Chapitre 4
Système respiratoire

Système respiratoire: finalité et utilité

- Finalité du système respiratoire
- Amener O_2 du milieu extérieur → milieu intracellulaire
- Eliminer CO_2 du milieu intracellulaire → milieu extérieur
- Contrôle et régulation du pH sanguin (H^+, HCO_3^-)

Système respiratoire: structure générale

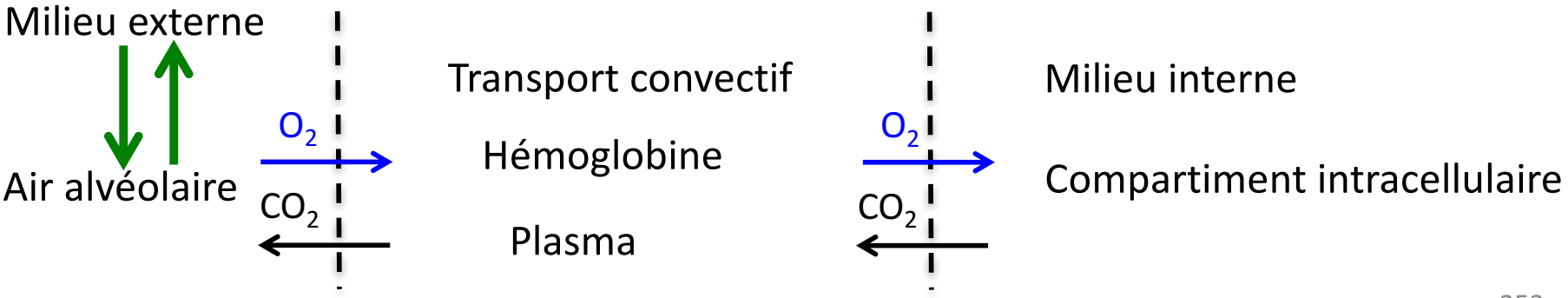
- Gestion liquide/gaz faible énergie hydrodynamique: Transfert de matière
  - *Cœur: propulsion matière* *Poumon: Echange matière*
- Transport de matière, d'énergie et d'information
- Géométrie de construction: tubulure et surface échange étendue
- Architecture alvéolaire et vasculaire
- Organisation spatiale arborescence
- Mécanique ventilatoire active/passive
- Régulation et limites: Boucle fermée ; Plateau (non-linéarité)

Système respiratoire: structure générale

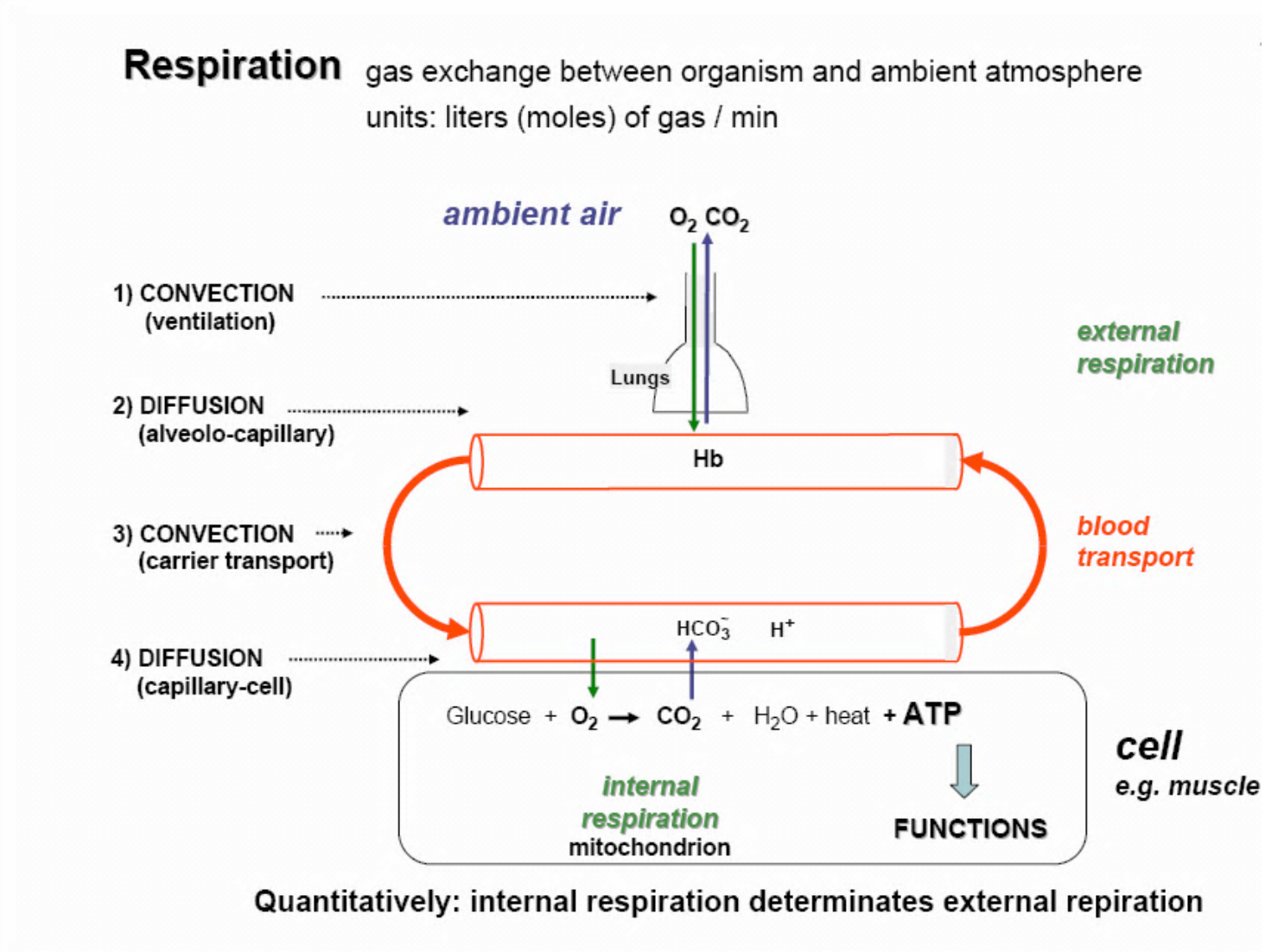
- Mécanismes mis en jeu
- Système ventilatoire: voies aériennes, mécanique ventilatoire
- Interface diffusion: gaz ↔ liquide
- Capacité diffusion membranaire: surface alvéolaire
- Système de distribution convectif: circulation sanguine
- Dispositif de transport: hémoglobine

Système respiratoire: principes généraux

- 2 fonctions: 1) Ventilation
  2) Respiration tissulaire
- 1) et 2) Régulés et limités (valeurs max. d'échange et transport)
- 1) Transfert air ambiant → Espace alvéolaire
- 2) Echanges alvéole ⇌ sang ⇄ milieu intracellulaire
- 1) et 2) Passage de 2 étapes distinctes



