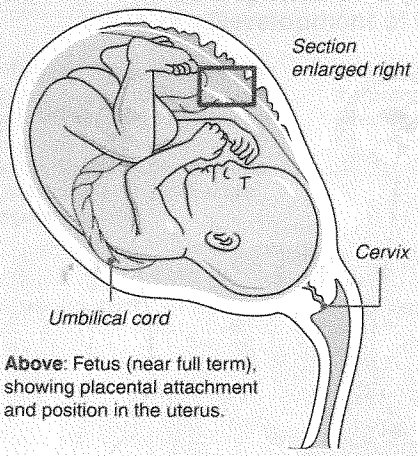
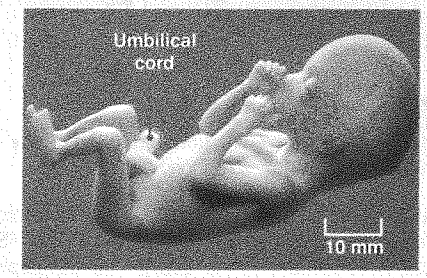
The Placenta

As soon as an embryo embeds in the uterine wall it begins to obtain nutrients from its mother and increase in size. At two months, when the major structures of the adult are established, it is called a fetus. It is entirely dependent on its mother for nutrients, oxygen, and elimination of wastes. The placenta is the specialized organ that performs this role, enabling exchange between fetal and maternal tissues, and allowing a prolonged period of fetal growth and development within the protection of the uterus. The placenta also has an endocrine role, producing hormones that enable the pregnancy to be maintained.

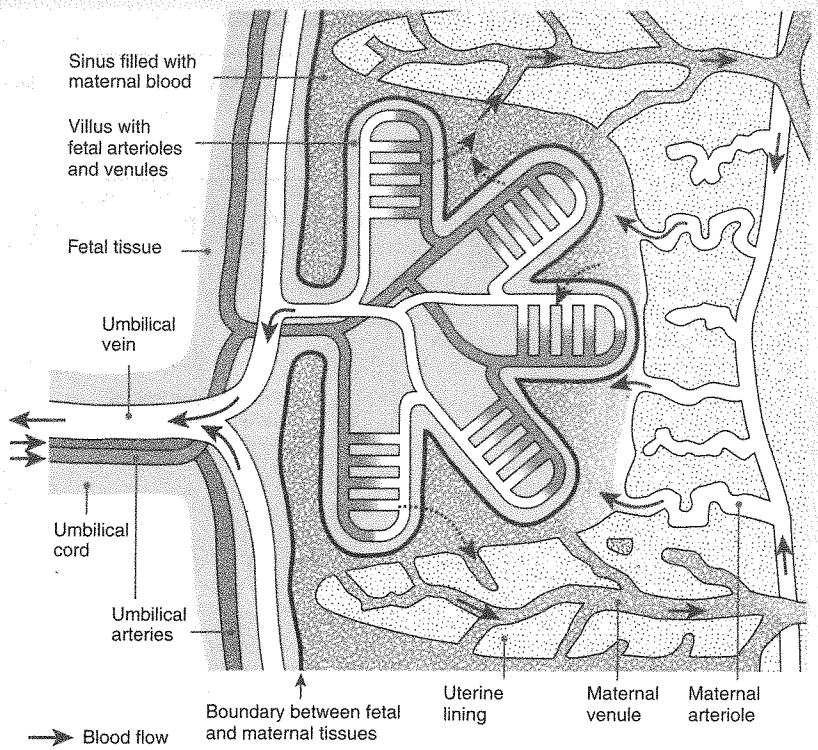


Above: Fetus (near full term), showing placental attachment and position in the uterus.

Below: Photograph shows a 14 week old fetus. Limbs are fully formed, many bones are beginning to ossify, and joints begin to form. Facial features are becoming more fully formed.



Schematic diagram showing part of the placenta in section



The placenta is a disc-like organ, about the size of a dinner plate and weighing about 1 kg. It develops when fingerlike projections (villi) from the fetal membranes grow into the uterine lining. The villi contain the numerous capillaries connecting the fetal arteries and vein. They continue invading the maternal tissue until they are bathed in the maternal blood sinuses. The maternal and fetal blood vessels are in such close proximity that oxygen and nutrients can diffuse from the maternal blood into the capillaries of the villi. From the villi, the nutrients circulate in the umbilical vein, returning to the fetal heart. Carbon dioxide and other wastes leave the fetus through the umbilical arteries, pass into the capillaries of the villi, and diffuse into the maternal blood. Note that fetal blood and maternal blood do not mix: the exchanges occur via diffusion through thin walled capillaries.

1. In simple terms, describe the basic structure of the human placenta: _____

   _____

   _____

   _____

2. The umbilical cord contains the fetal arteries and vein. Describe the status of the blood in each type of fetal vessel:

   (a) Fetal arteries: Oxygenated and containing nutrients / Deoxygenated and containing nitrogenous wastes (delete one)

   (b) Fetal vein: Oxygenated and containing nutrients / Deoxygenated and containing nitrogenous wastes (delete one)

3. Teratogens are substances that may cause malformations in embryonic development (e.g. nicotine, alcohol):

   (a) Give a general explanation why substances ingested by the mother have the potential to be harmful to the fetus:

   _____

   (b) Explain why cigarette smoking is so harmful to fetal development: _____

   _____

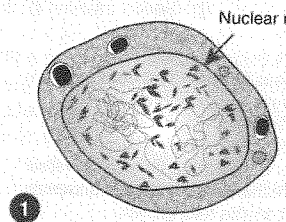
Apoptosis and Development

Apoptosis or programmed cell death is a normal and necessary mechanism in multicellular organisms to trigger the death of a cell. Apoptosis has a number of crucial roles in the body, including the maintenance of adult cell numbers, and defence against damaged or dangerous cells, such as virus-infected cells and cells with DNA damage. Apoptosis also has a role in "sculpting" embryonic tissue during its development, e.g. in the formation of fingers and toes in a developing human embryo. Apoptosis involves an orderly series of biochemical events that result in set changes in cell morphology and end in cell death.

