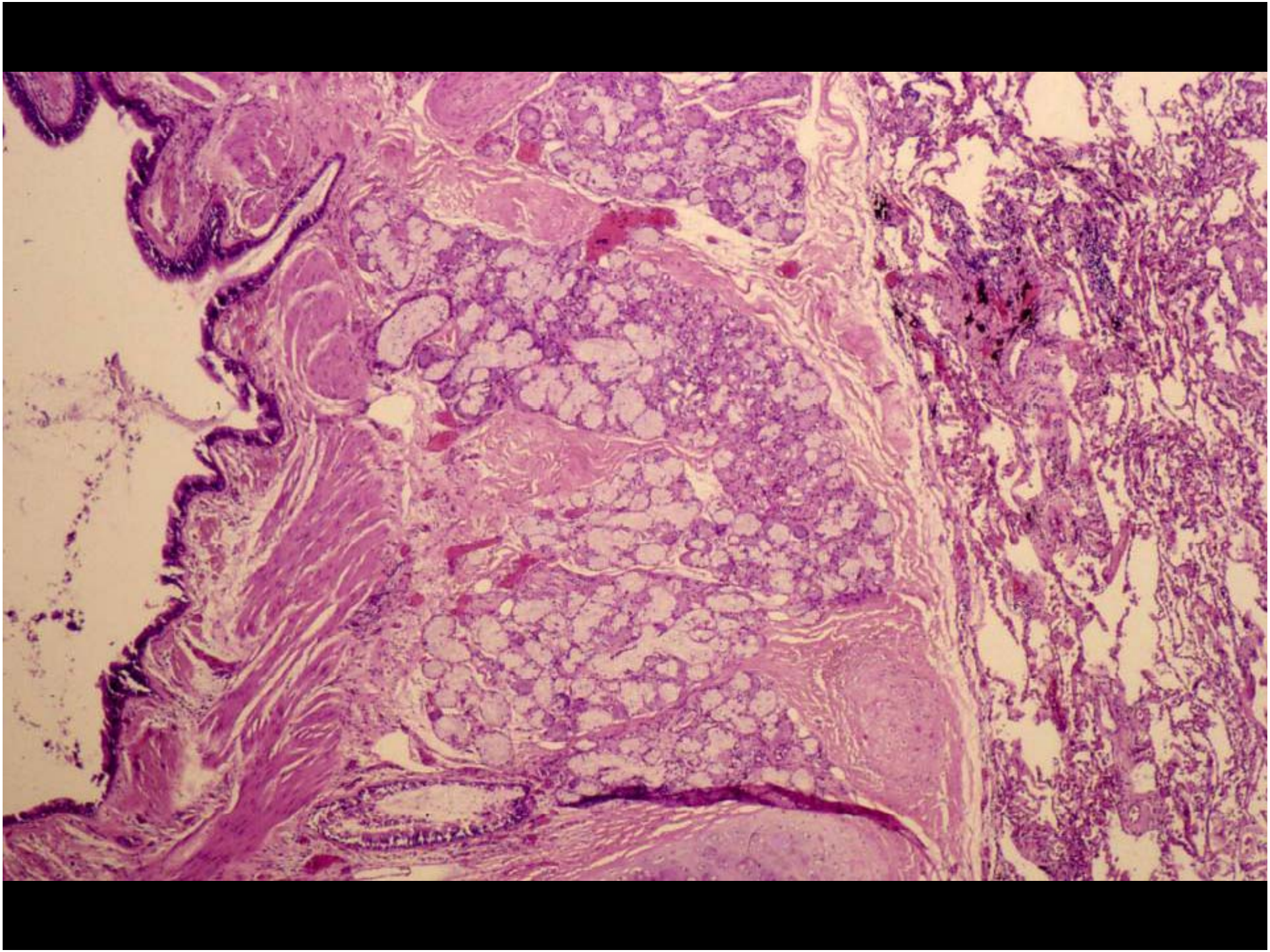
Disease of the conducting airways - Chronic bronchitis

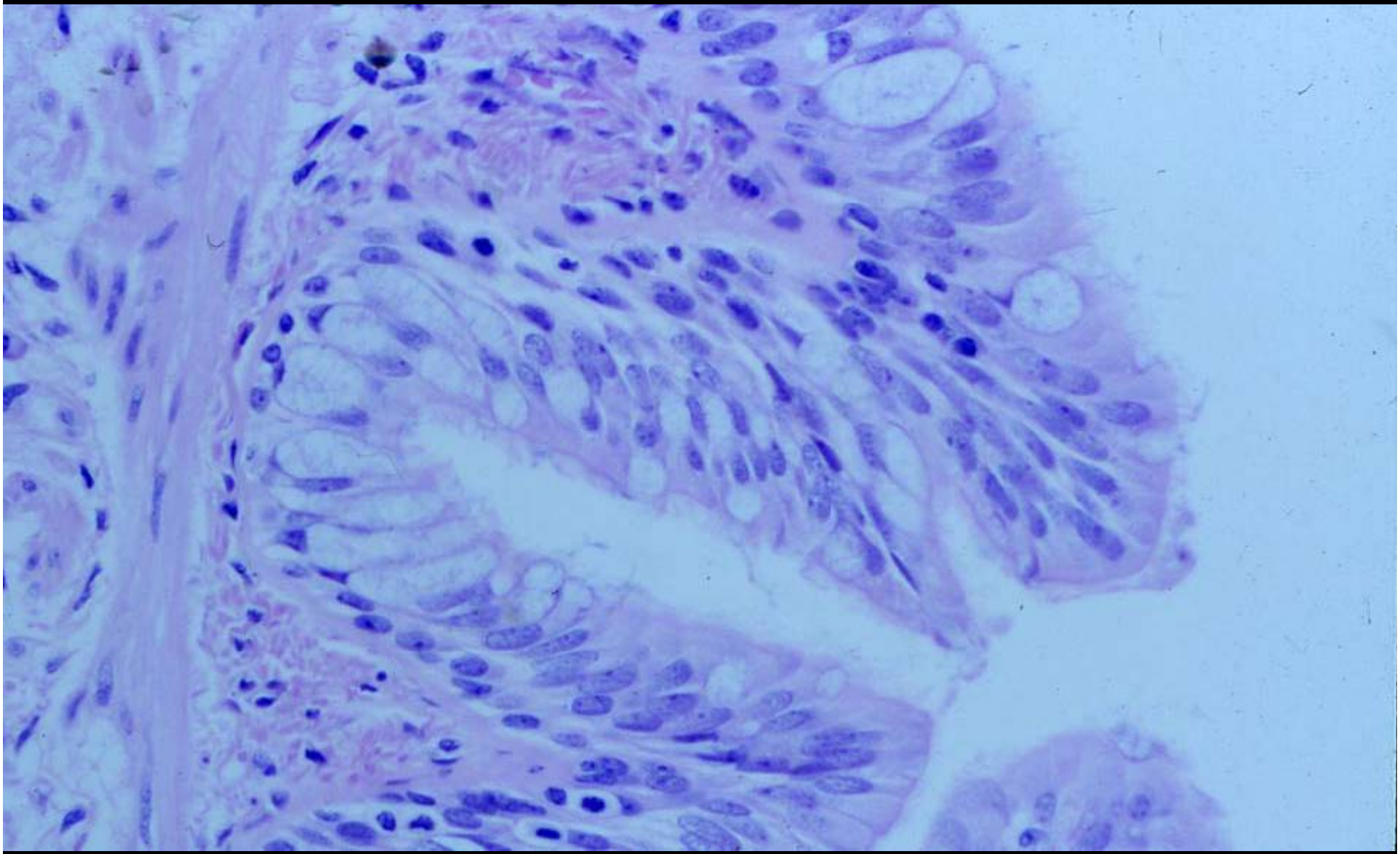
- Persistent cough with sputum production for 3 months in two 2 consecutive years.
- Smoking
- Repeated infections