Système respiratoire Principes de base



Système respiratoire Structure générale

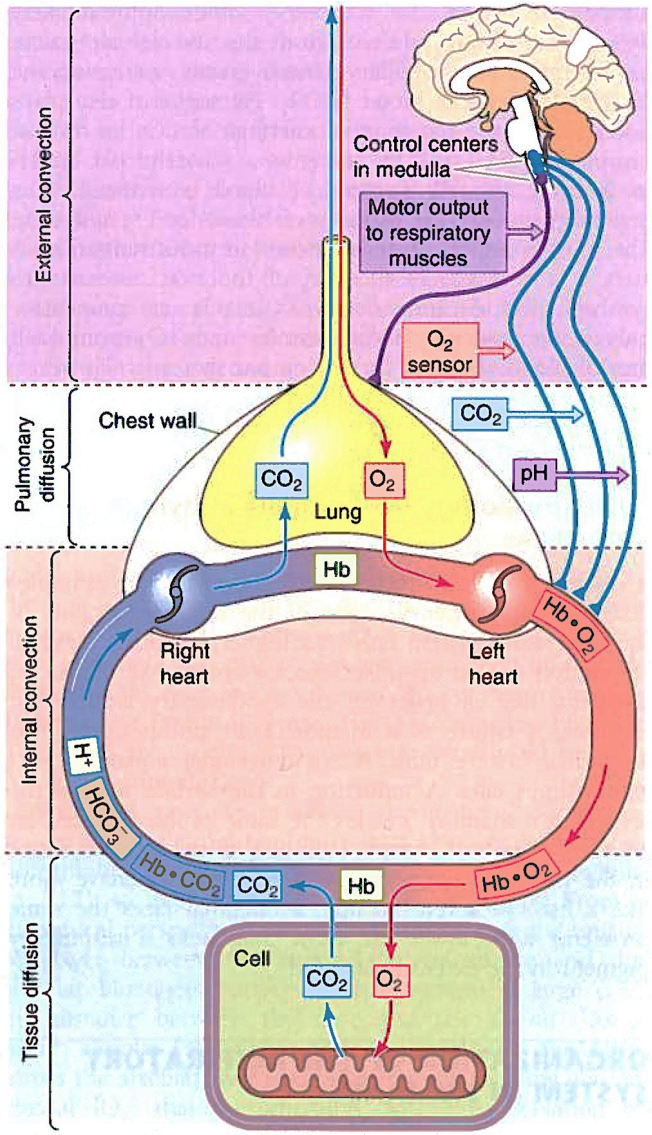
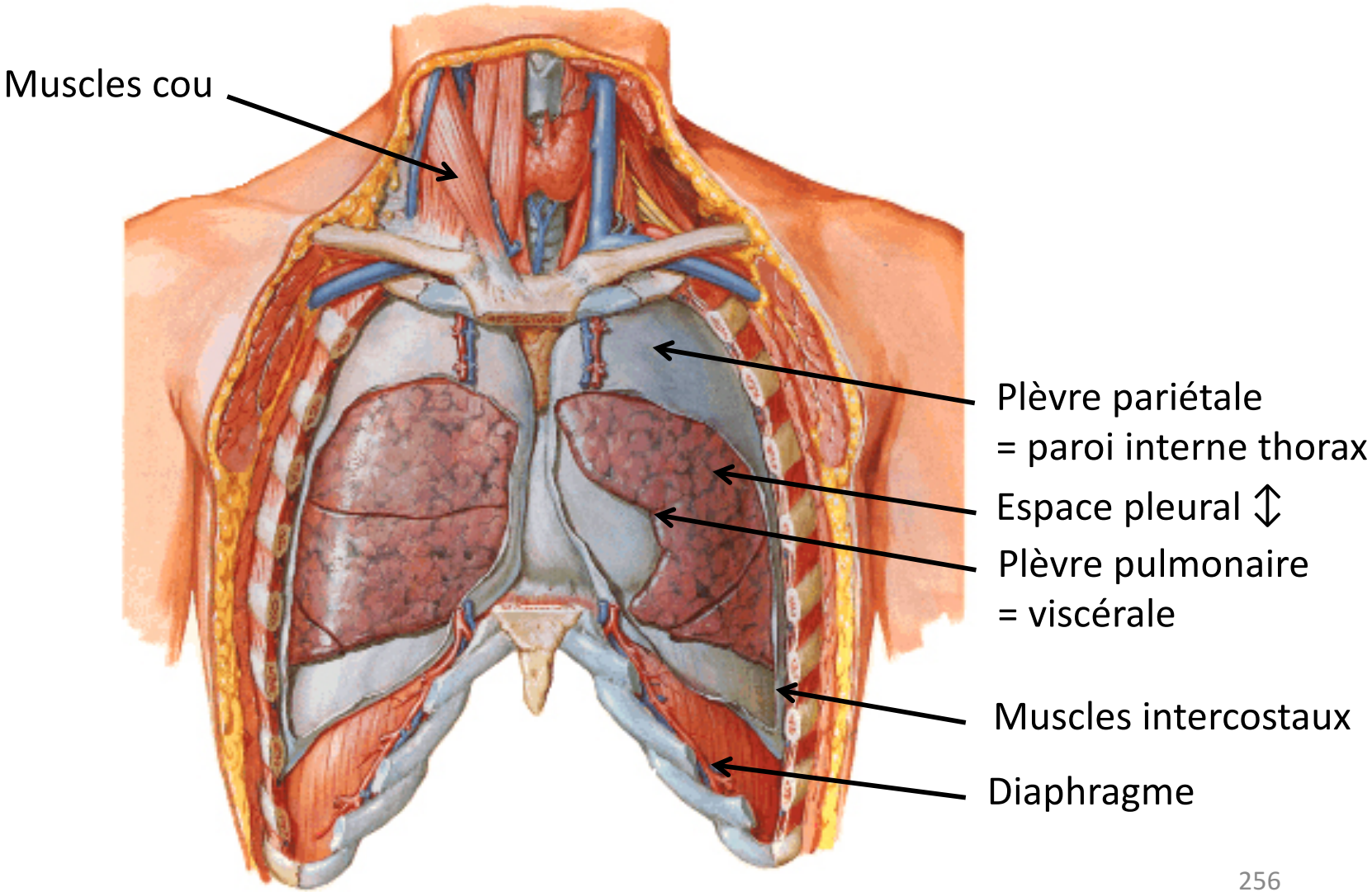


FIGURE 25–3. The respiratory apparatus in humans.

Système respiratoire Anatomie générale du thorax



Système respiratoire Anatomie des voies aériennes

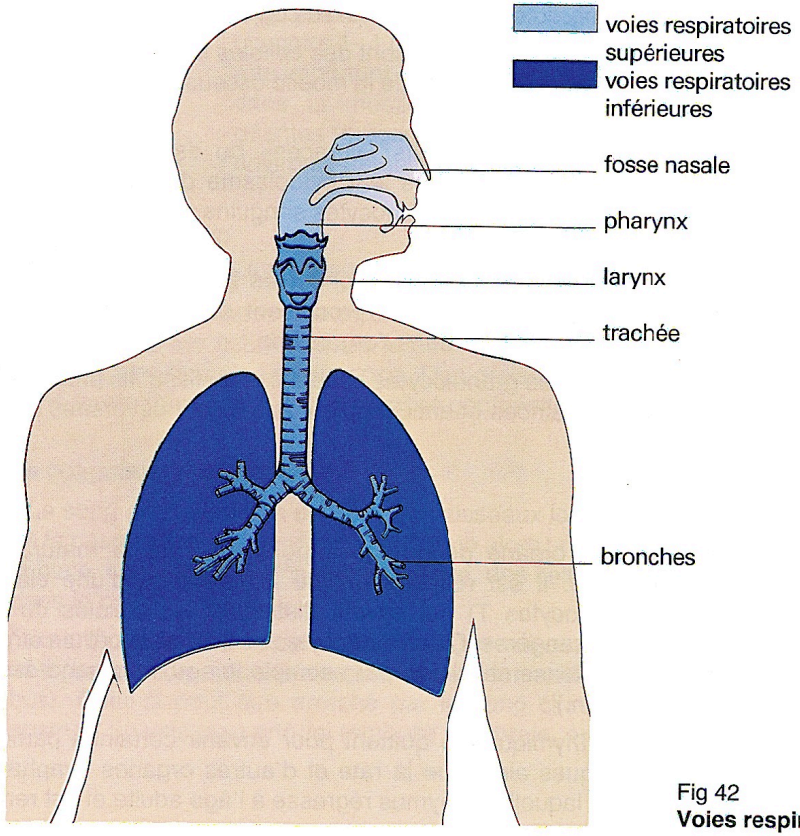


Fig 42
Voies respiratoires

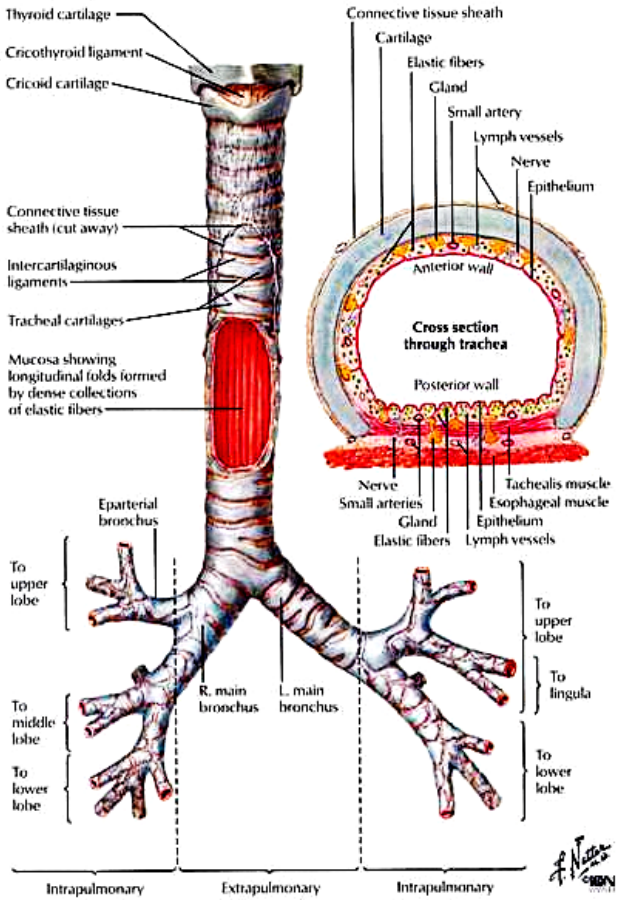


FIGURE 5.2 STRUCTURE OF THE TRACHEA AND MAJOR BRONCHI

The major conducting airways to the lungs include the cartilaginous trachea, the right and left main bronchus, and the intrapul- subsequent branching, the conducting airways become smaller and smaller in diameter (see Figure 5.3), eventually losing their carti-

