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Human Growth and Development

Fetal and Neonatal

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Spring 2009

University of Michigan
Medical School

Learning Objectives

- Understand aspects of normal fetal growth and causes of abnormal or insufficient growth during fetal gestation.
- Understand nutritional requirements during pregnancy and effects of insufficient nutrition on the fetus and mother.
- Understand methods for measuring fetal and infantile growth and development.
- Understand normal infant growth and developmental patterns and potential threats to each.
- Understand aspects of infant nutrition and effects of insufficient nutrition on the infant

Fetal Growth and Development

- Patterns of Growth
- Measures of Fetal Growth
- Abnormal Fetal Growth

Patterns of Fetal Growth

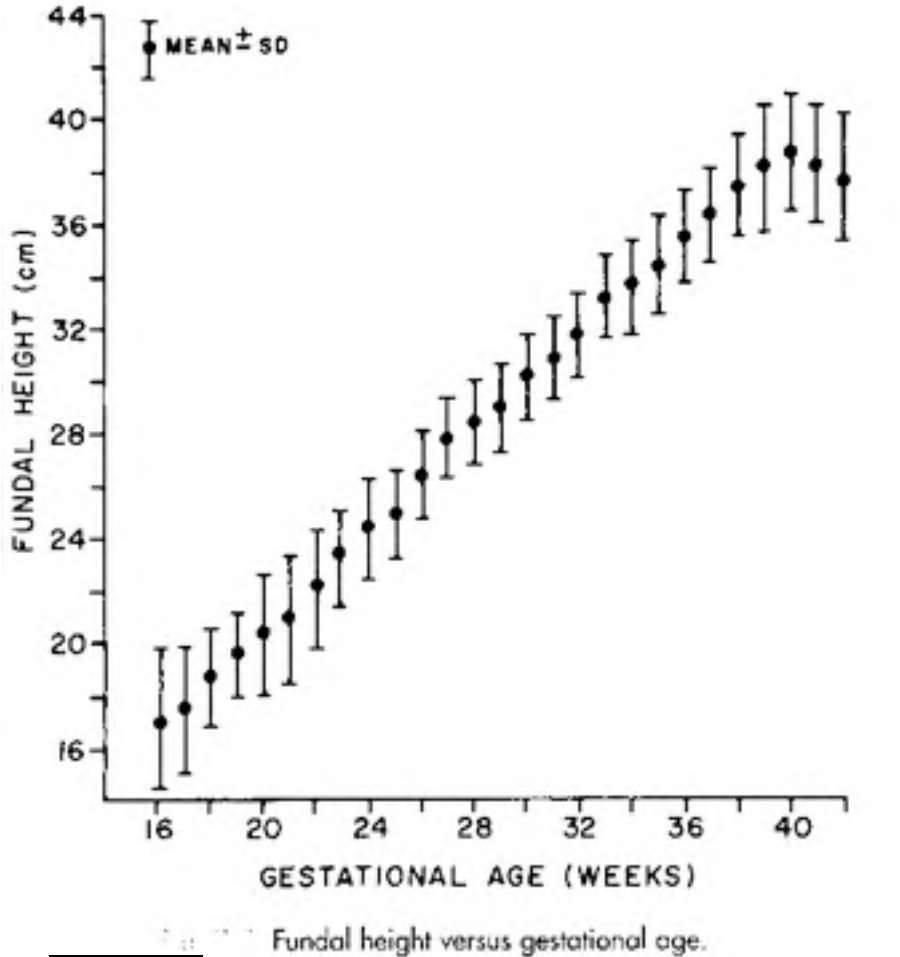
- Weeks 1-8
  - Embryonic period
- Weeks 8-20
  - Rapid growth and organogenesis
- Weeks 20-34
  - Differentiation and viability
- Weeks 34-40
  - Fat deposition

Measures of Fetal Growth

Fundal Height

- Distance from pubic symphysis to top of fundus
- Very accurate after 16 weeks gestation

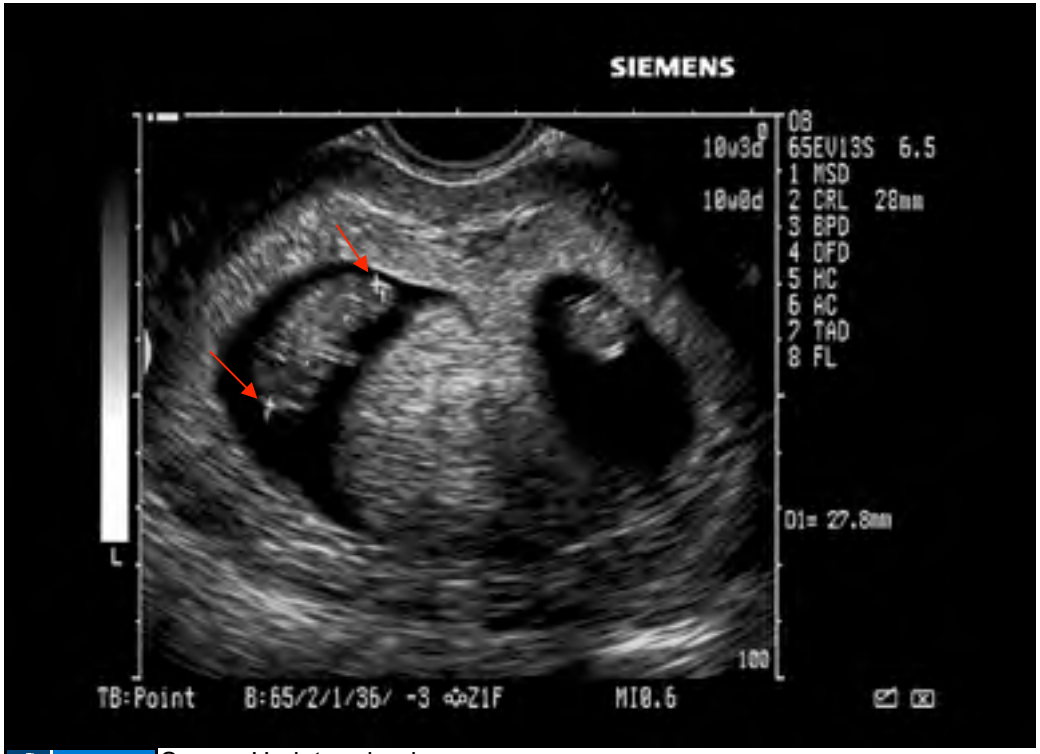
PD-INCL Source Undetermined



Fundal height versus gestational age.