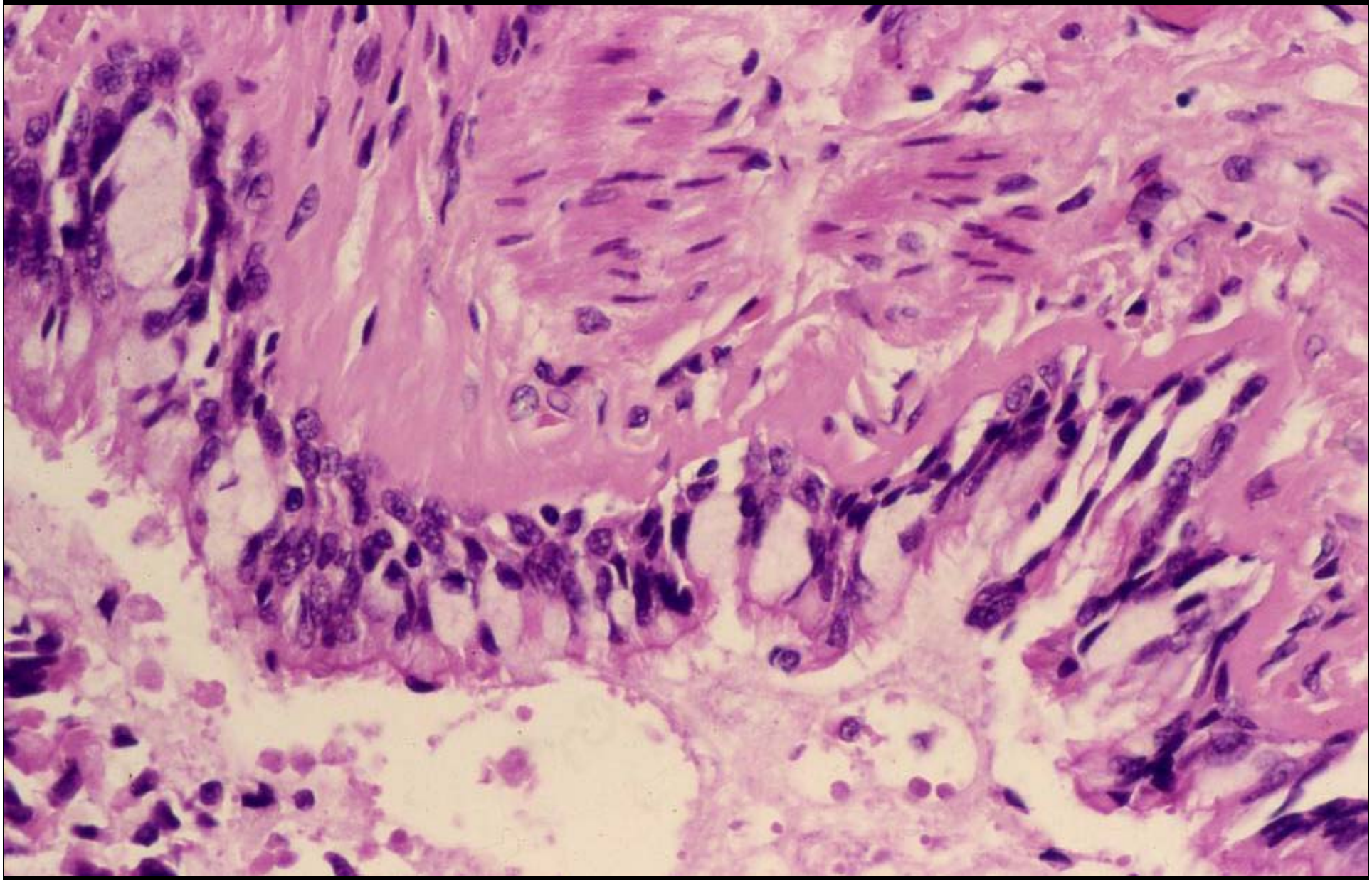
- **<u>Gross Pathology</u>: Brown discolored, mucus filled bronchi.**
- **<u>Microscopic :</u>**
  - **Bronchial gland hyperplasia**
  - **Goblet cell metaplasia**
  - **Chronic inflammation**
  - **Fibrosis of bronchioles**
  - **Loss of cilia**