Système respiratoire Anatomie des voies aériennes

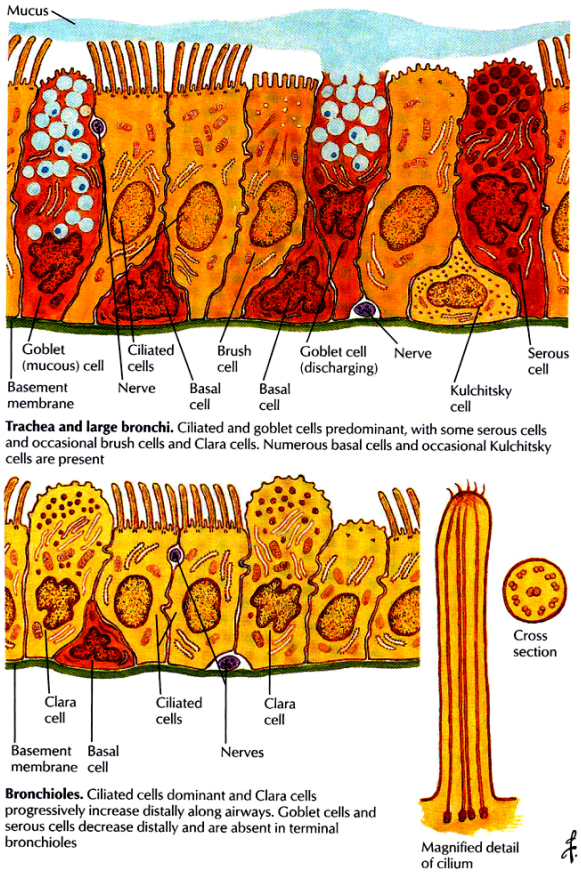
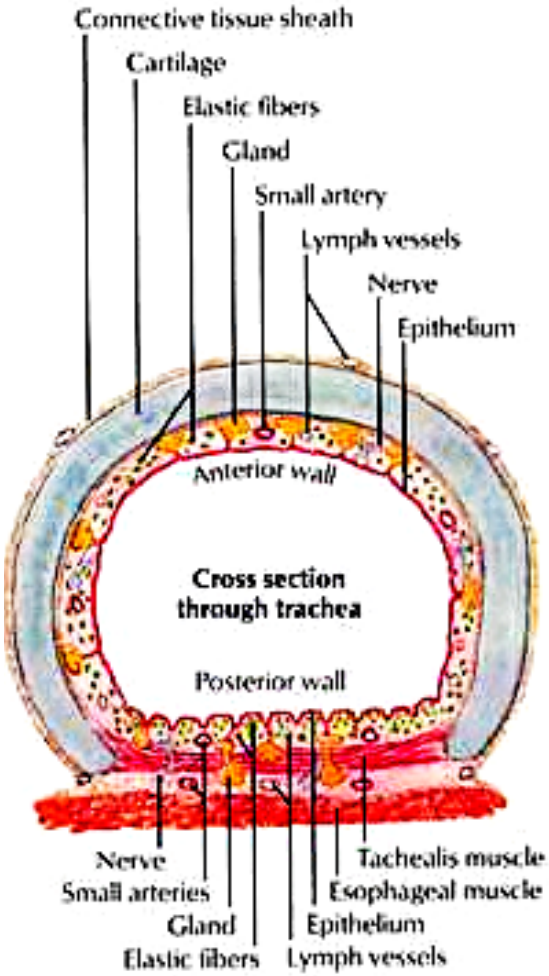


FIGURE 5.4 ULTRASTRUCTURE OF TRACHEAL, BRONCHIAL, AND BRONCHIOLAR EPITHELIUM

The respiratory airways are lined by a pseudostratified, ciliated columnar epithelium. In smaller airways the epithelium may become low columnar or simple cuboidal. The ciliated cells constitute approximately 30% of the total cell population. Goblet cells (30% of cell population) secrete mucus that coats the epithelial cells. This mucous coating protects the epithelial cells from desiccation and traps inhaled particulates that are then transported up the airways and out of the lungs by the ciliated cells—a process termed mucociliary transport. Basal cells (30% of cell population) are stem cells that give rise to the goblet, ciliated, and brush cells. The function of brush cells (3% of cell population) is not resolved. They may represent goblet cells that have released their contents, or they may have a sensory role. The Kulchitsky cells (3% of cell population) secrete a number of paracrine factors that likely regulate the function of nearby cells. They are part of the bodies diffuse neuroendocrine system (DNES). Clara cells secrete a surfactant-like material that reduces surface tension of the bronchioles. They may also degrade inhaled toxins. The function of the secretory product of the serous cells is not known.