PD-INCL Source Undetermined

Measures of Fetal Growth



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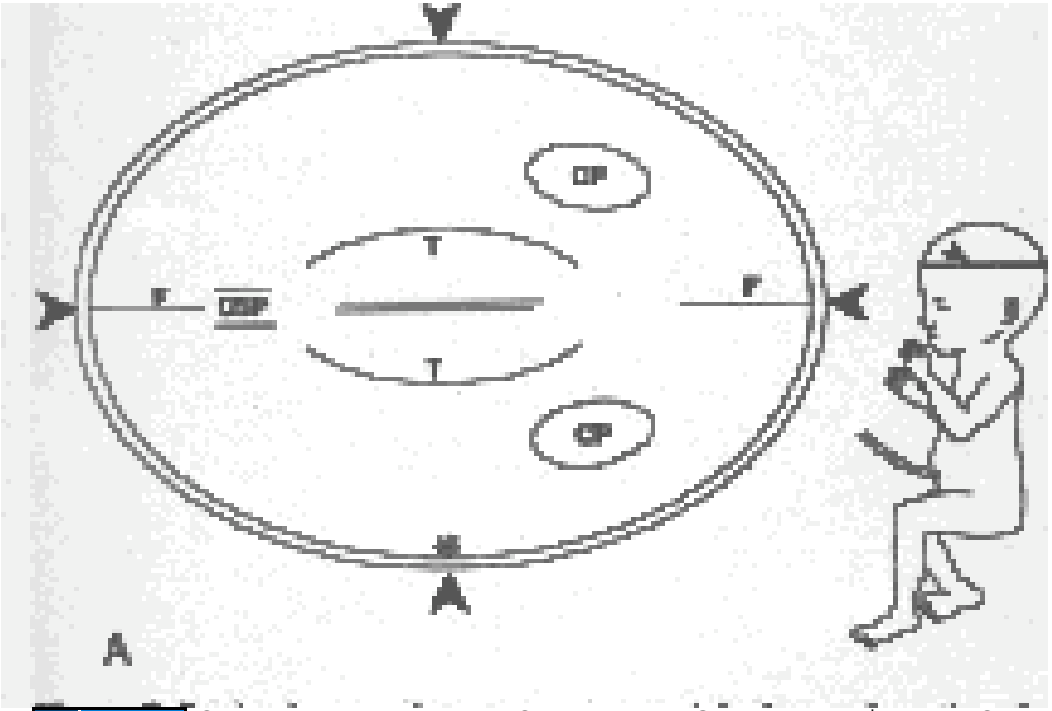
Crown-Rump Length (CRL)

- Very accurate as early as 6 weeks gestation
- CRL + 6.5 = menstrual age in weeks

Measures of Fetal Growth

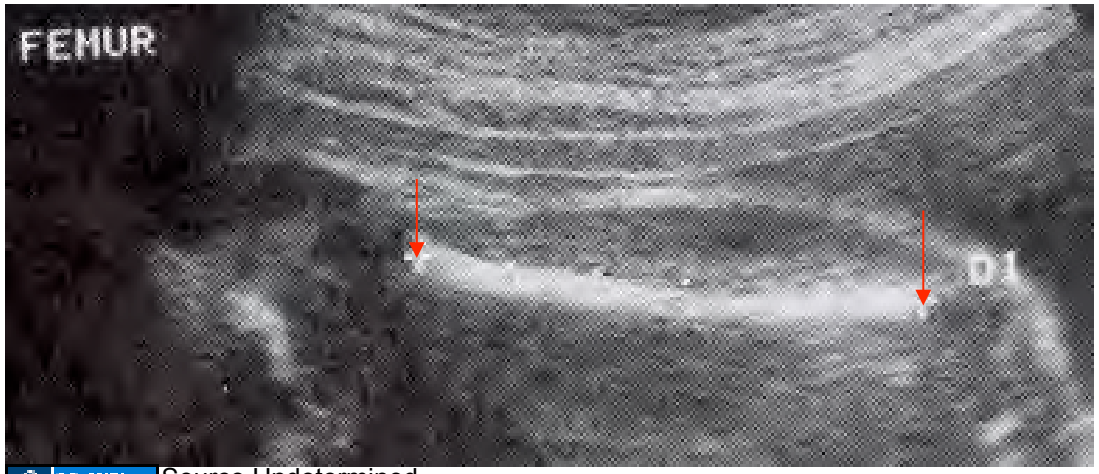


Callen. Ultrasonography in Obstetrics and Gynecology, 3rd Ed. WB Saunders Company, 1994.

Bi-Parietal Diameter

- Accurate after 12 weeks gestation
- Very accurate precursor of neonatal head circumference measurement

Measures of Fetal Growth



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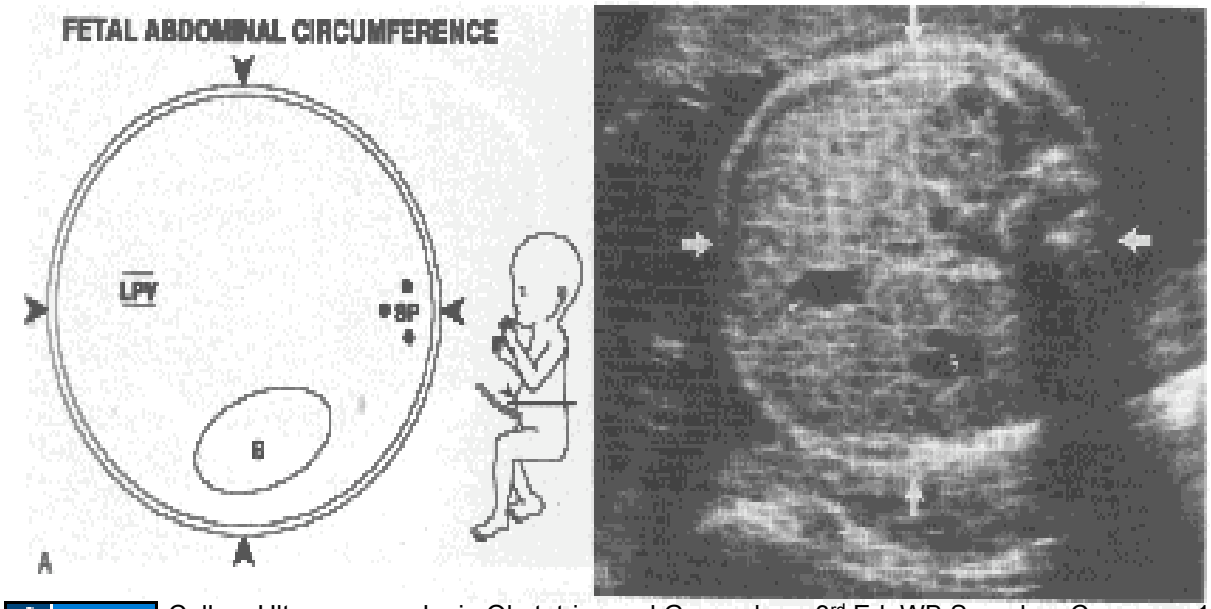
Femur Length

