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PHYSIOLOGY

ANA 206

QUESTION 1: **DEVELOPMENT OF THE LUNGS**

The **lungs** are the primary [organs](https://en.m.wikipedia.org/wiki/Organ_%28anatomy%29) of the [respiratory system](https://en.m.wikipedia.org/wiki/Respiratory_system) in [humans](https://en.m.wikipedia.org/wiki/Human) and many other animals including a few [fish](https://en.m.wikipedia.org/wiki/Fish) and some [snails](https://en.m.wikipedia.org/wiki/Snail). In [mammals](https://en.m.wikipedia.org/wiki/Mammal) and most other [vertebrates](https://en.m.wikipedia.org/wiki/Vertebrate), two lungs are located near the [backbone](https://en.m.wikipedia.org/wiki/Vertebral_column) on either side of the [heart](https://en.m.wikipedia.org/wiki/Heart). Their function in the respiratory system is to extract [oxygen](https://en.m.wikipedia.org/wiki/Oxygen) from the [atmosphere](https://en.m.wikipedia.org/wiki/Earth%27s_atmosphere) and transfer it into the [bloodstream](https://en.m.wikipedia.org/wiki/Bloodstream), and to release [carbon dioxide](https://en.m.wikipedia.org/wiki/Carbon_dioxide) from the bloodstream into the atmosphere, in a process of [gas exchange](https://en.m.wikipedia.org/wiki/Gas_exchange). [Respiration](https://en.m.wikipedia.org/wiki/Respiration_%28physiology%29) is driven by different [muscular systems](https://en.m.wikipedia.org/wiki/Muscle) in different species. Mammals, [reptiles](https://en.m.wikipedia.org/wiki/Reptile) and [birds](https://en.m.wikipedia.org/wiki/Bird) use their different [muscles](https://en.m.wikipedia.org/wiki/Muscle) to support and foster [breathing](https://en.m.wikipedia.org/wiki/Breathing). In early [tetrapods](https://en.m.wikipedia.org/wiki/Tetrapod), air was driven into the lungs by the [pharyngeal muscles](https://en.m.wikipedia.org/wiki/Pharyngeal_muscles) via [buccal pumping](https://en.m.wikipedia.org/wiki/Buccal_pumping), a mechanism still seen in [amphibians](https://en.m.wikipedia.org/wiki/Amphibian). In humans, the main [muscle of respiration](https://en.m.wikipedia.org/wiki/Muscles_of_respiration) that drives breathing is the [diaphragm](https://en.m.wikipedia.org/wiki/Thoracic_diaphragm). The lungs also provide airflow that makes vocal sounds including human [speech](https://en.m.wikipedia.org/wiki/Speech) possible.

