Embryology

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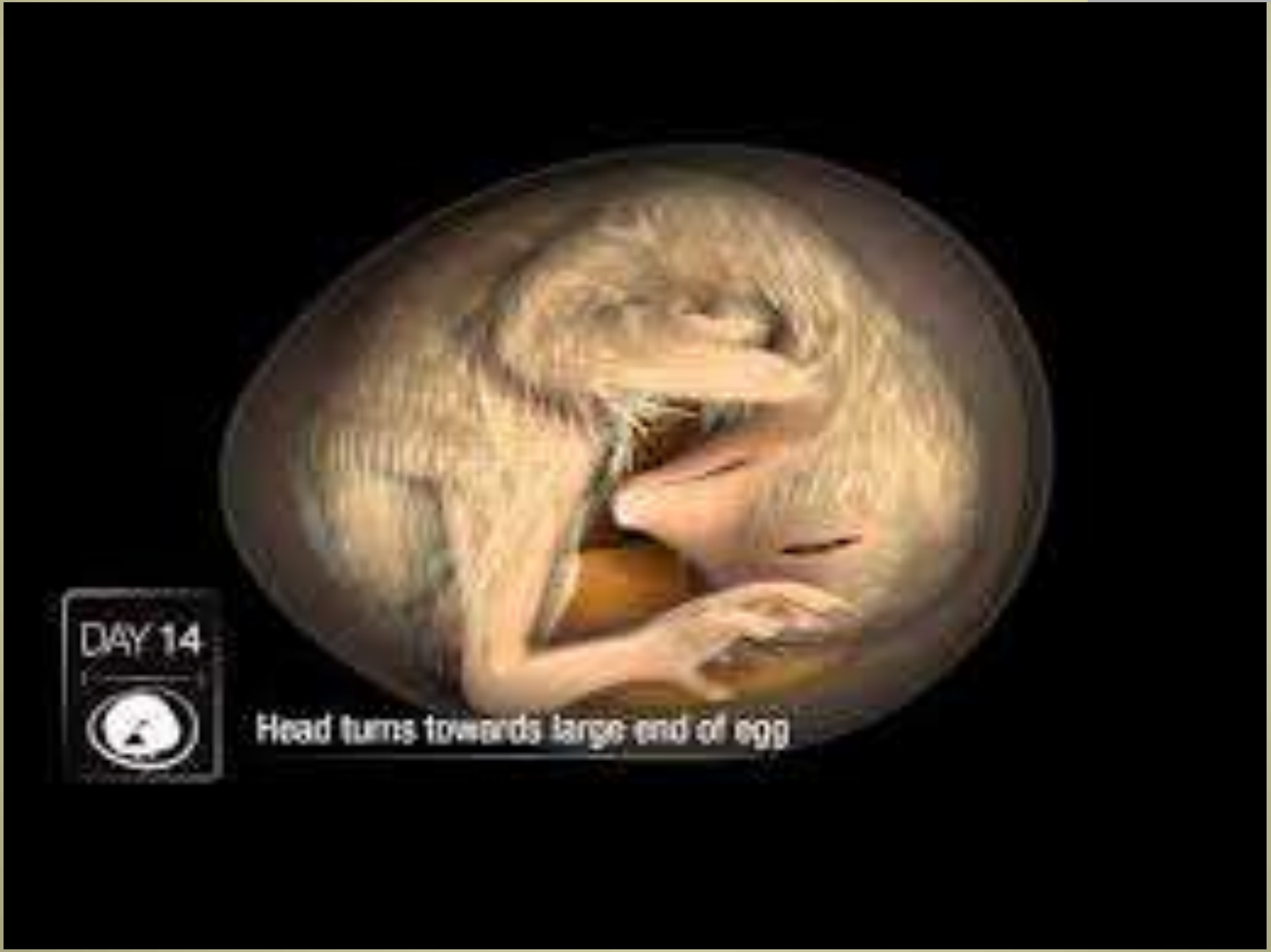


