

ONE US-letter sheet, both sides | R = regional; S = added at state AND nationals | Official rules B3-B4

RESPIRATORY | structure

Air route: nose/mouth > pharynx > larynx > trachea > main bronchi > smaller bronchi > bronchioles > respiratory bronchioles > alveolar ducts > alveoli. Conducting zone ends at terminal bronchioles; respiratory zone exchanges gas. Nose filters, warms, humidifies. Epiglottis helps protect airway during swallowing; vocal folds produce sound.

Lungs and defense

Right lung: 3 lobes; left: 2, cardiac notch. Visceral pleura covers lung; parietal pleura lines chest; fluid reduces friction. Tracheal C-shaped cartilage supports airway. Goblet cells make mucus; cilia move debris toward pharynx. Type I alveolar cells: thin diffusion surface. Type II: surfactant lowers surface tension. Alveolar macrophages: phagocytosis.

Ventilation

Inhale: diaphragm contracts/flattens; external intercostals lift ribs; thoracic volume rises; alveolar pressure falls below atmospheric; air enters. **Quiet exhale:** relaxation and elastic recoil; volume falls, pressure rises. Forced exhale uses abdominal/internal intercostal muscles. Boyle: pressure varies inversely with volume. Compliance = ease of expansion; fibrosis lowers it.

Breathing patterns

Eupnea: normal quiet. Tachypnea: fast rate. Hyperpnea: deeper breathing for demand. Hyperventilation: ventilation exceeds CO2 production, lowering CO2. Hypoventilation: CO2 rises. Apnea: pause. Dyspnea: difficult breathing. Orthopnea: worse lying flat. Kussmaul: deep/labored with metabolic acidosis. Cheyne-Stokes: waxing/waning with pauses. Cough/sneeze clear irritants; hiccup = involuntary diaphragm contraction.

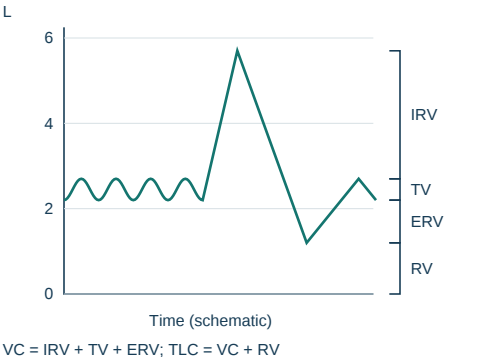
Volumes and calculations

TV: quiet breath (~0.5 L adult example, not universal). IRV: extra inhale; ERV: extra exhale; RV: left after maximal exhale.
VC = IRV + TV + ERV
TLC = VC + RV; IC = TV + IRV
FRC = ERV + RV
Minute ventilation = TV x breaths/min
Alveolar ventilation = (TV - dead space) x rate
Simple spirometry cannot directly measure RV, FRC or TLC. 1 L = 1000 mL. Example: TV .5, IRV 3, ERV 1, RV 1.2 L gives VC 4.5; TLC 5.7; FRC 2.2 L.

R | data practice

FEV1 = forced volume exhaled in 1 s; FVC = total forced vital capacity. Obstruction often lowers FEV1/FVC; restriction lowers TLC, often with preserved/high ratio. A ratio alone cannot confirm restriction. Read graph axes and units before subtracting volumes.

SPIROGRAM | volumes



RESPIRATORY | exchange

O2: alveoli > pulmonary capillary blood > tissues. CO2: tissues > blood > alveoli. Diffusion follows partial-pressure gradients across alveolar epithelium, basement membranes and capillary endothelium. More area/gradient increases exchange; greater thickness reduces it. Ventilation is airflow; perfusion is blood flow; both are needed.

R transport | S breathing control

Most O2 binds hemoglobin (up to 4 O2/Hb). Sigmoid curve reflects cooperative binding. More CO2, acid (lower pH), heat or 2,3-BPG shifts curve right: easier O2 unloading. Reverse shifts left. Most CO2 travels as bicarbonate; smaller amounts bind Hb or dissolve. Haldane: deoxygenated Hb carries CO2 more readily. CO2 + H2O <=> H2CO3 <=> H+ + HCO3-. More CO2 tends to lower pH. Medulla/pons regulate breathing. Central chemoreceptors sense CSF pH linked to CO2; carotid/aortic bodies sense O2, CO2 and pH.

Exercise and altitude

Exercise increases ventilation and tissue O2 use; heat/CO2 favor unloading. Altitude lowers inspired O2 partial pressure (air remains about 21% O2); ventilation rises, then EPO/RBC production increases over time. Hypoventilation can cause respiratory acidosis; hyperventilation can cause respiratory alkalosis.

