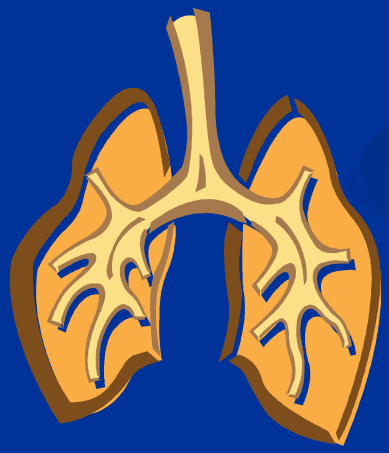
Pulmonary Function Testing



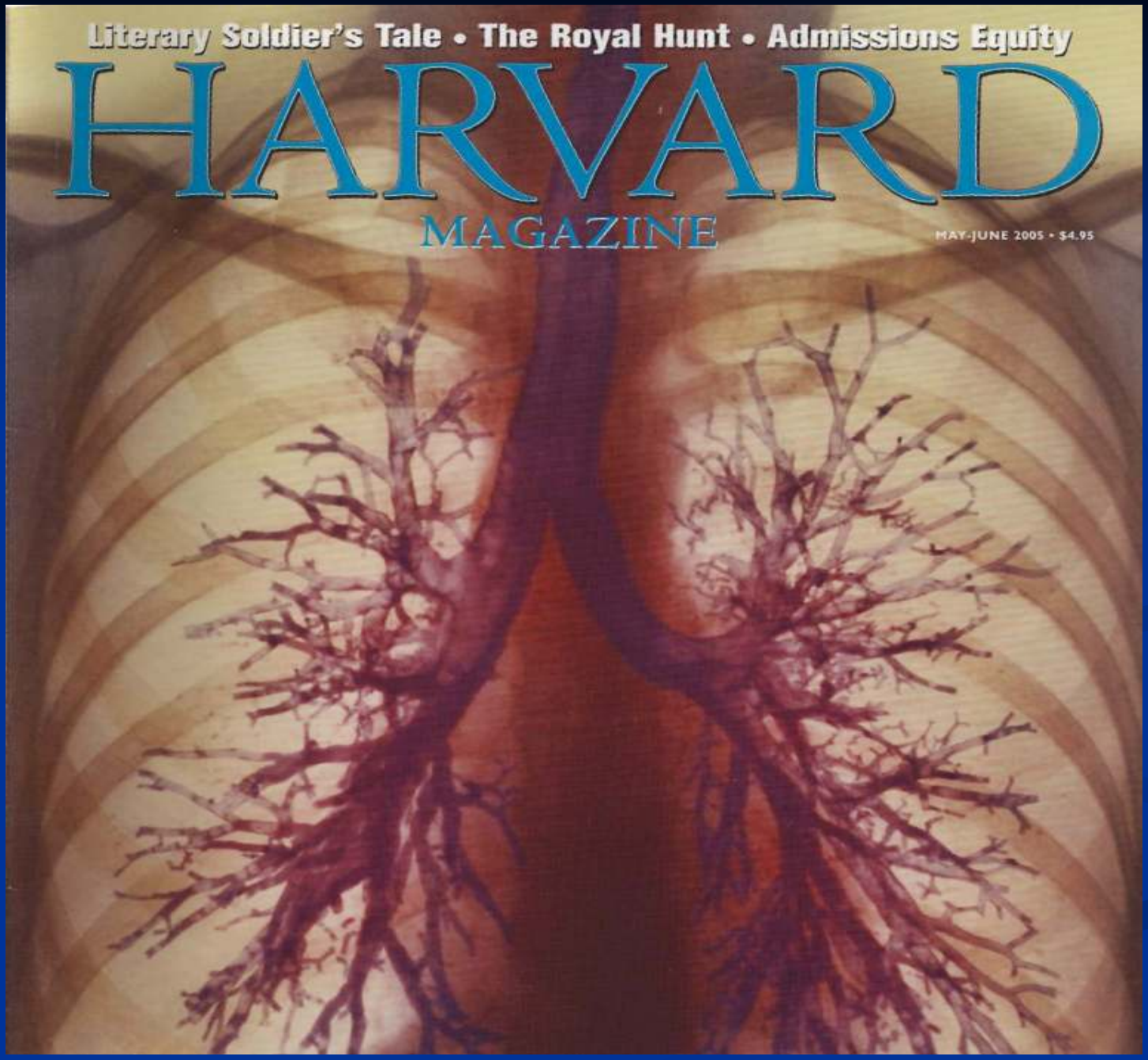
Most occupational respiratory illnesses can be diagnosed on the basis of the history, physical exam, chest x-ray and pulmonary function tests.