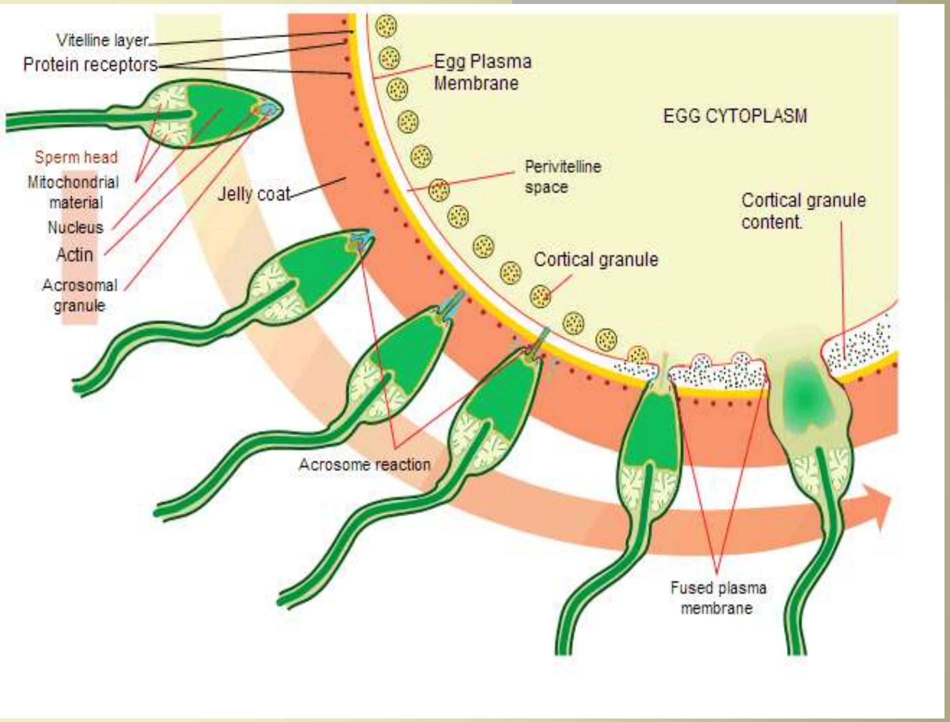
The union of a haploid oocyte with a haploid spermatozoon to produce a diploid zygote a single cell capable of developing into a new individual

Fertilization begins with gametes fusion (zygote formation). The fusion of a spermatozoon with a secondary oocyte takes place in the uterine tube in the ampullary region near the ovary:

— to begin, a spermatozoon binds to a specific glycoprotein on the zona pellucida that surrounds the oocyte

— the spermatozoon releases degradative enzymes (acrosomal reaction) that allows the sperm cell to penetrate the zona pellucida;

— spermatozoon and oocyte plasma membranes fuse (the secondary oocyte completes meiosis II);



- *- the oocyte precludes fusion with other sperm by immediately canceling its membrane potential (via Ca++ influx) and then by denaturing its zona pellucid (via enzymes released by exocytosis from oocyte cytoplasmic granules);*

- *male & female haploid pronuclei make contact, lose their nuclear membranes, and begin*
- *mitosis (mitosis begins 12 hours after sperm fusion; DNA synthesis takes place before mitosis)*
- *Fertilization ends with the initiation of zygote cell division (the start of cleavage)*

Fertilization

- *Fertilization is divided into internal and external, the external fertilization occur in the marine invertebrates and most fish and amphibian.*
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- *Internal fertilization is the more efficient mechanism, the characteristic of mammals during coitus, the male deposits the spermatozoa directly in the female genital tract.*

Cleavage:

Its series of mitotic divisions by which the large zygote is fractionated into numerous "normal size" cells.

