

CHAPTER 29

DEVELOPMENT, GROWTH, AGING, AND GENETICS

CHAPTER OVERVIEW: This chapter outlines human development from conception through death. The maternal and embryonic events of pregnancy are explored in detail. The hormonal influences on normal development are described. The changes associated with birth and with aging after birth are described. The principles of genetics and human heredity are briefly presented.

OUTLINE (one to three fifty-minute lectures):
Seeley, A&P, 5/e

t. ct.	Topic Outline, Chapter 29	Figures & Tables	Transparen Acetates
	I. Prenatal Development, p. 962		
	1. Clinical Age from Last Menstrual Period is 14 Days Longer than Postovulatory Age		
	2. Parts of Prenatal Period		
	a. Germinal Period - First 2 Weeks		
	b. Embryonic Period - Second to Eighth Week		
	c. Fetal Period - Last 30 Weeks Before Birth		
	A. Fertilization	Clinical Focus, p.968	
	1. Thousands of Sperm May Reach the Oocyte		
	2. Only One Sperm Cell Penetrates the Oocyte Membrane		
	a. Fertilization Event		
	b. Second Meiotic Division Stimulated, Forming Haploid Female Pronucleus		
	c. Enlarged Head of Sperm = Haploid Male Pronucleus		
	3. Fusion Product = Diploid Zygote	Fig. 29.1, p.963	
	B. Early Cell Divisions	Fig. 29.1b-d, p.963; Clinical Note, p.962	
	1. First Mitotic Divisions 18-39 hrs. After Fertilization		
	2. Cells Pluripotent		
	C. Morula and Blastocyst		
	1. 12 + cells in Solid Ball = Morula		
	2. 3-4 Days Post Fertilization, 32 Cells	Fig. 29.2, p.964	TA-582
	a. Develops Blastocoel Cavity		
	b. Hollow Sphere is Blastocyst with Two Parts		
	1). Trophoblast		
	2). Inner Cell Mass that Becomes Embryo		
	D. Implantation of the Blastocyst and Development of the Placenta	Clinical Note, p.964	
	1. Implantation Occurs About 7 Days after Fertilization		

2. As Blastocyst Invades Endometrium Placenta Forms	Fig. 29.3, p.965	
a. Cytotrophoblast = Proliferating Population	Fig. 29.4, p.965	TA-583
b. Syncytiotrophoblast = Non-Dividing Multi-Nuclear Syncytium		
1). Pools of Maternal Blood Still Connected to Maternal Circulation = Lacunae		
2). Cytotrophoblast Cords Surround Syncytiotrophoblast and Lacunae		
3). Chorionic Villi = Projections Facing Maternal Tissue		
E. Formation of the Germ Layer	Clinical Note, p.964	
1. Amniotic Cavity		
a. Forms Inside Inner Cell Mass		
b. Surrounded by Layer of Cells Called Amniotic Sac		
2. Inner Cell Mass Separates into Flat Embryonic Disk	Fig. 29.5, p.966	TA-584
a. Ectoderm - Side Adjacent to Amniotic cavity		
b. Endoderm - Side Opposite to Amniotic Cavity		
3. Yolk Sac		
a. Cavity Lined with Endoderm		
b. in Blastocoel		
4. Elongation of Embryonic Disk		
5. Medial Migration of Proliferating ectoderm to Form thickened Primitive Streak	Fig. 29.6, p.966	TA-585
6. Migration of Ectoderm Cells through Primitive Streak to form Mesoderm	Predict Quest. 1	
7. Formation of 3 Germ Layers = Beginning of Embryo		
8. Notochord Extends from Cephalic End of the Primitive Streak		
F. Neural Tube and Neural Crest Formation	Fig. 29.7, p.967	TA-586
1. Notochord Organizes Thickened Neural Plate 18 Days Post Fertilization		
2. Neural Crests Meet and Fuse to Form Neural Tube by 26 Days	Table 29.1, p.967	
3. Some Neural Crest Cells Break Away from Margin of Neural Crest		
G. Somite Formation		
1. Mesoderm Adjacent to Neural Tube Forms Somites		
2. Less Distinct Somitomeres in Head Region		
H. Formation of the Gut and Body Cavities	Fig. 29.8, p.969	TA-587

