BIO 004 · HUMAN ANATOMY · SOLANO COMMUNITY COLLEGE

Week 1 Course Notes.

Foundations · Tissues · Integumentary

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BIO 004 · WEEK 1

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The Language of Anatomy

Introduction to Anatomy

A reference for the anatomical terminology video and lab. Every position, plane, direction, and region named here is the shared vocabulary the rest of the course is built on.

BY THE END

1. List the six levels of structural organization in order.
2. Place the body in anatomical position and explain why it is the reference for every directional term.
3. Name the planes and sections and use the paired directional terms precisely.
4. Identify the major anterior and posterior regional terms and sort them as axial or appendicular.

Levels of Structural Organization

The body is organized from the simplest level to the most complex. Each level is built from the one before it.

1. **Chemical level** atoms and molecules, the smallest level
2. **Cellular level** cells, the smallest living units of the body
3. **Tissue level** groups of similar cells working together on a shared task
4. **Organ level** two or more tissue types forming a structure with a defined job
5. **Organ system level** organs that cooperate toward one broad function
6. **Organismal level** all organ systems together, the living person

Anatomical Position

Anatomical position	body erect, feet flat and slightly apart, head and eyes facing forward, arms at the sides, palms facing forward
Why it is the reference	every directional term assumes this position, so a description never changes with how the person is actually standing or lying
Supine	lying face up, on the back
Prone	lying face down, on the front

Body Planes and Sections

A plane is a flat surface that slices the body. The section is the cut surface it produces.

PLANE	ORIENTATION	DIVIDES THE BODY INTO
Sagittal	vertical	right and left parts
Midsagittal (median)	vertical, on the midline	equal right and left halves
Parasagittal	vertical, off the midline	unequal right and left parts
Frontal (coronal)	vertical	anterior and posterior parts
Transverse (horizontal)	horizontal	superior and inferior parts, a cross section
Oblique	at an angle	parts at an angle, between horizontal and vertical

Directional Terms

Directional terms come in pairs of opposites, always given from the patient's perspective in anatomical position. A structure between a medial and a lateral one is called intermediate.

TERM	ITS OPPOSITE	THE RELATIONSHIP THE PAIR DESCRIBES
Superior	Inferior	above versus below, toward the head or toward the feet
Anterior (ventral)	Posterior (dorsal)	toward the front versus toward the back of the body
Medial	Lateral	toward the midline versus away from the midline

TERM	ITS OPPOSITE	THE RELATIONSHIP THE PAIR DESCRIBES
Proximal	Distal	nearer versus farther from the trunk, used for the limbs
Superficial	Deep	toward versus away from the body surface
Cranial	Caudal	toward the head versus toward the tail end
Ipsilateral	Contralateral	on the same side versus the opposite side of the body

Regional Terms

The body divides into an axial region, the head, neck, and trunk, and an appendicular region, the limbs. Each named region has a precise term.

Axial regions

Cephalic	the head
Frontal	the forehead
Orbital	the eye
Nasal	the nose
Oral	the mouth
Buccal	the cheek
Mental	the chin
Otic	the ear
Occipital	the back of the head
Cervical	the neck
Thoracic	the chest
Sternal	the breastbone
Mammary	the breast
Abdominal	the belly
Umbilical	the navel
Vertebral	the spinal column
Lumbar	the lower back
Sacral	between the hips, over the sacrum
Gluteal	the buttock
Pelvic	the pelvis
Inguinal	the groin, where the thigh meets the trunk

Appendicular regions

Acromial	the point of the shoulder
Axillary	the armpit
Brachial	the arm, shoulder to elbow
Antecubital	the front of the elbow
Olecranal	the back of the elbow
Antebrachial	the forearm
Carpal	the wrist
Manus	the hand
Palmar	the palm
Pollex	the thumb
Digital	the fingers or toes
Coxal	the hip
Femoral	the thigh
Patellar	the front of the knee
Popliteal	the back of the knee
Crural	the leg, knee to ankle
Sural	the calf
Fibular	the lateral side of the leg
Tarsal	the ankle
Calcaneal	the heel
Pedal	the foot
Plantar	the sole of the foot
Hallux	the great toe

Why the words are not optional

Anatomical terms remove ambiguity. A chart that reads "wound on the anterior, distal forearm" means the same thing to every clinician on every shift, no matter how the patient is positioned.

Imaging is built on the planes. A CT slice is a transverse section. An MRI is often read in the sagittal and frontal planes. Knowing the plane tells you which view you are looking at.

Paired terms must be used precisely. **Proximal** and **distal** describe the limbs only, never the trunk. **Ipsilateral** and **contralateral** matter in neurology, where a lesion on one side of the brain can show its effect on the opposite side of the body.

Study questions

Work on answering these in writing, in your own words. They are the questions to bring to class, and good practice for the reasoning the exams ask for.