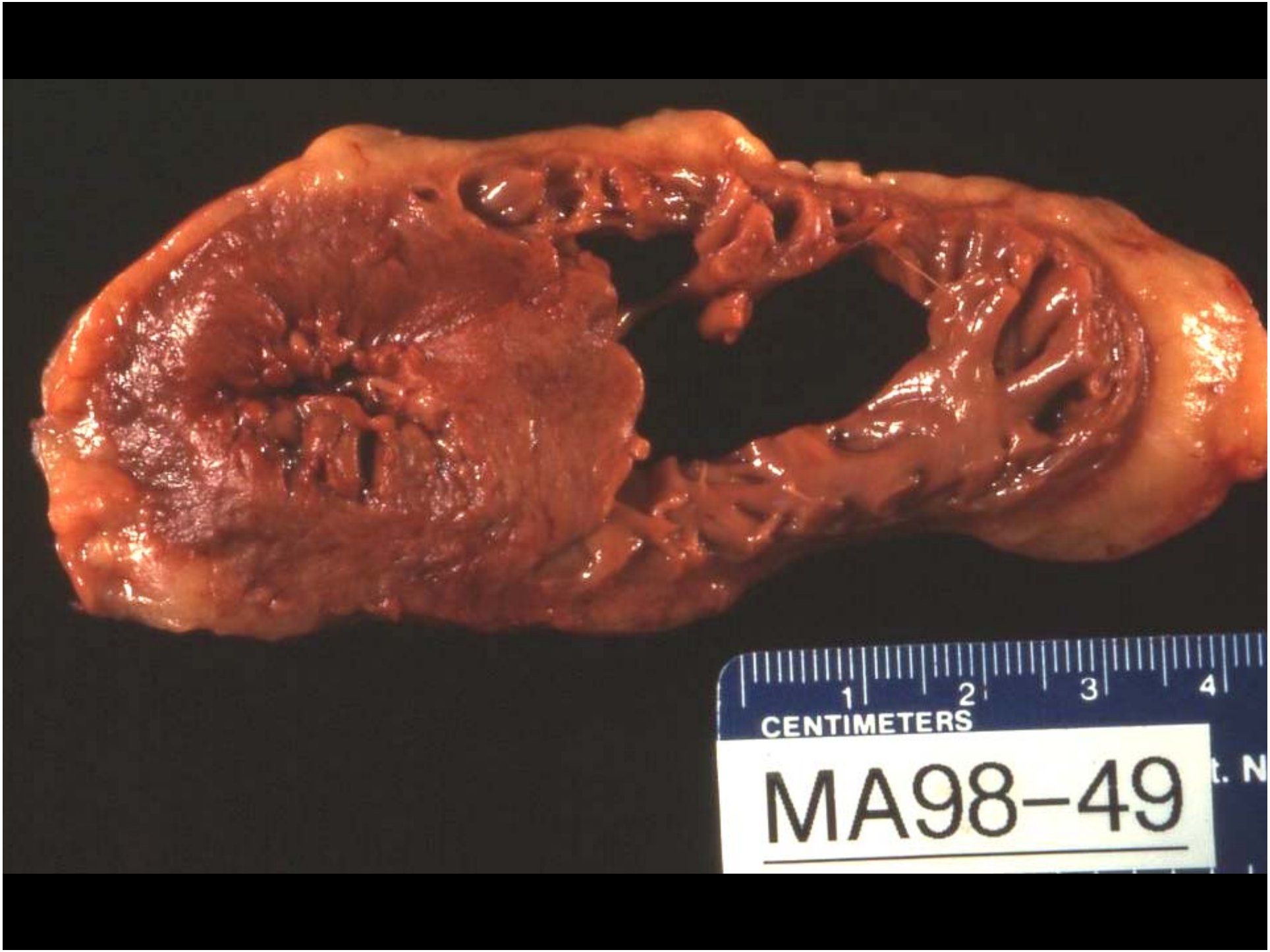








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Disease of the conducting airways - Chronic bronchitis

- **Gross Pathology: Brown discolored, mucus filled bronchi.**
- **Microscopic :**
  - **Bronchial gland hyperplasia**
  - **Goblet cell metaplasia**
  - **Chronic inflammation**
  - **Fibrosis of bronchiolar walls**
  - **Loss of cilia**

- **Functional Significance**
  - **Airway resistance, due to mucus, edema and narrowing. Obstructive disease**
  - **Degree of obstruction determines extent of V/Q mismatch**
  - **Lung capacity normal**
  - **Right heart failure and pulmonary hypertension can occur – hypoxic vasoconstriction and ?endothelial dysfunction**

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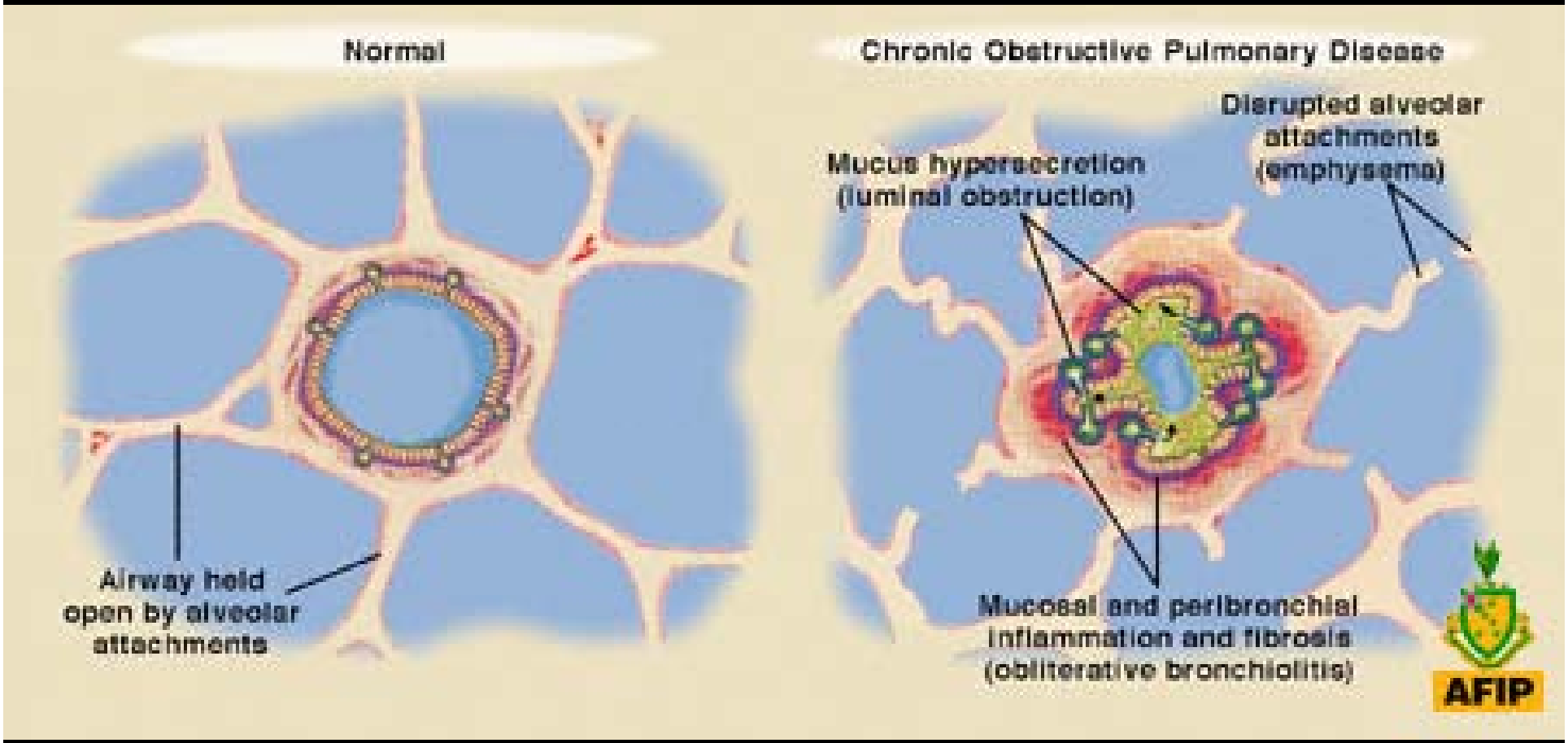