Humans have two lungs, a right lung, and a left lung. They are situated within the [thoracic cavity](https://en.m.wikipedia.org/wiki/Thoracic_cavity) of the [chest](https://en.m.wikipedia.org/wiki/Chest). The right lung is bigger than the left, which shares space in the chest with the [heart](https://en.m.wikipedia.org/wiki/Heart). The lungs together weigh approximately 1.3 kilograms (2.9 lb), and the right is heavier. The lungs are part of the [lower respiratory tract](https://en.m.wikipedia.org/wiki/Lower_respiratory_tract) that begins at the [trachea](https://en.m.wikipedia.org/wiki/Trachea) and branches into the [bronchi](https://en.m.wikipedia.org/wiki/Bronchi) and [bronchioles](https://en.m.wikipedia.org/wiki/Bronchiole), and which receive [air](https://en.m.wikipedia.org/wiki/Air) [breathed in](https://en.m.wikipedia.org/wiki/Inhalation) via the [conducting zone](https://en.m.wikipedia.org/wiki/Respiratory_tract#Structure). The conducting zone ends at the [terminal bronchioles](https://en.m.wikipedia.org/wiki/Bronchiole#Terminal_bronchioles). These divide into the [respiratory bronchioles](https://en.m.wikipedia.org/wiki/Bronchiole#Respiratory_bronchioles) of the [respiratory zone](https://en.m.wikipedia.org/wiki/Respiratory_tract#Structure) which divide into [alveolar ducts](https://en.m.wikipedia.org/wiki/Alveolar_duct) that give rise to the [alveolar sacs](https://en.m.wikipedia.org/wiki/Alveolar_sac) that contain the [alveoli](https://en.m.wikipedia.org/wiki/Pulmonary_alveolus), where gas exchange takes place. Alveoli are also sparsely present on the walls of the respiratory bronchioles and alveolar ducts. Together, the lungs contain approximately 2,400 kilometres (1,500 mi) of airways and 300 to 500 million alveoli. Each lung is enclosed within a [pleural sac](https://en.m.wikipedia.org/wiki/Pleural_sac) that contains pleural fluid, which allows the [inner and outer walls](https://en.m.wikipedia.org/wiki/Pulmonary_pleurae) to slide over each other whilst [breathing](https://en.m.wikipedia.org/wiki/Breathing) takes place, without much friction. This sac also divides each lung into sections called [lobes](https://en.m.wikipedia.org/wiki/Lobe_%28anatomy%29). The right lung has three lobes and the left has two. The lobes are further divided into [bronchopulmonary segments](https://en.m.wikipedia.org/wiki/Bronchopulmonary_segment) and [pulmonary lobules](https://en.m.wikipedia.org/wiki/Lung#Microanatomy). The lungs have a unique blood supply, receiving deoxygenated blood from the heart in the [pulmonary circulation](https://en.m.wikipedia.org/wiki/Pulmonary_circulation) for the purposes of receiving oxygen and releasing carbon dioxide, and a separate supply of oxygenated blood to the tissue of the lungs, in the [bronchial circulation](https://en.m.wikipedia.org/wiki/Bronchial_circulation).

The [tissue of the lungs](https://en.m.wikipedia.org/wiki/Parenchyma#Lung_parenchyma) can be affected by a number of [respiratory diseases](https://en.m.wikipedia.org/wiki/Respiratory_disease), including [pneumonia](https://en.m.wikipedia.org/wiki/Pneumonia) and [lung cancer](https://en.m.wikipedia.org/wiki/Lung_cancer). [Chronic obstructive pulmonary disease](https://en.m.wikipedia.org/wiki/Chronic_obstructive_pulmonary_disease) includes [chronic bronchitis](https://en.m.wikipedia.org/wiki/Bronchitis#Chronic_bronchitis) and [emphysema](https://en.m.wikipedia.org/wiki/Pneumatosis#Lungs), and can be related to [smoking](https://en.m.wikipedia.org/wiki/Smoking) or exposure to [harmful substances](https://en.m.wikipedia.org/wiki/Toxicity). A number of [occupational lung diseases](https://en.m.wikipedia.org/wiki/Occupational_lung_disease) can be caused by substances such as [coal dust](https://en.m.wikipedia.org/wiki/Coal_dust), [asbestos fibres](https://en.m.wikipedia.org/wiki/Asbestos), and [crystalline](https://en.m.wikipedia.org/wiki/Crystal) [silica](https://en.m.wikipedia.org/wiki/Silicon_dioxide) dust. Diseases such as [bronchitis](https://en.m.wikipedia.org/wiki/Bronchitis) can also affect the [respiratory tract](https://en.m.wikipedia.org/wiki/Respiratory_tract). In lung develop as an outpouching of the [foregut](https://en.m.wikipedia.org/wiki/Foregut), a tube which goes on to form the upper part of the [digestive system](https://en.m.wikipedia.org/wiki/Human_digestive_system). When the lungs are formed the [fetus](https://en.m.wikipedia.org/wiki/Fetus) is held in the [fluid-filled](https://en.m.wikipedia.org/wiki/Amniotic_fluid) [amniotic sac](https://en.m.wikipedia.org/wiki/Amniotic_sac) and so they do not function to breathe. Blood is also diverted from the lungs through the [ductus arteriosus](https://en.m.wikipedia.org/wiki/Ductus_arteriosus). [At birth](https://en.m.wikipedia.org/wiki/Adaptation_to_extrauterine_life#Breathing_and_circulation) however, air begins to pass through the lungs, and the diversionary duct closes, so that the lungs can begin to respire. The lungs only fully develop in early childhood.