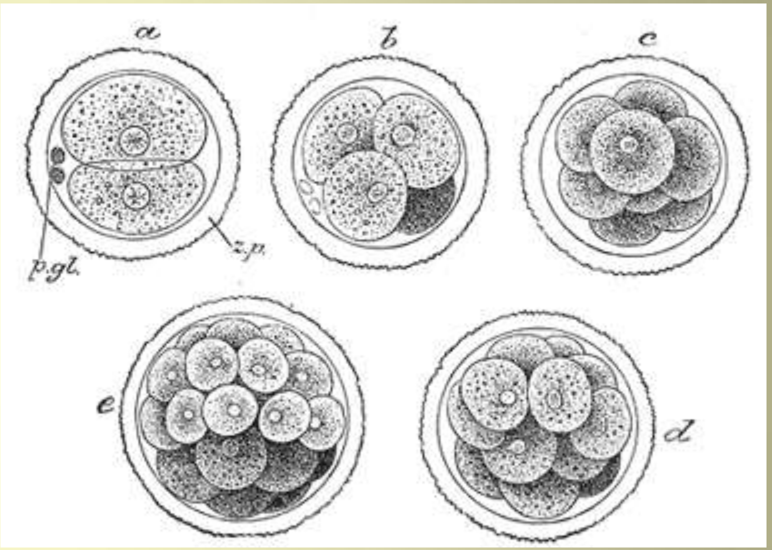
Each daughter cell of the cleavage process is termed a blastomere.

— cleavage begins with a zygote, progresses through compaction to a morula stage and terminates at the start of the blastocyst (blastula) stage

— the first eight blastomeres are undifferentiated and have identical potential in domestic mammals; thereafter, blastomeres differentiate into inner & outer cells with different mission.

***Note:** The first cleavage division occurs at 1 to 5 days following ovulation (depending on species), thereafter cells divide about once every 12 hours;*

As many as eight generations of mitoses may occur without intervening cell growth (cytoplasmic increase).



Zygote

The zygote has dual origin from two gametes- a spermatozoon from the male parent and an ovum from the female parent.

Morula:

*A **morula** is a solid ball of blastomeres, within a zona pellucida. A morula typically consists of 16 to 64 blastomeres = four to six cell divisions. Blastomeres become compacted; cells packed on the inside differentiate from those along the surface of the morula:*

Blastula

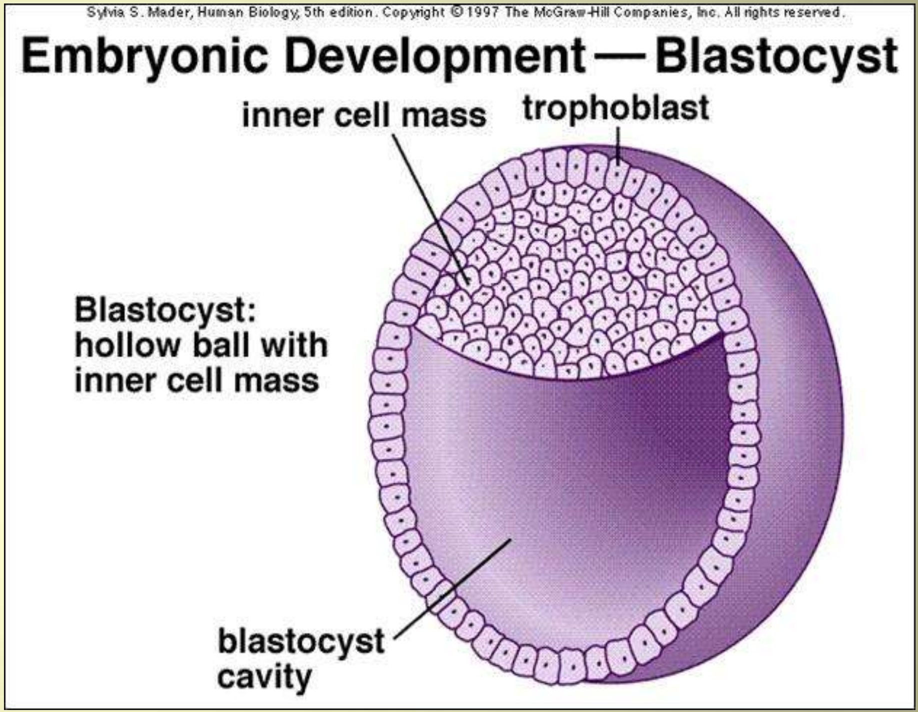
— *outer blastomeres become flattened and form tight junctions (resulting in reduced permeability to fluids); they develop the capacity to secrete fluid (internally); they are destined to become trophoblasts which form the chorion & amnion (fetal membranes);*

