Embryology

From Egg to Embryo

A. Terms

1. Pregnancy – events occurring from the time of fertilization (conception) until the infant

is born

2. Conceptus – developing offspring

3. Gestation period – extends from the last menstrual period until birth (280 days)

4. Pre-embryo – first two weeks following fertilization

5. Embryo – from the third through the eighth weeks after fertilization

6. Fetus – ninth week through birth

7. Infant – at birth

B. Fertilization – fusion of sperm and egg

1. Copulation must occur accordingly

A) Egg is viable for 12-24 hrs after ovulation

B) Sperm is viable for 24-72 hrs after ejaculation

C) Copulation must occur no more than three days before and no later than

24 hours after ovulation

2. Sperm must reach the egg

A) Only a few hundred thousand sperm in a male’s ejaculate actually make it to the

uterine tubes

1) Millions leak immediately from the vagina

2) Millions are destroyed by acidity of the vagina

3) Only about 2,000-3,000 sperm actually make it to the egg

3. Sperm must penetrate the egg

A) Requires capacitation, an acrosomal reaction, and fertilization membrane formation

1) Capacitation – breaking down of the acrosome to release the enzymes that

penetrate the oocyte membranes

a) Takes about 6-8 hours

2) Acrosomal reaction – release of the acrosomal enzymes triggered by the sperm

coming into contact with oocyte membranes

a) First-arriving sperm create holes in the corona radiata

i) It often takes hundreds of sperm to create the holes

b) A later-arriving sperm reaches the zona pellucida and releases enzymes

creating a hole in the zona pellucida

c) Once the sperm reaches the oocyte membrane, its nucleus is pulled into the

oocyte cytoplasm

3) Upon entry of the nucleus, the oocyte creates a fertilization membrane just

beneath the zona pellucida

a) Forces out other entering sperm & prevents entry of future sperm

4. Meiosis II must be completed

A) After a sperm’s nucleus enters the oocyte, the secondary oocyte completes meiosis

II and ejects the second polar body

B) The ovum and the sperm nuclei swell to form the male and female pronuclei which

merge giving rise to the zygote

1) Zygote – fertilized egg with single, diploid nuclei

C) Twins

1) In most pregnancies, only a single egg is fertilized resulting in a single, implanted embryo; there are, however, times when multiple embryos are

produced and implant themselves in the uterus resulting in multiple fetuses

a) Fraternal (dizygotic; non-identical) twins – result when the female produces

more than one oocyte during her monthly cycle (and more than one is

fertilized)

i) Children may be of the same sex or different sexes and are not genetically

identical

b) Identical twins (monozygotic) – result when a single zygote splits into

multiple embryos following fertilization

i) Children will be of the same sex and genetically identical

C. Pre-embryonic Development

1. Cleavage occurs as the pre-embryo travels through the uterine tube and into the uterus

A) Period of rapid mitotic divisions

1) 2-cell stage – 36 hours after fertilization

2) 4-cell stage – about 48 hours

3) 8-cell stage – about 72 hours

4) Morula – solid ball of cells that is 16 or more cells in size

2. The morula continues to increase in cell number as it hollows out and fills with fluid

(now known as a blastocyst)

A) Blastocyst – hollow ball of cells that will eventually implant in the uterus

B) Blastocoel – hollowed-out region of the blastocyst

3. The zona pellucida disintegrates and releases the blastocyst

A) The blastocyst is composed of 2 cell layers

1) Trophoblasts –the large flattened cells of the outer layer

a) Will take part in placenta formation

b) Secrete hCG to prompt the corpus luteum to continue secreting progesterone

in order to maintain the endometrium

2) Inner Cell Mass (ICM; a.k.a embryoblast) – a cluster of small rounded cells of

the inner layer

a) Becomes the actual embryo

4. Implantation

A) When the blastocyst reaches the uterus, it initially floats freely, receiving

nourishment from the endometrial secretions (uterine milk)

B) 6-7 days after ovulation, the trophoblast cells embed into the endometrium

and begin secreting digestive enzymes that degrade the endometrial surface

C) As the endometrium is eroded, the blastocyst burrows into the lining

D) The endometrial lining reacts by growing over the blastocyst

E) The chorion develops from the trophoblast cells starting to give rise to the placenta

5. Placenta Formation

A) Functions in the exchange of nutrients & waste products, and blood gasses

B) The chorion develops chorionic villi which extend into the endometrium where

they come into contact with maternal blood supply

C) Placenta takes over the role of secreting hCG and also secretes relaxin

1) Causes the pubic symphysis to soften and become more flexible

Embryonic Development

A. The blastocyst is converted into the gastrula in which the embryonic membranes develop

and three primary germ layers form

1. Gastrulation – process by which the embryonic tissues are formed

2. The embryonic membranes form as the inner cell mass splits to form upper and lower

cell layers

A) Amnion (amniotic sac) – forms from the upper cell layer

1) This sac fills with amniotic fluid that provides a buoyant environment that

protects the developing embryo

B) Yolk sac – forms from the lower cell layer

1) It serves to form part of the digestive tube, produces the earliest blood cells and

blood vessels, and is the source of primordial germ cells of the embryo’s gonads

C) Allantois – forms as a small out-pocketing of the yolk sac

1) Acts as the structural base of the umbilical cord and becomes part of the urinary

bladder

D) Chorion – develops from proliferating trophoblast cells giving rise to the placenta

