Animal and Veterinary Science Department
University of Idaho

EMBRYOGENESIS AND SEXUAL DIFFFERENTIATION

AVS 222 (Instructor: Dr. Amin Ahmadzadeh)
Chapter 4

I. DIFFERENTIATION

Primitive group of unspecialized cells develop a functional and specialized group of cells that provide a common function

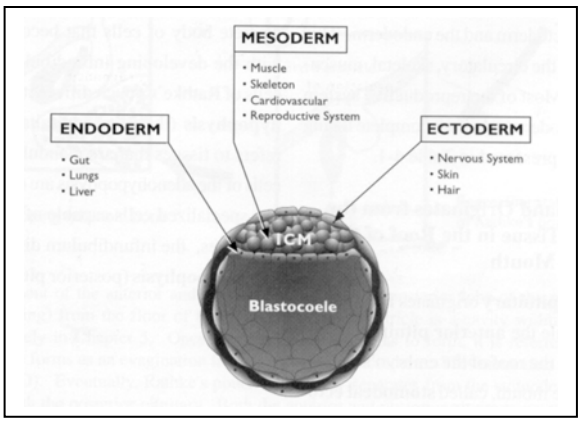
A. Involves Formation of **Three Germ Layers**

1. Embryonic tissue, which form all adult tissues and organs

B. Germ Layers Formed During Gastrulation (re-arrangement of the embryonic cells)

C. Three Germ Layers**: (Table 4-1)**

1. **Ectoderm:** in general, form exterior tissues **(Figure 4-1, adapted from Senger ©)**



a. Skin, hair, sweat glands
b. Mammary glands
c. Hypothalamus, anterior and posterior pituitary
d. Part of the reproductive tract (male and female)

2. **Mesoderm**: in general, forms structural tissue **(Figure 4-1)**

a. Muscle, Skeletal system, blood vessels
b. Reproductive system
gonads, uterus, cervix, part of vagina, accessory sex glands
e. Renal system

3. **Endoderm**: in general, form internal organs **(Figure 4-1)**

a. Digestive system, Liver, lungs
b. Majority of glands

II. SEXUAL DIFFERENTIATION AND DETERMINATION

A. Genetic differentiation

1. An individual's sex is genetically determined by the presence of a Y chromosome
2. Genetic differentiation takes place at fertilization when a sperm delivers either an X (female) or Y (male) chromosome to the oocyte
3. Sex determination gene of the Y chromosome causing the undifferentiated gonad develop into the testis is **Sry gene**

4. Sry gene of the Y chromosome responsible for the expression of substance called **testis determining factor (TDF) secreted by the sex cords.**

6. TDF controls the pathway towards either male or female development.

B. Gonadal differentiation (Figure 4-4)

1.Development of primordial germ cells in the yolk sac (first 15% of gestation)

2. Migration of primordial germ cells from the yolk sac into the **genital ridge**

Primordial germ cells stimulate other cells production forming primitive sex cords.

Genital ridge gives rise to indifferentiated gonad

3. Genital ridge with stimulation of sex cords give rise to renal system

4. Development of the urinary system (Figure 4-5)

- **pronephros** (primitive kidney)
- **mesonephros** (closely associated with the **indifferentiated gonad)**
- **metanephros** (becomes the functional kidney)

5. Development reproductive tract: Development of two distinct tubules structures which give rise to male or female reproductive tracts

a. **mesonephric duct** (**Wolffian Duct; male reproductive tract; Figure 4-7)**

b **paramesonepheric** duct (Mullerian Duct; female reproductive tract; **Figures 4-13 and 4-14**)

