

Chapter 17

Clearing the Air: Respiratory, Cardiovascular, and Excretory Systems

17.1 Effects of Smoke on the Respiratory System

- Exhaled smoke + smoke directly from cigarette tip = _____ (ETS)
- Affects _____ and _____ (non-smoker in high ETS area)

Effects of Smoke on the Respiratory System

- National Cancer Institute:
 - 4500 identified chemicals inhaled by active smoker
 - Probably many more exist
 - Passive smokers exposed to same chemicals, but in lower concentrations

Effects of Smoke on the Respiratory System

- Some chemicals are more concentrated for passive smokers
- Caused when the cigarette smolders but doesn't completely burn
- Most abundant gas in ETS is carbon monoxide (5x greater than in inhaled smoke)

Effects of Smoke on the Respiratory System

- ETS also contains particulates, small airborne particles called 'tar'
- The filter reduces the amounts of tar inhaled by active smokers
- Passive smokers do not have filters
- ETS is not filtered
- Airborne particles enter the **lungs** by way of inhalation through the nose and mouth
- Some chemicals can cross into the blood (like carbon monoxide gas)

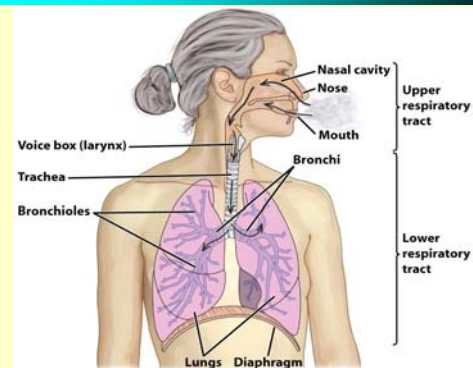


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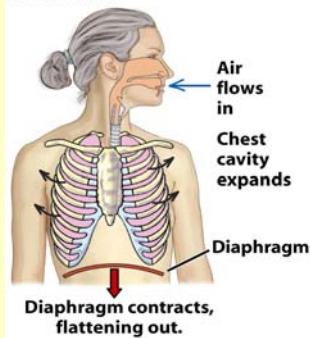
What Happens When You Take a Breath?

- You take a breath:
 - About 12 times every minute
 - 6 million times a year
- Inhale about 500 milliliters (~ 2 cupfuls) of air each time
- Every minute about 4 liters of air enter the lungs

Diaphragm

- The **diaphragm** is a muscle that contracts when we inhale
- This increases the volume of the chest cavity and decreases pressure

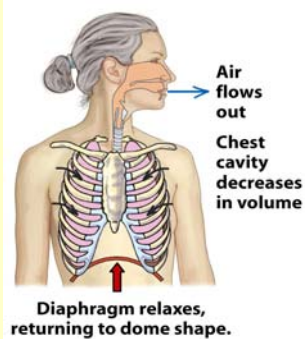
Inhalation



Diaphragm

- Air enters through the nose and through the **larynx** () and then through the **trachea** ()
- Finally into the lungs
- When we exhale, the diaphragm relaxes
 - The chest volume decreases
 - The pressure in the chest cavity increases – causing the air to flow back out

Exhalation



Diaphragm

- Breathing rate is controlled by the brain, which signals the diaphragm to contract in response to carbon dioxide levels in the blood
 - Breathing rate increases when carbon dioxide levels increase

Diaphragm

- Contraction of the diaphragm can also be controlled voluntarily
- Inhaling cigarette smoke requires a stronger contraction of the diaphragm than normal breathing does
- Holding your breath requires consciously overriding the signals from brain

Diaphragm

- Speaking or making any vocal noise requires active exhalation
- The movement of air through the larynx causes the vocal cords to vibrate and produce sound
 - The amount of air forced past the vocal cords determines the volume of our speech, while muscles that control the length of the vocal cords help determine the pitch of our speech
 - The shape of our mouths, lips, tongue, and the position of our teeth determines the actual sound that is produced
- Sustained exposure to tobacco smoke can scar parts of the larynx