**DEVELOPMENT OF THE LUNGS**

The development of the human lungs arise from the [laryngotracheal groove](https://en.m.wikipedia.org/wiki/Laryngotracheal_groove) and develop to maturity over several weeks in the foetus and for several years following birth

The [larynx](https://en.m.wikipedia.org/wiki/Larynx), [trachea](https://en.m.wikipedia.org/wiki/Trachea), [bronchi](https://en.m.wikipedia.org/wiki/Bronchus) and lungs that make up the respiratory tract, begin to form during the fourth week of [is](https://en.m.wikipedia.org/wiki/Human_embryogenesis) from the [lung bud](https://en.m.wikipedia.org/wiki/Lung_bud) which appears ventrally to the caudal portion of the [foregut](https://en.m.wikipedia.org/wiki/Foregut).



Lungs during development, showing the early branching of the primitive bronchial buds

The respiratory tract has a branching structure, and is also known as the respiratory tree In the embryo this structure is developed in the process of [branching morphogenesis](https://en.m.wikipedia.org/wiki/Morphogenesis), and is generated by the repeated splitting of the tip of the branch. In the development of the lungs (as in some other organs) the epithelium forms branching tubes. The lung has a left-right symmetry and each bud known as a [bronchial bud](https://en.m.wikipedia.org/wiki/Lung_bud) grows out as a tubular epithelium that becomes a bronchus. Each bronchus branches into bronchioles. The branching is a result of the tip of each tube bifurcation. The branching process forms the bronchi, bronchioles, and ultimately the alveoli The four genes mostly associated with branching morphogenesis in the lung are the [intercellular signalling protein](https://en.m.wikipedia.org/wiki/Hedgehog_signaling_pathway) – [sonic hedgehog](https://en.m.wikipedia.org/wiki/Sonic_hedgehog) (SHH), [fibroblast growth factors](https://en.m.wikipedia.org/wiki/Fibroblast_growth_factor) [FGF10](https://en.m.wikipedia.org/wiki/FGF10) and FGFR2b, and [bone morphogenetic protein](https://en.m.wikipedia.org/wiki/Bone_morphogenetic_protein) [BMP4](https://en.m.wikipedia.org/wiki/Bone_morphogenetic_protein_4). FGF10 is seen to have the most prominent role. FGF10 is a [paracrine signalling](https://en.m.wikipedia.org/wiki/Paracrine_signalling) molecule needed for epithelial branching, and SHH inhibits FGF10. The development of the alveoli is influenced by a different mechanism whereby continued bifurcation is stopped and the distal tips become dilated to form the alveoli.

At the end of the fourth week the lung bud divides into two, the right and left [primary bronchial buds](https://en.m.wikipedia.org/wiki/Lung_bud) on each side of the trachea. During the fifth week the right bud branches into three secondary bronchial buds and the left branches into two secondary bronchial buds. These give rise to the lobes of the lungs, three on the right and two on the left. Over the following week, the secondary buds branch into tertiary buds, about ten on each side. From the sixth week to the sixteenth week, the major elements of the lungs appear except the [alveoli](https://en.m.wikipedia.org/wiki/Pulmonary_alveolus). From week 16 to week 26, the bronchi enlarge and lung tissue becomes highly vascularised. Bronchioles and alveolar ducts also develop. By week 26 the terminal bronchioles have formed which branch into two respiratory bronchioles. During the period covering the 26th week until birth the important [blood–air barrier](https://en.m.wikipedia.org/wiki/Blood%E2%80%93air_barrier) is established. Specialised [type I alveolar cells](https://en.m.wikipedia.org/wiki/Alveolar_cells) where [gas exchange](https://en.m.wikipedia.org/wiki/Gas_exchange) will take place, together with the [type II alveolar cells](https://en.m.wikipedia.org/wiki/Alveolar_cells) that secrete [pulmonary surfactant](https://en.m.wikipedia.org/wiki/Pulmonary_surfactant), appear. The surfactant reduces the [surface tension](https://en.m.wikipedia.org/wiki/Surface_tension) at the air-alveolar surface which allows expansion of the alveolar sacs. The alveolar sacs contain the primitive alveoli that form at the end of the alveolar ducts, and their appearance around the seventh month marks the point at which limited respiration would be possible, and the premature baby could survive

