

Obstructive lung diseases

Mechanisms, morphology, and clinicopathologic patterns

COPD · Asthma · Bronchiectasis

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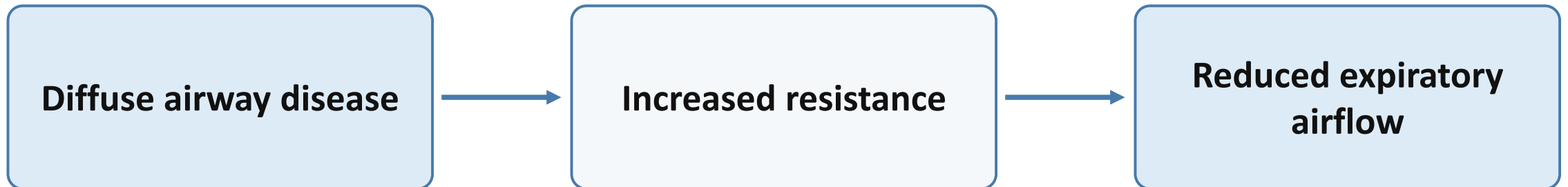
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Teaching objectives

- Define the mechanism of airflow obstruction and its spirometric pattern
- Localize the major obstructive disorders to bronchi, bronchioles, or acini
- Link characteristic morphology to symptoms and functional impairment
- Distinguish COPD, asthma, and bronchiectasis using pathology

Airflow obstruction: The central lesion

- Diffuse airway disease increases resistance to moving air
- Obstruction can occur at several levels of the respiratory tree
- Forced expiration is particularly affected



Schematic

Obstructive versus restrictive physiology

OBSTRUCTIVE

- Increased airway resistance
- Reduced maximal forced expiratory flow
- Low FEV₁/FVC ratio

RESTRICTIVE

- Reduced lung expansion and total lung capacity
- FEV₁ decreases proportionately with FVC
- FEV₁/FVC ratio remains normal

FEV₁/FVC: Physiological distinction

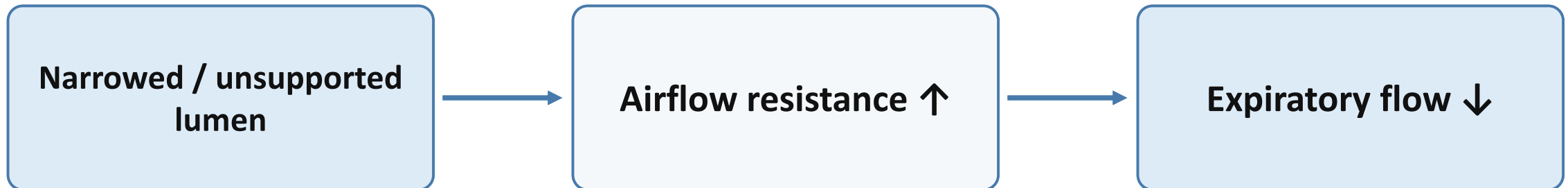
- FEV₁ quantifies volume expired during the first second of forced exhalation
- FVC is the total volume expired during forced expiration
- FEV₁/FVC below 0.7 generally indicates obstruction
- Restriction produces proportionate reductions, preserving the ratio

FEV₁ / FVC

< 0.7: Usually obstruction

Why forced expiration is affected

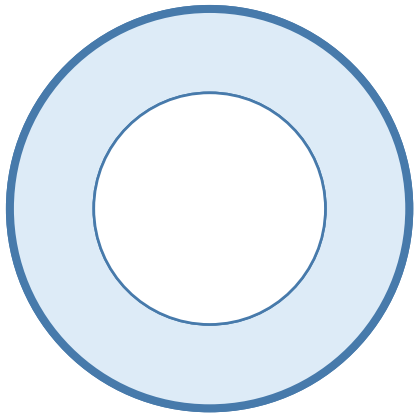
- Narrowing of airway caliber increases resistance
- Loss of surrounding elastic support allows small airways to collapse
- Mucus plugs and airway-wall inflammation further restrict expiration



Schematic

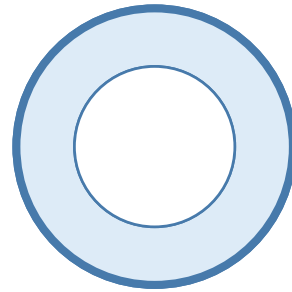
Anatomic sites of airway disease

Bronchus



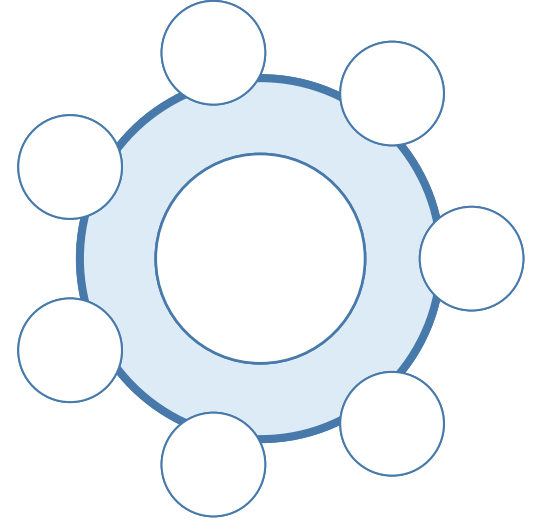
Bronchitis · asthma · bronchiectasis

Bronchiole



Small-airways fibrosis

Acinus



Emphysema

Five pathology patterns associated with obstruction

Disease	Primary site	Dominant change
Chronic bronchitis	Bronchus	Mucous gland enlargement
Bronchiectasis	Bronchus	Dilation and scarring
Asthma	Bronchus	Smooth muscle, mucus, inflammation
Emphysema	Acinus	Wall destruction
Small-airways disease	Bronchiole	Inflammatory scarring

A single functional defect, distinct substrates

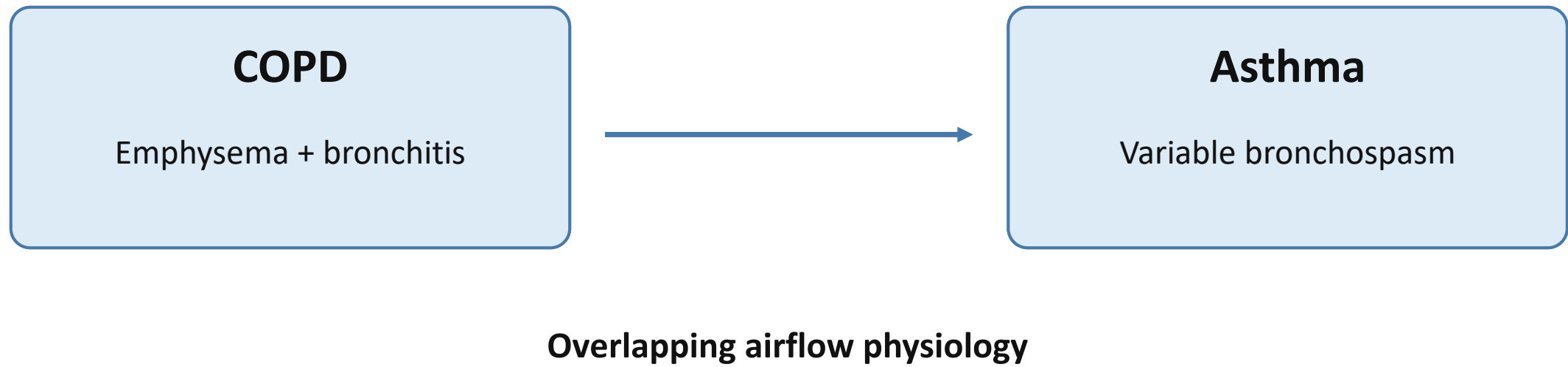
LUMINAL NARROWING

- Mucus accumulation reduces the conducting lumen
- Bronchospasm transiently narrows bronchial caliber