Diaphragm

- The diaphragm also may contract involuntarily for other reasons
 - When you cough, you involuntarily inhale first
- Coughing is a reflex that helps _____

- Keeping air passageways into the lungs clear is crucial for maintaining adequate oxygen uptake

Lungs

- Healthy lungs are:
 - Pink
 - Rounded
 - Spongy in texture

Human lungs



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Lungs

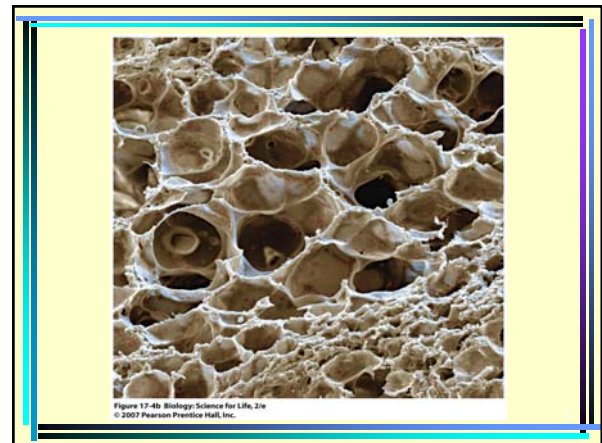
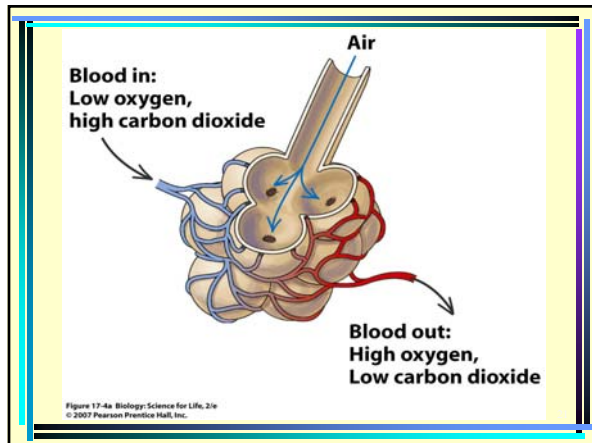
- The exterior of the lungs is connected to the lining of the chest cavity by 2 thin membranes, one covering the lungs and one lining the chest cavity
- The membranes are moist and stick to each other
- If the membranes separate, the lungs can collapse

Lungs

- Once inside the lungs, air flows into tubes called _____
- The bronchi separate into smaller _____
- At the end, there are sacs called _____
- The 300 million alveoli contain the **respiratory surface** of our bodies (_____)
 - About the same surface area as a tennis court

Lungs

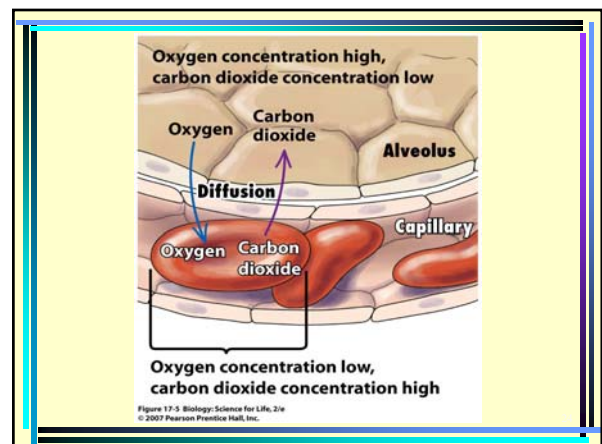
- Each alveoli is surrounded by **capillaries** (net of tiny blood vessels), connecting the gases exchanged in these structures with the entire body
- Smoke exposure can damage or destroy alveoli surfaces
- Can cause shortness of breath and wheezing



Gas Exchange

- The process of **gas exchange** (_____

_____) is the primary function of the lungs
 - Oxygen into blood
 - Carbon dioxide out of blood
- Gas exchange occurs by diffusion



