🏆 Let's Take Attendance 🏆

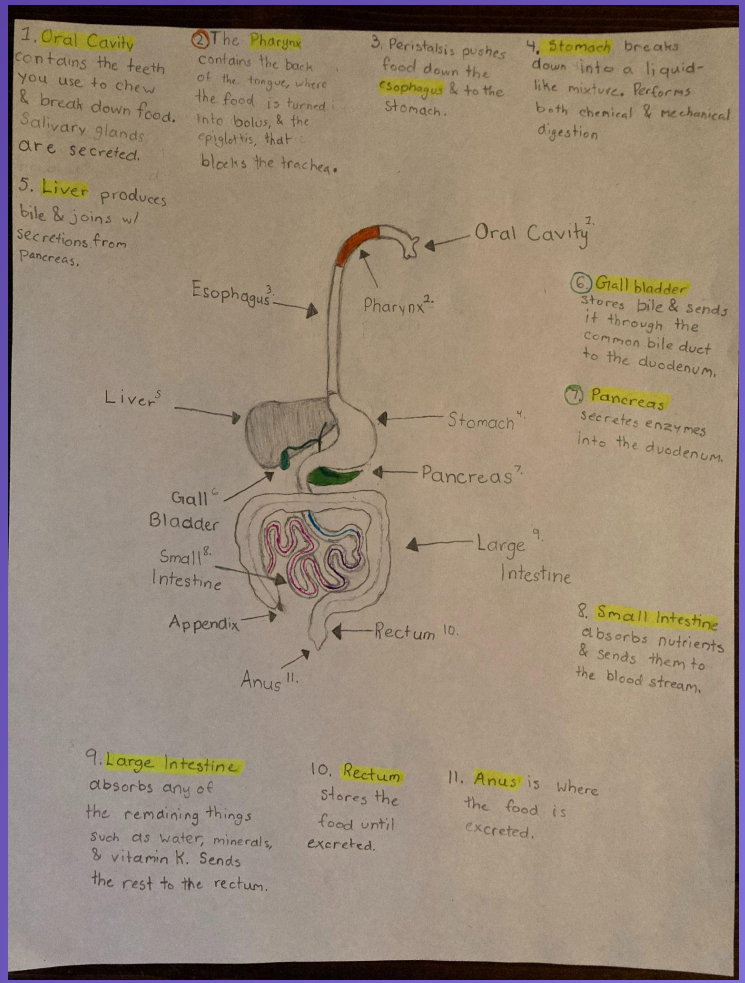
http://sciovirtual.org/attendance

Attendance code: **neuro85**

ICEBREAKER QUESTION (put in chat): What was the last meal you had?

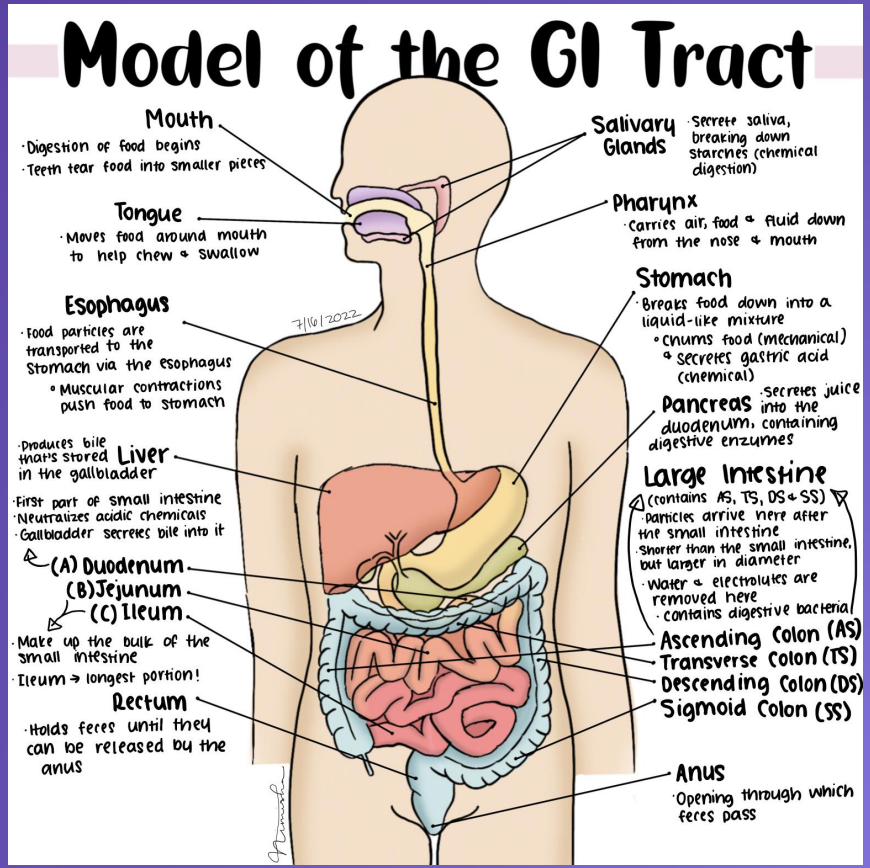
Course Challenge 1 Winners!!

Amritpreet!