LOSS OF TETHERING

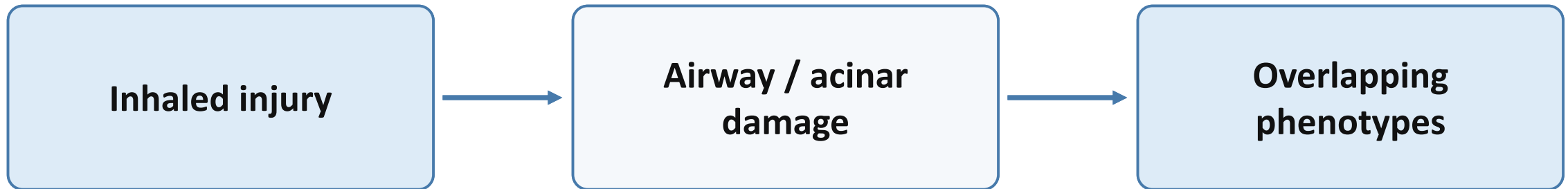
- Alveolar destruction reduces elastic traction
- Small airways collapse preferentially during expiration

Obstructive disorders frequently coexist



Shared exposures, different lesions

- Cigarette smoke is a major shared cause of emphysema and bronchitis
- Air pollutants contribute to chronic airway inflammation
- Infections exacerbate established COPD and can injure bronchi in bronchiectasis



Schematic

COPD: Clinicopathologic definition

- Persistent respiratory symptoms accompany airflow limitation
- Abnormalities may involve airways, alveoli, or both
- Exposure to noxious particles or gases is central to the textbook definition

COPD contains two major injury patterns

EMPHYSEMA

- Alveolar wall destruction
- Loss of elastic recoil
- Dynamic expiratory collapse

CHRONIC BRONCHITIS

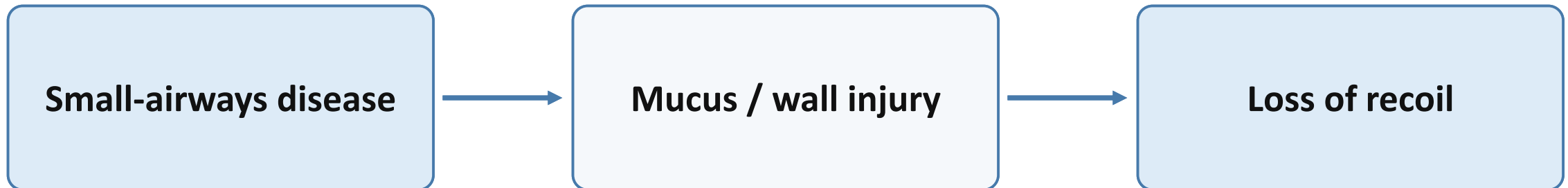
- Mucus hypersecretion
- Inflamed and scarred bronchioles
- Airway plugging

Risk factors for COPD

- Heavy cigarette smoking has a strong association with COPD
- Environmental and occupational pollutant exposure contributes
- Poor early-life lung development and airway hyperresponsiveness contribute
- Certain genetic polymorphisms modify risk

COPD: Pathways to airflow limitation

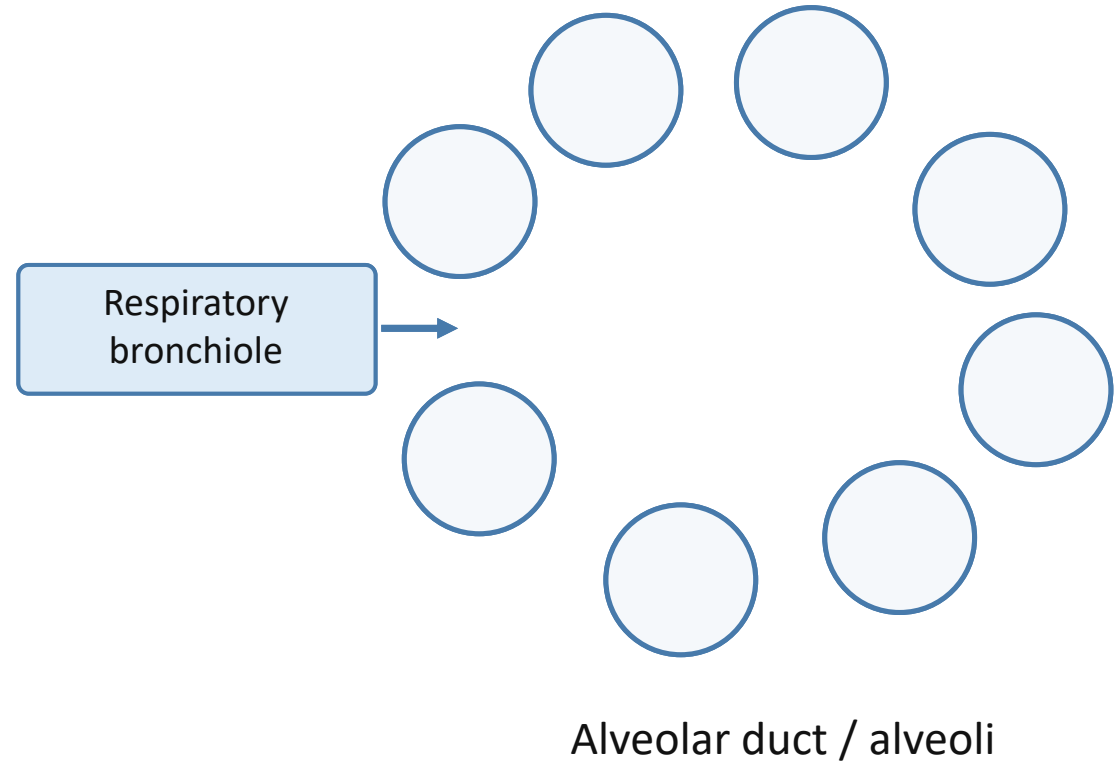
- Small-airway inflammation and fibrosis narrow bronchioles
- Bronchitic mucus hypersecretion obstructs lumens
- Emphysema reduces radial traction and expiratory patency



Schematic

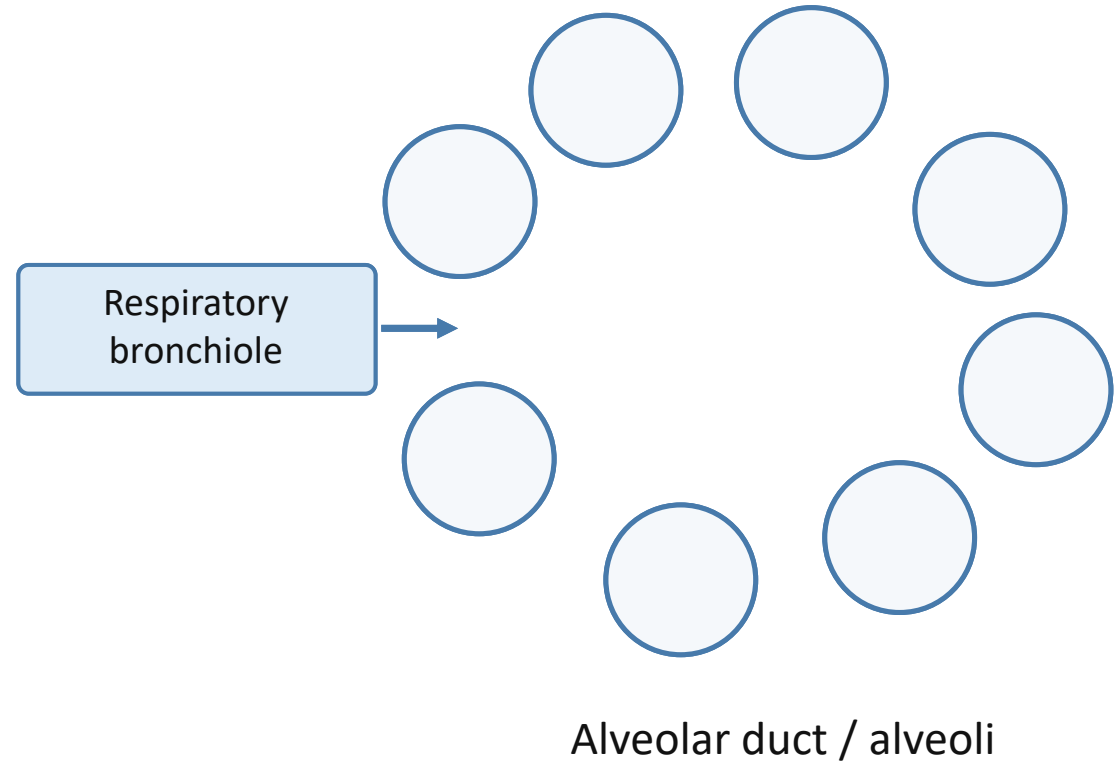
Emphysema is a destructive acinar disease