The Role of Hemoglobin in Gas Exchange

- Hemoglobin is a respiratory pigment in the blood that _____

- Hemoglobin contains iron that can bind to oxygen
- When oxygen attaches to the iron atom, the hemoglobin becomes red, giving our blood its distinctive color

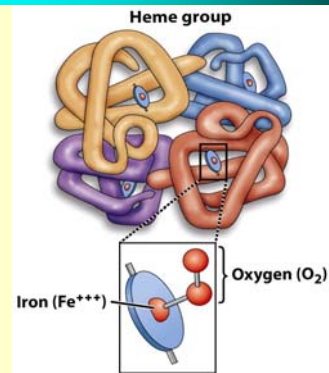


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The Role of Hemoglobin in Gas Exchange

- There are 250 million hemoglobin molecules in each red blood cell
- Each red blood cell can carry 1 billion oxygen molecules

The Role of Hemoglobin in Gas Exchange

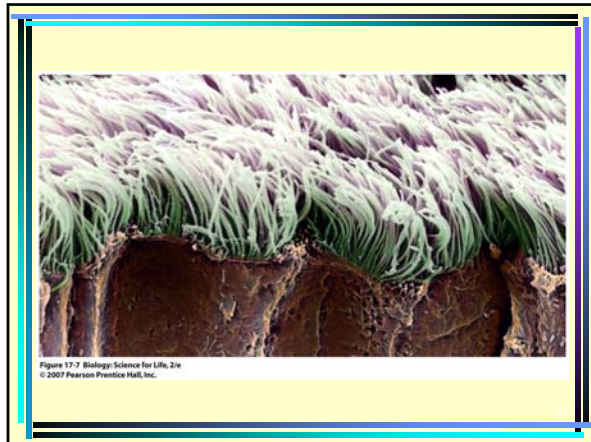
- Hemoglobin also binds to carbon monoxide, from cigarette smoke
 - Ties up hemoglobin
- Less oxygen getting to tissues

The Role of Hemoglobin in Gas Exchange

- Smoking when pregnant:
 - Carbon monoxide is very damaging to developing fetuses since they must acquire the oxygen they need through exchange with their mother's blood supply
 - Can cause low birth weight babies, which may be due to their relative oxygen deprivation

Smoke Particles and Lung Function

- Particles too small to be removed by coughing settle on trachea or bronchi
- These particles become trapped in mucus produced by tissue lining these structures
- The mucus ball is swept upward toward the mouth and nose by the actions of tiny hair-like projections called cilia on the tissue surface
- When the mucus reaches the tip of the larynx, it is coughed up, expelled out of the nose, or swallowed
- Smoke particles increase mucus production, but they also damage the cilia – more difficult to expel mucus ball
- This damage in turn can lead to inflammation of the bronchi called _____

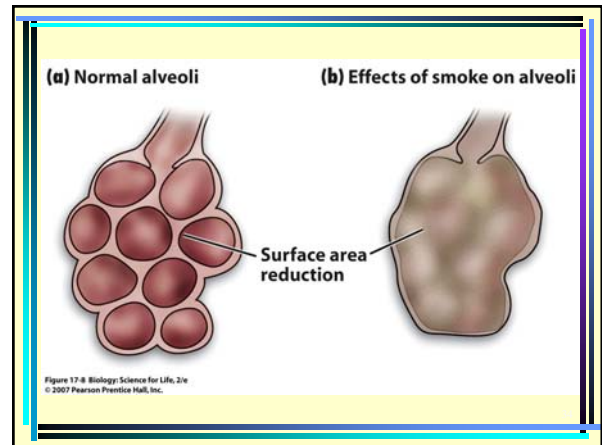


Smoke Particles and Lung Function

- The tiniest particulates in ETS remain airborne and can be drawn deeply into the lungs, even into the alveoli
- Because alveoli lack cilia, the movement of foreign materials out of these structures is much more limited
- Small particles can remain in the alveoli for long periods, promoting inflammation and fluid accumulation and reduced gas exchange
- Particulates are also known to exacerbate _____, an allergic response where bronchi are constricted and excess mucus is produced, but difficult to expel

