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Analysis on perceptions of motherhood and sexuality in
scientific literature and popular media“

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Pavla Debeljak BSc., MSc.

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‘There are so many kinds of happiness. According to the genes.’

Naomi Mitchinson, Solution Three (1970)

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1 Introduction

1.1 Research interest

In June 2012, Dr. Sigrid Schmitz, Professor of Gender Studies, and the Gender Research Office at the University of Vienna, organized a workshop with the title: "Epigenetics, Society and Gender". This workshop was held in cooperation with the department of biochemistry and cellular biology. As a student of both biology and gender studies, I was invited to the workshop by both sides of the organizing committee. It was out of this workshop that the idea for this master's thesis was developed and the topic has held its attraction for research ever since. In an effort to form a comprehensive analysis, this thesis will take a dualistic approach, tackling the subject "from both ends"- biology and sociology. Because epigenetic research has received much attention within the popular media of recent years, it presented a suitable topic for investigation.

1.1.1 Subject

The subject of this thesis is situated in the field of Gender Studies, with a strong focus on Science and Technology Studies (STS). It will incorporate articles from scientific literature, and popular media, applying content analysis techniques (Berelson 1952, Krippendorff 1989) to examine their place at the nexus of biology and sociology. By studying Gender Studies I have been able to explore the interdisciplinary field of sociological sciences and have come to find a strong interest in STS as it combines aspects of the knowledge production and the perception of scientific research in our society. It is also not solely concerned with science critique as is often claimed, but with the observation of scientific results and their transformation through different media.

In the field of STS, epigenetic research has been cause for many debates, and the topic of many publications, across a wide range of spheres- including the social sciences- as it seems to be an area where the core of biology and sociology are once again challenged. The

production of epigenetic knowledge is related to both new and established technologies, tools and methodologies, with rapid growth in public and private investment. This investment includes international research programs to develop epistemic infrastructure and an increasing number of publications. Results from epigenetic research are very important for the area of gender studies, as women are positioned at the centre of much of the epigenetic programming and transmission, and as a significant locus of medical and public health interventions in the post genomic age (Richardson 2014). Furthermore, epigenetics offer a new perspective in the “nature versus nurture” debate, and can be seen as bridge between these two.

1.1.2 Position

In research it is often anticipated to act as a connections-producing anonymous which is rarely the case. Through a recent lecture I have come to see a researcher as a subject of knowledge on the move which is constantly advancing and adapting with current surroundings and being influenced by these. Knowledge is an inconclusive ontho-epistemic consideration (Van der Tuin 2014). In my master thesis I would like to follow these observations of science by both STS and feminist scholars and work as a subject on the move adapting and advancing to my current surroundings and being aware of these influences. I would like to state that I myself am a product of my research and I am aware that my statements are as well influenced by the social environment I am living in.

1.1.3 Research approach

The thesis is divided in three parts. First, the theoretical background of the epigenetic discourse is explained. Several aspects are important in this introduction, such as the debate surrounding nature versus nurture and the question of objectivity, especially in the field of feminist science studies. Then the epigenetic discourse is introduced and the introduction concludes with the gender aspect of the thesis. In the methodological part I explain how I

have chosen the analysed articles and defined my categorical system. Second is the analysis, the main part of this work. Through the defined categories I analyse five case studies. Each case study consists of an original publication, one or two popular articles, and a discussion at the end. The third and final part is the overall conclusion, focusing on the research questions and results.

1.1.4 Research questions and objectives

The aim of the research is to analyse the debate around epigenetic research in the life sciences and the popular media and to illustrate how sexuality and motherhood are perceived through this research. Therefore my main questions are:

- *How is scientific literature used in popular media?*
- *Which mechanisms are used in the popularization?*
- *Which categories are repeatedly found in scientific literature and popularized science media?*

Additional questions also addressed include:

- *How are female bodies, women and motherhood described through epigenetic research?*
- *How are epigenetics used in the explanations of different sexual orientations?*
- *Which social structures are being thus promoted and which are being rejected in this discourse?*

These questions allowed determining categories for the analysis of the articles.