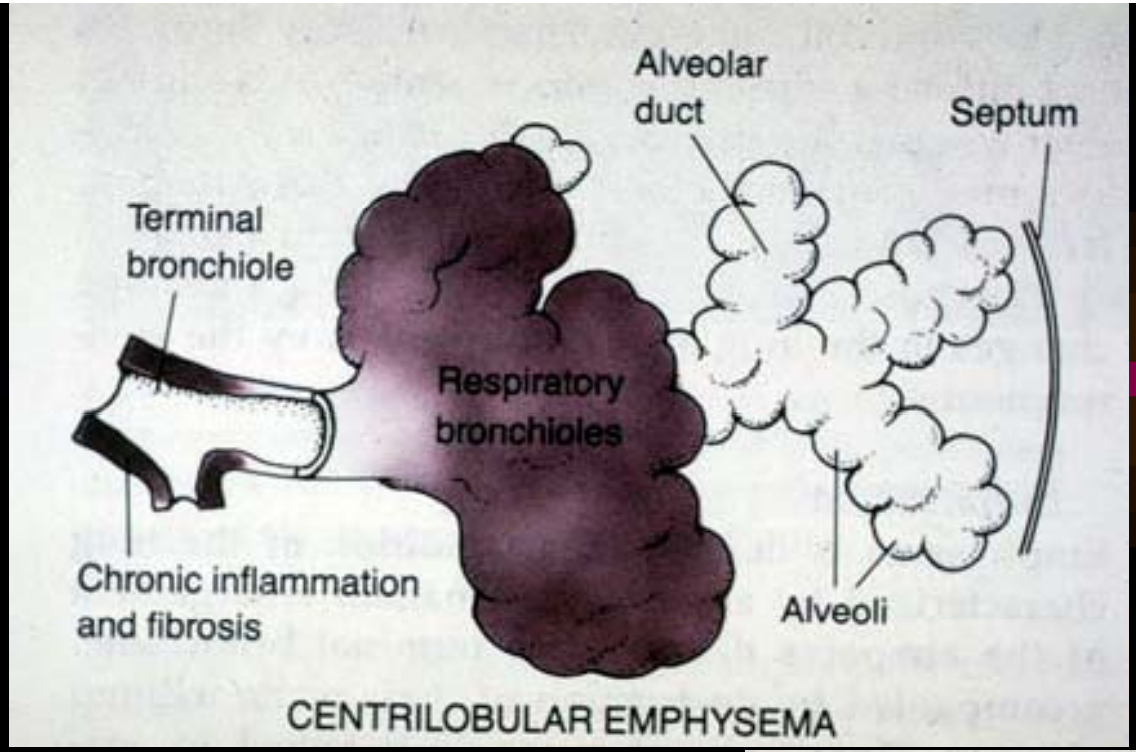
From NEJM
2000;343:270

Destruction of acinar walls - Emphysema

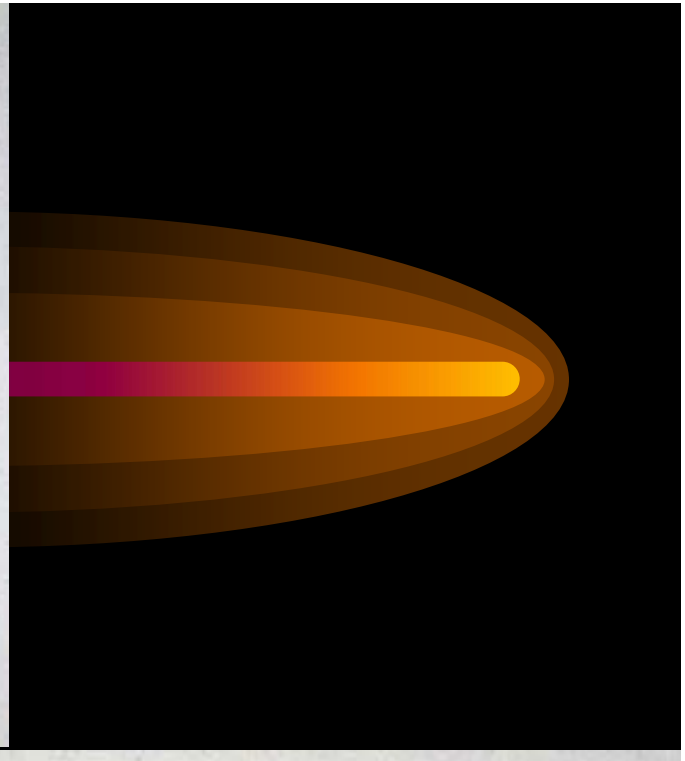
- Obstructive disease
- Involves the airway distal to the terminal conducting bronchiole
- Airway wall is damaged, and fibrosis can be present.
- Is classified by pattern/ location of damage within the respiratory acinus