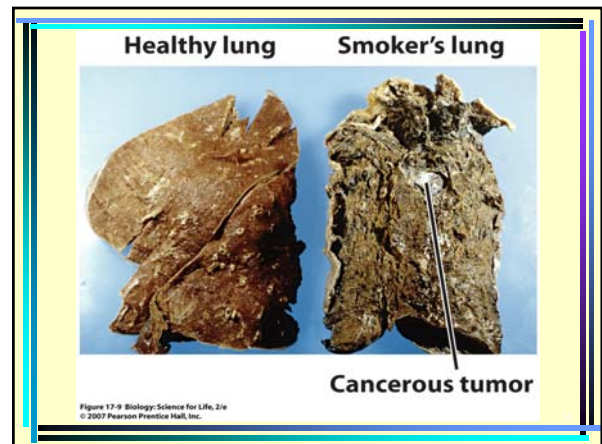
Smoke Particles and Lung Function

- _____ is the formation of scar tissue in lungs due to chronic bronchitis and asthma
- Bronchi are permanently blocked
- The inflammation damages alveoli walls, causing:
 - Small alveoli to merge into fewer larger sacs
 - This reduces overall surface area, which reduces gas exchange
- The buildup of scar tissue also makes the lungs less elastic, meaning that the passive process of exhalation is ineffective
- As more air remains in the lungs, they become overinflated, gradually increasing the size of the chest
- Individuals with emphysema are chronically short of breath and unable to participate in vigorous activity



Lung Cancer

- Tobacco smoke contains cancer-causing chemicals called _____
- Carcinogens cause changes to the structure or sequence of DNA molecules (mutations)
- Lungs of long time smokers are black with trapped 'tar'
- Because these tobacco smoke carcinogens are retained in the lungs, the DNA of lung cells remains under the treat of cancer-causing mutations long after smoke inhalation has stopped
- 170,000 new cases of lung cancer in the U.S. every year



How Do We Know That Tobacco Smoke Kills?

- **Epidemiology** is the testing of hypotheses about the distribution and causes of diseases in human populations
 - Such as “secondhand smoke causes cancer in humans”
- Can't experiment on humans for ethical reasons, so the relationship between cancer and ETS exposure is studied using correlational studies
- Correlational studies show:
 - Nonsmokers exposed to ETS have a 20% to 30% higher risk of lung cancer than unexposed non-smoker

Name	Description	Pros	Cons
Ecological studies	Examine specific human populations for unusually high levels of various diseases (e.g., documenting a “cancer cluster” around an industrial plant).	Inexpensive and relatively easy to do	Unsure whether exposure to environmental factor is actually related to onset of the disease
Cross-sectional surveys	Question individuals in a population to determine amount of exposure to an environmental factor and whether disease is present.	More specific than ecological study	<ul style="list-style-type: none"> • Expensive. • Subjects may not know exposure levels. • Cannot control for other factors that may be different among individuals in survey. • Cannot be used for rare diseases.
Case-control studies	Compare exposures to specific environmental factors between individuals who have a disease and individuals matched in age and other factors but who do not have a disease.	<ul style="list-style-type: none"> • Relatively fast and inexpensive • Best method for rare diseases 	<ul style="list-style-type: none"> • Does not measure absolute risk of disease as a result of exposure • Difficult to select appropriate controls to eliminate alternative hypotheses • Examines just one disease possibly associated with an environmental factor
Cohort studies	Follow a group of individuals, measuring exposure to environmental factors and disease prevalence.	Can determine risk of various diseases associated with exposure to particular environmental factor	<ul style="list-style-type: none"> • Expensive and time-consuming • Difficult to control for alternative hypotheses • Not feasible for rare diseases

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17.2 Spreading the Effects of Smoke: The Cardiovascular System