1. Whole Embryo Becomes Tube-Shaped Over Surface of Yolk Sac
2. Yolk Sac Becomes Separated into
 - a. Foregut at Cephalic End
 - 1). Pharynx
 - 2). Pharyngeal Pouches
 - b. Hindgut at Caudal End
 - c. Overlying Ectoderm
 - 1). Oropharyngeal Membrane
 - 2). Cloacal Membrane
3. Digestive Tract Becomes Tube Open to the Outside at Both Ends
4. Evaginations off Basic Tube Become a Variety of Organs
5. Isolated Cavities Fuse into Coelom, then Separate into Distinct Body Cavities
 - a. Pericardial Cavity
 - b. Pleural Cavities
 - c. Peritoneal Cavity

0 I. Limb Bud Development Fig. 29.9, p.970

1. Apical Ectodermal Ridge
2. Limb Buds Form
 - a. Buds Elongate
 - b. Limb Tissue Develops in Proximal to Distal Sequence

1 J. Development of the Face Fig. 29.10, p.971 TA-588

1. Results from Fusion of Five Structures
 - a. Single Frontonasal Process (with Two Nasal Placodes)
 - b. Two Maxillary Processes
 - c. Two Mandibular Processes
2. Primary Palate Formed from Fusion of Maxillary Processes with Frontonasal Process
3. "Human" Appearance of Face by about 50 Days
4. Secondary Palate = Roof of Mouth
 - a. Fusion Complete by about 56 Days
 - b. Failure to Fuse Results in Cleft Palate

Clinical Note,
p.970
Table 29.2,
pp.972-973

1 K. Development of the Organ Systems

1. Period of Organogenesis 14-60 Days Post Fertilization
2. Skin
 - a. Epidermis from Ectoderm
 - b. Dermis from Mesoderm
 - c. Melanocytes and Sensory Receptors from Neural Crest Cells
3. Skeleton
 - a. Face Bones From Neural Crest Cells
 - b. Rest of Skull, Vertebral column and Ribs from Somite- or Somiomere-Derived

Mesoderm

- c. Appendicular Skeleton Develops from Limb Bud Mesoderm
4. Muscles
 - a. Multinucleated Myoblasts Produce Skeletal Muscle Cells
 - b. Precursors Migrate from Somites
 - c. Fusion into Myoblasts followed by Growth of Nerves into Area
 - d. Muscle Growth in size
 - 1). Before Birth by Increases in Number of Cells
 - 2). After Birth by Increased Size of Set Number of Cells
5. Nervous System Clinical Notes 1 & 2, p.974
 - a. From Neural Tube and Neural Crest
 - b. Proceeds from Anterior End Posteriorly Fig. 13.3, p.384 TA-243
 - c. Neurons whose Cell Bodies are Located in CNS Develop from Neural Tube
 - d. Sensory Neurons and Post-Ganglionic Autonomic Neurons from Neural Crest Cells
6. Special Senses Fig. 13.3, p.384 TA-243
 - a. Olfactory Bulb and Nerves = Evaginations from Telencephalon
 - b. Eye = Evaginations from Diencephalon
 - 1). Optic Stalk
 - 2). Optic Vesicles
 - 3) Ectoderm Over Vesicle Thickens to Form Lens
 - c. Ear = Invagination of Ectodermal Placode
7. Endocrine System
 - a. Pituitary Gland
 - 1). Posterior Pituitary = Evagination from Floor of Diencephalon
 - 2). Anterior Pituitary = Evagination from Roof of Oral Cavity
 - b. Thyroid Gland = Evagination off of Pharynx
 - c. Parathyroid Glands = From Pharyngeal Pouches, Migrate Toward Thyroid
 - d. Adrenal Glands
 - 1). Medulla from Neural Crest Cells
 - 2). Cortex of Mesodermal Origin
 - e. Pancreas from Two Evagination of Duodenum which Fuse Fig. 29.8c, p.969 TA-587
8. Circulatory System
 - a. Blood and Vessels From Blood Islands
 - 1). Mesoderm Patches
 - 2). Located on Surface of Yolk Sac and in Embryo