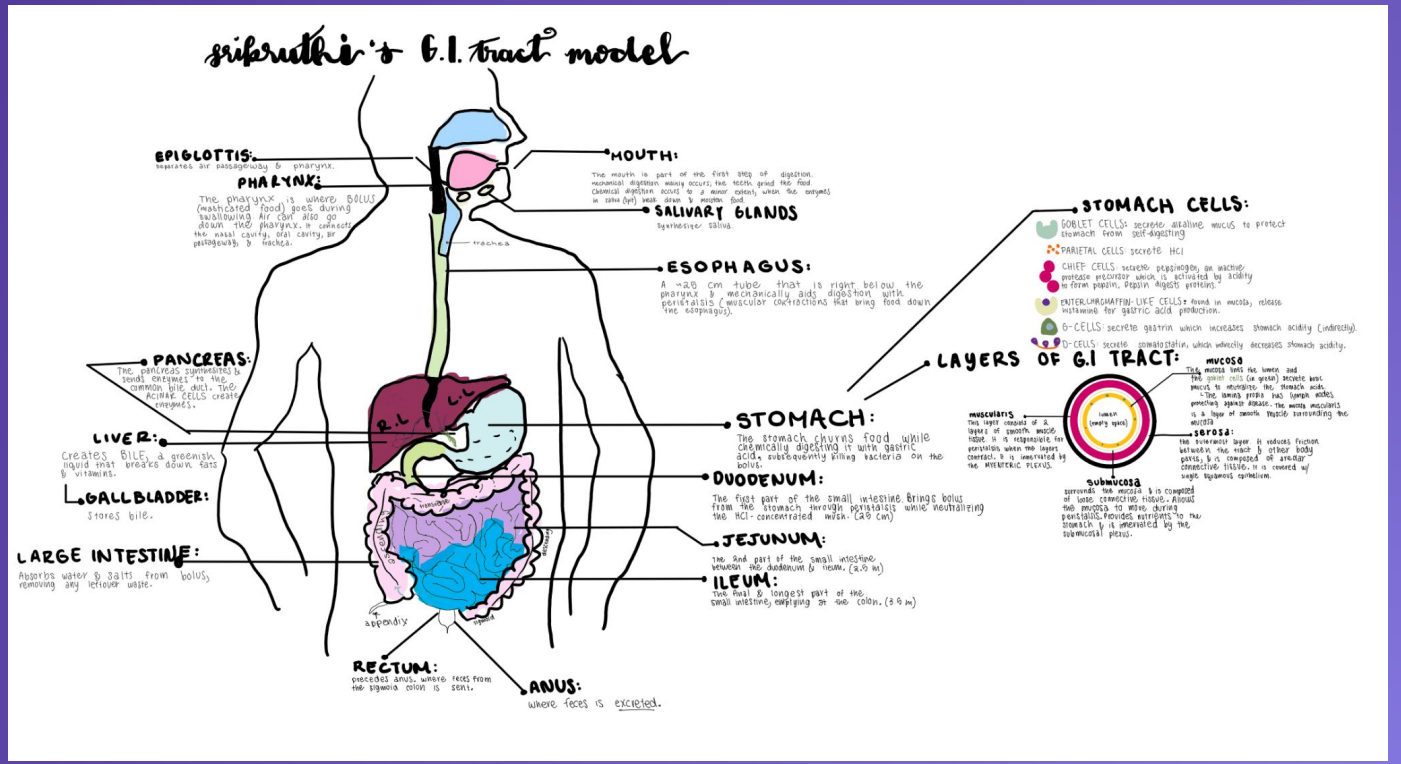
Course Challenge 1 Winners!!

Nimisha!



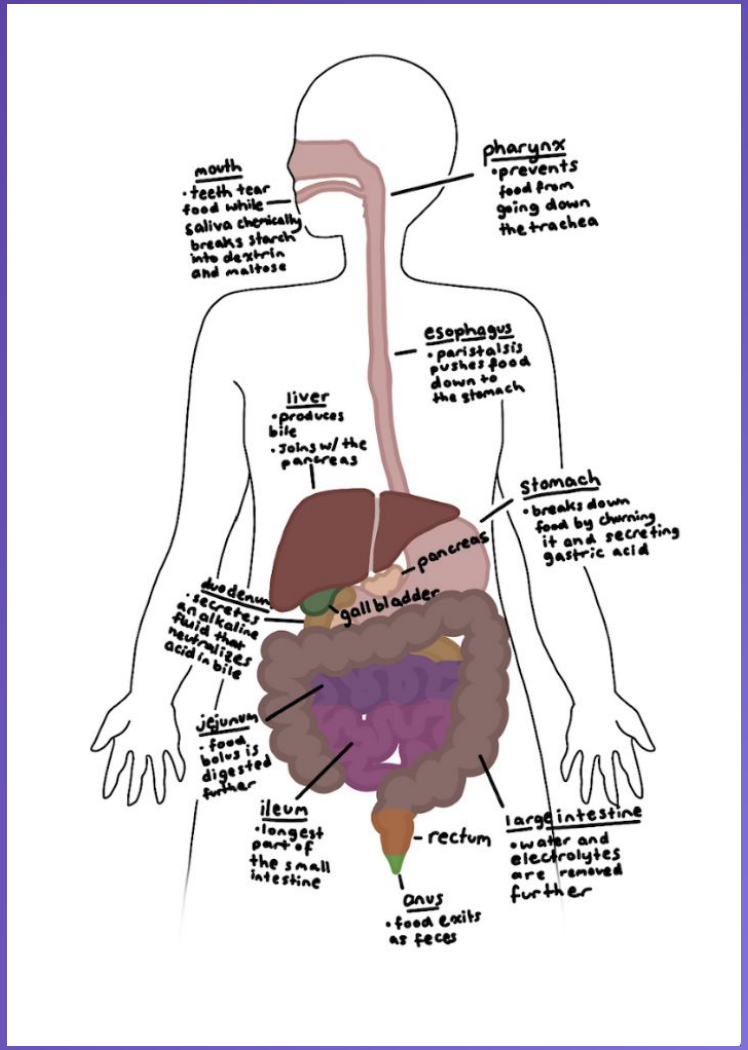
Course Challenge 1 Winners!!

Srikruthi!