1.2 Nature and Nurture in Feminist Science Studies

Feminist scholars have identified the sciences as both a source and a locus of gender inequalities, as the institutions of science have a long tradition of excluding women as practitioners. Feminist perspectives on science therefore reflect a broad spectrum of epistemic attitudes toward an assessment of science. An important debate that has been influenced by feminist scholars, such as Evelyn Fox-Keller and Anne Fausto-Sterling, exists at the nexus of biology and sociology, when discussing nature versus nurture. This debate has often been characterized as outdated. The reason being that, in many fields of research, closed feedback loops have been found in which ‘nature’ and ‘nurture’ influence one another constantly. In other fields, such as epigenetics and fetal development, the dividing line between an inherited and an acquired trait is becoming unclear, and the debate has gained new importance through research. This is especially the case in environmental epigenetics.

The term “nature” is applied to traits that seem genetically determined, fixed in their final form and present in all cultures, as in discussion about human nature. The term “nurture”, on the other hand, implies variable rearing conditions, including human culture (Stotz 2008). The discord surrounds the dichotomy of nature as the genetic, stable factors of development, and nurture as the environmental and plastic influences (Kitcher, 2001).

In biology researchers often refer to processes that are ‘natural’. In this sense the word is better explained as something that exists in, or derives from, nature (Merriam-Webster Dictionary retrieved June 2015). This work will highlight how, through epigenetic research, certain processes are explained as ‘natural’.

The description of this debate in its modern sense was popularized by the Victorian English polymath Francis Galton in his discussion of the influence of heredity and environment on social advancement (West & King 1987). Galton also introduced an important caveat into his beliefs about the competition between nature and nurture by his assumption of ‘equal terms’ for the competition between nature and nurture (West & King 1987).

The widely held view that the physiological or behavioural phenotype derives from either nature or nurture, or from both nature and nurture together, is challenged by new conceptions of development (Stotz 2008). Since no genetic factor can be studied independently or only in addition to the environment neither of these models are useful in a biological way. Furthermore, the environment itself is a concept that includes a wide variety of very different

causes and factors, from the genomic environment of a gene, over its chromatin packaging and cellular context, up to ecological, social and cultural influences upon the whole organism (Stotz 2008).

In *The Mirage of a Space between Nature and Nurture* (2010), Evelyn Fox-Keller suggests that new post genomic research fields such as epigenetics, systems biology, and studies of phenotypic plasticity portend a post-genomic life sciences, trending toward an appreciation of complexity and offering an alternative to the old, deterministic, reductionist, “particulate” explanatory paradigms of genetics.

Rather than explaining these differences simply as related to genetic (nature) or cultural (nurture) influences, Anne Fausto-Sterling uses Dynamic Systems Theory to explain how cultural differences translate into physical differences (Fausto-Sterling 2003). As opposed to a commonly held view that nature and nurture are completely isolated factors, Fausto-Sterling explains that “nature and nurture are components of a single dynamic system.” Thus genetic factors act in conjunction with environmental components (Fausto-Sterling 2003).

The question whether the post-genomic research field of epigenetics is truly an appreciation of complexity will be discussed through the analysis of results in this thesis.

1.3 The Question of Objectivity and the Popularization of Science

Another aspect that inherently concerns biological sciences and therefore also STS is the creation of objective truth or truth value through scientific inquiry. Truth is described when statements are accord with fact or reality, or fidelity to an original or to a standard or ideal (Burgess & Burgess 2011). The concept of objective truth is discussed and debated in several contexts. Scientific objectivity is a characteristic of scientific claims, methods and results. It expresses the idea that the claims, methods and results of science are not, or should not be influenced by particular perspectives, value commitments, community bias or personal interests. Objectivity is often considered as an ideal for scientific inquiry, as a good reason for valuing scientific knowledge, and as the basis of the authority of science in society (Douglas 2004).