Système respiratoire Anatomie des poumons

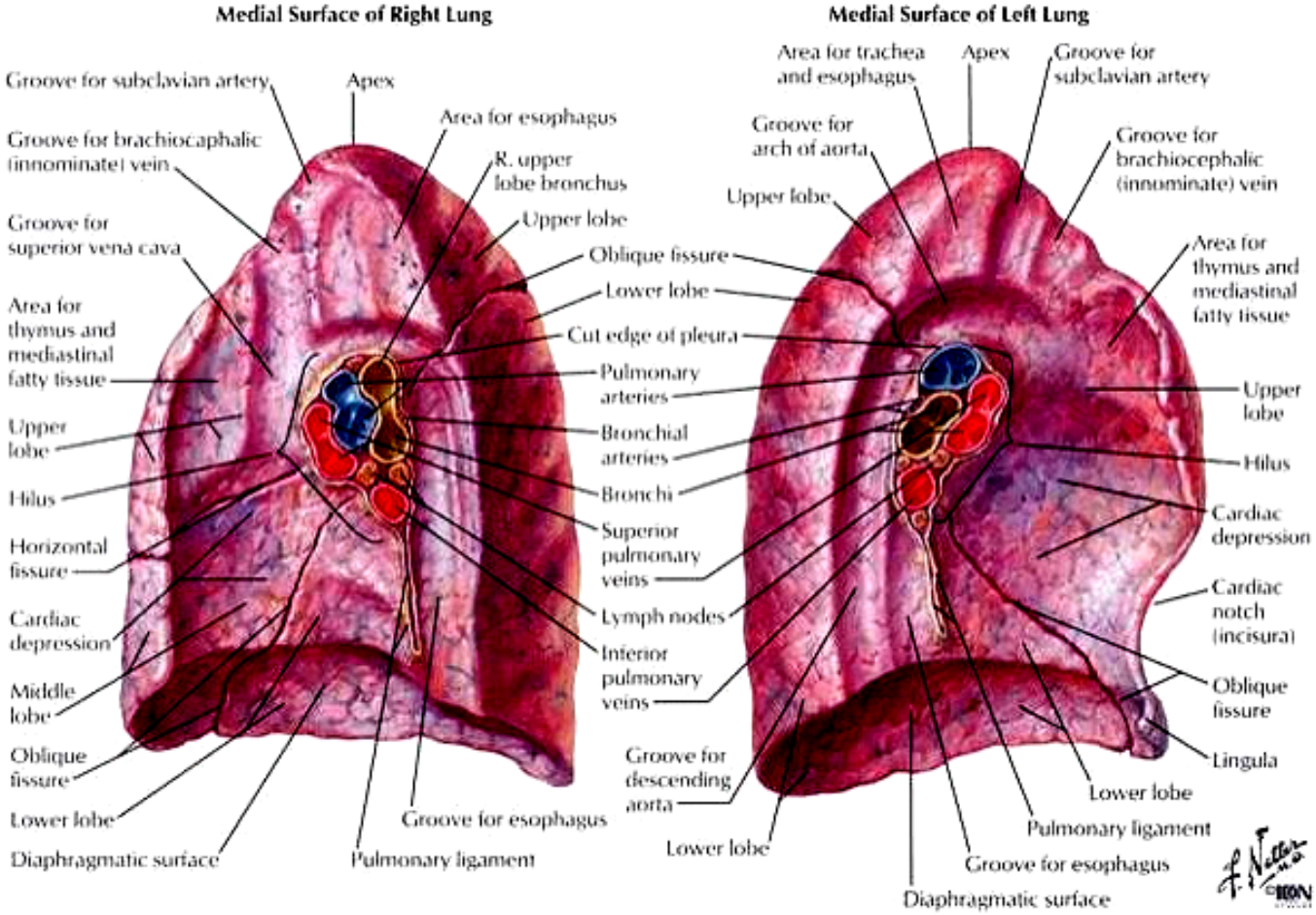
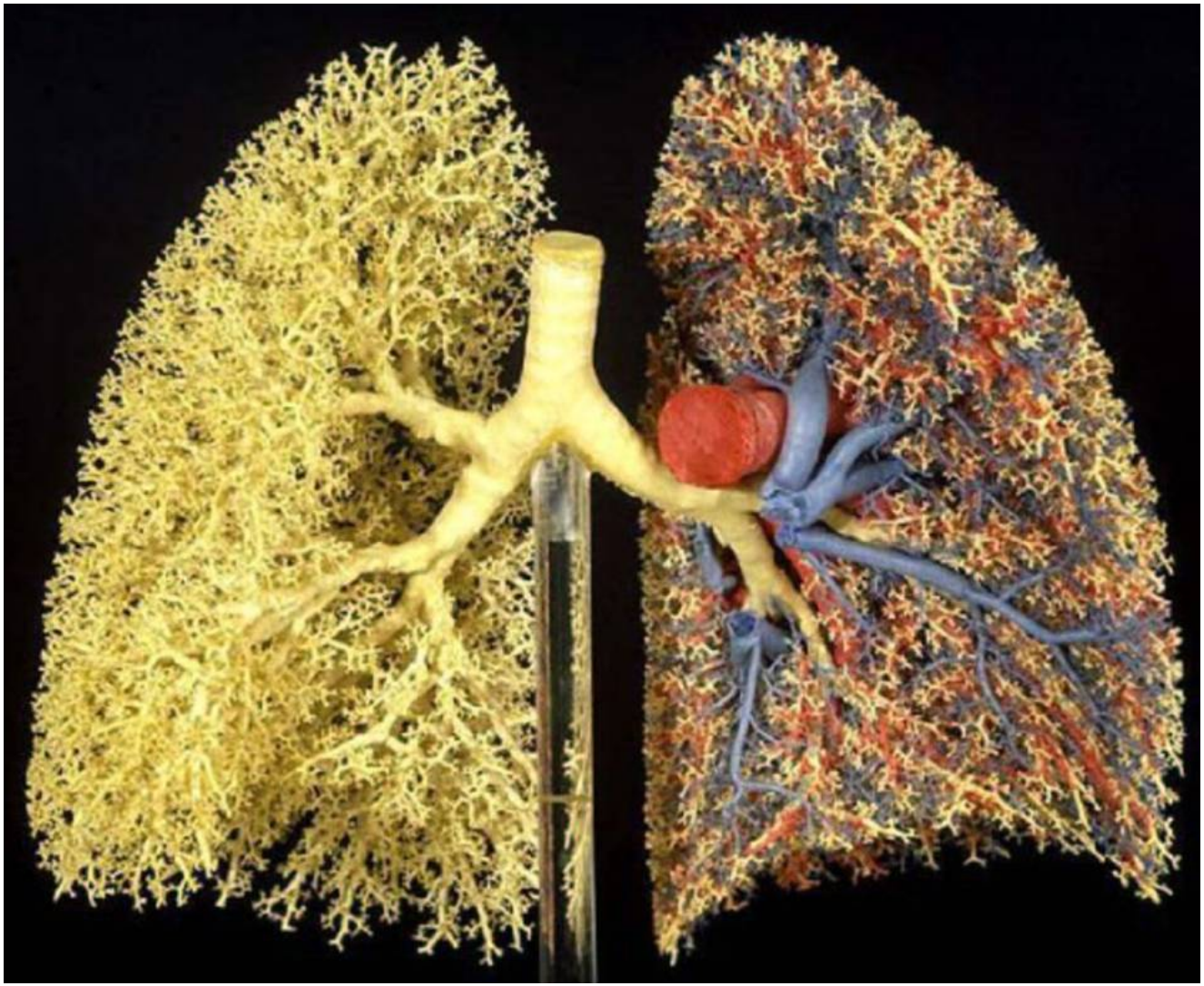


FIGURE 5.1 MEDIAL SURFACE OF THE LUNGS

Breathing, or ventilation of the lungs, is an automatic, usually rhythmic, and centrally controlled process. The right lung has three lobes, and the left lung has two lobes, with the bronchi, pulmonary vessels, nerves, and lymphatics entering or leaving each lung at the hilum, which is situated on the medial aspect of the lung. The trachea bifurcates into primary bronchi, which then enter the lobes of the lung and further subdivide into smaller and smaller segments (bronchioles and ultimately alveolar ducts and sacs).

Système respiratoire Anatomie des poumons



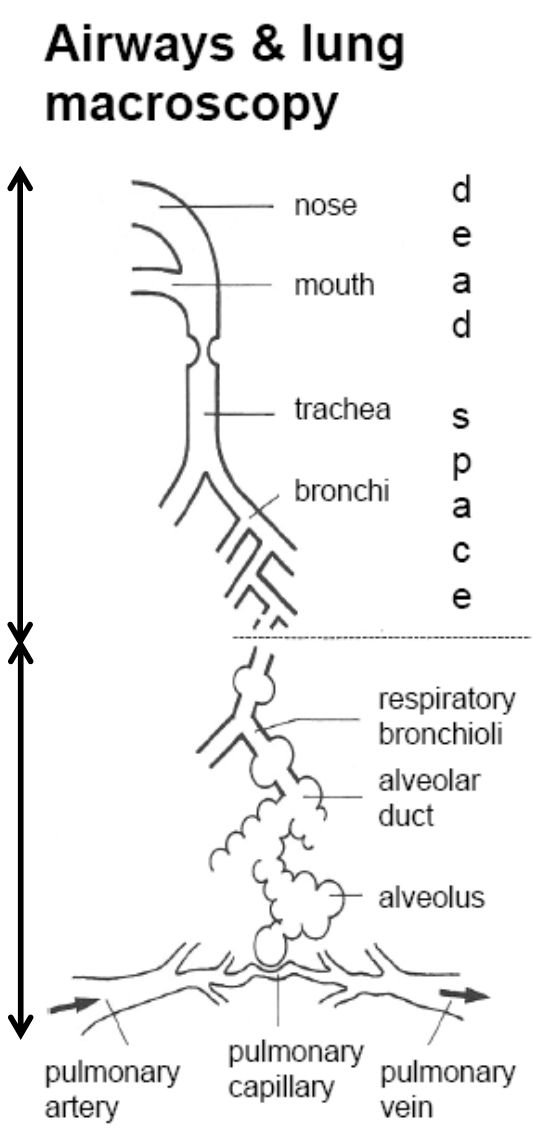
L'image de gauche montre les voies aériennes pulmonaires. L'image de droite montre les voies aériennes, accompagnées des artères et veines pulmonaires. Les images et le moulage ont été généreusement fournis par Walter Weder (Institut d'anatomie, Université de Berne, Berne, Suisse).