1. Why is anatomical position the agreed reference for every directional term? What goes wrong without it?

2. A wound is charted on the proximal, lateral left forearm. Describe where that is, and explain why proximal and distal are used for limbs but not the trunk.
3. Compare the sagittal, frontal, and transverse planes. For each, name the two parts it divides the body into.
4. Sort these as axial or appendicular and state your rule: brachial, thoracic, popliteal, vertebral, carpal.
5. Walk through the six levels of structural organization and explain how each is built from the one before.

Body Cavities & Regions

Introduction to Anatomy

A reference for the Body Cavities video and your lab work. The body cavities enclose and organize the viscera, and the abdominopelvic regions and quadrants give every clinician one shared map for locating organs, pain, and masses.

BY THE END

1. Distinguish the dorsal (posterior) and ventral (anterior) body cavities and name every subdivision of each.
2. Define a serous membrane and differentiate its parietal and visceral layers in the pleural, pericardial, and peritoneal cavities.
3. Map the boundaries and the four subdivisions of the mediastinum, and identify the major structures each contains.
4. Classify abdominopelvic organs as intraperitoneal or retroperitoneal using SADPUCKER, and locate organs on the nine-region and four-quadrant grids.

Directional Terms

The vocabulary you use to describe where one structure sits relative to another. Always given from the patient's perspective in anatomical position.

Directional terms come in opposing pairs. Learn each pair together: knowing one term gives you its opposite.

TERM	OPPOSITE	AXIS OR RELATIONSHIP
Superior	Inferior	Vertical axis. Superior is above, toward the head; inferior is below, toward the feet.
Anterior (ventral)	Posterior (dorsal)	Front-to-back axis. Anterior is toward the front of the body; posterior is toward the back.
Medial	Lateral	Relative to the midline. Medial is toward the midline; lateral is away from it.
Proximal	Distal	Along a limb. Proximal is closer to the trunk or point of attachment; distal is farther from it.
Superficial	Deep	Relative to the body surface. Superficial is closer to the surface; deep is farther in.
Cranial (cephalad)	Caudal	Along the long axis of the trunk. Cranial is toward the head; caudal is toward the tailbone.
Ipsilateral	Contralateral	Side comparison. Ipsilateral is the same side of the body; contralateral is the opposite side.

The Body Cavities

Dorsal (Posterior) Cavity

Cranial cavity	formed by the cranial bones, encloses the brain
Vertebral cavity	runs through the vertebral foramina, encloses the spinal cord
One continuous space	the cranial and vertebral cavities connect, both lined by the meninges

Ventral (Anterior) Cavity

Thoracic cavity	superior to the diaphragm, walled by the rib cage
Pleural cavities (2)	one on each side, each surrounds a lung
Mediastinum	median partition between the pleural cavities, see the section below
Pericardial cavity	surrounds the heart, sits within the mediastinum
Abdominopelvic cavity	inferior to the diaphragm, the largest cavity of the body
Abdominal cavity	superior portion, holds the stomach, intestines, liver, spleen, pancreas, kidneys
Pelvic cavity	inferior portion, cradled by the bony pelvis, holds the bladder, rectum, internal reproductive organs
No dividing wall	the abdominal and pelvic cavities are continuous, named regions of one space

The Boundary

Diaphragm	musculotendinous partition, the floor of the thoracic cavity and the boundary with the abdominopelvic cavity

Serous Membranes

What a serous membrane is

Serous membrane	a thin, double-layered membrane lining a ventral body cavity
Mesothelium	the simple squamous epithelium of the membrane, resting on areolar connective tissue
Parietal layer	lines the cavity wall
Visceral layer	covers the outer surface of the organ
Serous cavity	the narrow, fluid-filled space between the parietal and visceral layers
Serous fluid	slippery secretion of the mesothelium, lets the organ glide against the wall

The three named pairs

Each serous membrane has the same two-layer plan. Compare them side by side: the parietal layer always lines the wall, the visceral layer always covers the organ.

MEMBRANE	WHERE IT SITS	PARIETAL LAYER	VISCERAL LAYER
Pleura	around each lung, within the thoracic cavity	parietal pleura lines the thoracic wall, mediastinum, and diaphragm	visceral pleura clings to the outer surface of the lung
Pericardium	around the heart, within the middle mediastinum	parietal layer of the serous pericardium, fused to the inner surface of the fibrous pericardium	visceral layer, also called the epicardium, the outer surface of the heart
Peritoneum	around the abdominopelvic organs	parietal peritoneum lines the wall of the abdominopelvic cavity	visceral peritoneum covers the outer surface of the organs

The Mediastinum

The median partition of the thoracic cavity, set between the two pleural sacs. In the clinic you locate a mass, a sound, or a bleed by the compartment it occupies.

