

# Development of Endodermal Organs

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## DEVELOPMENT OF THE DIGESTIVE SYSTEM

- Primitive Gut Tube
- Proctodeum and Stomodeum
- Stomach
- Duodenum
- Pancreas
- Liver and Biliary Apparatus
- Spleen
- Midgut

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## Primitive Gut Tube

- The **primitive gut tube** is derived from the dorsal part of the **yolk sac**, which is incorporated into the body of the embryo during folding of the embryo during the fourth week.
- The primitive gut tube is divided into three sections.
- The **epithelium** of and the **parenchyma of glands** associated with the digestive tract (e.g., liver and pancreas) are derived from **endoderm**.
- The **muscular walls** of the digestive tract (lamina propria, muscularis mucosae, submucosa, muscularis externa, adventitia and/or serosa) are derived from **splanchnic mesoderm**.
- During the **solid stage** of development the endoderm of the gut tube proliferates until the gut is a solid tube.
- A process of **recanalization** restores the lumen.

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## Proctodeum and Stomodeum

- The proctodeum (anal pit) is the **primordial anus**, and the stomodeum is the **primordial mouth**.
- In both of these areas ectoderm is in direct contact with endoderm without intervening mesoderm, eventually leading to degeneration of both tissue layers. **Foregut, Esophagus.**
- The **tracheoesophageal septum** divides the foregut into the esophagus and trachea. information.

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## Stomach

- The primordium of the **primitive stomach** is visible about the end of the fourth week.
- It is initially oriented in the median plane and suspended from the dorsal wall of the abdominal cavity by the **dorsal mesentery** or **mesogastrium**.
- During development the stomach rotates 90 degrees in a clockwise direction along its longitudinal axis, placing the **left vagus nerve** along its anterior side and the **right vagus nerve** along its posterior side.
- Rotation of the stomach creates the **omental bursa** or **lesser peritoneal sac**.

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## Duodenum

- The duodenum acquires its C-shaped loop as the stomach rotates.
- Because of its location at the junction of the foregut and the midgut, branches of both the **celiac trunk** and the **superior mesenteric artery** supply the duodenum.

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## Pancreas

- The pancreas develops from two outgrowths of the endodermal epithelium, the **dorsal pancreatic bud** and the **ventral pancreatic bud**.
- During rotation of the gut these primordial come together to form a single pancreas.
- The ventral pancreatic bud forms the uncinete process and part of the head, while the dorsal pancreatic bud forms the remainder of the head, body, and tail of the pancreas.
- The ducts of the pancreatic buds join together to form the **main pancreatic duct**, but the proximal part of the duct of the dorsal pancreatic bud may persist as an **accessory pancreatic duct**.

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Pancreas

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## Liver and Biliary Apparatus

- The liver develops from endodermal cells that form the **hepatic diverticulum**.
- The liver grows in close association with the **septum transversum**, which later forms part of the diaphragm.
- As it grows the hepatic diverticulum divides into a **cranial part**, which forms the **parenchyma** of the liver, and the **caudal part**, which gives rise to the **gallbladder** and **cystic duct**.
- The **hemopoietic cells, Kupffer cells, and connective tissue** of the liver are derived from **mesenchyme** in the septum transversum.
- The embryonic liver is large and fills much of the abdominal cavity during the seventh through ninth weeks of development.
- Blood formation (hemopoiesis) begins in the liver during the sixth week of development, and bile formation begins in the twelfth week.

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Liver and Biliary Apparatus

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## Spleen

- The spleen develops from mesenchymal cells located between layers of the dorsal mesogastrum.

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Spleen

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## Midgut

- The midgut communicates with the yolk sac via the **yolk stalk**.
- As the midgut forms, it elongates into a U-shaped loop (**midgut loop**) that temporarily projects into the umbilical cord (**physiological umbilical herniation**).
- The cranial limb of the midgut elongates rapidly during development and forms the **jejunum** and **cranial portion of the ileum**.
- The caudal limb forms the **cecum, appendix,**

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Midgut

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## RESPIRATORY SYSTEM

- Lower Respiratory System**
- Larynx**
- Trachea**
- Bronchi**

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RESPIRATORY SYSTEM

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## Lower Respiratory System

- The primordium of the lower respiratory system develops in about the fourth week.
- The **laryngotracheal diverticulum** arises from endoderm on the ventral wall of the foregut.
- Tracheoesophageal folds** develop on either side and join to form a **tracheoesophageal septum** that separates it from the rest of the foregut.
- This divides the foregut into the **laryngotracheal tube** (ventral) and the **esophagus** (dorsal).
- The caudal end of the laryngotracheal diverticulum enlarges to form the **lung bud**, which is surrounded by **splanchnic mesenchyme**.

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Lower Respiratory System

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## Larynx

- The opening of the laryngotracheal tube becomes the **inlet of the larynx**.
- **The laryngeal cartilages** are derived from the **fourth and sixth pharyngeal arches**.

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Larynx

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## Trachea

- The **epithelium and glands** of the trachea develop from **the endoderm of the laryngotracheal tube**.
- The **cartilage, connective tissue, and smooth muscle** are derived from the surrounding **splanchnic mesenchyme**.

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Trachea

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## Bronchi

- At the end of the fourth week the lung bud divides into two **bronchial buds**, which enlarge to form the **primary bronchi**.
- The **right bronchus** is **larger** and **more vertically oriented** than the left one, and this relationship persists throughout life.
- In the fifth week, each bronchial bud divides into **secondary bronchi**.
- In the eighth week the secondary bronchi divide to form the **segmental bronchi** (tertiary bronchi), ten in the right lung and eight in the left.
- Each segmental bronchus becomes a bronchopulmonary segment (segment in a lung).
- The **smooth muscle, connective tissue, and cartilaginous plates** in the bronchi are derived from **splanchnic mesenchyme**.