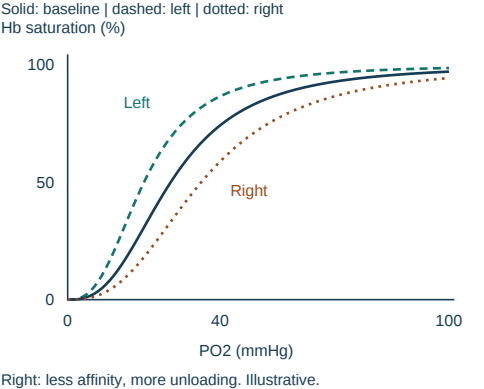
R disorders | S treatment

Asthma: inflamed, hyperresponsive narrowed airways; often reversible; bronchodilation and anti-inflammatory treatment. **Chronic bronchitis:** chronic airway inflammation/mucus. **Emphysema:** alveolar wall destruction, reduced area/recoil, air trapping. Both occur in COPD. **Pneumonia:** infectious alveolar inflammation/fluid; bacteria, viruses or fungi. **Sleep apnea:** repeated pauses; obstructive airway collapse versus central signaling failure; CPAP supports obstructed airway. **Cystic fibrosis:** inherited CFTR dysfunction, thick secretions, lung infection and pancreatic obstruction; airway clearance and selected CFTR therapy. Prevention principles: avoid smoke, relevant vaccines, infection control. Antibiotics target bacteria, not ordinary viral infections.

S | additional lung disorders

TB: M. tuberculosis; multidrug antibiotics, airborne control. Edema: lung fluid; treat cause, oxygen; diuretics for cardiogenic cases. Pleurisy: painful inflamed pleura; treat cause, anti-inflammatory pain control. Fibrosis: scarred stiff lung; selected antifibrotics, oxygen/rehab, transplant. Small-cell cancer: rapid spread, usually systemic therapy/radiation; non-small-cell: surgery if localized, selected radiation/systemic/targeted therapy. Pneumoconiosis: silicosis (silica), coal worker lung (coal), asbestosis (asbestos); exposure control, supportive care. Smoking avoidance reduces lung-cancer risk.

OXYGEN-HEMOGLOBIN CURVE



DIGESTIVE | structure

Food route: mouth > pharynx > esophagus > stomach > duodenum > jejunum > ileum > cecum > ascending/transverse/descending/sigmoid colon > rectum > anus. Accessory organs: teeth, tongue, salivary glands, liver, gallbladder, pancreas. Food does not pass through salivary glands, liver, gallbladder or pancreas. Parotid: near ears; submandibular: below jaw; sublingual: below tongue. Adult teeth: 8 incisors cut, 4 canines tear, 8 premolars + 12 molars grind (including wisdom teeth).

Processes and tissue

Ingestion = intake; propulsion = swallowing/peristalsis; mechanical digestion = physical breakdown; chemical digestion = hydrolysis; absorption = entry to blood/lymph; defecation = waste exit. Peristalsis propels; segmentation mixes. Bolus: swallowed food; chyme: stomach mixture. **Wall, inside out:** mucosa (epithelium, lamina propria, muscularis mucosae) > submucosa (vessels, Meissner plexus) > muscularis externa (circular then longitudinal; Auerbach plexus) > serosa/adventitia. Stomach adds oblique muscle.

Regional specializations

Esophagus: stratified squamous protects from abrasion. Stomach: simple columnar, pits/glands; cardia, fundus, body, pylorus. Small intestine: folds, villi, microvilli increase area; crypts. Colon: no villi, many mucus-producing goblet cells; water/electrolyte recovery (most water absorption occurs earlier in small intestine).

Cells | S liver/pancreas detail

Parietal cells: HCl and intrinsic factor (B12 absorption later in ileum). Chief cells: pepsinogen. Mucus/bicarbonate protect stomach. G cells: gastrin stimulates acid/motility. Liver: bile, nutrient processing, glycogen storage, plasma proteins, detoxification; portal vein brings gut blood; Kupffer cells are macrophages. Gallbladder stores/concentrates bile. Pancreas exocrine: enzymes and bicarbonate to duodenum; endocrine: insulin/glucagon to blood. Secretin responds to duodenal acid: bicarbonate. CCK responds to fats/protein: pancreatic enzymes and gallbladder contraction; slows gastric emptying.

Nutrition and activity

Carbohydrate/protein ~4 kcal/g; fat ~9. Fat-soluble vitamins A,D,E,K; water-soluble B,C. Fiber supports stool bulk and microbial activity; soluble fiber can slow glucose absorption. Balanced nutrients support tissues and immunity. Intense exercise may reduce gut blood flow; obesity raises risks of reflux, gallstones and fatty liver. Vitamins/minerals provide no calories.

