Respiratory System (Ch. 23)
Human Anatomy lecture

I. Overview
A. Functions with cardiovascular system (= cardiopulmonary system)
   ① Deliver O₂ to blood
   ② Remove CO₂ from blood
   Also
   - Modifies air, delivers smells, produces sounds
   - other physiological functions

B. Functionally 2 divisions
   1. Conducting division: nose → lungs
   2. Respiratory division: site of gas exchange in alveoli (& some other distal portions)

C. Anatomically divided differently
   1. Upper respiratory tract: nose and pharynx (NOTE your text divides below larynx)
   2. Lower respiratory tract: everything else

II. Upper respiratory tract (KNOW Fig. 23.2)
A. Nose
   Nasal cavity divided by nasal septum into Left & Right nasal fossae

   External nose
   → formed by bone (nasal & maxilla) + hyaline
   L. & R. naris (pl. = nares)  cartilage (9+ plates)
   ↓
   L. & R. vestibule → lined with stratified squamous epi.
   ↓

   Internal nose
   3 prs meatuses formed by 3 prs conchae (turbinates)
   mucous membrane with
   ↓
   pseudostrat. ciliated col. epi
   except patch on superior meatus:
   olfactory epithelium.
   L & R posterior nasal apertures → at end of hard palate
   (choanae)
   ↓
   pharynx

   • Why conchae? → increase surface area to clean, warm & moisten air
   • L & R inferior conchae have erectile tissue (swell body) → alternately engorged
B. Pharynx (= throat)

1. Funnel-shaped passage (parts common to both food and air) - posterior to nasal and oral cavities

2. 3 Divisions (Fig. 23.2c)

   - **nasopharynx**
     - posterior nares (end of hard palate) →
     - uvula (end of soft palate) →
     - pseudostratified ciliated col. epithelium

   - **oropharynx**
     - uvula (end of soft palate) → tip of epiglottis
     - stratified squamous epithelium

   - **laryngopharynx**
     - tip of epiglottis → cricoid cartilage
     - stratified squamous epithelium

   - oral cavity → fauces → lingual & palatine tonsils

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III. Lower respiratory tract

A. Larynx (voice box) → **KNOW** Fig. 23.4 (partially)

1. Short passageway anterior to C₄-C₆

2. 9 cartilages, several ligaments and muscles
   - 1 epiglottis - leaf-shaped, superior
   - 2 thyroid (Adam’s apple) – shield-shaped, anterior
   - 3 cricoid – ring-shaped, inferior → only complete ring in respiratory tract
     + 3 small pairs posteriorly and laterally

3. Mucosa forms 2 pairs of folds (Fig. 23.5)
   - vestibular folds (false vocal cords) – superior
   - vocal cords (vocal folds) – inferior
   - glottis – vocal cords and space between them

4. Lined w/stratified squamous epi. (superiorly); pseudostratified ciliated col. epi. (inferiorly)

5. When you swallow:
   - larynx elevates,
   - epiglottis hinges “down,”
   - vestibular folds close glottis
   - avoids “breathing” food
B. Trachea (windpipe) → **KNOW Fig. 23.7a**
1. Anterior to esophagus, C6-T5
2. Tubular passage of 16-20 stacked C-shaped cartilaginous rings
3. Lined w/pseudostratified ciliated col. epi.
   - abundant goblet cells & glands → mucus
   → result is a mucociliary escalator
4. Trachealis muscle (smooth) and elastic c.t. hold ends of “C” together
5. Outer layer is an adventitia

Why cartilage? Why C-shaped and not complete rings?
• maintains patency (openness) of tube
• allows expansion of esophagus
• allows adjustment of diameter and thus airflow

C. Bronchial tree (Fig. 23.7a)
1. System of branching tube/tubules (your text doesn’t include trachea)

   - trachea
   ↓
   L + R main bronchi – enter lungs
   ↓
   Lobar bronchi – one for each lobe of lung
   ↓
   Segmental bronchi – 10/lung?, supply bronchopulmonary segments
   ↓
   bronchioles – no cartilage, <1mm diameter
   ↓
   ↓
   ↓
   terminal bronchioles