- Accurate after 14 weeks gestation

Measures of Fetal Growth



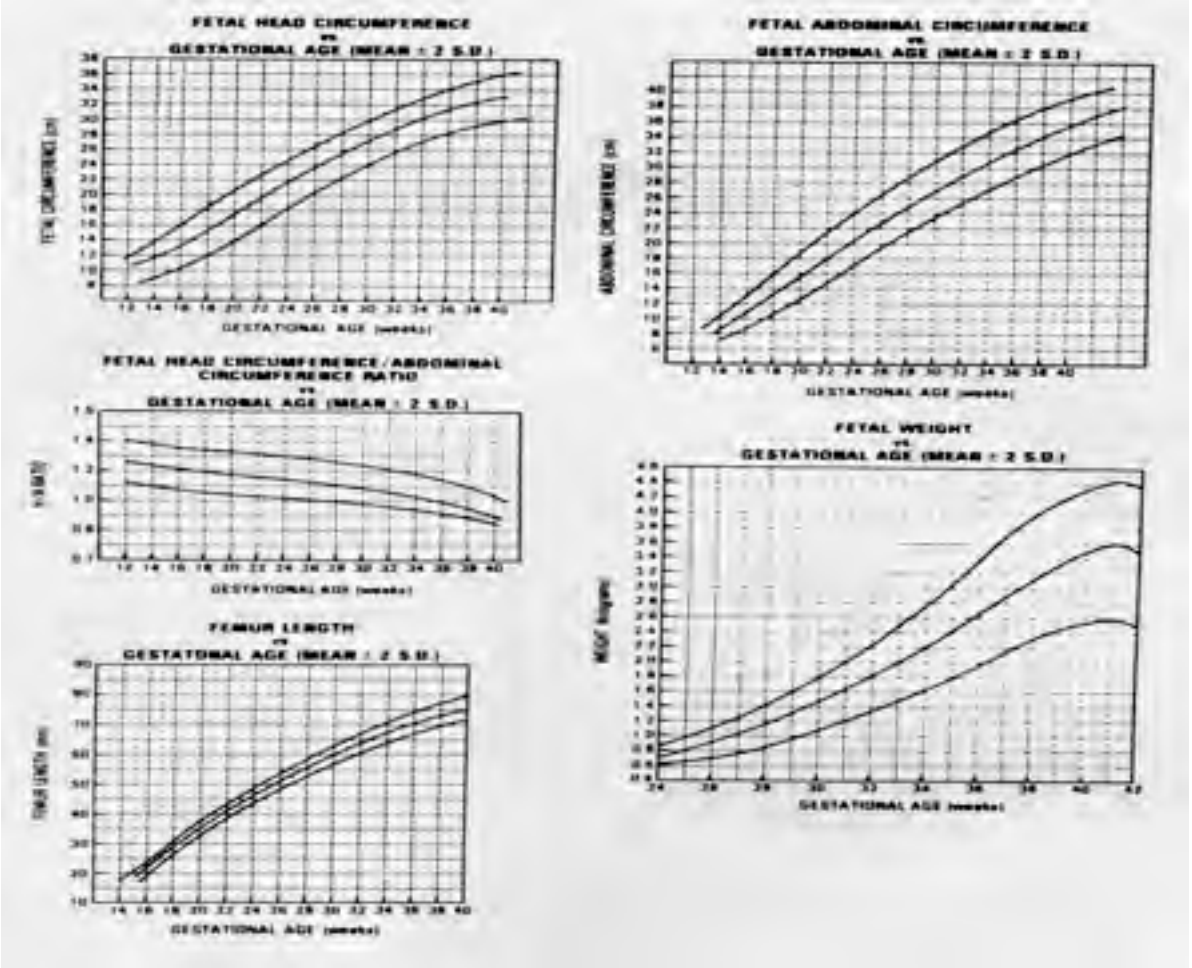
PD-INCL Callen. Ultrasonography in Obstetrics and Gynecology, 3rd Ed. WB Saunders Company, 1994.

Abdominal Circumference

- Very sensitive indicator of asymmetric growth retardation

Measures of Fetal Growth

Summary of Normal Fetal Growth Parameters



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Newer Modalities

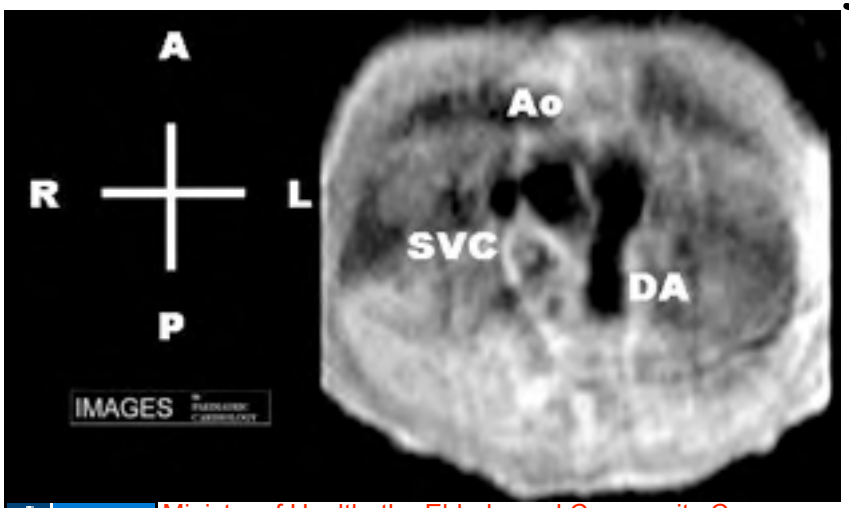
- Chorionic Villus Sampling
  - Useful modality to investigate suspected chromosomal anomalies

Original image: http://www.nlm.nih.gov/medlineplus/ency/presentations/100194_3.htm

Original image: http://www.nlm.nih.gov/medlineplus/ency/presentations/100194_5.htm

Newer Modalities

- Fetal Echocardiography



PD-INCL Ministry of Health, the Elderly, and Community Care

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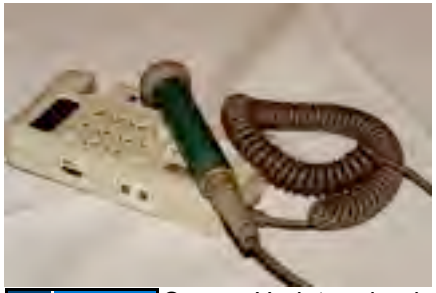