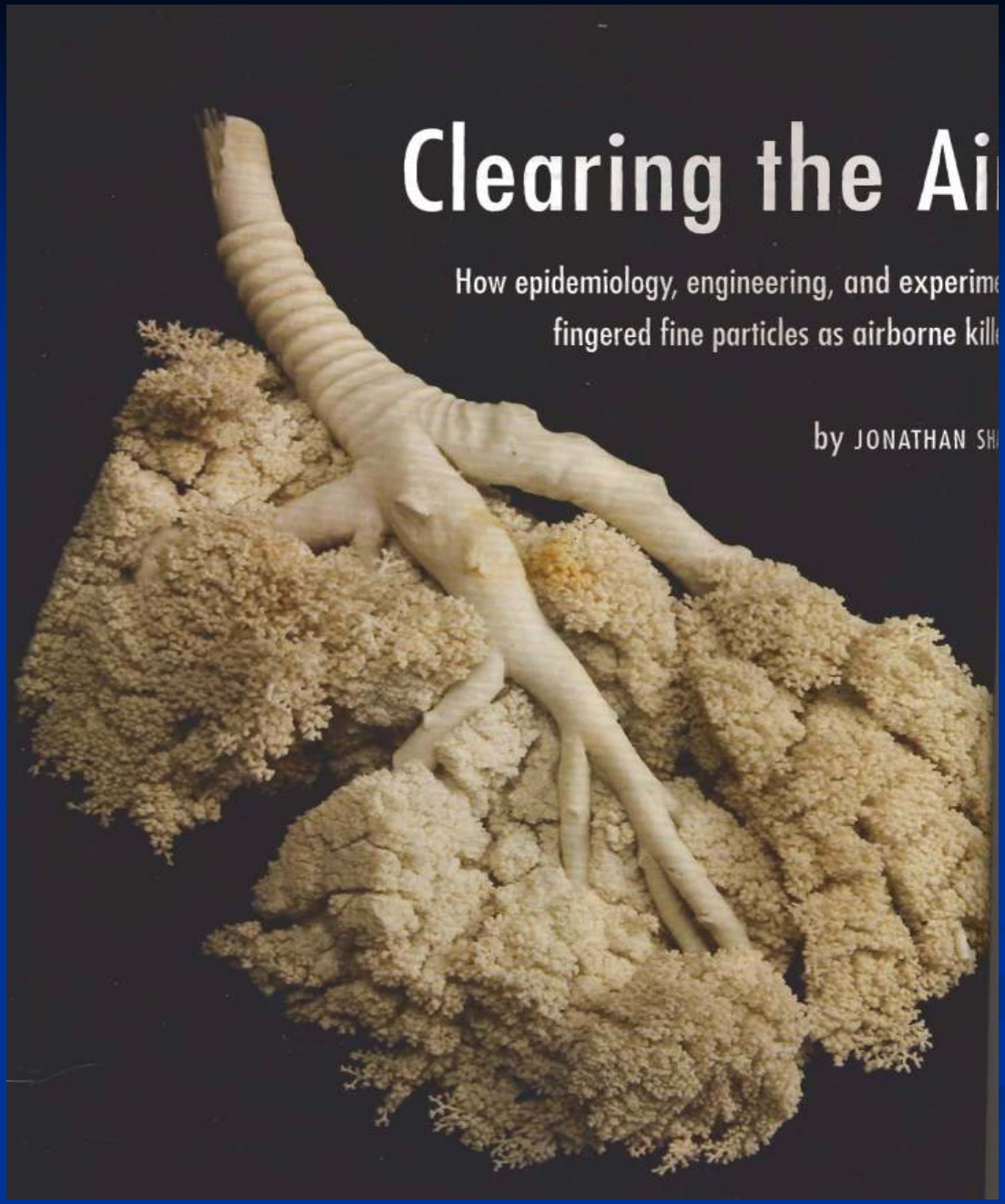
The Lung

- Anatomy - Imaging
- Physiology – Measures of Function

Tracheal Bronchial Tree

- Branching segments
- Upside Down Tree
- Trachea
- Bronchi
- Bronchioles
- Alveolar ducts
- Alveoli – O_2 (oxygen) – CO_2 (carbon dioxide) exchange


Literary Soldier's Tale • The Royal Hunt • Admissions Equity
HARVARD
MAGAZINE
MAY-JUNE 2005 • $4.95


Clearing the Ai
How epidemiology, engineering, and experim
fingered fine particles as airborne kill
by JONATHAN SH