- Airspaces distal to terminal bronchioles enlarge irreversibly
- Destruction of alveolar walls is essential to the definition
- Expansion without destruction is not equivalent to true emphysema



Acinar anatomy determines emphysema type

- The acinus is the terminal respiratory unit beyond a terminal bronchiole
- Respiratory bronchioles form proximal acinar components
- Alveolar ducts and alveoli occupy more distal portions

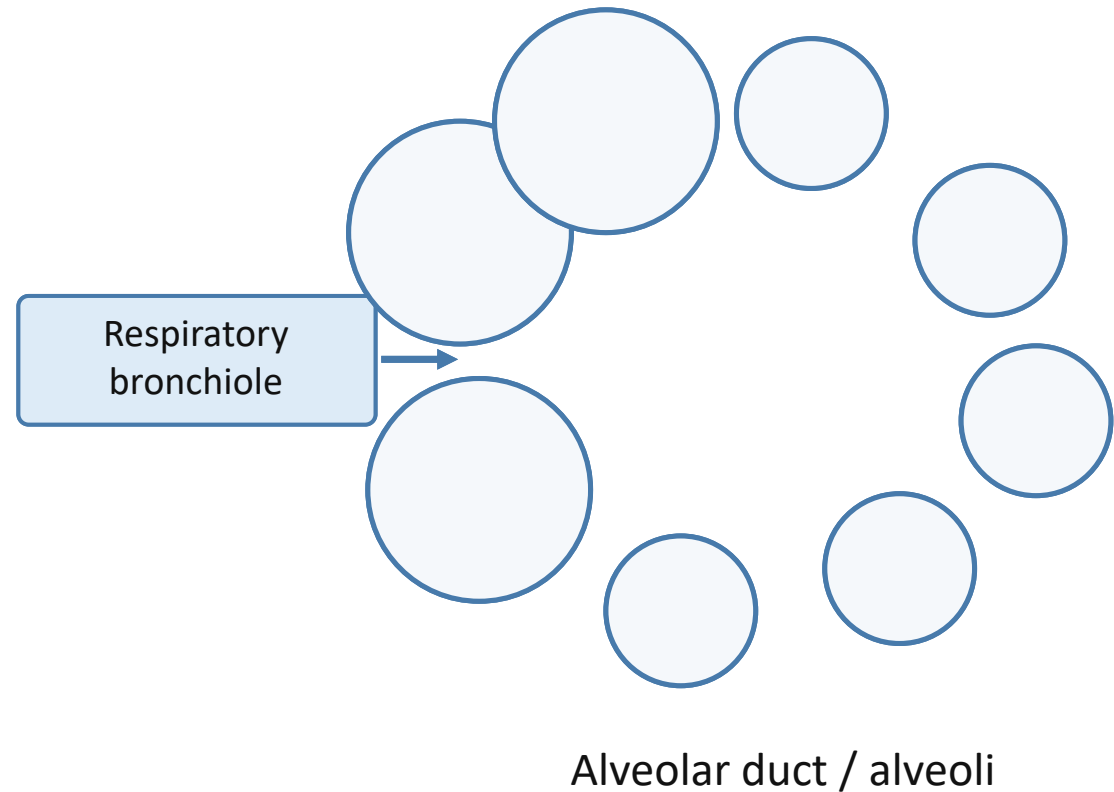


Emphysema classification by distribution

Type	Acinar zone	Principal association
Centriacinar	Proximal acinus	Smoking; Upper lobes
Panacinar	Entire acinus	α_1 -antitrypsin deficiency
Distal acinar	Peripheral acinus	Subpleural blebs
Irregular	Patchy	Scarring

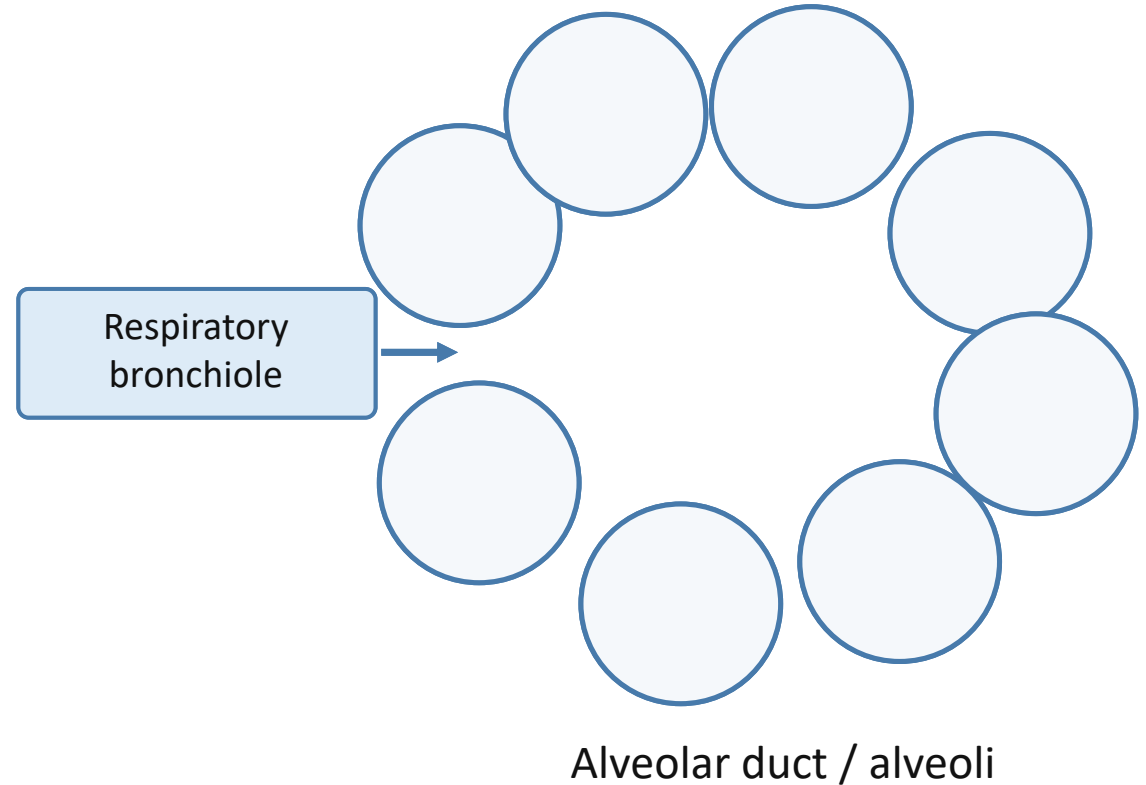
Centriacinar emphysema

- Respiratory bronchioles are affected before distal alveoli
- Emphysematous and relatively preserved spaces coexist in one acinus
- Upper lobes, particularly apices, are often more severely affected
- Closely associated with heavy cigarette smoking



Panacinar emphysema

- The acinus enlarges from respiratory bronchiole to terminal alveoli
- Often involves lower lung zones and is most severe at lung bases
- Associated with α_1 -antitrypsin deficiency; Smoking worsens disease



Schematic · distribution only, not histology

Centriacinar versus panacinar patterns

CENTRIACINAR

- Proximal acinar injury
- Initially spared distal airspaces
- Smoking-associated; Often upper-lobe dominant

PANACINAR

- Uniform acinar involvement
- Respiratory bronchioles to terminal alveoli
- α_1 -antitrypsin deficiency; Lower-zone bias

