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Epigenetics and its Implications on Postgenomic Maternal Health and Eugenics

Introduction

Over the last 100 years, there have been profound conceptual discoveries on the notion of heredity that have transformed how evolutionary science is perceived and understood. From the advent of soft hereditarian concepts brought by the Mendelian Revolution to the making and unmaking of hard heredity under Francis Galton, and finally the transition back into soft heredity in the current postgenomic era, science is constantly influenced by both biological and social factors. In particular, the emergence of environmental epigenetics represents an incarnation of postgenomics that challenges current concepts of race and biological plasticity where reproductive women and the fetus are becoming important frameworks for study. Although epigenetics is a relatively new science of biological and environmental variation, it has much potential to develop into a framework that can act as a molecular confluence between nature and nurture, thus providing a new foundation for understanding post-genomic science.

` While the emergence of epigenetics is presented as a new, non-deterministic model of biological plasticity that is deeply rooted in biology and genetics, epigenetics is also intertwined within socioeconomic and cultural situations. By refocusing the attention away from the individual to the broader environment, it suggests that there is a collective causation for health outcomes, which appears as an anti-racist science (Mansfield and Guthman, 2014). Its appeal in that it can be used to advocate for social justice presents epigenetics as a welcoming science, but also lends itself to new approaches to thinking about what race and developmental origins of health and disease are constituted from. With this change in outlook, there is interest in improving healthy gene expression by intervention at the molecular level as well as managing regulation through social and nutritional environments (Landecker and Panofsky, 2012). By focusing on nutritional environments, women and gestation become important models of study. Yet although epigenetics is centered on a non-determinist, biologically plastic model, it has contributed to new notions of race, reproduction, and gender that have resulted in new meanings of abnormalities and how to treat these abnormalities based on ideals of normalization (Mansfield and Guthman, 2014). These new notions allow epigenetics to have the potential to produce new concepts of racialization and racial science that stem from controlling reproduction and the uterine environment as a site for intervention, as well as ideals of perfecting the human genome.

This paper argues that epigenetics is a reproductive science with women and the uterine environment as central areas of study with the potential to reify eugenic logic through possibilities of re-racialization and an alternative ontology of race, heredity, and biology. Furthermore, with epigenetics being heavily related to the uterine environment, what does it mean for pregnant women and their responsibilities? How will the understanding of reproduction and roles of women change? This paper will examine these issues by first looking at the biochemistry of epigenetics, secondly how reproduction and gestation are key figures in the becoming of epigenetics, and finally how epigenetics is tied to the reemergence of soft heredity through eugenic logic by reproductive science.

The Biology of Epigenetics

To understand the entirety of what epigenetics fundamentally is, it is important to understand the biochemical processes that allow it to function. Epigenetics is defined as the study of variations in gene function that are heritable, but do not arise from direct alterations in the DNA sequence itself (Feil and Fraga, 2012). Much of the epigenetic phenomena seen today are caused by chemical or structural modifications of chromatin and DNA methylation, where environmental factors can play a large role in influencing gene expression and phenotype without changing the genetic code (Feil and Fraga, 2012). Because epigenetic modifications can occur or transform throughout a lifetime, it is important to discern what how and why the changes are attributed to environmental influence as well as look at the cell on a molecular level to see how genes are regulated within an epigenetic context.

Although there are many different types of epigenetic modifications, DNA methylation is commonly recognized as the key mechanism of epigenetic gene regulation. In eukaryotic cells, DNA is tightly packaged into chromatin where modifications on the chromatin structure can greatly influence gene expression, leaving lasting changes in gene function (Feil and Fraga, 2012). DNA methylation involves the modifications of chromatins, and results from "the post-synthetic addition of methyl groups to the 5-position of cytosines [which] alters the appearance of the major groove of the DNA to which the DNA proteins bind" (Jones and Takai, 2001). From this, methylation not only can block gene expression but also affects the interactions between DNA and proteins that can change the rate of transcription. By either increasing or decreasing the rate of transcription, this leads to disruptions in the chromatin structure that form epigenetic mutations which in turn can lead to substantial diseases (Jones and Takai, 2001). Even with knowledge on DNA methylation and other epigenetic mechanisms, there is still uncertainty regarding the stability of these mutations and how they are received in a transgenerational manner.