2

- 3). Outer Cells Form Vessels
- 4). Inner Cells Form Blood Cells
- b. The Heart Fig. 29.11, p.975 TA-589
 - 1). Two Endothelial Tubes Fuse in Midline
 - 2). Series of Dilations
 - 3). Fused Tube Bends so Ventricle at Apex Predict Quest. 2
 - 4). Part of Sinus Venosus Becomes SA Node = Pacemaker
 - 5). Interatrial Septum Forms Fig. 29.11c-e, TA-589
p.975
Clinical Note,
p.976
9. Respiratory System Fig. 29.12, p.977 TA-590
 - a. Single Midline Evagination from Foregut
 - b. Branches into Two Lung buds Fig. 29.12a, TA-590
p.977
 - c. Buds Elongate with Multiple Branchings Fig. 29.12b, TA-590
p.977
 - 1). 17 Generations of Branching by End of Sixth Month
 - 2). Continue Branching After Birth Until Twenty-Four Generations of Branching Completed
10. Urinary System Fig. 29.13, p.978 TA-591
 - a. From Mesoderm Between Somites and Lateral Embryo
 - b. Cervical Pronephros Soon Degenerates
 - c. Mesonephros
 - 1). Functional in Embryo
 - 2). Single Duct with Tubules and Glomeruli
 - d. Cloaca= Enlargement of Caudal Hindgut
 - 1). Hindgut Opens into Cloaca
 - 2). Urogenital Sinus of Allantois Opens into Cloaca
 - 3). Eventually Separated by Urorectal Septum into Digestive System and Urethra
 - e. Ureter and Metanephros off Caudal Mesonephric Duct
 - 1). Metanephros Develops into Adult Kidney
 - 2). Mesonephros Degenerates
11. Reproductive System Fig. 29.14, p.979 TA-592
 - a. Gonadal Ridges Form Along Ventral Border of Mesonephros
 - b. Primordial Germ Cells Migrate to Gonadal Ridges form Surface of Yolk Sac
 - c. Gonads Descend from Abdomen
 - 1). to Pelvis in Females
 - 2). through Inguinal Canal to Scrotum in Males (Completed by about One Month before Birth) Clinical Note, p.976

3

- d. Paramesonephric Ducts
 - 1). Develop Lateral to Mesonephric Ducts
 - 2). Enter Cloaca as Single Midline Tube
- e. In Males with Presence of Testosterone from Testes
 - 1). Mesonephric Duct System Enlarges to Form Male Duct System
 - 2). Mullerian-Inhibiting Hormone from Testes Causes Paramesonephric Ducts to Degenerate
- f. In Females with Absence of Testosterone
 - 1). Mesonephric Duct System Degenerates
 - 2). Absence of Mullerian-Inhibiting Substance Allows Paramesonephric Ducts to Form Female Duct System
- g. External Genitalia of Both Sexes Begin From Similar Structures
 - 1). Under Influence of Testosterone
 - 2). Under Absence of Testosterone

Fig. 29.14c, TA-592
p.979

L. Growth of the Fetus

Fig. 29.15, p.980

- 1. Embryo Becomes Fetus 60 Days Past Fertilization
- 2. Most Organs are Now Present, Development continues
- 3. Primarily a time of Growth
 - a. 3 cm and 7.5 g at 60 Days
 - b. 50 cm and 3,300 g at Term (38 weeks)
- 4. Lanugo and Vernix Caseosa Protect Fetus from Amniotic Fluid
- 5. Subcutaneous Fat Deposition
- 6. Placenta Stops Growing at about 35 Weeks
- 7. At about 38 weeks Fetus can Survive Outside the Uterus
 - a. 3250 g for Females
 - b. 3300 g for Males

