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Critical Issue Report: That First Step

That First Step: Organic Food and a Healthier Future

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It's hard to overestimate the importance of this report, exploring practical ways to start turning the tide on some of our most urgent health issues.

When I started in pediatric practice, it was unusual to see a child with high blood pressure, high blood glucose, high triglycerides, low HDL, and/or increased waist size of 38 inches or more. These were all conditions of middle age. Together, these major heart disease risk factors make up metabolic syndrome, an important concept explored in this report.

Stunningly, today about two-thirds of U.S. teens already have at least one of these middle age conditions, according to a study of almost 2,000 children aged 12 to 19 (de Ferranti et al., 2004). About 1 in 3 of all overweight or obese kids age 12 to 19 already have full-blown metabolic syndrome. Not only is it harder for these children to exercise, it's harder for them to lose weight even if they do. It's far better and easier to prevent insulin resistance than to treat it. Still, those kids who have already developed metabolic syndrome need focused help today to prevent a downward spiral that will only worsen with time. For the reasons explained in this report, those with metabolic syndrome are at very high risk for developing unhealthy arteries, heart disease, and Type 2 diabetes.

In the recent past, Type 2 diabetes was called adult-onset diabetes because this obesity-related condition was also a problem of the middle-aged and the elderly. It usually takes years of unhealthy eating to tip someone into this type of diabetes. It was rarely seen before age 30 or even 40.

Sadly, today we do see Type 2 diabetes in children. A family I saw last week had a 10-year-old who already had it. Pediatricians across the country are having similar experiences. But until a recent significant study none of us knew exactly how large the problem had become.

A huge study of millions of kids revealed for the first time the true extent of Type 2 diabetes in children in the United States. The results appeared in the June 27, 2007 *Journal of the American Medical Association* (*JAMA, 2007*). Today 22 percent of all diabetes diagnosed in US children is Type 2. And in kids aged 10-19, Type 2 diabetes was more common among some groups of kids than Type 1 (previously called juvenile diabetes)

The message is clear: Overweight, obesity, and diabetes are among our nation's most urgent health problems. It's time to feed our kids healthy amounts of healthy foods and to ensure that they get a liberal dose of active play every day. This important report goes a step further and explores six mechanisms by which organic food and farming can give the added edge we need to slow and reverse the rise of these profound problems.

Beyond this, it has been my experience for myself, my family, and for many families I work with, that choosing organic food is indeed the first step on a path toward a healthier lifestyle. Paying attention to the food that goes in our bodies is an excellent place to start.

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EXECUTIVE SUMMARY

Organic food and farming can help slow, and potentially reverse the rising incidence of overweight, obesity, and diabetes through six principal mechanisms.

Starting Out

Three of these mechanisms are grounded in the human reproductive cycle. In the months before a child is conceived, during fetal growth, and through adolescence, a well-balanced diet composed of ample organic fruits and vegetables, and dairy and grain products will:

1. Promote healthy patterns of cell division and differentiation, and lay the groundwork for normal endocrine system regulation of blood sugars, lipids, energy intake, and immune system functions.

2. Establish and help sustain taste-based preferences in the child for familiar nutrient-dense, flavorful foods.

3. Largely eliminate dietary exposures to approximately 180 pesticides known to disrupt the development or functioning of the endocrine system.

An expecting mother's diet just before and during pregnancy directly controls the adequacy of the nutrients available to the developing embryo and fetus and also plays a major role in determining how many toxic chemicals are present in amniotic fluids, and whether the levels approach those capable of blocking normal development.

Changes in the embryo and during fetal development can lead to abnormal patterns of cell differentiation and gene expression. These sorts of changes are called epigenetic, and entail deviant gene expression patterns that alter the developmental and health trajectories of individuals, without altering underlying DNA.

Mounting evidence links exposure to endocrine disrupting chemicals, including dozens of pesticides, to epigenetic changes that predispose a person to face, later in life, the challenges of living with overweight, obesity, and diabetes. In addition, science has now convincingly proven that, in the case of epigenetics and human development:

The timing of exposures is just as important, and in some cases more important than the dose levels delivered to the developing embryo and fetus.

In 1993 when Dr. Theo Colborn and colleagues published the first list of endocrine disrupting chemicals, it contained 35 pesticides representing about 20 percent of the commercially important pesticide products at that time. An updated 2009 list provided by Dr. Colborn includes 180 pesticide active ingredients. Well over half the important pesticides used by farmers in the U.S. and globally are on the list. Most Americans are exposed to four to seven of these chemicals on a near-daily basis.

The Rest of Life

During adolescence and adulthood, and as we age, nutrient-dense, organic foods high in phytochemicals can contribute to weight management and prevention of diabetes, while also lessening or delaying the complications linked to both. Organic food and farming may help do so by:

4. Possibly helping to trigger or reinforce a sense of satiety, or fullness, thereby reducing excessive caloric intake.

5. Lessening or limiting the cellular and genetic damage done by reactive oxygen species (so-called free radicals), and in this way reducing the risk of diabetes and other diseases rooted in inflammation (arthritis, cardiovascular disease) and rapid cell growth (cancer).

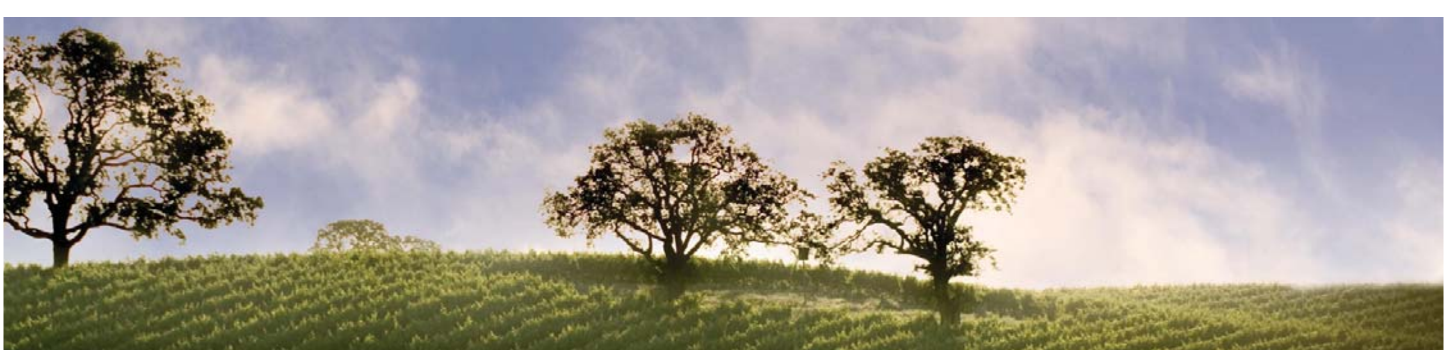
6. Slowing, and perhaps even reversing certain neurological aspects of the aging process, leading to better memory and retention of cognitive skills.

One phytochemical in particular – resveratrol – has captured the attention of scientists and the food industry. This stilbene, a polyphenolic activator of a key regulatory protein, mimics the effects of calorie restriction in lower organisms. Moreover, the most potent analogue of resveratrol has actually reversed neurological aging in animal studies, leading some to wonder if resveratrol is the source of the mythical "Fountain of Youth."

Several studies have shown that organic farming enhances resveratrol levels in red grapes by, on average, about 30 percent. Conventional farming can do the opposite. One study focused on five Muscadine grape cultivars managed using a typical, nine-spray fungicide disease control program, in contrast to an organic system. In one variety, the harvested grapes that were sprayed with fungicides contained one-fifth the concentration of resveratrol, compared to the grapes from vines under organic management. The resveratrol levels in the organic grapes grown from two other cultivars were about three-fold higher.

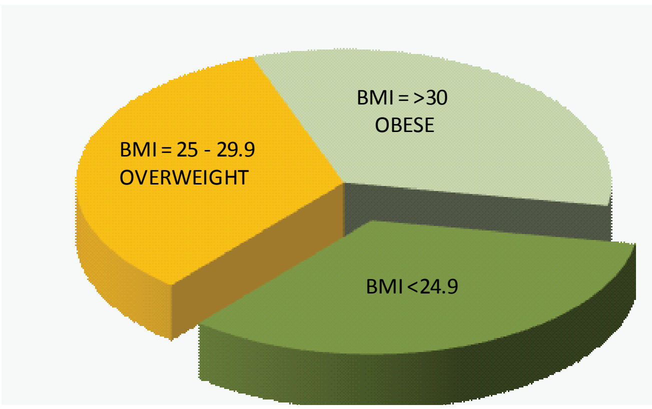
In this study, the ability of the organic grape vines to fight off the adverse impacts of plant pathogens through biosynthesis of resveratrol was nearly comparable to vines treated nine times with fungicides.

Higher levels of dietary intakes of certain phytochemicals have also been shown to help preserve sensitivity to insulin, a key step in preventing pre-diabetes from progressing to full-fledged diabetes.



In helping manage blood glucose levels and promoting cardiovascular health, organic food and farming delivers benefits in two important ways. It exposes people to fewer of the endocrine disrupting chemicals that can set off the disease process and trigger epigenetic changes, and second it delivers higher daily intakes of health-promoting phytochemicals that reinforce the body's defense and repair mechanism.

Scope of the Challenge



Weight distribution of U.S. adults (CDC)

The magnitude of this problem is unmistakable and immense. About one-third of adults 20 to 74 years of age in the United States are obese (Body Mass Index[1] ≥ 30) and another third are overweight (BMI 25.0 to 29.9). The Centers for Disease Control and Prevention (CDC) reports that the number of obese people (about 34 percent) now outnumber those who are overweight (about 33 percent).

Overweight and obesity are also rising among children, setting the stage for far more cases of Type 2 diabetes, and cases that strike earlier in life, leaving more time for the insidious complications of diabetes to erode well being and drive up health care costs.

If current obesity trends continue, by the year 2030, experts expect that over 85 percent of adults will be overweight or obese, and over one-half will be obese. In fact, if current trends are not successfully altered, all Americans would be overweight or obese by 2048.

Diabetes is a serious condition associated with overweight and obesity. The CDC reported that the rate of new diabetes cases nearly doubled over the last decade, reaching 9.1 new cases per 1,000 persons between 2005 and 2007.

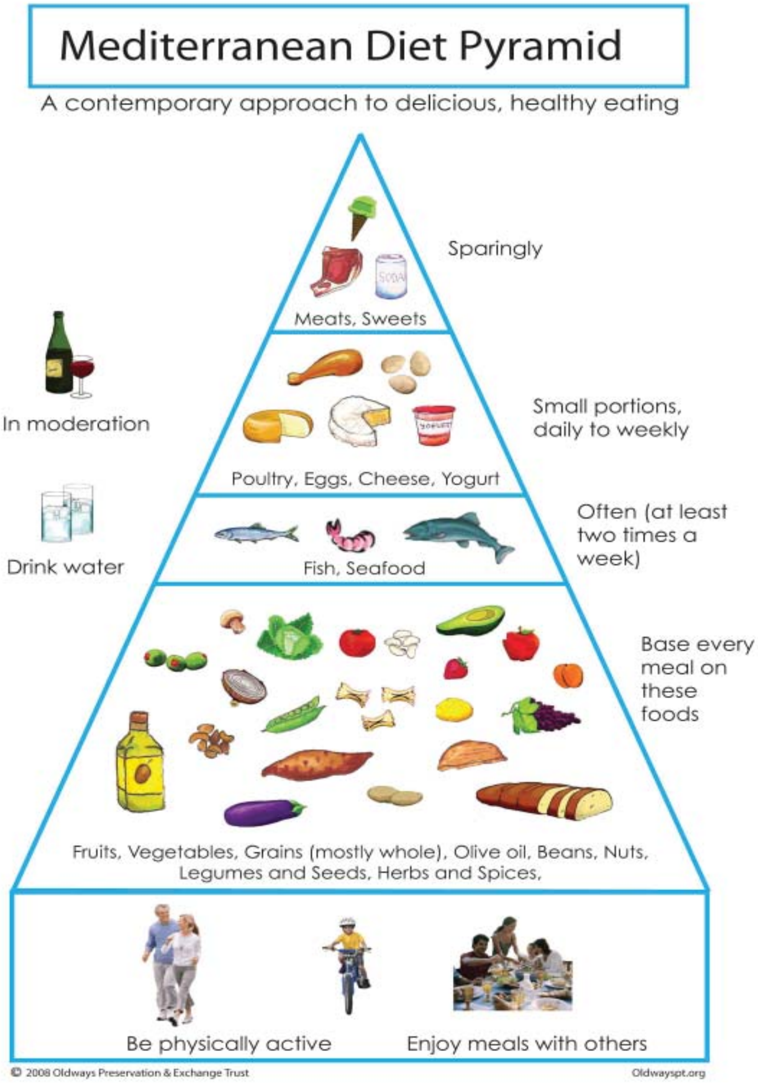
Total health care costs attributed to obesity/overweight and their complications are projected to double every decade to nearly $1 trillion in 2030, accounting for 16-18 percent of total U.S. health care costs.

Turning the Tide

The upward trend in overweight, obesity, and diabetes must be stopped and then reversed in order to offer any hope that the health and longevity of the baby-boomer generation will equal that of the previous generation. Achieving this goal is a public health, fiscal, and human imperative.

Clearly, no silver bullet will get this job done. There will be no single pill or medical breakthrough, no unique change in policy or education programs, no diet, nor a revolution across the food industry that will turn the tide on overweight, obesity, and diabetes. Substantial changes will be required in all these arenas. While the secret to success will differ across individuals, substantial and sustained progress depends, most fundamentally, on changing people's attitudes and behaviors about food, exercise, and balancing food energy intakes to not exceed food calories burned.

[1]Body Mass Index (BMI) is calculated by dividing an individual's body weight in kilograms by the square of his or her height in meters.



The good news is that relatively modest changes in exercise and food consumption patterns could dramatically alter the trajectory of current trends, especially among young people and those moving toward, but not yet into the overweight zone. A net reduction in excess caloric intake of 100 to 200 calories per day would, according to some experts, stop the progression to overweight among as many as 90 percent of Americans.

Most adults ingest 2000 to 2500 calories daily. Accordingly, a 5 percent to 10 percent reduction in caloric intake would get the average person at least halfway to the goal line. Accomplishing such a reduction could be achieved by cutting back on portion size by three or four bites during a meal, drinking an 8 ounce glass of water instead of a 12 ounce soda, or replacing a sweetened, energy-dense dessert with a serving of fresh fruit.

Burning an extra 100 calories a day is not a daunting task for most Americans. Walking for an extra 15 minutes a day, or about 2,000 to 2,500 steps, gets the job done for most people, as would walking up three flights of stairs instead of riding the elevator, growing a garden, riding a bike, walking the dogs or bowling. The list goes on.

Other steps in the right direction are described at the end of both Chapters 1 and 4. Practical and proven steps include: emphasizing — and enabling — sound dietary choices in food and nutrition programs and policies, including access to fresh, local and organic produce and organic dairy products.

A shift toward a Mediterranean diet (see figure on this page) would also benefit many Americans, as discussed in Chapter 4. The evidence is strong that eating more foods from the bottom of this contemporary Mediterranean diet "pyramid" will deliver health benefits.

Maternity leave policy in the U.S. should include economic incentives (e.g., paid maternity leave) so that women need not choose between careers, keeping food on the table and what is best for their newborn children.

Such policies are already the norm in most other developed countries in the world. This change in policy is acutely needed for non-affluent women and women with inflexible work schedules.

It is also important to point out what won't work. For people now consuming too many calories and making poor dietary choices, switching to organic versions of the same foods will do little good in combating overweight and diabetes. People engaging in unhealthy lifestyles, or who are under merciless stress and lack adequate sleep, may experience some improvements in health from switching to organic food, but major improvements will likely be constrained by these other negative factors.

The First Step is the Most Important

We have drawn upon over one-hundred fifty scientific studies in this report in describing six mechanisms through which organic food and farming can undermine, to one degree or another, the factors leading to ever-higher rates of overweight and diabetes in the United States. We must conclude, however, by acknowledging there is essentially no peer-reviewed science exploring or documenting what may be the most important mechanism of all.

Reams of consumer research show that the conscious decision by an individual to first seek out and purchase organic food is usually motivated by a personal desire to improve one's own health and/or the health of family members.

Forging a new relationship with food is ***the*** critical first step that every dietitian, doctor, educator, and concerned friend is searching for as they interact with a person headed toward or already contending with overweight and diabetes.

We see anecdotal evidence in the nutrition education literature and consumer surveys that the decision to start purchasing organic food is often the first of an incremental series of steps that change in progressively deeper ways a person's attitudes and behaviors toward food, diet, and health.

Even if it reaches only a segment of society, this is a trajectory of change that is worth supporting in every way possible, since the exact nature and order of steps taken by people establishing new and healthier relationships with food matters less than steady and sustained progress along this path.

1. Getting Children Off to a "Good Start" and Keeping Them on the Right Track

Overview and Summary of Key Points

The six months prior to conception, pregnancy, and the first two years of a child's life are periods of heightened vulnerability to developmental abnormalities, some with life-long consequences.

Eating a well-balanced diet composed of ample organic fruits and vegetables, dairy and grain products throughout this period can both largely eliminate dietary exposure to pesticides and establish and sustain taste-based preferences in the child for nutrient-dense, flavorful foods.

An expecting mother's diet during pregnancy directly controls the adequacy of the nutrients available to the developing fetus and also plays a major role in determining how many toxic chemicals are present in amniotic fluids, and whether the levels approach those capable of blocking normal development.

Outlined below are specific steps that both society and parents can take to get their children off to a good start, and keep them on the right track as they continue to develop.

Public food and nutrition assistance programs and policies should emphasis sound dietary choices and provide ample resources to assure that children and pregnant women have access to organic fruits, vegetables, and dairy products.