#### **Vitamin A deficiency**

The developing lung is particularly vulnerable to changes in the levels of [vitamin A](https://en.m.wikipedia.org/wiki/Vitamin_A). [Vitamin A deficiency](https://en.m.wikipedia.org/wiki/Vitamin_A_deficiency) has been linked to changes in the epithelial lining of the lung and in the lung parenchyma. This can disrupt the normal physiology of the lung and predispose to respiratory diseases. Severe nutritional deficiency in vitamin A results in a reduction in the formation of the alveolar walls (septa) and to notable changes in the respiratory epithelium; alterations are noted in the extracellular matrix and in the protein content of the basement membrane. The extracellular matrix maintains lung elasticity; the basement membrane is associated with alveolar epithelium and is important in the blood-air barrier. The deficiency is associated with functional defects and disease states. Vitamin A is crucial in the development of the alveoli which continues for several years after birth.

### **After birth**

At [birth](https://en.m.wikipedia.org/wiki/Childbirth), the baby's lungs are filled with fluid secreted by the lungs and are not inflated. [After birth](https://en.m.wikipedia.org/wiki/Adaptation_to_extrauterine_life#Breathing_and_circulation) the infant's [central nervous system](https://en.m.wikipedia.org/wiki/Central_nervous_system) reacts to the sudden change in temperature and environment. This triggers the first breath, within about 10 seconds after delivery Before birth, the lungs are filled with foetal lung fluid.  After the first breath, the fluid is quickly absorbed into the body or exhaled. The [resistance](https://en.m.wikipedia.org/wiki/Vascular_resistance) in the lung's blood vessels decreases giving an increased surface area for gas exchange, and the lungs begin to breathe spontaneously. This accompanies [other changes](https://en.m.wikipedia.org/wiki/Adaptation_to_extrauterine_life) which result in an increased amount of blood entering the lung tissues

At birth the lungs are very undeveloped with only around one sixth of the alveoli of the adult lung present The alveoli continue to form into early adulthood, and their ability to form when necessary is seen in the regeneration of the lung. Alveolar septa have a double [capillary network](https://en.m.wikipedia.org/wiki/Capillary#Structure) instead of the single network of the developed lung. Only after the maturation of the capillary network can the lung enter a normal phase of growth. Following the early growth in numbers of alveoli there is another stage of the alveoli being enlarged

QUESTION 2: **ROTATION OF THE STOMACH AND FORMATION OF OMENTAL BURSA**

The **stomach** is located between the esophagus and the small intestine. ... The longitudinal **rotation of the stomach** involves a 90° clockwise **rotation** resulting in the right side of the **stomach** becoming posteriorly oriented and the left side of the **stomach** facing anteriorly.

**FORMATION OF THE OMENTAL BURSA**

The **omental bursa** or **lesser sac** is a hollow space that is formed by the [greater and lesser omentum](https://www.kenhub.com/en/library/anatomy/greater-and-lesser-omentum) and its adjacent organs. It communicates with the greater sac via the epiploic foramen of winslow, which is known as the general cavity of the [abdomen](https://www.kenhub.com/en/library/anatomy/abdomen-and-pelvis) that sits within the [peritoneum](https://www.kenhub.com/en/library/anatomy/the-peritoneum), but outside the lesser sac.

This space has well-defined borders which are represented by certain organs or their parts, so they are quite easy to spot and form a mental image of the omental bursa. In addition, like anything in anatomy, the omental bursa doesn't just exist as a standalone and isolated entity, but rather it communicates with several other spaces and recesses found throughout the body

**BORDERS**

The borders of the omental bursa are demarcated as follows:

* **anteriorly** by the [quadrate lobe of the liver](https://www.kenhub.com/en/library/anatomy/functional-division-of-the-liver), the gastrocolic ligament and the lesser omentum
* to the **left** it is limited by the left [kidney](https://www.kenhub.com/en/library/anatomy/kidneys) and the left [adrenal gland](https://www.kenhub.com/en/library/anatomy/adrenal-glands)
* **posteriorly** it is walled off by the [pancreas](https://www.kenhub.com/en/library/anatomy/the-pancreas)
* to the **right**, the epiploic foramen and lesser omentum can be found and the greater sac beyond that.