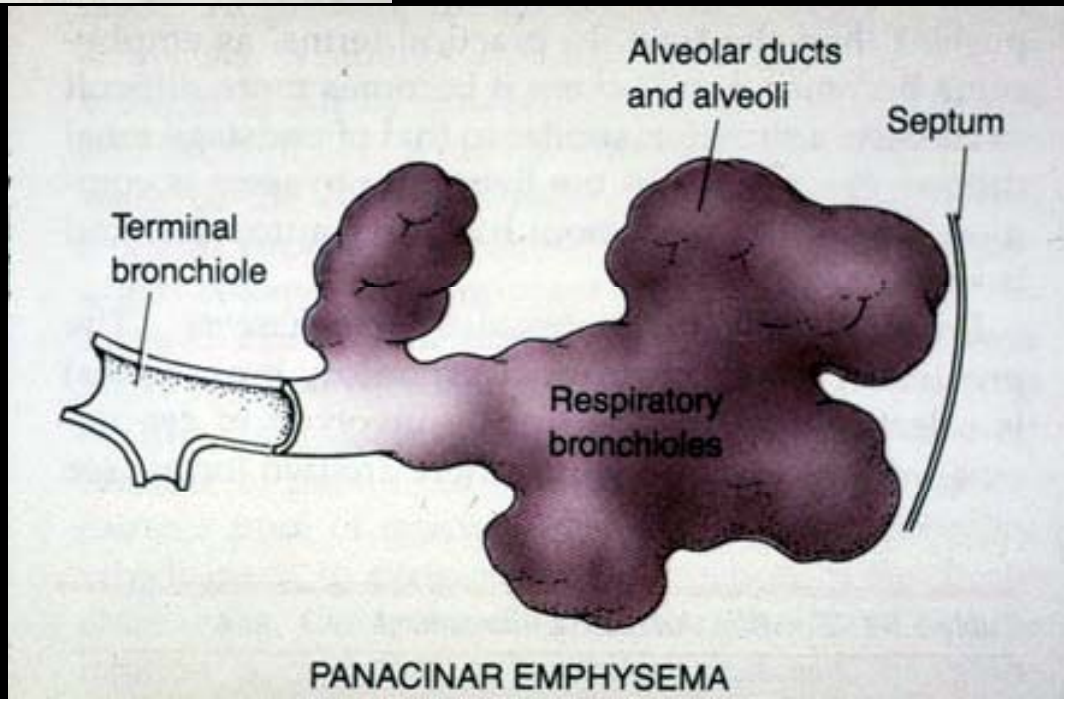
Destruction of acinar walls - Emphysema

- **Centriacinar (Centrilobular)**
  - **Smoking**
  - **Damage is to the respiratory bronchiole. When severe disease develops, whole acinus involved.**
  - **Upper lobes, especially apical portions most affected**
- **Panacinar (Panlobular)**
  - **Damage is to the entire acinar unit from respiratory bronchiole to alveolar sac**
  - **More severe at bases, but is more diffuse than CLE**
  - **Alpha -1 antitrypsin deficiency**