Examples of organic food interventions based on economic incentives include farm to cafeteria programs that increase children's access to organically-produced, local foods and increasing access to organic foods through the Supplemental Nutrition Assistance Program (formerly Food Stamps) and WIC (Special Supplemental Nutrition Program for Women, Infants and Children).

Maternity leave policy in the U.S. should include economic incentives (e.g., paid maternity leave) so that women need not choose between careers, keeping food on the table and what is best for their newborn children.

Policies of this sort are already the norm in many developed countries. Mother-friendly policy changes are most acutely needed for non-affluent women and mothers with inflexible work schedules.

Parents also have an important role to play in tilting the odds toward their children's proper development and good health. Such strategies include:

- Breastfeeding infants at least through six months of age;
- Purchasing more organic fresh fruits and vegetables with their nutrient-rich peels;
- Planting a home or family garden or participating in a CSA farm;
- Consuming a healthful breakfast everyday;
- Cooking and eating more family meals at home; and
- Trying new recipes and quick meal ideas that incorporate organically produced, raw and minimally processed foods.

What is a "Good Start" and What is the Right Track?

The building blocks for healthy development in children should ideally be put in place at least six months before conception. A healthful diet and other sound lifestyle choices are critical before and throughout pregnancy and during the first two years of the child's life. This is the period when a child gets his or her start in life. Once a child reaches two years old, it is essential for parents and other care givers to keep the child on track.

A. Getting Children Off to a "Good Start" Begins Before and During Pregnancy

By this we mean growing and developing at a healthy, but not excessive, pace. Nutrient needs remain high, as do developmental dangers associated with exposure to toxic chemicals. While many of the child's major organs and systems are fully or nearly formed by age two, some continue to progress through multiple, critical developmental stages through adolescence. The brain, nervous system, and reproductive organs are the last major parts of the child's body to reach full development.

As noted above, a healthful diet and sound lifestyle choices are critical before and throughout pregnancy. Both under- and over-nutrition of the fetus as well as exposing the fetus to environmental toxins may have long-term negative effects on human health (Gillman et al., 2007). The most common permanently disabling birth defect in the United States is spina bifida (CDC and Spina Bifida Association websites, 2009).

Spina bifida occurs within the first few weeks of pregnancy, often before a woman knows she is pregnant. Spina bifida is a neural tube defect. The neural tube is embryonic tissue that gives rise to the brain and spinal cord. In spina bifida, the fetal spinal column doesn't close (NIH website, 2009).

Another neural tube defect is anencephaly. In anencephaly, much of the brain doesn't develop, thus, babies with enencephaly are either stillborn or die shortly after birth (NIH website, 2009). Pregnant Mexican mothers who worked in agriculture and were exposed to agricultural

chemicals during the acute risk period – three months before and the one month after the last menstruation period – had children with a higher risk of anencephaly (Lacasaña et al., 2006). Thus, production of organic fruits and vegetables reduces the pesticide exposure of agricultural workers in the field and consumers in the home, both before and during pregnancy.

Folic acid given before pregnancy, especially in the acute risk period, reduces the incidence of spina bifida (CDC website, 2009)[2]. In addition, in pregnant Agouti mice, dietary supplements of folic acid and other related vitamins produces pups that grow up to have lower rates of obesity, diabetes, and cancer (Gillman et al., 2007).

The epigenetic[3] mechanism associated with this observed phenomenon involves switching off the Agouti gene by methyl groups from the supplements (Waterland and Jirtle, 2004). Some of these effects are tissue specific and can be induced in normal rats by maternal dietary manipulation (Lillycrop et al., 2005). Furthermore, the transgenerational effects of prenatal exposure to the Dutch famine on neonatal adiposity (fatness) and health later in life have been observed (Painter et al., 2008). Epigenetic changes in one generation can result in phenotypic changes across multiple generations (Gillman et al., 2007).

Fruits and vegetables are good sources of food folate that should be consumed by women of childbearing age as part of a healthful diet. Koebnick and colleagues (2001) found that long-term high vegetable intake favorably affected plasma folate as well as red blood cell (RBC) folate concentrations throughout pregnancy and reduced the risk of folate deficiency if adequate vitamin B12 was supplied (Koebnick et al., 2001).

A more recent Dutch study found that women who consumed a Mediterranean-style dietary pattern rich in fruits, vegetables, healthful oils, fish and whole grains had a reduced risk of giving birth to a child with spina bifida than women who consumed the least Mediterranean-like dietary pattern. The more closely the women adhered to the Mediterranean-style diet, the higher their serum and RBC folate and serum Vitamin B12 levels were. When controlling for other factors, including folic acid supplements as well as body mass index (another risk factor for having a baby with spina bifida), the researchers found the Mediterranean-style dietary pattern independently reduced spina bifida risk (Vujkovic et al., 2009).

Recently, exposure to multiple environmental toxins during pregnancy has been linked to a higher body mass index in offspring. For example, exposure to cigarette smoke and DDE[4] (DDE – the main metabolite of the pesticide DDT), were linked to a higher body mass index in toddlers (Verhultst et al., 2009). In another

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[2] In 1998, the Food and Nutrition Board of the National Academy of Sciences Institute of Medicine (IOM) recommended that to reduce their risk for a neural tube defect, all women capable of becoming pregnant should take 400 micrograms of synthetic folic acid daily, from fortified foods or supplements or a combination of the two, in addition to consuming food sources of folate from a varied diet (IOM, 1998).

[3] An "epigenetic" change is a change where environmental factors influence the activity of genes but do not cause structural changes or mutations in the genes.

[4] DDE = dichlorodiphenyldichloroethylene, DDT = Dichlorodiphenyltrichloroethane

study, researchers found that children whose mothers were exposed to hexachlorobenzene (a fungicide) during pregnancy had a higher risk of being overweight at 6 years of age (Smink et al., 2008). Researchers at the National Institute of Environmental Health Sciences (NIEHS) also reported that brief exposure early in life to environmental endocrine (hormone) disrupting chemicals (especially diethylstilbestrol - DES) resulted in increases in body weight as mice aged (Newbold et al., 2007).

Such findings are part of the growing scientific field termed "the developmental origins of adult disease," which is concerned with how perinatal[5] influences may affect the development of chronic disease later in life (Newbold et al., 2007). Perinatal influences of concern include exposure to either under- or over-nutrition as well as exposure to environmental toxins, including exposures to environmental endocrine disrupting chemicals (Gillman et al., 2007).

For example, in a non-human primate model, chronic maternal overfeeding resulted in fetal oxidative stress in the liver, resulting in fatty liver and disordered lipid handling by the fetus (McCurdy et al., 2005; McCurdy et al., 2009). These same authors observed that reversing the maternal high fat diet to a low-fat diet during a subsequent pregnancy improved fetal liver triglyceride levels and partially normalized gluconeogenic enzyme expression, without changing maternal body weight (McCurdy, 2009).

In addition, Lassiter and colleagues (2008, p. 1461) observed that, "it is increasingly evident that exposures experienced during fetal or neonatal life, including chemical exposures such as those studied here [parathion, which is an organophosphate (OP) pesticide] can lead to misprogramming of metabolism, appetite, and endocrine status contributing ultimately to morbidities such as obesity and diabetes." In a separate study, fetal and neonatal rats exposed to chlorpyrifos (another OP pesticide) had excessive weight gain and leptin dysfunction (leptin is a hormone that regulates appetite) (Lassiter and Brimjioin 2008).

Obesity and diabetes also can result from intrauterine malnutrition and SGA (small-for-gestational-age) births. In 1991, Hales and Barker (Hales and Barker, 1991) studied 468 64-yr-old men with known birth weights and weights at one year of age. Ninety-three of these men had impaired glucose tolerance or hitherto undiagnosed diabetes. The affected men had a lower mean birth weight and a lower weight at one year. The proportion of men with impaired glucose tolerance fell progressively from 26 percent (6/23) among those who had weighed 18 pounds or less at one year to 13 percent (3/24) among those who had weighed 27 lb or more. Corresponding figures for diabetes were 17 percent (4/23) and nil (0/24).

A follow-up study in men and women aged 50 years (Phipps et al., 1993) found that the subjects with impaired glucose tolerance or non-insulin-dependent diabetes mellitus had lower birthweight and a smaller head circumference and

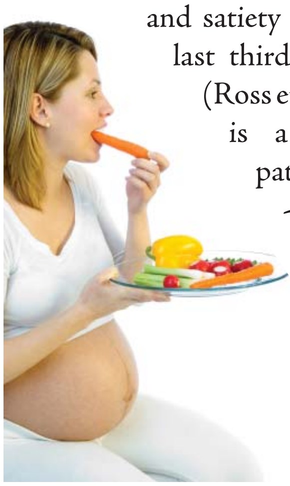
[5] Perimatal is defined as the period beginning after the 28th week of pregnancy through 28 days following birth.

were thinner at birth. The prevalence of impaired glucose tolerance or diabetes fell from 27 percent in subjects who weighed 5.5 pounds or less at birth to just 6 percent in those who weighed more than 7.5 pounds. The trends with birthweight were independent of duration of gestation, so the authors concluded that the results were related to reduced fetal growth rates.

This phenomenon was evident in children as young as seven years of age (Law et al., 1995). Obesity may also be linked to this effect, since, in a separate study, adults born small for gestational age were more likely to be obese than adults born at an appropriate size (Meas et al., 2008).

B. Developing and Maintaining Self-Control – Matching Appetite with Food Intake

Ross and colleagues have proposed that both appetite and satiety mechanisms develop during the last third of gestation during pregnancy (Ross et al., 2003). A "satiety mechanism" is a biochemical or neurological pathway in the body that results in a -- "I am getting full" -- signal from the stomach to the brain.



Exposing the fetus to high maternal nutrient intake may result in changes within the central appetite regulatory network (Muhlhausler et al., 2006). For example, exposure to a high fat diet in utero may affect the appetite center of the fetus' brain, resulting in possible problems with appetite control after birth (Dr. Jacob Friedman, Personal Communication, February 9th, 2009).

As noted in the previous section, exposure to certain OP pesticides (e.g., parathion and chlorpyrifos) during the fetal and neonatal periods may also result in a misprogramming of appetite (Lassiter et al., 2008; Lassiter and Brimjioin, 2008). Thus, intra-uterine imprinting of appetite mechanisms may affect appetite control in the infant, child, and adult, with the risk of generating dysfunctional appetite and perhaps obesity (Ross et al., 2003). Hence, consuming a healthful diet during pregnancy that includes an ample supply of organically-produced foods may play an important role in the developing fetus' appetite control.

Another important strategy for regulating calorie intake and maintaining appetite control during infancy is breastfeeding. Breastfeeding gives infants more control over how much they eat, thus helping them self-regulate calorie intake and reduce the risk of pediatric overweight and obesity. Breastfeeding may also influence the appetite control hormone leptin (Bergenstal et al., 2007).

In addition, inappropriate parental child feeding behaviors, particularly parental restriction, during early childhood are associated with child weight gain (Clark et al., 2007), This is because parental restriction of a child's food intake may actually teach a child to overeat. Thus, parents should allow infants and toddlers to eat until they are satiated and avoid coercive "clean your plate" feeding practices (Fox et al., 2006).

C. Developing Healthful Food Preferences, Dietary Patterns and Lifestyles

A published review of risk factors for overweight[6] in preschool-aged children found evidence for a direct association between childhood overweight and maternal pre-pregnancy body size, maternal smoking during pregnancy, and children's television media use. A strong inverse association between breastfeeding and overweight was found while moderate evidence was found for children's physical activity level (Hawkins and Law, 2006). In addition, a recent longitudinal study found that being in the highest quintile of weight gain between birth and five months, as well as maternal smoking, almost doubled the odds of being overweight at 4.5 years (Dubois and Girard, 2006)

Parental overweight or obesity and being raised in middle-income or poor families also raised the odds of children being overweight at 4.5 years (Dubois and Girard, 2006). As noted earlier, researchers are beginning to evaluate how exposure to other environmental toxins during pregnancy, such as pesticides, may increase a child's body mass index during the early years, and possibly later in life (Verhultst et al., 2009; Smink et al., 2008).

During pregnancy and lactation, a mother can help her baby become familiar with the tastes of a variety of healthful foods by consuming these foods herself and consequently passing on the flavors of these foods to her baby via amniotic fluid and breast milk. The human fetus swallows larger amounts of amniotic fluid during pregnancy, with the amount increasing as gestation proceeds (Ross et al., 1997). Thus, the flavors of foods that are consumed by a pregnant woman transfer to the amniotic fluid. For example, the amniotic fluid of women consuming garlic a few minutes before amniocentesis has been found to have a definite garlic odor (Mennella et al., 1995).

The progression from normal weight (boy on left) to overweight (middle) to obese (boy on the right) can occur as a result of consuming 100 to 200 calories per day in excess of energy expenditure.

[6] For children and teens (aged 2-19 years), Body Mass Index (BMI) ranges are defined so that they take into account normal differences in body fat between boys and girls and differences in body fat at various ages. Previously, BMI ranges above a normal weight in children and teens were labeled as "overweight" (a BMI at or above the 95th percentile for children of the same age and sex) and "at risk of overweight" (a BMI at or above the 85th percentile and lower than the 95th percentile). More recently, these labels have been changed to "obesity" and "overweight," respectively (CDC, 2009).

Mennella and colleagues designed a study in which women consumed carrot juice during both the third trimester and the first two months of lactation, only during gestation, only during lactation, or not at all. About one month after starting on infant cereal, the infants were fed cereal made with carrot juice. The infants whose mothers consumed carrot juice exhibited fewer facial expressions when fed the carrot-flavored cereal compared to the plain cereal. Those infants exposed in the uterus were perceived as enjoying the carrot-flavored cereal most of all (Mennella et al., 2001).

Breastfeeding also exposes an infant to the flavors of food via his or her mother's breast milk. In fact, when a lactating woman consumes garlic, her breast milk develops a garlic odor after about an hour, which peaks at about two hours, and decreases thereafter. A nursing infant can apparently detect these changes, since the infant attaches to the breast for longer periods of time and sucks more when the milk smelled like garlic (Mennella et al., 1991).

In order to establish food preferences, foods need to be tasted. Infants exposed to a single new food (e.g., green beans or peas) for eight to ten consecutive days increase their acceptance (increased intake and less adverse facial reactions) of that novel food (Sullivan and Birch, 1994; Forestell and Mennella, 2007). Variety is a second approach to promoting vegetable acceptance during infancy. Eight or nine days of feeding four different vegetables within or between meals lead to increased acceptance of carrots, green beans, and spinach (Mennella et al., 2008) or carrots and a novel food, chicken puree (Gerrish and Mennella, 2001).

Healthful dietary habits and patterns need to be continued throughout childhood. Such habits include eating a good breakfast, consuming a variety of fruits and vegetables and other nutrient dense foods, and drinking the right fluids. Consuming more foods in their fresh form, or slightly processed form, can also promote good health. Reducing time spent watching television, increasing physical activity, and getting an adequate amount of sleep every night are other important health-promoting behaviors. Each of these healthful lifestyle behaviors is reviewed in more detail in this section.

Eating a Good Breakfast

Eating a good breakfast is important for children, not only for learning (Benton, 2007), but also for reducing the risk of obesity, and thus diabetes. For adolescents with an obese parent, eating breakfast was a favorable factor for protecting the adolescent from obesity (Fiore et al., 2006). Unfortunately, breakfast consumption by older children declines with age (Barton et al., 2005).

Consuming a Variety of Fruits and Vegetables and Other Nutrient Dense Foods

Recent research has found that infants and toddlers may not be exposed to an adequate variety of fruits and vegetables in their diet. Fox and colleagues (2004) found that from 18 percent to 33 percent of infants and toddlers between the ages 7 and 24 months consumed no discrete servings of vegetables, and 23 percent to 33 percent consumed no fruits. French fries were one of the three most common vegetables consumed by infants 9 to 11 months of age. By 15 to 18 months, French fries were the most common vegetable.

A high preference for nutrient-dense foods, such as fruits and vegetables, may protect a child from becoming overweight. Lakkakula and colleagues studied 341 black children (43 percent boys, 68 percent 4th graders) attending low-income, public elementary schools in Louisiana. The researchers found that children who reported a very low preference for fruits and vegetables were more likely to be categorized as at risk for overweight or overweight than those who reported a high preference for fruits and vegetables (Lakkakula et al., 2008). Parental modeling behavior and exposing infants, toddlers and young children to the taste of different foods in the home can increase their intake of fruits, vegetables and other nutrient-dense foods, which in turn, may decrease the risk of childhood overweight.

The Organic Center published a State of the Science Review (SSR) entitled, "Do Organic Fruits and Vegetables Taste Better than Conventional Fruits and Vegetables?" in September 2006 (Theuer, 2006). It reviewed published studies comparing the organoleptic qualities of organic versus conventional foods, with a focus on fruits and vegetables. Organoleptic qualities include taste and flavor, aroma, mouth feel, juiciness, and suitability for storage. This SSR found that more often than not organic fruits and vegetables including apples, tomatoes and strawberries tasted better than their conventional counterparts. Evidence in support of superior taste in organic produce was found to be strongest in apples (Theuer, 2006).

Previous research has found that organic apples are firmer and have superior storage capacity (Hajslova et al., 2005), a phenomena associated with lower plant tissue nitrate levels and slower growth rates and greater physiological maturity at harvest. However, the Organic Center's SSR noted that maturity at harvest and storage methods generally trump production methods with respect to organoleptic quality. Thus, it was also concluded that future cultivation studies should include measurement of tissue nitrate levels (which may influence storage capacity, shelf-life and taste) and organoleptic quality, including product firmness and taste testing (Theuer, 2006).

A more recent review on the quality of plant products from organic agriculture reaffirmed that a variety of organic fruits and vegetables taste better than their conventional counterparts. Better taste and smell for bread made from organic grain were also reported (Rembialkowska, 2007).