This ideal of objectivity has been criticized repeatedly in philosophy of science, questioning both its value and its attainability. Feminist standpoint theorists such as Donna Haraway (1988) and Sandra Harding (1991) deny the internal coherence of a view from nowhere: all human knowledge is at the base human knowledge and is therefore necessarily from someone's perspective. Following Donna Haraway no position is innocent and therefore intentions should be laid open. She proposed the concept of *situated knowledges* as a new form of objectivity. If it is apparent where the knowledge is coming from and who is speaking, science loses the totalitarian effect (Haraway 1988).

The question of objectivity is also of importance in the area of epigenetic research and through my analysis I will discuss how claims are produced as 'objective' in the discourse. Objectivity claims of science are further of interest as scientific knowledge is widely popularized and thus the societal role of 'objective' scientific claims needs to be observed.

Through the development of transfer media, in particular mass media and the establishment of professional science journalists, the presentation of scientific information and the construction of certain images of science in the public sphere were enhanced. Several questions were thus raised by scholars in the area of science studies. What is happening with scientific knowledge in the public space? How is it interpreted and how is it implemented in existing non-scientific knowledge debates (Felt et al. 1995)?

Popularization of science was thought to be a transmission process between a receptor and a transmitter connected through intermediary agents. In this model scientists were producing genuinely scientific knowledge that can be simplified and made 'comprehensible' to the general public (Felt et al. 1995). Since the 1970 science and technology scholars have begun to deviate from this classical view as the rigid separation of purely scientific and popular knowledge appeared problematic. Foremost scientists themselves are constantly simplifying their work in order to make it understandable for colleagues and co-workers. In addition the work of Bruno Latour and Steve Woolgar described how scientific knowledge itself is a process of collective negotiations of claims. In this case popularization of the scientific production of 'facts' is an extension of this process and thus also a negotiation of claims. Eventually the feedback of popularised knowledge back to the research process and the interaction of science and the public sphere in expanded and differentiated discourses can have an impact for the scientific knowledge production and should not be neglected (Felt et al. 1995). According to science sociologist Peter Weingart the public sphere cannot be

considered as 'passive'. Science does not hold the privileged status of communicating true knowledge anymore which is then taken from popular media and transmitted without change (Weingart 2003). The further the differentiations in science the more abstract are the researched objects resulting in a highly specialized scientific language. This increases the gap between science and the social surrounding and intensifies the transmission und translation efforts (Weingart 2003).

Popular media hold a powerful status in the construction and grounding of the public opinion. In my thesis I will work on several popularization mechanisms, such as sensationalism or simplification concerning epigenetic research, that are often applied by popular media. The perception of popular articles contributes to existing societal roles and through popular media moral implications are transported often based on life science research. Further the discourse of activation or in-activation of genes is embedded in socio-biological paradigms of gender differences (Schmitz 2015). Overall studies on epigenetic further strengthen the importance of debates over biological processes in the Gender Studies (Fausto-Sterling 2003).

1.4 The Epigenetic Discourse

Epigenetics are defined by stable and long-term alterations in the transcriptional potential of a cell although the DNA sequence itself is not being altered (Egger 2004). The field can be described as the study of how exogenous factors contribute to genetic expression through epigenetic modification. These changes do not take place in the sequence of the genetic code but on many levels above the genome, thus the term *epi* from the Greek upon. Exterior factors such as environment, stress and diet have an effect on the epigenetic level inside any cell's nucleus.