Boundaries

Superior boundary	the superior thoracic aperture, also called the thoracic inlet
Inferior boundary	the diaphragm
Anterior boundary	the sternum
Posterior boundary	the bodies of thoracic vertebrae T1 through T12
Lateral boundaries	the mediastinal pleura, the medial wall of each pleural cavity

The four compartments

The transverse thoracic plane, running from the sternal angle to the disc between T4 and T5, splits a superior mediastinum from an inferior mediastinum. The inferior mediastinum is then divided into anterior, middle, and posterior compartments. Locate a mass, a sound, or a bleed by the compartment it occupies.

COMPARTMENT	LOCATION	KEY CONTENTS
Superior mediastinum	above the transverse thoracic plane	arch of the aorta and its three branches, brachiocephalic veins, upper superior vena cava, trachea, esophagus, thoracic duct, thymus, phrenic and vagus nerves
Anterior mediastinum	inferior mediastinum, between the body of the sternum and the pericardium	thymus or its fatty remnant, lymph nodes, fat, connective tissue
Middle mediastinum	inferior mediastinum, the pericardium and the structures within it	heart within the pericardium, ascending aorta, pulmonary trunk, lower superior vena cava, main bronchi, phrenic nerves
Posterior mediastinum	inferior mediastinum, between the pericardium and the thoracic vertebral column	thoracic (descending) aorta, esophagus, thoracic duct, azygos and hemiazygos veins, sympathetic trunks, vagus nerves

Peritoneum and Peritoneal Relationships

The peritoneum is the serous membrane of the abdominopelvic cavity. Whether an organ lies inside that membrane or behind it changes how you reach it surgically and how fluid and infection travel.

The peritoneum

Parietal peritoneum	lines the wall of the abdominopelvic cavity
Visceral peritoneum	wraps the surface of the organs
Peritoneal cavity	the potential space between the two layers, holding a thin film of serous fluid
Mesentery	a double fold of peritoneum that slings an organ from the body wall and carries its vessels and nerves
Greater omentum	the apron of peritoneum hanging from the greater curvature of the stomach
Lesser omentum	the fold linking the lesser curvature of the stomach and the duodenum to the liver
Mesocolon	the peritoneal fold anchoring the transverse and sigmoid colon
Peritoneal recesses	low points of the peritoneal cavity where fluid, blood, or pus can collect, the reason body position matters when you look for free fluid

Intraperitoneal versus retroperitoneal

Every abdominopelvic organ has one of these two relationships to the peritoneum. The relationship sets how mobile the organ is and how a surgeon reaches it.

RELATIONSHIP	DEFINITION	ORGANS
Intraperitoneal	almost completely wrapped in visceral peritoneum and slung from the body wall by a mesentery, so they are relatively mobile	stomach, liver, gallbladder, spleen, first part of the duodenum, jejunum, ileum, transverse colon, sigmoid colon, cecum and appendix, tail of the pancreas
Retroperitoneal	lie against the posterior abdominal wall behind the parietal peritoneum, with peritoneum covering only their anterior surface	the structures that sit behind the peritoneum, remembered with SADPUCKER below

SADPUCKER, the retroperitoneal checklist

A memory aid for the structures that sit behind the peritoneum. Each letter is one retroperitoneal organ or vessel.

SADPUCKER

LETTER	STRUCTURE	WHAT LIES RETROPERITONEAL
S	Suprarenal glands	the adrenal glands, capping each kidney
A	Aorta and IVC	the abdominal aorta and the inferior vena cava
D	Duodenum	the second, third, and fourth parts; the first part is intraperitoneal
P	Pancreas	the head, neck, and body; the tail is intraperitoneal
U	Ureters	both ureters, running down the posterior wall
C	Colon	the ascending and descending colon; the transverse and sigmoid colon are intraperitoneal
K	Kidneys	both kidneys, set in the perirenal fat
E	Esophagus	the short abdominal segment below the diaphragm
R	Rectum	the lower portion, below the peritoneal reflection

Abdominopelvic Regions (Nine)

The four planes that draw the grid

Midclavicular planes (2) two vertical planes dropped from the midpoint of each clavicle

Subcostal plane horizontal, across the inferior margins of the rib cage

Transtubercular plane horizontal, across the tubercles of the iliac crests

The nine regions

The four planes divide the abdomen into a three-by-three grid. Read it like a tic-tac-toe board, top row to bottom row.

REGION	POSITION	KEY ORGANS
Right hypochondriac	upper right	gallbladder, right lobe of the liver
Epigastric	upper center	stomach, duodenum, pancreas
Left hypochondriac	upper left	spleen, tail of the pancreas
Right lumbar	middle right	ascending colon, right kidney
Umbilical	center	transverse colon, coils of small intestine
Left lumbar	middle left	descending colon, left kidney
Right iliac (inguinal)	lower right	cecum, appendix
Hypogastric (pubic)	lower center	urinary bladder, sigmoid colon
Left iliac (inguinal)	lower left	sigmoid colon

Four Quadrants

The two planes

Median plane the vertical midsagittal plane, divides right from left

Transumbilical plane the horizontal plane through the umbilicus, divides upper from lower

