RESPIRATORY SYSTEM
How You Breathe

- Bronchi
- Alveolar duct
- Alveolar sac
- Alveolus

Lungs (localized internal organs)

Model of a pair of human lungs
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 \((O_2)\) \(\rightarrow\) lungs
   metabolism \(\leftarrow\) cells \(\leftarrow\) blood

2. Metabolism cell waste \(CO_2\)
   outside air \(\leftarrow\) lungs \(\leftarrow\) blood
Parts of your respiratory system

Air: In & Out

Nose ➔ Nasal cavity ➔ Throat (pharynx)

Mouth ➔ Throat (pharynx)

Voice box (larynx)

Vocal cords
(a) Overview of the human respiratory system
Vocal cords *vibrate* with air: we make a *sound*.
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 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)*

---

*Copyright © 2005 Pearson Prentice Hall, Inc.*
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

Tissues
CO$_2$ in cells: reverse direction

1. Cells $\rightarrow$ capillaries $\rightarrow$ veins
2. To heart $\rightarrow$ lungs $\rightarrow$ alveoli
3. CO$_2$ 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 $\rightarrow$ nerve impulses

$\rightarrow$ 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 CO₂

- Example: ↑ exercise ↑ metabolism
  ↑ Blood CO₂
- CO₂ reacts with H₂O → 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: \textbf{O}_2 \rightarrow \text{blood} \\
\text{placenta} \\
\textbf{fetal capillaries} \xleftarrow{\text{diffuses}} \\
\text{cell respiration (fetal tissue)} \\
\textbf{CO}_2: \textbf{reverse}: \text{mom "exhales" fetus waste CO}_2 \text{ 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

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
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 O₂ –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)
SUDDEN INFANT DEATH SYNDROME (SIDS)

Step 1
Life-threatening event → Asphyxia and brain hypoperfusion → Head lifting or turning

Step 2
Failure of arousal → Progressive asphyxia

Step 3
Hypoxic coma

Step 4
Bradycardia and gasping

Step 5
Failure of autoresuscitation resulting in death
(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