Fast test checks

Underline NOT/EXCEPT and select ALL. Give requested number of examples. Use named structures, mechanisms and consequences. For graphs: axes > trend > mechanism > prediction. Recheck units and numbering; reserve the final 5 minutes for unanswered items.

GUT WALL | inside to outside

LUMEN (food side)	
MUCOSA	epithelium + lamina propria + muscle
SUBMUCOSA	vessels, nerves; Meissner plexus
MUSCULARIS EXTERNA	inner circular / outer longitudinal
SEROSA / ADVENTITIA	outer covering or attachment
Auerbach plexus lies between muscle layers. Schematic; not histology or thickness to scale.	

DIGESTIVE | chemical steps

Starch: salivary amylase in mouth, pancreatic amylase in small intestine > smaller sugars; brush-border maltase/sucrase/lactase > monosaccharides (glucose, fructose, galactose).

Protein: stomach acid denatures; pepsin (from pepsinogen) > peptides; pancreatic trypsin/chymotrypsin and peptidases > amino acids/small peptides. Enteropeptidase activates trypsinogen; trypsin activates other zymogens.

Fat: bile salts physically emulsify; pancreatic lipase chemically hydrolyzes triglycerides to monoglycerides/free fatty acids. Bile is NOT an enzyme.

Nucleic acids: pancreatic nucleases and intestinal enzymes produce absorbable components.

Absorption routes

Most absorption: small intestine. Sugars/amino acids > villus capillaries > hepatic portal vein > liver. Most long-chain fats: micelles deliver products to enterocytes > triglycerides rebuilt > chylomicrons > lacteals > lymph > blood. Shorter-chain fatty acids can enter portal blood directly. Micelles and chylomicrons are different. Ileum absorbs bile salts and B12 with intrinsic factor.

R disorders | S treatment

Peptic ulcer: mucosal injury, commonly *H. pylori* or NSAIDs; acid suppression; eradicate *H. pylori* when present.

Lactose intolerance: low lactase, undigested lactose causes gas/osmotic diarrhea; not milk allergy; lactase reduction or lactase.

Diarrhea: watery stools; replace fluid/electrolytes, treat cause.

Hepatitis: inflamed liver, viral/toxic/autoimmune causes; A often fecal-oral, B/C blood-related transmission; vaccines for A/B; cause-specific therapy (including antivirals for selected viral hepatitis), safe food/water and blood precautions.

Appendicitis: inflamed appendix; rupture risks peritonitis; appendectomy, antibiotics.

Cancers: uncontrolled growth in tract or accessory organs; connect location to impaired function; surgery, chemotherapy/radiation or targeted therapy depend on site/stage.

S | additional gut disorders

GERD: reflux into esophagus. Diverticulosis: pouches; diverticulitis: inflamed pouches. Ulcerative colitis: continuous colon/rectal mucosal disease. Crohn: anywhere in GI tract, skip lesions, transmural. Celiac: gluten-triggered autoimmune villus injury and malabsorption; gluten avoidance. IBD is not IBS. GERD/PUD: reduce acid (PPIs), eradicate *H. pylori* when present. IBD: anti-inflammatory/immune-targeted drugs, selected surgery; colectomy can remove UC, Crohn can recur. Diverticular care: fiber when appropriate; antibiotics/selected surgery for complicated inflammation. Celiac: gluten-free diet.

Cross-system links

CF can impair lungs and pancreatic digestion. Celiac links adaptive immunity to absorption. IgA protects respiratory and gut mucosa. Aspiration can connect swallowing failure to pneumonia. Malnutrition can impair immune function.

IMMUNE | organs and cells

Red bone marrow: blood-cell origin, B-cell maturation. Thymus: T-cell maturation/selection. Lymph nodes filter lymph; spleen filters blood. Tonsils, Peyer patches and appendix are mucosal immune tissues. Skin/mucosa form physical and chemical barriers.

Innate defenses

Toll-like receptors recognize conserved pathogen patterns. Rapid innate defenses: skin, mucus/cilia, acid, lysozyme, normal microbiota. Neutrophils: early phagocytes. Monocytes become macrophages: engulf and present antigen. Dendritic cells: strong antigen presenters. NK cells: kill stressed/infected cells without prior antigen-specific priming. Eosinophils: parasites/allergy. Basophils/mast cells: histamine/allergy. Complement: C3b tags targets (opsonization); C3a/C5a promote inflammation; C5b-C9 form lytic MAC. Interferons help antiviral defense.