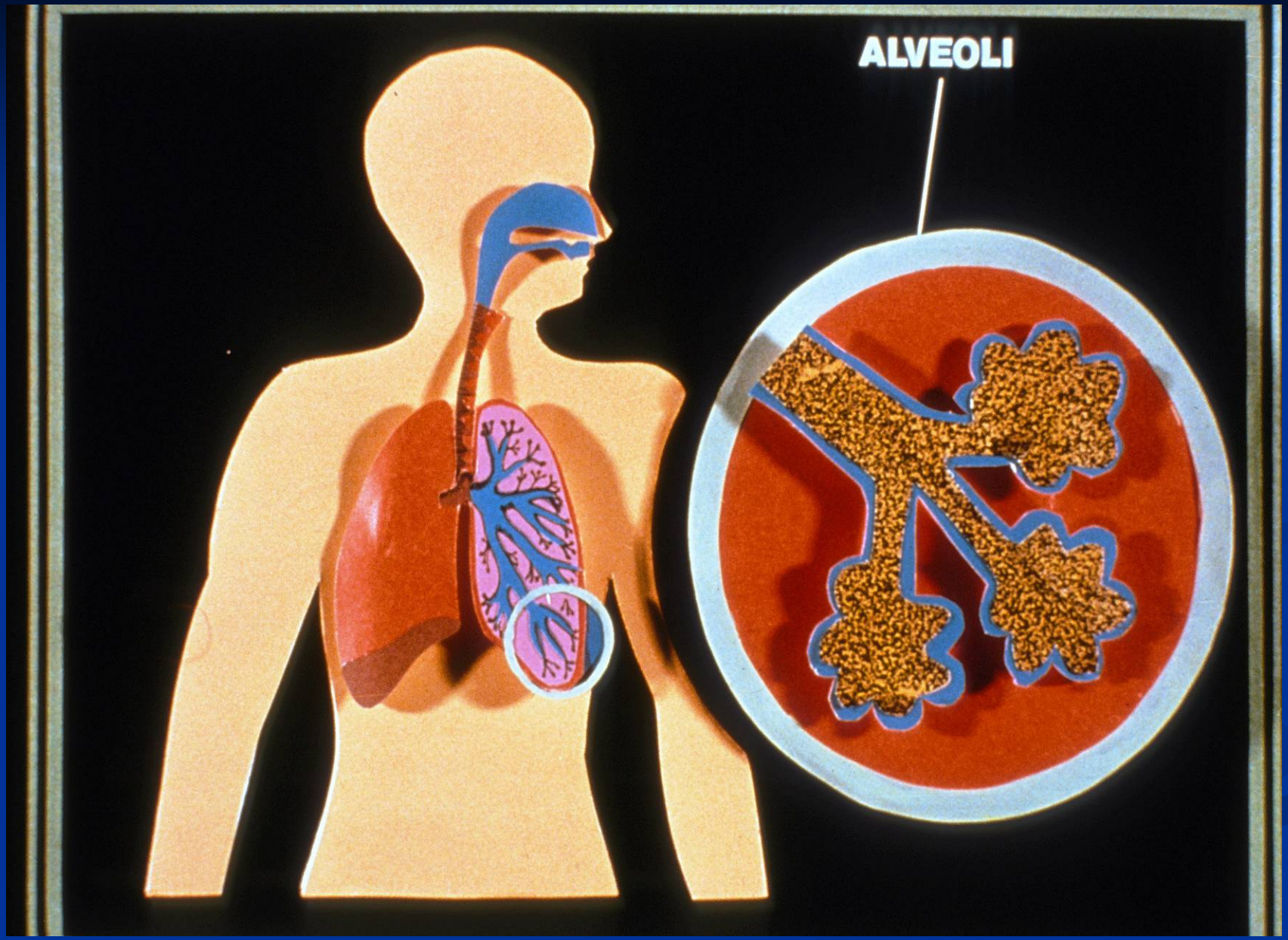
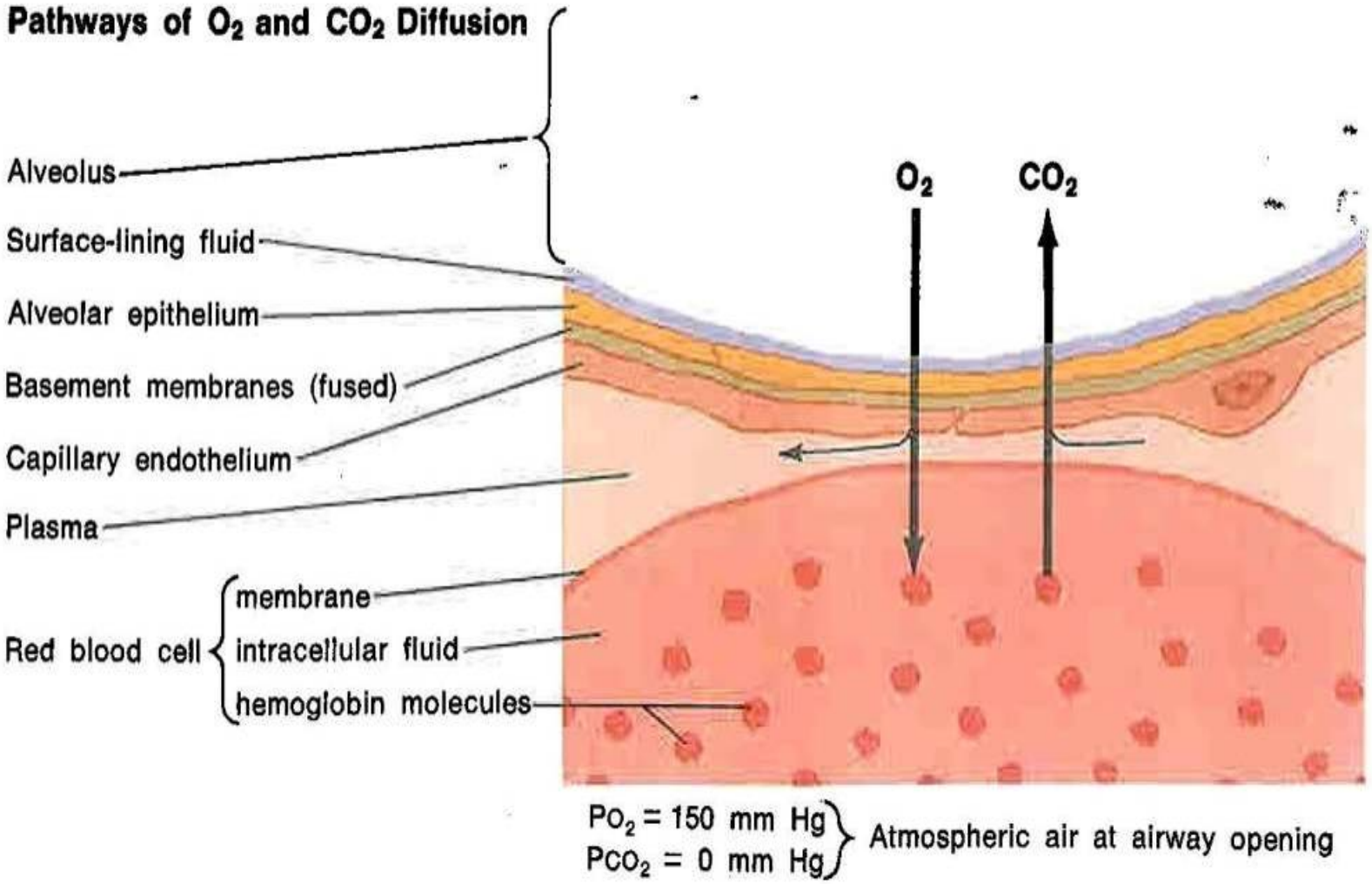