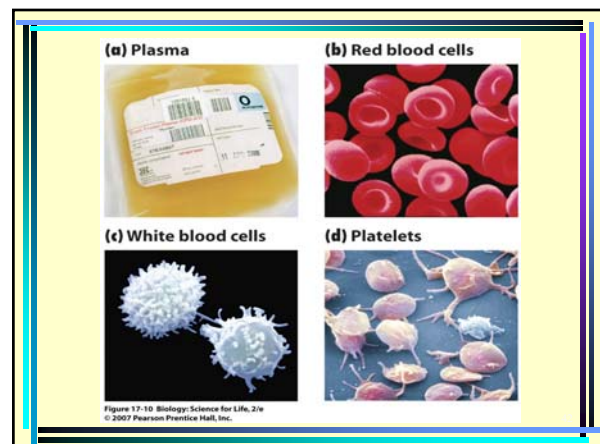
- Risks of smoking go beyond the respiratory system to include:
 - Increased rates of throat, bladder, and pancreatic cancer
 - Higher rates of heart attack, stroke, and high blood pressure
 - Premature aging of the skin

Structure of the Cardiovascular System

- The cardiovascular system distributes gases and other materials around the body in most animals
- Consists of 3 major components
 1. A circulating fluid (usually _____)
 2. A pump (usually a _____)
 3. A vascular system (_____)

Blood

- The 5 liters (11 pints) of blood in an adult human consists of
 - **Plasma:** _____
 - Cells: the solid portion (mostly red blood cells, hence, the red color of blood)



Blood

- Cells in blood are produced by _____, tissue found in the cavities of certain bones
- **Red blood cells** carry _____
- **White blood cells** work in the _____, attacking invading organisms as well as removing toxins, wastes, and damaged cells throughout the body
- **Platelets** act to _____

Blood

- _____ is the process that stems the flow of blood out of damaged blood vessels
 - Platelets attach to damaged area
 - Blood vessels constrict
 - Chemicals are released to initiate clotting

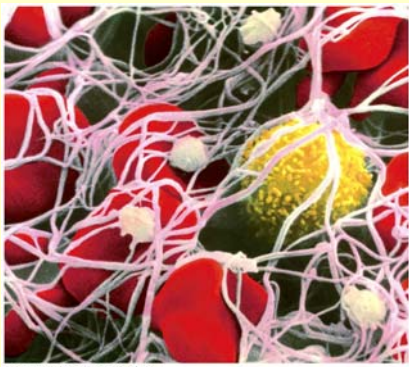


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Blood

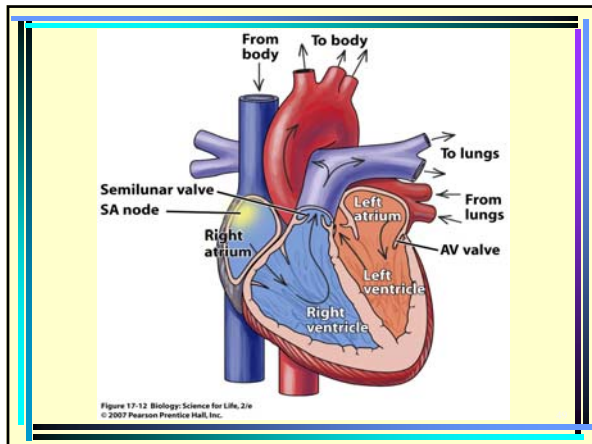
- Smokers have platelets that are stickier than normal – making clots form more readily
- If clot occurs inside vessel, blood flow is blocked – this is called _____
- If a clot breaks free it can travel throughout the bloodstream until it becomes lodged in another artery or capillary bed – called _____
- When a thrombus or an embolus becomes lodged within a blood vessel of the heart or any other organ, it can cause cells to die and severe damage

Heart

- The **heart** pumps blood through the body
- Two muscular pumps
 - Right side pumps blood to _____
 - Left side pumps blood to _____

Heart

- Each pump divided into two chambers
 - The _____ is on the top and has thin walls
 - The _____ is on bottom and has thick walls