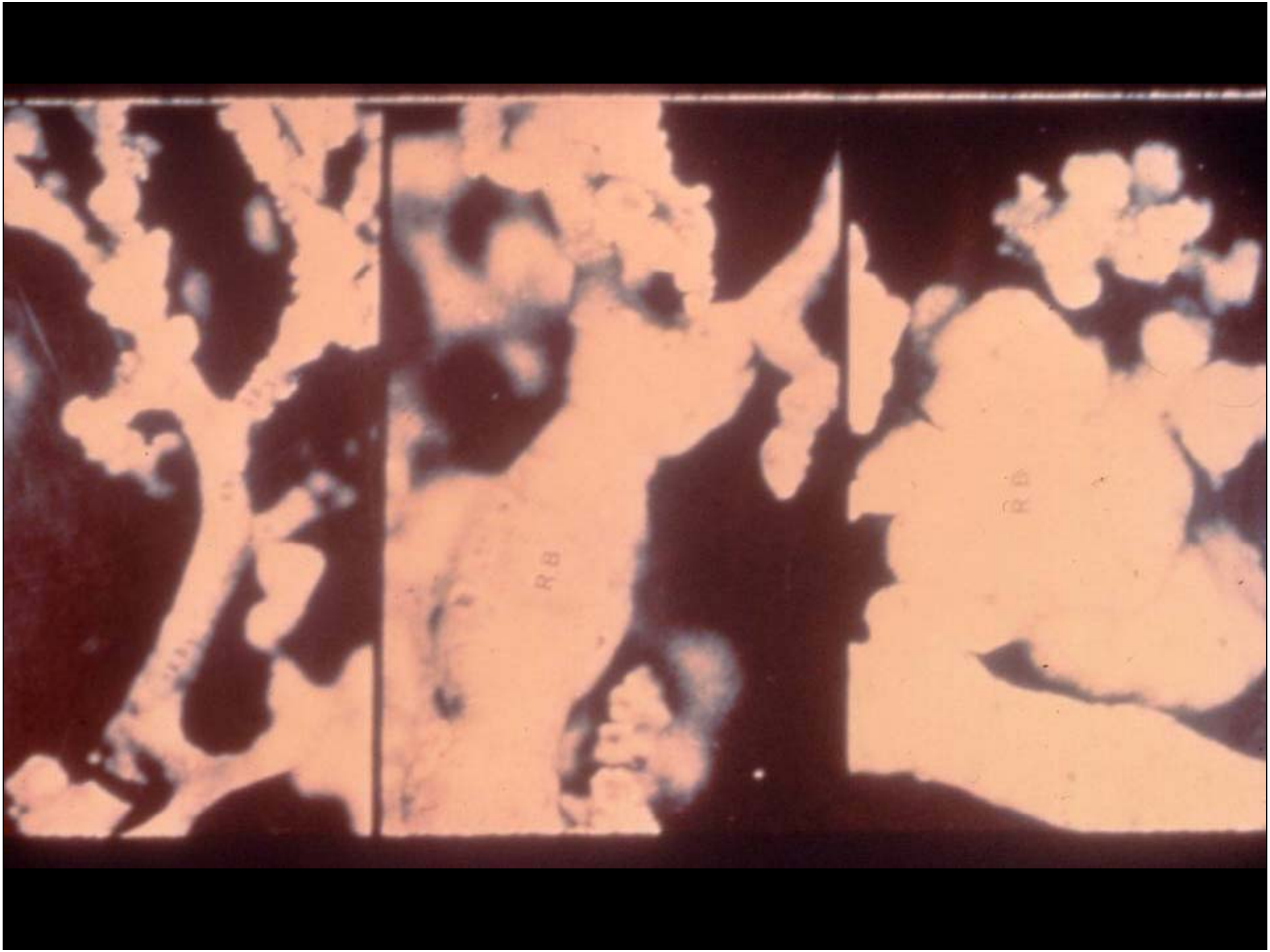


CENTRILOBULAR EMPHYSEMA





PANACINAR EMPHYSEMA



Destruction of acinar walls - Emphysema

- Pathogenesis
  - Protease/Antiprotease hypothesis
    - **Imbalance between neutrophil derived elastase and deficiency in anti-elastase activity from alpha-1-antitrypsin**
    - **Neutrophil elastase is unchecked, causing tissue destruction**
    - **Smoking causes more rapid evolution of panacinar emphysema.**

Destruction of acinar walls - Emphysema

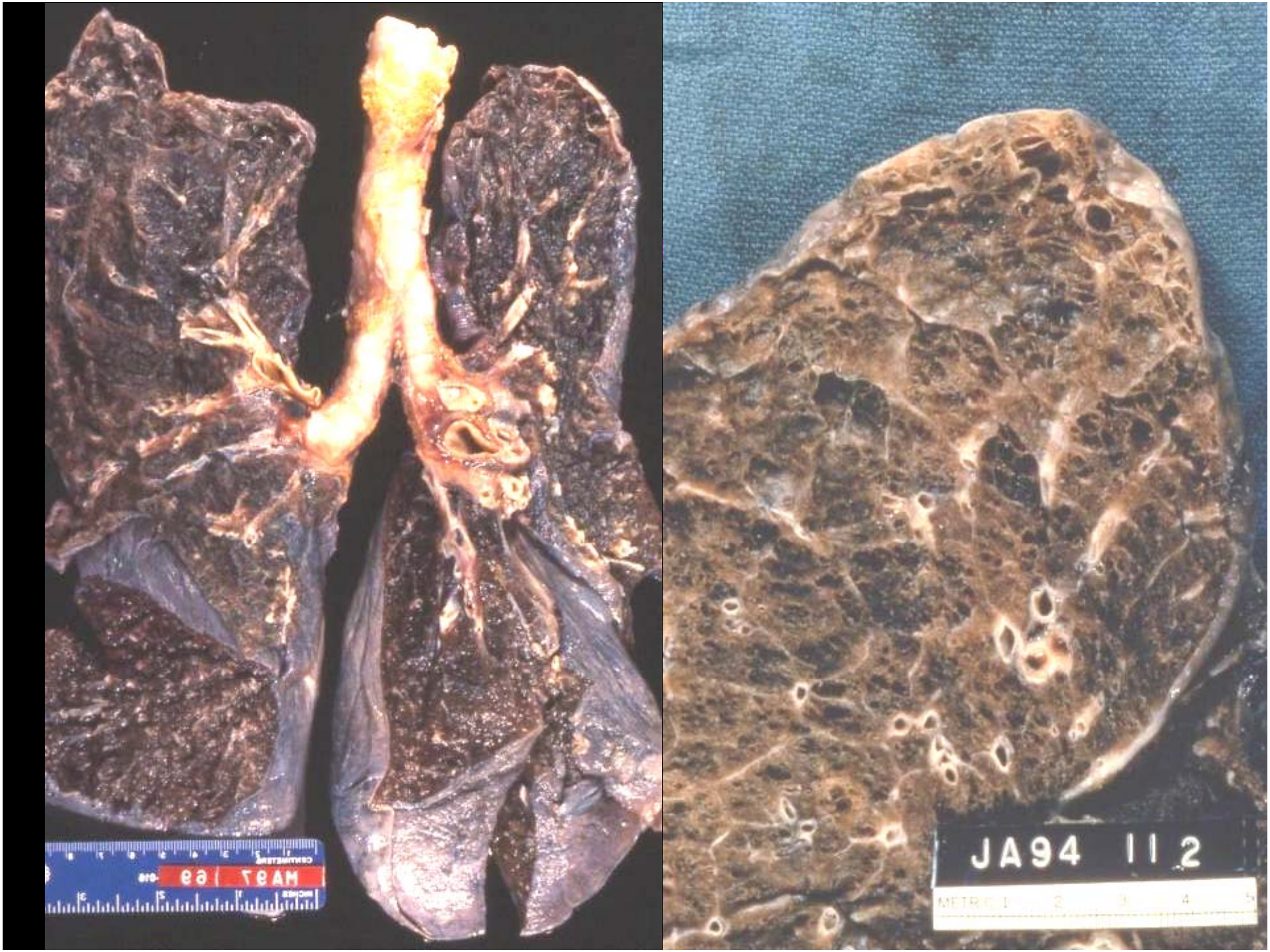
- Pathogenesis
  - Protease/Antiprotease hypothesis
    - **In panacinar emphysema, deficiency in alpha 1 anti-trypsin is a genetic defect**
    - **In centrilobular emphysema, the interplay of cigarette smoke, acquired deactivation of A1AT activity and activation of a perhaps broader spectrum of neutrophils and macrophage derived proteases may be significant. These may include proteinase 3, cathepsins and matrix metalloproteinases (1,2,9,12)**
    - Other inhibitors of protease activity may also play a role – e.g. TIMPs