Distal acinar and irregular emphysema

PARASEPTAL

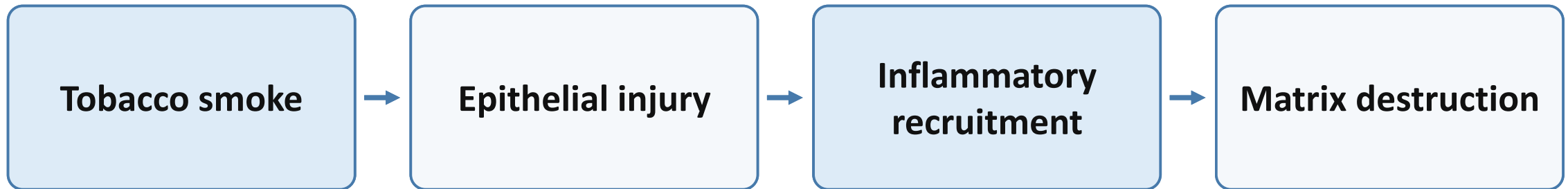
- Peripheral acinar destruction
- Subpleural involvement
- May be associated with spontaneous pneumothorax

IRREGULAR

- Nonuniform, scar-associated lesions
- Often limited focal involvement
- Frequently of little functional significance

Tobacco smoke drives acinar injury

- Inhaled toxic particles damage respiratory epithelium
- Resident cells and inflammatory cells amplify local inflammation
- Inflammatory mediators promote leukocyte influx and matrix injury



Schematic

Protease–antiprotease imbalance

- Neutrophils and other cells release proteolytic enzymes
- Antiproteases normally restrain destruction of matrix proteins
- Relative antiprotease deficiency favors alveolar wall breakdown



Schematic

α_1 -Antitrypsin protects alveolar matrix

- α_1 -Antitrypsin inhibits proteases, notably neutrophil elastase
- Severe deficiency increases susceptibility to emphysema
- Panacinar change is especially associated with deficiency
- Smoking amplifies inflammatory protease burden



Schematic

Oxidant-mediated parenchymal injury

- Oxidants originate from cigarette smoke and inflammatory cells
- Oxidative stress produces tissue damage and sustains inflammation
- NRF2 activates cellular defenses against oxidant injury



Schematic

How alveolar destruction obstructs airflow

- Intact parenchyma provides radial traction on respiratory bronchioles
- Destruction reduces elastic recoil and the outward tethering force
- Small airways collapse during expiration despite no fixed intraluminal plug



Schematic

Loss of recoil versus fixed narrowing

DYNAMIC COLLAPSE

- Emphysema removes alveolar elastic tissue
- Radial traction falls
- Bronchioles collapse during expiration

FIXED NARROWING

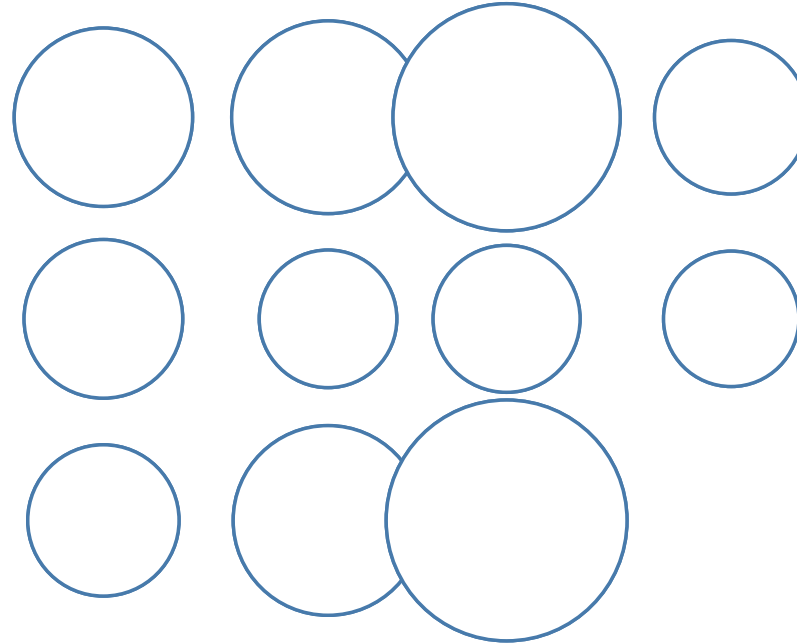
- Bronchiolitis causes inflammation and fibrosis
- Wall changes narrow the lumen
- Both mechanisms may coexist in COPD

Gross emphysema: Characteristic architecture

- Advanced lungs are voluminous and hyperinflated
- The anterior lung may overlap the heart; Diaphragm becomes flattened
- Cut sections contain visibly enlarged airspaces and sometimes bullae

Microscopic emphysema: What is lost?

- Enlarged airspaces have attenuated or destroyed septa
- Small-airway attachments and the capillary bed are reduced
- Thin residual septa may form projecting or blind-ended strands

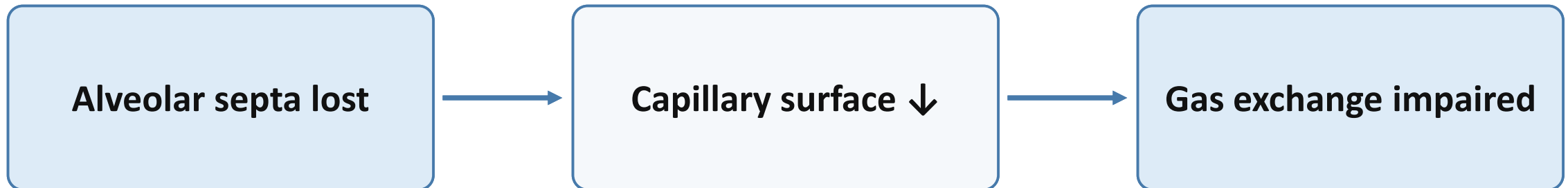


Enlarged airspaces

Schematic, not a photomicrograph

Capillary loss compounds emphysema

- Alveolar destruction removes gas-exchanging surface area
- Capillary bed reduction accompanies septal destruction
- Hypoxemia and vascular injury can contribute to pulmonary hypertension



Schematic

Bullae and pneumothorax

- Blebs and bullae may complicate advanced emphysema
- Subpleural airspaces can rupture
- Air entering the pleural cavity produces pneumothorax



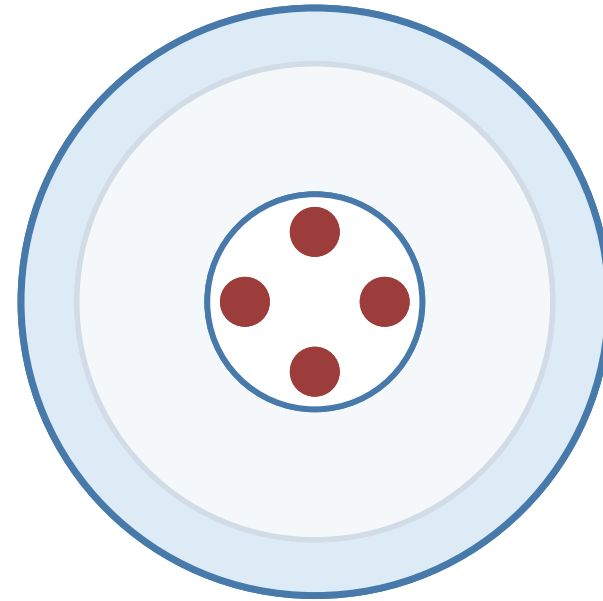
Schematic

Chronic bronchitis is clinically defined

- Productive cough for at least 3 months per year
- Present over at least 2 consecutive years
- No other identifiable explanation for the cough and sputum
- The clinical definition is distinct from histologic gland enlargement