Drinking the Right Fluids

Soft drink consumption has increased by 300 percent in the past 20 years, and 56-85 percent of children in school consume at least one soft drink daily. The odds ratio of becoming obese among children increases 1.6 times for each additional can or glass of sugar-sweetened drink consumed beyond their usual daily intake of the beverage. Soft drinks currently constitute the leading source of added sugars in the diet and exceed the U.S. Department of Agriculture's recommended total sugar consumption for adolescents. (Harrington, 2008)

Drinking sweetened beverages between meals is of particular concern. Dubois et al. (2007) found that 6.9 percent of children who were non-consumers of sugar-sweetened beverages between meals between the ages of 2.5 to 4.5 years were overweight at 4.5 years, compared to 15.4 percent of regular consumers (four to six times or more per week) at ages 2.5 years, 3.5 years, and 4.5

years. Thus, consumption of sugar-sweetened beverages between meals more than doubles the odds of being overweight when other important factors are considered in multivariate analysis (Dubois et al., 2007).

A systematic review of large cross-sectional studies, in conjunction with those from well-powered prospective cohort studies with long periods of follow-up, show a positive association between greater intakes of sugar-sweetened beverages and weight gain and obesity in both children and adults (Malik et al., 2006). These authors also noted that a school-based intervention found significantly less soft-drink consumption and prevalence of obese and overweight children in the intervention group than in control subjects after 12 months, and a recent 25-week randomized controlled trial in adolescents found further evidence linking sugar-sweetened beverage intake to body weight.

One goal for parents is to help their children develop a taste for nutritious beverages such as milk. Daughters of milk-drinking mothers consume more milk and fewer soft drinks, so they have more adequate calcium intakes (Fisher et al., 2004), and thus they are likely to have denser bones (Fiorito et al., 2006). Preschool children, on average, drink less milk each day than the recommended 16 ounces (O'Conner et al., 2006). Long-term consumption of soft drinks by children weakens bones whereas long-term consumption of milk strengthens bones (Libuda et al., 2008).

Maintaining a Healthful Lifestyle

Survey research based on a population-based study in Minnesota found that adolescents who value at least two of following food production practices – organically produced, locally grown, non-genetically engineered and non-processed – are more likely than their peers to have a dietary pattern that is consistent with the Healthy People 2010 objectives for fruit, vegetable and fat intake. In addition, the percentage of adolescents indicating support for organic food was higher among non-overweight than overweight adolescents (Robinson-O'Brien, et al., 2009).

Adolescents who valued each of the above mentioned food production practices were more likely than their peers to be nonwhite ($p < 0.001$) and have a low socioeconomic status ($p < 0.001$) (Robinson-O'Brien et al., 2009). These results are, in part, consistent with findings by the Hartman Group, who reported that Hispanic Americans and Asian Americans are more likely than Caucasian Americans to purchase organically-produced food (Baxter, 2006).

Even though adolescents from low socioeconomic status groups may be more likely to value food from alternative food production practices (e.g., organically-produced foods) than persons with higher socioeconomic status, it has been observed that persons residing in lower-income neighborhoods often have limited access to organic foods (APHA, 2007).

Unfortunately, the populations with the highest rates of obesity – e.g., low-socioeconomic status, inner-city, agricultural populations – are the same populations with greater exposures to OP pesticides (Lassiter et al., 2008; Eskenaki et al., 2007; Perera et al., 2005; Fenske et al., 2000). With this information in mind, it may be beneficial to discuss alternative production practices (e.g., organically-produced foods) as part of nutrition education programs for adolescents (Robinson-O'Brien et al., 2009). Increasing lower-income consumers' access to organically-produced foods, through multiple venues (e.g., supermarkets, farmers' markets, and farm to cafeteria programs), is also critical.

Another part of a healthful lifestyle is getting an adequate amount of sleep every night. Unfortunately, due to hectic schedules and a face-paced lifestyle, the number of hours of sleep Americans get every night has decreased over time. Epidemiological studies have found a positive association between short sleep duration and obesity in both children and adults (Jones et al., 2008).

Because low leptin and high ghrelin levels (two hormones involved in appetite control) have been observed during sleep deprivation, short sleep duration could result in obesity by increasing appetite (Jones et al., 2008). Researchers in Denmark found that animals fed a low-fertilizer input diet without pesticides had a more restful sleep than animals fed a diet with pesticides (Lauridsen et al., 2008).

Physical activity also needs to be part of a healthful lifestyle. Physical activity and TV viewing were the only significant predictors (other than baseline BMI) of BMI among a tri-ethnic cohort of 3-4-year-old children followed for 3 years. Both physical activity (negatively associated) and TV viewing (positively associated) became

stronger predictors as the children aged. It appears that 6 or 7 years of age is a critical age when TV viewing and physical activity may affect BMI. Therefore, focusing on reducing time spent watching television and increasing time spent in physical activity may be successful means of preventing obesity among this age group (Jago et al., 2005).

The American Academy of Pediatrics (AAP) recommends limiting television viewing to no more than one to two hours of quality programming per day for children aged two years and older. Parent should discourage television viewing for children younger than two years of age, and encourage more interactive activities that promote proper brain development (e.g., talking, playing, singing, and reading) (AAP, 2001).

Physical inactivity, high consumption of sweetened beverages, and skipping breakfast were three controllable risk factors for the higher obesity observed in adolescents in poor families compared to those in non-poor families (Miech et al., 2006). In contrast, consuming cereal for breakfast was associated with more healthful eating throughout the entire day, including consumption of less fat and more fiber and calcium, and greater physical activity among girls (Albertson et al., 2008).

D. Concrete Steps Toward Healthy Childhood Development

Parents need tools to help tilt the odds toward a healthy pregnancy and birth, and normal development of their children. Rising unemployment and today's economic downturn has pushed millions of people into, or closer to poverty. Another challenge is society's lack of financial commitment towards disease prevention, wellness, and self-care. Concrete steps that society and parents can take to promote healthy childhood development are listed below.

Steps Society Can Take

Our society invests heavily in the treatment and management of chronic diseases such as Type 2 diabetes for adults. In contrast, it spends very little for the prevention and treatment of childhood obesity to stave off the onset of Type 2 diabetes. Thus, unless there is a significant investment in obesity prevention and treatment during childhood within schools, communities, and the health care system, recent trends in childhood obesity will likely lead to increases in Type 2 diabetes among young adults, resulting in even greater costs to society and the health care system (Lee, 2008).

1) Base food interventions and public policies on economic incentives.

One way to deal more effectively with the economic challenges that many families face while reducing the future costs to society and the health care systems, is to base food interventions on economic incentives.

Research has shown that a targeted subsidy provided to WIC participants that enabled them to purchase fruits and vegetables resulted in increased fruit and vegetable consumption (Herman et al., 2006; Herman et al., 2008).

Examples of food interventions based on economic incentives include:

- USDA's Fruit & Vegetable Snack Program - a program designed to increase fruit and vegetable availability in schools,
- Farm to cafeteria programs,
- Bonuses and vouchers that enable Supplemental Nutrition Assistance Program (SNAP) recipients to purchase more fruits and vegetables, and
- The new Supplemental Nutrition Program for Women, Infants and Children (WIC) food package – which includes fruits and vegetables (fresh, frozen, dried or canned), whole wheat bread, other whole grains as well as other culturally diverse healthful food items (Darmon and Drewnowski, 2008).

Changes to the WIC program also include providing incentives to promote breastfeeding among WIC participants by increasing the amount of fruit and vegetable vouchers allotted to women who breastfeed (Levi et al., 2008). This is one positive step to increase the rates of breastfeeding by lower-income women in the United States (U.S.). However, recent research found that the strongest predictor of whether or not a woman would continue breastfeeding was whether or not she returned to work within six weeks of delivery.

In addition, the risk of not establishing breastfeeding was higher among mothers who went back to work between 6 to 12 weeks after delivery than women who were still not working at this time. Finally, women who held positions as managers, had flexible work schedules and more job autonomy were more likely than other women to start breastfeeding, and to continue breastfeeding their infants longer (Guendelman et al., 2009).

Thus, current federal government policy in the U.S. may not make it economically feasible for a woman to sustain breastfeeding during the first 6 months of life, particularly for non-affluent women or women who do not have a flexible work schedule (Gundelman et al., 2009). To improve rates of sustained breastfeeding in the U.S., pediatricians and other health care professionals can advocate for "extending paid postpartum leave and flexibility in working conditions for breastfeeding women." (Gundelman et al., 2009).

California is one of several states in the U.S. that provides workers with paid maternity leave. In addition, California's Paid Family Leave Program extends its state disability insurance (SDI) benefits (for paid pregnancy leave) up to six additional weeks postpartum for infant bonding (Gundelman et al., 2009).

2) *Develop and implement innovative school-based initiatives and strategies.*

Schools have a role to play in addressing the obesity epidemic. Given the current economic environment, schools are experimenting with new strategies that can lower costs while increasing revenues.

One such experiment is the School Lunch Initiative in Berkeley, CA. As part of this initiative, Berkeley United School District has upgraded its school kitchens to better handle fresh food, and reheat meals made from scratch in a central kitchen. They have a salad bar in each school that serves fresh fruits and vegetables daily, where priority is given to locally-produced organic food (Newman et al., 2008).

Previous experience has shown that participation in a school-based organic salad bar program increased children's and staff's consumption of fruits and vegetables (Flock et al., 2003). Schools can also implement gardening programs to increase students' willingness to taste fruits and vegetables and increase preference for fruits and

Chef Ann Cooper: "The Renegade Lunch Lady" is the director of nutrition services for the Berkeley Unified School District.

vegetables among children whose current preferences for fruits and vegetables are low (Robinson-O'Brien et al., 2009).

Other innovative school-based strategies include hosting tasting parties and making changes to the cafeteria environment. For example, hosting "tasting parties" could be held where students are asked to rate different versions of a healthful snack or entrée (Newman et al., 2008). Other strategies include making changes to the cafeteria environment including longer lunch periods, shorter lunch lines, and more pleasant seating arrangements.

Students who have more time to eat their lunch are more likely to eat all of their lunch, and as a result, may eat a more balanced meal. Pleasant seating arrangements during the lunch hour that allow time for socialization can also promote more healthful eating behaviors among students (Newman et al., 2008).

Steps Parents Can Take

Many excellent books have been written about parenting in these challenging times, including *Raising Baby Green* (2007) and *Feeding Baby Green* (2009) by Dr. Alan Greene, a renowned pediatrician and member of the Center's Board of Directors. Dr. Greene's website, www.drgreene.com, offers parents up to date information on a wide range of topics and challenges.

In addition, registered dietitian and therapist, Ellyn Satter, MS, RD, has published excellent books on topics such as infant and child feeding practices, parenting practices, and breastfeeding. For more information, see: *Your Child's Weight: Helping without Harming* (2005) and *Child of Mine: Feeding with Love and Good Sense* (2000), both of which are available at: www.ellynsatter.com

A list of recommended strategies to tilt the odds toward good health, while sticking to a budget, follows.

1) If possible, breastfeed your child at least through six-months of age.

Breastfeeding is very inexpensive compared to the cost of purchasing infant formula. The US Preventive Services Task Force on Breastfeeding has concluded that coordinated interventions, with both prenatal and postnatal components, can increase breastfeeding initiation, duration and exclusivity (Calonge et al., 2008).

Some researchers believe that low rates of sustained breastfeeding may at least partially explain why disadvantaged US children are at greater risk of becoming overweight. For example, using data from a large school-based study, Woo and colleagues (2008) reported that being breastfed for longer than 4 months was associated with a lower body mass index *z*-score and lower odds of being at risk for overweight or overweight – independent of race or parental education. Their analysis also found that being breastfed for longer than 4 months partially explained the association between social disadvantage and increased adiposity.

Based on these results, the researchers concluded that "increasing breastfeeding duration could result in lower adolescent adiposity for all racial and socioeconomic status groups and potentially minimize socioeconomic disparities in adiposity" (Woo et al., 2008).

Other researchers reported that the rate of breastfeeding was lower in youth with Type 2 diabetes (for Hispanic, white and African American youth) (Mayer-Davis et al., 2008). Further analysis revealed that the protective effect of breastfeeding against Type 2 diabetes was in large part attributable to its effect in moderating current childhood overweight status (regardless of ethnic group). However, additional analyses that incorporated duration of breastfeeding and potential confounders provided evidence of a dose response, even after inclusion of body mass index *z*-score. Thus, these researchers concluded that breastfeeding may protect against the development of Type 2 diabetes in youth (Mayer-Davis et al., 2008).

2) Purchase and consume more organic fresh fruits and vegetables, and consume produce with edible skins such as apples, pears, and cucumbers without removing their nutrient-rich peels.

Parents should purchase and consume organic fruits and vegetables themselves and offer them to their children. A diet consisting of primarily organic foods provides a dramatic and immediate protective effect against exposure to organophosphate (OP) pesticides, such as malathion and chlorpyrifos (Curl et al., 2003; Lu et al., 2006; Lu et al., 2008).

Especially during pregnancy and lactation, exposing babies to new flavors via amniotic fluid and breast milk is good; exposing babies and young children to OP pesticides is not good. The ability to safely consume organic apples and other organic fruits and vegetables with their nutrient-dense skins intact is also an economically-important advantage. Mothers can serve organic produce after a light washing to remove dirt or bacteria, and in this way assure their children are getting the most nutrient "bang" for the family's food "buck."

3) Purchase organic foods through a CSA (community supported agriculture) farm or at a farm stand or farmers' markets.

Purchasing organically produced foods through a community supported agriculture (CSA) farm or at a farm stand or farmers' market are strategies that can be implemented to deal with rising food costs. One survey found that the number one reason to participate in a CSA farm was to increase access to high quality organically-produced foods (ATTRA, 1995). Locally-produced organically grown foods, when in season, can be lower in price than non-organically produced foods. You can freeze and/or can what you don't use for later use. To find a CSA farm or farmers' market near you, go to: www.localharvest.org.

The Group Health Cooperative of South Central Wisconsin reimburses its members for participating in a CSA farm as a "wellness" reimbursement. Non-profit organizations such as Just Food (www.justfood.org) provide low-income individuals with different mechanisms that enable them to participate in a CSA farm. These include: sliding-scale

prices, work shares, accepting Food Stamps[7] (electronic benefit cards), and spreading payments out over time.

4) Plant a home garden.

Planting a home garden is one way to increase access to organically produced fruits and vegetables while increasing opportunities for physical activity (Burros, 2008). Establishing a home garden can also help families re-establish a sense of control over their food supply, and to connect with nature (thereby reducing stress) (Wells and Evans, 2006).

Preschool-aged children in rural Missouri who almost always ate home-grown produce were 2.3 times more likely to eat five servings of fruits and vegetables a day than preschool-aged children who reported rarely or never eating home-grown produce. Frequent consumption of home-grown produce also promoted a positive home environment by increasing the availability of produce (Nanney et al., 2007).

Another study found that implementation of a home-based food gardening program resulted in significantly higher intakes of vitamin A (beta-carotene) in young children from households that had gardens than young children from households without gardens (Faber et al., 2002).

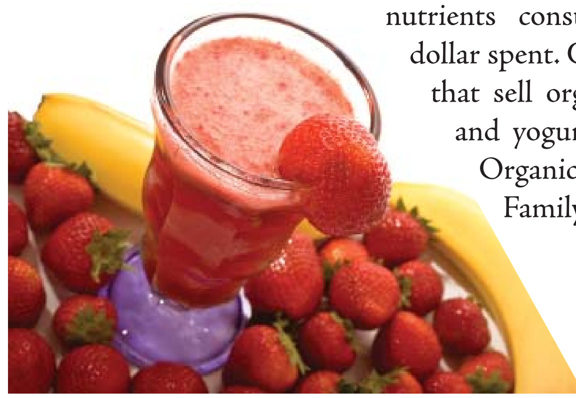
5) In off-season months, seek out organic dried fruits, canned or frozen fruits and vegetables, and organic fruit and vegetable juices that can be purchased in bulk.

Everyone needs four to 13 servings of fruits and vegetables every day, year round (for individuals two years of age and older) (DHHS and USDA Dietary Guidelines, 2005)[8]. Reaching this goal can be a challenge in winter months. This is why families should seek out organic fruits and vegetables that can be purchased in bulk, or in case lots. Smart comparison shopping can often lower the price per unit of an organic fruit or vegetable product to below the cost of highly processed and excessively sweetened conventional products.

6) Introduce the family to fruit and vegetable based blended drinks and smoothies and other food items made with organic yogurt, milk, juices, and fresh or dried produce.

Even with attention to detail and good planning, most families discard uneaten a portion of the fresh fruits and vegetables that find their way onto countertops or into refrigerators. Most overly ripe produce can be easily incorporated in tasty and nutritious blended drinks, such as smoothies and/or used in the making of nutritious breads (e.g., banana nut bread). Of course, as with any food or drink item, portion control must be practiced.

By expanding the options for consuming fruits and vegetables, families can drive down the percent of food that is wasted and increase nutrients consumed per dollar spent. Companies that sell organic milk and yogurt, such as Organic Valley Family of Farms



[7] The Food Stamp Program is now called the Supplemental Nutrition Assistance Program or SNAP.

[8] Nine servings (or 4 and one half cups) of fruits and vegetables are recommended per day based on a 'reference 2000 calorie diet', with lower or higher amounts depending on the calorie level (1000 - 3200 calories per day). This results in a recommended range of 4-13 servings of fruits and vegetables per day (for 1000 - 3200 calorie levels, in individuals 2 years of age and older) (US DHHS & USDA, 2005 Dietary Guidelines for Americans).

(http://www.organicvalley.coop/coupons) and Stonyfield Farm (http://www.stonyfield.com/coupons/signin.cfm), offer valuable coupons on their websites. These can be downloaded for use at local supermarkets. Using coupons, such as these, is another way to economize food choices while supporting the health of your family.

7) Consume a healthful breakfast everyday.

Among girls aged 9 to 10 years, consuming cereal for breakfast was associated with more healthful eating throughout the entire day, including consumption of less fat, more fiber and calcium consumption, and with less soda consumption (Albertson et al., 2008). In addition, participation in the School Breakfast Program may protect against childhood obesity "by encouraging students to consume breakfast more regularly" (Gleason and Hedley, 2009).