Inflammation and presentation

Vasodilation/permeability cause redness, heat, swelling, pain. Leukocytes adhere, cross vessel wall (diapedesis), follow signals (chemotaxis), engulf targets. Innate receptors detect shared patterns; adaptive receptors are antigen-specific. Antigen = recognized molecular target; pathogen = disease-causing agent; antibody = antigen-binding immunoglobulin. MHC I on most nucleated cells presents intracellular peptides to CD8 cytotoxic T cells. MHC II on professional APCs presents to CD4 helper T cells. Dendritic cells, macrophages and B cells can be APCs.

Adaptive response

Recognition > activation/clonal expansion > effector response > contraction and memory. B cells > plasma cells secrete antibodies (humoral). Helper T cells coordinate via signals; cytotoxic T cells kill infected/abnormal cells; regulatory T cells restrain response. Memory B/T cells yield faster, stronger repeat responses. Antibody binding can neutralize, clump and tag targets; antibodies do not engulf.

Antibody classes

IgG: main serum class, crosses placenta, strong secondary response.

IgA: mucosal secretions, tears, saliva, breast milk.

IgM: early primary response; secreted pentamer.

IgE: immediate allergy, parasites; mast-cell binding.

IgD: B-cell receptor role.

2 heavy + 2 light chains form an antibody unit. Variable regions bind antigen; constant region determines class. Secretory IgA is usually dimeric; serum IgA mostly monomeric.

Sources of protection

Active = own response, develops memory: natural infection or artificial vaccination. Passive = transferred antibodies, temporary, no new recipient memory from the antibodies: placenta/milk or injected immunoglobulin. Primary response has delay; secondary faster/larger due to memory.

IMMUNE | disorders

Allergy: response to otherwise harmless antigen.

Autoimmunity: response to self. Immunodeficiency: inadequate defense.

HIV/AIDS: HIV damages CD4 helper T cells; AIDS is advanced immune deficiency.

CVID: deficient antibody production.

SCID: severe T-cell dysfunction with impaired combined immunity.

MS: CNS myelin injury.

RA: inflamed synovial joints.

Hashimoto: thyroid damage, low hormone.

Graves: antibodies stimulate TSH receptor, high hormone.

Hypersensitivity I to IV

I: IgE/mast cells, rapid; urticaria (hives), anaphylaxis.

II: IgG/IgM against cell/tissue targets; destruction OR altered receptors (myasthenia blocks ACh receptor; Graves stimulates TSH receptor).

III: deposited immune complexes; serum sickness, Arthus reaction.

IV: T-cell mediated/delayed; contact dermatitis. Not antibody mediated.

S | transplants and immunotherapy

Autograft: same person. Isograft: genetically identical donor.

Allograft: different person, same species. Xenograft: other species. Matching HLA/ABO and immunosuppression reduce allograft rejection. Hyperacute: pre-existing antibodies; acute: cellular/antibody; chronic: progressive injury.

Monoclonal antibodies bind selected targets. Checkpoint inhibitors release inhibitory signals on immune responses.

CAR-T: engineered T cells recognize selected tumor antigens.

S | treatment and prevention

Vaccines build active memory; immunoglobulin supplies passive protection. Antihistamines reduce histamine effects; epinephrine is first-line for anaphylaxis.

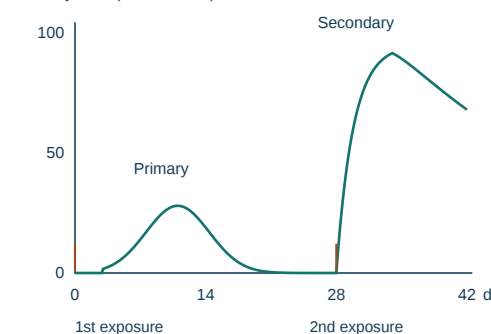
Anti-inflammatory/immunosuppressive and targeted biologic treatments reduce damaging immune activity but can increase infection risk. Antiretroviral therapy suppresses HIV. CVID: immunoglobulin replacement. SCID: stem-cell transplant/selected gene therapy. MS/RA: disease-modifying immune therapies. Hashimoto: thyroid hormone replacement. Graves: antithyroid drugs, radioiodine or surgery. Myasthenia: AChE inhibitors/immune therapy. Hives: antihistamines; contact dermatitis: avoid trigger/topical steroids; serum sickness/Arthus: remove trigger, inflammation control.

S | additional immune disorders

SLE: systemic immune-complex injury; hydroxychloroquine/selected immunosuppression, sun protection. Dermatomyositis: rash + muscle weakness; steroids/immune therapy, rehab. Scleroderma: excess collagen/fibrosis; organ-specific and immune/fibrosis-directed therapy. Psoriasis: scaly inflammatory plaques; topical drugs, phototherapy/biologics. Psoriatic arthritis: joint inflammation; disease-modifying drugs/biologics.

PRIMARY / SECONDARY RESPONSE

Antibody level (relative units)



Repeat antigen: faster, larger memory response.