3. During the third week, the primary germ layers form along the embryo

A) Ectoderm – gives rise to skin and nervous system

B) Endoderm – gives rise to the functional linings of the digestive, respiratory, and

urogenital systems

C) Mesoderm – gives rise to muscle, bone, blood vessels, kidneys and all the other

components of organs (except linings)

4. Circulation in fetus versus newborn

A) Fetal circulation has several adaptations so that the lungs and liver are largely

bypassed because they are non-functional

1) The umbilical vein carries oxygen- and nutrient-rich blood from the placenta to

the fetus

2) The umbilical arteries carry deoxygenated, waste-laden blood from the fetus to

the placenta

3) The ductus arteriosus and foramen ovale allow blood to partially bypass the

lungs

4) The ductus venosus allows blood to partially bypass the liver

5. Development through the end of the embryonic period

A) Head nearly as large as body

B) All major brain regions present; first brain waves in brain stem

C) Liver disproportionately large and begins to form blood cells

D) Limbs present; digits initially webbed but become separated later

E) Ossification begins and spontaneous muscle contractions occur

F) Cardiovascular system is fully functional

G) All body organs/systems present though not fully developed

H) Final approximate crown-to-rump length is 30 mm (1.2 inches)

Events of Fetal Development

A. 9 to 12 weeks

1. Head still dominant with brain enlargement continuing and cervical and lumbar

enlargements of the spinal cord are obvious.

2. Skin epidermis and dermis are obvious; facial features in crude form.

3. Liver is prominent and bile being secreted; smooth muscle increasing.

4. Blood cells formation begins in bone marrow.

5. Notochord degenerating and ossification accelerating.

6. Sex readily detected from the genitals.

7. Final approximate crown-to-rump length is 90 mm.

B. 13-16 weeks

1. Cerebellum becoming prominent; sensory organs differentiate, eyes and ears assume

shape and position; sucking motions of lips occurs.

2. Face looks human and body beginning to outgrow head.

3. Glands developed in GI tract; meconium is collecting.

4. Kidneys attain typical structure.

5. Most bones are now distinct and joint cavities are apparent.

6. Final approximate crown-to-rump length is 140 mm.

C. 17-20 weeks

1. Fatty secretions from sebaceous glands and silk-like hair cover body.

2. Fetal position assumed because of space restrictions.

3. Limbs near-final proportions.

4. Muscular activity of fetus increases.

5. Final approximate crown-to-rump length is 190 mm.

D. 21-30 weeks

1. Increase in weight.

2. Myelination of cords begins; eyes are open.

3. Distal limb bones are beginning to ossify.

4. Skin is wrinkled and red; fingernails and toenails are present.

5. Body is lean and well proportioned.

6. Bone marrow becomes sole site of blood cell formation.

7. Testes reach scrotum in seventh month.

8. Final approximate crown-to-rump length is 280 mm.

E. 30-40 weeks

1. Skin whitish pink; fat laid down in subcutaneous tissue.

2. Final approximate crown-to-rump length is 360-400 mm

Parturition (Birth)

A. Initiation of labor

1. High estrogen levels induce oxytocin receptors to increase on the myometrial cells and

inhibit progesterone secretion by the placenta

A) Weak irregular contractions begin

2. Fetal cells produce oxytocin, which stimulates prostaglandin production by the placenta

A) Both hormones stimulate contraction

3. Increasing stress causes the hypothalamus of the mother to cause oxytocin release by

the pituitary gland (posterior)

B. Stages of labor

1. Dilation stage – rhythmic contractions occur until the cervix dilates 10 cm

A) The head of the fetus rotates and descends through the pelvic outlet

2. Expulsion stage – extends from full cervical dilation (10cm) until birth of the infant

3. Placental stage – delivery of the afterbirth

A) Consists of the placenta and its attached membranes

C. Lactation

1. The breasts are prepared for lactation during pregnancy by high blood levels of

estrogen, progesterone, and placental lactogen

1. Oxytocin is important in stimulating the “let-down” phase

1) Let-down = the actual release of milk from the alveoli of the mammary glands

2) Suckling also stimulates the release of oxytocin and promotes let-down

a) The let-down will occur in BOTH breasts, not just the suckled one

2. Colostrum is produced towards the end of the pregnancy, and for the first 2-3 days after

birth

A) A pre-milk fluid that is a fat-poor fluid that contains more protein, vitamin A, and

minerals than true milk (It’s similar to skim milk.)

3. True milk is produced around day 3 in response to suckling which stimulates the

hypothalamus to prompt the pituitary gland to secrete even more prolactin and oxytocin

4. At first, ovulation and menses are absent or irregular during nursing