8) Cook and eat more family meals at home.

Restaurant meals (both sit down restaurant and fast food meals) have been shown to contain more calories than meals prepared at home (Binkley, 2008). In another study, having few shared meals and 'eating on the run' was associated with poorer dietary intake in young adults (e.g., higher intakes of soft drinks, fast food and fat) (Larson et al., 2009). Thus, preparing and sharing more meals together at home may be an important health-promotion strategy.

9) Try new recipes and quick meal ideas that incorporate organically produced foods.

Recipes and quick meal ideas that incorporate organically produced foods can be found on the following websites:

Chef Dominica Catelli: http://www.mom-a-licious.com

Earthbound Farm: http://www.ebfarm.com/Recipes/index.aspx

Organic Valley Family of Farms: http://www.organicvalley.coop/recipes

Spectrum Organic Oils: http://www.spectrumorganics.com/?section=recipes

Stonyfield Farms: http://www.stonyfield.com/Recipes

2. Beneficial Phytochemicals in Food

Overview and Summary of Key Points

Plants produce a dizzying array of natural chemicals often referred to as "plant secondary metabolites." These phytochemicals are part of a plant's response to stress from excessive sunlight and heat, pest attacks, too much or too little water, inclement weather, and mineral or chemical imbalances in the soil.

Most phytochemicals are antioxidants and polyphenols. Some are vitamins. The antioxidants ingested on a daily basis by an individual via food and beverages augment the antioxidants produced by the body. As we age, we rely more heavily on antioxidants in food and beverages because our body's ability to synthesize antioxidants gradually wears out over time.

Polyphenol and antioxidant phytochemicals account for a significant share of the well-documented benefits of a diet rich in fruits and vegetables. Science is incrementally identifying the specific, beneficial roles played by individual phytochemicals in preventing or slowing progression of a number of diseases, especially those triggered or made worse by inflammation.

While intakes of individual phytochemicals can be important to help people deal with specific health problems, the overwhelming weight of evidence points to routine, daily total antioxidant intake from a variety of different foods as the most reliable indicator of whether the phytochemicals in a person's diet will promote good health.

A number of studies have shown that consumption of phytochemicals in conjunction with high-fat diets can reduce or reverse the expected adverse impacts on blood

lipids and sugar levels. In one study, rutin or coumaric acid dietary supplementation reduced the insulin levels in the blood of rats on a high-fat diet by one-half to over two-thirds (Hsu et al., 2009).

Anything that increases average daily human consumption of phytochemicals is likely to contribute positively to the prevention of disease and promotion of healthy development and aging.

Dozens of studies have compared the polyphenol and antioxidant content of organic food, compared to conventional foods grown on the same soils in the same region. Organic production increases total phenolic and antioxidant content of food by, on average, 25 percent (Benbrook et al., 2008).

Scientists worldwide are scrambling to discover the chemical triggers of satiety in humans (a sense of fullness). Research investments are driven by the hope that once these triggers are understood, they can be manipulated in plants by farmers or otherwise exploited in future weight control programs and pharmaceutical-based interventions.

One phytochemical in particular – resveratrol – has captured the attention of scientists and the food industry. This stilbene, a polyphenolic activator of a key regulatory protein, mimics the effects of calorie restriction in lower organisms. (Jiang, 2008). Moreover, the most potent analogue of resveratrol has been shown to actually reverse certain aspects of the aging process, leading some journalists to ask if this phytochemical might be the source of the mythical "Fountain of Youth."

The resveratrol in red grapes and red wine is thought to account for some of the benefits linked to the Mediterranean Diet. Organically managed vineyards produce wine grapes containing markedly more resveratrol than nearby conventionally managed vineyards (Levite et al., 2000; Miceli et al., 2003; Dani et al., 2007).

A typical fungicide spray program in a conventional grape vineyard in the Southeastern U.S. triggered dramatic declines in resveratrol levels in grape leaves and fruit. In one grape variety, resveratrol levels were almost five-times higher in the plots not treated with nine applications of fungicides, and for two other cultivars, the levels were about three-fold higher (Magee et al., 2002).

A. Resveratrol, Cardiovascular Health, and the "Fountain of Youth"

Resveratrol is a polyphenol stilbene compound present in red grapes, peanuts, and several other dark-colored fruits, vegetables, and some legumes (Udenigwe et al, 2008). Resveratrol also is found in green grapes, hops, blueberries, bilberries, and cranberries, but at concentrations generally well below those found in red grapes and peanuts.

Resveratrol is produced by grapevines in response to attack by fungal pathogens, including Botrytis cinerea (van Baarlen et al., 2004). Other biotic and abiotic sources of stress are also known to trigger resveratrol synthesis.

Stilbenes combat fungi by inhibiting their respiration (van Baarlen et al., 2004). Often, the initial form of a stilbene produced by a plant changes in response to enzymatic action, either altering its ability to access fungi or increasing its inherent toxicity. For example, pterostilbene and piceid are formed as a result of enzymatic transformation of resveratrol, and both are more toxic to many fungi than resveratrol.

Resveratrol is the focus of intense research by food scientists and medical researchers, in large part because relatively high intakes of resveratrol appear to play an important role in the unexpectedly positive cardiovascular health outcomes among those people consuming a Mediterranean Diet that is high in fruits and vegetables,

Grapes affected by *Botrytis cinerea* (also known as noble rot), a grey mold pathogen known to trigger resveratrol synthesis. Image by A. Haenni

whole grains, legumes, olive oil, fresh herbs, yogurt, and seafood. Wine, usually red, is consumed in moderation.

One recent study done at Tufts University led to speculation in the popular press that resveratrol might be the magic potion behind the mythological "Fountain of Youth." The experiment added 0.016 percent of the most potent analogue of resveratrol – pterostilbene – to the diet of aged rats. Remarkably, this stilbene actually reversed cognitive deficits, as well as dopamine release. It also improved working memory in the treated rats (Joseph et al., 2008). This is one of the only studies suggesting that consumption of phytochemicals can actually reverse certain aspects of the aging, as opposed to simply slowing down the aging process.

The Health Benefits of Resveratrol

Few phytochemicals have been more intensively studied than resveratrol, in large part because of resveratrol's wide range of documented health benefits. Possible impacts, which include longevity, blood glucose management and diabetes, cholesterol metabolism, inflammation, and metabolic syndrome are reviewed in detail in Chapter 4. Here, we introduce briefly some of the evidence showing the breadth of resveratrol's other health benefits, along with the ways that farmers can enhance resveratrol levels in harvested foodstuffs.

Oxidative stress and inflammation play a role in cardiovascular dysfunction in aging. Following stroke, levels of free heme increase significantly inside cells. Heme is part of the protein "hemoglobin." Free heme (heme that is not bound to protein) is a prooxidant (i.e., it increases oxidative stress). Resveratrol stimulates the neuroprotective enzyme that breaks down free heme (Zhuang et al., 2003). This is one of the reasons resveratrol and other polyphenol compounds are under intense study in the hope that they may be useful in anti-aging therapeutic strategies (Labinsky et al., 2006).

Resveratrol inhibits the growth of estrogen-sensitive human breast cancer cells in a dose-dependent fashion (Lu and Serrero, 1999). Its anti-cancer activity is mainly due to its ability to trigger cancer cell death via a number of pathways (Udenigwe et al., 2008). It has been shown in various studies to help stop tumor initiation, slow tumor promotion, and block tumor progression. Thirteen published studies between 2006 and 2007 document the anti-cancer properties of resveratrol in a wide range of human and animal cell models (for the list, see Udenigwe et al., 2008).

Alzheimer disease is characterized by accumulation of amyloid-beta plaques in the brain. Resveratrol protects against amyloid-beta toxicity in central nervous system cells (Chen et al., 2005), suggesting therapeutic potential for resveratrol and other similar compounds in Alzheimer's patients. Other animal research has shown that resveratrol may protect against cartilage loss associated with arthritis (Elmali et al., 2005).

Given the many positive effects of resveratrol observed in a wide array of experimental models, ensuring a generous intake of this substance is clearly a prudent dietary measure, especially since there is no evidence of any adverse effects from levels of consumption of resveratrol that are possible via diet.

Consuming organic red grapes and red wine is a step in the right direction, since organic management increases resveratrol nutrient density in grapes by at least a third on average. There are, moreover, promising opportunities to

further increase resveratrol concentrations in grapes and other produce through farming system changes.

Increasing Resveratrol Concentrations in Food

Cultural practices on the farm impacting a variety of sources of plant stress can influence resveratrol accumulation in grapevine leaves and fruit. Potential plant triggers for resveratrol synthesis include pesticides, UV radiation, wounding, salicylic acid, systemic acquired resistance, ethylene, and ozone (van Baalen et al., 2004).

Furthermore, a negative correlation was found between resveratrol levels and the rate of nitrogen fertilization, a classic example of the dilution effect (Fregoni et al., 2000; Bavaresco et al., 2001).

Fungicide applications have also been shown to reduce concentrations of resveratrol. In a study involving muscadine grapes grown in the Southeast, the impacts of fungicide applications on resveratrol levels were quantified.

During the growing season, four fungicides were applied in a rotation totaling nine applications. On average across several cultivars, disease severity was cut in half by these treatments (from a score of "severe" to "moderate"), compared to an untreated control. The impacts of fungicide applications were modest in three of five cultivars, and were more significant in two.

The biggest differences observed in the experiment, however, entailed the impacts of fungicide sprays on resveratrol levels. In the Noble variety, the resveratrol levels in the unsprayed plots were almost five times higher than in the fungicide treated plots. There was about a three-fold difference in two other cultivars, and modest increases in the last two (Magee et al., 2002).

Moreover, this study shows that a grape variety bred for a high level of disease resistance, e.g. Noble, can protect itself nearly as effectively through resveratrol synthesis as when sprayed nine times with four different fungicides.

Even if there is a modest increase in the percent of culls and somewhat lower yields in untreated vineyards, as there was in some varieties in the muscadine grape study, the economic tradeoff would still be positive, or at least nearly neutral for the farmer, since nine fungicide applications entail cash costs well over $100 per acre.

Other management system changes can increase resveratrol nutrient density. Some studies show that increased potassium fertilization correlates with higher levels of resveratrol (Fregoni et al, 2000). The exogenous application of a live soil-borne biological control Bacillus species (Paul et al, 1998) has also been reported to lead to an increased accumulation of resveratrol in grapevine leaves.

A number of studies show that organically grown grapes generally contain substantially higher concentrations of resveratrol. ***Several studies have shown that organic farming systems can increase resveratrol concentrations by one-third or more (Levite et al, 2000; Miceli et al., 2003; Dani et al., 2007).***

Most scientists conducting such experiments explain the differences by pointing out that plants under organic

management must rely more heavily on their innate defense mechanisms (i.e., biosynthesis of resveratrol) to contain damage from pathogens, compared to plants in conventional vineyards where fungicides are routinely applied to knock down fungal pathogen populations. The Muscadine grape study discussed above provides powerful support for this explanation.

B. Other Health-Promoting Phytochemicals

Vitamin C

Many studies have focused on Vitamin C levels in human blood as an indicator for intake of fruits and vegetables. A recent European study found that individuals in the top quintile for plasma Vitamin C levels (i.e., the 20 percent of the people in the study with the highest Vitamin C levels in blood) had an odds ratio of only 0.38 for contracting diabetes, compared to individuals in the low Vitamin C quintile (Harding et al., 2008).

This means that those individuals in this study consuming fruits, vegetables, and/or Vitamin C supplements sufficient to raise their Vitamin C levels enough to get into the top quintile had a 68 percent lesser chance of contracting diabetes.

Salicylic Acid and Salicylates

Salicylic acid is a phenolic acid responsible for the anti-inflammatory action of aspirin. Patients who take aspirin prophylactically to reduce blood clotting have a reduced risk of heart attacks, atherosclerosis, and colorectal cancer. Salicylic acid and its salts, the salicylates, are natural constituents of fruits and vegetables (Swain et al., 1985). Blood salicylate levels are higher in vegetarians than in non-vegetarians (Blacklock et al., 2001).

Consumption of organic foods may increase the intake of salicylic acid. Organic vegetable soups contained almost six-times more salicylic acid than non-organic ones (Baxter et al., 2001), suggesting that the vegetables and plants used to prepare them contained greater amounts of this phenolic acid than the corresponding non-organic ingredients.

The serum concentrations of salicylic acid in vegetarians overlap those of patients taking the most commonly recommended prophylactic dosage of aspirin used to reduce blood clotting, 75 mg daily (Blacklock et al., 2001). However, the total amount of salicylate metabolites excreted in the urine indicates that the daily intake of bioavailable salicylates by vegetarians is considerably lower than that supplied by a 75-mg dose of aspirin (Lawrence et al., 2003). Consequently, the amount of salicylic acid available from vegetables may be too low to provide any health benefits for most people (Janssen et al., 1996; Janssen et al., 1997).

The "Defense Protein" Osmotin

Phytoalexins are "self-defense" substances that are formed by plants in response to pest attack. Resveratrol is a "phytoalexin" that is synthesized by the grapevine in response to attack by the gray mold fungus, *Botrytis cineria*, and other fungal pathogens. But plants can also protect themselves with other substances.

Fungal infections in plants can induce plants to produce defense proteins that target specific metabolic processes that are essential to fungal growth and survival. Fungi have cells that are surrounded by a plasma membrane. Plants under attack by fungi can produce the protein "osmotin" (Narasimhan et al., 2001), a phytochemical known to erode fungal plasma membrane components.

Fruits and vegetables grown on organic farms generally must contend with higher levels of fungal pathogens because they are raised without the use of synthetic fungicides. This can lead to higher concentrations of osmotin per gram of plant tissue. Osmotin is very resistant to digestion.

Surprisingly, osmotin is a biological analog of the mammalian hormone adiponectin, which regulates cellular lipid and sugar metabolism in humans (Narasimhan et al., 2005). Adiponectin levels are higher in women who adhere to the healthier Mediterranean dietary pattern rich in whole grains, olive oil, and fruits and vegetables (Mantzoros et al., 2006). Organic cultivation may yield fruits and vegetables with elevated levels of osmotin, among other phytochemicals providing specific benefits in keeping human lipid and sugar metabolism within healthy bounds. Further research is needed to confirm these mechanisms and to better understand how to grow nutritionally enhanced, phytochemical dense foods.

Rutin and Coumaric Acid

Rutin is a flavonoid glycoside found in buckwheat, the leaves of Rheum species, and a variety of fruits and vegetables. Coumaric acids are derivatives of the phytochemical cinnamic acid and are found in peanuts, tomatoes, carrots, garlic, apple skins, and a variety of other foods.

These chemicals were used in a just-published study carried out with rats fed a very high-fat diet for eight weeks (Hsu et al., 2009). After eight weeks on the high-fat diet, several indicators of lipid and blood glucose metabolism were measured in groups of rats fed a control diet, the high fat diet, and high fat diet plus a low or high dose of rutin or coumaric acid. Hsu and colleagues (2009) report that dietary supplementation with these two phytochemicals decreased body weight gain, reduced liver weight and the buildup of fat tissue, and improved several markers of blood health, despite high fat diets.

The high-fat diet increased insulin levels in the blood from 4.3 ng/liter to 8.8 ng/liter. In the group of rats receiving the high dose of rutin, insulin levels dropped to 6.4 ng/liter, and in the high-diet coumaric acid group, the level fell to 5.7 ng/liter (Hsu et al., 2009). ***Accordingly, these phytochemicals reduced the buildup of insulin in the blood of the rats on a high fat diet by 48 percent to 68 percent.***

3. Endocrine Disruptors, Pesticides, and Other Environmental Toxins

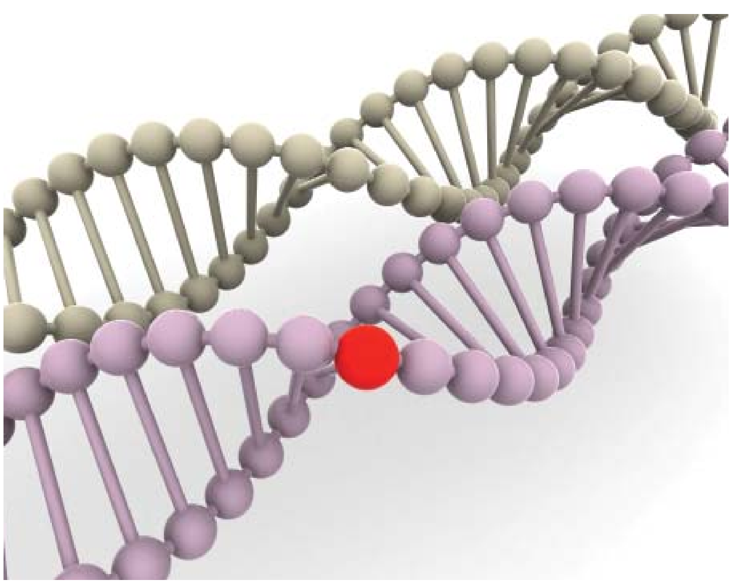
Overview and Summary of Key Points

About 30 percent of today's children are obese or overweight, according to a variety of government statistics. That means around 70 percent are growing up while managing their weight within a healthy range. Why?

A significant share of today's overweight and obese children will develop diabetes during their lifetimes, while the remainder will not. Why will a child fall in one group or the other?

What accounts for the vast differences in health outcomes among children raised in similar settings, consuming similar diets? Why are there many families with one or two overweight or obese children, living alongside and eating the same meals as normal-weight siblings?

A big part of the answer to these questions is rooted in epigenetics – changes in gene expression patterns that alter the health trajectories of individuals, without altering an individual's underlying DNA.



