RESPIRATORY SYSTEM
How You Breathe
Why do you **breathe**?
What is **oxygen** used for?
Where does **CO2** come from?
Respiration: exchange of gases between air & your body cells

1. Outside air (O\textsubscript{2}) $\rightarrow$ lungs $\leftarrow$ metabolism $\leftarrow$ cells $\leftarrow$ blood

2. Metabolism cell waste CO\textsubscript{2} $\rightarrow$ outside air $\leftarrow$ lungs $\leftarrow$ blood
Parts of your respiratory system

Air: In & Out

Nose → Nasal cavity

Mouth → Throat (pharynx)

Voice box (larynx)

Vocal cords
(a) Overview of the human respiratory system

- Pharynx
- Esophagus
- Larynx (voice box)
- Trachea (windpipe)
- Right lung
- Left lung
- Bronchus
- Bronchiole
- Diaphragm
- Nasal cavity
- Heart
Vocal cords **vibrate** with air: we make a **sound**
Larynx

Wind pipe (trachea)

Right
Bronchus

Right Lung
Bronchioles

Left
Bronchus

Left Lung
Bronchioles
Cells lining respiratory tract:
Nasal cavity  Trachea  Bronchi & Bronchioles

- Have **cilia** and release **mucus**
- Mucus (traps dirt, bacteria): cilia pushes mucus → **throat**
  - spit out
  - swallow
Alveoli = air sacs

- Sprout from bronchioles
- Covered by capillaries
- 300 million in 2 lungs
Alveoli = Air Sacs
Alveoli: where gas (O₂ & CO₂) exchange happens. Great surface area: tennis court.
Ventilation: moving air in & out
Lungs sit in the **thoracic cavity** (space)

Change in Pressure - thoracic cavity: air moves in & out
Air in: **diaphragm** - muscular partition (thoracic/abdominal cavities): contracts - moves **down** flat
Air in: ribs move upward/outward
Thoracic cavity: larger (lower pressure) → air rushes (inhalation)
Air out (exhalation):
1. Diaphragm **relaxes**
2. Moves upward *(dome shaped)*
3. Ribs drop **back down**
4. ↑ **Pressure**- thoracic cavity *(compressed)*
5. Air forced **out**
Alveoli: gas exchange
1. **O₂** in alveoli **diffuses** into capillaries
2. Taken up: **hemoglobin**
3. Back to heart
4. Finally, to cells
5. Cell Respiration
Lungs

Concentration Gradient
High to Low
CO₂ in cells: reverse direction

1. Cells → capillaries → veins

2. To heart → lungs → alveoli

3. CO₂ diffuses into air: exhaled

4. Concentration Gradient: high to low
Why can’t you hold your breath very long?

- Breathing is automatic
- Breathing control center: **medulla oblongata**

Medulla ➔ nerve impulses ➔ diaphragm, rib muscles ➔ contraction: you inhale
1. CO₂ levels in the blood rise as a result of exercise.

2. Breathing control centers in the brain monitor the rising CO₂ levels in the blood.

3. Nerve signals trigger contraction of muscles to increase breathing rate and depth.
At rest: 10-14 Inhalations/min

Between inhalations: muscles relax

You exhale
Primary control breathing rate: regulated by changes in blood CO\(_2\)

- Example: ↑ exercise  ↑ metabolism  ↑ Blood CO\(_2\)
- CO\(_2\) reacts with H\(_2\)O → carbonic acid
- ↓ Blood pH & cerebrospinal fluid (bathing brain)
Medulla detects:

- pH

Impulses

Breathing

muscles

Rate & depth

Breathing
• Result: you exhale \( \text{CO}_2 \)
• pH returns to normal (homeostasis)
• At same time: as you breathe deeper: \( \uparrow \text{O}_2 \) in blood: needed for cell respiration (glucose metabolism)
• Bottom line: breathing rate coordinated with metabolism
Secondary
Control
Breathing

O2 sensors:
Aorta &
Carotid
Arteries
Blood $O_2$

Ex. High altitudes

Sensors detect

Low $O_2$

Impulses:
Breathing
Muscles

↓ Rate & depth- breathing
Does a fetus breathe air?

- Placenta, containing maternal blood vessels and fetal capillaries
- Umbilical cord, containing fetal blood vessels
- Amniotic fluid
- Uterus
Fetus Lungs: filled with fluid-nonfunctional

- Mom "breathes" for herself & fetus
- Mom brings $O_2$ to fetus and removes fetus $CO_2$ through her blood
• Placenta:
  Fetus & maternal tissues
• Mom and fetus
  Blood don’t mix
Mom’s lungs: $\text{O}_2 \rightarrow$ blood

placenta

fetal capillaries $\leftarrow$ diffuses

cell respiration (fetal tissue)

$\text{CO}_2$: \textit{reverse}: mom “exhales” fetus waste $\text{CO}_2$ from cell respiration
At birth: baby

