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Programming Future Generations:
Good Nutrition Throughout the Lifecycle
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Birth Defects (U.S.)

- 1 in 33 births; 120,000/yr.
- Abnormalities in structure, function, or metabolism
- 70% cannot be explained
- Genetic components
- Environmental factors
- Combination of genes and environment

(www.marchofdimes.com/printableArticles/14332_1206.asp)

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Chronic Conditions

- CHD
- DM
- HTN
- Kidney disease
- Multiple Sclerosis (MS)
- Evidence they begin in fetal life

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Growing By Leaps and Bounds

- DNA synthesis is rapid
- Genes direct the growth, development and functioning of every system
- When genetic information is faulty, then problems can occur in normal development

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Teratogens

- Alcohol
- Lead
- Toxoplasmosis
- Mercury

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Epigenetics

- Epigenetics (literally “on top of genetics”) also influences genetic information and affects growth and development *in utero*

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Epigenetics

- Gene expression is altered in response to environmental factors, but DNA is not changed (not a mutation)
- Yet, epigenetic changes are heritable, so a child's health may have been influenced by his grandmother as well as his mother

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Epigenetics and Embryogenesis

- Epigenetic changes are common during embryogenesis
- Mom's nutrition (and other lifestyle habits) influences the environment in the womb influencing the epigenomic "programming" of her child
- Some epigenetic changes can increase the risk of birth defects and chronic conditions

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Diabetes (DM): Genes Don't Explain Everything

- You must inherit a predisposition
- There must be an environmental trigger
- ID twins and type 1: the other twin has only half the chance of developing it
- ID twins and type 2: other twin has 3 in 4 chance

(www.diabetes.org/diabetes-basics/genetics-of-diabetes/html?print=t)

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Genetics and Type 2 DM

- If mom has type 2 DM, may increase the risk further than if just dad
- If both parents, chances are 1 in 2

(www.diabetes.org/diabetes-basics/genetics-of-diabetes.html?print=t)

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Type 2 DM and Obesity

- Obesity is a strong risk factor (environmental trigger)
- Incidence of type 2 DM in adolescents: 10 times what it was 20 years ago
- 17% of 12 -19 year-olds have a BMI at or above 95th percentile

(www.diabetes.org/diabetes-basics/genetics-of-diabetes.html?print=t) Ogdien et al JAMA 295(13):1549)

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**Creating an Optimal
Pregnancy Environment
The Role of Nutrition**

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Multifactorial Birth Defects

- A combination of genetics and environment
- Examples:
 - Neural tube defects (NTD)*
 - Oral-Facial Clefts*
 - Heart defects

*among the most common
(www.marchofdimmes.com/printableArticles/14332_1206.asp)

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Neural Tube Defects (NTD)

- Incidence: 1 in 1,000 pregnancies in US
- NT: embryonic structure that develops into the brain and spinal cord; in normal development, closes by day 28
- Most common NTB: Spina bifida (SB)

(U.S.Preventive Health Services Task Force, Ann Intern Med 2009;150:626-631; March of Dimes; Spina Bifida Association)

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Neural Tube Defects

- A complex disorder caused by a combination of multiple genes and multiple environmental factors including:
 - Folic acid deficiency
 - Poorly controlled maternal IDDM
 - Maternal use of certain anti-seizure meds
 - Maternal obesity

(U.S.Preventive Health Services Task Force, Ann Intern Med 2009;150:626-631)

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Neural Tube Defects: Genetics

- General population's risk: .1%
- Once you've had a pregnancy affected by a NTD, your chance in the next pregnancy is **2 - 5%**; if you've had 2 affected pregnancies, it's **10%** for the next pregnancy
- One parent with SB: about a 4% chance in the offspring
- Identical twins have NTDs more often than both fraternal twins.