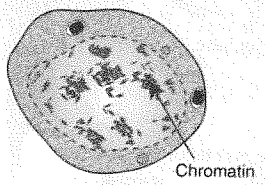
The process is carried out in such a way as to safely dispose of cell remains and fragments. This is in contrast to another type of cell death, called **necrosis**, in which traumatic damage to the cell results in spillage of cell contents. Apoptosis is tightly regulated by a balance between the factors that promote cell survival and those that trigger cell death. An imbalance between these regulating factors leads to defective apoptotic processes and is implicated in an extensive variety of diseases. For example, low rates of apoptosis result in uncontrolled proliferation of cells and cancers.

Stages in Apoptosis

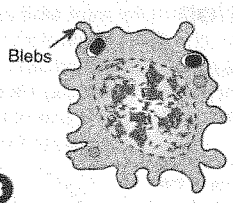
Apoptosis is a normal cell suicide process in response to particular cell signals. It characterized by an overall compaction (shrinking) of the cell and its nucleus, and the orderly dissection of chromatin by endonucleases. Death is finalized by a rapid engulfment of the dying cell by phagocytosis. The cell contents remain membrane-bound and there is no inflammation.



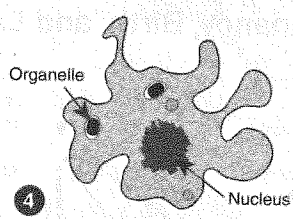
1. The cell shrinks and loses contact with neighboring cells. The chromatin condenses and begins to degrade.



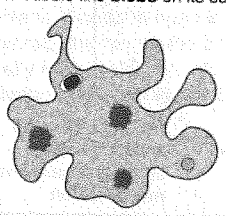
2. The nuclear membrane degrades. The cell loses volume. The chromatin clumps into **chromatin bodies**.



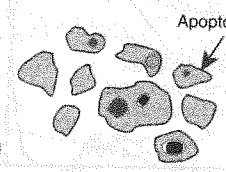
3. **Zeiosis**: The plasma membrane forms bubble like **blebs** on its surface.



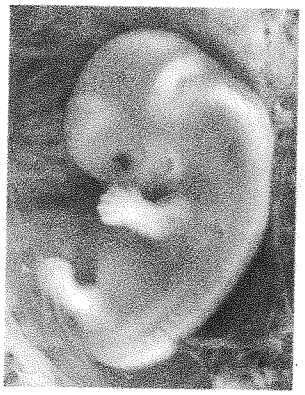
4. The nucleus collapses, but many membrane-bound organelles are unaffected.

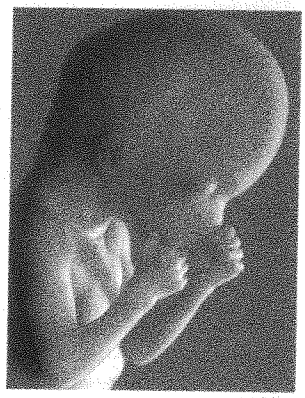


5. The nucleus breaks up into spheres and the DNA breaks up into small fragments.



6. The cell breaks into numerous **apoptotic bodies**, which are quickly resorbed by phagocytosis.





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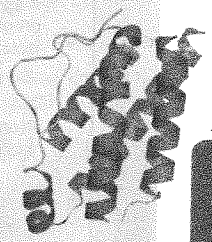
In humans, the mesoderm initially formed between the fingers and toes is removed by apoptosis. 41 days after fertilization (top left), the digits of the hands and feet are webbed, making them look like small paddles. Apoptosis selectively destroys this superfluous webbing and, later in development, each of the digits can be individually seen (right).

Regulating Apoptosis

Apoptosis is a complicated and tightly controlled process, distinct from cell necrosis (uncontrolled cell death), when the cell contents are spilled. Apoptosis is regulated through both:

Positive signals, which prevent apoptosis and allow a cell to function normally. They include:

- interleukin-2
- bcl-2 protein and growth factors

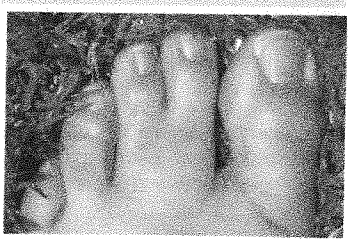


Interleukin-2 is a positive signal for cell survival. Like other signalling molecules, it binds to surface receptors on the cell to regulate metabolism.

Negative signals (death activators), which trigger the changes leading to cell death. They include:

- inducer signals generated from within the cell itself in response to stress, e.g. DNA damage or cell starvation.
- signalling proteins and peptides such as lymphotoxin.

1. The photograph (right) depicts a condition called syndactyly. Explain what might have happened during development to result in this condition:



_____

_____

2. Describe one difference between apoptosis and necrosis: _____

_____

3. Describe two situations, other than digit formation in development, in which apoptosis plays a crucial role:

(a) _____

_____

(b) _____

_____