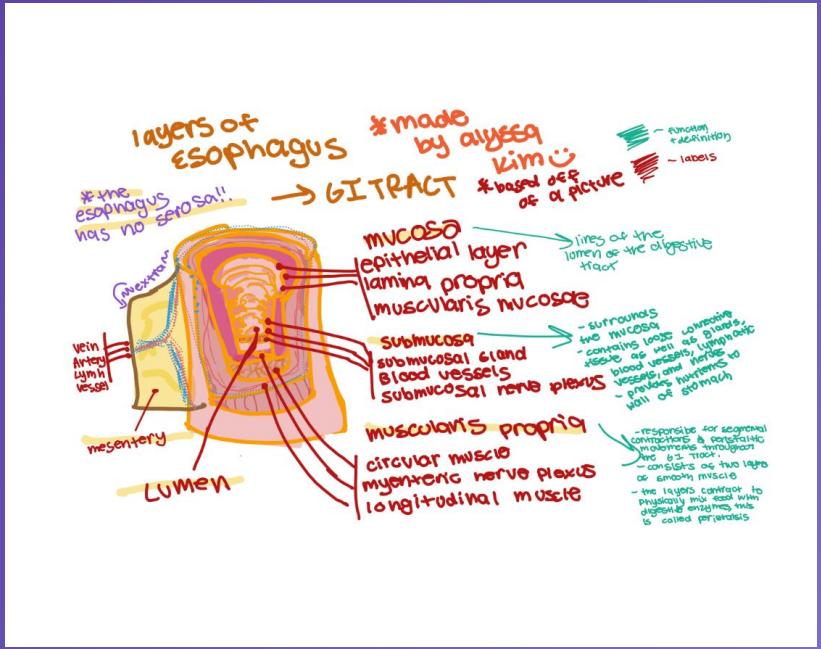
Course Challenge 1 Winners!!

Emily Y.,
Alice,
Sarah and
Angela!



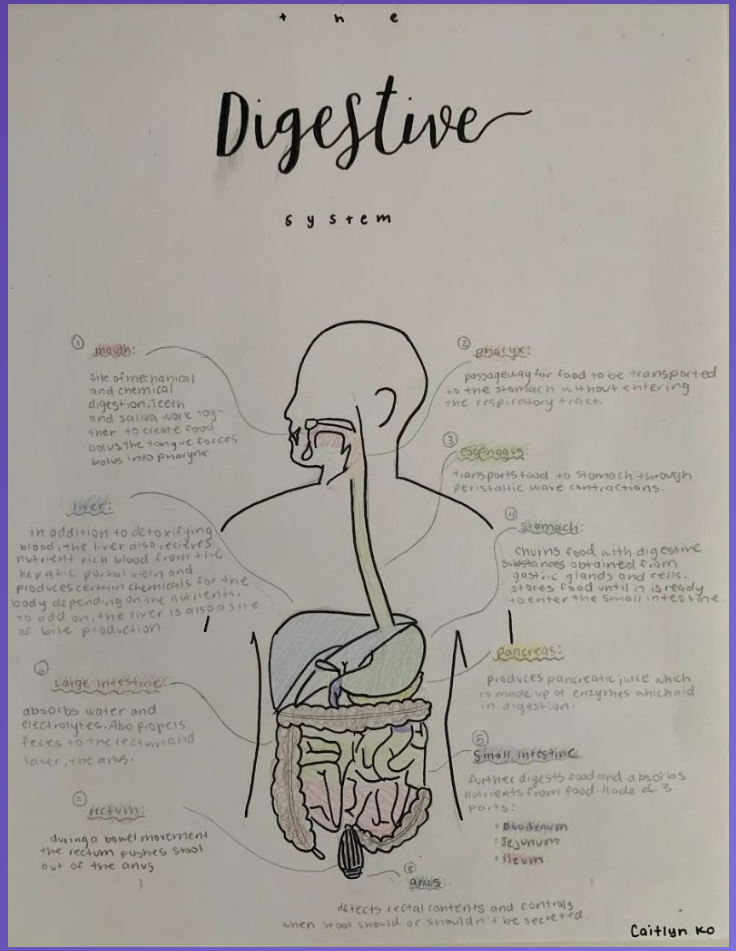
Course Challenge 1 Winners!!

Alyssa!



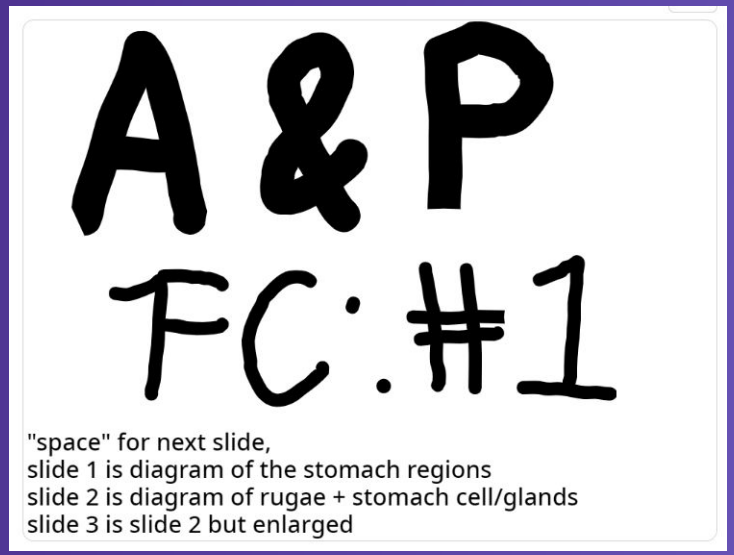
Course Challenge 1 Winners!!