**Switches:**
Living in **water**
(maternal breathing)

↓
Breathing **air**

on his/her own
• Placental O₂ and CO₂ exchange stops
• CO₂ increases in baby’s blood
• ↓ pH
• Stimulates baby’s breathing control center
• Result: baby’s first breath
Smoking during pregnancy: may reduce $O_2$ reaching placenta by 25%
Breathing & Disease

Pneumonia: inflammation of lung tissue

- Coughing
- Shortness of Breath
- Pain in chest
- Chills
- Fever
- **Pneumonia:**
  - Mild (along with cold)  
  - Life threatening
- **50 different causes**
  1. Bacteria
  2. Virus
  3. Chemical irritants

  Pneumococcal **vaccine**: protection—pneumococcus bacteria
Asthma:

• Airways inflamed & swollen
• Airway muscles - tighten (constrict) = bronchospasm
• Airway membranes: ↑ mucus - narrow airways
Lung Disorders

Three common chronic lung disorders restrict the flow of air out of the bronchial passages: chronic bronchitis, emphysema and asthma. Another lung disorder, lung cancer, is the leading cause of cancer deaths in the United States.

In asthma (see right), lung airways become inflamed and swollen. Muscles surrounding the airways tighten and constrict, and membranes in airway linings secrete excess mucus.

In emphysema, the alveoli walls are damaged by inflammation. Alveoli can lose their natural elasticity, become overstretched and rupture.

Chronic bronchitis is a chronic inflammation and thickening of the walls of the bronchial tubes, which narrows them.
Asthma: causes

• ↑ risk: family members have asthma
• Triggered by allergies
• Chemical irritants (240 identified)
• Cockroaches: body parts/droppings
• ↑ cockroaches ↑ asthma - inner cities - children
Emphysema: Damage,
Inflammation
Alveoli walls: Overstretch & Rupture
Chronic Bronchitis inflammation, thickening: bronchial tubes walls: narrow
Air Pollution can aggravate many respiratory problems
Healthy Left, Lung Cancer Right
Cancer Deaths: Women

SELECTED CANCER DEATH RATES FOR WOMEN*

Lung cancer death rates have soared, while colorectal, stomach, and uterine cancer deaths have dropped.

*Age-adjusted to U.S. population, 1970  
Source: American Cancer Society.
Cancer Deaths: Men

SELECTED CANCER DEATH RATES FOR MEN*

The steep rise in adenocarcinoma of the esophagus isn't yet visible in total esophageal death rates.

*Age-adjusted to U.S. population, 1970    Source: American Cancer Society.
Passive smoking causes lung cancer in non-smoker
Chronic Obstructive Pulmonary Disease (COPD): 12 million Americans

- Before considered: old man’s disease
- ↑ women smoking 1950-1970’s
- Year 2000: COPD deaths
  - women > men
- Combo: emphysema + bronchitis
- Lungs look moth-eaten
- Breathing crisis: “like breathing through a straw”
Madeline Gallagher - 65: Lung volume reduction therapy: 30% each lung removed
Iron Lung
Portable Ventilators

Undaunted by her ventilator, Jessica Leahy, 6, did ballet positions at a Newton day camp yesterday.

When life hangs by a tube
Sleep apnea: breathing passages temporarily close

- Sleeper stops breathing
- Suffocating level \( \text{O}_2 \) – nightly
- Wake up: 500 times- gasping-air
- Increased risk- heart disease
- Snoring common
- Daytime: chronically tired
Sleep apnea: football players

• Texas State University
• 6/15 players tested: sleep apnea
• Related to body weight: 21 players 250 pounds, 7 weigh 300 pounds or more
• NFL lineman: body weight + large necks: 1/3 have sleep apnea
In obstructive sleep apnea, the muscles that normally keep your airway open relax and sag during sleep, causing your tongue, tonsils, soft palate or uvula to repeatedly block your breathing.
Continuous Positive Airway Pressure (CPAP)
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**SUDDEN INFANT DEATH SYNDROME (SIDS)**
(SIDS):
• During 1st 6 months life
• Causes not completely known
• ? Abnormalities: Heart/Medulla Oblongata
At risk: SIDS

- During cold weather, males, premature, low birth weight babies, mom: smoker, drug user, other siblings - death from SIDS

WAYS TO PREVENT

- “Back to sleep” – sleep on back, no tummy
- Firm (not thick, soft) mattress
- No secondhand smoke
- Fan in room
- Breast feeding
- Don’t overheat room
- Electronic monitoring: heart/breathing rate
Crucifixion: pathophysiology

- Iron spikes nailed through wrists & feet to wooden crossbar/post
- Wounds to body: blood loss- hypovolemic shock (↓ blood volume, poor O2 supply to tissues)
- Body weight pulling down: fix rib muscles in inhalation state
- Interference with exhalation
Crucifixion: pathophysiology

- Breathing shallow
- Primarily use of **diaphragm**
- \( \uparrow \text{CO}_2 \) in blood: **acidosis**
- Circulatory failure
- **Exhaustion asphyxia**

Combined \( \downarrow \text{O}_2 \) and \( \uparrow \text{CO}_2 \) in blood