Chronic bronchitis: Epithelial response

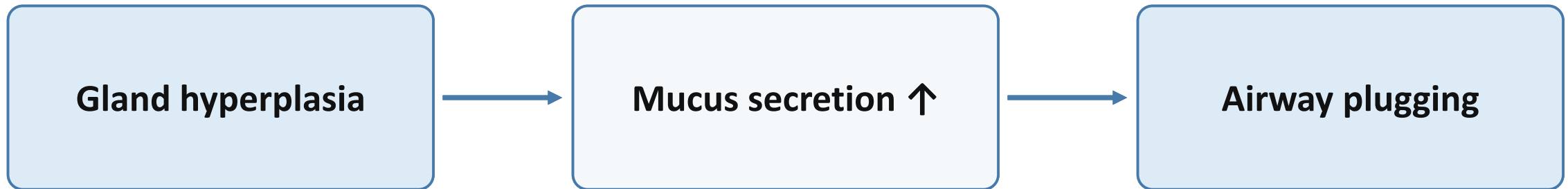
- Smoke and other irritants injure airway-lining cells
- Mucus glands enlarge within larger conducting airways
- Goblet cells also increase within smaller bronchi and bronchioles



Airway cross-section · schematic

Mucous gland enlargement explains sputum

- Submucosal glands enlarge in trachea and bronchi
- Increased secretory capacity raises mucus burden
- Excess mucus forms a physical obstacle within airway lumens



Schematic

Acquired CFTR dysfunction in smokers

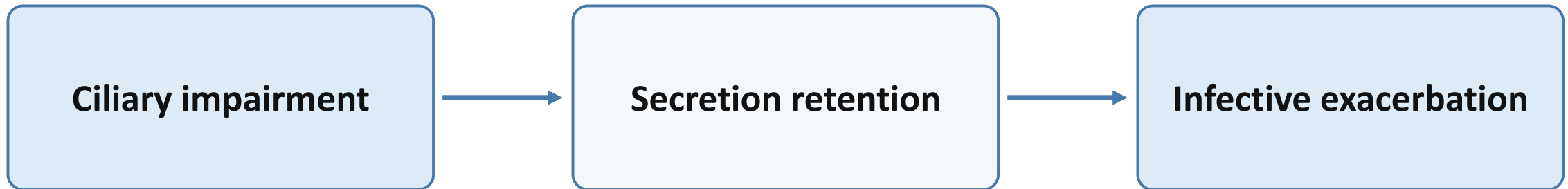
- The text identifies smoking-related acquired CFTR dysfunction
- Altered secretion contributes to dehydrated, abnormal mucus
- Thick secretions aggravate chronic bronchitic symptoms



Schematic

Impaired ciliary clearance favors infection

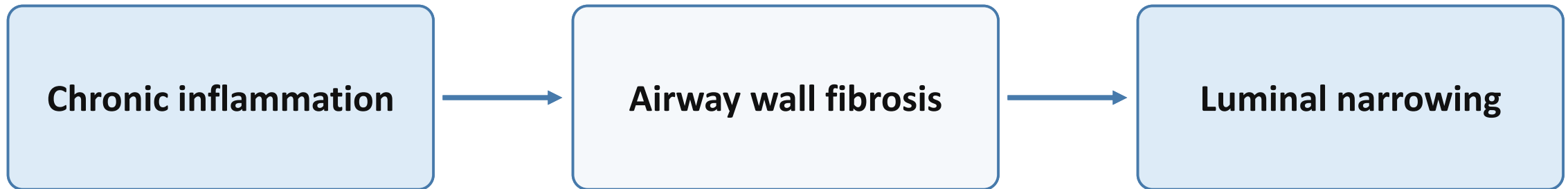
- Cigarette smoke interferes with ciliary function
- Retained mucus favors microbial persistence
- Infections may sustain bronchitis and precipitate exacerbations



Schematic

Chronic inflammation scars small airways

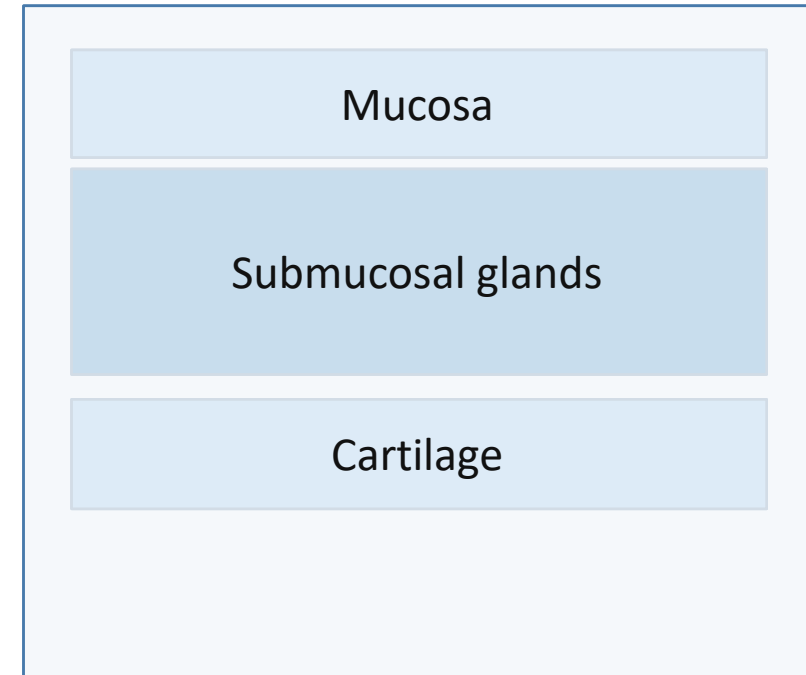
- Irritant injury recruits neutrophils, macrophages, and lymphocytes
- Wall thickening reflects inflammatory injury and matrix deposition
- Peribronchiolar fibrosis narrows the small-airway lumen



Schematic

The Reid index and bronchial gland thickening

- Reid index compares gland-layer thickness with bronchial wall thickness
- A normal value around 0.4
- The index typically rises with chronic bronchitis
- Its measurement describes morphology, not the clinical cough definition

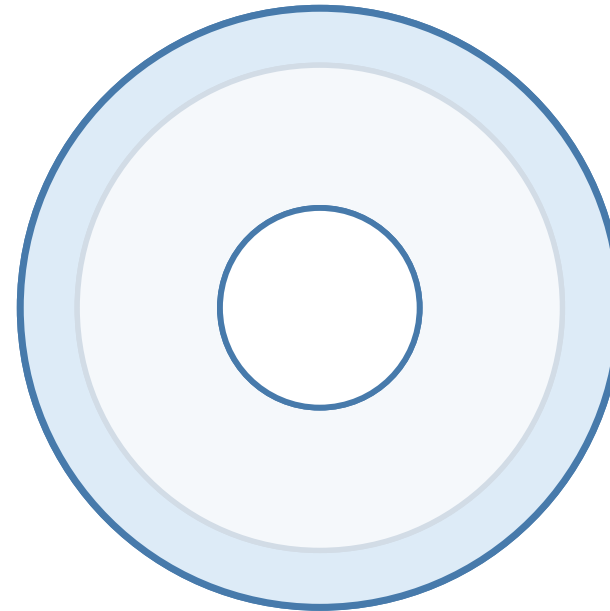


Reid index = gland thickness / wall thickness

Schematic; Relative dimensions not measured

Microscopic airway remodeling in bronchitis

- Goblet cell hyperplasia accompanies mucus-gland enlargement
- Smooth muscle thickening and peribronchial fibrosis may occur
- Some small airways are severely narrowed or obliterated
- Squamous metaplasia or dysplasia may accompany smoke exposure



Airway cross-section · schematic

COPD presentation reflects mixed pathology

- Slowly progressive exertional dyspnea and chronic cough are frequent
- Sputum burden increases with a bronchitic contribution
- Acute infections can precipitate symptomatic exacerbations
- Spirometry is central to recognizing airflow limitation

Predominantly emphysematous COPD

EMPHYSEMA-DOMINANT

- Dyspnea and hyperinflation predominate
- Cough may be slight
- Diffusing capacity can be low