The quadrants

QUADRANT	KEY ORGANS	CLASSIC PAIN PATTERN
RUQ, right upper	liver, gallbladder, right kidney, hepatic flexure, head of the pancreas	gallbladder disease, hepatitis
LUQ, left upper	stomach, spleen, left kidney, splenic flexure, tail of the pancreas	splenic injury, gastric pain
RLQ, right lower	cecum, appendix, right ovary	classic site of appendicitis pain
LLQ, left lower	sigmoid colon, left ovary	classic site of diverticulitis pain

The cavity tells you the consequences

Each cavity has its own access procedure. **Thoracentesis** drains the pleural cavity. **Pericardiocentesis** drains the pericardial cavity. **Paracentesis** taps the peritoneal cavity. A **lumbar puncture** samples the vertebral cavity. The cavity tells the clinician where the needle goes.

Intraperitoneal versus retroperitoneal changes the picture. Blood from an intraperitoneal organ spreads freely and irritates the whole cavity. A **retroperitoneal** bleed, from the aorta or a kidney, can stay hidden behind the peritoneum and present instead as flank or back pain.

Where the finding sits narrows the list before any imaging is ordered. **RLQ** pain with rebound points to appendicitis until proven otherwise; **LLQ** pain in an older adult points to diverticulitis.

Study questions

Work on answering these in writing, in your own words. They are the questions to bring to class, and good practice for the reasoning the exams ask for.

1. Distinguish the dorsal and ventral body cavities and name every subdivision of each.
2. Explain the two-layer plan of a serous membrane, using the pleura as your example.
3. Map the four compartments of the mediastinum and name one structure in each.
4. Classify three abdominopelvic organs as intraperitoneal or retroperitoneal and explain how you decided.

Anatomy of the Cell

Cell Anatomy

A reference for the cell anatomy video and lab. The cell is the smallest living unit of the body. Every tissue, organ, and system is built from cells, so the structures named here are the foundation for the histology page that follows.

BY THE END

1. Name the three basic regions of a generalized cell and state what each one contains.
2. Describe the plasma membrane, distinguish integral from peripheral proteins, and name its surface specializations.
3. Identify the membranous and non-membranous organelles and state the job of each.
4. Explain how the nucleus stores the genetic material and how the nuclear pores control its traffic.
5. Trace the path a product follows through the endomembrane system, from the ER to the cell surface.

The Generalized Cell

Cells vary widely, but a composite model shows the three regions and the structures common to most body cells.

Generalized cell	a composite model showing the features shared by most body cells
Plasma membrane	the outer boundary that encloses the cell and separates it from its surroundings
Cytoplasm	everything between the plasma membrane and the nucleus, the cytosol plus the organelles
Nucleus	the control center, usually the largest structure in the cell

The Plasma Membrane

The outer boundary of the cell, and a selective barrier that controls which substances enter and leave. Compare its components by where each one sits and what each one does.

Membrane structure

COMPONENT	LOCATION IN THE MEMBRANE	ROLE
Phospholipid bilayer	a double layer of phospholipids, the basic fabric of the membrane	forms the continuous sheet; the fluid mosaic model describes proteins drifting within it
Integral proteins	firmly embedded in the bilayer; most span it completely as transmembrane proteins	form the channels, carriers, and receptors
Peripheral proteins	attached loosely to one face of the membrane or to integral proteins, not embedded	act as enzymes and brace the cell shape
Cholesterol	wedged among the phospholipids	stabilizes the membrane and keeps it fluid
Glycocalyx	the fuzzy external coat of glycoproteins and glycolipids	the cell's identity badge, used in recognition and adhesion

Surface specializations

SPECIALIZATION	DESCRIPTION	FUNCTION
Microvilli	finger-like extensions of the cell surface	increase surface area for absorption
Cilia	short hair-like extensions, built on a 9+2 microtubule core (nine doublets around a central pair)	sweep substances across the cell surface
Flagellum	a single long extension, also a 9+2 microtubule core	propels the cell; the only human example is the sperm tail

The Nucleus

The control center of the cell. It stores the genetic code and directs the building of proteins.

Nuclear envelope	the double membrane that encloses the nucleus, its outer membrane is continuous with the rough ER
Nuclear pores	protein-lined channels through the envelope that regulate traffic both ways, messenger RNA and ribosomal subunits move out while proteins needed inside move in
Nucleoplasm	the fluid inside the nucleus that suspends the other nuclear structures
Nucleolus	a dense body inside the nucleus where ribosomal subunits are assembled
Chromatin	the loose, threadlike form of DNA wound on proteins, present when the cell is not dividing
Chromosomes	the tightly coiled form of chromatin, visible when the cell divides

Cytoplasm and Organelles

The cytoplasm is the cytosol, a gel-like fluid that suspends the organelles, plus the organelles themselves, the small structures that each carry out a specific job. Compare them by structure and function.

