Unit 2: Anatomy of the Respiratory and Circulatory Systems

Subject: Human Anatomy

Unit 2: Anatomy of the Respiratory and Circulatory Systems

(Respiratory System • Organs of the Respiratory Tract • Circulatory System – Structure of the Heart • Major Arteries & Veins with Applied Anatomy)

2.1 Respiratory System — Overview and Functions

The **respiratory system** sustains life by exchanging gases between air and blood and by supporting voice and smell. It works as a two-zone conduit:

- **Conducting zone:** nose → pharynx → larynx → trachea → bronchi → terminal bronchioles (warms, filters, humidifies air; no gas exchange).
- **Respiratory zone:** respiratory bronchioles → alveolar ducts → **alveoli** (site of gas exchange across a thin blood–air barrier).

Core functions

- **Ventilation:** mechanical movement of air by the thoracic pump (diaphragm & intercostals).
- **Gas exchange:** O_2 in, CO_2 out at **alveoli**.
- **Air conditioning & defense:** cilia, mucus, IgA, cough/sneeze reflexes.
- **Phonation:** laryngeal vocal folds.
- **Olfaction:** nasal cavity roof (olfactory epithelium).
- **Acid–base balance:** CO_2 regulation influences blood pH.

2.2 Structure of the Organs of the Respiratory Tract

2.2.1 Nose & Paranasal Sinuses

- **External nose** with **nares** opens into the **nasal cavity**, divided by a septum (vomer + perpendicular plate + cartilage).
- **Turbinates (conchae):** create turbulence → warming & humidification.
- **Epithelium:** respiratory (ciliated pseudostratified columnar with goblet cells); **olfactory** mucosa at roof.
- **Sinuses:** frontal, ethmoidal, sphenoidal, maxillary—lighten skull, condition air, resonate voice.
  Applied: deviated septum, sinusitis, epistaxis; **Jala Neti** (saline rinse) improves nasal hygiene when done correctly.

2.2.2 Pharynx (nasopharynx, oropharynx, laryngopharynx)

Muscular tube shared by **respiratory & digestive** systems; houses **tonsils** (immune role).
Applied: sleep-disordered breathing (enlarged tonsils), aspiration risks.

2.2.3 Larynx (voice box)

- **Cartilages:** single (thyroid, cricoid, epiglottis) and paired (arytenoid, corniculate, cuneiform).
- **Vocal folds:** true (phonation) vs false (vestibular).
- **Muscles & nerves:** intrinsic muscles adjust tension and glottis; chiefly innervated by branches of **vagus nerve** (superior laryngeal & recurrent laryngeal).
  Applied: hoarseness (recurrent laryngeal injury), laryngospasm, safe voice use in teaching.

2.2.4 Trachea & Bronchial Tree

- **Trachea:** C-shaped hyaline cartilage rings; posterior muscular wall (trachealis); lined by **ciliated respiratory epithelium**.
- Bifurcates at **carina** → **right main bronchus** (shorter, wider, more vertical) & **left main bronchus**.
- Further divides: lobar (secondary) → segmental (tertiary) bronchi → bronchioles → **terminal bronchioles** → **respiratory bronchioles**.

Conducting vs respiratory portions

Feature	Conducting	Respiratory
Structures	Nose to terminal bronchioles	Respiratory bronchioles → alveoli
Epithelium trend	Ciliated → simple cuboidal	Simple squamous (Type I pneumocytes)
Function	Air conditioning & defense	Gas exchange

2.2.5 Lungs, Pleura & Segments

- **Right lung:** 3 lobes (upper, middle, lower); **Left lung:** 2 lobes + lingula.
- **Pleura:** visceral (on lung) & parietal (lining thoracic wall) with **pleural cavity** (thin fluid film).
- **Bronchopulmonary segments (surgical units):** pyramidal, each with its own segmental bronchus & artery; disease can be localized/resected by segments.

2.2.6 Alveoli & the Blood–Air Barrier

- **Alveolar wall cells:**
  - **Type I pneumocytes:** thin squamous; gas diffusion.
  - **Type II pneumocytes:** produce **surfactant** (reduces surface tension, prevents collapse).
  - **Alveolar macrophages:** phagocytosis.
- **Blood–air barrier:** surfactant → Type I cell → fused basement membrane → capillary endothelium.

Applied: neonatal respiratory distress (surfactant deficiency), pneumonia (alveolar exudate), pulmonary edema (thickened barrier).

2.2.7 Pulmonary & Bronchial Circulation; Lymph & Nerves

- **Pulmonary arteries** carry **deoxygenated** blood from right ventricle → capillaries around alveoli → **pulmonary veins** return **oxygenated** blood to left atrium.
- **Bronchial arteries** (from aorta) nourish airway walls; bronchial veins drain partly to azygos system.
- **Lymphatics:** superficial & deep networks → hilar nodes → tracheobronchial nodes.
- **Innervation:**
  - **Parasympathetic (vagus):** bronchoconstriction, mucus ↑.
  - **Sympathetic:** bronchodilation, mucus ↓.
    Applied: asthma (bronchoconstriction & inflammation) responds to bronchodilators and controlled breathing techniques.