While epigenetic changes can be seen as biological anomalies, it is important to note that they also portray that genes can be developmentally plastic in that they respond in dynamic ways with the environment. Not only this, DNA methylation within epigenetic gene regulation plays a crucial role in early mammalian development, where it is especially influenced by nutritional and environmental factors due to high rates of new tissue and DNA growth (Dolinoy and Jirtle, 2008). Because nutritional and environmental influence on DNA methylation occur early during embryogenesis, embryogenesis is shown to be a critical frame of vulnerability to epigenetic mutations (Dolinoy and Jirtle, 2008). Fetal development is an important period where environmental factors can influence genes, which in turn influences multigenerational predispositions to disease and health. With the emphasis of epigenetics being centered on outside forces, it is no surprise that women and the uterine environment have been popular areas of study for epigenetic programming.

Epigenetics and Gestation

In understanding genetics and heredity under the concept of epigenetics, it is important to note that the emphasis on the environment as a major influence on future progeny and inheritance of certain genes creates a gendered point of attention. There is once more an extreme shift in attention towards the roles of mothers, the uterine environment, as well as the fetus in understanding how the maternal body influences the ways genes are developed (Meloni, 2016). The growing interest in improving genes and removing detrimental genes from the human genome has turned to gestation as the main target of intervention, thus reinforcing the idea that epigenetics transcends the environment in that it is a reproductive science as well (Mansfield and Guthman, 2014). From this, the rise of maternal-fetal epigenetic programming science “points to an emerging post genomic explanatory order in which traditional forms of genetic determinism and reductionism are subtly reformulated” (Richardson, 2015). The introduction of these new reformulations calls for the need of more research and understanding on the maternal body in relevance to epigenetics, as well as new approaches to answer the raising questions that have resulted in the postgenomic era. With the epigenome being so plastic during fetal development, looking at women and gestation brings about gendered responsibilities that emphasize reproduction as an intervention to improving genes and quality of life.

Interest on the fetal origins of disease as well as transgenerational epigenetic inheritance has expanded to more research being focused on the fetal environment including the role of mothers. Already it can be seen that this extended responsibility of sustaining and maintaining a thriving uterine environment is strongly gendered towards women and their responsibility as mothers. With the fetus being represented as vulnerable and fragile, gestation and women become prime targets of intervention (Mansfield and Guthman, 2014). Returning to the questions addressed in the beginning of the paper, what does it mean for pregnant women and their responsibilities? How will the understanding of reproduction and roles of women change? New research emphasizes the concerns on lifestyles and health of women during the pre-pregnant period as well as during pregnancy, which then enforces new responsibilities that they must uphold (Meloni, 2016). The uterine environment is placed upon a high pedestal, where light is shone on the importance of its health which shapes the future of the human epigenome. This pressures mothers “to make lifestyle changes in the service of their genetic lineage, while maintaining that these changes are unlikely to bring them or their offspring any benefit” (Richardson, 2015). With the fetus as the main center of attention, women can be seen as mere instruments to serve as a flourishing niche for the fetus to grow. From this, it can be concluded that epigenetics emerges not only as a reproductive science, but as a technology as well, where women are responsible for sustaining optimal uterine health in order to better future progeny (Mansfield and Guthman, 2014).

Not only is gender highlighted when studying epigenetics and gestation, race and class also play roles in the intergenerational passing of hereditary traits. While socioeconomic factors do affect phenotypes of individuals, contemporary racism and systemic discrimination produces cumulative effects of chronic stress that negatively impact maternal biology and are passed down "each successive generation via the intrauterine environment" (Meloni, 2016). Social stress experienced while under pervasive threats of racism,discrimination, and poverty affect women of color in that these forms of stress can be transmitted to their offspring. The establishment of these recapitulated epigenetic markers can therefore be found in the offspring transmitted by gametes (Kuzawa and Sweet, 2009). An example of epigenetic recapitulation is a study on nurture and anxiety on lactating rats where the maternal phenotype was able to "construct a rearing environment that tends to replicate the same phenotype in the next generation" through transgenerational recapitulation of epigenetic marking instead of genes (Kuzawa and Sweet, 2009). From this, it can be seen how racism and discrimination can physically and biologically be passed down by the maternal germline, therefore both producing and reproducing biological differences in future generations.