Membranous organelles

ORGANELLE	STRUCTURE	FUNCTION
Rough ER	a ribosome-studded membrane network	makes and packages proteins
Smooth ER	a tubular membrane network with no ribosomes	makes lipids and stores calcium
Golgi apparatus	a stack of flattened membrane sacs	sorts, packages, and ships cell products
Lysosomes	membrane sacs of digestive enzymes	break down worn parts and debris
Peroxisomes	membrane sacs of enzymes	neutralize toxins and free radicals
Mitochondria	double-membraned organelles	produce most of the cell's ATP
Vesicles	small membrane sacs	move substances within the cell

Non-membranous organelles

ORGANELLE	STRUCTURE	FUNCTION
Ribosomes	tiny particles of RNA and protein, free in the cytosol or attached to the rough ER	build proteins
Cytoskeleton	an internal protein framework	gives the cell shape and allows movement
Microfilaments	the thinnest fibers, made of actin	support the cell surface and enable movement
Intermediate filaments	rope-like fibers	resist pulling forces and give the cell strength
Microtubules	the thickest fibers, hollow tubes	form tracks for transport inside the cell
Centrosome	a region near the nucleus	organizes the microtubules
Centrioles	paired rod-shaped structures within the centrosome, nine microtubule triplets in a 9+0 array	organize the spindle during cell division

The Path Materials Take Through the Cell

The membranous organelles connect into one route, the endomembrane system: the nuclear envelope, the ER, the Golgi apparatus, vesicles, and lysosomes. The numbered path below traces a secreted protein in order, from where it is made to where it leaves the cell. The mechanism belongs to physiology and is not covered here.

1. **Rough ER** the start of the path, where a new protein is made and enters the endomembrane system
2. **Transport vesicle** buds from the ER and carries the product to the Golgi apparatus
3. **Golgi apparatus** the mid-path stop, where the product is sorted, modified, and packaged
4. **Secretory vesicle** the carrier on the final leg, from the Golgi to the plasma membrane or to a lysosome
5. **Exocytosis** the exit point, where the vesicle fuses with the plasma membrane and the product leaves the cell

Supporting structures on the route

Endocytosis	the reverse direction, where material is taken into the cell inside a newly formed vesicle
Microtubules	the tracks the vesicles follow between stops on the path
Nuclear pores	the gateway on the path between the nucleus and the cytoplasm, where messenger RNA exits

Cells Vary With Their Job

No single cell looks like the generalized model. A cell's shape and its mix of organelles match the work it does: structure follows job, and a cell built for a task carries the organelles that task needs. Compare three examples.

CELL TYPE	STRUCTURAL ADAPTATION	WHY IT FITS THE JOB
Muscle cell	long and packed with mitochondria	contraction demands a constant, heavy supply of ATP
Red blood cell	loses its nucleus and organelles	frees interior space for oxygen-carrying contents
White blood cell	changes shape freely	can squeeze between cells to reach a site of infection

The organelle points to the disease

Cell structure shows up in the clinic. Lysosomes that cannot break down their contents cause the lysosomal storage diseases, such as Tay-Sachs.

Cilia that do not form correctly cause primary ciliary dyskinesia, where the airways cannot clear mucus and infections build up.

Because mitochondria carry their own small set of DNA, mitochondrial disorders follow a distinctive inheritance pattern. When you know what an organelle does, you can predict what fails when it is defective.

Study questions

Work on answering these in writing, in your own words. They are the questions to bring to class, and good practice for the reasoning the exams ask for.

1. Name the three regions of a generalized cell and state what each one contains.
2. Trace a secreted protein through the endomembrane system, from where it is made to where it leaves the cell.
3. Compare membranous and non-membranous organelles and give two examples of each.
4. Explain how the structure of the plasma membrane makes it a selective barrier.

Histology: The Four Tissue Types

Tissues & Histology

A reference for the histology video and lab. A tissue is a group of cells that share a structure and a job. Four tissue types build every organ in the body, and reading them on a slide is a core lab skill.

BY THE END

1. Name the three embryonic germ layers and the kinds of tissue each one gives rise to.
2. For each of the four tissue types, state its function, where it is found, and its defining structural features.
3. Classify epithelial tissue by cell layers and cell shape, and explain what the surface and junction structures do.
4. Describe connective tissue as cells, fibers, and ground substance, and recognize the overview features of cartilage, bone, muscle, and nervous tissue.

Where Tissues Come From

Early in development the embryo forms three primary germ layers. Every tissue in the body traces back to one of them. Compare them by position and what each one forms.

GERM LAYER	POSITION	WHAT IT FORMS
Ectoderm	the outer germ layer	the epidermis of the skin and all nervous tissue
Mesoderm	the middle germ layer	muscle, bone, cartilage, blood, and most connective tissue
Endoderm	the inner germ layer	the epithelial lining of the digestive and respiratory tracts and their glands

The Four Tissue Types

All tissues sort into four basic types. Compare what each one does and where it dominates, then study each in detail below.