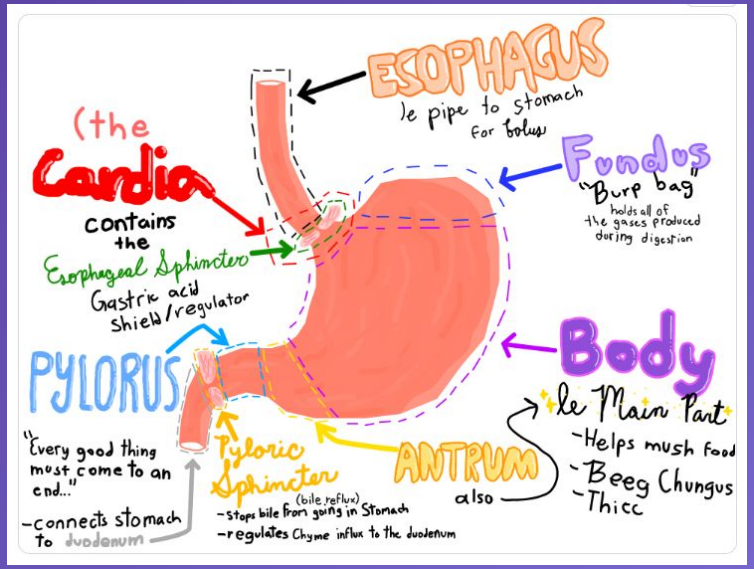
Caitlyn!

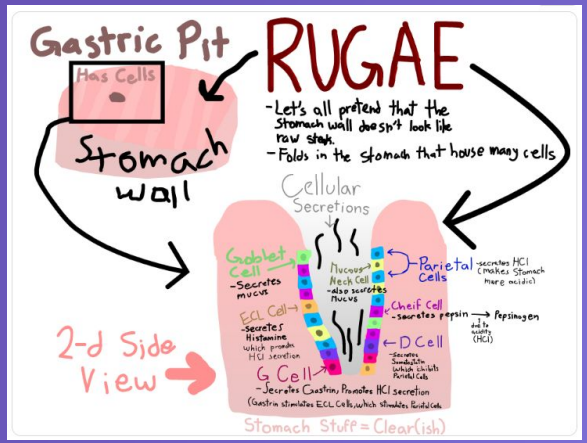


Course Challenge 1 Winners!!

Joshua!







Homework #1 Top Scorers

- A lot of people did what was asked so it came down to minute details:
  - Srikruthi
  - Joshua
  - Austin

Course leaderboard

- Updated with week 1 challenge and week 1 bonus
- Will be updated with week 2 challenge and week 2 bonus on Monday
  - Amritpreet
  - Nimisha
  - Srikruthi
  - Alice Chi

Course Updates

- Homework #3(covering lessons 5 and 6) along with course challenge 2 will be released today
- Due by end of Sunday night
- Scores will be updated on top scorers revealed on Monday

Respiratory System

Take a deep **breath**, and let's get started!

M

Function

- Provide oxygen to blood
- Eliminate CO_2 from blood
- Regulate blood pH
- Forms speech sounds
- Defends against inhaled microbes
- Influences concentrations of chemical messengers (ex. hormones) by exchange with pulmonary arteries

R

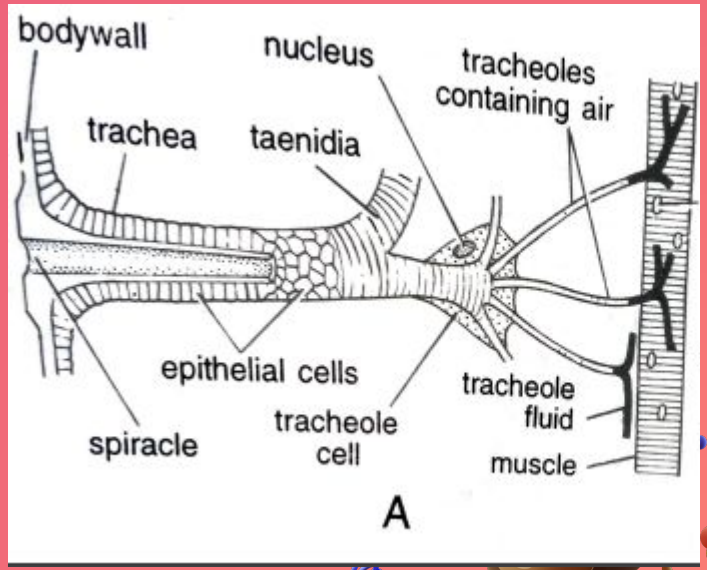
Respiration in Different Animals

- Plasma membrane
  - In unicellular organisms (amoeba), animals absorb O_2 and release CO_2 via diffusion.
- Body wall
  - Tapeworms, earthworms, leeches use skin (containing capillaries).
  - Frogs can exchange gas through skin.

M

Respiration in Different Animals

- Tracheal system
  - In insects
  - Air (O_2) enters spiracles
    - THORAX
  - Diffuses to body tissue and enters every cell.
  - CO_2 released enters tracheal tubes (and tracheoles) and exits through spiracles.
  - Rings of **chitin** keep trachea open.
  - Air sacs are formed from enlarged trachea.
    - Speed up diffusion
  - Muscle contractions in flying insects help to pump air quickly through the system.



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Fishies!

- Gills
  - In fish/prawn, gills use O_2 dissolved in water and contain blood vessels that help exchange.

1. **Fish gulp water through their mouth.**
   a. The gills are covered by the operculum which work with the jaws to pump water over the gill arches
2. **Water passes into the gill chamber through gill slits**
   a. Each gill arch has 2 rows of gill filaments.
   b. Gill filaments are composed of flattened lamellae.
3. **Gas exchange: Blood flowing through lamellae capillaries pick up O_2 from water**
   a. Oxygen from water enters the blood due to countercurrent exchange (AKA a gradient which is maintained through the entire length of the gill)