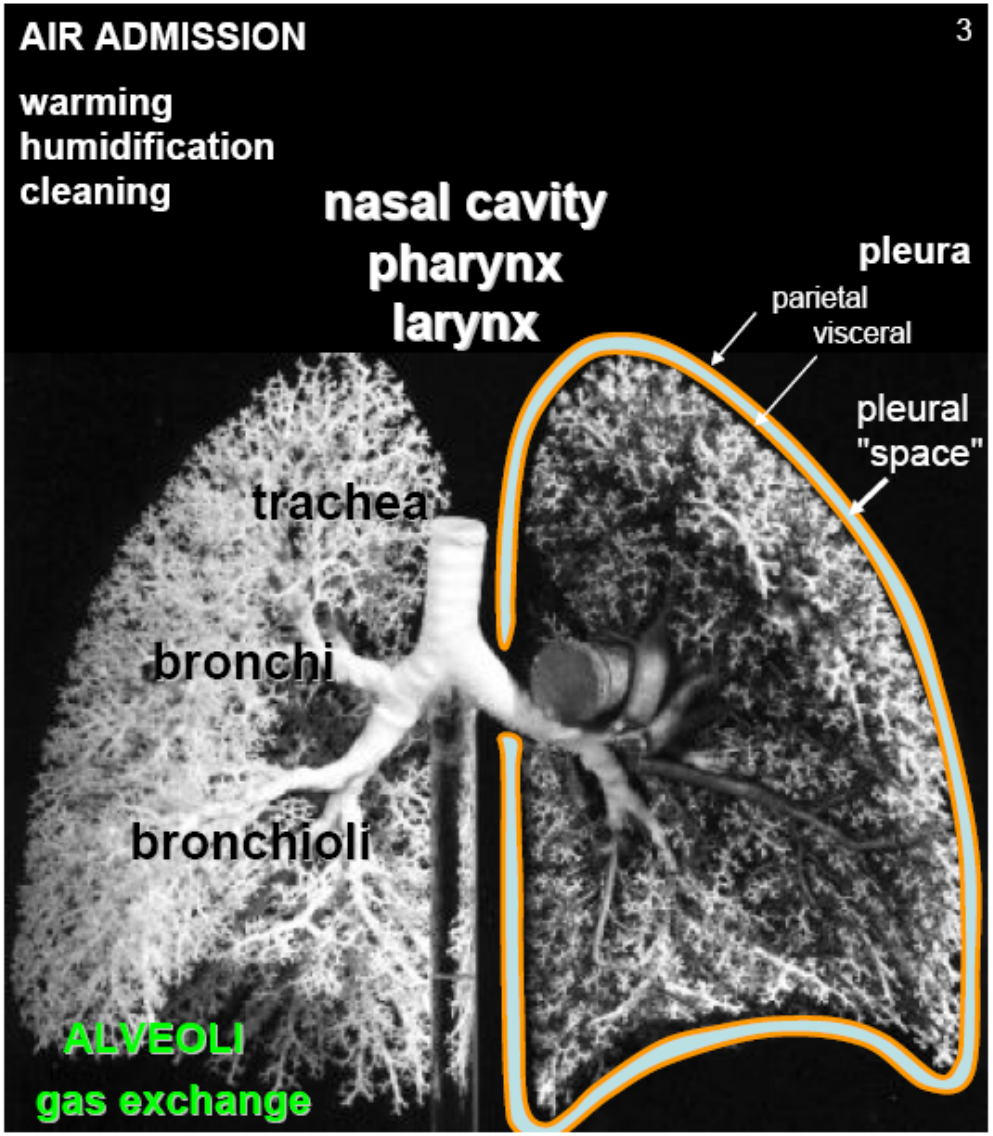
Système respiratoire Anatomie de la cage thoracique osseuse

Système respiratoire Anatomie fonctionnelle 2 types d'espaces

Espace mort

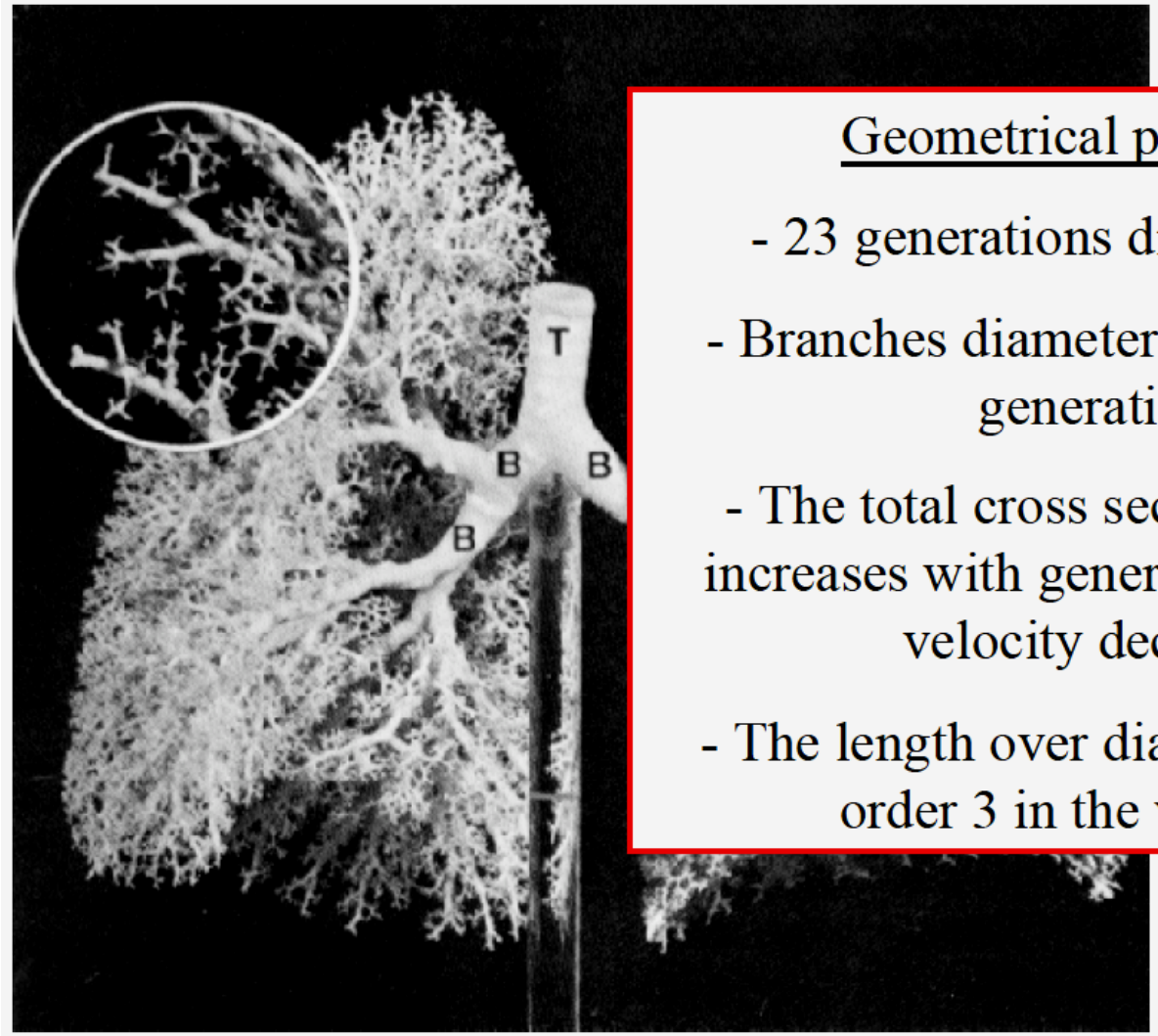
Espace fonctionnel





Plèvre
pariétale
viscérale

Système respiratoire Anatomie de l'arbre bronchique



Geometrical properties :

- 23 generations dichotomic tree
- Branches diameters decreases with generations.
- The total cross section of the tree increases with generation and the air velocity decreases.
- The length over diameter ratio is of order 3 in the whole tree

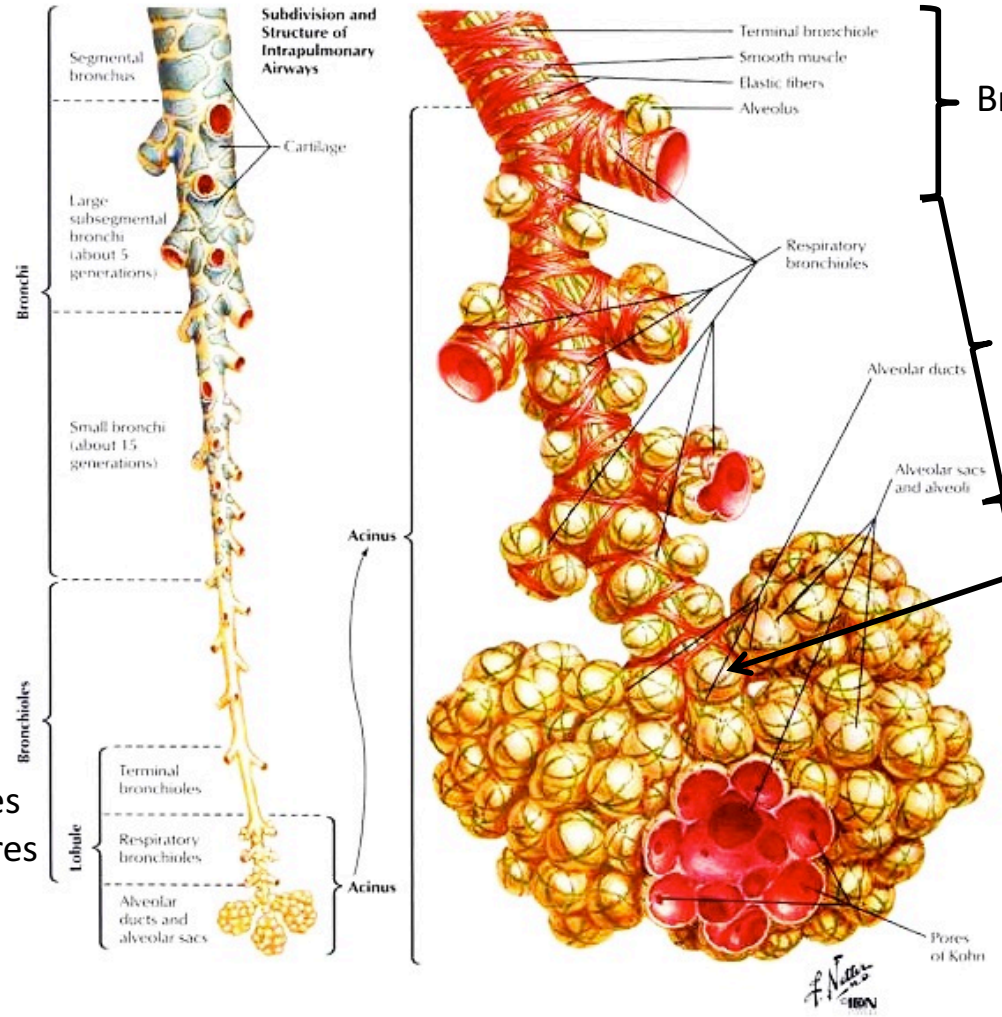
Système respiratoire Anatomie de l'alvéole