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Abnormal Fetal Growth

- AGA-appropriate for gestational age
- SGA-small for gestational age
  - IUGR-intrauterine growth retardation
- LGA-large for gestational age

Small for Gestational Age (SGA)

Definition

- Birth weight at < 5th percentile for gestational age

Cause

- unknown

Intrauterine Growth Retardation (IUGR)

Definition

- SGA with a **known cause**

Diagnosis

- Abnormal Biophysical Profile
- Clinical Obstetric Clues
- Neonatal Examination

Large for Gestational Age (LGA)

Definition

- Birth weight at > 95th percentile for gestational age

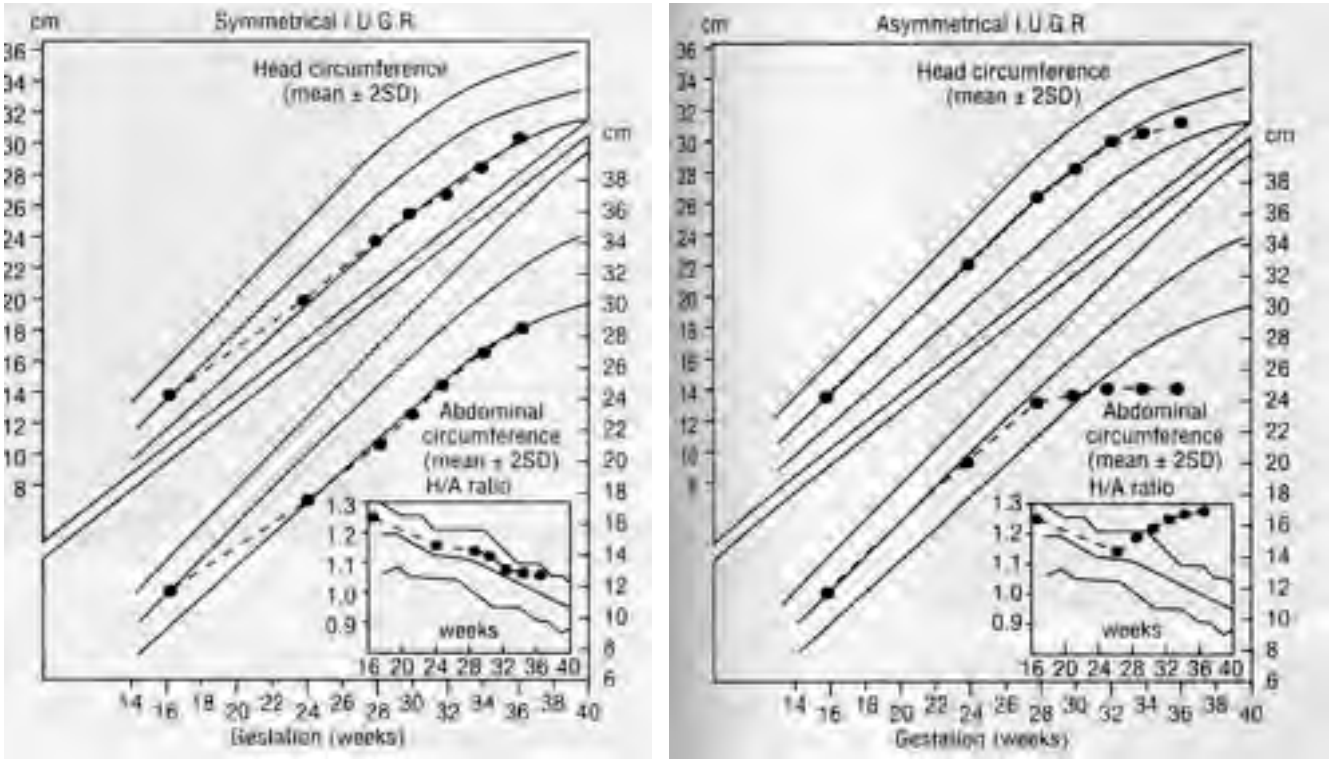
Causes

- Infant of a Diabetic Mother
- Maternal Obesity
- Cerebral Gigantism
- Genetic Disorders