Heart

- **Sinoatrial (SA) node:** small patch in the right atrium which controls heart rhythm
 - Acts as the heart's _____
 - Sends out signals to cause atria to contract
 - The ventricles contract 1/10th of a second later

Heart

- The _____ is one complete sequence of filling with blood and pumping it out
- Two parts
 - **Diastole** – _____
 - **Systole** – _____

Heart

- The **AV valves** (between atrium and ventricle) close when ventricles contract
 - This is the 'lubb' sound of the heartbeat
- The **semilunar valves** (between the ventricles and the rest of the body) close when the ventricle relaxes
 - This is the 'dupp' sound of the heartbeat

Heart

- The heart rate is regulated by the SA node (internal pacemaker) and signals from the brain and spinal cord
- Heart rate can increase in response to danger, emotion, or from drugs
 - Such as nicotine

Heart

- The heart requires a lot of oxygen
- A thrombus or embolus in the heart can kill some heart muscle

Blood Vessels

- _____ – system of tubes that carries blood in body
- **Blood vessels**
 - _____
 - _____
 - _____

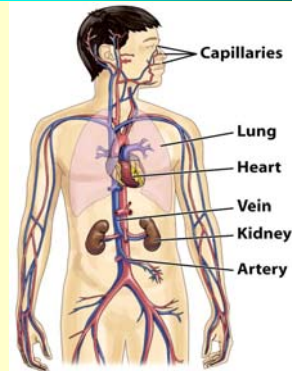


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Blood Vessels

- **Arteries** – _____
- **Veins** – _____
- **Capillaries** – tiny thin-walled blood vessels where _____

Blood Vessels

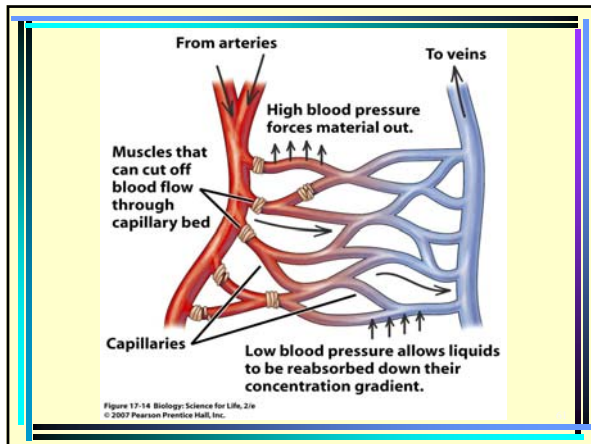
- When the ventricles contract, the arteries expand as the mass of blood travels
 - This is the _____

Blood Vessels

- Liquid is forced out of capillaries by high blood pressure at the arterial end of a **capillary bed**
- Liquid from body tissues then flows back into the capillaries because of concentration differences at the vein end of the capillary bed

Blood Vessels

- Muscles surrounding the arterial ends of the capillary bed can contract to restrict flow through the bed in order to redirect the delivery of blood and nutrients
 - More essential regions receive these instead of less-needy organs



Blood Vessels

- Veins have much thinner, less-elastic walls than arteries, and the pressure of the blood is much lower once it reaches these vessel
- Blood tends to pool in veins – which swell

Blood Vessels

- To move the blood back to the heart, the skeletal muscles contract to compress the veins
- Blood only flows one way in the veins due to valves
- Movement of blood from the veins back to the heart is facilitated by the contraction of skeletal muscles, which compress the veins and squeeze the blood through them
- Blood flows in only one direction, toward the heart, due to the presence of one-way valves within the veins