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Bronchi

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## BODY CAVITIES

- **Intraembryonic Coelom**
- **Diaphragm**

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BODY CAVITIES

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## Intraembryonic Coelom

- The **primitive intraembryonic coelom** forms in the **lateral and cardiogenic mesoderm** about the fourth week of development.
- The embryo undergoes two foldings and this cavity is eventually divided into the **pericardial, pleural, and peritoneal** embryonic body cavities.
- During the fourth week the **septum transversum** grows to separate the pericardial cavity from the pleural cavities.
- During the sixth week the **pleuroperitoneal membranes** grow to separate the pleural cavities from the peritoneal cavity.
- During the seventh week the **pleuropericardial membranes** separate the pericardial cavity from the pleural cavities. In the adult the pleuropericardial membranes form the **fibrous pericardium of the heart**.

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Intraembryonic Coelom

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## Diaphragm

- The diaphragm separates the thoracic and abdominal cavities. It arises from tissue from four sources:
  - The **septum transversum**, which forms the **central tendon of the diaphragm**.
  - The **pleuroperitoneal membranes**, which contribute only a small amount to the adult diaphragm
  - The **dorsal mesentery of the esophagus**, which forms the **crura** and median portion of the diaphragm
  - The **body wall**, which forms the periphery of the diaphragm
- The diaphragm develops initially at the level of **cervical somites 3-5** and it "descends" to the level of **L1** as the embryo grows.
- As it moves it takes along its innervation, which explains why the **phrenic nerve** arises from **cervical roots three, four, and five** ("C3-4-5 keeps a man alive.")

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Diaphragm

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## SENSE ORGANS-EYE

- About the fourth week, **optic sulci** (optic grooves) develop in the **diencephalon**.
- The optic sulci evaginate to form **optic vesicles**.
- The optic vesicles enlarge and form **hollow optic stalks**.
- The optic vesicles **induce the surface ectoderm** of the head to form **lens placodes**.
- The optic vesicles then invaginate to form double-walled optic cups, and the ventral surfaces of the optic stalks invaginate to form **optic fissures**.
- Mesenchyme within each optic cup forms the **hyaloid artery and hyaloid vein**.
- In the meantime, the lens placodes have sunk in to form **lens pits**.
- The pits detach from the surface ectoderm to form **lens vesicles**.
- The retina is derived from the walls of the optic cups.
- The proximal parts of the hyaloid vessels form the **central artery and vein of the retina**.
- The distal parts of the hyaloid vessels **disappear before birth**.

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# Growth and Differentiation

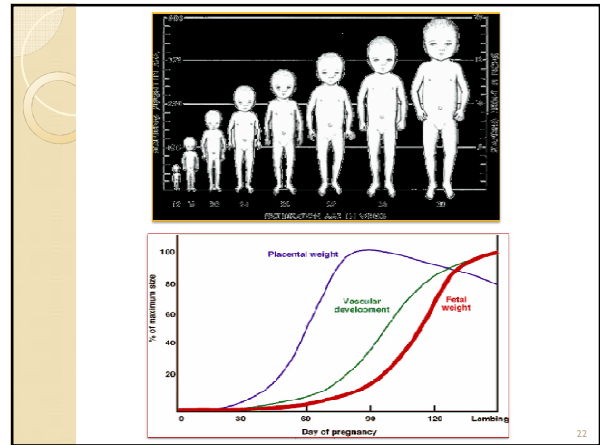
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## Growth

- Growth is the enlargement of a tissue or organism.
- Growth continues after the embryonal stage, and occurs through cell **proliferation**, enlargement of cells or accumulation of extracellular material.
- In plants, growth results in an adult organism that is strikingly different from the embryo.
- The proliferating cells tend to be distinct from differentiated cells (**stem cell and progenitor cell**).
- In some tissues proliferating cells are restricted to specialised areas, such as the **growth plates of bones**.
- But some stem cells **migrate** to where they are needed, such as **mesenchymal stem cells** which can migrate from the **bone marrow** to form e.g. muscle, bone or adipose tissue.
- The size of an organ frequently determines its growth, as in the case of the **liver** which grows back to its previous size if a part is removed.
- Growth factors**, such as **fibroblast growth factors** in the animal embryo and **growth hormone** in juvenile mammals, also control the extent of growth.

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## Metamorphosis

- Most animals have a **larval** stage, with a body plan different from that of the adult organism.
- The larva abruptly develops into an adult in a process called **metamorphosis**.
- For example, **caterpillars** (butterfly larvae) are specialized for feeding whereas adult butterflies (**imagos**) are specialised for flight and reproduction.
- When the caterpillar has grown enough, it turns into an immobile **pupa**.
- Here, the imago develops from **imaginal discs** found inside the larva.

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### Butterfly

### Frog

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## Regeneration

- **Regeneration** is the reactivation of development so that a missing body part grows back.
- This phenomenon has been studied particularly in **salamanders**, where the adults can reconstruct a whole limb after it has been amputated.
- Researchers hope to one day be able to induce regeneration in humans (**regenerative medicine**).
- There is little spontaneous regeneration in adult humans, although the **liver** is a notable exception. Like for salamanders, the regeneration of the liver involves **dedifferentiation** of some cells to a more embryonal state.

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Regeneration

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