PD-ANEL Source Undetermined

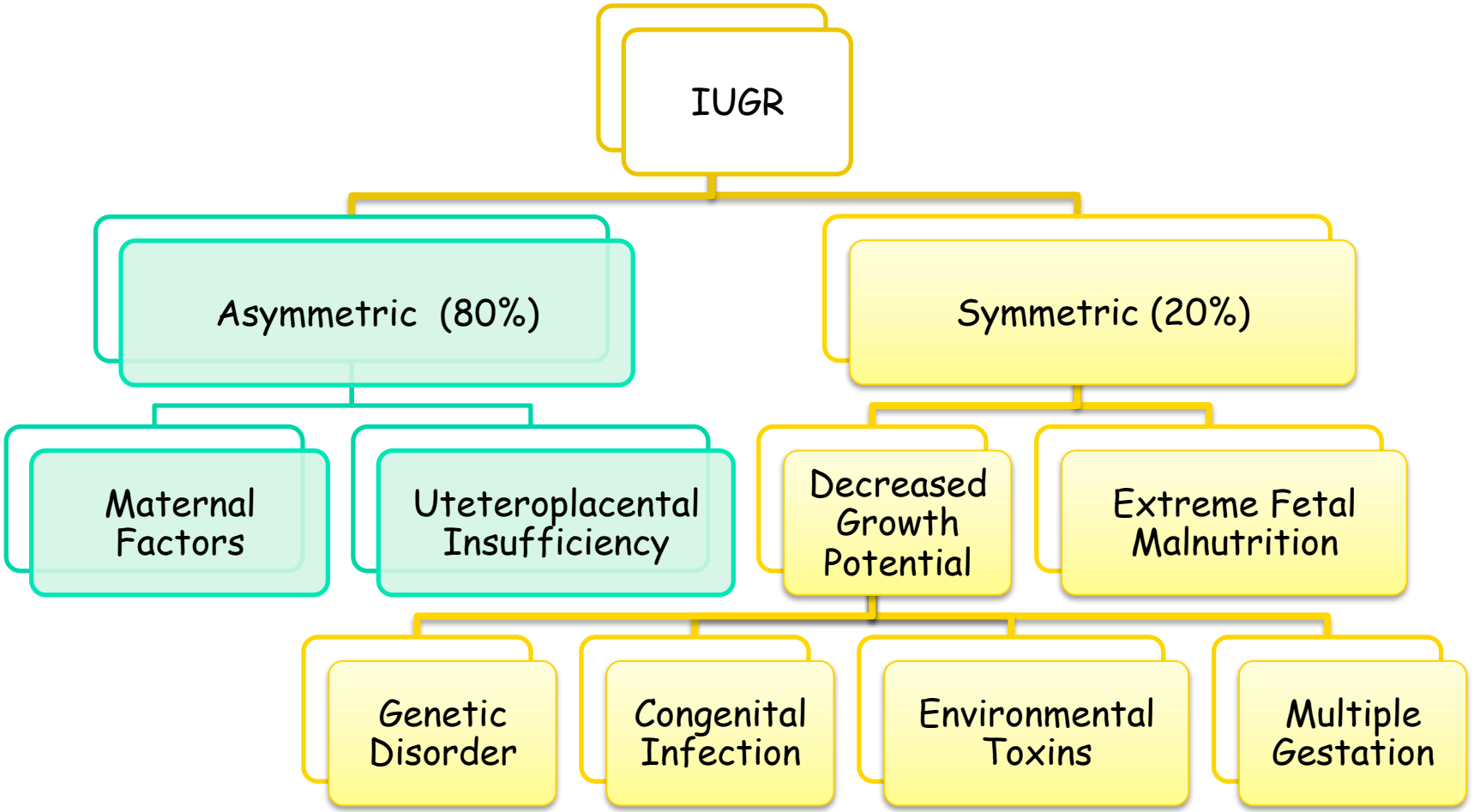
IUGR Classification

- Symmetric
- Asymmetric



PD-INCL Source Undetermined (Both Images)

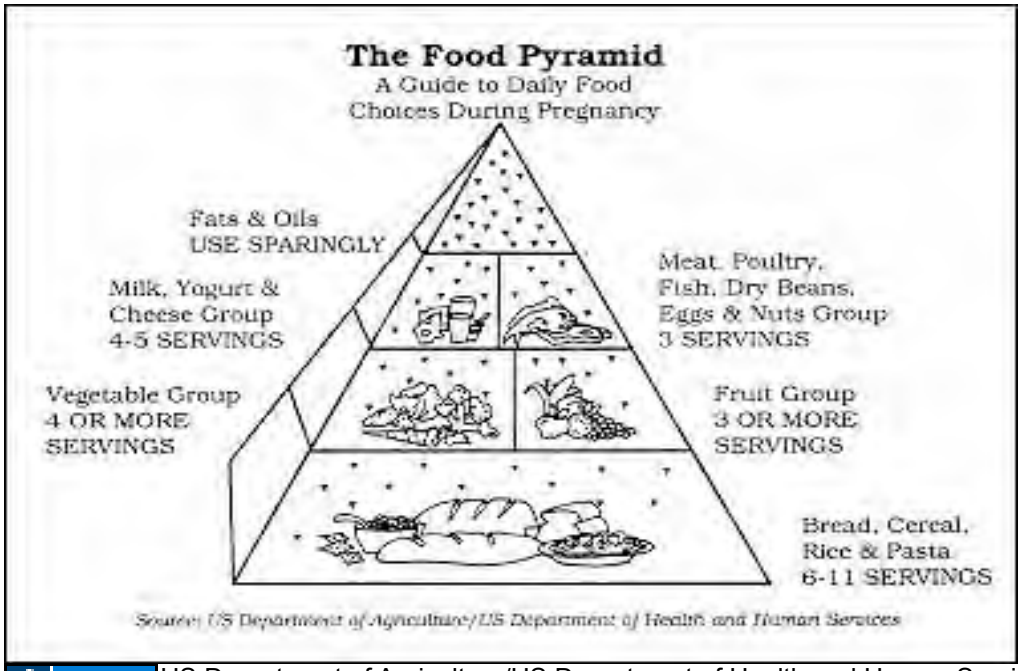
IUGR Etiologies



Asymmetric IUGR- Maternal Factors

Maternal Malnutrition

- Caloric Requirements
- Vitamin and Mineral Requirements
- Effects of Maternal Age



PD-GOV US Department of Agriculture/US Department of Health and Human Services

Prepregnancy weight and weight gain during pregnancy account for 10% of the variance in birth weights

Asymmetric IUGR- Maternal Factors

Maternal Illness

- Hypoxemia
- Hematologic/ immunologic
- Substance abuse/cigarette smoking
- Medications (anticonvulsants, antineoplastic agents)

Asymmetric IUGR- Uteroplacental Insufficiency

- Abnormal vasculature
- Chronic infection
- Ideopathic inflammatory lesions
- Placental mosaicism

Symmetric IUGR- Genetic Disorders

- Trisomy 13,18,21
- Turner Syndrome
- Achondroplasia
- Russell-Silver dwarfism
- Seckel Syndrome
- Cockayne Syndrome

Karyotype abnormalities account for about 20% of IUGR

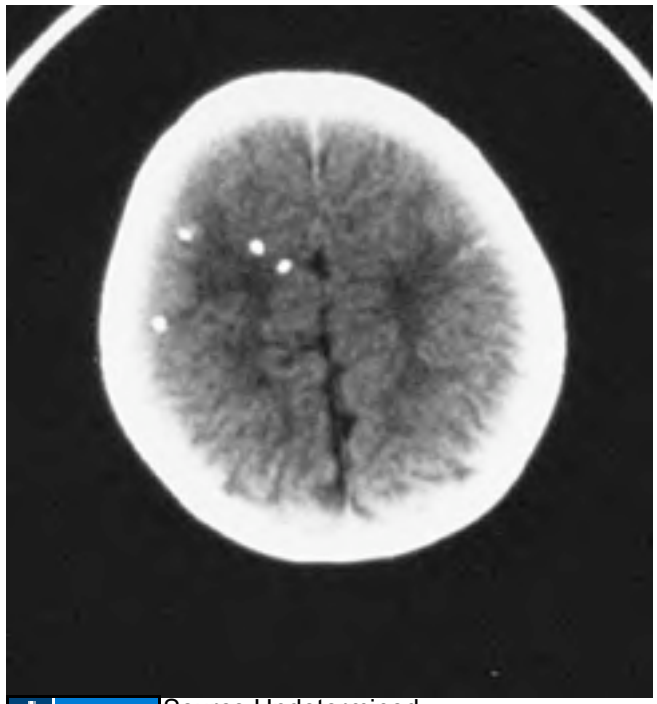
PD-INCL Source Undetermined

Symmetric IUGR- Congenital Infections

- Cytomegalovirus
- Rubella
- Toxoplasmosis
- Herpes simplex
- Syphilis
- Parvovirus
- HIV