The cavity itself is almost completely closed, save its communication with the greater sac and the entrance through the omental foramen and is filled with a capillary film. The greater part of the omental bursa consists of its **superior recess** which extends cranially between the [esophagus](https://www.kenhub.com/en/library/anatomy/esophagus) and the [inferior vena cava](https://www.kenhub.com/en/library/anatomy/inferior-vena-cava)

The **splenic recess** extends to the left between the splenic ligaments and the [stomach](https://www.kenhub.com/en/library/anatomy/the-stomach). Finally, the **inferior recess** of the omental bursa extends caudally between the stomach and the [transverse colon](https://www.kenhub.com/en/library/anatomy/the-colon). Other anatomical landmarks of note include a varied number of small peritoneal folds, recesses and fossae which seem to accumulate mostly around the [cecum](https://www.kenhub.com/en/library/anatomy/cecum-and-vermiform-appendix) and the [duodenum](https://www.kenhub.com/en/library/anatomy/the-duodenum).

Due to the growth of the organs, they gradually become larger and have to shift in order to fit into the abdominal cavity. The stomach rotates 90 degrees, the [spleen](https://www.kenhub.com/en/library/anatomy/the-spleen) is displaced to the left and the liver moves to the right. The peritoneum twists with these movements which lead to the formation of the falciform ligament, the lesser omentum and the [coronary ligaments of the liver](https://www.kenhub.com/en/library/anatomy/ligaments-of-the-gastrointestinal-tract) . Throughout this entire process, the cavity of the lesser sac is created.

QUESTION 3: **DEVELOPMENT OF THE ESOPHAGUS**

The **esophagus**, informally known as the **food pipe** or **gullet**, is an [organ](https://en.m.wikipedia.org/wiki/Organ_%28anatomy%29) in [vertebrates](https://en.m.wikipedia.org/wiki/Vertebrate) through which [food](https://en.m.wikipedia.org/wiki/Food) passes, aided by [peristaltic contractions](https://en.m.wikipedia.org/wiki/Peristalsis), from the [pharynx](https://en.m.wikipedia.org/wiki/Human_pharynx) to the [stomach](https://en.m.wikipedia.org/wiki/Stomach). The esophagus is a [fibromuscular](https://en.wiktionary.org/wiki/fibromuscular) tube, about 25 centimetres long in adults, which travels behind the [trachea](https://en.m.wikipedia.org/wiki/Trachea) and [heart](https://en.m.wikipedia.org/wiki/Human_heart), passes through the [diaphragm](https://en.m.wikipedia.org/wiki/Thoracic_diaphragm) and empties into the uppermost region of the [stomach](https://en.m.wikipedia.org/wiki/Stomach). During swallowing, the [epiglottis](https://en.m.wikipedia.org/wiki/Epiglottis) tilts backwards to prevent food from going down the [larynx](https://en.m.wikipedia.org/wiki/Larynx) and lungs.