Bronches: ·segmentées
·sous-segmentée
·petit diamètre

Bronchioles

Lobules: ·bronchioles terminales

Acinus: ·bronchiole respiratoires
·canaux alvéolaires
·sacs alvéolaires



Bronchiole terminale

Bronchiole respiratoire

Canaux alvéolaires

Sacs alvéolaires
alvéoles

Acinus

FIGURE 5.3 INTRAPULMONARY AIRWAYS

As air enters the trachea during inspiration, it will pass through as few as 10 or as many as 23 generations, or branchings, on its journey to alveoli. The initial bronchi constitute the conducting zone and are incapable of gas exchange. Bronchioles represent a transitional zone with some alveoli, and the terminal bronchioles are lined with alveolar ducts and sacs, representing the respiratory zone.

Système respiratoire Anatomie de l'alvéole: interface vasculaire

artériole pulmonaire
(sang veineux!)

veinules pulmonaires
(sang artériel!)

Capillaires pulmonaires
(échanges gazeux)

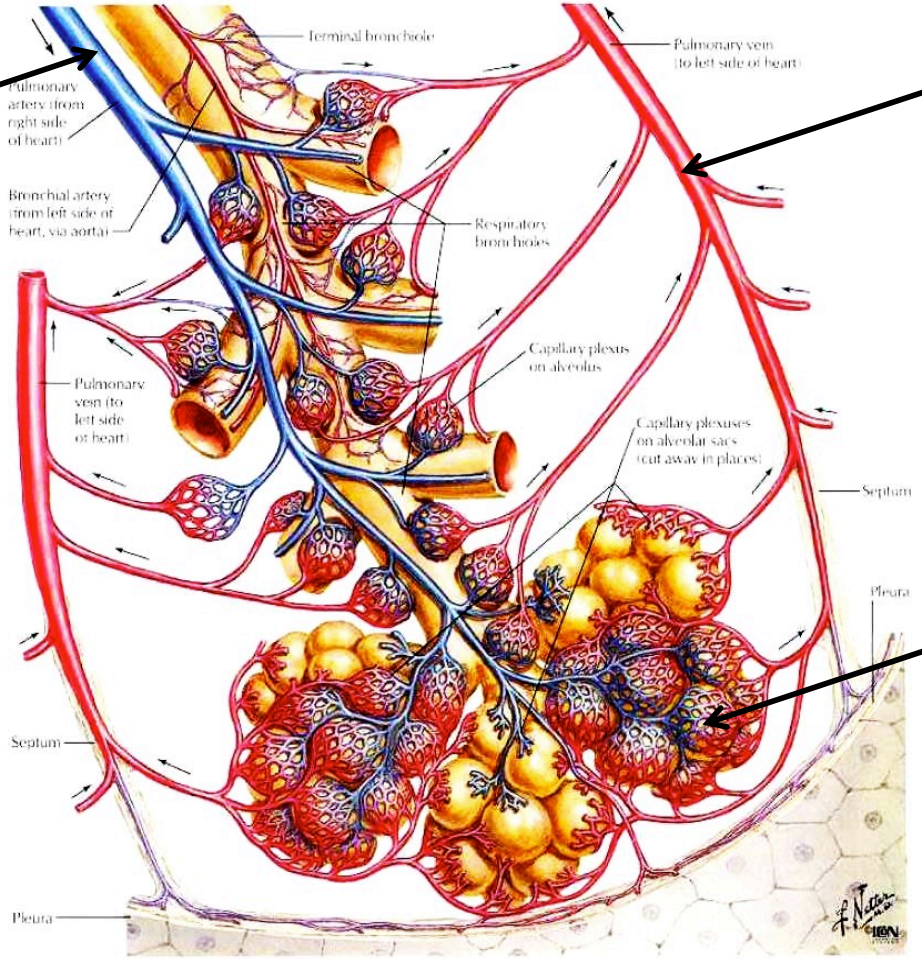
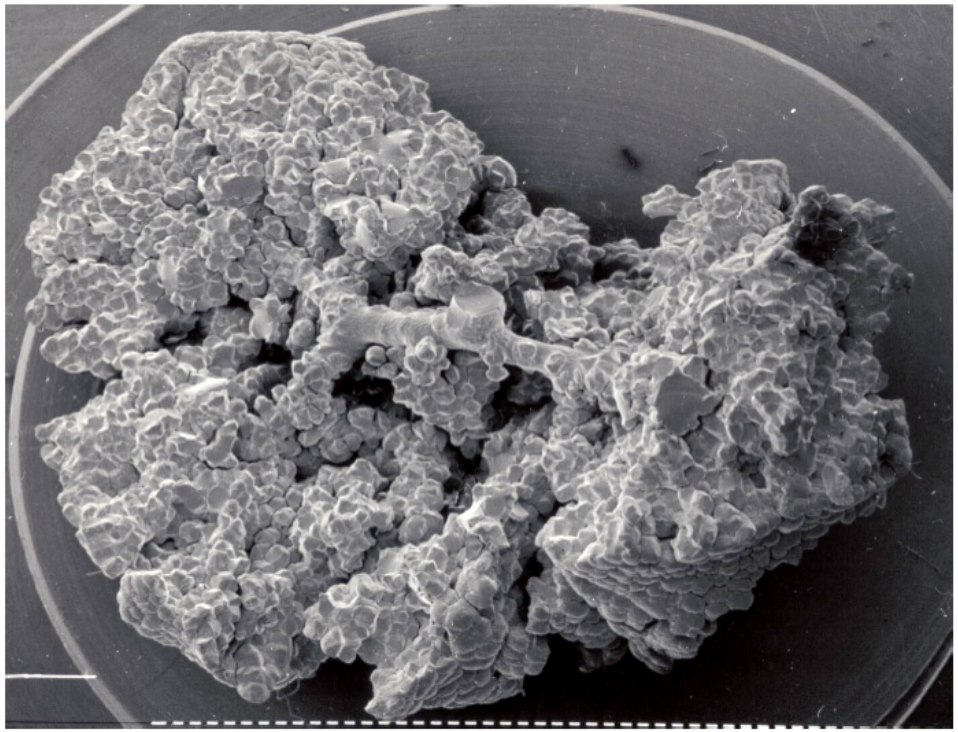


FIGURE 5.13 INTRAPULMONARY BLOOD CIRCULATION

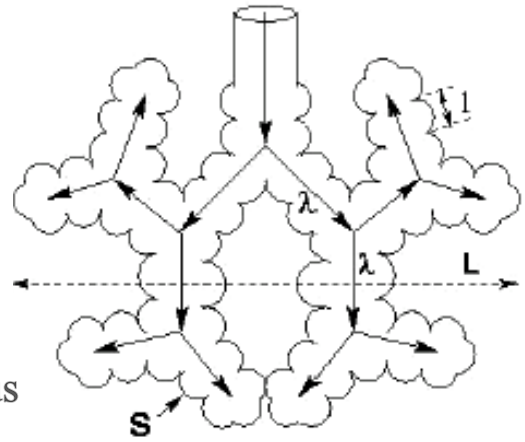
Blood from the right ventricle of the heart perfuses the lungs (via the pulmonary arteryt at a relatively high rate (approximately 5 L/min) but under low pressure (driving pressure of about 6 mm Hg). Pulmonary capillary plexuses envelop the alveolar sacs, where most of the gas exchange occurs. Pulmonary veins collect the oxygenated blood and return it to the left side of the heart for distribution to the systemic circulation. In a normal resting adult, the lungs contain about 75 mL of blood distributed variably across its vasculature.