Source Undetermined

Source Undetermined



Source Undetermined

Account for about 5% of IUGR births

Symmetric IUGR- Environmental Toxins

- Maternal Medications
- Illicit Drug Use
- Alcohol
- Cigarette Smoking

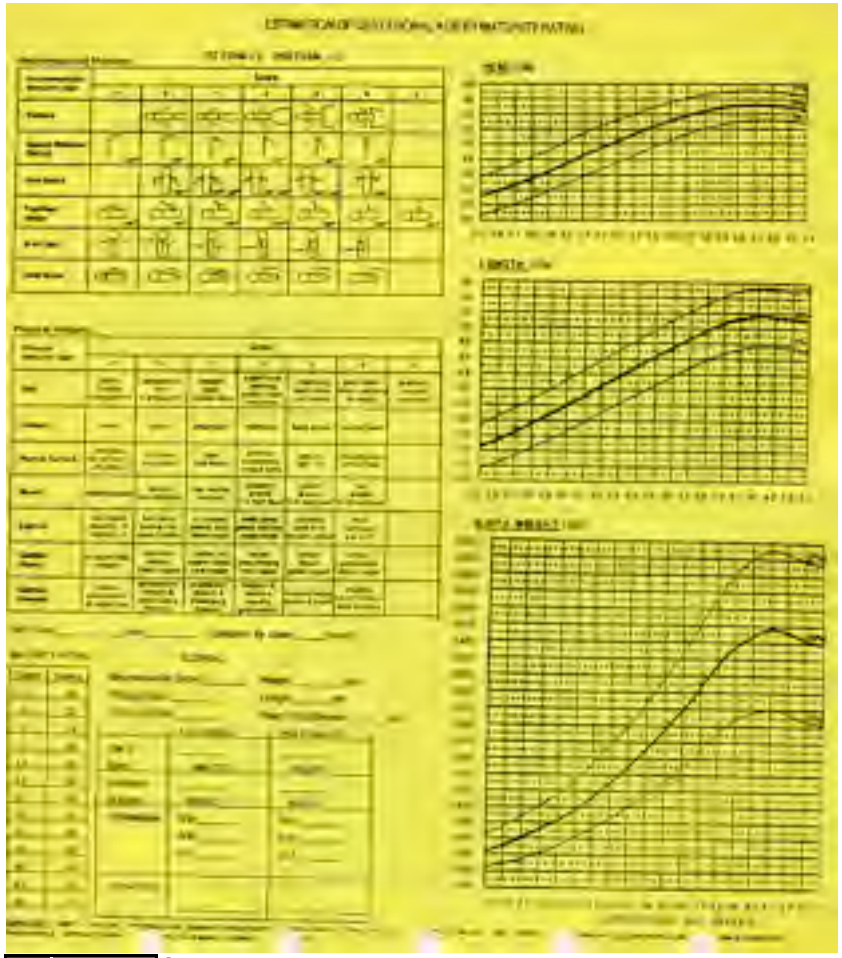
PD-INCL Source Undetermined

Infant Growth and Development

- Measures
- Normal Patterns
- Causes of Abnormal Growth and Development

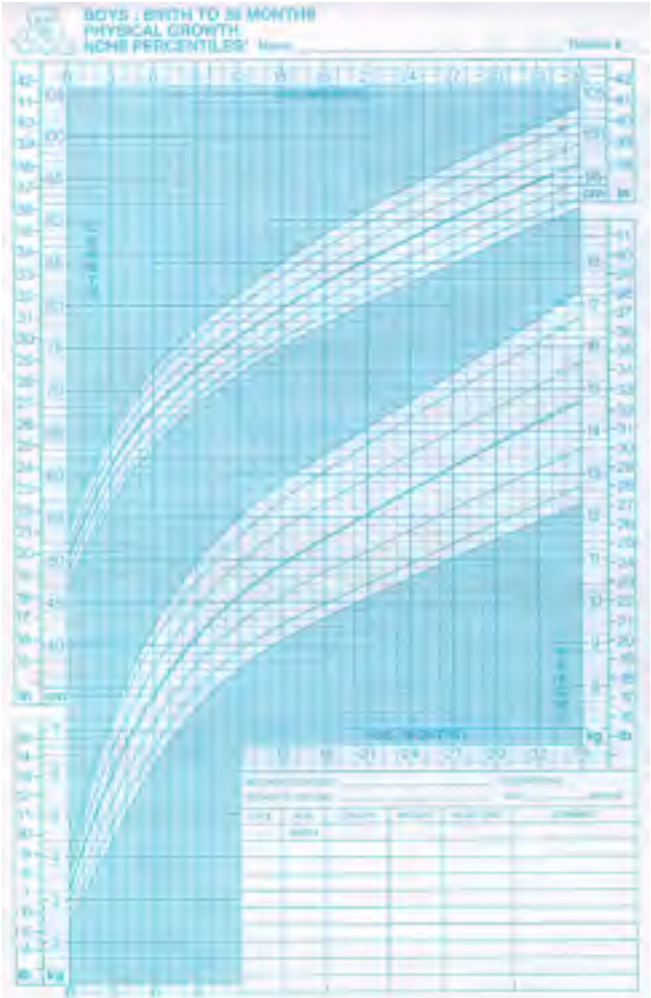
Infant Growth and Development-Measures

- Neonatal Growth Chart
- Ballard Test of Neonatal Maturity



Infant Growth and Development- Measures

- Infant Growth Chart



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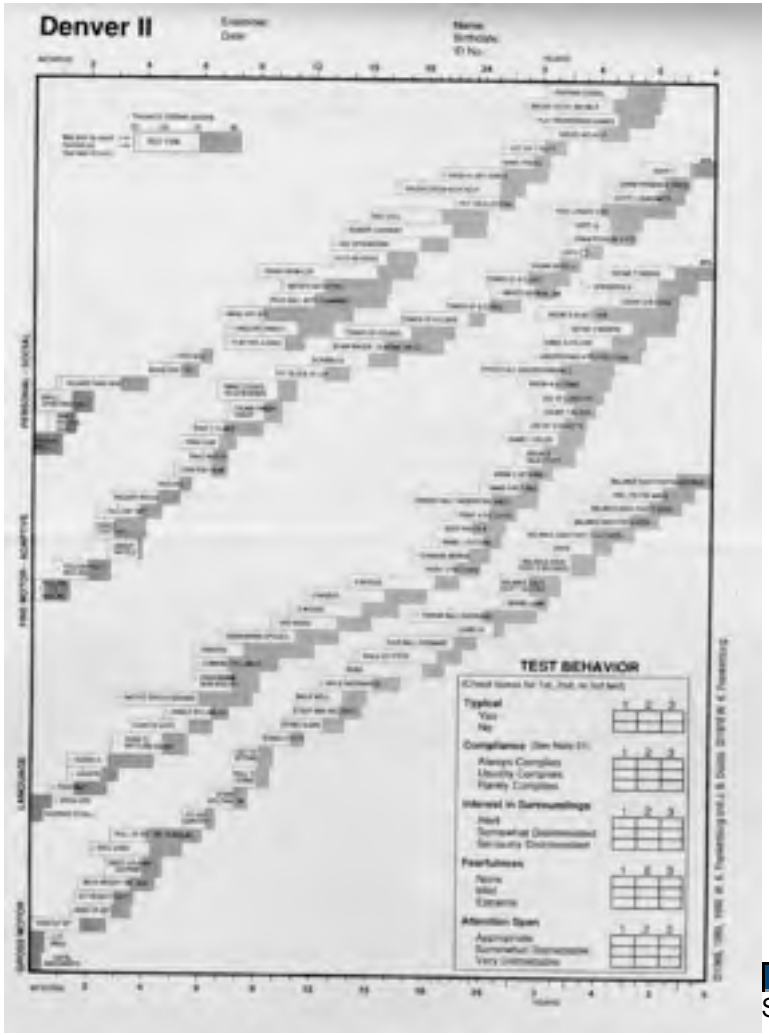
Infant Growth and Development- Measures