[www.chg.duke.edu/diseases/ntd.htm]; AGOG Practice Bulletin, 44, July 2003 (reaffirmed 2008)]

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NTD Prevention: Folic Acid

- Most NTD occur in the absence of any positive FH.
- Women capable of becoming pregnant: 400 - 800 ug/day of folic acid
- Previous pregnancy affected by a NTD: 4000 ug/day
- Women carrying multiples; those with DM; and those with epilepsy may need more folic acid
- Low folate levels throughout pregnancy: associated with preterm birth, LBW, fetal growth restriction

(U.S. Preventive Health Services Task Force. Ann Intern Med 2009;150:626-631; Berry, R, et al. NEJM 1999;341:1485-1490)

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Oral-Facial Clefts

- Gaps in the lip and palate
- About 6,800 US babies affected yearly
- Occur about 5-7 weeks post conception
- Causes: several genes; maternal smoking, ETOH use; folic acid def.
- One preg affected by oral-facial clefts = 3% to 5% chance of having another affected pregnancy

(www.marchofdimes.com/prnec/4439_1210)

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Oral-Facial Cleft Risk and Folic Acid Intake

- Women taking multivitamins with folic acid before and during the first 2 months of pregnancy reduced the risk by one-third.

(Wilcox AJ, et al. Br Med J. January 26, 2007)

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Nutrients of Concern in the Childbearing Years

Helping Women to Close the Gaps

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Dietary Patterns of Women in the US are deficient in:

- Calcium
- Fiber
- Magnesium
- Vitamin E
- Carotenoids
- Potassium

(USDA, USDHHS. Dietary Guidelines for Americans, 2005)

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Other Nutrients of Concern:

- Folic acid
- Iron

(USDA, USDHHS. Dietary Guidelines for Americans, 2005)

- Docosahexaenoic Acid (DHA)
- Phytonutrients
- Vitamin D
- Choline

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Choline

- Essential nutrient, B-like vitamin
- CNS development, particularly the hippocampus; acetylcholine production; muscle control; liver function
- Associated with lower risk of NTD, independent of folic acid status

(Dietary Reference Intakes; Jensen, HH, et al. Experimental Biology, 2007; Shaw G, et al. Amer J of Epid, 2004;160:102-109)

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Choline

- Choline is oxidized to betaine, which is a methyl donor
- DNA methylation influences the expression of some genes and is one of the mechanisms involved in epigenetic changes

(Zeisel S, da Costa, K-A. Nut Rev 2009;67(11):615-623)

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Do Some Women Need More Choline?

- Up to 50% of the population, particularly premenopausal women, may have genetic polymorphisms that increase dietary methyl requirements, of which choline is a major source
- Current Dietary Reference Intakes (DRI) do not account for genetic variations

(Zeisel S, da Costa, K-A. Nut Rev 2009;67(11):615-623)

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Choline DRIs

- Just 10% of women, pregnant women, and lactating women consume the DRIs.
- Women: 425 mg/day
- Pregnant: 450 mg/day
- Lactation: 550 mg/day

(DRI, IOM, Jensen, HH, et al. Experimental Biology, 2007)

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Common Choline Sources

- Egg yolk, large: 125 mg
- Cooked ground beef, 3 ounces: 83 mg
- Cooked chicken, 3 ounces: 65 mg
- Cooked salmon, 3 ounces: 65 mg
- Cooked legumes, 1/2 cup: 60 mg
- Cooked broccoli or cauliflower, 1 1/4 cups: 40 mg

(USDA)

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**Docosahexaenoic Acid
(DHA)**

- LCPUFA: dominant fat in brain and retina
- Pregnant and lactating women: at least 200 mg/day of DHA
- ALA is converted to DHA, but rate is considered poor (about 1%)
- ALA supplementation has no appreciable effect on infant DHA levels and breast milk levels of DHA

(Innis, SM. Brain Res 2008;1237:35-42; Groet de RH, et al. Am J Clin Nutr 2004;79:251-259; Koletzko, et al. Br J Nutr 2007;98:973-977; Koletzko, et al. J Perinatal Med 2008;36:2-14)

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DHA

- Fish and shellfish are rich sources of preformed DHA, which gets preferential transport across the placenta and is readily available in breast milk
- Higher maternal DHA intakes during pregnancy and lactation are linked to improved vision and cognition