Système respiratoire Anatomie de l'alvéole: unité de base l'acinus

About
30 000
acini in the
human lung

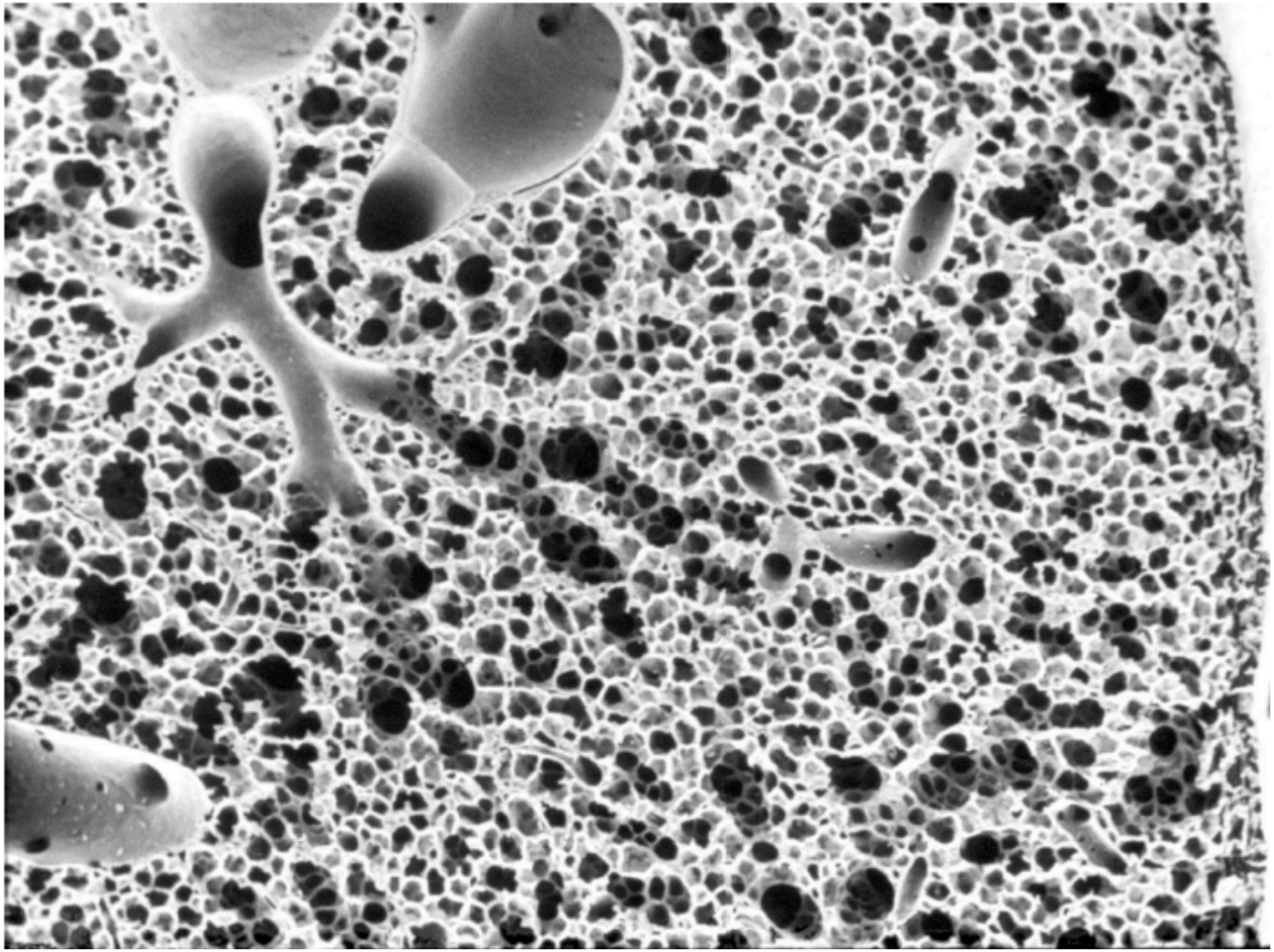


About
10 000
alveoli
per acinus

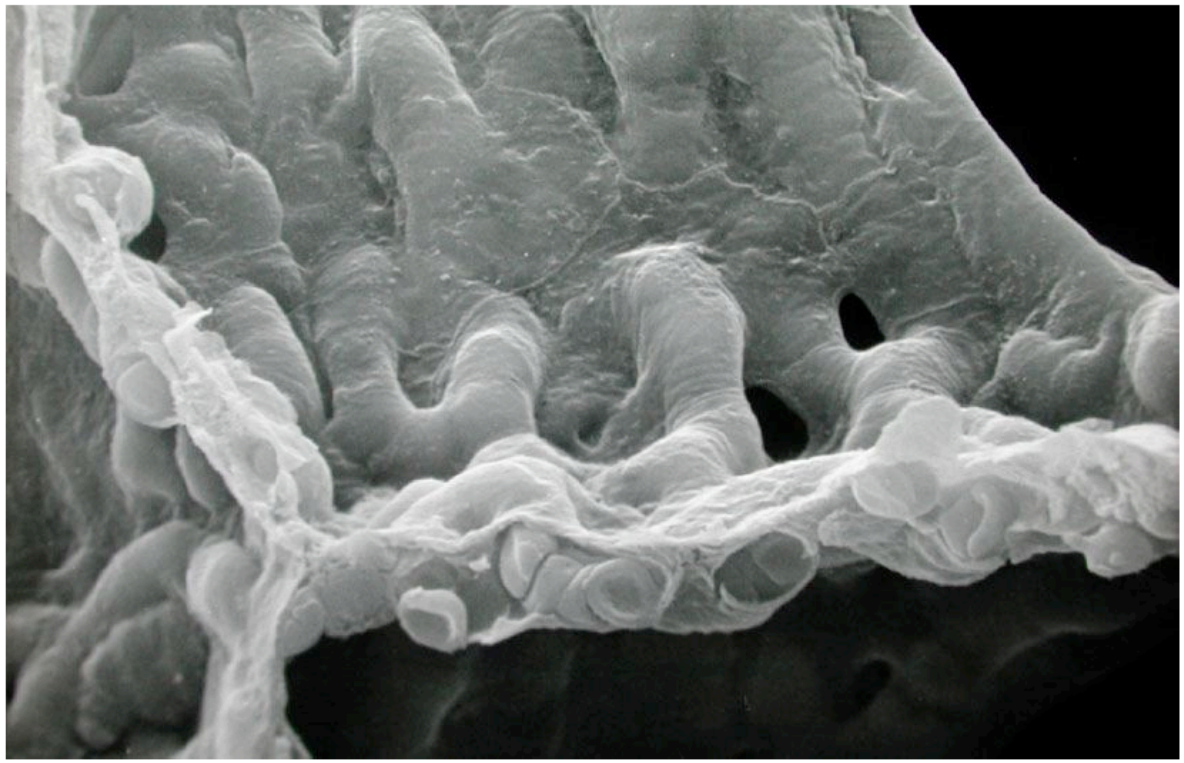


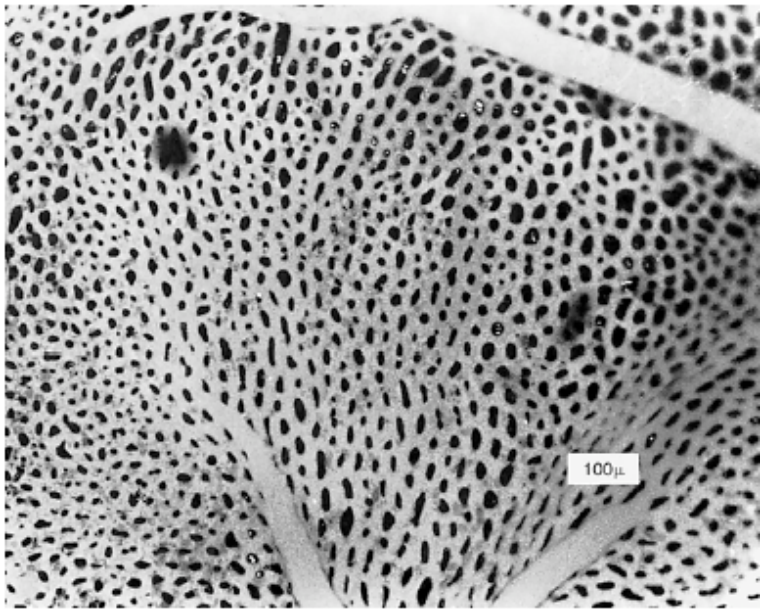
3. 10^8 alveoli in the human lung

Système respiratoire Anatomie de l'alvéole: coupe planaire de l'acinus

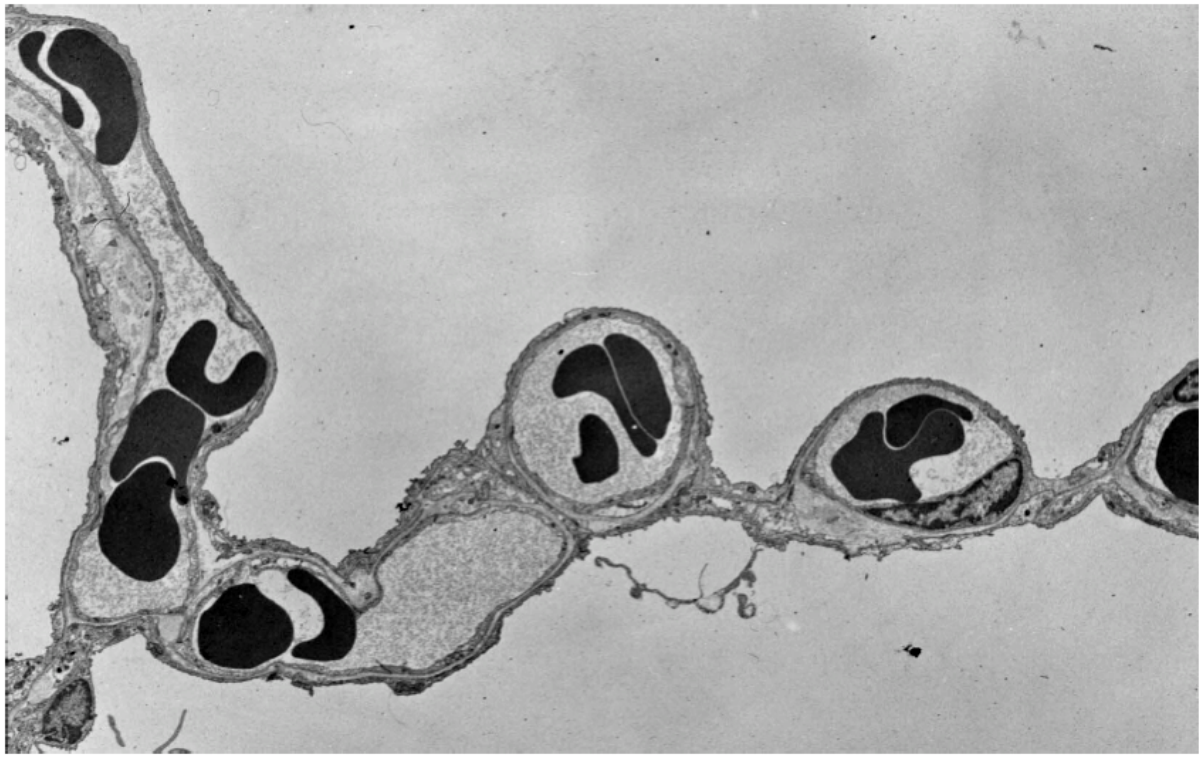


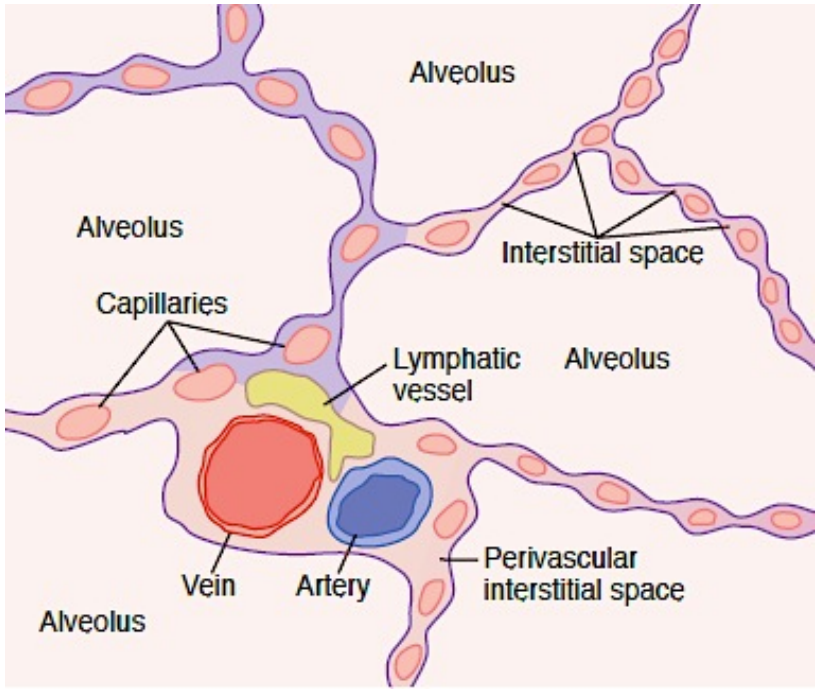
Système respiratoire Anatomie de l'alvéole: membrane et capillaire sanguin





Système respiratoire Anatomie de l'alvéole: capillaire sanguin

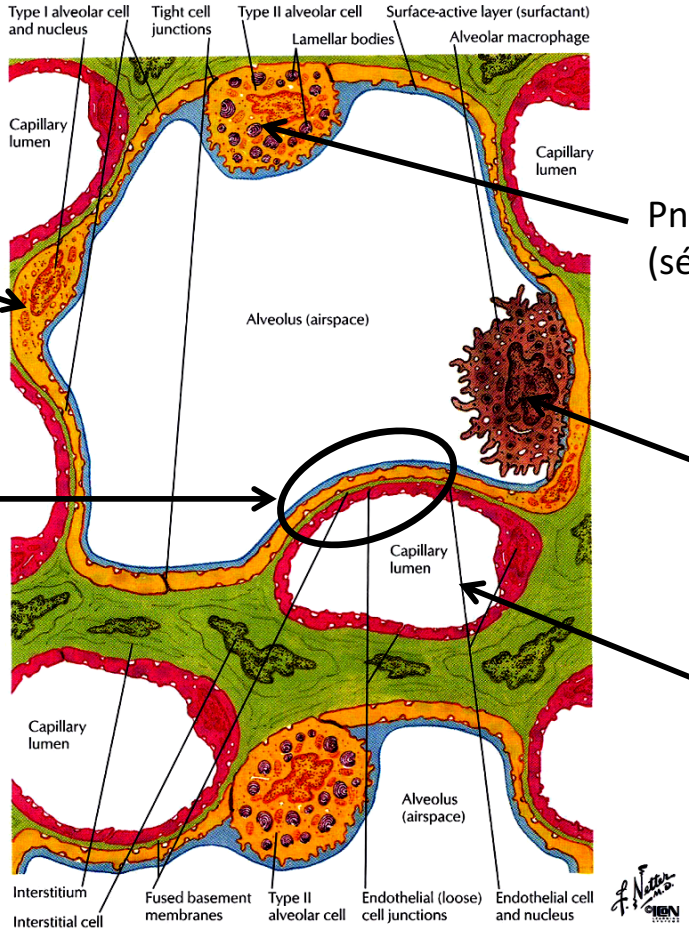




Système respiratoire Anatomie de l'alvéole: la barrière respiratoire

Pneumocyte type I
(paroi alvéole)

Barrière respiratoire
(=membrane pneumocyte I
+ membrane capillaire)



Pneumocyte type II
(sécrète surfactant)

Macrophage
(défense)

Capillaire sanguin
(transport hémoglobine)

FIGURE 5.14 ULTRASTRUCTURE OF PULMONARY ALVEOLI AND CAPILLARIES

Gas exchange occurs across the type I alveolar cells, the basement membrane, and the capillary endothelial cell. The type II alveolar cells secrete surfactant, which forms a thin layer over the fluid that coats the surface of the alveolus. Alveolar macrophages migrate out of the capillaries and can be found in the interstitium of the alveolar septa or within the alveolus itself. They serve to engulf inhaled particulates and bacteria.