- Denver Developmental Screening Test II
- Bayley
- Gesell
- Battelle
- MIDI
- Ages and Stages



Infant Growth and Development

Birth Averages

- Weight: 3.2 kg (7 pounds, 7 ounces)
  normal range: 2.8-3.8 kg
- Length: 50 cm (20 inches)
  normal range: 46-54 cm
- Head circumference: 35cm (13.8 inches)
  normal range: 33 to 37 cm

Infant Growth and Development

Weight

- Initial weight gain is 15-30g/day
- 6 months: double birth weight
- 12 months: triple birth weight
- 2 years: quadruple birth weight

- 12 mo old ~ 10 kg; 5 yo ~ 20 kg; 10 yo ~ 30 kg

Head Circumference

- Will be about 80% of adult size by age 2, 90% by age 7

Infant Growth and Development

Length

- 4 years: double birth length
  13 years: triple birth length

Boy	Girl	% Adult Height
27 mo	20 mo	50%
6 yrs	5 yrs	66%
9 yr	7 yrs	75%

- adult height (adult height (girls) = 1.73 x height at age 3 years
  boys) = 1.87 x height at age 3 years

Infant Growth and Development

Normal Development

- Development is *stepwise* and progresses at a *non-linear* rate

- Domains:
  - Gross motor
  - Fine motor/Adaptive
  - Personal/Social
  - Language

Infant Growth and Development

Gross Motor Development

- Primitive Reflexes- Asymmetric tonic neck reflex (ATNR), Grasp, Moro
- Should be gone by 4-6 months of age

BY-NC-SA Mileena, flickr

BY-SA ThrasherDave, flickr

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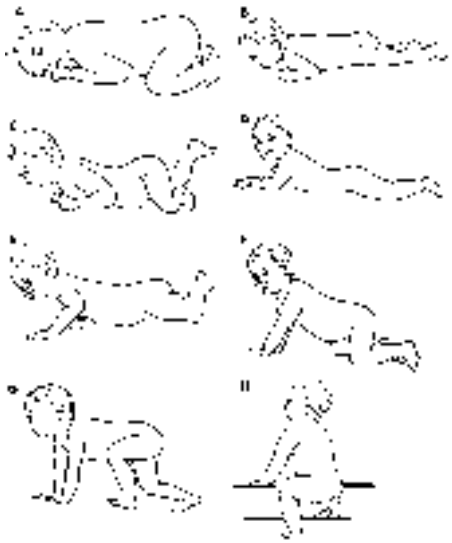
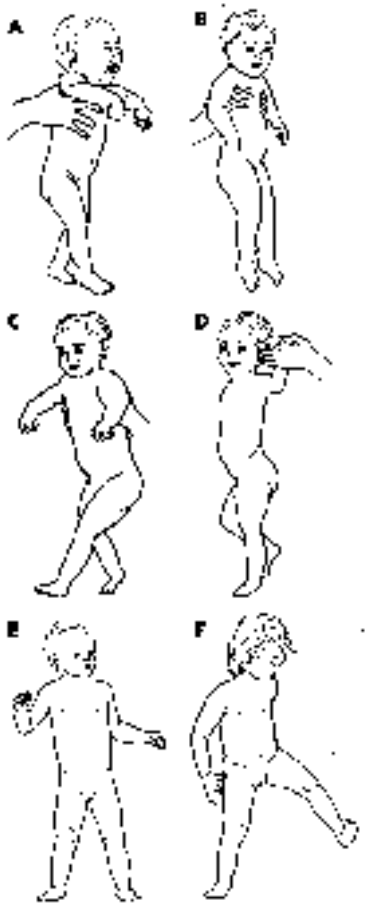
Infant Growth and Development

Gross Motor Development

- Key dates:
  - Neck control: 2 months
  - Sit without support: 7 months
  - Walk independently: 12-14 months

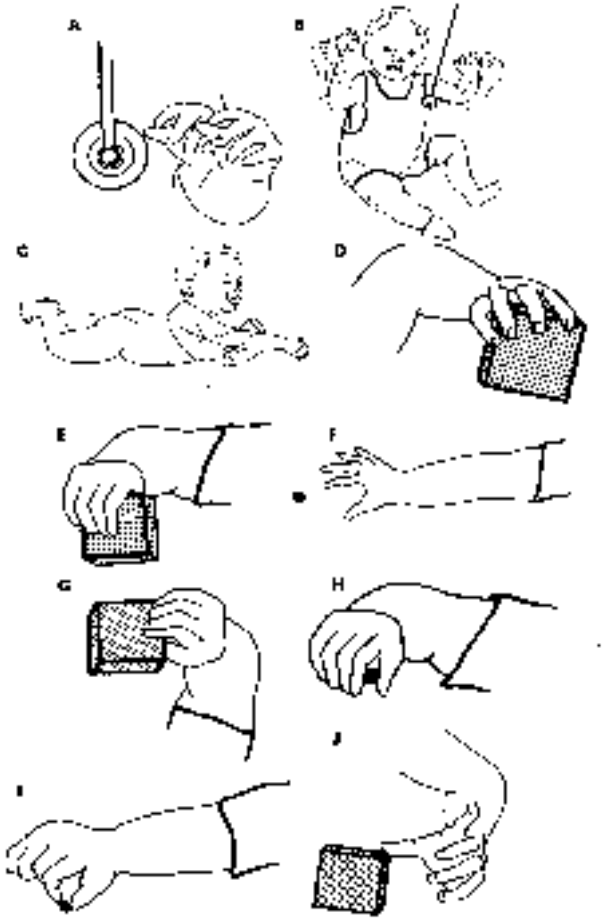




Infant Growth and Development

Fine Motor Development

- Key dates:
  - Reaches and grasps objects: 4 months
  - Fine pincher grasp: 12 months
  - Stacks blocks, sorts shapes: 15 months