(Helland, et al. Ped 2003;111(1):e39-e44; Hoffman, et al. PLEFA 2009;81:151-158)

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Sources of DHA (mg)

- Salmon, coho, farmed, 3 oz cooked: 740
- Expecta Lipil, 1 pill: 200
- Blue crab, 3 oz, cooked: 196
- Tuna, light, canned, drained, 3 oz: 190
- Chicken, roasted, dark meat, 1 cup: 70
- Fortified eggs, 1 large: 50 - 150
- Fortified cheese, 1 oz: 32
- Fortified soy beverages, milk, yogurt, 8 oz: 32

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Vitamin D

- Many women in the northern part of the US, especially those of color, are at risk for vitamin D deficiency
- Overweight women are at greater risk for vitamin D deficiency

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Vitamin D and The Genesis of Multiple Sclerosis

- Nurses' Mothers' Study/35,794 pairs/16 yrs.
- Moms who reported the highest intake of vitamin D during pregnancy were 45% less likely to have a daughter who went on to develop MS than those who consumed the least.
- First study about gestational exposure to vitamin D and MS risk

(Mirzaei F. AAN 2010)

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Vitamin D

- Maternal vitamin D status (determined by 25-OH-D) largely determines vitamin D status of the fetus and newborn
- Pregnant, lactating, nonpregnant DRI: 200 IU/day (UL: 2,000 IU/day), but possibly much higher

(IOM, DRI, Wagner, CL, Greer, FR. Ped 2998:122:1142-1152)

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Iron

- Necessary for hemoglobin production, oxygen transport, fetal immunity, energy production, CNS development
- Estimated 8 million women of CB age have iron-deficiency anemia (test serum ferritin)
- Iron stores at conception are a strong indicator for iron-deficiency anemia later in pregnancy

(CDC. A Report of the CDC/ATSDR Preconception Care Work Group and the Select Plan on Preconception Care. Schmitt, T. AJCN, 2005, 81:1218S-1222S)

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Iron DRIs

- Nonpregnant: 18 mg/day
- Pregnant: 27 mg/day
- Lactation: 9 mg/day
- Iron-deficiency during pregnancy may increase pre-term delivery, LBW, perinatal mortality
- CDC: 30 mg elemental iron/day to prevent anemia and 60 to 120 mg to treat

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**Alcohol, Caffeine,
and Other Safety Issues**

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Considering Caffeine

- March of Dimes: 200 mg/day or less during pregnancy
- Trying to conceive: limit to same level?

(Weng, et al. Amer Journ Obstet Gyn 2008;198: 279.e1-279.e8;March of Dimes)

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Common Caffeine Sources

- Starbucks coffee, 16 oz: 330 mg
- Einstein Bros coffee, 16 oz: 300 mg
- Foosh Energy Mints, 1: 100 mg
- Red Bull, 8.3 oz: 75 mg
- Mountain Dew, 12 oz: 71mg
- Diet Coke, Coke, 12 oz: ~50 mg
- Tea, 8 oz: 47 mg

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Alcohol: No Amount is Safe

- No alcohol during pregnancy and when trying for a baby
- Moderate drinking (1/day) may lengthen time to conception
- Drink = 12 oz regular beer OR 5 oz wine; OR 1 1/2 oz 80-proof distilled spirit

(March of Dimes. Drinking Alcohol During Pregnancy; NIH. Fetal Alcohol Syndrome)

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Alcohol's Lasting Effects

- Interferes with cell differentiation in the first trimester
- Deprives fetus of oxygen and nutrients
- Causes irreparable harm that lasts a lifetime

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Fetal Alcohol Syndrome (FAS)

- Leading cause of Mental Retardation in the US
- Learning disabilities
- Birth defects
- Behavioral problems
- Emotional problems

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Fish Safety

- Avoid methylmercury, PCBs, dioxin
- FDA: 12 ounces of lower-mercury fish a week, such as shrimp, canned light tuna, salmon, sardines, catfish
- Limit white tuna to 6 ounces/week
- EWG: www.ewg.org/safefishlist

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Maternal Overweight and Obesity
Setting the Stage For Childhood Obesity?