Clinical Note, p.981
Fig. 29.16, p.981

Clinical Focus, p.982

4 II. Parturition

A. Delivery Date Calculated to Occur 280 Days After Last Menstrual Period

Fig. 29.17, p.983 TA-593
Predict Quest. 3;
Clinical Note, p.981

B. Labor = Period of Spontaneous Uterine Contractions Which Expels Fetus from Uterus

- 1. First Stage
 - a. Begins with Regular Uterine Contractions
 - b. Ends with Maximum Dilation of Cervix
 - c. Lasts 8-24 hrs.
- 2. Second Stage
 - a. From Maximum Cervical Dilation to Exit of

Clinical Note, p.982

Baby

- b. Duration One Minute to One Hour
- c. Abdominal contractions Assist Uterine Contractions

d. Blood Flows to Fetus Slowed or Stopped during Periods of Intense Contractions

Clinical Note 3, p.984

3. Third Stage

- a. Expulsion of Placenta
- b. Uterine Smooth Muscle Contracts Compressing Blood Vessels, Limiting Bleeding

4. Vaginal Discharge with Small Amounts of Blood and Degenerated Endometrium Normally Persist for One Week Post-Partum

C. Factors That Influence Parturition

1. Rapidly Increased Maternal Estrogen Levels

- a. Excitability Effect on Uterine Smooth Muscle

Fig. 29.18, p. 984 TA-594

b. Overcomes Inhibitory Effect of Progesterone

2. Fetal Adrenal Cortex Gland Enlarged Before Parturition

Fig. 29.18, p.984 TA-594

a. Late Term Produces Stress on Fetus

b. Fetal Anterior Pituitary Secretes ACTH

c. Increased Glucocorticoids from Fetal Adrenal Cortex

d. Glucocorticoids Act at Placenta

1). Decreased Rate of Progesterone Secretion

2). Increased Rate of Estrogen Secretion

3). Initiate Prostaglandin Secretion

3. Oxytocin

Predict Quest. 4

a. Neural Reflexes Initiated by Stretch of Uterine Cervix

1). Causes Increased Oxytocin Release From Maternal Posterior Pituitary

2). Sets up Positive Feedback Loop as Long as Fetus is in Birth Canal

b. Drops in Maternal Progesterone Allows Increased Oxytocin Secretion

c. Estrogens Increase Uterine Sensitivity to Oxytocin by Increasing Oxytocin Receptors

5 III. The Newborn or Neonate, p. 985

A. Circulatory Changes

Fig. 29.19, pp.986-987

TA-595

1. Expansion of Lungs Changes Resistance to Flow in Lungs

2. Decreased Flow through Foramen Ovale Between Two Atria - Closed Foramen Ovale Becomes Fossa Ovalis

3. Ductus Arteriosus Between Pulmonary Trunk and Aorta

Clinical Note, p 985

- a. Closes off within 1-2 Days After Birth - Probably due to Local Pressure and O₂ Content
- b. Sphincterlike Closure of Artery
- c. Becomes Ligamentum Arteriosum
- 4. Loss of Functional Connection to Placental
 - a. Degeneration of Umbilical Vein and Artery
 - b. Remnant of Umbilical Vein Becomes Round Ligament of Liver (Ligamentum Teres)
 - c. Remnant of Ductus Venosus Becomes Ligamentum Venosum
 - d. Remnants of Umbilical Arteries Become Umbilical Ligaments

B. Digestive Changes

- 1. Loss of 5-10 % of Total Body Weight in First Few Days of Life
- 2. First Greenish Anal Discharge is Meconium
- 3. Stomach Becomes Acidic in first 8 hrs. Postpartum - Maximum Acidity at 4-10 Days
- 4. Immature Liver can Lead to Jaundice
 - a. Temporary in Full-Term Babies - Enzymes for Bilirubin Metabolism Present within 2 Weeks
 - b. Jaundice Often Seen in Premature Babies
- 5. Capable of Lactose Digestion from Birth, Declines During Infancy, May Be Lost in Adults
- 6. Gradual Development of Ability to Digest Solid Food by Two Years

C. APGAR Scores

- 1. Used to Assess Infant's Physiological Condition
 - a. Appearance
 - b. Pulse
 - c. Grimace
 - d. Activity
 - e. Respiratory Effort
- 2. Each Scored on Scale of 0 (Seriously Impaired) to 2 (Normal)
- 3. Total APGAR Score of 8-10 at 1-5 min. after Birth is Considered Normal

