CHAPTER 1

STRESS DURING PREGNANCY

FETAL-PLACENTAL MECHANISMS AND ANTIDOTES

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Introduction

Biology is narrative. This chapter discusses pregnancy and fetal-placental development in light of new research on maternal stress. We are calling for a new understanding of how pregnant mothers and their families are treated during this sacred time of life. During pregnancy, a bridge is formed between a woman's or girl's biology and her emerging narrative or story of her pregnancy. It now appears that the placenta takes on functions that were typically thought to be unique to the central nervous system, such as the capability of receiving, processing, and acting upon a wide variety of external stimuli. Thus the placenta plays a very important role and is designed to act on behalf of the fetus as both a sensory and motor organ. It acts as a transducer and integrator of environmental signals into the developmental process of the fetus epigenetically. This will be explained below. The developmental process of the baby can thus be profoundly impacted in terms of long-term health and well-being from maternal stress. Thus attention must and should be placed on the mom since her biology can manifest as sensation, feelings, emotions, and different states of mind.

Recent research has identified prenatal stress as a very serious detriment to the immediate and long-term health and well-being of the embryo, fetus, infant, and adult (Danese and McEwen 2012; Lupien *et al.* 2009; Sandman and Davis 2012; Shonkoff, Boyce, and McEwen 2009; Van den Bergh *et al.* 2005; Wadhwa 2005; Wadhwa *et al.* 2002, 2011). Many women and girls report experiencing high levels of stress in their lives and feel they

have little time and limited resources they can use to fulfill their needs in healthy ways. Researchers Wadhwa *et al.* (2011) explain that stress is a 'person–environment interaction, in which there is a perceived discrepancy between environmental demands and the individual's psychological, social or biological resources'. Direct links have been made between prenatal maternal mood and fetal behavior, as well as significant genetic adaptations in the human placenta from different types of stress (Monk, Spicer, and Champagne 2012; Myatt 2006; Wadhwa *et al.* 2001).

Some pregnant women and girls have experienced past or recent severe stress and trauma. Robert Scaer, an expert in the field of trauma, notes that during a traumatic experience, severe stress escalates to the point where an individual feels her life is threatened. A feeling of helplessness is also a key component of traumatic experience (Scaer 2007, 2012). These pregnant women and girls may experience traumatic stress symptoms and post-traumatic stress disorder (PTSD) during pregnancy which may be associated with pregnancy complications that impact the health and development of their offspring (Yehuda *et al.* 2005), including their birthweight and length of gestation (Seng *et al.* 2011). PTSD will be discussed below.

Some mothers experience a state of chronic stress. This can include the stress induced by a diet that provides inadequate maternal nutrition, which modifies the physiology and metabolism of the pregnant and postpartum mother, and programs the fetus for heart disease later in life (Saad *et al.* 2016). Cigarette smoking and exposure to second-hand smoke are also very stressful on the embryo and fetus and are linked to childhood obesity (Durand, Logan, and Carruth 2007), anxiety and cardiovascular disease (see CDC 2016 for a complete list of the effects of smoking during pregnancy).

Stress may also be triggered intermittently by any event in the external or internal environment of the mother. Stephen Porges (2004) coined the term 'neuroception' to describe how an individual, in microseconds and beneath conscious awareness, perceives and reacts to their internal and/or external environment. The specific psychophysiological states associated with the neuroception of environmental safety, danger, or life threat are expressed in an individual's neuroendocrine, cardiovascular, and immune systems. If a mother's neuroception of her environment evokes an experience of safety, her social engagement system will be activated. When a mother's neuroception of her internal and/or external environment evokes an experience of danger, fight-or-flight responses will be activated. When her neuroception of her

internal and/or external environment evokes an experience of life threat, freeze/dissociation/shutdown behaviors will be activated. It must be pointed out that in a clinical setting, the establishment of safety is of critical importance when working with a pregnant mom.

Epigenetics and morphology

Embryonic-fetal growth and development are influenced by two dynamics. The first is the expression of one's epigenetic influences (Holt and Patterson 2006). There is a sleeve around the DNA in the cell nucleus that signals when to switch on and switch off optimal genes during development. The sleeve around the DNA is divided into zones depending on what is being built by the cell. It is like a sheet of music specifying which note is played and when it is played. The switching can be influenced by a mother's psycho-emotional state or even by the last meal she ate. If there is a stress influence, a less optimal gene may be expressed from the particular zone being targeted. This is the science of epigenetics in brief.