Mounting evidence, moreover, links epigenetic changes during fetal development to the likelihood a person might suffer later in life from overweight, obesity, and/or diabetes. This is a string of events referred to as the "Developmental Origins of Health and Disease (Gillman et al., 2007)," "the developmental origins of adult disease," (Newbold et al., 2007) or the "fetal origins of adult disease."

In fact, the majority of epigenetic changes linked to overweight, obesity, and diabetes happen within the womb during fetal development and of these, many are driven by exposures to environmental endocrine disruptors.

The timing of exposures is just as important, and in some cases, more important than the dose levels delivered to the developing embryo and fetus.

Over one-half of the most widely used pesticides on the market today are known endocrine disruptors, including nine of the ten pesticides accounting for the largest share of overall pesticide dietary risks. For most Americans, exposures to these chemicals are regrettably common, and happen several times most days.

Extensive data compiled by the U.S. Department of Agriculture show that the average person is exposed to 10 to 13 pesticides each day via food, beverages, and drinking water (Benbrook, 2008, drawing on the annual results of the USDA's "Pesticide Data Program"). Fresh fruits and vegetables and beverages, including milk and drinking water, account for most of these exposures.

Some foods contribute several residues in a single serving. Around 2 billion apples in 2004 were consumed that contained five or more pesticides and/or pesticide metabolites, according to USDA pesticide residue and food consumption data (Benbrook, 2008). In recent years the average serving of fresh fruits and vegetables has contained two residues.

A few of the pesticides ingested each day are among those known to cause epigenetic changes in gene expression patterns that, among other impacts, might disrupt normal glucose and fat metabolism and evoke signs of a "pre-diabetic" state (e.g., elevated serum glucose).

In a seminal article in ***Environmental Health Perspectives*** in 1993, Dr. Colborn and colleagues published the first list of endocrine disrupting chemicals, a list that included 35 pesticides representing about 20 percent of the commercially important pesticides at that time (Colborn et al., 1993). Dr. Theo Colborn and her colleague Dr. Lynn Carroll provided the Center an up-to-date list of pesticides known to disrupt endocrine system functions.

There are now 180 pesticide active ingredients identified as endocrine disruptors. The 2009 list encompasses well over half the important pesticides used by farmers in the U.S. and globally. Most Americans are exposed to five to seven of these chemicals on a daily basis.

Steroid hormones are given to a majority of the nation's dairy cattle to improve the cost-effectiveness of artificial insemination (Caraviello et al., 2006). Multiple injections with these endocrine disrupting drugs are made within two to five months prior to the culling and slaughter of many treated dairy cows. A significant portion of beef cattle are also treated with hormone injections to synchronize artificial insemination.

Because the government is not routinely testing for these hormones in animal tissues or hamburger, there is no way to estimate exposures or risk to pregnant women and their children.

Likewise, millions of doses of steroid hormones are administered to beef cattle in feedlots during the last few months of their life to promote growth and feed efficiency. The quantity of these drugs given to beef cattle in commercial feedlots is significant, and sufficient to lead to detectable levels of the drugs in crop fields, nearby streams and reservoirs. Little is known about levels of exposure to these endocrine disruptors through the food supply because, again, limited routine testing is done in commercial beef products.

Consuming organic foods during pregnancy is a simple, accessible way for mothers to virtually eliminate dietary exposures to pesticides and animal drugs, thereby lowering risk, while also increasing daily intakes of polyphenols and antioxidants. Organic fruits and vegetables are, on average, about 25 percent more nutrient dense than comparable conventional foods (Benbrook et al., 2008). These extra nutrients can help both mother and child repair some of the damage done by exposures to endocrine disruptors via the air, water, or in and around the home.

Reducing routine, day-to-day exposures to endocrine disruptors in food is one proactive, prevention-oriented step that families can take to tilt the odds in favor of healthy passage for a newborn through the ever-so-critical early stages of development. Organic food free of endocrine-disrupting pesticide residues is so important at this stage of life because even minute levels of endocrine disruptors during critical windows of development can trigger epigenetic changes leading, in some cases, to serious and negative lifelong consequences.

A. Are Genetic Changes Driving the Increase in Obesity and Diabetes?

Why are health outcomes often so different for children that grow up in the same family, eating the same food and spending time in the same places?

Why are the odds much greater that an overweight individual will develop Type 2 diabetes than a person of normal weight, yet still, many normal weight individuals end up being afflicted by the disease?

Science is beginning to deliver answers to these questions, some tentative and others more certain, although also situation specific. While a person's genes surely have a big influence on how an individual develops, genes alone do not control destiny. Lifestyle factors, diet, exposures to chemicals, illnesses early in life, and luck play big roles in how each infant develops and matures and in how their personal health trajectory will unfold.

The genes contributed by mom and dad place distinct boundaries around the possible pathways of development for each child from the moment after conception. With each passing day though, the possible pathways will multiple and diverge as a result of factors impacting cell division and differentiation, gene expression, damage to DNA, and the ability of the mother and the developing embryo and fetus to repair gene-replication mistakes along the developmental highway.

Genes are not destiny in large part because of epigenetics, which encompasses, and is the result of, the process through which gene expression patterns are altered over a lifetime, resulting in different development trajectories. Wikipedia defines epigenetics as –

> "In biology, the term epigenetics refers to heritable changes in phenotype (appearance) or gene expression caused by mechanisms other than changes in the underlying DNA sequence (hence the name epi – 'in addition to' - genetics). These changes may remain through cell divisions for the remainder of the cell's life and may also last for multiple generations. However, there is no change in the underlying DNA sequence of the organism; instead, non-genetic factors cause the organism's genes to behave (or 'express themselves') differently."

Most of the epigenetic changes linked to overweight, obesity, and diabetes happen within the womb during fetal development (see Newbold et al., 2007 for a recent review). The changes are driven largely by exposures to environmental endocrine disruptors, as well as other maternal environmental influences such as smoking, stress levels, and drug use (Gillman et al., 2007). The timing of exposures is just as important, and in some cases, more important than the dose levels delivered to the developing embryo and fetus.

Pesticides are one of the triggers for epigenetic changes during fetal development, and, in fact may emerge as one of the most important (Amway and Skinner, 2005; Colborn and Carroll, 2007), especially for pregnant women living in areas with intensive pesticide use (Arbuckle et al., 2001; Garry et al., 2002). Adverse impacts on sperm quality may be among the factors contributing to aberrant developmental outcomes (Swan et al., 2003; Colborn and Carroll, 2007).

B. Endocrine Disruptors in the Food Supply

The endocrine system includes a series of glands including the pancreas, thyroid and parathyroid, the adrenal glands, and the pituitary (the master gland of the endocrine system; located at the base of the brain).

The glands of the endocrine system secrete proteins and hormones that turn on, turn off, and otherwise modulate the activity of virtually all aspects of development, reproduction, blood sugar management, and normal, day-to-day metabolism.

Collectively, the endocrine system functions as a sort of "motherboard," or master control switch for the ongoing daily functions of the body that none of us consciously thinks about or can control. The box "An Overview of the Endocrine System" is taken from the TEDX (The Endocrine Disruptor Exchange) website (http://www.endocrinedisruption.com/endocrine.introduction.overview.php). Dr. Theo Colborn founded TEDX, which serves as a clearinghouse for scientific information on endocrine disruptors.

Excerpt from TEDX Overview of the Endocrine System

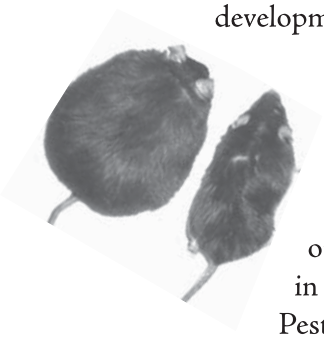
"The endocrine system is the exquisitely balanced system of glands and hormones that regulates such vital functions as body growth, response to stress, sexual development and behavior, production and utilization of insulin, rate of metabolism, intelligence and behavior, and the ability to reproduce.

Hormones are chemicals such as insulin, thyroxin, estrogen, and testosterone that interact with specific target cells. The interactions occur through a number of mechanisms, the easiest of which to conceptualize is the lock and key. For example, target cells such as those in the uterus contain receptors (locks) into which specific estrogenic hormones (keys) can attach and thereby cause specific biological actions, such as regulating ovulation or terminating pregnancy.

Other endocrine disrupting mechanisms include binding hormone transport proteins or other proteins involved in signaling pathways, inhibiting or inducing enzymes, interfering with uptake and export from cells, and modifying gene expression."

As explained in the box, endocrine disruptors are chemicals or contaminants that can work in a myriad of ways, and some of those ways can push an individual toward obesity by disturbing the body's hormonal regulation (Keith et al., 2006). Many endocrine disruptors are "lipophilic" or fat-soluble. Most are environmentally stable. Concentrations of fat-soluble, persistent endocrine disruptors tend to bioaccumulate to higher levels within food chains.

Many endocrine disruptors bind to estrogen receptors. The estrogen receptors α and β (***ESR1, ESR2***) play a role in adiposity (fat buildup), lipid metabolism and feeding behavior (Nilsson et al., 2007). This suggests the intriguing possibility that during fetal development, exposures to environmental estrogens could change feeding behavior, as well as alter the pathway of adipocyte (fat cell) development.



Endocrine disruptors include several pesticides, some polychlorinated biphenols (PCBs), alkylphenols, dichlorodiphenyltrichloroethane, and organotin compounds, which are used in antifouling paints and as fungicides. Pesticides and steroid hormone animal drugs are the most relevant classes of endocrine disruptors in assessing the potential impacts of organic farming on obesity and diabetes, and are the focus of the balance of this chapter.

C. Pesticide Impacts on Obesity and Diabetes

The average American is exposed to 10 to 13 different pesticides and/or pesticide metabolites through food, beverages, and drinking water every day (Benbrook, 2008). Where does this estimate come from?

The USDA's "Pesticide Data Program" (PDP) tests food and beverages for pesticide residues and has created an enormous database on pesticide residues in food and beverages, including drinking water. The PDP tested over 86,000 samples of conventional fruits and vegetables from 1993 to 2006: 39,130 fruit and 47,180 vegetable samples. About three-quarters of the 39,000 conventional fruit samples contained residues, while 60 percent of vegetables were found to contain one or more residues.

Two or more residues were found on most samples of several important fruits and vegetables. For example, there were 743 samples of apples tested by the PDP in 2004, and 73 percent contained three or more residues and one-quarter had five or more. Each sample of apples tested by the PDP represents about 3.6 million pounds of apples, or 11 million apples. Accordingly, consumers ate around 2 billion apples in 2004 involving fruit with five or more pesticide and/or pesticide metabolite residues.

On average, fresh fruit and vegetables contain about two residues per sample, based on recent USDA testing.

Recent USDA food consumption surveys show that the average American consumes about 3.6 servings of fresh and processed fruits and vegetables daily. Of these, about two are composed of fresh fruits and vegetables, the food groups most likely to contain pesticide residues. Accordingly, an average person consumes four residues daily just through fresh fruits and vegetables.

Another two to three residues are ingested through fluid milk, and on average, another two to three residues are ingested in a normal day from other foods, juices, and beverages, for a total of eight to ten from food, juices, and beverages.

Drinking water is another important source of pesticide exposure, particularly for people living in the Midwest and other farming regions. The PDP also tests drinking water as it comes out of the tap. About 54 percent of drinking water samples tested positive for one or more pesticides and pesticide metabolites in 2004 (see Appendix M in the 2004 PDP annual report for detailed findings). The average American consumes about six servings of drinking water per day, about half of which contain pesticides, leading to two to three exposures daily through drinking water.

When exposures via drinking water are added to those from the diet, the total is 10 to 13 pesticide and/or pesticide metabolite residues a day. Any exposures from

pesticide use in and around the home, schools, offices, or parks will further increase the number of daily exposures.

Pesticides Known to Disrupt Endocrine System Functions

It is an obviously complex task to estimate the possible impacts of so many exposures to pesticides on endocrine system function, especially given the need to take into account the possible additive and/or synergistic impacts resulting from simultaneous exposures to multiple chemicals.

To isolate those pesticides most likely to pose risks through endocrine disruption, we asked Dr. Theo Colborn, a member of the Center's scientific advisory committee, to provide an up-to-date list of pesticides shown to function as endocrine disruptors. Dr. Lynn Carroll on the staff of TEDX provided us with the latest version of her growing list of pesticides shown to disrupt endocrine system function in one or more published studies. This most current list appears in Appendix Table 1. The list includes currently registered pesticide active ingredients, as well as several pesticides no longer registered and used, (e.g., DDT and toxaphene).

Table 3.1 reports the numbers of pesticides identified as endocrine disruptors by type of pesticide. ***Remarkably, there is now evidence that 180 pesticides pose risk of endocrine disruption.*** Insecticides account for nearly half, or 79. The three nematicides on the list include two of the most widely used contemporary active ingredients: metam sodium and methyl bromide.

The top two herbicides used by American farmers are among five widely applied active ingredients on the list: glyphosate, atrazine, acetochlor, metolachlor, and 2,4-D.

The 79 insecticides on the list also include the market leader in pounds applied (chlorpyrifos), and collectively account for most of the insecticide pounds applied in recent years across U.S. agriculture.

In the 1993 article in ***Environmental Health Perspectives,*** Dr. Colborn, Fred vom Saal, and Ana Soto published the first list of endocrine disrupting chemicals (Colborn et al., 1993). A total of 35 pesticides appeared on the 1993 list, representing about 20 percent of the commercially important pesticide active ingredients used by farmers around the world at that time.

Table 3.1 Pesticides Identified as Endocrine Disruptors by Type of Pesticide

Acaracides (mite control)	9
Fungicides (plant disease control)	45
Herbicides (weed control)	44
Insecticides (insect control)	79
Nematicides (nematode control)	3
All Pesticides	180

Source: Dr. Theo Colborn, TEDX (The Endocrine Disruptor Exchange)

Sixteen years later, the list contains 180 active ingredients and encompasses well over half the important pesticides used by farmers in the U.S. and globally.

The increase in the number of pesticides shown to impair endocrine system function tells only part of the story. The endocrine system impacts and/or directly controls many organ systems, all aspects of development, and most important metabolic functions. For this reason, there is a vast array of possible impacts, through dozens of mechanisms of action. Data compiled by TEDX shows that several of the most widely used pesticides that are also often present in the American food supply can disrupt endocrine system function in several different ways, at multiple stages of development, resulting in adverse impacts on a wide range of organ systems and metabolic processes.

Nine out of ten of the top pesticide dietary risk drivers in recent years are endocrine disruptors and most of these target two or more aspects of endocrine system function, and a few impair four or more (see Benbrook, 2008 for a description of the dietary risk index used to identify these dietary risk drivers). These nine high-risk pesticides, in terms of human dietary exposure, are chlorpyrifos, methamidophos, endosulfan, dimethoate, acephate, diazinon, azinphos methyl, dicofol, and methomyl. The tenth dietary risk driver lacking evidence of endocrine disruption is oxamyl.

Only modest steps to reduce exposures to these dietary risk drivers have been taken by the Environmental Protection Agency (EPA) since passage of the "Food Quality Protection Act" (FQPA) in 1996. The new law directed the Administrator of EPA to begin a testing program for pesticides to determine their capacity to act like estrogens and/or other hormones in the environment. That program of testing has not started yet after 12 years of discussions, stakeholder meetings, and controversy over what to test for and how.

Examples of Pesticides Known to Disrupt the Endocrine System

The fungicide vinclozolin is among the 45 fungicides identified as an endocrine disruptor. It was first registered in the U.S. in 1981 to control various types of rot caused by Botrytis species, Sclerotinia species, and other types of mold- and blight-causing organisms, on strawberries, lettuce (all types), stonefruit, grapes, raspberries, onions, and succulent beans. It has also been used on turf in golf courses, commercial and industrial sites, and ornamentals in green houses and nurseries.

At the peak of vinclozolin use around year 2000, the PDP found residues in six of the approximate 15 foods tested

that year, including several important children's foods (grapes, strawberries, green beans). As recently as 2005, 47 percent of 263 frozen green bean samples tested by PDP were found to contain residues of vinclozolin (mean level 0.049 ppm). Most food uses of vinclozolin were discontinued over the past decade. The remaining food uses are on Belgian endive, canola, and wine grapes, which were scheduled to end in 2008 (Environmental Protection Agency, 2003).

In 2005 a shocking study was published in *Science* magazine by a team at the Center for Reproductive Biology, Washington State University in Pullman, WA. Anway et al. (2005) showed that transient vinclozolin exposure to a gestating female rat during the period of gonadal sex determination (an example of a "critical window of development") produced an adult male rat phenotype in the F1 generation showing decreased sperm production and viability and increased male infertility. But even more important, the team found that these male reproductive deficits were transferred through the male germ line through four full generations.

The organochlorine pesticides methoxychlor and endosulfan are endocrine disruptors. These broad-spectrum insecticides have been used against flies, mosquitoes, cockroaches, chiggers, and a wide variety of other insects. Both have been used on agricultural crops and livestock, and in animal feed, barns, grain storage bins, home garden, and on pets. All methoxychlor tolerances were revoked in 2002 (Environmental Protection Agency, 2002). While the use of methoxylchlor had been declining for years, it has remained in the food supply.

The last residues of parent methoxychlor were found by PDP in two pear samples in 1998. A methoxychlor metabolite (olefin) was found in two apple samples in 2004 and three cherry samples in 2001. Methoxyclor p,p', another metabolite, was found in wheat grain samples in 2006 and 2005, in wheat flour in 2004, barley and wheat flour in 2003, and rice in 2002.

Endosulfan, also known as Thiodan, remains in widespread use, especially in developing countries and is

one of the most worrisome insecticides still on the market. Endosulfan and its metabolic breakdown products (endosulfan 1, endosulfan II, and endosulfan sulfate) are frequently found in many fresh fruits and vegetables during annual PDP testing.