Destruction of acinar walls - Emphysema

CENTRILOBULAR VS. PANACINAR

- **Gross pathology**
  - **Upper lobe, irregularly dilated airspaces**
  - **Thin walled and grossly apparent**
- **Microscopic**
  - **Dilated spaces, alongside normal alveoli**
  - **Anthracotic pigment**

- **Gross Pathology**
  - **Lower lobe, more uniformly dilated spaces**
  - **Voluminous lungs**
- **Microscopic**
  - **Dilated spaces, uniformly dilated.**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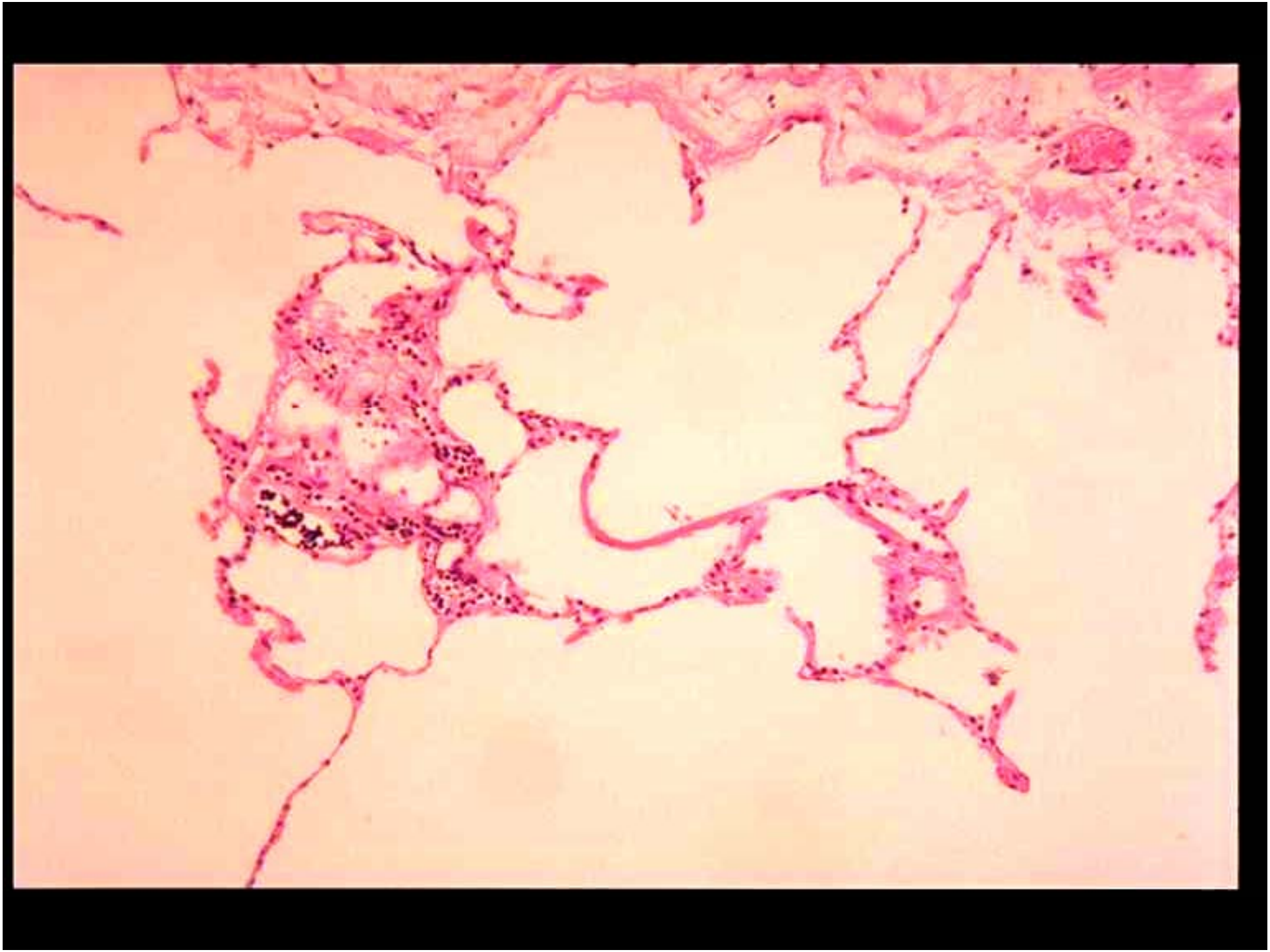