Aspects of the fetal environment can indicate underlying reasons for certain heritable diseases which in turn has called for new analytic approaches in order to properly study epigenetics within the uterine environment and gestation. The biochemical processes of epigenetics raises the question of the role of a person's, especially the mother's, external milieu, the uterine environment that nurtures developing genes, and how epigenetic markers are formed where they can be passed onto future progeny. From this, maternal-fetal epigenetic programming is a relatively new and flourishing field of human epigenetics that examines "how exposures during the prenatal and perinatal periods can induce long-lasting epigenetic changes that lead to adult disease and are potentially passed onto future generations" (Richardson, 2015). Maternal-fetal epigenetic programming and the concept of fetal programing is now commonly known as the theory of developmental origins of health and disease (DOHaD), where the uterine environment plays an extensive role in the formation and maintenance of epigenetic marks through the germline (Zhu et al., 2019). By introducing epigenetic modifications, DOHaD researchers believe that the maternal body is an adaptive environment for the fetus where development can be influenced by these modifications as well as transmit early developmental cues to the baby (Richardson, 2015). Furthermore, Sarah Richarsdon explains that maternal bodies are now emerging as "epigenetic vectors" in DOHaD research, where they serve as conduits for epigenetic intervention (Richardson, 2015). While the future health of the next generation is important, DOHaD research fails to realize that focusing solely on maternal bodies is unrealistic because of different circumstances each individual has. Social critique mainly includes the class of women, where DOHaD promotes maternal responsibilities that may be unattainable in reality due to mothers being poor and unable to access resources. (Meloni, 2016). With this, DOHaD places too much emphasis on the maternal body as a point of intervention, seemingly forcing a "one size fits all" approach to women when it may be impractical depending on social standing.

The focus on gestation and the uterine environment as key points of intervention not only on one hand places emphasis on the extended responsibilities of women, but on the other hand also brings into the consideration of using artificial wombs to create precise, controlled environments for cultivating genes. DOHaD research has engendered a new array of analyses on "epigenetic processes before and during fetal development within and beyond the womb" (Lappé and Landecker, 2015). Looking beyond the womb, technology such as the introduction of artificial wombs could be used as new targets of intervention rather than using maternal bodies, thus shifting extended responsibility from women to synthetic technology. Because of the transparency within the technology itself, artificial wombs allow for invitations to greater interventions (Rosen, 2003). These interventions include epigenetics, where focus on gestation has been a prime target for experimentation. The ability to meticulously adjust the womb's environment can allow scientists to perfect the artificial womb where it becomes a healthier environment than the human's womb; therefore, allowing them to have "precisely regulated sources of temperature and nutrition and ongoing monitoring by expert technicians in incubation clinics" (Rosen, 2003). With the perfection of an artificial womb, conceiving children the traditional way through a human womb may soon be seen as a thing of the past. While much of the discussion on artificial wombs remains sparse in the context of epigenetics, the introduction of artificial wombs raises questions on the implications for women and their roles not only biologically, but socially as well.

If artificial wombs were to become normalized in the future, the option to do so may change how women and pregnancy are perceived. Proponents of artificial wombs advocate for the medical benefits of the technology such as an increase in maternal health and safety, where mothers can bypass serious health risks and the unpleasantness of pregnancy as well as the increase of reproductive options (Olsen and Pellisier, 2011). Furthermore, fetal health and safety are guaranteed as artificial wombs allow perfectly adjusted environments individually catered to each fetus without the impending possible dangers if the mother falls prey to addiction, alcoholism, and other risks (Olsen and Pellisier, 2011). This brings into the question of epigenetics and its implications on the fetal environment, where artificial wombs can be adjusted to cater to every individual's needs in order to conceive the healthiest baby. Not only do artificial wombs further the advancement of human reproductive technologies, they also advance women's social equality where women can finally be freed from the obligation of reproduction and conceiving children would be much more convenient (Rosen, 2003). This also expands the amount of choices available for women if they do wish to conceive children, spawning new freedoms that could greatly propel more opportunities in which women never had before. Freeing women from the subjugation of their reproductive responsibilities allows them to finally achieve equality with men in that they don't have to bear biological maternal duties if they wish to conceive a child, allowing women to freely move on with their careers (Olsen and Pellisier, 2011). Ectogenesis and artificial wombs can be seen as progressive development towards a future that not only changes the responsibility of women, but also implies the use of epigenetics on controlling the fetal environment for desired outcomes.

