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IMPLANTATION:

Implantation is the stage at which the embryo adheres to the wall of the uterus. At this stage of prenatal development, the conceptus is called a blastocyst. Through this adhesion, the embryo receives oxygen and nutrients from the mother to be able to grow.

Implantation usually occurs about nine days after ovulation and can last 6-12 days. The lining of the uterus (endometrium) prepares for the developing blastocyst to attach to it through many internal changes. Implantation will not occur without these changes and the embryo sloughs off during menstruation.

Before embryogenesis begins, the ovary releases an unfertilized egg cell, called an oocyte, which then travels down the fallopian tube. The egg is enveloped in an extracellular matrix called the zona pellucida. Sperm can fertilize the egg in the zona pellucida, which prevents the fertilized egg, called a zygote, from adhering to the wall of the fallopian tube. If the zygote implants in any area besides the uterus, the result is an ectopic pregnancy. This condition prevents the complete development of the embryo, and it can cause fatal hemorrhaging in a pregnant female.

As the zygote moves through the fallopian tube it undergoes several rounds of cell division, a process called cleavage. These cell divisions produce the inner cell mass, which will become the embryo, and the trophoblast, which surrounds the inner cell mass and interacts with maternal tissues. Together, the inner cell mass and the trophoblast are called the blastocyst. A blastocyst successfully implants in the uterus when, as the zona pellucida exits the fallopian tube, the blastocyst leaves the zona pellucida and binds to the endometrium.

The endometrium is one of the few uterine surfaces to which a blastocyst cannot always implant. The properties of the endometrium change, and only in a brief window can the blastocyst implant on the tissue. In humans, that window includes days six through ten after ovulation. Just prior to ovulation, the endometrium begins to thicken and to expand in response to the release of estrogen from the ovaries. As the embryo moves through the fallopian tubes, the endometrium proliferates, changes in shape, becomes receptive to implantation, and produces a hospitable environment for the embryo. Signaled by the release of progesterone from the ovaries, a series of changes called decidualization occurs. Decidualization includes the gathering of white blood cells around endometrial arterioles, or blood vessels leading from arteries to capillary beds. As that vasculature forms, a molecule that stores energy, called glycogen, accumulates in the expanding connective tissues of the uterus. Furthermore, the endometrium swells as interstitial fluid accumulates in it. The endometrium, swollen with interstitial fluid, vasculature, and nutrients, provides a hospitable environment for embryogenesis.

As the blastocyst moves through the uterus it realigns itself so that the inner cell mass is adjacent to the uterine wall, and the trophoblast contacts the endometrium. The position of the inner cell mass in relation to the endometrium establishes the head to tail, or dorsal-ventral, axis of the embryo, with the dorsal side of the embryo facing the uterine wall. This is the first embryonic event that dictates the organization of the future body.

Successful implantation depends on the blastocyst binding to the endometrium. There are many molecules that are thought to dictate this interaction, but integrins, a type of cell-adhesion molecule, have been identified as a primary component. Integrins extend from the lining of the uterus and from the surface of the blastula. Integrins have many functions in nearly all tissue types, and they have a role in cell adhesion, conveying information about the extracellular environment to the nucleus, and modulating the local immune response. Immediately following implantation, integrins help regulate gene expression in the embryo.

Despite the contact between the blastocyst and the endometrium, implantation can fail. There are many potential causes of errors. If implantation does not occur, the endometrium breaks down and sheds, along with the blastocyst, as part of the menstrual cycle. However, if a blastocyst does implant, then the endometrium remains in the uterus, and together with uterine tissue, becomes the maternal portion of the placenta, called the decidua.

Once the blastocyst adheres to the uterine wall, the trophoblast secretes enzymes that digest the extracellular matrix of endometrial tissue. The trophoblast cells then begin to intrude between the endometrial cells, attaching the blastocyst to the uterine surface. Further secretions of enzymes allow the blastocyst to bury itself deeply among the uterine stromal cells that form the structural components of the uterus. Subsequently, trophoblast cells continue to divide and form two extraembryonic membranes. These membranes form the fetal portion of the placenta called the chorion. Additional enzymes and signaling factors secreted by these membranes remodel the uterine vasculature to bathe the fetal or embryonic blood vessels in maternal blood. Chorionic villi are the folds of tissue and blood vessels that connect maternal and fetal blood pools. Maternal blood diffuses into the villi, and it travels through them into the fetus's vasculature. Similarly, fetal blood diffuses from the villi and into the maternal vasculature. Normally fetal and maternal blood do not mix, but the relationship between the two circulatory systems enables the transfer of nutrients and oxygen to the fetus or embryo, and carbon dioxide and urea from the fetus to the mother.