Table 29.3, p.987

6 IV. Lactation

- A. Production of Milk by Mother's Breast
 - 1. Follows Parturition
 - 2. Continues 2-3 yrs. if Regular Suckling Occurs
- B. Hormonal controls
 - 1. Elevated Estrogens and Progesterone of Pregnancy
 - a. Estrogen Causes Breast Growth
 - b. Progesterone Causes Development of

Fig. 29.20, p.988 TA-596

Secretory Alveoli, but not Secretory
Capability

2. Prolactin from Anterior Pituitary
 - a. Responsible for Milk Production
 - b. Prolactin Effects Greatest When Estrogens and Progesterone Falls
 - c. Suckling is Mechanical Stimulus for Neural Pathway to Hypothalamus
 - 1). Increases Prolactin-Releasing Factor (PRF)
 - 2). Decreases Prolactin-Inhibiting Factor (PIF)
3. Other Essential Hormones for Breast Development of Secretory Capability
 - a. Growth Hormone
 - b. Thyroid Hormone
 - c. Glucocorticoids
 - d. Insulin
 - e. Human Somatotropin
 - f. Human Placental Lactogen

C. Initial Secretion Called Colostrum

Clinical Note,
p.988

1. Little Fat and Less Lactose Than Milk
2. Contains Antibodies that Contribute to Passive Immunity of Infant

D. Milk Letdown

Predict Quest. 5

1. Oxytocin Secretion in response to Suckling and Higher Cortical Centers
2. Contraction of Cells Around Alveoli
3. Release of Previously Formed Milk

V. First Year After Birth, p. 989

A. Changes Related to Ongoing Development of Brain and Nervous System

1. Significant Variation from Child to Child
2. Dates are Rough Estimates Only

B. At 6 Weeks

1. Holds up Head when in Prone Position
2. Smiles in Response to People and Objects

C. At 3 Months

1. Limbs Move Apparently Aimlessly
2. Voluntarily Sucks Thumb
3. Follows Moving Person with Eyes

D. At 4 Months

1. Raises Itself by its Arms
2. Grasps Projects Placed in the Hand
3. Coos and Gurgles
4. Rolls from Back to its Side
5. Listens Quietly to Voices or Music
6. Holds Head Erect
7. Plays with its Hands

E. At 5 Months

1. Laughs
2. Reaches for Objects
3. Turns its Head to Follow Objects
4. Lifts Head and Shoulders
5. Sits with Support
6. Rolls Over

F. At 8 Months

1. Recognizes Familiar People
2. Sits up without Support
3. Reaches for Specific Objects

G. At 12 Months

1. Pulls itself to Standing Position
2. May Walk without Support
3. Picks up Objects and Examines them Carefully
4. Understands Much of What is Said to it
5. May Say Several Words of its Own

7 VI. Life Stages and Aging, p. 989

A. Extend from Fertilization to Death

1. Germinal Period
2. Embryo
3. Fetus
4. Neonate
5. Infant
6. Child
7. Adolescent
8. Adult
 - a. Young Adults
 - b. Middle Age
 - c. Older Adult / Senior Citizen
9. Death

8

B. Aging Processes Begin at Fertilization

1. Variable Rates of Cell Proliferation and Cell Loss Among Different Cell Types
2. Decline in Mitochondrial DNA Function with Age
3. Tissues Become less Plastic as Collagen Gets Cross-Linked
4. Decline in Muscular Strength After Age 20-30 yrs.
5. Decline in Cardiac Function with Advancing Age
6. Atherosclerosis
 - a. Deposition of Soft Gruel-Like Material
 - b. Subsequent Calcification and Fibrosis of Deposit = Arterio-sclerosis
7. Degenerative Changes Possible in all Crucial Organs
 - a. Ingestion/Exposure to Harmful Agents
 - b. Basic Cellular Wear and Tear
8. Nutritional and Exercise Habits may be Lost

Fig. 29.21, p.989

- 9. Loss of Immune System Functions and Increased Sensitivity to Autoantigens
- 10. Genetic Predispositions to Accelerate Aging Processes - Especially Pronounced in Progeria
- 11. General Inability to cope with Stress

8 VIII. Death, p. 991

- 1. Not Attributable to Actual Age, but to Failure of an Organ or Organ system
- 2. Usually Clinically Defined as the Point of Brain Death which Includes both
 - a. Absence of Spontaneous Respiration and Heart Beat
 - b. Isoelectric (Flat) Electroencephalogram for at Least 30 min.