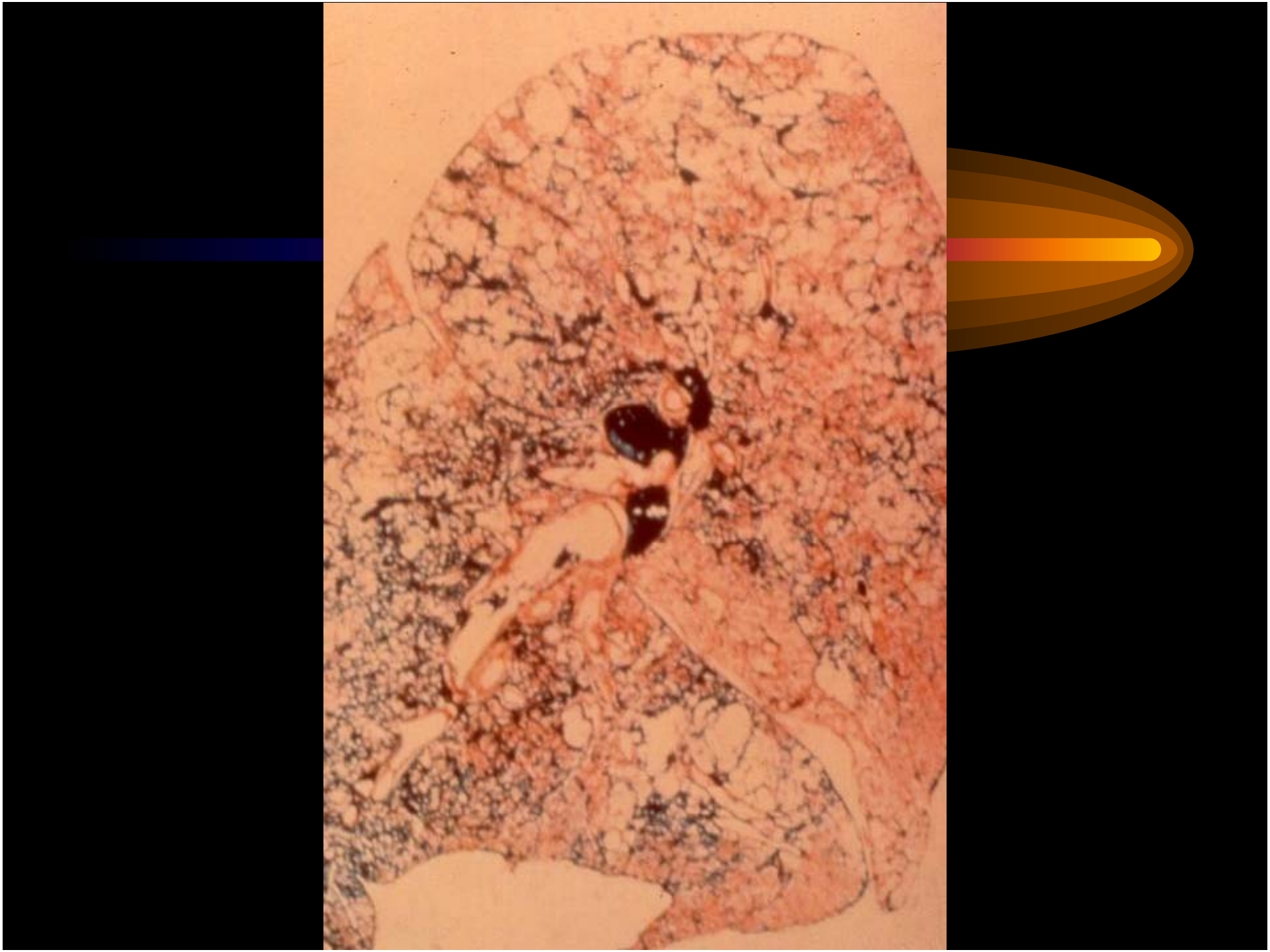

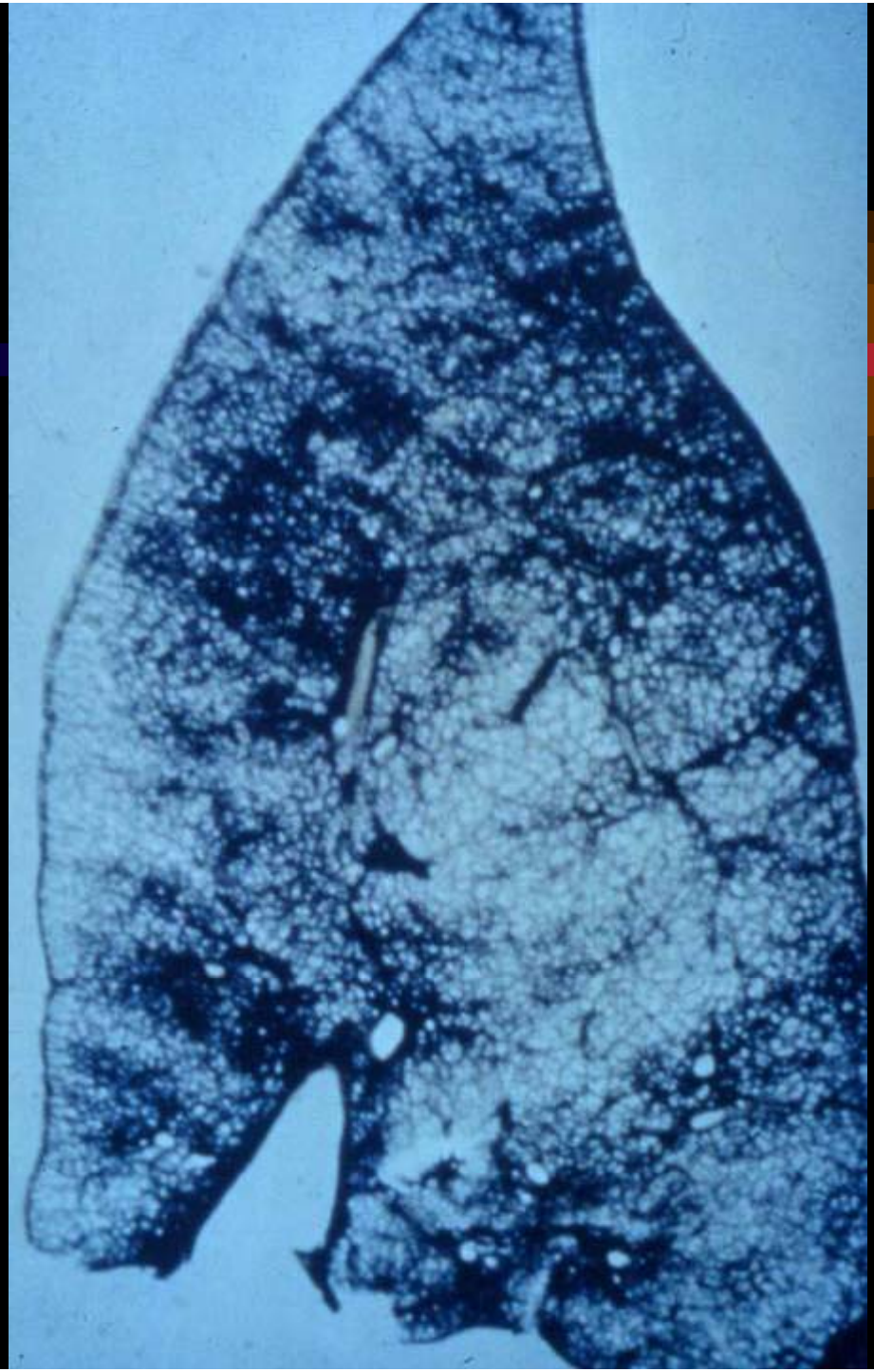

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Destruction of acinar walls - Emphysema

STRUCTURAL VS. FUNCTIONAL

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- **Total lung capacity increase**
- **Lung compliance increased (elastin destruction)**
- **V/Q mismatch mild - airway and capillary destruction**
- **Recoil decreased; lose radial traction on airways**

Obstructive; worsens on forced expiration