TISSUE TYPE	PRIMARY FUNCTION	WHERE IT DOMINATES
Epithelial tissue	covers body surfaces, lines cavities and vessels, and forms glands	the epidermis, gut and vessel linings, all glands
Connective tissue	binds, supports, and protects; the most diverse and widespread type	throughout the body, between and within organs
Muscle tissue	produces movement by contracting	skeletal muscles, the heart wall, the walls of hollow organs
Nervous tissue	senses change, processes information, and directs responses	the brain, spinal cord, and nerves

Epithelial Tissue

Function and location

Function	protection, absorption, secretion, filtration, and sensory reception
Location	the epidermis, the lining of the gut, vessels, ducts, and the airways, and all glands
General features	cells packed tightly with little matrix, one free apical surface, avascular but innervated, high capacity to regenerate

Classification

Epithelia are named on two axes: the number of cell layers and the shape of the surface cells. Compare the terms by what each one is named for.

CLASS	NAMED FOR	DESCRIPTION
Simple epithelium	number of cell layers	one cell layer, built for absorption, secretion, and filtration
Stratified epithelium	number of cell layers	many cell layers, built for protection against wear
Squamous cells	shape of the surface cells	flat and thin, allow rapid diffusion and filtration
Cuboidal cells	shape of the surface cells	cube-shaped, common in glands and kidney tubules, for secretion and absorption
Columnar cells	shape of the surface cells	tall, line absorptive and secretory surfaces such as the gut
Pseudostratified	special arrangement	one layer that looks layered, often ciliated, lines the airways
Transitional	special arrangement	stretches and recoils, lines the urinary tract

Special structures and what they do

Basement membrane	a thin sheet that anchors the epithelium to the connective tissue below; made of a basal lamina (collagen, laminin, glycoproteins) plus a deeper reticular lamina (collagen and glycoproteins)
Apical microvilli	finger-like projections that increase surface area for absorption
Cilia	hair-like projections that sweep mucus and particles across the surface

The five cell junctions

Epithelial cells are bound and sealed by five junction types. Know what each one does, what it links to, and its major protein.

JUNCTION	WHAT IT DOES	LINKS TO / FOUND IN	MAJOR PROTEIN
Tight junction	fuses adjacent membranes to seal the gap between cells, so nothing leaks between them	stomach, intestine, and bladder linings; blood-brain barrier	claudins, occludins
Adherens junction	an adhesion belt that helps surfaces resist separation during contraction	attaches to microfilaments; intestinal epithelium	cadherins
Desmosome	plaques that rivet cells together against pulling forces	attaches to intermediate filaments; epidermis and cardiac muscle	cadherins
Hemidesmosome	anchors a cell to the basement membrane beneath it	skin and heart muscle	integrins
Gap junction	protein channels that pass ions and small molecules so cells communicate	cardiac and smooth muscle, neurons, GI tract, lens	connexins

Glandular epithelium

GLAND TYPE	DUCT	HOW IT SECRETES	EXAMPLES
Exocrine glands	has a duct	secrete their product onto a surface through the duct	sweat and salivary glands
Endocrine glands	ductless	release hormones directly into the blood	thyroid and adrenal glands

Connective Tissue

Function and the basic plan

Function	binds and supports, protects, insulates, stores energy, and transports
The three ingredients	every connective tissue is cells plus fibers plus ground substance
Extracellular matrix	the fibers and ground substance together, where most of the tissue volume sits

Cells, fibers, ground substance

Fibroblasts	the cells that build the fibers and matrix of connective tissue proper
Ground substance	the gel that fills the space between cells and fibers and holds tissue fluid

Three fiber types run through the matrix. Compare them by their property and their job.

FIBER TYPE	PROPERTY	ROLE
Collagen fibers	strong and ropelike	resist pulling forces; the most abundant fiber
Elastic fibers	stretch and then recoil to the original shape	let tissue spring back, as in skin and the walls of arteries
Reticular fibers	fine branching networks	support soft organs such as lymph nodes and the spleen

Connective tissue proper

SUBTYPE	CATEGORY	DESCRIPTION AND LOCATION
Areolar	loose	soft packing material, wraps and cushions organs, holds tissue fluid
Adipose	loose	fat, stores energy, insulates, and cushions
Reticular	loose	the supportive framework of lymph nodes, the spleen, and bone marrow
Dense regular	dense	parallel collagen, forms tendons and ligaments, strong in one direction
Dense irregular	dense	collagen running in all directions, forms the dermis and organ capsules
Dense elastic	dense	mostly elastic fibers, in the walls of large arteries

Blood, a fluid connective tissue

Blood	cells and cell fragments suspended in a fluid matrix called plasma, functions in transport

Cartilage and Bone, an Overview

Cartilage

Function — firm but flexible support, and a smooth low-friction surface for movement

Avascular — cartilage has no blood vessels, so it heals slowly

Three types of cartilage differ in the fibers their matrix contains. Compare them by property and location.