IX. Genetics, p. 991

- 1. For Traits Passed From Parents to Children Inheritable Unit is the Gene

- a. Contained within Chromosomes
- b. Consists of a part of a DNA Molecule

- 2. Only 15 % of Congenital (from birth) Disorders have Known Direct Genetic Causes Clinical Note, p.992

9 A. Chromosomes

- 1. Normal Body Cells Contain 46 Total Chromosomes Fig. 29.22, p.991

- a. Two Copies Each of 23 Chromosomes
- b. 44 Autosomes (Pairs 1-22)
- c. 2 Sex Chromosomes (23rd Pair
 - 1). Females XX
 - 2). Males XY

Fig. 29.23, p.992 TA-597

- 2. Some Genetic Abnormalities (Eg. Down's syndrome) Result from Abnormal Numbers of Chromosomes

22 B. Genes

Fig. 3.30, p. 88 TA-61

- 1. Consists of a Portion of a DNA Molecule
- 2. Both Chromosomes of a Given Pair Contain Similar Genes
- 3. Genes Occupying the Same Locus are Alleles to each Other
 - a. Homozygous = the Alleles for a Particular Gene are Identical on both Chromosomes Containing the Locus for that Gene in a Diploid Individual
 - b. Heterozygous = Different Alleles for a Particular Gene Occupy the Locus for that Gene on Each of the Chromosomes of a Diploid Individual
- 4. Structural Genes Serve as Template for mRNA
- 5. Regulatory Genes Control Which Structural Genes Are Transcribed
- 1. Genome - All Genes of One Individual

Clinical Note, p.993

Predict Quest. 6

Fig. 29.24, p.994

- 2. Dominant and Recessive Genes Predict Quest. 7
- 3. Genotype VS Phenotype
- 4. Use of Punnett Square to Determine Outcome of Crosses
- 5. Carriers With Abnormal Recessive Gene
- 6. Sex-Linked Traits
 - a. Different Patterns of Inheritance Occur due to Mismatched Sizes of X and Y Chromosomes
 - b. X-Linked (Sex Linked, Recessives More Commonly Seen in Males) Hemophilia A Fig. 29.25, p.994

Other Types of Gene Expression

Fig. 29.26, p.995 TA-598

- a. Incomplete Dominance - Sickle Cell Anemia/Trait
- b. Codominance
- c. Polygenic Traits

3 A. Genetic Disorders

Table 29.4, p.996

1. Congenital Disorders

Fig. 29.27, p.997 TA-599

- a. Teratogens
- b. Mutagens

Predict Quest. 8;
Clinical Focus,
p.998

1. Cancer

- a. Oncogenes
- b. Carcinogens
- c. Genetic Predisposition

Figure 29B TA-600

A. Genetic Counseling

1. Pedigree Analysis

IMPORTANT CONSIDERATIONS: In courses with fewer class sessions this material may have to be incorporated with discussions of each organ system or included with the reproductive system discussions. If only one session is available, the instructor will have to decide whether the students being served by the course would benefit most from study and understanding of development or study and understanding of genetics. If three sessions are available then the material splits nicely into one session on prenatal development, one session on parturition, development after birth and aging, and a final session on genetics and inheritance.

Study of this topic does not have to be solely for its own sake. There are basic structural relationships among organs in the adult that make more sense when considered in light of the developmental history of the body. If instructors have been including developmental information throughout the course as each organ system was discussed in detail, then only a summary review of this topic will be required at this point.

SEE INSTRUCTOR'S MANUAL AND COURSE SOLUTIONS MANUAL FOR ADDITIONAL RESOURCES.