BRONCHITIS-DOMINANT

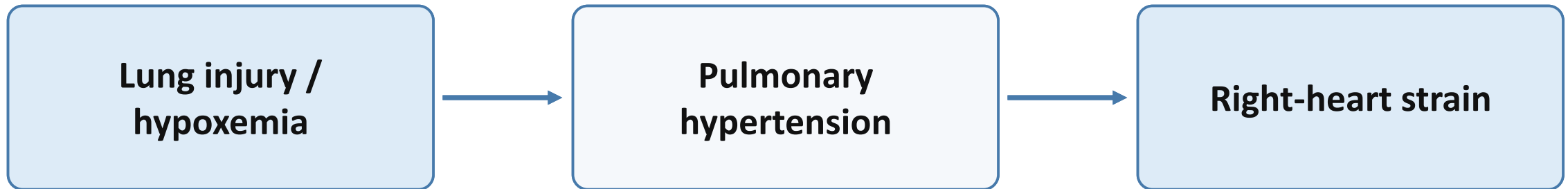
- Chronic productive cough predominates
- Airway resistance is increased
- Hypoxemia and hypercapnia may occur

Predominantly bronchitic COPD

- Productive cough is the dominant clinical feature
- Hypoxemia and hypercapnia can become marked
- Pulmonary hypertension and cor pulmonale may develop
- Most patients have mixed emphysematous and bronchitic findings

Pulmonary hypertension in advanced COPD

- Persistent hypoxemia contributes to vascular changes
- Loss of capillary beds accompanies alveolar destruction
- Pulmonary hypertension increases right ventricular afterload
- Cor pulmonale may follow advanced disease



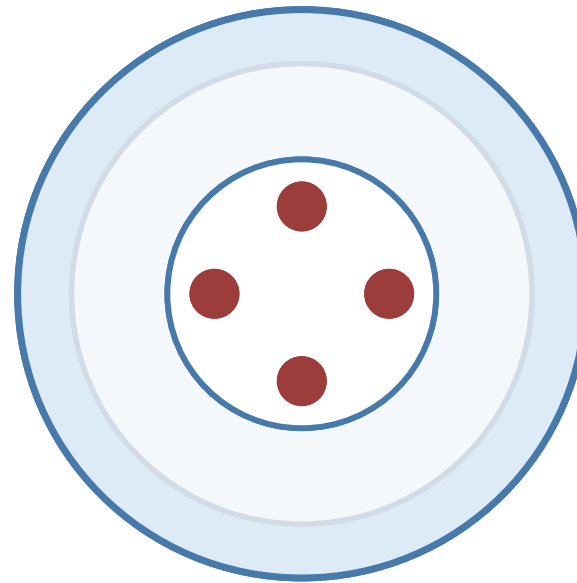
Schematic

Asthma: Variable expiratory obstruction

- Chronic airway inflammation underlies heterogeneous phenotypes
- Episodic wheeze, dyspnea, cough, and chest tightness fluctuate
- Bronchoconstriction is central to acute attacks
- Between attacks some patients are nearly asymptomatic

Asthma: Three contributors to narrowing

- Contraction of airway smooth muscle produces bronchospasm
- Mucosal edema and excess mucus further reduce lumen diameter
- Chronic remodeling may add persistent airflow limitation



Airway cross-section · schematic

Common asthma triggers

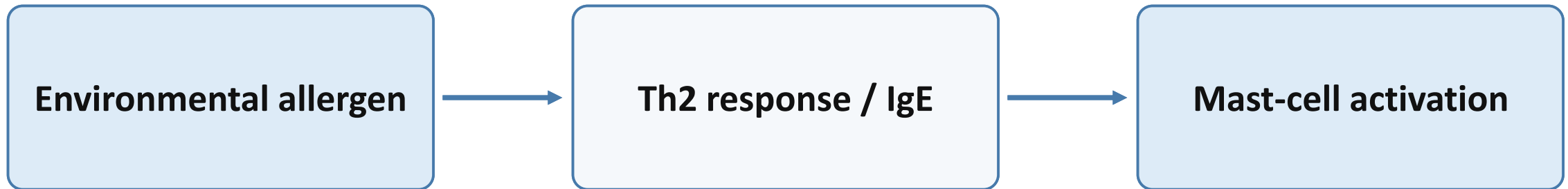
- Environmental allergens can provoke atopic disease
- Respiratory infections and inhaled irritants exacerbate attacks
- Cold air, exercise, and stress may also precipitate symptoms



Schematic

Atopic asthma: Allergen sensitization

- The textbook frames atopic disease as type I hypersensitivity
- Th2 polarization and IgE sensitization precede responses to allergens
- Allergic rhinitis, eczema, and family history may coexist



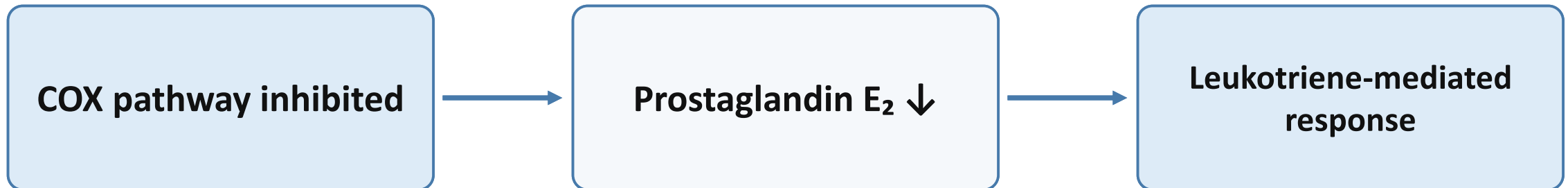
Schematic

Nonatopic asthma: No allergen sensitization

- Skin tests for allergen sensitization are generally negative
- Viral infection is an important trigger
- Irritants and physical triggers contribute to airway hyperreactivity

Aspirin-sensitive asthma

- Associated with recurrent rhinitis and nasal polyps
- Aspirin and some other nonsteroidal anti-inflammatory drugs trigger attacks
- Cyclooxygenase inhibition shifts mediator balance toward leukotriene effects



Schematic

Occupational asthma

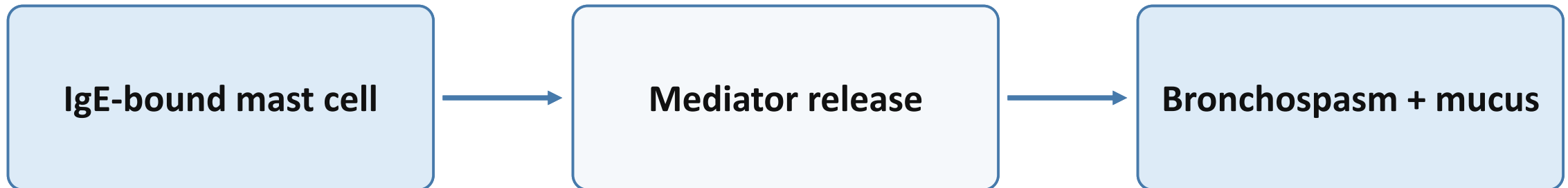
- Fumes, chemical dusts, gases, and other agents can trigger attacks
- Attacks generally follow repeated occupational exposure
- Mechanisms differ: IgE responses or other bronchoconstrictor pathways

Th2 cytokines in atopic asthma

Mediator	Principal effect	Pathology consequence
IL-4	B-cell IgE production	Allergen sensitization
IL-5	Eosinophil activation	Eosinophilic inflammation
IL-13	Mucus production	Secretory hyperplasia

Immediate allergic response in asthma

- Allergen exposure activates mast cells bearing surface IgE
- Bronchoconstriction dominates the early reaction
- Mucus secretion, vasodilation, and permeability also increase



Schematic

Late-phase inflammatory reaction

- Recruitment of eosinophils and additional leukocytes follows
- T cells and epithelial chemokines sustain the response
- Repeated injury lays the foundation for airway remodeling