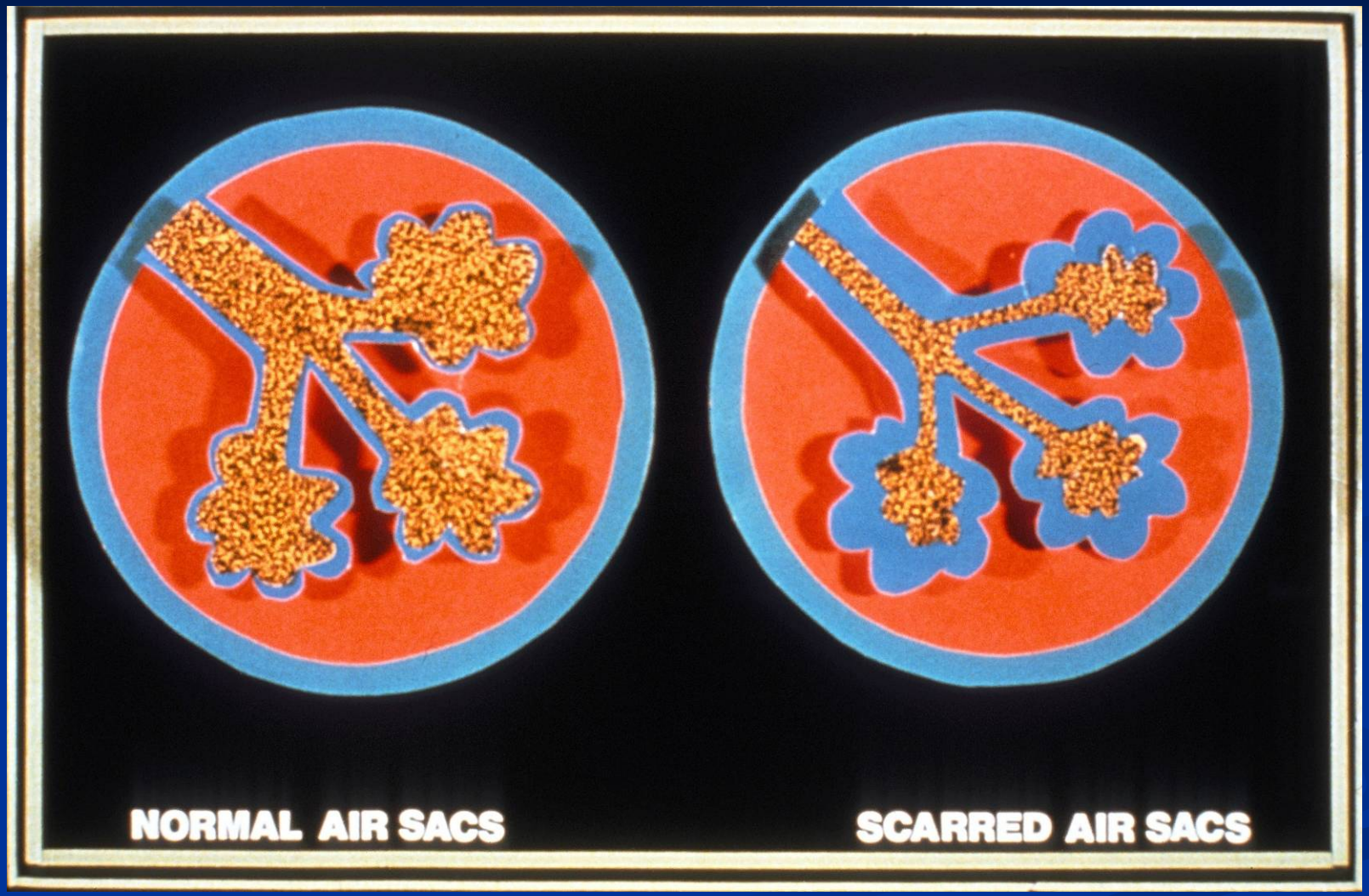