The second influential dynamic of growth and development is from the morphology (the physical and fluid movement) of cells, cell aggregates, individual structures within embryos, the whole form of the embryo and the fetus. All cells in the body are interconnected via fluid communication systems with a substrate of, firstly, biological water and, secondly, the blood. In addition, there are signaling proteins in each cell that connect with every cell in the body like an interstate highway system. Therefore, epigenetics and morphology are partners in the dance of development throughout our lifespan, but especially prenatally. Both involve movement at a microscopic and whole-body level. At the level of the whole body, a woman may begin to sense the enormity of her and her baby's metabolism.

The epigenetic process may be an evolutionary attempt, as imperfect as it is, by the developing organism to prepare for, or adapt to the environment based on environmental exposures of the past and present. In a way, there are no perfectly optimal growth vectors because the human organism is constantly adapting, which is natural. However, bringing forward transgenerational family imprinting can be a less than optimal adaptation. At the same time the embryo and fetus is responding to the natural world in the present moment. Although the human embryo has similarities in its development, every human embryo has different time lines for the differentiation of

structures and functions. This means that the term *optimal* has a wide range of possibilities, as does the term *normal* or *natural*.

Stress imprinting

The mother's body–mind equilibrium is essential during pregnancy and she needs support to become more conscious of such equilibrium. It is vital that the care provided to the mother assists her in developing stress reduction skills that may reduce the negative impacts of stress on her embryo and fetus-placenta, including the influence of stress on the expression of genes (epigenetics) in the embryo and fetus-placenta. This type of support or education must be based on loving kindness rather than fear. The negative impacts of stress and traumatic stress include pregnancy complications such as intrauterine growth restriction (IUGR) and premature birth (Wadhwa *et al.* 2001, 2011). IUGR (which is discussed below) is associated with epigenetic switching, which also causes a wide variety of other challenges during pregnancy, birth, and the postpartum period (Hunt 2006; Huppertz *et al.* 2006; Sibley *et al.* 2005).

Stress imprinting (epigenetic imprinting) can occur at any time in the lifespan of an egg or a sperm, from the time when the egg first differentiated (when the mother herself was an embryo in her mother's womb), during the mom and dad's adolescence, and all the way up through ovulation and fertilization. Every egg is different in this way, as are sperm. Some eggs could be 'hibernating' in the ovaries for 30 years with an imprint, and others might not get imprinted until ovulation. No two eggs are the same, and the same imprint does not occur in the egg immediately adjacent to it. And, yes, it is the same process with the sperm cell. So again, what is optimal for one embryo and fetus may be quite different for another, even in identical twins.

Fetal programming

Because numerous diseases have now been identified as having their origins in the fetal environment – diabetes, heart disease, hypertension, obesity, and others – a new scientific model of pregnancy has been developed. It is called the *fetal programming hypothesis* or stress vulnerability model (Wadhwa 2005). This model postulates that maternal stress during pregnancy impacts the in-utero environment and can alter the development of the fetus

during particularly sensitive periods. This may also include a permanent effect on what is called the phenotype or the end expression of genetic inheritance. This typically shows up in low-birthweight babies or babies who are obese at birth or quickly become obese after birth (Gillman 2008; Whitaker 2004). The occurrence of low-birthweight babies has tripled in the past ten years according to the Harvard T.H. Chan School of Public Health (2016). What has not been revealed are effective measures to stem the tide of this epidemic. Haig (1993, 1996), an evolutionary biologist, refers to this as the 'struggle of pregnancy'. One common measurement is the cost to the health care system, which can be enormous in some disease processes. As much as stress imprinting and fetal programming may create a metabolic struggle in the mother, there is equally a system of cooperation, which will be discussed shortly.

Obesity has become particularly problematic in our culture. At its most basic, the term 'obesity' describes having too much body fat. The most commonly used measure of weight status is the body mass index, or BMI. BMI uses a simple calculation based on the ratio of one's height and weight. Determining one's BMI and its interpretation can readily be done on the internet. More recent research has shown that waist circumference and measurement of visceral fat to determine obesity also correlates well with important health outcomes such as heart disease, diabetes, cancer, and overall mortality. Pregnant moms can be obese along with their unborn babies. Low-birthweight babies can become obese shortly after birth as mentioned, indicating a significant metabolic problem established during or possibly before the pregnancy. Obese babies are now a growing concern because of dysregulated metabolism in the baby leading to the likelihood of metabolic syndromes such as diabetes, heart disease, and continued obesity through the lifespan. More children than ever before are manifesting heart disease.