Schematic

Type 2 immunity extends beyond Th2 cells

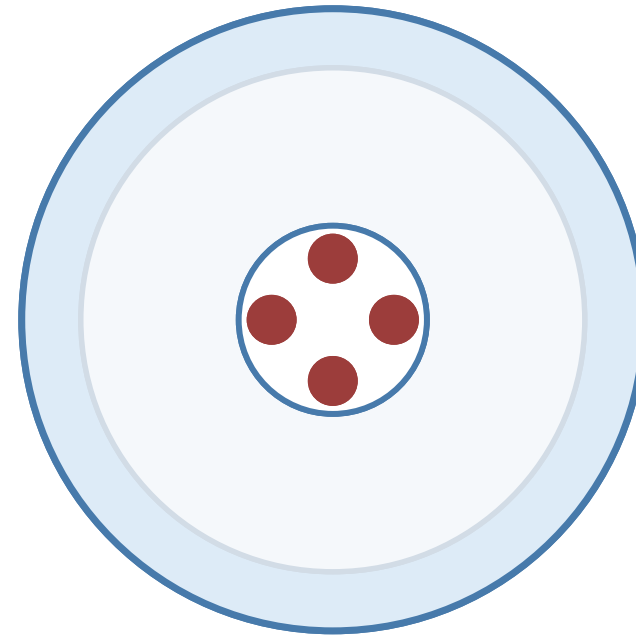
- Type 2 innate lymphoid cells can produce similar cytokines
- Epithelial injury releases signals capable of activating ILC2s
- Type 2 inflammation is not exclusively antigen-receptor dependent



Schematic

Asthma remodeling creates a fixed component

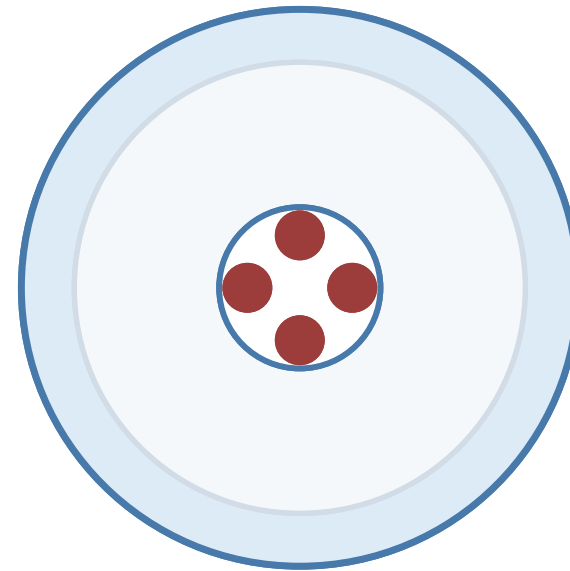
- Smooth muscle hypertrophy and hyperplasia thicken the airway wall
- Subepithelial fibrosis stiffens bronchial architecture
- Mucous gland and goblet cell increases enlarge secretory burden
- New vessels and chronic inflammatory cells further thicken the wall



Airway cross-section · schematic

Morphology of acute severe asthma

- Lungs may be hyperinflated with focal atelectasis
- Bronchi and bronchioles can be blocked by tenacious mucus
- Mucus plugs may contain desquamated respiratory epithelium



Airway cross-section · schematic

Eosinophils and mucus-plug structures

- Atopic asthma sputum may contain numerous eosinophils
- Curschmann spirals represent coiled mucus material
- Charcot–Leyden crystals contain eosinophil-derived galectin-10

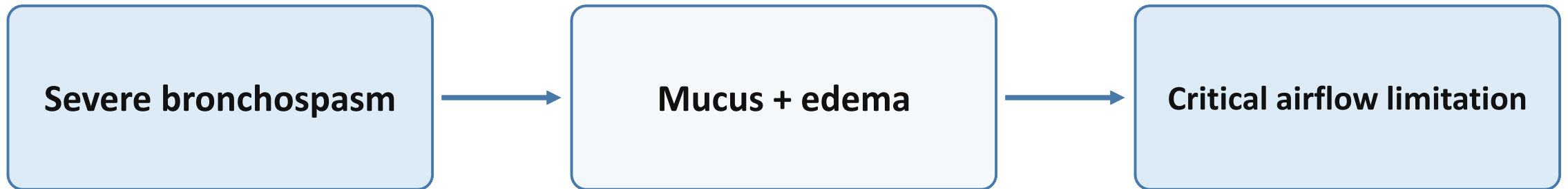
Asthma and COPD are not mutually exclusive



Overlapping airflow physiology

Acute severe asthma: Functional risk

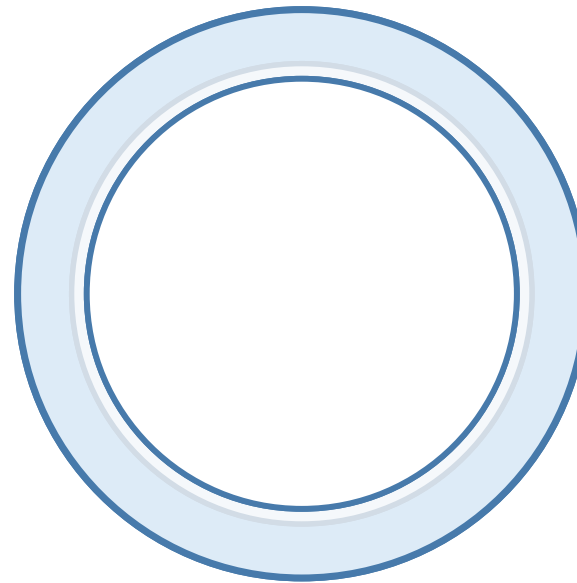
- Unremitting bronchospasm may persist for days or weeks
- Mucus obstruction and edema further restrict ventilation
- Severe attacks can produce cyanosis and may be fatal



Schematic

Bronchiectasis: Permanent bronchial dilation

- Inflammation destroys bronchial smooth muscle and elastic tissue
- Damaged airway walls become irreversibly dilated
- Persistent or severe infection and defective clearance are central