ALVEOLI

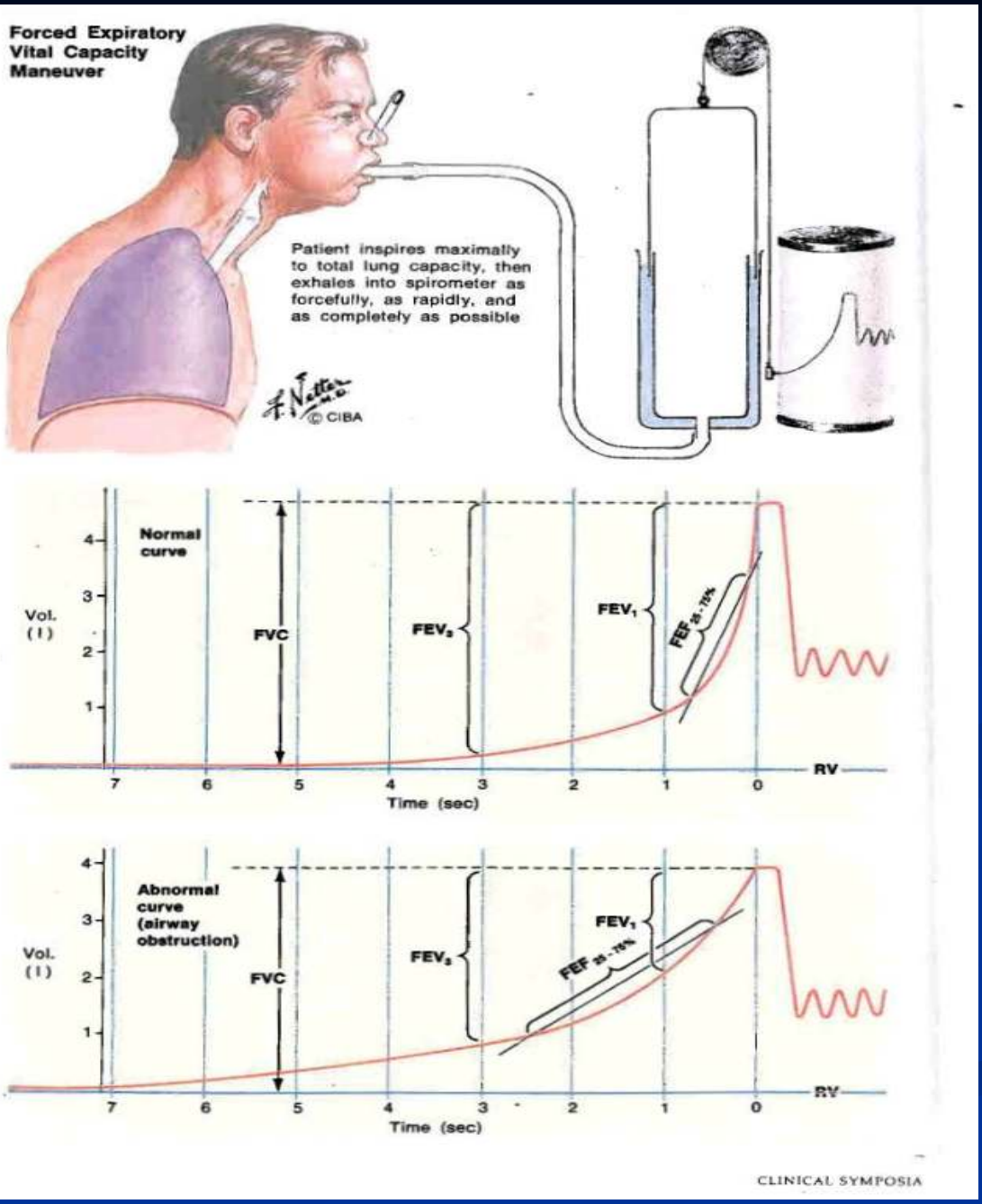
Plate 18


Pathways of O_2 and CO_2 Diffusion
Alveolus
Surface-lining fluid
Alveolar epithelium
Basement membranes (fused)
Capillary endothelium
Plasma
Red blood cell
membrane
intracellular fluid
hemoglobin molecules
O_2
CO_2
Po_2 = 150 mm Hg
Pco_2 = 0 mm Hg
Atmospheric air at airway opening


NORMAL AIR SACS
SCARRED AIR SACS

Interstitial fibrosis

- Inflammation and scarring
  - Alveoli, spaces between alveoli
  - Alveoli and capillaries


Forced Expiratory Vital Capacity Maneuver
Patient inspires maximally to total lung capacity, then exhales into spirometer as forcefully, as rapidly, and as completely as possible
© CIBA
Normal curve
Vol. (l)
FVC
FEV1
FEV3
FEF25-75%
RV
Time (sec)
Abnormal curve (airway obstruction)
Vol. (l)
FVC
FEV1
FEV3
FEF25-75%
RV
Time (sec)

Pulmonary Function Tests - FVC

- Spirometry – “measurement of air”
- FVC – Forced Vital Capacity – maximum volume air which can be exhaled forcefully after a max inspiration.
- ↓ in stiff lungs, fluid, fibrosis, tumor, interference w/inspiration;
- Measure of restrictive defect

FEV1 – Obstructive Pattern

- FEV1 – Forced Expiratory Volume (1 second)
- Def – volume of air forcefully expelled during 1st second of expiration
- Assess airflow limitations
- ↓ in EM, Chronic Bronchitis, Asthma
- Primary measure of obstructive pattern

Results are “effort dependent”

- Largest and next to largest in 3-8 attempts
- Isolated set can lead to misdiagnosis
- Recommend serial testing
- American Thoracic Society (ATS) Standards

Predicted (a.k.a. Expected) Values

- **Observed** compared to **Predicted** results
  - Specific for sex, age, height, race
  - But not body build (legs-torso)
- FVC is inversely related to age
- Observed/Predicted (e.g. FEV1 <80%)
- ATS Guidelines

DLCO

- Measure of efficiency of gas transfer alveolar-capillary (diffusion)
- Function of structure (e.g. fibrosis) and function (e.g. pulmonary embolus, anemia)
- Single breath – held 10 seconds
- Measure difference inspired & expired air for CO

Decreased DLCO

- thickened alveolar/capillary membrane
- ↓ available exchange surface area, lung volume
- increasing age, anemia, smokers

- Firefighters, tunnel workers

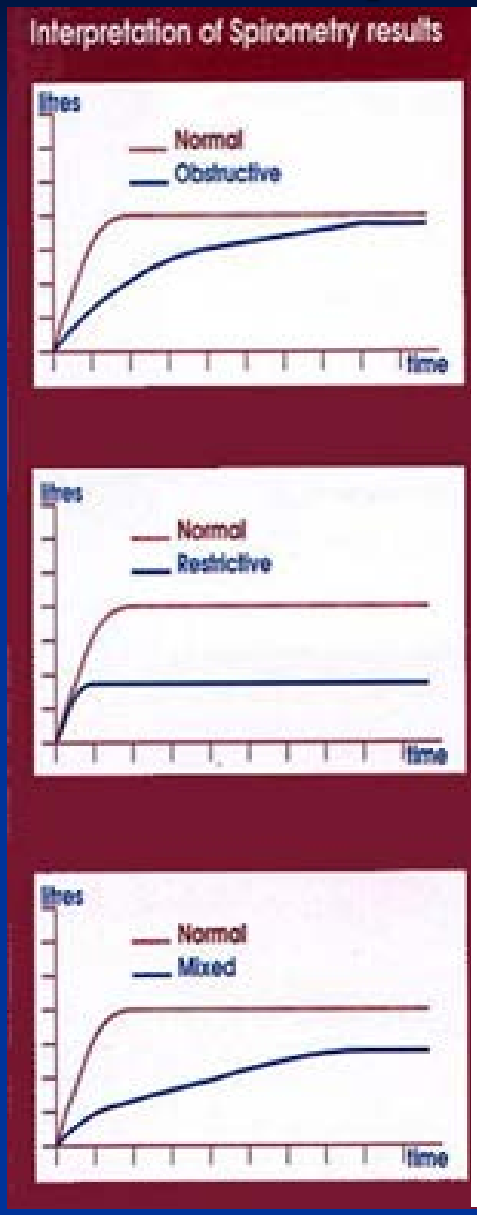
DLCO

- ↓ w/COPD, EM
- ↓ Interstitial fibrosis
- ↓ Sarcoid, CBD
- ↓ w/ anemia, cvasc, CHF, MI, pul emboli
- NL w/asthma (except during attacks)
- Increased w/polycythemia vera