Changes in gene expression can be caused by many regulatory systems involving DNA methylation, histone modification, nucleosome location, or noncoding RNA (Bird 2007; Riddihough & Zahn 2010). DNA methylation is the process by which a methyl group (CH₃) is appended to the physical structure of the DNA molecule (Mehler 2008). The presence of methylation at a particular gene locus typically prevents gene expression via physical obstruction of DNA transcriptase and other DNA-binding proteins (Mehler 2008, Richardson

2014). The epigenetic regulation of gene expression is seen as essential to the development of an organism, playing important roles in diverse processes such as cell differentiation and genomic imprinting (Feil & Fragga 2012). Methylation is heritable through the generations and depending on where the methylation is located it can have tremendous effects such as diseases disposition of the next generation.

The studies of epigenetics have caused for a lot of attention in the recent years, however not only out of interest for molecular biology but also in the broader academic society and popular sciences. Through controversial agendas and discourses a heterogeneous view on epigenetics has been constructed. It encompasses some of the most exciting contemporary biology and is portrayed by the popular press as a revolutionary new science - an antidote to the idea that we are pre-determined by our genes. Several media have claimed that epigenetics offer new aspects of gene regulation as well as a crucial paradigm shift in developmental biology (Niewöhner 2011).

A crucial topic in this context is the social implication of environmental epigenetics, a part of epigenetics that studies environmental influences, which could cause changes in the genome regulation. While epigenetic is purely biologically regulated through changes in gene expression, environmental epigenetic research has shown that a difference in the environment can produce long-term epigenetic effects in studies mostly performed on twins (Ballestar 2010). Recent studies are focusing on potential (epigenetically determined) consequences on human health. The term "epigenetic inheritance" is used to describe both cell to cell and organism to organism information transfer. The information transfer from organism to organism is further defined as transgenerational epigenetics. Although these two levels of epigenetic inheritance are equivalent in unicellular organisms, they may have different mechanisms and evolutionary distinctions in multicellular organisms (Jablonka & Lamb 2010). Indications on genetic modification in form of transgenerational epigenetics have their roots in the beliefs of Lamarckian inheritance and are controversial to classical genetics. Jean Baptiste Lamarck incorporated the idea that an organism can pass on characteristics it acquired during its lifetime, to its offspring, into his evolutionary theories (Lamarck 1914). This is controversial to Francis Crick's dogma that has coined the 20th century and postulates that DNA is coding for RNA which is then coding for proteins. From the protein, thus from the phenotype there is no way back to the DNA according to classical genetics. Thus far there are only a few hints suggesting that taught or acquired abilities can be transferred from one generation to the other through germ cells. Further a transfer to the following generation is not

proof enough for an epigenetic manifestation (Hughes 2014). Epigenetic changes may be mitotically (or even meiotically) heritable – although how far this is or could be the case is still debated. Meanwhile several scientific networks have been established in which studies to epigenetic factors are collected (<http://www.ncbi.nlm.nih.gov/epigenomics>).

In spite of the expanding discourse of epigenetics, the term itself was first introduced over 70 years ago by Conrad Hall Waddington (Waddington 1942). Waddington mentioned several factors influencing the cell nonetheless, through the ‘hype’ around epigenetics, this has been reduced to the factors that are directly targeting DNA and are in interaction with it. Thus epigenetics is not as “new”, and the ways in which it is constructed as novel speak to wider debates about the scope and nature of biomedicine (Pickersgill et al. 2014).

In a recent article researchers have plead for multidisciplinary between biology and sociology in order to create more space for environmental epigenetic studies and to achieve established results in collaboration (Pickersgill et al. 2013). This poses an enormous challenge as in biology itself very little is known so far on the mechanisms that seem to be governing epigenetic regulation of cells. Epigenetics could serve as a bridge between the social sciences and the biological sciences, allowing a truly integrated understanding of human health and behaviour (McGowan and Szyf 2010).

1.5 Gender and Motherhood

The maternal body has long been seen as posing a troubling counterpoint to the mythical well-bounded, fully unified, seamless masculine body (Kukla 2005, Richardson 2014). At the same time, the capacity of the maternal body to nurture, via its womb and its breasts, seems to give its boundaries a different kind of lack of fixity to bridge the gap between two bodies, becoming both one and two at once through gestation and milk (Kukla 2005).