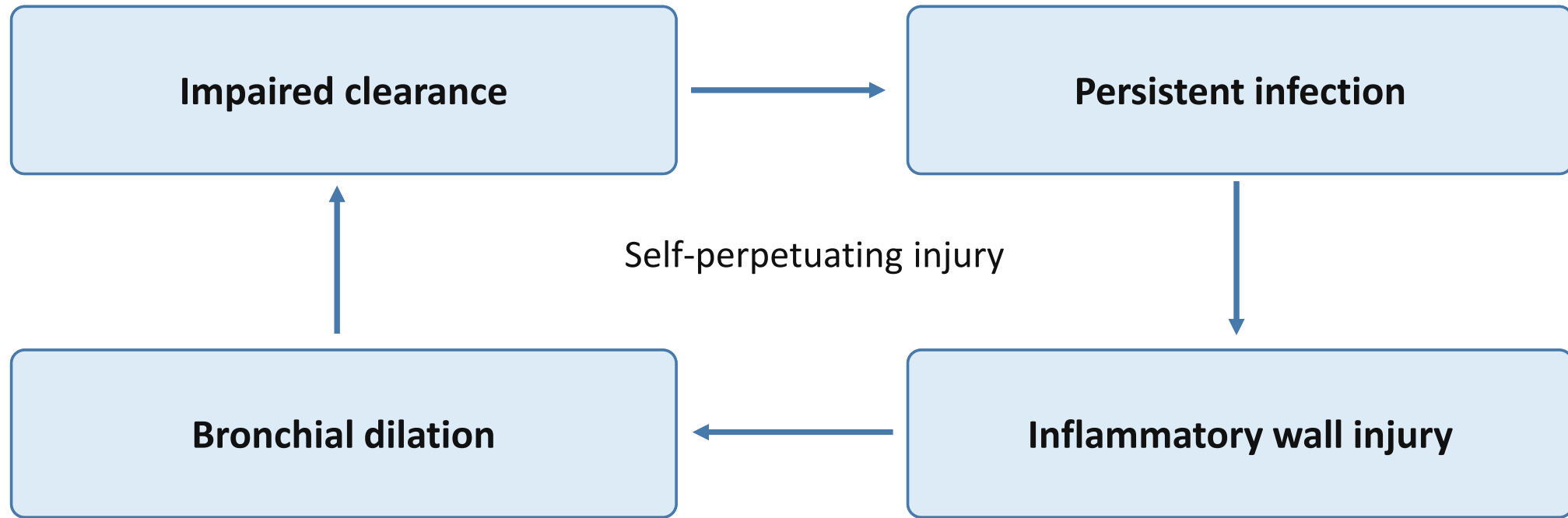


Airway cross-section · schematic

Bronchiectasis: Major predisposing settings

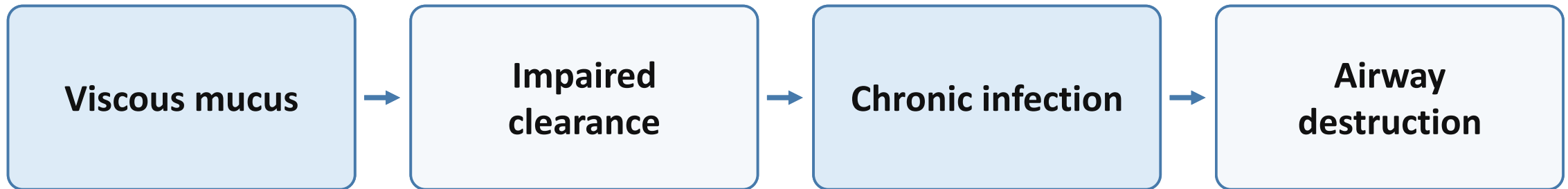
Setting	Initiating defect	Typical consequence
Cystic fibrosis	Viscous mucus	Often widespread
Primary ciliary dyskinesia	Defective ciliary clearance	Recurrent infections
Tumor / foreign body	Focal obstruction	Localized
Severe infection	Necrotizing airway injury	Bronchial wall destruction
Immune disturbance	Altered host defense	Chronic infection

Obstruction–infection cycle



Cystic fibrosis and bronchiectasis

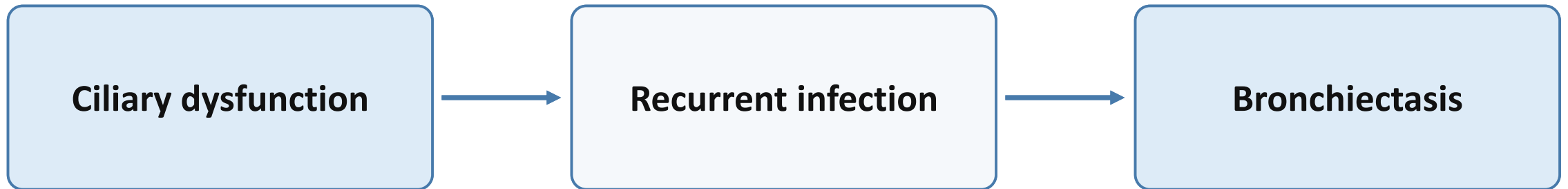
- Abnormal ion transport generates viscous mucus
- Defective mucociliary clearance promotes airway obstruction
- Recurrent infections damage airway walls
- Bronchi dilate while small bronchioles may scar shut



Schematic

Primary ciliary dyskinesia

- Defects in ciliary motor proteins impair mucus clearance
- Recurrent respiratory infection creates bronchiectatic injury
- Kartagener syndrome links bronchiectasis, sinusitis, and situs inversus



Schematic

Allergic bronchopulmonary aspergillosis

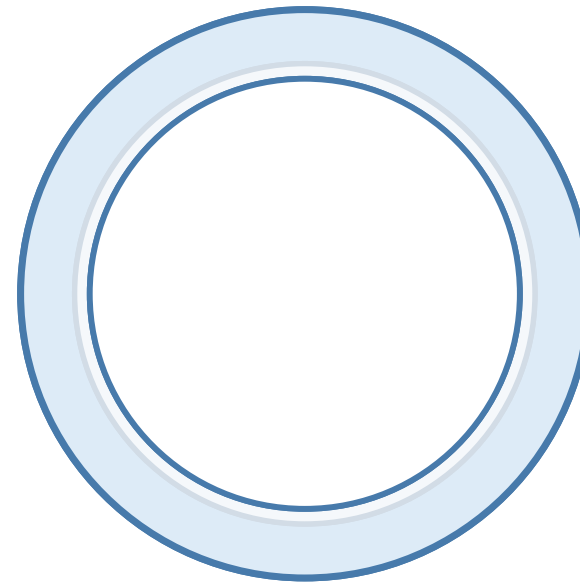
- Occurs in some patients with asthma or cystic fibrosis
- A hypersensitivity response to *Aspergillus* drives eosinophilic inflammation
- Mucus plugging contributes to subsequent bronchial dilation



Schematic

Bronchiectasis: Gross morphology

- Bronchi and bronchioles are widened, sometimes markedly
- Damaged peripheral conducting airways may extend near the pleura
- Cyst-like dilated bronchi can contain mucopurulent material



Airway cross-section · schematic

Bronchiectasis: Active microscopic injury

- Acute and chronic inflammatory cells occupy damaged airway walls
- Epithelial sloughing and ulceration may be prominent
- Necrosis can progress to abscess formation

Bronchiectasis: Chronic sequelae

- Fibrosis and peribronchiolar scarring accompany chronic injury
- Squamous metaplasia may further impair mucociliary clearance
- Progressive fibrosis can markedly reduce bronchiolar lumens



Schematic

A single comparison: Mechanism of obstruction

Entity	Dominant tissue change	Functional consequence
Chronic bronchitis	Mucous gland enlargement	Plugging / small-airway injury
Asthma	Bronchospasm; Inflammation	Variable airway narrowing
Emphysema	Alveolar wall destruction	Loss of radial traction
Bronchiectasis	Bronchial wall destruction	Dilation / secretion stasis

Clinical clues to the anatomic lesion

- Prominent dyspnea and hyperinflation suggest emphysema contribution
- Chronic productive cough suggests bronchitic mucus hypersecretion
- Episodic wheeze favors asthma physiology
- Purulent sputum with recurrent infection supports bronchiectasis

Case reasoning: Progressive dyspnea

- A long-term smoker develops gradually worsening exertional dyspnea
- The lungs show enlarged airspaces and reduced elastic tissue
- What mechanism best explains expiratory airflow limitation?
- Answer: Loss of radial traction promotes small-airway collapse

Case reasoning: Recurrent purulent sputum

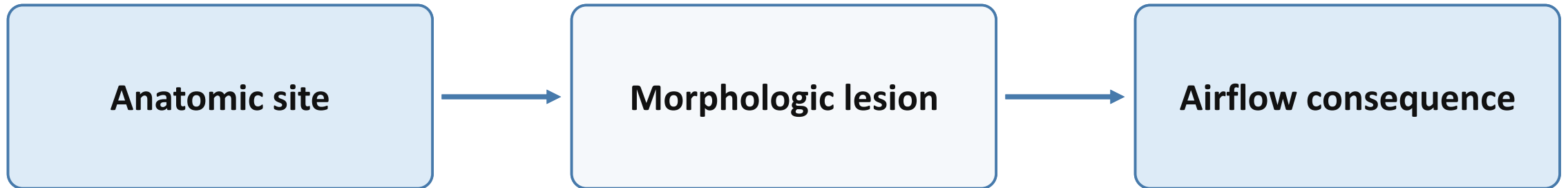
- A patient has repeated infections and copious purulent sputum
- Airways are permanently dilated and surrounded by fibrosis
- What sequence connects the infection to the structural defect?
- Answer: Persistent inflammation destroys smooth muscle and elastic tissue

Case reasoning: Fluctuating wheeze

- Episodes of wheeze follow allergen exposure
- The airway shows mucus, eosinophils, and smooth-muscle thickening
- Which pathways explain acute obstruction and chronic structural change?
- Answer: Mast-cell bronchospasm plus type 2 inflammatory remodeling

Synthesis: Trace morphology to physiology

- Identify the anatomic compartment: Bronchus, bronchiole, or acinus
- Identify the process: Mucus, smooth muscle, fibrosis, or matrix loss
- Explain how the process decreases expiratory flow
- Expect overlap rather than rigidly separated clinical categories



Schematic

Reference and source boundaries

- Robbins, Cotran & Kumar: Pathologic Basis of Disease, 11th edition (2026)
- Chapter 15, The Lung — obstructive/restrictive framework and obstructive diseases
- Source-grounded overview extended into adjacent COPD, asthma, and bronchiectasis sections
- Conceptual drawings are original editable schematics; not specimens