Challenge Testing

- Bronchial Provocation Testing (see PM E-500 § 18)
  - Non-specific – methacholine
  - Specific antigens
- Observe for “bronchoconstriction”
- ↓ in FEV1 with Asthma

Interpretation of Spirometry Results



Obstructive

Narrowed airways decrease the volume of air that can be forcibly exhaled in the first second (FEV1). Note that the FVC is only achieved after a long exhalation. The Fev1/FVC ratio is markedly reduced. Expiration is prolonged with a slow rise in the curve and the plateau is not reached for as long as 15 seconds (in emphysema).

Restrictive

Both FEV1 and FVC are reduced. As the airways are open and unblocked expiration is rapid and completed within 2-3 seconds. The FEV1/FVC ration is normal or increased. A high or normal proportion is exhaled in the first second, resulting in rapid rise in the curve but with long volumes reduced compared with predicted levels.

Mixed

Expiration is prolonged with a slow rise to plateau levels. The vital capacity is likely to be significantly reduced compared with an obstructive defect. Mixed patterns, if less severe, can be difficult to differentiate from obstructive patterns.

With acknowledgement to Dr. David Bellamy, GP Bournemouth

PFT Caveats

- Results do not provide a precise, specific or pathologic diagnosis
- Results usually are non-specific;
- Requires review of total clinical picture;
- Vary w/experience and training (even among most experienced) w/exception of most severe defects

Restrictive Pattern

- Restrictive pattern – ↓ FVC;
- AND ↓ FEV1 (because overall lung capacity is reduced); But FEV1/FVC "Normal"
  - Interstitial or parenchymal disease
  - Fibrosis, granulomas (sarcoid, TB)
  - Fluid, pneumonia
  - Pleural disease
  - Chest wall abnormalities, obesity

Obstructive Pattern

- Obstructive patterns – ↓ FEV1
  - e.g. Asthma
  - Reversible w/bronchodilator
- Emphysema, Chronic Bronchitis
- Obstructing tumor; foreign body

3 Major Obstructive Lung Conditions

- Asthma
- Chronic Bronchitis
- Emphysema

Asthma

- Airflow obstruction
- Bronchial hyper-responsiveness
- Sudden onset, reversible, intermittent
- “Paroxysmal”
- Responds to bronchodilator