— *inner blastomeres form gap junctions to maximize intercellular communication; they are destined to become inner cell mass which forms the embryo (plus two fetal membranes).*

Note: • *As few as three inner blastomeres are sufficient to produce an entire embryo (and adult).*

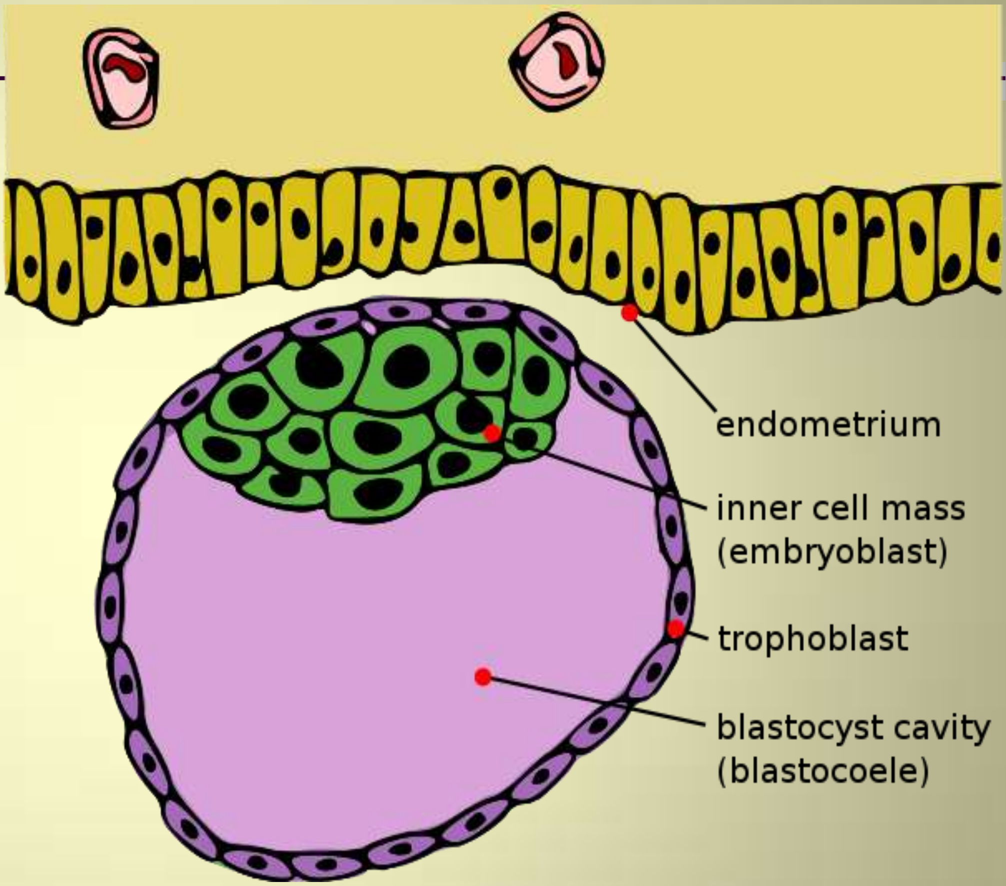
• *When a morula leaves the uterine tube and enters the uterus (uterine horn) it is at about the 16-cell stage, around 4 to 7 days after fertilization (depending on species).*