Blood Vessels

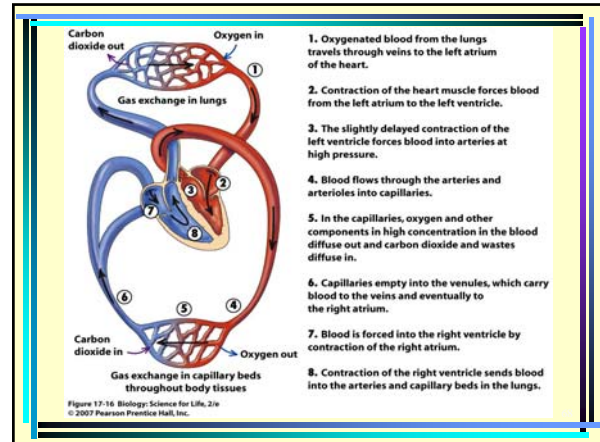
- _____ is the force of blood against vessel walls
 - Results from pulse and artery diameter
- Blood pressure rises when arteries become constricted
- Normal blood pressure can rise in response to stress or activity, then returns to normal

Blood Vessels

- _____ is the name for chronic high blood pressure
- Hypertension may be caused by constant psychological stress or by the accumulation of fat in artery walls from aging, diet, or exposure to tobacco smoke
 - Can damage vessel walls because it is harder for the heart to pump the blood

Movement of Materials Through the Cardiovascular System

- Two distinct circuits
 - _____ circuit (heart to lungs to heart)
 - _____ circuit (heart to body tissues to heart)



1. Oxygenated blood from the lungs travels through veins to the left atrium of the heart.
2. Contraction of the heart muscle forces blood from the left atrium to the left ventricle.
3. The slightly delayed contraction of the left ventricle forces blood into arteries at high pressure.
4. Blood flows through the arteries and arterioles into capillaries.
5. In the capillaries, oxygen and other components in high concentration in the blood diffuse out and carbon dioxide and wastes diffuse in.
6. Capillaries empty into the venules, which carry blood to the veins and eventually to the right atrium.
7. Blood is forced into the right ventricle by contraction of the right atrium.
8. Contraction of the right ventricle sends blood into the arteries and capillary beds in the lungs.

Movement of Materials Through the Cardiovascular System

- Oxygen is picked up in the lungs and taken to the heart by veins
- Veins empty into left atrium
- Valves let blood into left ventricle
- Blood forced into arteries and travels to tissues

Movement of Materials Through the Cardiovascular System

- At capillaries, oxygen diffuses into tissue cells and blood picks up waste and carbon dioxide
- Blood travels in veins to right atrium
- Then into right ventricle
- Back to lungs

Movement of Materials Through the Cardiovascular System

- Right atrium → tricuspid valve → right ventricle → pulmonary semilunar valve → pulmonary trunk → pulmonary arteries → lungs → pulmonary veins → left atrium → bicuspid valve → left ventricle → aortic semilunar valve → aorta → systemic arteries → systemic capillaries → systemic veins → inferior and superior venae cavae

Movement of Materials Through the Cardiovascular System

- It takes a blood cell about one minute to travel this path
- Any contaminants in blood travel quickly throughout the body

Smoke and Cardiovascular Disease

- Lung cancer and other lung diseases are not the primary risk of smoking
- The primary risk is heart and blood vessel damage (**cardiovascular disease**) which is caused by nicotine, the primary active ingredient in tobacco

Smoke and Cardiovascular Disease

- **Nicotine** is produced by tobacco plants as a natural pesticide
 - It is readily absorbed by the blood and carried throughout the body
- Nicotine is toxic to humans in high doses
- Low doses, nicotine interacts with cells in the brain to stimulate the release of adrenaline, which in turn increases heart rate and blood pressure

Smoke and Cardiovascular Disease

- Nicotine is addictive – it stimulates the reward center of the brain, region whose activity is associated with feelings of well-being and happiness
- Nicotine may increase LDL (bad cholesterol) and reduce HDL (good cholesterol) and cause higher risk for blockages in blood vessels (_____ – the accumulation of fats and other debris on the interior walls of arteries, reducing their interior diameter)