In 2006 PDP testing endosulfan sulfate was found in 12 of the 21 fresh and processed foods tested. Almost 84 percent of summer squash contained endosulfan sulfate residues, as did 29 percent of winter squash. Peaches, potatoes, spinach, collard greens, and eggplant contained residues in 2 percent or more of the samples tested. In addition, mean residue levels were relatively high in some crops – 0.59 ppm in collard greens and 0.15 ppm in plums.

Prochloraz is an imidazole fungicide that displays multiple endocrine activities. It inhibits steroid synthesis and acts as an androgen receptor antagonist (Noriega et al., 2005). It is used in Europe on cereals such as wheat and barley and on a few other crops, but is not allowed in the U.S. or Canada.

Methoxychlor, prochloraz, and vinclozolin can produce infertility and anatomical alterations in experimental animals as a result of disruptions of one sort or another in the endocrine system (Anway et al., 2005; Anway et al., 2006; Cupp et al., 2003; Noriega et al., 2005; Uzumcu et al., 2004).

Pesticides and Obesity

An obese individual has a greater amount of body fat than normal-weight individuals, and hence also carries a much greater burden of fat-soluble endocrine disruptors than does a relatively lean individual (Pelletier et al., 2002; Pelletier et al., 2003). Fat-soluble, persistent endocrine disruptor concentrations have increased in the environment in the past three decades.

Concentrations of less persistent pesticides identified as endocrine disruptors have not, as a general rule, risen as dramatically, and in some cases have fallen in step with reductions in the volume of a pesticide applied. For example, there was only a slight drop in average concentrations of the major metabolite of chlorpyrifos in the urine of individuals included in the 1988-1994 NHANES study (National Health and Nutrition Examination Study), compared to the 2001-2002 NHANES (Schafer et al., 2004). Levels of a metabolite of methyl parathion fell about 20 percent between the two surveys, as did levels of the herbicide 2,4-D.

Another important scientific finding has emerged in recent years. Exposure to low doses of certain organophosphate (OP) insecticides during critical phases of development can increase the risk of excessive weight gain and impaired glucose and fat metabolism. More specifically, laboratory data provides evidence that:

- Exposure to chlorpyrifos (an OP pesticide) during neonatal and fetal periods results in excessive weight gain and leptin dysfunction, leading to impaired regulation of fat tissues and failure to recognize satiety (a sense of fullness during meal times), (Lassiter and Brimijoin, 2008);

- Low-dose exposure to parathion (also an OP pesticide) resulted in increased weight gain and evoked signs of a pre-diabetic state (e.g., elevated serum glucose and impaired fat metabolism) in a rat study (Lassiter et al, 2008).

- Exposure to the OP malathion may lead to insulin resistance (Vosough-Ghanbari et al., 2007), causes a transitory hyperglycemia in rats (Abdollahi et al., 2004), and also elevates LDL and triglycerides (Lasram et al., 2009).

All OP insecticides are neurotoxins, and most have been shown to impair neurological development in one way or another, and in many cases, in multiple ways. It is no surprise, then, that fetal exposures to these ubiquitous insecticides can impair the intricate processes of development that determine the propensity of a child to manage weight and normally control blood sugar levels. New findings, and deeper insight into the mechanisms through which OP insecticides may be contributing to the nation's current epidemic of childhood overweight and obesity, and diabetes are coming, given the scope of research underway on this topic.

In the interim, there is compelling evidence that a predominantly organic diet dramatically reduces exposures to OP insecticides. The important studies of Dr. Alex (Chensheng) Lu, now at the Harvard University School of Public Health, have shown that providing a predominantly organic diet to school age children virtually eliminates, after just a few days, evidence of dietary exposure to OP insecticides (Lu et al, 2008; Lu et al, 2006; Curl et al., 2003).

In a 2008 State of Science Review, The Organic Center drew on USDA PDP pesticide residue data and EPA toxicological data to estimate that organic production of the fruits and vegetables consumed in the United States would reduce pesticide dietary risks by 97 percent (Benbrook, 2008).

By choosing organic foods in the months before planning to conceive, and then through pregnancy, a mother can eliminate one of the most common daily sources of endocrine disruptors. A mother's choice to consume organic food will not guarantee safe passage for the developing child through its many critical windows of development. It will improve the odds that development proceeds normally, such that exposures to OP insecticides do not increase the likelihood that the growing child will encounter problems moderating hunger and controlling blood sugars.

D. Other Chemicals and Contaminants

Several hundred other chemicals are known to disrupt endocrine system function. Here we focus only on those associated with food production, and which are also substantially eliminated through organic farming.

Steroid Hormones in the Food Supply

A possible contributor to the obesity epidemic is the use of steroid hormones in meat production and on conventional dairy farms (Keith et al., 2006). Estrogens and progestogens are given to the cows on most conventional dairy farms to synchronize estrus, with the goal of reducing the time and cost involved in artificial insemination programs (Colazo et al., 2006; Colazo et al., 2005; Martinez et al., 2002; Martinez et al., 2004). A 2004 survey of 103 conventional dairy farms across the country found that 87 percent of the herds used hormonal synchronization injections (Caraviello et al., 2006).
Three reproductive management programs account for most of the cows treated on conventional dairy farms: Ov-Synch, PreSynch, and HeatSynch. The Ov-Synch

program synchronizes ovulation in lactating dairy cows. It begins with an injection of the hormone GmRH (Gonadotropin-Releasing Hormone), followed seven days later by an injection of $PGF_{2\alpha}$, a prostaglandin, and then two days later with a second GnHR injection. Twenty-four hours later, the cow is artificially inseminated.

The PreSynch programs adds two additional $PGF_{2\alpha}$ treatments to the OvSynch program. These treatments occur 28 days and 14 days before the first GnHR injection, and are followed by another injection of $PGF_{2\alpha}$, and then two days later, the second GnHR injection. Again, twenty-four hours later, the treated cow is artificially bred.

The HeatSynch program replaces the second GnRH injection in the PreSynch program with a treatment of ECP (estradiol cypionate) designed to induce ovulation. The cows are then either artificially inseminated 48 hours later, or breed to estrus (Caraviello et al., 2006).

These three reproductive management programs entail three, five, and five injections per treated cow. Moreover, many high-producing dairy cows experience serious negative energy balance, since normal metabolism and milk production is burning more food energy each day than the animal is consuming via feed. As a result, such cows lose weight and are often difficult to rebreed, hence the need for reproductive management assistance from steroid hormones.

A significant percentage of the dairy cows treated with reproductive hormones and TAI ("timed artificial insemination") experience no pregnancy, so the cows are treated again, and again, and some several times more. The Caraviello et al. survey (2006) reported that dairy farm managers tried to achieve pregnancy an average of 8.8 times before culling a hard-to-breed cow.

A significant share of the hamburger supply in the U.S. comes from culled dairy cattle, many of which have recently been through at least two and sometimes more rounds of reproductive aid injections in an attempt to get them to rebreed. Moreover, these treatments usually occur within three to five months of when the farmer would typically cull a cow and send her to slaughter, since milk production levels tend to drop off quickly when lactations extend beyond approximately 305 days.

Opinions vary widely over whether exposures to these hormones matter in terms of human health. But since reproductive aids involving steroids and hormones are not permitted on organic dairy farms, organic milk and meat derived from organically managed dairy cows do not contribute to dietary exposures and possible risks from these compounds.

Steroids in Beef Cattle Production

Trenbolone acetate is an anabolic steroid used to promote growth in conventionally raised cattle (Cranwell et al., 1996; Mader, 1998). Trenbolone acetate is hydrolyzed to the active compound, 17-beta-trenbolone, which is also one of the metabolites excreted by cattle. Reproductive alterations have been reported in fish living in waters receiving cattle feedlot effluent, and in vitro androgenic activity displayed by feedlot effluent samples has been related to these effects (Durhan et al., 2006; Wilson et al., 2002).

Steroid hormone administration to organically managed livestock is not permitted, so organic beef production poses no risk of exposures to synthetic growth promoting hormones via the food supply.

4. Obesity, Metabolic Syndrome and Diabetes

Overview and Summary of Key Points

Globalization of markets, with wider access to the market economy and lower cost processed foods, has a depressing downside. Humanity is getting fatter and fatter, and diabetes and other metabolic diseases of affluence are becoming epidemic. Even in parts of the world where malnutrition and undernutrition are problems, it is not unusual for a family to include both undernourished and overnourished individuals (Doak et al, 2005). Although many Americans believe that increasing rates of obesity are strictly a U.S. phenomenon, they are, in fact, occuring around the world. (Popkin, 2001; Popkin, 2008).

To reverse the increasing trends of global obesity and obesity-related diseases, an increased emphasis is needed on dietary patterns that promote human health, including increased consumption of fruits and vegetables and vegetable protein, and decreased consumption of meat (particularly red meat) and saturated fats. A Mediterranean-style diet fits this type of dietary pattern. In fact, mounting evidence shows that a Mediterranean style-diet may be useful in preventing and treating chronic diseases related to mild chronic inflammation such as visceral (abdominal) obesity, metabolic syndrome, and Type 2 diabetes (Guigliano and Esposito, 2008). Excess abdominal fat is believed to increase blood levels of fatty acids, which can inhibit insulin's regulation of glucose (Bergenstal et al, 2007). A new study by researchers in Spain also concluded that long-term adherence to a Mediterranean diet could contribute to the prevention of age-related changes in blood pressure (Nunez-Cordoba et al, 2009).

A Mediterranean-style diet is rich in fruits, vegetables, whole grains, and dairy products (Guigliano and Esposito, 2008). It is also high in dietary fiber and low in refined carbohydrates. Finally, a Mediterranean-style diet contains a moderate to high content of vegetable proteins and a moderate content of fats (mostly unsaturated fats) (Guigliano et al., 2008). Consuming an organic Mediterranean-style diet offers additional protective health benefits, including elimination of dietary exposure to toxic pesticides (such as organophosphate pesticides) and increased levels of polyphenolic compounds (antioxidants) that may play an important role in alleviating inflammation and insulin-resistance, which are associated with an increased risk of chronic disease (e.g., metabolic syndrome and Type 2 diabetes).

In the following sections, current trends in obesity, diabetes and metabolic syndrome are highlighted. A review of how consumption of energy dense diets may be associated with an increased risk of obesity, metabolic syndrome and Type 2 diabetes is also provided. In contrast, evidence is presented for why a Mediterranean-style diet offers a practical approach to avoiding adult-onset obesity, metabolic syndrome and diabetes. Finally, in order to ensure optimal health, the chapter ends with a list of specific suggestions on how to follow an organic Mediterranean-style diet.

A. Obesity, Diabetes, and Metabolic Syndrome

In the United States, about a third of adults 20 to 74 years of age are obese (BMI $\geq$ 30) and another third are overweight (BMI 25.0 to 29.9) (Ogden et al., 2006). According to new statistics released by the Centers for Disease Control and Prevention (CDC), the number of obese American adults (about 34 percent) now outnumber those who are overweight (about 33 percent) (Reuters Health, 2009).

Children and adolescents have also grown fatter over the last two decades. A child weight's status is determined based on an age- and gender-specific percentile for BMI rather than by the BMI categories used for adults. Classifications of overweight and obesity for children and adolescents are age- and gender-specific because their body composition varies as they age and varies between boys and girls. The BMI value is plotted on the U.S. CDC growth charts to determine the corresponding BMI-for-age percentile (see the box on this page for definitions of childhood overweight and obesity).

In 2005-2006, 15.5 percent of U.S. children and adolescents aged two through 19 years were at or above the 95th percentile for BMI for age (now referred to as "obese") and 14.6 percent were at or above the 85th percentile for BMI for age and less than the 95th percentile (now referred to as "overweight")." Thus, collectively, 30.1 percent of children and adolescents aged two through 19 years were overweight or obese. The prevalence of high BMI in both children and adolescents showed no significant increases between 2003-2004 and 2005-2006. However, data from 2007-2008 are needed to further examine these trends (Ogden et al, 2008).

Definitions of Childhood Overweight and Obesity	
Classification	Definition
Overweight	Body Mass Index (BMI)-for-age at or above the 85th percentile and lower than the 95th percentile
Obese	BMI-for-age at or above the 95th percentile
Source: CDC, 2009	

Most recently, it was estimated that if current obesity trends continue, by the year 2030, 86.3 percent of adults will be overweight or obese and 51.1 percent will be obese. Black women (96.9 percent) and Mexican-American men (91.1 percent) would be the most affected. These same researchers estimated that, if current trends continue, by the year 2048, all Americans would be overweight or obese. In children, the prevalence of obesity (~ 15 percent) (BMI-for-age at or above the 95th percentile) would nearly double by 2030. Total health care costs attributed to obesity/overweight would double every decade to \$860.7-\$956.0 billion U.S. dollars by 2030, accounting for 16-18 percent of total US health care costs (Wang et al., 2008).

Diabetes is a serious condition associated with overweight and obesity (Geiss et al., 2006). There are two types of diabetes. Type 1 diabetes is "insulin-dependent diabetes." Type 2 diabetes is "insulin-resistant diabetes." Type 2 diabetes is strongly associated with obesity and cardiovascular risk. According to data from the National Health and Nutrition Examination Survey (2005-2006), the crude prevalence of diagnosed diabetes in persons aged 20 years and older rose from 5.1 percent in 1988-

1994 to 7.7 percent in 2005-2006, even after accounting for differences in age and gender. Compared with non-Hispanic whites, age- and gender-standardized prevalence of diagnosed diabetes was approximately twice as high in non-Hispanic blacks and Mexican Americans (Cowie et al, 2009).

A recent report released by the Centers for Disease Control and Prevention (CDC) reported that the rate of new diabetes diagnoses has nearly doubled over the last decade. The average-age-adjusted incidence of diabetes rose from 4.8 new cases per 1,000 persons (between 1995 and 1997) to 9.1 new cases per 1,000 persons (between 2005 and 2007). In the 2005-07 survey, the incidence rate of diabetes was highest in West Virginia and lowest in Minnesota. The ten states with the highest quartile of age-adjusted diabetes incidence included nine of 16 states located in the southern region of the U.S. (Alabama, Florida, Georgia, Kentucky, Louisiana, South Carolina, Tennessee, Texas and West Virginia) (MMWR, 2008). Factors associated with an increased risk for diabetes include older age, lower educational attainment, physical inactivity, obesity, weight gain, and being categorized in a racial/ethnic minority population (Geiss et al., 2006).

Obesity is a risk factor for the development of insulin resistance, with pancreatic beta cells compensating for insulin resistance by augmenting insulin secretion. The failure of beta-cells is believed to cause pre-diabetes, a condition that can lead to diabetes. Because it can take up to 10 years or longer for obese individuals to develop Type 2 diabetes, the full impact of the childhood obesity epidemic on the rate of Type 2 diabetes in young adults has not yet been seen (Lee, 2008).

In the future, it is estimated that more young adults will develop Type 2 diabetes in their 20s and 30s instead of at a much older age, e.g., in their 50s or 60s. If confirmed, this trend will prove costly since the longer a person has Type 2 diabetes, the more likely it is that he or she will develop serious diabetes-related complications such as kidney failure. To better handle this challenge, the U.S. health care system needs to develop "new models of care that address long-term chronic disease risk originating in childhood and extending into adulthood" (Lee, 2008). Increasing public resources for dietary interventions that prevent childhood obesity and related chronic diseases, such as Type 2 diabetes, must be part of this change.

As noted previously, overweight and obesity are associated with significant increase in cardiovascular risk. Overweight and obese subjects are more likely to have hypertension and abnormally high levels of the blood lipids cholesterol and triglycerides than are normal-weight subjects (Janssen et al., 2004). A relatively new term – "the metabolic syndrome" – has been added to the medical lexicon with a World Health Organization definition (Reaven, 2006).

"The Metabolic Syndrome"

An individual has "the metabolic syndrome" if he or she satisfies the following criteria. First, he or she must have at least one of the following conditions: diabetes mellitus, abnormal glucose tolerance, abnormally high fasting blood glucose level, or insulin resistance. Second, he or she must have at least two of the following four conditions:

(a) a waist-to-hip ratio of 0.9 or greater for men and 0.85 or greater for women and a BMI greater than 30;
(b) an elevated serum triglyceride level or a low serum high-density lipoprotein ("HDL") level;
(c) elevated blood pressure (hypertension); and
(d) protein in the urine.

The reason for creating the diagnosis of the metabolic syndrome was to identity persons at risk for cardiovascular disease.

B. Energy Dense Diets and Obesity, Diabetes and Metabolic Syndrome

Dietary energy density is defined as the amount of energy able to be metabolized per unit weight or volume of food (Yao and Roberts, 2001). Assuming people do not change their level of activity and burn more calories, a high energy density of a given volume of food consumed will result in increased energy intake and weight gain. Lower energy density diets can be achieved through dietary patterns that are consistent with the Dietary Guidelines for Americans. Dietary energy density can be lowered by increasing fruit and vegetable intake while limiting intake of foods high in saturated and *trans* fats such as baked goods and fried vegetables (US DHHS and USDA, 2005; Savage et al., 2008).

In a prospective study of 50,000 women, researchers found that high dietary energy density was reflective of a dietary pattern higher in saturated and *trans* fat and refined carbohydrates. However, these researchers noted that it would be misleading to recommend foods solely based on their energy density values since some foods with higher energy density values, such as olive oil and nuts, were not associated with weight gain, while consumption of foods with low energy density values, such as soda, fruit punches and potatoes, were associated with weight gain (Bes-Rastrollo et al., 2008). Other recent research reported that non-Hispanic white women who consumed lower energy density diets ate fewer meals and snacks in front of the television and more dinners as a family at the table (Savage et al., 2008).

Dietary energy density was associated with body mass index and waist circumference but not other metabolic risk factors in a cross-sectional study of free-living, young Japanese women (Murakami et al, 2007). In another cross-sectional study, dietary energy density was associated with elevated fasting insulin and metabolic syndrome in a nationally representative sample of U.S. adults (Mendoza et al, 2007). Finally, in a longitudinal study, an energy-dense, low-fiber, high-fat diet was associated with higher fat mass and greater odds of excess adiposity in young children (Johnson et al., 2008).