In contrast, critics who claim that reproductive technologies actually pose harm to women's social status express that artificial wombs would make women obsolete in that their reproductive abilities would be taken away and commodified, therefore leaving women without a proper role in society (Rosen, 2003). While some feminists view artificial wombs as liberating, others see it as a threat to what the very essence of being a woman is. From this, ectogenesis is also viewed by some feminists as part of an inherently sexist project, where artificial wombs are "developed as a result of the patriarchal desire for 'scientific' control of human reproduction" (Hedman, 1990). The creation of artificial wombs would therefore lead to the "death of the female", where women's innate power of reproduction would be taken away and women would possibly become obsolete (Rosen, 2003). Artificial wombs would be taking away women's inherent ability to reproduce not only biologically, but also by the assumptions that women's bodies are not as capable of conceiving children compared to artificial wombs. The advancement of these reproductive technologies can project women to be seen merely as "a collection of body parts" driven by both capitalist greed and the desire to produce the genetically healthiest children under perfectly adjusted conditions (Hedman, 1990). Ethics also play a role in the growing concern over artificial wombs and reproductive technology, where artificial wombs bring up questions of ethical implications that could be bestowed upon women, the fetus, and scientists (Alghrani, 2007). In comparison to artificial wombs being a progressive development, artificial wombs are also seen as inherently regressive where these technologies can actually suppress women and impose a new confrontational ontology of what reproduction is.

Within the context of epigenetics, artificial wombs can be viewed as an expansion of a new concept of becoming, one that can control the outcome of future progeny but change the way mothers and pregnancy is perceived. From this comes the idea of motherhood and how the meaning of motherhood can be changed in regards to the advancement of artificial wombs. The very meaning of human pregnancy and motherhood is held at a stake in the debate of artificial wombs and reproductive technology, along with " the meaning of the mother-child relationship, the nature of the female body, and the significance of being born, not made" (Rosen, 2003). While the woman and the mother are released from societal and biological expectations of reproduction, the idea of motherhood can be lost as artificial wombs replace human wombs. Not only this, the bond between mother and child would be weakened because the idea of being conceived in a machine is more abstract and less intimate compared to a human pregnancy (Rosen, 2003). While the concept of mother has changed significantly throughout the decades depending on social and scientific developments, the introduction of artificial wombs may further complicate the meaning of the term and what it means to be a mother. Artificial wombs can also expand on a new concept of motherhood, one that is separate from just carrying a child but geared more towards the idea of motherly care and nurture.

Epigenetics and its Ties to Eugenic Logic

With epigenetics as a revolutionary field of study in the postgenomic era, the rise in reproductive technologies to satisfy the desire to control maternal bodies and uterine environments are readily sought after, but not without impending social, biological, and ethical consequences that may arise from them. Given the new influence from epigenetics and the understanding of the genome as constantly responsive with the environment, the epistemic dichotomy between genetics and environment can be displaced with a new reconceptualization of the genome (Keller, 2012). From this, we can see a paradigm shift from the reigns of genetic determinism and hard heredity, which have been the foundations of genetics for over a century, to a return to the rejected views of soft heredity. The present ascendancy of epigenetics imply an enlarged evolutionary role for the environment, where the environment can influence genes not only through natural selection but through a direct impact on development systems (Meloni, 2016). Epigenetics challenges traditional foundations of what is understood as genetics and heredity, bringing in environmental factors that are changing existing concepts of what is deemed normal and abnormal. From this, the focus on improving abnormalities in the genome is tied to eugenic logic in that it seeks to improve life transgenerationally with the uterine environment as a central target of intervention (Mansfield and Guthman, 2014). While epigenetics is centered around non-determinism, it has the potential to be a science of new eugenics by focusing on biological plasticity and how to improve quality of life.