(a) Normal artery (b) Atherosclerotic artery

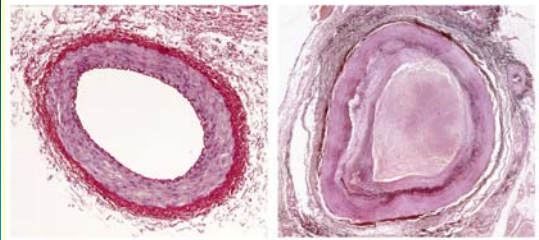


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Smoke and Cardiovascular Disease

- Nicotine stimulates blood clot formation
- If blood clot forms in constricted artery, blood flow can stop
- Blockages in arteries to the brain can result in a _____ – causing death to brain tissue
- Blockages in arteries to the heart can result in _____ – causing death to heart muscle tissue
- Stroke and heart attack are the primary causes of death from cardiovascular disease

Smoke and Cardiovascular Disease

- In addition to nicotine, smokers inhale carbon monoxide
- Fortunately, the effects of nicotine and carbon monoxide on cardiovascular health are reversible over time – because the chemicals are broken down and excreted

Smoke and Cardiovascular Disease

- Risk of heart disease drops by 50% after 1 year of quitting smoking
- After 15 years, the risks are the same for ex-smokers as for people who have never smoked

17.3 Removing Toxins from the Body: The Excretory System

- The excretory system has two tasks
 - _____
 - _____

Removing Toxins from the Body: The Excretory System

- Major organs of the excretory system in human include:
 - _____, which filter and cleanse blood
 - Send waste to bladder through _____
 - _____, which stores waste
 - Sends waste out of body through _____

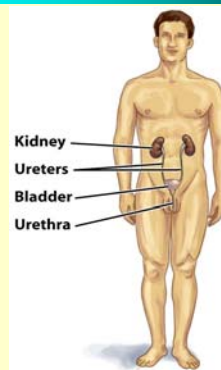


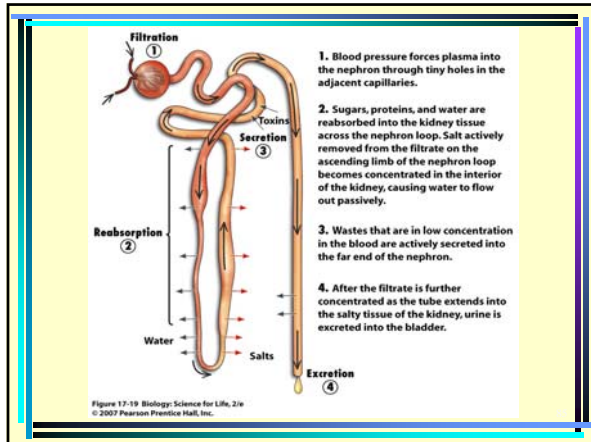
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Kidney Structure and Function

- Two kidneys behind the liver and stomach
 - Each about the size of a fist
 - Packed with a dense network of looped tubules called _____
- Each person has about 85 miles of nephrons (each kidney containing ~1,250,000 nephrons)
 - They are surrounded by capillaries
 - Blood is filtered here and waste diffuses out of the blood and into these tubules for excretion

Kidney Structure and Function

- The total blood volume passes through the kidneys hundreds of times per day, such that each kidney filters about 1000 liters of blood every 24 hours
- The processing of waste in kidneys has 4 distinct phases:
 - _____, _____, _____, and _____



Kidney Structure and Function

- _____ – blood plasma forced into the nephron
- _____ – recaptures recyclables (sugars, proteins, water); water flows out passively
- Active _____ of wastes like nicotine
- _____ – concentrated fluid (_____) leaves nephron and ultimately flows to the bladder; release of urine from the bladder is called _____

Smoking and the Excretory System

- Smoking can damage the filtration ability of kidneys
- Causing less efficient waste removal
- And less efficient recapture of nutrients

Smoking and the Excretory System

- Kidney cancer is higher for smokers than people who have never smoked
- Bladder cancer is more common in smokers than in nonsmokers
- Not sure about effects for passive smokers
- Anything inhaled can affect the respiratory, cardiovascular, and excretory systems