2.2.8 Mechanics of Breathing

- **Primary muscle: diaphragm** (domes descend → thoracic volume ↑).
- **External intercostals:** elevate ribs (inspiration).
- **Internal intercostals (interosseous):** forced expiration.
- **Accessory inspiratory muscles:** sternocleidomastoid, scalenes (in distress or effort).

Phase	What happens	Energy
Quiet inspiration	Diaphragm contracts; ribs elevate	Active
Quiet expiration	Elastic recoil of lungs & chest wall	Passive
Forced expiration	Abdominals + internal intercostals	Active

Yoga/clinical link: diaphragmatic (abdominal) breathing improves lower-lobe ventilation, reduces accessory neck muscle overuse, supports vagal tone. Avoid prolonged breath-holds in **uncontrolled hypertension, cardiac disease, glaucoma**.

2.3 Circulatory System — Structure of the Heart

2.3.1 Position & Coverings

- **Location:** mediastinum; 2/3 left of midline; apex at 5th left intercostal space, mid-clavicular line.
- **Pericardium: fibrous** (outer) + **serous** (parietal & visceral/epicardium).

2.3.2 Layers of the Heart Wall

Epicardium (visceral pericardium) → **Myocardium** (cardiac muscle; thickest) → **Endocardium** (endothelium + CT).

2.3.3 Chambers, Valves & Flow

- **Right atrium** (from SVC/IVC/coronary sinus) → **tricuspid valve** → **right ventricle** → **pulmonary valve** → pulmonary trunk/arteries.
- **Left atrium** (from pulmonary veins) → **mitral valve** → **left ventricle** → **aortic valve** → aorta.
- **Chordae tendineae** + **papillary muscles** prevent AV valve prolapse.

Heart sounds: S1 (AV valves close; start systole), **S2** (semilunar close; start diastole).
Murmurs = turbulent flow (e.g., regurgitation/stenosis).

2.3.4 Conduction System

SA node (pacemaker, RA) → **AV node** (delay) → **Bundle of His** → **right & left bundle branches** → **Purkinje fibers** (ventricular depolarization).
Autonomics: sympathetic ↑ rate & force; parasympathetic (vagus) ↓ rate.

2.3.5 Coronary Circulation

- **Right coronary artery (RCA):** SA nodal branch (often), right marginal, **posterior interventricular** (PDA in right-dominant hearts).
- **Left coronary artery (LCA): LAD** (anterior interventricular) & **circumflex**.
- **Venous drainage:** great/middle/small cardiac veins → **coronary sinus** → RA.

Applied: LAD occlusion = "**widow-maker**" myocardial infarction; angina (ischemia), revascularization options.

2.3.6 Cardiac Cycle (overview)

- **Diastole:** ventricular filling (passive → atrial kick); AV valves open.
- **Systole:** isovolumetric contraction → ejection; semilunar valves open.
- **Stroke volume (SV) × Heart rate (HR) = Cardiac output (CO).**

Practitioner note: avoid intense **kumbhaka** or strong **bandhas** in unstable cardiac conditions; favor gentle, paced breathing and low-intensity movement with medical clearance.

2.4 Major Arteries and Veins of the Body — with Applied Anatomy

2.4.1 Arterial Tree (high-yield map)

Aorta

- **Ascending aorta → coronary arteries**.
- **Arch of aorta →**
    1. **Brachiocephalic trunk → right common carotid** & **right subclavian**,
    2. **Left common carotid**,
    3. **Left subclavian**.
- **Thoracic aorta:** intercostals, bronchial, esophageal branches.
- **Abdominal aorta:**
    - **Unpaired viscera: Celiac trunk** (foregut), **SMA** (midgut), **IMA** (hindgut).
    - **Paired:** renal, suprarenal, gonadal, lumbar.
    - Ends as **common iliac** arteries → **external iliac** (→ **femoral**) & **internal iliac** (pelvic).

Upper limb pathway: subclavian → **axillary** → **brachial** (→ **radial** & **ulnar**).
Lower limb pathway: external iliac → **femoral** → **popliteal** → **anterior tibial** (→ **dorsalis pedis**) & **posterior tibial** (→ plantar).