In a large, population-based prospective study involving more than 21,000 men and women of European-Caucasian origin, researchers reported a positive association between dietary energy density and the risk of developing Type 2 diabetes, independent of baseline BMI, total energy intake, fat intake and lifestyle factors. Dietary energy density was calculated as the available dietary energy per unit weight of foods (Wang et al., 2008). The researchers found there was a 60 percent higher risk in the highest quintile of energy density compared to the lowest quintile, in the adjusted analysis. More specifically, the researchers found that, "[c]ompared with the highest DED (energy-dense) quintile, participants in the lowest DED (energy-diluted) group consumed significantly more fresh fruit, more vegetables, less meat, less processed meat, [fewer] soft drinks, more alcoholic drinks, more non-energy containing beverages, and a lower percentage of energy from fat." Additional research is needed to determine the mechanism by which dietary energy density may contribute to the development of Type 2 diabetes.

C. The Mediterranean Diet: A Practical Approach to Reducing the Risk of Adult-Onset Diabetes, Metabolic Syndrome and Obesity

A practical approach to improving general health and avoiding the affluent disease trio of metabolic syndrome, Type 2 diabetes, and obesity is adopting a Mediterranean dietary pattern. The Mediterranean Diet refers to the

diet historically consumed in Southern Europe and the Mediterranean Basin. This diet nourished the healthiest people in the world. However, a new report by the Food and Agriculture Organization has warned that in places like Greece, Italy, Spain, Portugal, and Cyprus, the traditional Mediterranean Diet is being abandoned for a more Western diet that has contains more calories from meat and saturated fat (Tufts University Health & Nutrition Letter, December 2008). Such a trend is likely to have major negative health (and economic) consequences, if it's not reversed.

Martinez-Gonzalez et al. (2008) found that high adherence to a traditional Mediterranean diet was associated with an 83 percent relative reduction in the risk of developing Type 2 diabetes. These authors assessed adherence to the Mediterranean diet by using a score created by Trichopoulou et al. (1995), where the Mediterranean diet has a high ratio of monounsaturated to saturated fatty acids, moderate intake of alcohol, high intake of legumes, high intake of grains, high intake of fruit and nuts, high intake of vegetables, low intake of meat and meat products, moderate intake of milk and dairy products, and high intake of fish. Previously, researchers reported an inverse association between adhering to the Mediterranean diet and metabolic syndrome (Tortosa et al., 2007).

Martinez-Gonzalez et al (2008) cautioned against extrapolating the results of their research to non-Mediterranean countries where the consumption of favorable foods (e.g., olive oil, plant-based foods such as fruits, vegetables and legumes) are much lower in the general population. However, researchers who carried out a recent prospective study in the United States (U.S.), involving over 214,000 men and over 166,000 women (the National Institutes of Health – AARP – formerly known as the American Association of Retired Persons – Diet and Health Study) found that there was "strong evidence for a beneficial effect of higher conformity with the Mediterranean dietary pattern on risk of death from all causes, including deaths due to CVD (cardiovascular disease) and cancer, in a US population" (Mitrou et al., 2007).

Furthermore, in a 2-year study titled, "Dietary Intervention Randomized Controlled Trial" (DIRECT), researchers reported that, in addition to weight loss, adherence to a Mediterranean diet resulted in beneficial metabolic effects (Shai et al., 2008). According to these authors, among participants with diabetes (n = 36), "changes in fasting plasma glucose and insulin levels were more favorable among those assigned to the Mediterranean diet than among those assigned to a low-fat diet ($p < 0.001$ for the interaction among diabetes and Mediterranean diet and time with respect to fasting glucose levels)" (Shai et al., 2008).

Key elements of the Mediterranean Diet are high intakes of cereals, whole grains, vegetables, dried beans, olive oil, garlic, fresh herbs, seafood, and fruit. Wine, usually red wine, is consumed with food and in moderation. Meat and poultry are also eaten in moderation; poultry is served much more frequently than red meat. Eggs are included, but butter, cream and lard are not part of the Mediterranean Diet. The Mediterranean Diet includes whole grains. Whole wheat provides insoluble fiber. Whole grain oats and whole grain barley are rich sources of soluble fiber in the form of "beta-glucan". The Mediterranean Diet comprises more "unrefined" foods than most Western diets. Modern Western diets comprise many energy-dense foods with added sugars and added fats. Unrefined foods such as whole grains, fruits, and vegetables have a greater nutrient density than energy-dense refined foods (Drewnowski, 2005).

The amount of fat in authentic Mediterranean diets may vary from less than 30 percent of the calories in the traditional diet of Southern Italy to about 40 percent in the island of Crete (Contaldo et al., 2003). The main contributor is olive oil, which is rich in monounsaturated fatty acids. Scientists in Spain reported that subjects consuming a breakfast high in saturated fat (butter) had a higher expression of the pro-inflammatory cytokine, tumor necrosis factor–alpha, than subjects consuming either a breakfast with monounsaturated fat (olive oil) or a polyunsaturated omega-3 rich fat (walnuts) (Jimenez-Gomez et al., 2009). In addition, Mediterranean diets supplemented with either virgin olive oil or nuts down-regulated cellular and circulating inflammatory biomarkers related to atherogenesis in persons at high risk of cardiovascular disease (Mena et al., 2009).

Other sources of fat in the Mediterranean Diet are fatty fish (rich in omega-3 fatty acids) and eggs. Eggs of hens fed in the traditional Mediterranean manner contain higher levels of omega-3 fatty acids than the eggs of hens fed conventional layer diets (Simopoulos and Salem, 1992). The Mediterranean Diet is also rich in antioxidant phytochemicals . A recent study reported that moderate wine consumption was associated with higher omega-3 fatty acid levels (EPA and DHA) in a person's blood, even when fish consumption was taken into account. The authors concluded that components in the wine other than alcohol - antioxidants called polyphenols - may have exerted these effects, and that part of the cardio-protection of alcohol may be mediated through increased omega 3 fatty acids (EPA and DHA) (di Giuseppe et al., 2009). Rich sources of antioxidant phytochemicals in the Mediterranean Diet are

red wine (Dugo et al., 2003), fresh fruits and vegetables (Benbrook 2005; Rembialkowska, 2007; Benbrook et al., 2008); fresh herbs (e.g., rosemary and sage) (Fortes, 2005), and olive oil (Selvaggini et al., 2006).

There are various mechanisms that may explain the protective effect of the Mediterranean diet (as reviewed in Schroder, 2007 and Perez-Martinez et al., 2007). First, results from two research trials found that virgin olive oil protects against insulin resistance and metabolic syndrome (Estruch et al., 2006). A diet including olive oil, which is rich in monounsaturated fatty acids, may improve insulin sensitivity and result in better lipid profiles than diets rich in carbohydrate (Garg, 1998; Ros, 2003; Perez-Jimenez et al., 2002).

Second, adherence to an overall Mediterranean type dietary pattern is related to lower plasma concentrations of inflammatory markers and markers of endothelial dysfunction (Fung et al., 2005; Lopez-Garcia et al., 2004) – biomarkers which predict future occurrence of diabetes (Meigs et al., 2004). Third, increased adherence to the Mediterranean diet rich in whole grains, olive oil, and fruits and vegetables was associated with higher adiponectin levels (Mantzoros et al., 2006), which are associated with a reduced risk of diabetes (Martinez-Gonzalez, 2008). Finally, scientists are exploring the mechanisms by which resveratrol, the major antioxidant found in the skins of grapes (which is consumed as part of the Mediterranean Diet) may exert positive effects.

D. Resveratrol: a Role in Obesity and Diabetes?

Different phytochemicals may help ameliorate the effects of obesity and diabetes through multiple mechanisms of action. The major antioxidant found in red wine, resveratrol, has been studied the most extensively (King et al., 2006). As noted earlier, resveratrol is a natural polyphenolic stilbene derivative found in high concentrations in the skins of grapes. It is also found in commercial products of cranberries and grapes (Wang et al., 2002), and in other food items, such as berries and peanuts (Udenigwe et al., 2008).
Research suggests that the numerous potential benefits of resveratrol (e.g., vaso-protective, anti-inflammatory, anti-aging) may be due, at least in part, to its antioxidant properties (Manna et al., 2000; Olas et al., 2002; Liu et al., 2003; Udenigwe et al., 2008). Additional proposed mechanisms of action for resveratrol involve inhibition of cyclooxygenase (COX) activity, inhibition of certain activated immune cells and pro-flammatory mediators, and inhibition of transcriptional factors such as nuclear factor-kB (NF-kB) and activator protein (Udenigwe et al., 2008).

Resveratrol has been shown to activate a key gene called the "Silent Information Regulation 2 homolog 1" (SIRT1). When this gene "kicks in," it triggers a series of biochemical interactions that have been shown to extend lifespan, improve metabolic function, or combat metabolic disease in animal models (Ahn et al., 2008). For example, resveratrol was found to prolong the lifespan of mice fed a high calorie diet (Barger et al., 2008). In a randomized clinical trial, the effects of resveratrol on appetite and satiety are also being investigated (Clinical Trials Identifier NCT00654667, February 17th 2009),

Other examples of resveratrol's possible protective effects are reviewed below.

Hyperglycemia – elevated blood sugar – is the hallmark symptom of diabetes. The elevated sugar content makes blood "hypertonic", also called "hyperosmotic." Cells in the lining of blood vessels and white blood cells, which are directly involved in immune system function, can undergo apoptosis (cell death) in response to this hyperosmotic state. Apoptotic biochemical changes during hyperosmotic shock-induced cell death are blocked by pretreatment with antioxidants. Resveratrol decreases hyperglycemia-induced apoptotic changes in human leukemia cells (Chan, 2005).

The rat made diabetic by streptozotocin has elevated blood sugar and blood lipid levels, just as humans with diabetes do. Resveratrol reduced the plasma glucose concentration by 25 percent and the triglyceride concentration by 50 percent in streptozotocin-induced diabetic rats (Su et al., 2006). Resveratrol may reverse the insulin resistance syndrome and facilitate control of human Type 2 diabetes (McCarty, 2005). The body has an "insulin signaling pathway", which is the biochemical pathway that controls how much insulin is manufactured. Resveratrol inhibits the insulin signaling pathway (Zhang, 2006).

More recently, long-term administration of resveratrol was found to reduce high plasma concentrations of triglycerides, total cholesterol, free fatty acids, insulin and leptin in obese Zucker rats. The resveratrol treatment also improved inflammatory status in the rats by increasing the concentration of adiponectin and lowering tumor necrosis factor-alpha production in visceral adipose tissue. Finally, the elevated systolic blood pressure in these obese rats was significantly improved by the resveratrol treatment (Rivera et al., 2008).

Diabetes is also associated with elevated blood levels of low-density lipoproteins. Low-density lipoproteins are carriers of "bad" cholesterol. Resveratrol inhibits copper-mediated low-density lipoprotein oxidation (Belguendouz et al., 1997). Resveratrol protects low-density lipoproteins against oxidative degradation in two ways, by binding pro-oxidant metals like copper and by scavenging free radicals. Currently, a randomized trial is being conducted to investigate the effects of resveratrol on cholesterol metabolism and insulin sensitivity in older adults (over the age of 50) with insulin resistance (Clinical Trials Identifier NCT00654667, February 17th 2009),

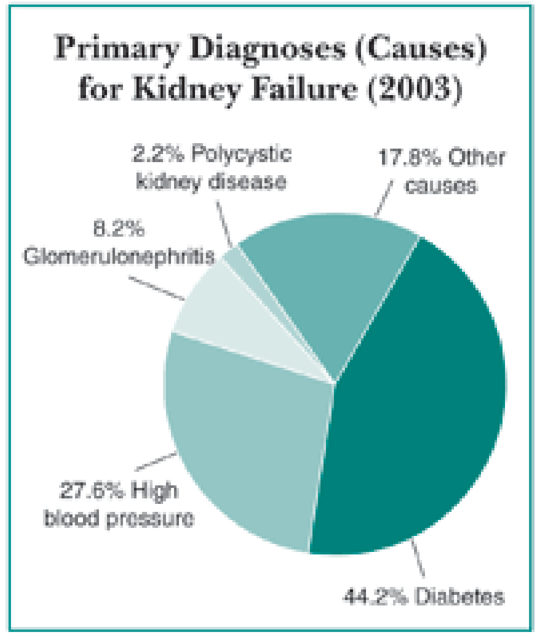
Other research has found that resveratrol inhibits ethanol-induced steatohepatitis in rats, due to its antioxidant properties (Kasdallah-Grissa et al., 2006; Kashdallah-Grissa et al., 2007). Steatohepatitis is a liver disease characterized by inflammation with concurrent fat accumulation. Two of the negative health complications associated with the current obesity epidemic are development of hepatic steatosis ("fatty liver") and non-alcoholic fatty liver disease (NAFLD) (Ahn et al., 2008). Data from numerous studies provide support that NAFLD is the hepatic (liver) manifestation of metabolic syndrome (Marchesini et al., 2003). The prevalence of NAFLD and non-alcoholic steatohepatitis (NASH) in obese patients has been reported to range from 69-100 percent and 25-30 percent of cases, respectively (Clark, 2006; Dixon et al., 2001; Ratziu et al., 2000). Thus, NAFLD and NASH are

Other sources of resveratrol include peanuts and mulberries important therapeutic targets for ameliorating symptoms resulting from metabolic syndrome.

With this information in mind, Korean researchers investigated the possible beneficial effects of resveratrol on hepatic gene expression, lipid content, lipid profiles, and non-alcoholic steatohepatitis (NASH) on mice fed an atherogenic (Ath) diet (Ahn et al., 2008). These researchers found that mice fed the Ath diet had significantly higher plasma total cholesterol (TC) and fasting cholesterol (FC) levels relative to the control group. The mice fed the Ath diet also had an increase in hepatic levels of total lipid, triglycerides, and TC compared with the control diet. The addition of resveratrol reduced the increase in the plasma levels of TC and FC caused by the Ath induced diet. Histological grading of the liver sections confirmed that resveratrol significantly ameliorated both hepatic steatosis and inflammation.

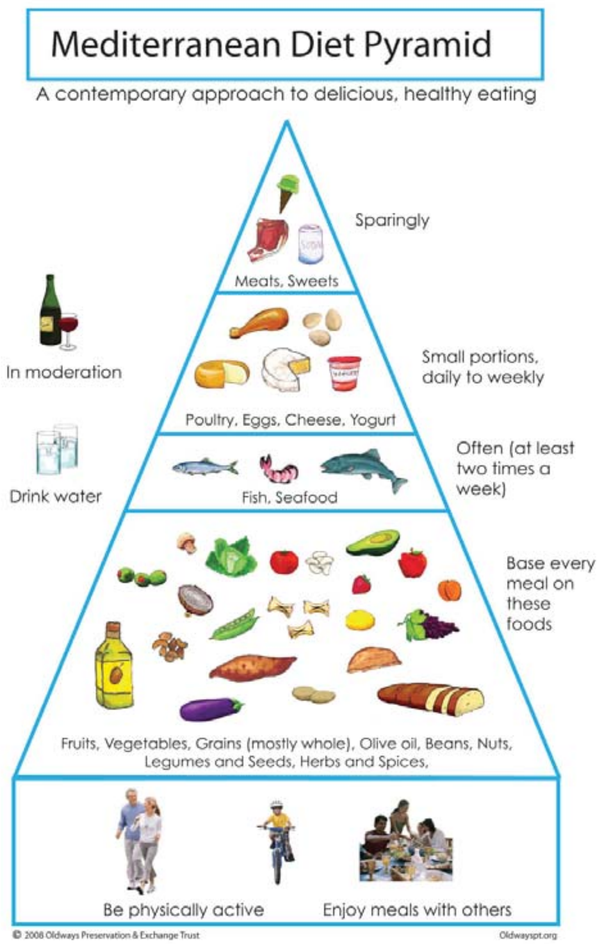
These researchers also found that the Ath diet up-regulated the mRNA expression of various genes involved in lipogenesis (the processes of fatty acid synthesis and subsequent triglyceride synthesis), and the addition of resveratrol to the diet reduced their expression. In contrast, the expression of factors involved in fatty acid beta-oxidation (lipolysis), were up-regulated by resveratrol treatment. Finally, hepatic expression of SIRT1 was increased by the resveratrol treatment. Based on these results, the researchers concluded that that resveratrol has beneficial effects on the prevention and treatment of NASH associated with obesity (Ahn et al., 2008).

One of the most serious complications of diabetes is kidney damage, called "diabetic nephropathy." This kidney damage first manifests itself as the loss of protein in the urine. The final stage of kidney damage is renal failure, where dialysis or a kidney transplant is required for survival. Hypertension – high blood pressure – is common in diabetes. Hypertension increases the risk of diabetic nephropathy. Resveratrol may have a positive effect on the elevated blood pressure of diabetes. The fructose-fed rat is an experimental model used in research on diabetes and the metabolic syndrome. Chronic treatment with resveratrol prevents the increase in systolic blood pressure and cardiac hypertrophy normally seen in the fructose-fed rat (Miatello et al., 2005).



Increased oxidative stress is a major reason why diabetic nephropathy develops. Resveratrol reduces oxidative stress in a widely used laboratory model for diabetes, the rat made diabetic by the administration of the chemical streptozotocin. Six weeks after they were given streptozotocin, rats developed excessive protein in the urine and a marked increase in oxidative stress. Treatment with resveratrol significantly reduced renal dysfunction and oxidative stress (Sharma et al., 2006).

Given the many positive effects of resveratrol on experimental models of diabetes and the metabolic syndrome, ensuring a generous intake of this substance is a prudent dietary measure. Resveratrol has not been found to produce adverse effects, even when consumed at high concentrations. However, the question remains as to how much resveratrol should be consumed on a daily basis in order to derive the most benefits from its protective effects (Udenigwe et al., 2008).