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Prevalence of Overweight in Women of Childbearing Age

- Pre-pregnancy overweight is at an all-time high
- About **60%** of women of CB age are overweight (BMI ≥ 25); **34%** are obese (BMI ≥ 30)

[Flegal, et al. JAMA 2010;303(3)]

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Maternal Adiposity at Conception

- Associated with greater fat mass in infants at birth and subsequent overweight in children
- BMI ≥ 30 : Increased risk of structural defects, including NTD, heart defects, hypospadias, limb reduction defects
- Increases the risk of post-partum weight retention

(Oken, et al. Am J Obstet Gynecol 2007;196:322.e1-322.e8; Rasmussen, et al. Am J Obstet Gynecol 2006;195:611-19; Waller, et al. Arch Pediatr Adolesc Med 2007;161:745-50; IOM, 2009)

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**Weight Gain During
Pregnancy**
Reexamining the Guidelines
Institute of Medicine, 2009

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New Weight Guidelines

- Rising obesity rates in women of CB age since last edition (1990)
- Large proportion of women with excessive gestational weight gain (GWG)
- Strength of the evidence linking GWG to pregnancy outcomes

(IOM, 2009)

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**Criteria for Classifications of Pre-pregnancy
Weight Status**

Body Mass Index (kg/m ²)	
Underweight	<18.5
Normal	18.5-24.9
Overweight	25.0-29.9
Obese	≥30

(IOM, 2009)

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Recommended Weight Gain for Pregnant Women (in pounds)

Prepregnancy BMI (kg/m ²)	Recommended Weight Gain (singleton)	Recommended Weight Gain (twins)
<18.5	28 to 40	N/A*
18.5-24.9	25 to 35	37 to 54
25.0-29.9	15 to 25	31 to 50
≥30	11 to 20	25 to 42

* No guidelines were established based on lack of sufficient data. (ICM, 2009)

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Birth Weight and Chronic Conditions

- IUGR followed by rapid post-natal catch up growth associated with CHD, stroke, DM, HTN
- Macrosomia: DM, CVD

(www.who.int/nutrition/topics/4_dietnutrition_prevention/en/print.html)

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Primed for Pregnancy

The Importance of Preconception Planning

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**Recommendations to Improve
Preconception Health and Health Care
(2005)**

- Details the goals of preconception care for an estimated 62M American women ages 15-44
- Emphasizes the critical role of all health care providers who routinely treat women
- Nutrition and weight control cited as important prior to pregnancy

(CDC. A Report of the CDC/ATSDR Preconception Care Work Group and the Select Plan on Preconception Care)

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Be Prepared for Pregnancy

- Nearly 50% of pregnancies in US are unexpected or mistimed; fetus is highly susceptible to birth defects and other problems during the first 8 weeks
- Women with unintended pregnancies are less likely to seek early prenatal care and are more likely to expose the fetus to noxious substances and inadequate folic acid

(AAP/ACOG; Brown and Eisenburg, eds. 1995)

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Future Mom's To-Do List

- Get a check-up.
- Achieve a healthy weight before pregnancy and gain the appropriate pounds based on prepregnancy BMI.
- Eat a balanced diet with adequate nutrients, including folic acid, vitamin D, choline, and iron.
- Take a daily multivitamin.

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Future Mom's To-Do List

- Cut out noxious substances: alcohol, medications, cigarettes, second-hand smoke, herbal supplements, etc.
- Avoid unsafe foods.
- Avoid contact with cat's litter box.
- Avoid rodents, hamsters, mice, guinea pigs.

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Resources

- www.ghr.nlm.nih.gov/handbook
- www.migeneticsconnection.org
- Expect the Best, Your Guide to Healthy Eating Before, During, & After Pregnancy (Wiley, 2009)
- www.expectthebestpregnancy.com
- Contact: elizabethwardRD@gmail.com