6. Male (**See Figure 4-5; 4-6)**

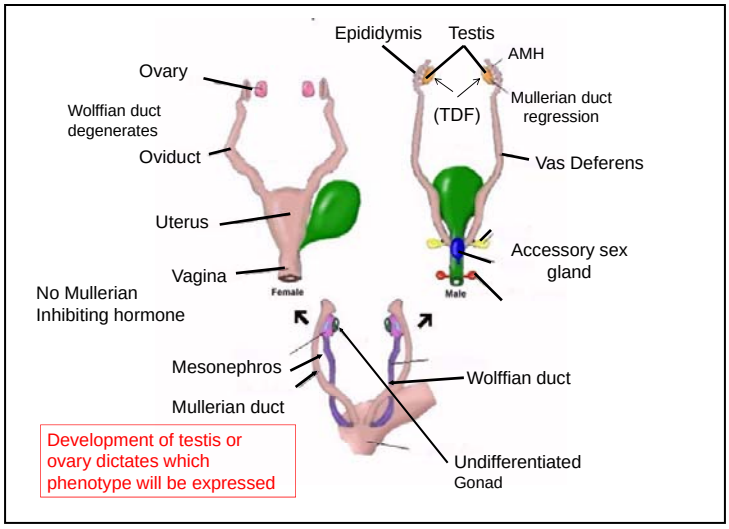
In the presence of Y chromosome and Sry gene:

Presence of TDF → Development of indifferentiated gonad to testes and Sertoli cells → Secretion of **anti-mullarian hormone (AMH) by sertoli cells** → Degeneration of Mullerian duct and development of Wolffian duct → differentiation of interstitial Leydig cells → Secretion of testosterone and development of male reproductive duct system

7. Female (**See Figure 4-14)**

In the absence of Sry Gene:

No TDF → development of ovaries → no Sertoli cells →absence of AMH → degeneration of Wolffian duct and development of Mullarian duct → development of female reproductive tract



C. **Hypothalamic differentiation** (brain sexual differentiation differentiation, **Figure 6-1**)

Pre-knowledge: Hypothalamic GnRH surge center is necessary for initiation of the estrous cycle and follicular ovulation in the female

A. Male

"**Defeminization (**Masculinization)" of the brain in the male:

1. Testosterone from the fetal testis reaches the brain → 2. testosterone is converted to estradiol by aromatase enzyme in the hypothalamus→ 3. regression of the hypothalamic GnRH surge center by estradiol → 4. defeminization of the hypothalamus (no surge center)

B. Female

If synthesis of estradiol in the hypothalamus responsible for defeminization of the surge center, why doesn't the female (with a lot circulating estradiol) become "defeminized"?

Estradiol in female binds with a liver protein called **alpha-fetoprotein** → **the new complex cannot cross the blood brain barrier where the surge center is located→ therefore, estradiol cannot affect the GnRH surge center**

III. Testicular descent

A. Four phases **(Figures 4-8 and 4-9)**

1. Growth and elongation of the body away from the stationary testes.
2. Rapid growth of the distal **gubernaculum**
   - rapid growth results in the testes being pulled from the region of the tenth thoracic vertebra to the inguinal ring
3. Shrinkage of the gubernaculum within the scrotum pulls the testes through the inguinal ring;
4. Continued regression of the gubernaculum situates the testes within the scrotum

B. Growth and regression of the gubernaculums **(Figure 4-8 and 4-9)**

1. Testicular factor **"descendin**" has been shown to cause growth in gubernacular cells in vitro
2. Testosterone or gonadotropins do not appear to play a major role in gubernacular growth
3. Intra- abdominal pressure may play a larger role in the movement of the testes out of the abdomen and into the scrotum

What happens when the testes fail to descend? (Figures 4-11 and 4-12)

1. Cryptorchid:

a. bilateral: both testes retained: sterile
b. unilateral: one testis retained: fertile-sub-fertile

2. Hormone production is NOT decreased in cryptorchid males

a. will exhibit secondary sex characteristics and normal reproductive behavior

3. Cryptorchidism is heritable-therefore cull
    a. it is possible to surgically or with pharmaceuticals lower the retained testis; however it is most likely that fertility will be compromised
    b. in production animals, **why keep a cryptorchid?**
4. descent of testes from the body cavity into the scrotum occurs by
    a. mid-gestation (bull and ram)
    b. last quarter of gestation (boar)
    c. just before birth/ at birth (stallion)

Why are bilateral cryptorchids sterile?

Temperature regulation!

The temperature requirements for normal spermatogenesis must be different

If you increase the temperature of the scrotum or insulate the scrotum against heat loss, spermatogenesis is impaired (increased # of abnormal sperm=decreased fertility)