Eugenics emerged in the early 20th century as a science that seeks to improve qualities of race, specifically inborn qualities composed of genes and DNA, over generations. Within eugenics, two important distinctions are the concepts of positive and negative eugenics. Positive eugenics seeks to improve the human race by encouraging the reproduction of those with genes deemed normal or superior, while negative eugenics discourages the reproduction with traits deemed abnormal or inferior by sterilization methods (Kelves, 1999). The push for improving the quality of life by reinforcing ideals of normalization through targeting reproduction portrays how eugenics not only emphasizes the improvement of race, but also what is considered a "good" quality of life determined by genes. With the notion of abnormalities as problems in the human gene pool needed to be fixed, eugenic logic is defined as the concept of improving life and "purifying it by eliminating biological abnormalities" (Mansfield and Guthman, 2014). With this, epigenetics not only expands the idea of abnormalities but also seeks ways to eradicate these differences in order to achieve what is deemed as normal or better for humanity under the new guise of plasticity. The rise of epigenetics has brought much uncertainty in that it may bring back eugenic logic, but one that is novel in that it focuses on epigenetic plasticity rather than determinism.

Although epigenetics is centered on a non-deterministic model of biological plasticity, there are wider implications on how to improve biological variations now that humans are not just determined by their genes. Focusing on plasticity rather than determinism allows for the spatiotemporal and socionatural life to be "open to improvement and intervention, and even optimization" (Mansfield and Guthman, 2014). This is shown in how epigenetics is directed towards and centered on women and the uterine environment, where gestation acts as the main point of intervention for the genes of future progeny. For instance, DOHaD epigenetics generally promotes the perpetuation of control over the maternal body, seeking to control what is to become by controlling reproduction (Meloni, 2016). The ability to adjust and control the environment in which genes are cultivated allows epigenetics to reorient science to emphasize the plasticity of biological development, therefore highlighting the ease of improvement. Epigenetics is emerging as a technology to improve life, and "aims to do so through biomedical and behavioral intervention to eliminate 'defective' biological differences to fix the individual and so that defects cannot be passed on into the future" (Mansfield and Guthman, 2014). This brings us back to the logic of eugenics, where the notion of epigenetic intervention operates as the desire to eliminate undesirable biological abnormalities in order to bring optimal life to those in the future (Mansfield and Guthman, 2014). Under these circumstances, epigenetics has the potential to give opportunity to the rise of "epi-eugenics", where epigenetics is used to prevent disease or enhance certain human properties in a favored direction (Juengst et al., 2014). Even if it rejects non-determinism, epigenetics is tied to eugenic logic because of its focus on improving human life through removing undesired genetic abnormalities.

With the notion of a new epi-eugenics comes the question of whether this novel form of eugenics based on biological plasticity can be a "perfect" eugenics or not. While it looks different because of the introduction of plasticity, it is new in that it "offers a new form of racialization based on processes of becoming rather than on pre-given nature" (Mansfield and Guthman, 2014). From this, epi-eugenics focuses on intervention of gestation, where controlling the process of becoming is sought after in order to shape the genome in a particular favorable manner. Furthermore, epi-eugenics also shifts the focus from the individual to the environment, where the environment is considered a major exposome in influencing genetic risk factors (Shostak and Moinester, 2015). While the individual, specifically women and mothers, still hold responsibility as being receptacles for future progeny, epi-eugenics holds that heredity involves much more than just genes. Maternal effects allow the mother to cultivate and adjust specific phenotypes without changing the genotypes of the fetus in response to the environment she is in, therefore transmitting information to the fetus of the environment they soon will inhabit (Meloni, 2016). Epigenetics is simultaneously reawakening old claims on heredity as well as new inferences on environmental quality that can be passed down through generations. Because epigenetics and the concept of epi-eugenics is so novel, we are entering uncharted waters with unknown ramifications; thus it is hard to say if epi-eugenics will become the new "perfect" eugenics. However, the double-edged sword of biological plasticity remains sharp: is it good that we can now reverse experiences of bad eugenics? Or since some experiences turn into bad biology, can epigenetics evolve into something worse? (Meloni, 2016). Also, who are the ones who decide if it is good or bad? It is hard to say since epigenetics still remains a controversial science today with much needed caution in how to proceed with it, especially regarding humans and the human genome.