Palpable pulse points (exam & clinic)

Site	Artery	Note
Neck	**Carotid**	Palpate one side at a time
Arm	**Brachial**	BP cuff placement (mid-arm, artery alignment)
Wrist	**Radial**	Common pulse check; **Allen test** before cannulation
Groin	**Femoral**	Central pulse; hemorrhage control
Knee	**Popliteal**	Deep; knee slightly flexed
Ankle/Foot	**Posterior tibial**, **Dorsalis pedis**	Peripheral vascular check (diabetes)

2.4.2 Venous System (deep vs superficial; key conduits)

- **Superior vena cava (SVC):** returns blood from head, neck, upper limbs, thorax; formed by **brachiocephalic** veins (internal jugular + subclavian). **Azygos** drains thoracic wall to SVC.
- **Inferior vena cava (IVC):** returns from abdomen, pelvis, lower limbs; tributaries include **common iliac**, **renal**, **hepatic** veins.

Portal system: portal vein = **splenic** + **superior mesenteric**; carries nutrient-rich blood to **liver** → **hepatic veins** → IVC.
Porto-systemic anastomoses: esophageal, umbilical, rectal (varices risk in portal hypertension).

Superficial veins of clinical use

- **Upper limb: cephalic**, **basilic**, **median cubital** (common venipuncture).
- **Lower limb: great saphenous** (medial; graft source), **small saphenous** (posterior calf).
  Applied: varicose veins (valve failure), **DVT** (calf pain, swelling; risk → pulmonary embolism); early mobilization, calf pumps, hydration help prevention.

2.5 Integrated Applied Anatomy — From Lab to Mat

- **Breathing practice:** prioritize **diaphragmatic** & **long exhale** patterns to mobilize lower ribs and favor vagal tone. Avoid strong breath retentions in uncontrolled **hypertension/ischemia**.
- **Posture & lungs:** upright/seated postures improve **functional residual capacity** vs prolonged slumped sitting; gentle thoracic extension aids ventilation.
- **Pulse/BP skills:** know **radial** (routine), **brachial** (BP), and **carotid** (emergency) pulse sites; correct cuff size &

placement prevent false readings.
- **Vascular care:** during long sessions, encourage **ankle pumps** and **walking breaks** in at-risk participants to reduce venous stasis.

Unit Summary

The **respiratory system** conducts, conditions, and exchanges gases: air travels from nose to alveoli, where a microscopic **blood–air barrier** enables O_2–CO_2 exchange. Mechanics depend on the **diaphragm, intercostals**, chest wall, and lung elasticity. The **heart**—a valved, four-chambered pump with its own conduction and coronary blood supply—drives circulation. From the **aorta** flow the great arteries; blood returns via the **caval** and **portal** systems, supported by deep and superficial veins. Applied understanding guides safe breathing practices, accurate pulse/BP assessment, and vascular health during yoga and community work.

Key Terms

- **Conducting zone / Respiratory zone • Alveolus (Type I/II), Surfactant**
- **Pleura (visceral/parietal) • Diaphragm • Bronchoconstriction/Bronchodilation**
- **Pericardium (fibrous/serous) • SA/AV node, Purkinje • Coronary arteries (RCA, LCA, LAD, Circumflex)**
- **Systole/Diastole, S1/S2 • Aorta (arch branches, abdominal branches)**
- **SVC/IVC • Portal vein & porto-systemic anastomoses • DVT, Varicose veins**
- **Pulse sites • Allen test • Functional residual capacity**

Self-Assessment

MCQs

1. **Surfactant** is produced by:
   a) Type I pneumocytes b) Type II pneumocytes c) Alveolar macrophages d) Goblet cells
2. The **right main bronchus** is:
   a) Longer and narrower b) Shorter, wider, more vertical c) Longer and more horizontal d) Absent in many people
3. **S1** corresponds to closure of:
   a) Aortic & pulmonary valves b) Mitral & tricuspid valves c) Only aortic valve d) Only mitral valve
4. The **widow-maker** infarct typically involves the:
   a) Circumflex artery b) Right marginal artery c) LAD (anterior interventricular) d) Posterior interventricular artery
5. **Great saphenous vein** drains into the:
   a) Popliteal vein b) Femoral vein c) External iliac vein d) IVC directly

Answer key: 1-b, 2-b, 3-b, 4-c, 5-b

Short Answer

1. Trace the airflow from **nares to alveoli** and name two defenses that condition/clean the air.
2. Describe the **blood–air barrier** and explain why edema impairs gas exchange.
3. Sketch the pathway of blood through the **heart** starting from the SVC/IVC to the aorta, naming all valves.
4. List the **arch of aorta** branches and two **abdominal aorta** unpaired branches with their territories.
5. Name **four pulse points** and one clinical use for each.

Reflective/Application

1. In a seated breathing practice, place one hand on the **upper chest** and one on the **abdomen**. Describe how the movement changes when you shift to **diaphragmatic breathing**. How does your perceived calm change after 3 minutes?
2. During community screening, you palpate a **weak dorsalis pedis** pulse on one side. What **history questions** and **follow-up checks** will you perform next?

End of Unit 2: Anatomy of the Respiratory and Circulatory Systems