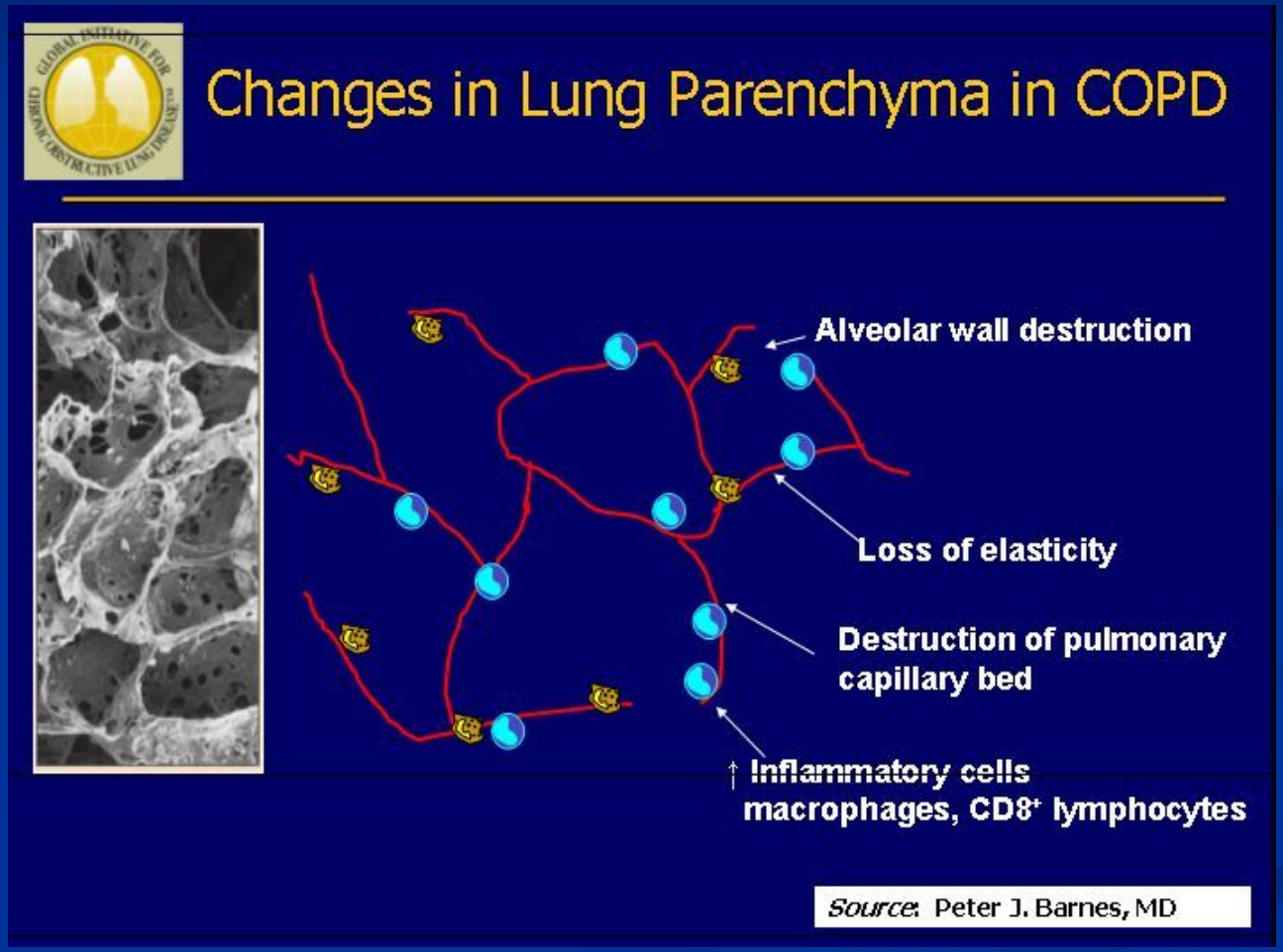
Chronic Bronchitis

- Chronic Bronchitis – historically interchanged w/EM (Often overlapping features)
- Clinical, functional def - Cough, sputum, breathlessness
- Bronchial hypersecretion (mucoid/mucopurulent)
- “Excess mucous occurring most days for at least 3 mo in a year, for a least 2 consecutive years”
- Chronic, recurring, insidious, persistent

Emphysema

- airflow obstruction, persistent, irreversible, destruction of alveoli
  - Anatomic def - Dilated, destroyed/collapsed air spaces beyond terminal bronchiole; insidious;
  - Begins in small, peripheral airways; progression leads to involvement up tree
  - Collapse of airways on forced expiration
  - CXR – over-inflated lungs, ↓ DLCO

EM – Permanent Destruction of Airspaces



Differential Etiology - COPD

- Tobacco
- Industrial Bronchitis – e.g. miners, silica
- COPD among non-smokers exposed to dusts, gases (e.g. SO2, NH3, metal fumes).
- Construction, textiles, laborers, welding
- Asbestos – can aggravate COPD
- Interaction between smoking/workplace

(see DMC Handbook – cautions DMCs not to deny based on smoking alone)

Aggravation vs. Consequential Condition

Aggravation:

- worsening of pre-existing condition, e.g. asthma, liver damage

Consequential:

- complications of disease (e.g. metastasis)
- complications of treatment (e.g. steroid induced osteoporosis for pulmonary fibrosis)
- unforeseen events - fracture from fall on way to physician's office

Consequential Conditions

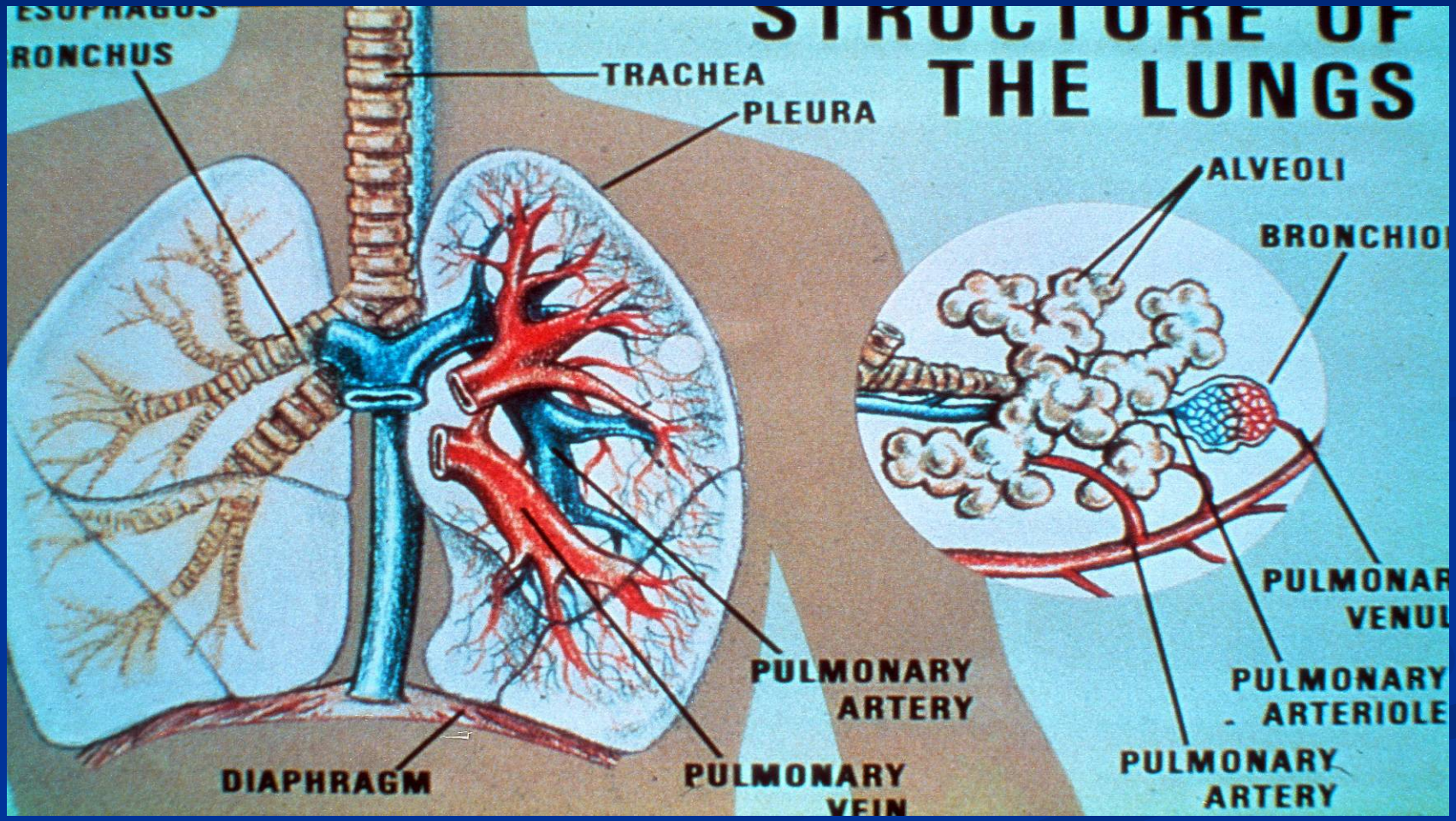
- PM 2-1000, “Consequential Injuries”
- Metastatic cancer sites
- Cancer Symptoms – N&V, pain, extreme fatigue
- Treatment related - radiation pneumonitis, anemia, osteoporosis (from steroids), wt loss
- Linked conditions -psychiatric consequences, pneumonia