CARTILAGE TYPE	PROPERTIES	LOCATION
Hyaline cartilage	the most common type, fine collagen, glassy matrix	the ends of bones, the nose, and the airways
Elastic cartilage	flexible, packed with elastic fibers	the external ear and the epiglottis
Fibrocartilage	tough and shock-absorbing, thick collagen bundles	the intervertebral discs and the knee menisci

Bone (osseous tissue)

Function — supports the body, protects organs, provides levers for movement, stores minerals

Well vascularized — unlike cartilage, bone has a rich blood supply and heals well

Bone tissue comes in two textures. Compare them by structure and role.

BONE TISSUE	STRUCTURE	ROLE
Compact bone	the dense outer layer, built around repeating units called osteons	resists stress and provides the strength of the bone surface
Spongy bone	an open lattice of trabeculae, lighter than compact bone	houses bone marrow and lightens the bone

Muscle Tissue, an Overview

Muscle tissue produces movement by contracting. Three types differ in their striations, their control, and their cell shape. Compare them side by side.

MUSCLE TYPE	STRIATIONS	CONTROL	LOCATION	CELL DESCRIPTION
Skeletal muscle	striated	voluntary	attached to bone	long cylindrical cells with many nuclei
Cardiac muscle	striated	involuntary	only in the heart wall	branching cells joined by intercalated discs
Smooth muscle	no striations	involuntary	the walls of hollow organs and vessels	spindle-shaped cells with one nucleus

Nervous Tissue, an Overview

Function — senses change, processes information, and directs the body's responses

Neurons — the signaling cells, carry electrical impulses

Neuroglia — the supporting cells that protect and assist neurons

Location — the brain, the spinal cord, and the nerves

Body Membranes

Membranes are thin sheets that combine an epithelium with an underlying connective tissue, except the synovial membrane, which has no epithelium. Compare the four by what they are made of and where they sit.

MEMBRANE	COMPOSITION	WHERE IT IS
Cutaneous membrane	a keratinized epithelium over dense connective tissue, a dry membrane	the skin, covering the body surface
Mucous membrane	an epithelium over loose connective tissue, kept moist	lines body cavities that open to the outside, such as the gut and the airways

MEMBRANE	COMPOSITION	WHERE IT IS
Serous membrane	a simple squamous epithelium over a thin connective tissue layer	lines the closed ventral cavities, covered in full on the Body Cavities page
Synovial membrane	connective tissue only, with no epithelium	lines joint cavities and secretes lubricating fluid

Tissue structure predicts how it heals and how it fails

Epithelium is packed with dividing cells and a rich nerve supply, so it heals quickly and a small cut hurts. Cartilage is avascular, which is why a torn knee meniscus barely repairs itself.

Dense regular connective tissue is strong in one direction, the reason tendons and ligaments tear when they are twisted rather than pulled straight.

Tissue of origin even names disease. Most cancers are carcinomas, which arise from epithelium, the tissue that turns over the most.

Study questions

Work on answering these in writing, in your own words. They are the questions to bring to class, and good practice for the reasoning the exams ask for.

1. For each of the four tissue types, state its function, one location, and a defining structural feature.
2. Classify epithelium by cell layers and cell shape, and explain what each axis is named for.
3. Describe connective tissue as cells, fibers, and ground substance, and compare two subtypes.
4. Compare the three muscle tissues and the two cell types of nervous tissue.

The Integumentary System

Integumentary & Skin

A reference for the integumentary video and lab. The skin is the body's largest organ. This page names its layers, the strata of the epidermis, and the accessory structures that grow from it: hair, nails, and glands.

BY THE END

1. Name the two layers of the skin and the hypodermis beneath them.
2. List the five strata of the epidermis in order and identify the cell types of the epidermis.
3. Distinguish the papillary and reticular layers of the dermis and the structures each contains.
4. Identify the accessory structures of the skin: hair, nails, and the glands.

The Integument, an Overview

The integumentary system is the skin plus the structures that grow from it. The skin itself has two layers, with a fatty hypodermis beneath.

Integumentary system	the skin together with its accessory structures: hair, nails, and glands
Skin (integument)	the body's largest organ, made of two layers, the epidermis and the dermis
Epidermis	the superficial layer, keratinized stratified squamous epithelium, no blood vessels
Dermis	the deep layer, mostly connective tissue, holds the vessels, nerves, and glands
Hypodermis	the subcutaneous layer beneath the skin, mostly adipose, anchors the skin to the structures below, not part of the skin proper

The Epidermis

The strata, deep to superficial

The epidermis is built in layers. A keratinocyte is born in the deepest stratum and is pushed toward the surface as new cells form beneath it. Follow the strata in order, deep to superficial.