E. An Organic Mediterranean-Style Diet: The Best Bet for Optimal Health

Consuming a Mediterranean Diet has been shown to offer numerous potential public health benefits. Examples of these important public health benefits include: reducing a woman's risk of having a baby with spina bifida (Vujkovic et al., 2009); reducing the risk of chronic diseases related to chronic inflammation (e.g., metabolic syndrome, and Type 2 diabetes) (Guigliano and Esposito, 2008); and preventing age-related changes in blood pressure (Nunez-Cordoba et al., 2009).

Consuming an organic Mediterranean-style diet offers additional important public health benefits including reducing farmers,' agricultural workers' and consumers' exposures to toxic pesticides as well as increasing the dietary intake of polyphenolic compounds (antioxidants) that may play an important role in alleviating inflammation and insulin-resistance, both of which are associated with an increased risk of chronic disease (e.g., metabolic syndrome and Type 2 diabetes).

Below are specific steps for adhering to an organic Mediterranean-style dietary pattern.

1. Enjoy meals with others. Persons who share meals with family and friends often consume a more healthful diet than persons who eat in front of the television or "on the run." Taking time to enjoy meals with others also slows the pace at which food is consumed, giving the brain more time to signal that the stomach is "full".

2. Get regular physical activity every day - at a level that promotes a healthy weight, fitness and general well-being.

3. Consume an abundance of organic foods from plant sources including fruits and vegetables, whole grains and breads, lentils and other dried beans, seeds, and nuts (e.g., walnuts, almonds, pecans). Because nuts are high in calories, eat no more than a handful a day.

4. Emphasize a variety of minimally-processed and, wherever possible, seasonally fresh and locally grown organic foods.

5. Use olive oil as the principal fat, along with other plant-based oils high in monounsaturated fat such as canola oil. Choose these plant-based oils carefully. Whenever you can, purchase extra virgin and canola oils that are cold-pressed. When buying other oils, look for organic brands that use cold press technology as well. Organic oils are not extracted with hexane, a chemical that may pose health risks. By reducing the pressure and heat when oil is extracted from canola, soybeans or corn, organic oil processing typically produces oils higher in vitamins and antioxidants.

6. Use organic herbs and spices in cooking. Fresh aromatic herbs (and spices) are high in antioxidants and add taste to meals. You can grow fresh, organic herbs in a kitchen garden.

7. Eat fish on a regular basis (twice a week or more). Consume fish high in omega-3 fatty acids such as salmon, sardines, mackerel (N. Atlantic, Chub) and anchovies as well as lean finfish and shellfish.

8. Consume small portions daily to weekly of foods such as organic yogurt, poultry, cheese, and eggs. For individuals two years of age and older, limit high fat dairy options such as whole or two percent milk and limit high fat cheeses (instead use lower to medium fat cheeses such as feta, goat, and mozzarella). Choose low-fat poultry options. Eggs are limited to less than four per week (including those used in cooking and baking).

9. Use red meat and sweets only "sparingly." Substitute fish or poultry for red meat. Consume fresh fruit for dessert.

10. If acceptable to your primary care physician, consume wine with meals - in moderation (moderation is the equivalent of one 5 ounce glass of wine per day for women and two glasses of wine a day for men). If you drink alcohol, consume red wine made with organic grapes. Red wines made from organic grapes generally contain substantially more resveratrol than similar varietal red wines, based on reports from several countries (Levite et al., 2000; Miceli et al., 2003; Dani et al., 2007). Consumption of alcohol should be avoided during pregnancy and whenever it puts an individual at risk for a medical problem. Drinking organic purple grape juice can be a healthful alternative to drinking red wine.

Conclusions and Summary

Globalization of markets, with wider access to the market economy and lower cost processed foods, has led individuals to adopt more "energy dense" Western diets, which is believe to be at least a partial contributor to increasing rates of obesity worldwide. In contrast, mounting scientific evidence is illustrating that adoption of a Mediterranean-style diet may prevent or reduce the risk of numerous public health problems including spina bifida, adult-onset obesity, metabolic syndrome, Type 2 diabetes, and age-related changes in blood pressure.

Consuming an organic Mediterranean-style diet offers additional protective health benefits, including elimination of dietary exposure to toxic pesticides (such as OP pesticides) and increased levels of polyphenolic compounds (antioxidants) that may play an important role in alleviating inflammation and insulin-resistance.

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Appendix Table 1: Pesticides and Metabolites with CAS Numbers That Have Been Reported to be Endocrine Disruptors, Based on Studies Compiled by TEDX (The Endocrine Disruptor Exchange)		
www.endocrinedisrupton.org		
PESTICIDE	PESTICIDE TYPE	CAS #
aldicarb	acaricide	116-06-3
carbaryl	acaricide	63-25-2
carbofuran	acaricide	1563-66-2
chlordimeform	acaricide	6164-98-3
clofentezine	acaricide	74115-24-5
alpha-cypermethrin	acaricide	67375-30-8
dicofol [kelthane]	acaricide	115-32-2
tetrasul	acaricide	2227-13-6
toxaphene [camphechlor]	acaricide	8001-35-2
benomyl	fungicide	17804-35-2
biteranol	fungicide	55179-31-2
carbendazim	fungicide	10605-21-7
chlozolinate	fungicide	84332-86-5
cycloheximide	fungicide	66-81-9
cyproconazole	fungicide	94361-06-5
dichlorophen [2,2'-methylenebis(4-chlorophenol)]	fungicide	97-23-4
difenoconazole	fungicide	119446-68-3
diflubenzuron	fungicide	35367-38-5
dinocap	fungicide	39300-45-3
DNOC [4,6-dinitro-o-cresol]	fungicide	534-52-1
epoxiconazole	fungicide	133855-98-8 (formerly 106325-08-0)
etridiazole	fungicide	93-15-9
fenarimol	fungicide	60168-88-9
fenbuconazole	fungicide	114369-43-6
ferbam	fungicide	14484-64-1
flutriafol	fungicide	76674-21-0
hexachlorobenzene [HCB]	fungicide	118-74-1
hexachlorobutadiene [HCBD]	fungicide	87-68-3
hexaconazole	fungicide	79983-71-4
imazalil	fungicide	35554-44-0

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PESTICIDE	PESTICIDE TYPE	CAS #
iprodione	fungicide	36734-19-7
mancozeb	fungicide	8018-01-7
maneb	fungicide	12427-38-2
metiram	fungicide	9006-42-2
myclobutanil	fungicide	88671-89-0
nabam	fungicide	142-59-6
penconazole	fungicide	66246-88-6
pentachloronitrobenzene	fungicide	82-68-8
prochloraz	fungicide	67747-09-5
procymidone	fungicide	32809-16-8
propiconazole	fungicide	60207-90-1
pyrimethanil	fungicide	53112-28-0
quintozene [PCNB]	fungicide	82-68-8
tebuconazole	fungicide	107534-96-3
thiophanate [thiophanate-ethyl]	fungicide	23564-06-9
thiram [diethyldithiocarbamic acid]	fungicide	137-26-8
triadimefon	fungicide	43121-43-3
triadimenol	fungicide	55219-65-3
tributyltin	fungicide	
tridemorph	fungicide	81412-43-3
triphenylin hydroxide	fungicide	76-87-9
vinclozolin	fungicide	50471-44-8
zineb	fungicide	12122-67-7
ziram	fungicide	137-30-4
2,4,5-T [2,4,5-trichlorophenoxyacetic acid]	herbicide	93-76-5
2,4-D [dichlorophenoxyacetic acid]	herbicide	94-75-7
2,4-dichlorophenoxybutyric acid	herbicide	94-82-6
acetochlor	herbicide	34256-82-1
alachlor	herbicide	15972-60-8
amitrole [aminotriazole]	herbicide	61-82-5
asulam	herbicide	3337-71-1
atrazine	herbicide	1912-24-9

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www.endocrinedisrupton.org		
PESTICIDE	PESTICIDE TYPE	CAS #
borax [disodium tetraborate]	herbicide	1303-96-4
bromacil	herbicide	314-40-9
bromacil lithium	herbicide	53404-19-6
bromoxynil	herbicide	1689-84-5
chlorthal [dacthal]	herbicide	
cyanazine	herbicide	21725-46-2
DCPA (USA) [chlorthal-dimethyl]	herbicide	1861-32-1
dinoseb	herbicide	88-85-7
diquat dibromide	herbicide	85-00-7
diuron	herbicide	330-54-1
fluazifop-butyl	herbicide	69806-50-4
glufosinate	herbicide	51276-47-2
glufosinate-ammonium	herbicide	77182-82-2
glyphosate	herbicide	1071-83-6
ioxynil	herbicide	1689-83-4
linuron	herbicide	330-55-2
metolachlor	herbicide	51218-45-2
metribuzin	herbicide	21087-64-9
molinate	herbicide	2212-67-1
N-(4-fluorophenyl)-N-(1-methylethyl)-2-[[5-(trifluoromethyl)-1,3,4-thiadiazol-2-yl]oxyacetamide/thiafluthamide (FOE 5043)	herbicide	142459-58-3
nitrofen	herbicide	1836-75-5
norflurazon	herbicide	27314-13-2
oryzalin	herbicide	19044-88-3
paraquat	herbicide	4685-14-7
pendimethalin	herbicide	40487-42-1
picloram	herbicide	1918-02-1
prodiamine	herbicide	29091-21-2
prometryn	herbicide	7287-19-6

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www.endocrinedisrupton.org

PESTICIDE	PESTICIDE TYPE	CAS #
propanil	herbicide	709-98-8
quizalofop-ethyl	herbicide	76578-12-6
simazine	herbicide	122-34-9
terbutryn	herbicide	886-50-0
thiazopyr	herbicide	117718-60-2
tri-allate	herbicide	2303-17-5
trichlorobenzene	herbicide	
trifluralin	herbicide	1582-09-8
1,2-dichloropropane	insecticide	78-87-5
abamectin [avermectin B1]	insecticide	71751-41-2
acephate	insecticide	30560-19-1
aldrin	insecticide	309-00-2
amitraz	insecticide	33089-61-1
azadirachtin	insecticide	11141-17-6
bifenthrin	insecticide	82657-04-3
S-bioallethrin	insecticide	28434-00-6
bioallethrin [d-trans allethrin]	insecticide	584-79-2
bioresmethrin	insecticide	28434-01-7
carbon disulfide	insecticide	75-15-0
carbon tetrachloride	insecticide	56-23-5
chlordane	insecticide	57-74-9
cis-chlordane	insecticide	5103-71-9
chlordecone [kepone]	insecticide	143-50-0
chlorfenvinphos	insecticide	470-90-6
chloroform	insecticide	67-66-3
chlorpyrifos	insecticide	2921-88-2
cyfluthrin	insecticide	68359-37-5
lambda-cyhalothrin	insecticide	91465-08-6
cypermethrin	insecticide	52315-07-8
DDT	insecticide	3563-45-9
deltamethrin	insecticide	52918-63-5
demephion-O	insecticide	682-80-4
demeton-S-methyl	insecticide	919-86-8

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www.endocrinedisrupton.org		
PESTICIDE	PESTICIDE TYPE	CAS #
diazinon	insecticide	333-41-5
dichlorvos	insecticide	62-73-7
dieldrin	insecticide	60-57-1
dimethoate	insecticide	60-51-5
dinitrophenols	insecticide	25550-58-7
alpha-endosulfan	insecticide	959-98-8
beta-endosulfan	insecticide	33213-65-9
endosulfan (alpha and beta)	insecticide	115-29-7
endrin [hexadrin]	insecticide	72-20-8
esfenvalerate	insecticide	66230-04-4
ethylene dibromide [1,2-dibromoethane; EDB]	insecticide	106-93-4
etofenprox [ethofenprox]	insecticide	80844-07-1
fenitrothrion	insecticide	122-14-5
fenoxycarb	insecticide	79127-80-3
fenthion	insecticide	55-38-9
fenvalerate	insecticide	51630-58-1
fipronil	insecticide	120068-37-3
fluvalinate	insecticide	69409-94-5
tau-fluvalinate	insecticide	102851-06-9
formothion	insecticide	2540-82-1
heptachlor	insecticide	76-44-8
beta-hexachlorocyclohexane [beta-HCH, beta-BHC]	insecticide	319-85-7
delta-hexachlorocyclohexane [beta-HCH, beta-BHC]	insecticide	319-86-8
hexachlorocyclohexane [HCH; benzenehexachloride BHC; mixed isomers]	insecticide	608-73-1
lindane [gamma-HCH; gamma BHC; 99%+]	insecticide	58-89-9
malathion [cythion]	insecticide	121-75-5
methomyl	insecticide	16752-77-5
methoprene	insecticide	40596-69-8

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www.endocrinedisrupton.org		
PESTICIDE	PESTICIDE TYPE	CAS #
methoxychlor	insecticide	72-43-5
mevinphos	insecticide	786-34-7
mirex	insecticide	2385-85-5
monocrotophos	insecticide	6923-22-4
omethoate	insecticide	1113-02-6
oxydemeton-methyl	insecticide	301-12-2
parathion [parathion-ethyl]	insecticide	56-38-2
parathion-methyl	insecticide	298-00-0
pentachlorobenzene	insecticide	608-93-5
permethrin	insecticide	52645-53-1
penthrin	insecticide	26002-80-2
phenthoate	insecticide	2597-03-7
phosphamidon	insecticide	13171-21-6
precocene I	insecticide	17598-02-6
pyrethrins	insecticide	121-29-9
pyriproxyfen	insecticide	95737-68-1
quinalphos	insecticide	13593-03-8
resmethrin	insecticide	10453-86-8
ronnel [fenchlorphos]	insecticide	299-84-3
TDE [p,p’-DDD,4,4’-DDD]	insecticide	72-54-8
tebufenozide	insecticide	112410-23-8
tefluthrin	insecticide	79538-32-2
temephos	insecticide	3383-96-8
tetrachlorvinphos	insecticide	22248-79-9
tetramethrin	insecticide	7696-12-0
trichlorfon	insecticide	52-68-6
chlorpyrifos metabolite	metabolite	6515-38-4
DDT metabolite	metabolite	14835-94-0
DDT metabolite	metabolite	34113-46-7
DDT metabolite	metabolite	65148-76-7
DDT metabolite	metabolite	65148-77-8
DDT metabolite		

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www.endocrinedisrupton.org		
PESTICIDE	PESTICIDE TYPE	CAS #
DDT metabolite	metabolite	65148-83-6
DDT metabolite	metabolite	53-19-0
DDT metabolite	metabolite	65148-75-6
DDT metabolite	metabolite	4329-12-8
DDT metabolite	metabolite	65148-80-3
DDT metabolite	metabolite	65148-81-4
DDT metabolite	metabolite	65148-82-5
DDT metabolite	metabolite	43216-70-2
DDT metabolite	metabolite	65148-72-3
DDT metabolite	metabolite	65148-73-4
DDT metabolite	metabolite	65148-74-5
diuron metabolite	metabolite	3567-62-2
methoxychlor metabolite	metabolite	2971-36-0
methoxychlor metabolite	metabolite	2132-70-9
pentachlorophenol	molluscicide	87-86-5
metam sodium	nematicide	137-42-8
DBCP [dibromochloropropane]	nematicide	96-12-8
methyl bromide	nematicide	74-83-9
3-trifluoromethyl-4-nitrophenol [TFM]	piscicide	88-30-2
chormequat chloride	plant growth regulator	999-81-5
chlorocholine chloride	plant growth regulator	99-81-5
n-2-fluorenylacetamide	rodenticide	53-96-3
pyrinuron [pyriminil]	rodenticide	53558-25-1
piperonyl butoxide	synergist	51-03-6
ethiozin [ebuzin/tycor]		64529-56-2

About the Co-authors

Dr. McCullum-Gómez is a food and nutrition consultant whose areas of expertise include: community food security and sustainable food systems, nutrition during pregnancy, obesity prevention, and public health nutrition. Previously, she held positions as assistant professor, clinical dietitian, nutrition educator, and dietetic program director at Mansfield University. She received a Ph.D. in Nutritional Sciences from Cornell University and obtained her B.S. and M.S. degrees in Nutrition from The Pennsylvania State University. Dr. McCullum-Gómez is a column editor for the *Journal of Hunger and Environmental Nutrition* and serves as an ad hoc reviewer for numerous scientific peer-reviewed journals including *Journal of the American Dietetic Association* and *Journal of Nutrition Education and Behavior*. She is a member of the American Dietetic Association and Society for Nutrition Education. She is also the mother of twins, Emilio and Isabella.

Dr. Charles Benbrook is the Chief Scientist of the Organic Center. He has served in that position for four years, and has been a consultant to the Center since 2004. He has carried out analysis of pesticide exposures and risk for many years, beginning in the early 1980s while serving as staff director of a Congressional subcommittee. Benbrook has a PhD in agricultural economics from the University of Wisconsin-Madison, and a BS degree from Harvard University.

Dr. Richard Theuer was a member of the inaugural National Organic Standards Board from 1992 to 1995 and Chair of its Processing, Handling, and Labeling Committee. Subsequently he was a Technical Advisory Panel reviewer for many of the materials included on the National List. He currently is a member of the Board of Directors of OMRI, the Organic Materials Review Institute, and served as Chair in 2005 and 2006. He has been a member of the American Society of Nutrition since 1971 and is a professional member of the Institute of Food Technologists. He is Adjunct Professor in Food Science at North Carolina State University in Raleigh and Adjunct Professor in Nutrition in the School of Public Health at the University of North Carolina at Chapel Hill. Dr. Theuer was the Vice President of Research & Development for the Beech-Nut baby food company from 1983 to 1999 and served as President and Chief Executive Officer from 1986 to 1989. He currently reviews materials as ingredients for processed organic foods and consults for industry in the areas of product improvement, regulatory compliance, claim substantiation, and presentations and submissions to regulatory agencies. He authored the December 2006 Organic Center's State of the Science Report "Do Organic Fruits and Vegetables Taste Better than Conventional Fruits and Vegetables?" Rich can be contacted at rtheuer@bellsouth.net