Cor Pulmonale

- Can lesions of the peripheral airways lead to pulmonary hypertension, right ventricular hypertrophy and right heart failure?

- Right side of Heart – pumps deoxygenated blood to lungs

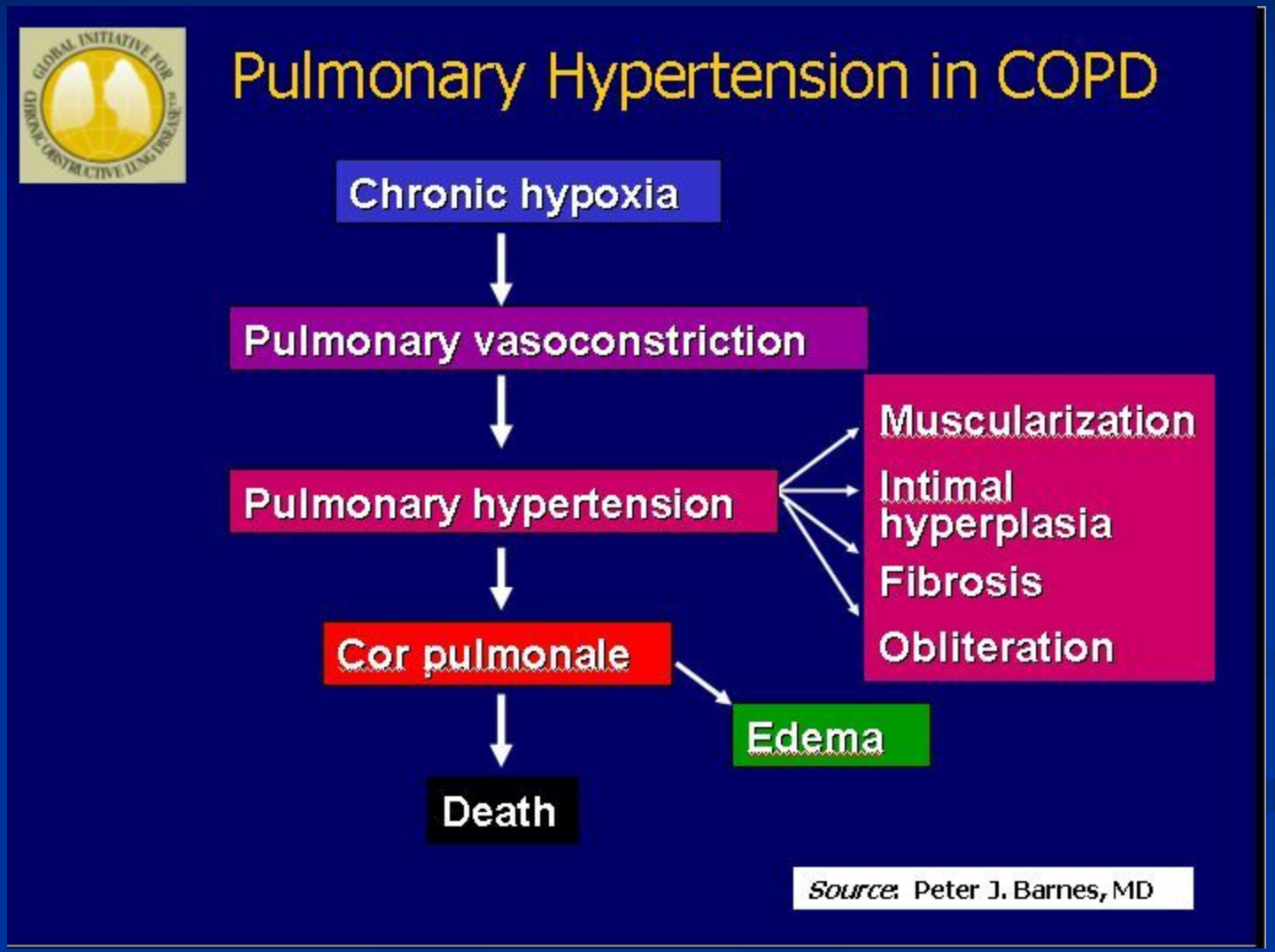
Lung w/Blood vv



Cor Pulmonale

- Consequential – enlargement of right ventricle, pulmonary hypertension
- 2nd to malfunctioning lung – COPD, ILD
- Hypoxia - Strain on right side of heart
- Clinical picture (RV Failure), CXR, EKG

Pulmonary Hypertension



What we've covered:

- Key pulmonary function parameters.
- How PFTs are interpreted.
- Distinction between obstructive and restrictive lung disorders.

What we've covered:

- How to distinguish asthma, chronic bronchitis and emphysema.
- How to distinguish aggravation from consequential conditions.
- How cor pulmonale can be a consequential condition.

Questions