• *The 32-cell stage morula (5-7 days post ovulation) is ideal for embryo transfer in cattle.*



Implantation

*A **blastocyst** (or blastula) develops during week two following rupture of the zona pellucida. It consists of a large number of blastomeres arranged to form a hollow (fluid filled) sphere/cylinder ,containing an **inner cell mass** (embryoblast), a collection of cells localized inside one pole (end) of the blastula. The surface cells of the blastocyst are designated **trophoblasts**, and the fluid cavity is called a **blastocoele.** Eventually the blastocyst attaches to the uterine wall (implantation).*

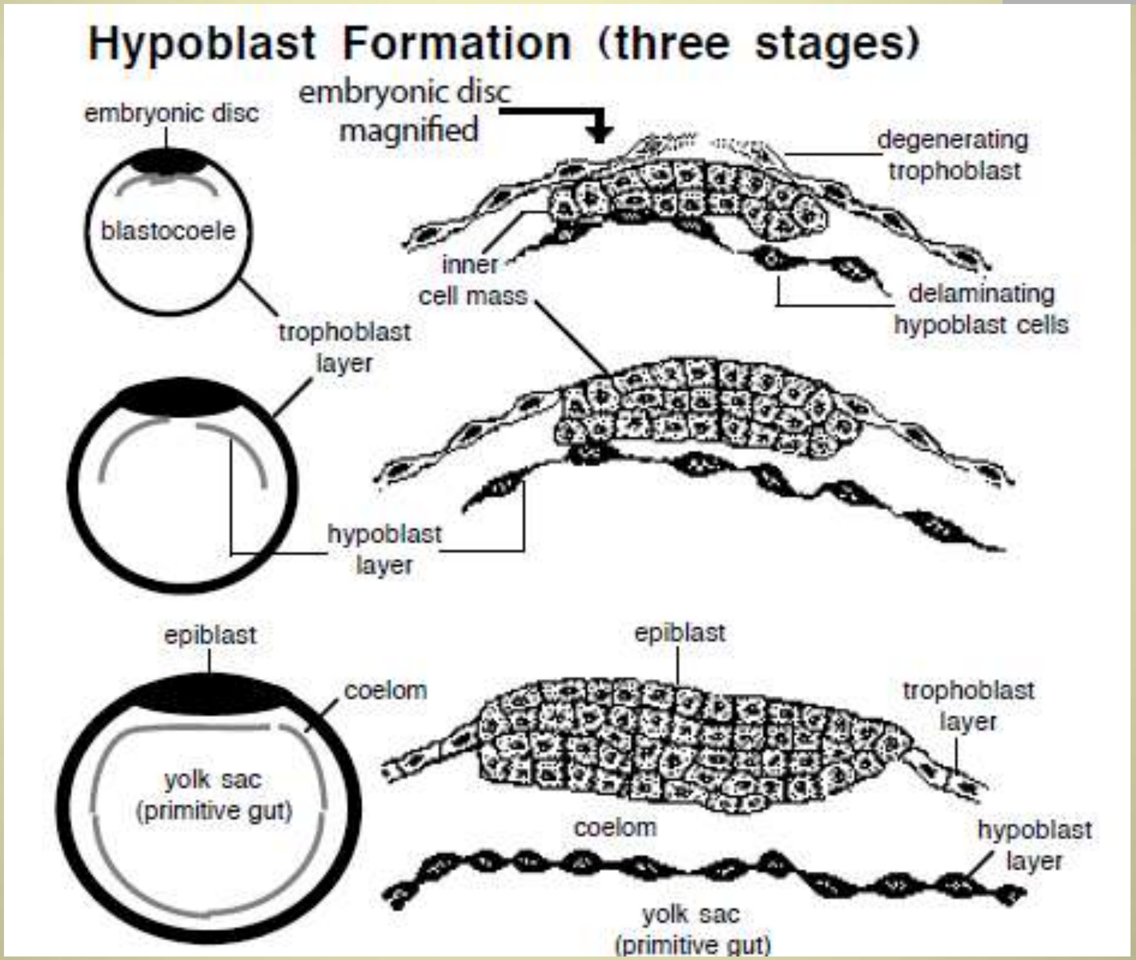


Gastrulation and formation of trilaminar embryonic disc:

- *Germ layers are formed during gastrulation:*
- *Ectoderm, mesoderm and endoderm are designated primary germ layers because origins of all organs can be traced back to these three layers.*
- ***Ectoderm** forms epidermis of the skin, epithelium of the oral and nasal cavities, and the nervous system and sense organs.*
- ***Mesoderm** forms muscle and connective tissue, including bone, and components of the circulatory, urinary and genital systems.*
- ***Endoderm** forms mucosal epithelium and glands of respiratory and digestive systems.*

Gastrulation:

- *is the morphogenic process that gives rise to three germ layers: **ectoderm**, **mesoderm**, and **endoderm**. Gastrulation includes the following sequence, beginning with a blastocyst:*
- *— A thickened embryonic disc becomes evident at the blastocyst surface, due to cell proliferation of the inner cell mass. Trophoblast cells overlaying the inner cell mass degenerate in domestic mammals (in some mammals, e.g., mouse and human, trophoblast cells overlaying the inner cell mass separate and, instead of degenerating, become amnionic wall.)*
- *— From the inner cell mass, cells proliferate, break loose (delaminate), and migrate to form a new cell layer inside the trophoblast layer. The new layer of cells is called the hypoblast; it forms a yolk sac. The remaining inner cell mass may henceforth be called epiblast.*