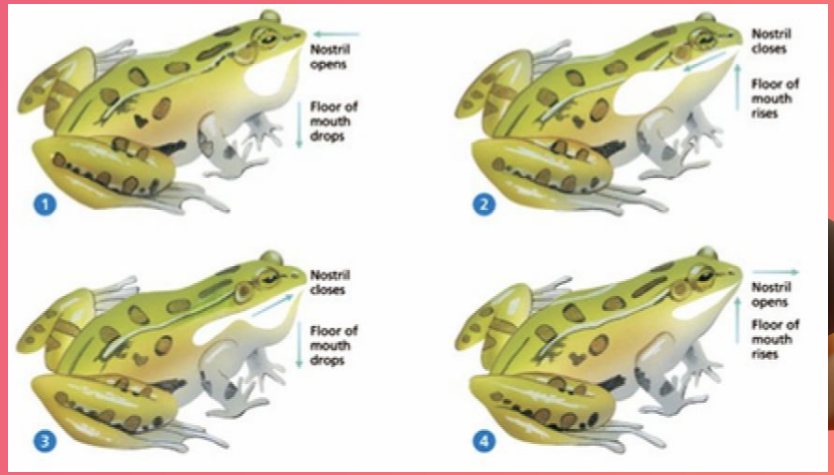
Respiration in Different Animals

- Plasma membrane
- Body wall
- Tracheal system
- Gills
- Lungs

R

Frogies! (Positive Pressure)

1. Frog **forces down air** through its nose as it lowers its oral cavity.
2. The oral cavity rises, so **air enters trachea**. (Nostrils closed)
3. The oral cavity drops. (Nostrils closed)
4. Nostrils open. **Air is expelled** by compressing body wall and lungs. The oral cavity rises.



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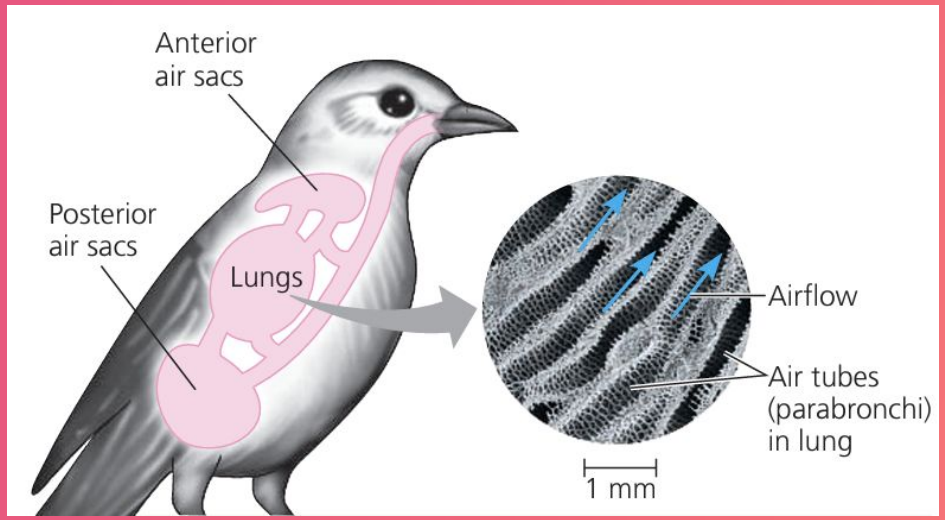
Birdies! (Unidirectional)

1. The bird inhales. Air fills **POSTERIOR** air SACS.
2. The bird exhales. Air leaves air sacs to the **LUNGS**.
3. The bird inhales. Air leaves lungs to **ANTERIOR** air SACS.
4. The bird exhales. Air leaves air sacs and exits body.



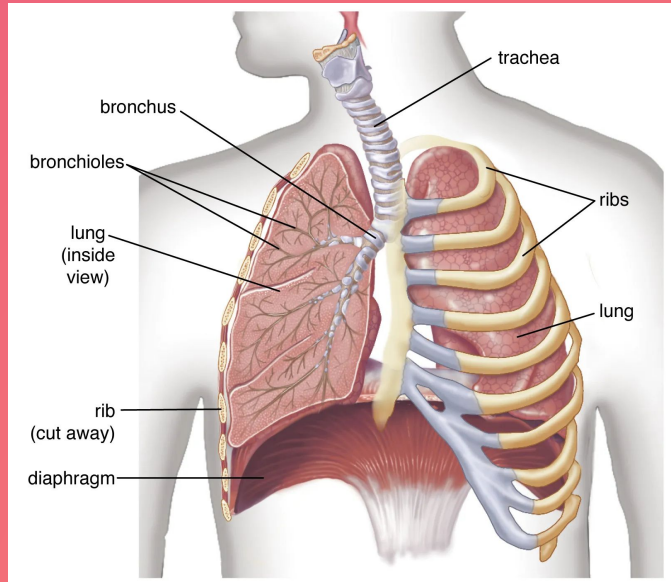
What's a benefit of unidirectional air flow?

R

Mammal! (Bidirectional)

1. Human inhales.
   a. Intercostal muscles contract, pulling ribs **up** and sternum **out**.
   b. Diaphragm contracts, expanding thoracic cavity **down**.
2. Human exhales.
   a. Thoracic muscles relax, reducing volume in cavity.
   b. So, air pressure increases (Boyle's Law) and air exits.

NOTE: The lungs in mammals don't empty with each breath, leaving a "residual volume." The airway path for inhalation is the same as exhalation [hence, bidirectional]



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Organization

Yellow = Upper airways
White = Conducting zone
Blue = Respiratory zone

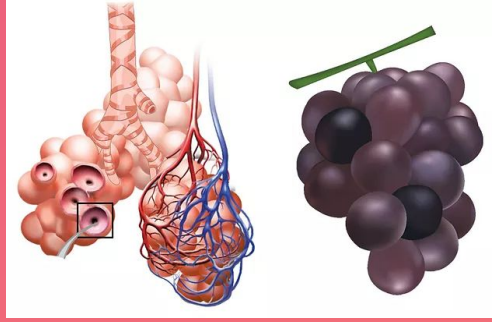
- Pharynx - where air from nose and mouth join together
  Q!
- Larynx - has vocal cords (flow of air through these horizontal elastic tissue causes sound)
- Trachea - long tube branches to 2 bronchi which each enter a lung
- Bronchus (Bronchi) - small tubes that branch further (bronchioles [terminal/respiratory]), surrounded by smooth muscle that controls the radius of the tube
- Alveoli - air-containing sacs which are the sites of **gas exchange,** 300 million in an adult, about 4 L of fresh air enters/leaves alveoli every min.
  - !!