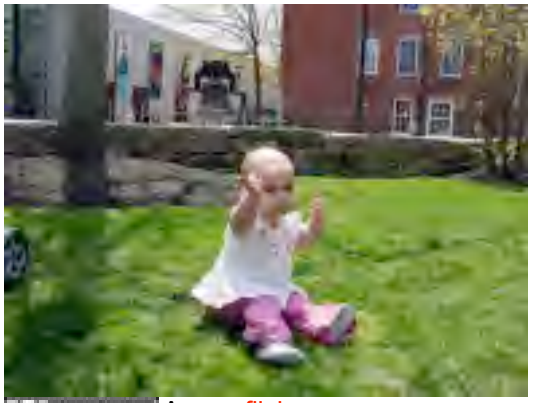


Infant Growth and Development

Personal/Social

 Ben+Sam, flickr

- Key dates:
  - Social smile: 6 weeks
  - Looks for dropped object: 6 months
  - Waves bye-bye: 10 months
  - Interactive games: 12 months



 Amos, flickr

Infant Growth and Development

Language

- Key dates:
  - Coos and fixes/follows: 2 months
  - Babbles in consonants and vowels: 6 months
  - Formed words: 12 months
  - 5-10 words: 15 months
  - 50 words: 2 years

Infant Growth and Development

Abnormalities may be caused by:

- Genetic Factors
- Organic Disease
- Environmental Exposures
- Nutritional Deficiency
- Psychosocial Dwarfism

Infant Nutrition

- Caloric Requirements
- Nutrient Sources for the Newborn
- Vitamin and Mineral Requirements
- Keys to Advancing the Infant's Diet

Infant Nutrition

Benefits of Human Breastmilk

- *Passive immunity*
  - sIgA, IgG, lactoferrin, immunomodulators
  - decreased incidence of acute gastroenteritis, otitis media, meningitis, bacteremia, UTI.

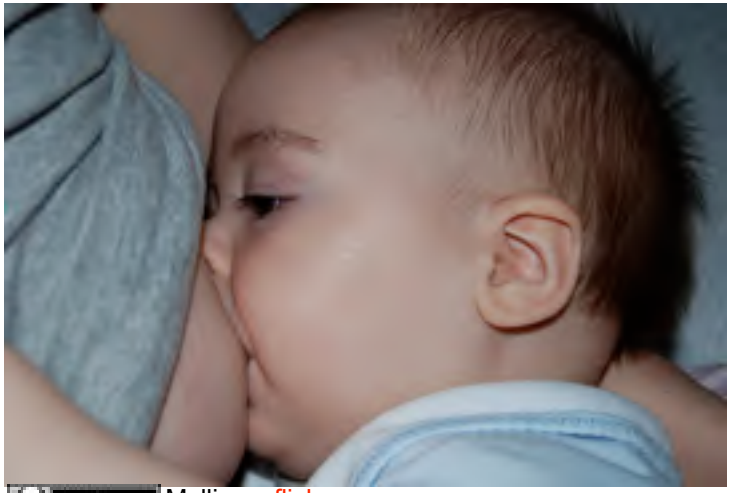
- *Species-specificity*
  - protein: lower content, higher whey:casein ratio, amino acids ideal (incl. taurine)
  - fat: long-chain polyunsaturated
  - carbohydrate: lactose

Infant Nutrition

Benefits of Human Breastmilk

- *Cost*-estimated savings $400/yr, decreased work absence due to illness
- *Bonding*-high prolactin levels may effect bonding
- *Long-term effects?*-Possible effect on incidence of atopy, SIDS, IDDM, Crohn's dz, cognitive development

- 12% of American babies are breastfed through 6 months of age



Infant Nutrition

- **Formulas** differ in carbohydrate, protein, and fat sources
- Cow's milk vs. Soy vs. Hydrolyzed Proteins vs. others

Table 4-4 Comparison of breast milk and infant formulas (nutrients per 100 calories).

	Breast Milk	Similac	Enfamil	Isomil
Protein (g)	1.54	2.14	2.10	2.45
% of calories	6	9	8	11
Source	mature term human milk	cow's milk	reduced mineral/ whey/nonfat milk	soy protein isolate
Fat (g)	5.74	5.40	5.3	5.46
% of calories	52	48	47	49
Source	mature term human milk	soy and coconut oils	palm olein/soy coconut/sunflower	soy and coconut oils
Cholesterol (mg)	22	1.6	< 1	0
Carbohydrate (g)	10.6	10.7	10.9	10.3
% of calories	42	43	43	41
Source	Lactose	Lactose	Lactose	Corn syrup
Vitamins				
Vitamin D (IU)	3.0	60	60	60
Vitamin K (mcg)	0.3	8.0	8.0	15
Minerals				
Calcium (mg)	41	73	78	105
Phos. (mg)	21	56	53	75
Iron (mg)	0.04	1.8	1.8	1.8
Renal Solute Load (milliosmolar)	11.1	14.3	14.2	16.3

Source: Department of Clinical Nutrition, Children's Hospital of Philadelphia.

Infant Nutrition-milk protein intolerance

- Colitis/proctitis
  -appears in the first few months of life
  -blood streaked stools in an otherwise healthy appearing infant
  -may have mild anemia, poor weight gain
  -usually resolve by 1 year with protein avoidance
- Enterocolitis
  -appears in the first year of life
  -bloody diarrhea and vomiting, infant may be "septic" appearing
  -90% resolve by 3 years
- Many infants cross react to soy protein

Infant Nutrition

Vitamin D

- Normally synthesized through sunlight exposure
- Important for calcium metabolism
- Not in breast milk at substantial levels
- Cases of rickets in breastfed babies have led to 2008 AAP recommendation for supplementation with 400IU VitD/ day

Infant Nutrition

Fluoride

- Fluoride strengths the tooth enamal and decreases the risk of dental caries by 20-65%
- Most municipal water sources are fluorinated
- Some controversy does exist about supplementation- excess fluoride can cause fluorosis (discoloration of teeth)

Infant Nutrition

Advancing the Infant Diet

- Water
- Starting Solids
  - 6 months
  - Cereals before Fruits/Vegetables before Meats
- Adding Finger Foods
  - 8-9 months
- Detecting Food Allergy

Health Supervision of Infants (well baby visits)

- Growth Parameters
- Developmental Assessment
- Social and Family History
- Physical Examination
- Immunization
- Disease Surveillance
- Anticipatory Guidance

all in 20-25 min!!

THE END

See you in Pediatric clinic!

Additional Source Information

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Slide 8: Source Undetermined
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