The wall of the esophagus from the [lumen](https://en.m.wikipedia.org/wiki/Lumen_%28anatomy%29) outwards consists of [mucosa](https://en.m.wikipedia.org/wiki/Mucosa), [submucosa](https://en.m.wikipedia.org/wiki/Submucosa) (connective tissue), [layers of muscle fibers](https://en.m.wikipedia.org/wiki/Muscular_layer) between layers of [fibrous tissue](https://en.m.wikipedia.org/wiki/Fibrous_tissue), and an outer layer of connective tissue. The mucosa is a [stratified squamous epithelium](https://en.m.wikipedia.org/wiki/Stratified_squamous_epithelium) of around three layers of squamous cells, which contrasts to the [single layer of columnar cells](https://en.m.wikipedia.org/wiki/Simple_columnar_epithelia) of the stomach. The transition between these two types of epithelium is visible as a zig-zag line. Most of the muscle is [smooth muscle](https://en.m.wikipedia.org/wiki/Smooth_muscle) although [striated muscle](https://en.m.wikipedia.org/wiki/Striated_muscle) predominates in its upper third. It has two muscular rings or [sphincters](https://en.m.wikipedia.org/wiki/Sphincter) in its wall, one at the top and one at the bottom. The lower sphincter helps to prevent reflux of acidic stomach content. The esophagus has a rich blood supply and venous drainage. Its smooth muscle is innervated by involuntary nerves ([sympathetic nerves](https://en.m.wikipedia.org/wiki/Sympathetic_nerve) via the [sympathetic trunk](https://en.m.wikipedia.org/wiki/Sympathetic_trunk) and [parasympathetic nerves](https://en.m.wikipedia.org/wiki/Parasympathetic_nerve) via the [vagus nerve](https://en.m.wikipedia.org/wiki/Vagus_nerve)) and in addition voluntary nerves ([lower motor neurons](https://en.m.wikipedia.org/wiki/Lower_motor_neurons)) which are carried in the vagus nerve to innervate its striated muscle.

The esophagus may be affected by [gastric reflux](https://en.m.wikipedia.org/wiki/GERD), [cancer](https://en.m.wikipedia.org/wiki/Oesophageal_cancer), prominent dilated blood vessels called [varices](https://en.m.wikipedia.org/wiki/Oesophageal_varices) that can bleed heavily, [tears](https://en.m.wikipedia.org/wiki/Mallory-Weiss_Syndrome), constrictions, and disorders of motility. Diseases may cause difficulty swallowing ([dysphagia](https://en.m.wikipedia.org/wiki/Dysphagia)), painful swallowing ([odynophagia](https://en.m.wikipedia.org/wiki/Odynophagia)), [chest pain](https://en.m.wikipedia.org/wiki/Chest_pain), or cause no symptoms at all. Clinical investigations include [X-rays](https://en.m.wikipedia.org/wiki/Upper_gastrointestinal_series) when swallowing [barium](https://en.m.wikipedia.org/wiki/Barium_sulphate), [endoscopy](https://en.m.wikipedia.org/wiki/Endoscopy), and [CT scans](https://en.m.wikipedia.org/wiki/CT_scan). Surgically, the esophagus is difficult to access

**DEVELOPMENT**

In early [embryogenesis](https://en.m.wikipedia.org/wiki/Human_embryogenesis), the esophagus develops from the [endodermal](https://en.m.wikipedia.org/wiki/Endoderm) [primitive gut tube](https://en.m.wikipedia.org/wiki/Gastrointestinal_tract). The ventral part of the embryo abuts the [yolk sac](https://en.m.wikipedia.org/wiki/Yolk_sac). During the second week of embryological development, as the embryo grows, it begins to surround parts of the sac. The enveloped portions form the basis for the adult gastrointestinal tract. The sac is surrounded by a network of [vitelline arteries](https://en.m.wikipedia.org/wiki/Vitelline_arteries). Over time, these arteries consolidate into the three main arteries that supply the developing gastrointestinal tract: the [celiac artery](https://en.m.wikipedia.org/wiki/Celiac_artery), [superior mesenteric artery](https://en.m.wikipedia.org/wiki/Superior_mesenteric_artery), and [inferior mesenteric artery](https://en.m.wikipedia.org/wiki/Inferior_mesenteric_artery). The areas supplied by these arteries are used to define the [midgut](https://en.m.wikipedia.org/wiki/Midgut), [hindgut](https://en.m.wikipedia.org/wiki/Hindgut) and [foregut](https://en.m.wikipedia.org/wiki/Foregut).

The surrounded sac becomes the primitive gut. Sections of this gut begin to differentiate into the organs of the gastrointestinal tract, such as the esophagus, [stomach](https://en.m.wikipedia.org/wiki/Stomach), and [intestines](https://en.m.wikipedia.org/wiki/Intestine). The esophagus develops as part of the foregut tube. The innervation of the esophagus develops from the [pharyngeal arches](https://en.m.wikipedia.org/wiki/Pharyngeal_arch).