Cited studies in this chapter on work-related stress and adverse pregnancy outcomes also show that occupational exposure is particularly associated with low birthweight, including physically demanding work, prolonged standing, shift and night work, and high levels of cumulative work fatigue. Physically demanding work is also related to pregnancy-induced hypertension and pre-eclampsia. Severe life events, such as the death of a family member, accidents, and illnesses, have been shown to increase the frequency of cranial neural crest malformations in the child (de la Cruz and Markwald 1998). This means that there will be a potential problem with the development of

the heart and vascular system. It is now known that over half of all birth defects are in the heart and vascular system (Kirby 2007). Neural crest cells (the earliest cells in the embryo that differentiate to become the autonomic nervous system) play an important role in the development of the aorta and certain parts of the heart during the embryonic and fetal time of life (Tomanek and Runyan 2001). These authors point out that over half of all birth defects are defects of the cardiovascular system.

As a pregnancy progresses, rest–activity cycles related to the mother's own imprinting in her autonomic nervous system begin to be linked to specific fetal heart rate patterns, as well as to the absence or presence of rapid eye movements (REM) in the mother. Rapid eye movements are now known to be critical to getting a good night's sleep; with the epidemic of insomnia in contemporary society, one can easily trace some of these poor sleeping patterns to the prenatal time of life. Sleep is restorative to the whole body and nervous systems.

Fetal movement – ADHD

Along with heart rate patterns and eye movements, fetal movement patterns are important indicators of fetal states and development. There are between 11 and 16 basic fetal body movements. When a fetus does not make these movements there is a direct link to learning disabilities in childhood and adolescence as well as attention deficit disorders (Birnholz, Stephens, and Faria 1976). Research by Van den Bergh and Marcoen (2004) links maternal stress and ADHD (Attention Deficit Hyperactive Disorder) in eight- and nine-year-olds. The sleep and stress control systems share particular brain locations, such as the locus coeruleus and the prefrontal cortex. It is very difficult to think clearly and to self-regulate emotionally when under stress and unable to sleep.

Maternal PTSD

Pregnant moms with a history of traumatic stress symptoms or diagnosed PTSD are also particularly vulnerable to dysregulated autonomic states during pregnancy that may affect the growing fetus. Cited research in this chapter suggests that maternal anxiety and stress-related mechanisms affect the fetal nervous system during the first two trimesters of pregnancy.

Van den Bergh *et al.* (2005) conclude that the link between maternal prenatal emotional stress and later infant or child behavior persists even after controlling for different research biases and other dynamics that occur in the prenatal and postnatal period of life. Because of this, there is now a great deal of support for the fetal programming hypothesis due to maternal stress.

Cited research in this chapter further indicates that maternal anxiety during pregnancy is also significantly associated with challenges in infant orientation and autonomic nervous system stability. Greater activation of the right hemisphere has been demonstrated in the infant as well as elevated levels of cortisol and norepinephrine. Elevated levels of these neurotransmitters can be quite toxic to the fetal and infant brain (Sandman and Davis 2012). Along with these elevated levels, lower levels of dopamine and serotonin in the newborn have been found (Nathanielsz 1996). Women and girls may experience both PTSD and depression in the preconception, prenatal and early postnatal period. Infants of mothers with symptoms of depression tend to cry excessively after birth and are difficult to console. It is clear that children of depressed mothers show increased autonomic arousal, including higher heart rates and reduced activity in brain regions that mediate positive social relational behavior. The link between prenatal stress and regulation problems at the cognitive, behavioral, and emotional levels in the child has now been clearly identified.

Maternal freeze/dissociation, freeze/shutdown responses, and endogenous opioids

Women and girls with past experiences of trauma and/or traumatic stress symptoms may experience a felt sense of life threat in the preconception, prenatal, and early parenting periods. If they are pregnant, they may experience a felt sense of life threat for their developing baby as well. They may experience a lack of control and helplessness as their bodies change over the course of the pregnancy. This may also occur if they experience medical conditions and complications during the pregnancy, as well as during medical exams and procedures and interactions with health care practitioners. A neuroception (Porges 2004) of life threat may be triggered in pregnant women and girls long after a traumatic event(s) is over. This may also happen in women receiving reproductive endocrinology treatment for infertility.