Conclusion

Epigenetics is a relatively new science based on a non-deterministic approach to biological variation, specifically focusing on the plasticity of biological development. Through epigenetics, we have been able to analyze and demonstrate how biological and social disparities manifest not only physiologically, helping constitute the chemicals, hormones, cells, and fibers of the human body, but also in a transgenerational manner that transverses race, gender, and class. With women and the uterine environment as main targets of intervention for improving the quality of life for future generations, epigenetic plasticity creates new gendered responsibilities for women through emphasis on the control of reproduction. From this, epigenetics materializes as a reproductive science where gestation becomes the best window of opportunity to intervene in order to provide the best quality of life and genes to future progeny. Epigenetics also actually embraces continuities with eugenic logic and genetic determinism from the habit of pathologizing differences in biological variations and the desire to correct these differences through intervening during fetal development. While epigenetics is still a relatively new science in the postgenomic era, there are still controversies regarding its function as well as its potential to evolve into a new contemporary form of eugenics. We can not for sure determine which way epigenetics will sway towards or the consequences it may have on heredity, but for now epigenetics offers a novel perspective on the relationship between human biology and society through a new conceptual framework.

Works Cited

Alghrani, A. (n.d.). The Legal and Ethical Ramifications of Ectogenesis. *Asian Journal of WTO & International Health Law and Policy*, *2*(1), 189–212.

Dolinoy, D.C. and Jirtle, R.L. (2008), Environmental epigenomics in human health and disease. Environ. Mol. Mutagen., 49: 4-8. doi:10.1002/em.20366

Feil, R., and Fraga, M. (2012). Epigenetics and the environment: emerging patterns and implications. *Nature Review Genetics,* 13 (2), pp. 97-109.

Hedman, Carl (1990). The artificial womb - patriarchal bone or technological blessing? *Radical Philosophy*. 56:15.

Jones, P. A., & Takai, D. (2001). The Role of DNA Methylation in Mammalian Epigenetics. *Science*, *293*(5532), 1068–1070. doi: 10.1126/science.1063852

Juengst, E. T., Fishman, J. R., Mcgowan, M. L., & Settersten, R. A. (2014). Serving epigenetics before its time. *Trends in Genetics*, *30*(10), 427–429. doi: 10.1016/j.tig.2014.08.001

Keller, E. F. (2012). “Genes, Genomes, and Genomics.” Biological Theory 6: 132 –140.

Kevles, D. J. (1999). Eugenics and human rights. *Bmj*, *319*(7207), 435–438. doi: 10.1136/bmj.319.7207.435

Kuzawa, C. W., & Sweet, E. (2009). Epigenetics and the embodiment of race: Developmental origins of US racial disparities in cardiovascular health. *American Journal of Human Biology*, *21*(1), 2–15. doi: 10.1002/ajhb.20822

Landecker, Hannah & Panofsky, Aaron. (2012). From Social Structure to Gene Regulation, and Back: A Critical Introduction to Environmental Epigenetics for Sociology. Annual Review of Sociology. 39. 10.1146/annurev-soc-071312-145707.

Lappé, M., & Landecker, H. (2015). How the genome got a life span. *New Genetics and Society*, *34*(2), 152–176. doi: 10.1080/14636778.2015.1034851

Mansfield, B., & Guthman, J. (2014). Epigenetic life: biological plasticity, abnormality, and new configurations of race and reproduction. *Cultural Geographies*, *22*(1), 3–20. doi: 10.1177/1474474014555659

Meloni, Maurizio. (2016). *Political Biology: science and social values in human heredity from eugenics to epigenetics*. Palgrave MacMillan.

Olsen, N., & Pellisier, H. (2011, December 20). #12: Artificial Wombs Will Spawn New Freedoms. Retrieved from https://ieet.org/index.php/IEET2/more/4758

Richardson, S. (2015). Maternal Bodies in the postgenomic order: gender and the explanatory landscape of epigenetics. In: Richardson, S. and Stevens, H., eds. *Postgenomics: perspectives on biology after the genome*. Durham (C.): Duke University Press, pp. 210-231.

Rifkin, J. (1998). The Biotech Century: Genetic Commerce and the Dawn of a New Era . *ARS Electronica* . doi: http://90.146.8.18/En/archiv_files/19991/E1999_047.pdf

Rosen, C. (2003). Why Not Artificial Wombs? *The New Atlantis,*(3), 67-76. Retrieved February 26, 2020, from www.jstor.org/stable/43152051

Shostak, S., & Moinester, M. (2015). The Missing Piece of the Puzzle? *Postgenomics*, 192–209. doi: 10.1215/9780822375449-010

Zhu, Z., Cao, F., & Li, X. (2019). Epigenetic Programming and Fetal Metabolic Programming. *Frontiers in Endocrinology* , *10*, 1–11. doi:10.3389/fendo.2019.00764