1. **Stratum basale** the deepest layer, a single row of dividing cells, sits on the basement membrane
2. **Stratum spinosum** several cell layers with a spiny appearance
3. **Stratum granulosum** cells filled with keratohyalin granules, where keratinization begins; keratinocytes here release lamellar granules of lipid that waterproof the epidermis
4. **Stratum lucidum** a clear, thin layer, present only in thick skin
5. **Stratum corneum** the surface layer, many flat dead keratinized cells

Thick vs thin skin	thick skin of the palms and soles has all five strata, thin skin lacks the stratum lucidum

Cells of the epidermis

CELL	ALSO CALLED	FUNCTION
Keratinocytes	the main epidermal cell	produce keratin, the tough protective protein of the epidermis
Melanocytes	the pigment cell	produce melanin, the pigment that colors the skin and shields against UV light
Tactile cells	Merkel cells	paired with a nerve ending for the sense of touch
Dendritic cells	Langerhans cells	immune cells that patrol the epidermis

The Dermis

The dermis has two layers. Compare them by depth, the tissue each is made of, and what each one is known for.

DERMAL LAYER	DEPTH	TISSUE	NOTABLE FEATURES
Papillary layer	the superficial dermis	areolar connective tissue	thrown into dermal papillae, finger-like projections up into the epidermis; on the palms and soles they raise friction ridges, the basis of fingerprints; tactile (Meissner) corpuscles for light touch sit within the papillae
Reticular layer	the deep dermis, the bulk of the dermis	dense irregular connective tissue	collagen and elastic fibers give strength and stretch; holds the blood vessels, nerve endings, glands, and hair follicles; lamellated (Pacinian) corpuscles for deep pressure lie in the deep reticular layer

Cells of the dermis

Fibroblasts	the main dermal cell, builds the collagen and elastic fibers of the matrix
Macrophages	wandering phagocytes that engulf debris and pathogens
Mast cells	scattered through the dermis, release chemicals during injury and allergy

Accessory Structures

Hair, nails, and glands all develop from the epidermis and reach down into the dermis.

Hair

Hair	a strand of keratinized cells produced by a hair follicle
Hair shaft	the part of the hair above the skin surface
Hair root	the part of the hair within the follicle
Hair follicle	the tube of epidermal and dermal tissue surrounding the root
Hair bulb	the expanded base of the follicle, where the hair grows
Cortex and medulla	the keratinized layers that make up the hair itself; melanocytes deposit pigment here, which sets hair color
Epithelial root sheath	the epidermal tube that wraps the root inside the follicle
Dermal root sheath	the connective tissue layer surrounding the follicle
Hair root plexus	sensory nerve endings around the follicle that detect hair movement
Arrector pili	a small smooth muscle that pulls the hair upright

Nails

Nail	a plate of hard keratin on the dorsal tip of a finger or toe
Nail plate	the visible body of the nail
Nail bed	the skin underneath the nail plate
Nail matrix	the growth region at the proximal end of the nail
Lunule	the pale crescent at the base of the nail
Cuticle	also called the eponychium, the fold of skin over the proximal nail

Glands

Five gland types develop from the epidermis. Compare them by what they secrete and where the secretion goes.

GLAND	SECRETION	WHERE IT OPENS
Sebaceous glands	sebum, an oily secretion	into hair follicles; softens the hair and skin
Eccrine sweat glands	watery sweat	directly onto the skin surface; the most numerous sweat gland
Apocrine sweat glands	a richer, thicker sweat	into hair follicles of the axillary and genital regions
Ceruminous glands	cerumen, or earwax	into the ear canal; a modified sweat gland
Mammary glands	milk	through ducts to the nipple; a modified sweat gland

How exocrine glands release their product

Glands are also classified by the mechanism they use to release secretion. Three modes appear in the skin.

MODE	HOW THE SECRETION IS RELEASED	EXAMPLE
Merocrine (eccrine)	the cell stays intact and releases product by exocytosis	eccrine sweat glands
Apocrine	the apical part of the cell pinches off with the secretion	apocrine sweat glands, mammary glands
Holocrine	the whole cell fills with product and ruptures, becoming the secretion	sebaceous glands

The skin layers map the depth of a burn

Burn depth is described by the skin layers it reaches. A first-degree burn damages only the epidermis, like a mild sunburn. A second-degree burn reaches into the dermis and blisters. A third-degree burn destroys the full thickness of the epidermis and dermis, and can be painless, because the nerve endings in the dermis are gone.

The layers also tell you where a needle goes. An intradermal test sits in the dermis, a subcutaneous injection in the hypodermis, each layer a different depth.

Healing depends on the stratum basale, the dividing layer that regenerates the epidermis. When a wound spares it, the skin can repair itself. When a burn destroys it, a graft is needed.

Study questions

Work on answering these in writing, in your own words. They are the questions to bring to class, and good practice for the reasoning the exams ask for.

1. Name the two layers of the skin plus the hypodermis, and the tissue each is made of.
2. List the five epidermal strata in order and explain how a keratinocyte changes as it moves up.
3. Compare the papillary and reticular layers of the dermis by tissue and what each contains.
4. Explain how the depth of a burn maps onto the skin layers it destroys.