General terms

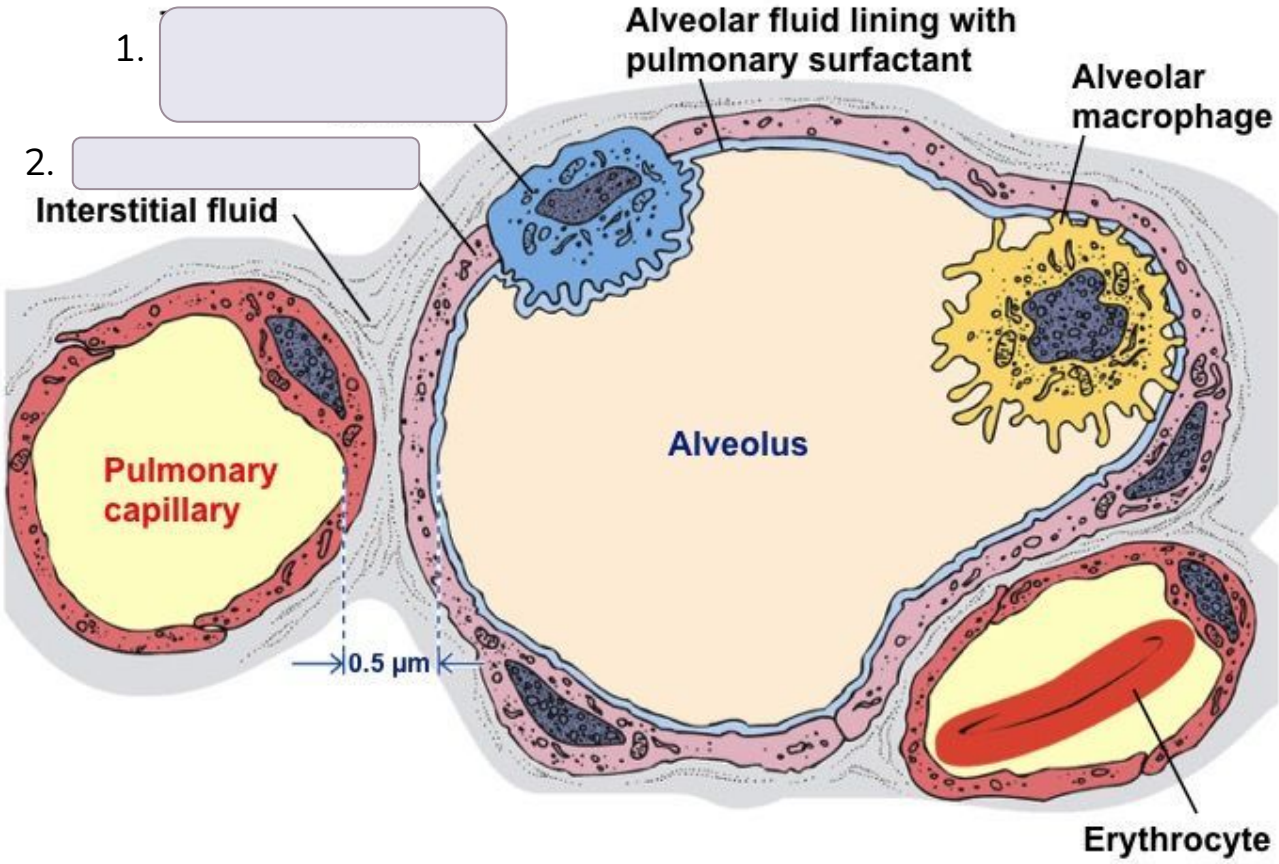
- Airways - tubes that air flows
- Respiratory cycle -1 inspiration (air from outside to alveoli during breathing) + 1 expiration

M

Alveoli (“Grape Clusters”)



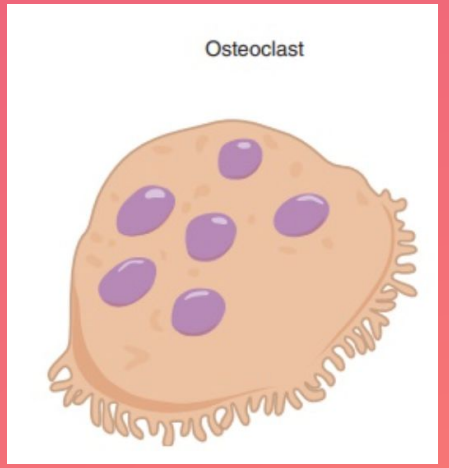
- Tiny hollow sacs separated by alveolar wall
- Surrounded by a film of liquid
- Have **white blood cells** that engulf foreign particles
- Type 1 alveolar cells: form a continuous layer of 1-cell thick, flat epithelial cell that lines surface of wall that faces the **air side**
- Type 2 alveolar cells: thicker, specialized cells produce **pulmonary surfactant** to prevent alveoli collapse
- Alveoli walls contain capillaries and small interstitial space
  - This enables oxygen and carbon dioxide to be exchanged by diffusion
  - In some alveolar walls, pores allow air to flow between alveoli.