2. As move “down” tree:
   diameter ↓
cartilage ↓
   smooth muscle ↑
   epithelium changes to non-ciliated simple cuboidal

3. Nicotine paralyzes cilia
   constricts smooth muscle, ↓ diameter of terminal bronchioles
   ↑ mucus production
D. Lungs

1. Surrounded by pleural membrane (Fig. 1.13 & 23.12)
   -insert sketch-
   -parietal pleura
   -pleural cavity
   -serous fluid
   -visceral pleura

   Functions?
   ① reduce friction
   ② create pressure gradient
   ③ compartmentalize (decreased chance of infection)

2. Gross anatomy **KNOW Fig. 23.9**
   - apex & base
   - costal & mediastinal surfaces
   - hilum – indented region
   - root = bronchus & neurovascular bundle
   - lobes and fissures
   - cardiac impression

3. Each lobe divided by inward extensions of visceral pleura into bronchopulmonary segments (see chap. opening art, p. 631)

4. Each bronchopulmonary segment subdivided into pulmonary lobules (2-15 mm), supplied by a bronchiole, which gives off 50-80 terminal bronchioles (<0.5 mm).

5. Within a pulmonary lobule: **(KNOW Fig. 23.11)**
   - bronchiole
     - terminal bronchiole → simple + smooth
       - cuboidal muscle
     - respiratory bronchiole → “low” scanty smooth
       - cuboidal muscle
   - alveolar duct
     - alveolus alveolar sacs simple squamous epi.
6. Lots of elastic fibers in c.t. surrounding all these and in walls of tubes

7. Lung receives double blood supply

   (deoxygenated) pulmonary A. \[\rightarrow\] pulmonary V. (deoxygenated)
   (oxygenated) pulmonary V. \[\leftarrow\] bronchial AA. (shunt)
   bronchial AA. \[\rightarrow\] azygos system

E. Alveolus
1. Designed to maximize $O_2/CO_2$ exchange:
   - 300 million, 0.3mm diameter
   - 70m$^2$ total surface area (~= handball court)

2. Histology (Fig. 23.11)
   ① squamous (type I) alveolar cells
      -95% of alveolus surface area
      -site of gas exchange
   ② great (type II) alveolar cells → outnumber type I
      -microvilli
      -secrete surfactant → prevents collapse
      -repair alveolar wall
   ③ Alveolar macrophages (dust cells) [WBC]
      - wander around
      - 100 million/day ride the escalator giving their lives for your health!

3. Alveolus jacketed by dense capillary network
   - gases must diffuse across respiratory membrane (Fig. 23.11c)
   - 6 layers (more than your text implies)
      ① surfactant
      ② squamous cell
      ③ squamous cell basement membrane
      ④ interstitial space
      ⑤ capillary basement membrane
      ⑥ capillary endothelial cell

4. Vital to prevent accumulation of fluid in lungs – How?
   - extensive lymphatic drainage
IV. Functional anatomy of breathing (Fig. 23.13)

A. Basic physics

\[
\begin{align*}
\uparrow \text{volume} &= \downarrow \text{pressure} \\
\downarrow \text{volume} &= \uparrow \text{pressure}
\end{align*}
\]

How do you accomplish this change in thoracic volume?

B. Normal inspiration

1. Diaphragm – ~ 2/3

\[\text{diaphragm relaxed between breaths} \rightarrow \text{diaphragm contracted during inspiration}\]

-- Increases vertical dimension of thorax 1 \(\rightarrow\) 7 cm

2. Ribs - ~ 1/3

\[\text{External intercostals contract} \quad \text{At rest, ribs angle } \rightarrow \text{Inspire: ribs angle } \rightarrow \text{“Bucket handle”}\]

Increases anterior-posterior (AP) and transverse dimensions

C. Forced inspiration uses additional accessory muscles of inspiration.

D. Normal expiration is a passive process

1. diaphragm and external intercostals relax
2. elastic c.t. returns lungs to original dimensions

E. Forceful expiration

-- internal intercostals contract: lower ribs more and quickly
-- abdominal muscles contract: raise diaphragm more & quickly

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