- *— On the epiblast surface, a primitive streak forms as differential cell growth generates a pair of ridges separated by a depression.*
- *NOTE: The primitive streak defines the longitudinal axis of the embryo and indicates the start of germ layer formation.*


Hypoblast Formation (three stages)
embryonic disc
embryonic disc
magnified
degenerating
trophoblast
blastocoele
inner
cell mass
delaminating
hypoblast cells
trophoblast
layer
hypoblast
layer
epiblast
epiblast
coelom
trophoblast
layer
yolk sac
(primitive gut)
coelom
hypoblast
layer
yolk sac
(primitive gut)

- — *The separation of the hypoblast layer from the epiblast establishes a space (**coelom/celom**) deep to the primitive streak. Subsequently, the coelom is temporarily filled by mesoderm that undergoes cavitation to restablish the coelom that gives rise to body cavities.*

- — *Epiblast cell proliferation along primitive streak ridges becomes the source of a cellular migration through the streak depression. The migrating cells form endoderm & mesoderm layers*.

- *Initial migrating cells join the hypoblast layer, forming embryonic*
- ***endoderm.*** *(The hypoblast constitutes yolk sac endoderm.)*
- *— The majority of migrating cells enter the coelom as primary*
- *mesenchyme and become* ***mesoderm****.The primary mesenchyme*
- *migrates laterally and cranially (but not along the midline region*
- *directly cranial to the primitive streak where notochord will*
- *form).*
- *Note: Mesoderm divides into: paraxial, intermediate, and*
- *lateral mesodermal regions.*
- *— Cavitation re-establishes a coelom (hoseshoe-shaped) within the lateral mesoderm. The mesoderm splits into two layers, bordering the coelom—somatic mesoderm is attached to the ectoderm and splanchnic mesoderm is joined to endoderm.*
- *— The remaining epiblast becomes* ***ectoderm*** *which forms skin epidermis & nervous system.*

Dorsal view embryonic disc