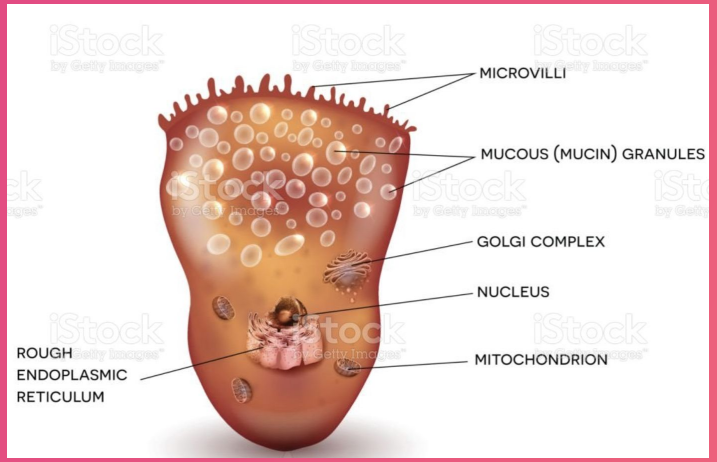

1.
2.
Interstitial fluid
Alveolar fluid lining with pulmonary surfactant
Alveolar macrophage
Pulmonary capillary
Alveolus
0.5 µm
Erythrocyte

M

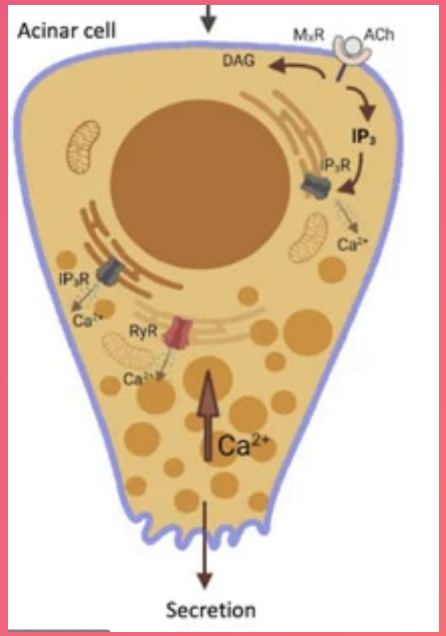
Remember...

Osteoclast (secrete collagenase and hydrogen ions which cause bone to dissolve and break down)





Foveolar cells (secrete mucus in the stomach)



What is similar between these cells and type 2 alveolar cells?

Acinar cells (secrete digestive enzymes in the pancreas)

M

Respiratory Distress Syndrome

- A breathing disorder in newborn (usually premature) babies with underdeveloped lungs.
- **Cause**: Lack of surfactant causes alveoli to thicken and be inflamed, reducing amount of oxygen and making it hard to breathe. Diagnosed by grunting, retractions, apnea, or cyanosis and jaundice of skin. Uses lung imaging tests (X-rays)
- Q!
- Treatment:
  - Nasal continuous positive airway pressure (device to provide breathing support by pushing air to the lungs)
  - Surfactant replacement therapy (via a breathing tube)

R

Cystic Fibrosis

- Epithelial surfaces usually have:
  - cilia that beat upward toward the pharynx (to get swallowed)
  - glands that secrete mucus
    - Dust (in air) sticks to the mucus, which gets swallowed.
  - immune cells to digest germs
- **The mucus secreted by epithelial surfaces is very important.**
- **Cause**: Problem with the CF transmembrane conductance regulator (CFTR) protein (an epithelial chloride channel)
  - Unable to move water/ion across membranes
  - Leads to thick mucus, lung infection
  - Also affects secretory organs in GI tract
    - Can you recall some of them?
- **Treatment**: therapy to improve mucus clearance, antibiotics prevent pneumonia

Movie!

M

Lungs

- Lungs are found in the thorax, completely surrounded by a pleural sac (pleura cells).
- Diaphragm - large, dome-shaped skeletal muscle, separates lungs from abdomen
- The pleura that touches the lungs is called visceral pleura (vs. parietal)
  The pleural sac has intrapleural fluid (lubricates) and pressure (P_{ip})
- **Lungs don't move during breathing**
  - Pleural fluid (adhesive "glue") allows lungs to be *pulled out* when the thoracic wall moves out during inspira
  - Thorac
    (compression of lungs).

How do you think the lung moves in and out during breathing?

Lung Demonstration

M

Ventilation

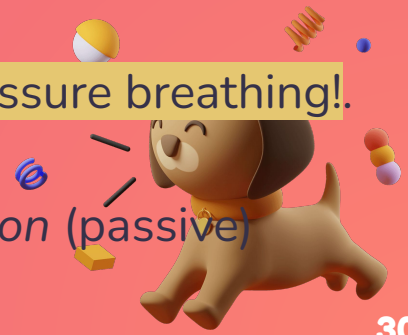
- The exchange of air via **bulk flow** between atmosphere and alveoli, from high to low pressure

$$F = \Delta P/R$$

  - P_{alv}=gas pressure in alveoli
  - P_{atm}=gas pressure at nose/mouth (around body)

$$F = (P_{alv} - P_{atm})/R$$

- When F is **negative**, air **enters** (inspiration) Negative Pressure breathing!. When F is positive, air exits.
- Don't confuse with gas exchange which occurs by *diffusion* (passive)



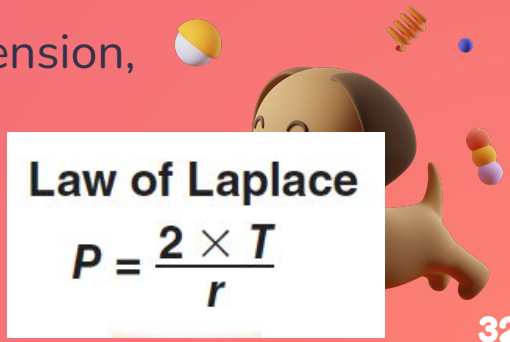
Pressure Differences in Lung

- **Atmospheric pressure** - Air outside body (0 mmHg)
- **Intra-alveolar (intrapulmonary) pressure P_{alv}** - Air inside alveoli
  - More negative than atmosphere during inspiration (-3 mmHg)
- **Intrapleural pressure P_{ip}** - Within pleural cavity
  - More negative during inspiration bc thoracic cavity expands (-6)
  - Fluid in intrapleural space lubricates lungs so that lungs can move *with* the chest during breathing
  - Usually NO air space (unless lungs collapse)
- **Transpulmonary pressure P_{tp} -** Difference across the wall of the lungs, between airway and pleural pressures (P_{alv} - P_{ip}), always positive

R

Physical Properties of Lungs

- Compliance: lungs expand when stretched
  - **100 times more stretchable than a toy balloon!**
  - Change in lung volume per change in transpulmonary pressure ($\Delta V/\Delta P$)
- Elasticity: lungs return to initial size after being stretched
  - Lungs have elastin proteins, and are in a state of TENSION because they are stuck to the chest wall.
  - Tension increases during inspiration (lungs *stretched*).
- Surface tension: lungs resist stretching
  - ST exerted by alveoli fluid (water has surface tension, collapsing alveoli due to the pressure)
  - Law of Laplace - Pressure created is *directly proportional* to surface tension and *inversely proportional* to the alveoli radius.



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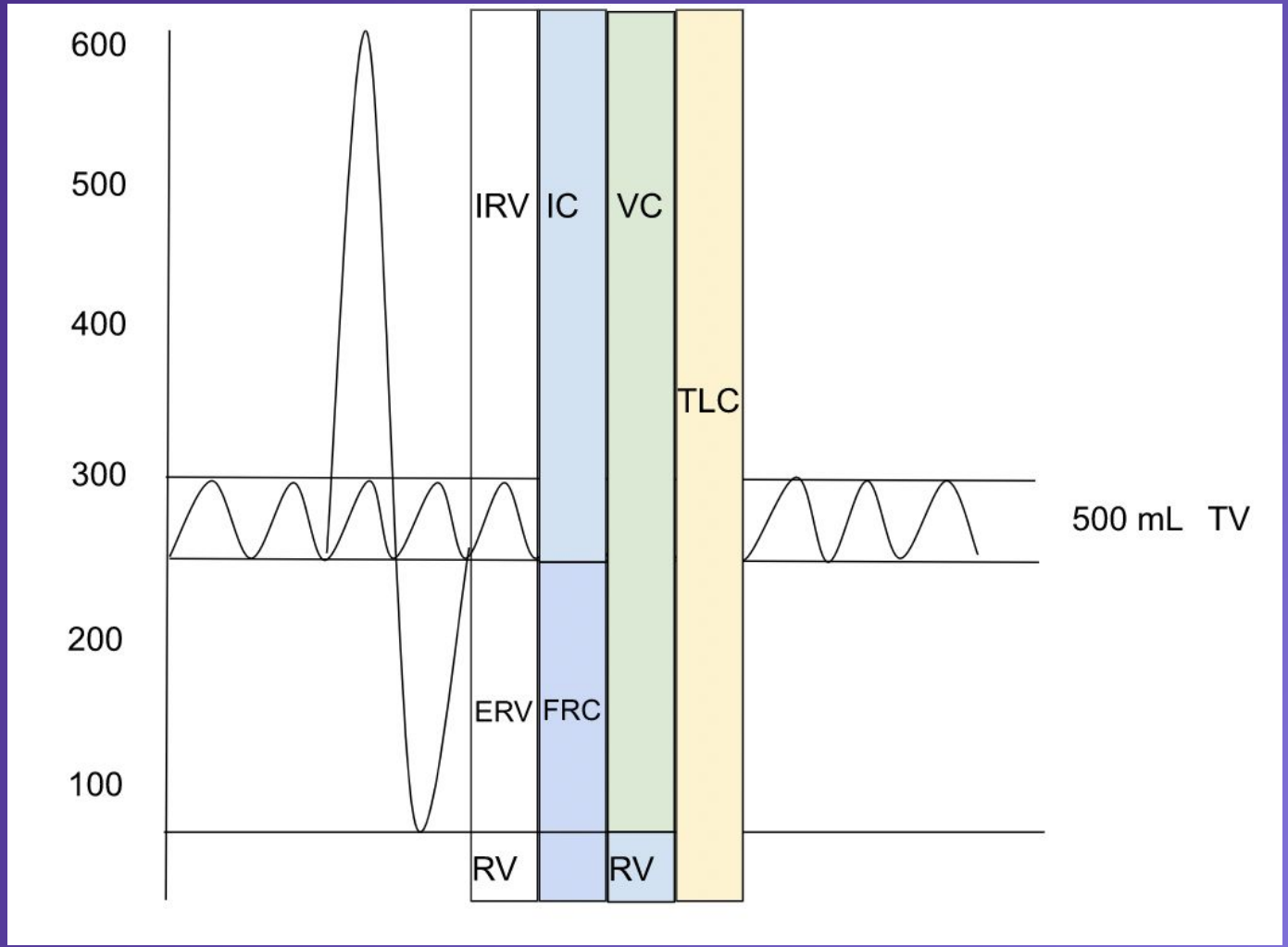
Respiratory Volumes

- Lung Volumes
  - Tidal volume
  - Inspiratory Reserve Volume
  - Expiratory Reserve
  - Residual Volume
- Lung Capacity
  - Inspiratory capacity
  - Total lung capacity
  - Vital capacity
  - Functional residual capacity


600
500
400
300
200
100
IRV
IC
VC
TLC
ERV
FRC
RV
RV
500 mL TV

M

Control of Breathing

- Medulla oblongata, pons - breathing control centers establish RHYTHM of breathing
  - Medulla uses pH of surrounding tissue fluid to gauge blood CO_2
  - If CO_2 is too high...
    - This is detected by sensors in blood vessels.
    - Medulla detects a low pH in cerebrospinal fluid.
    - Medulla tells rib muscles and diaphragm to **increase depth and rate of breathing**.
    - Blood CO_2 levels fall and pH recovers.
  - If O_2 is too low...
    - Aorta and carotid arteries send signals to **increase breathing rate**.
- During deep breathing, negative feedback prevents lungs from over-expanding during inhalation.