Female sexuality and the female capacity to give birth are seen as grounds for affirming both the power and the value of the female body. Women's maternal bodies are seen as a source of positive values to set against male norms, stressing care and inter-subjectivity, as opposed to autonomy and duty (O'Brien 1981, Ruddick 1989). Women's engagement with the reproductive process is also regarded with respect for the natural world, which puts them at

the forefront of ecological movements (Griffin 1978). In this sense women's bodies are given a positive value. However, such approaches hold the dangers of homogenising what are very variable experiences both of sexuality and maternity. The social and the psychological constructions of 'normal' mothers (with 'normal' being synonymous with 'good' and with 'ideal') run counter to the reality of motherhood (Phoenix & Woollett 1991). Furthermore the paradoxical character of motherhood has been observed, as both a socially determined, potentially oppressive role and one that also provides profound personal meaning that can expand the boundaries of women's lives (McMahon 1995).

In my thesis I wanted to focused on main results in the epigenetic research of the past decade, particularly focussing on the notions of environmental and transgenerational epigenetics, and its popularized statements. The social construction of female bodies and motherhood in the context of epigenetics is the most important aspect I want to analyse. In this discourse of epigenetic research, women are seen as the first environment for their children. This notion can produce different moral discourses and may expose them to further analysis (Niewöhner 2011). Not only is the female body seen as the first environment it is also the infant delivery that plays a role in epigenetic research. Another focus of my thesis was on explanations of sexual orientation which is also connected to the female body as processes are described that have epigenetic consequences *in utero*.

There are several examples of experimental animal studies that have observed the impact of maternal behaviour on methylation patterns (Meaney et al. 2001, McGowan et al. 2009). In some studies maternal behaviour in rats and mice can be seen as the base for environmental epigenetics in proposing similar behaviour in humans. This mirroring of animal studies in human epigenetic research will also be emphasized in the context of environmental epigenetics.

2 Material and Methods

2.1 Research strategy

After the above mentioned workshop I had a course at the University about the popularization of science from a gender studies perspective. Through the application of special strategies such as simplification, sensationalism, fictionalization and others, scientific knowledge is made ‘understandable’ for the public. It was then that I decided I would like to compare articles from the scientific literature with the popular media for my master thesis. The choice of the articles is based on my research interest and the focus of the above mentioned debates around the highly popularized original publications. The articles have been chosen solely by research on epigenetic studies with the focus on especially popularized media. Through my first research I have become aware that this work will continue in the direction of pregnancy. I searched for epigenetic studies in humans and most of the work I found was around the topic of pregnancy opening the field for my thesis to broaden the topic of nature versus nurture through this debate. The articles from the popular media are not older than 5 years and the originals are not older than 10 years. I wanted to keep my analysis as recent as possible to show the actuality of this research and its importance in societal changes, thus most of the article are from the last two years. The aim of the research was to analyse how certain statements evolve in popular media through the connection with epigenetic research.

Through a popular science blog I found an article about the process of giving birth and the epigenetic mechanisms that have been observed. In this *first case study* I went from the popular media back to the original publication. I have chosen these articles out of personal reason and current interest around this debate. I was personally born through a Caesarean section as this was the only option to secure the life of my mother and me. It is through articles like these that are easily accessible in the internet that personal health problems are put into question. In an age where the internet is much too often used as the best answer concerning symptoms it raises concerns what consequences studies like these and their popularization can have on socially constructed ideas of health.

Then I found a BBC documentary about environmental and transgenerational epigenetics with the title: “The Ghost in our Genes”. I am sure that several analyses could be based solely on

this one hour documentary as it provides strong stereotypes of modern life science research practices.

“At the heart of this new field is a simple but contentious idea – that genes have a 'memory'. That the lives of your grandparents – the air they breathed, the food they ate, even the things they saw – can directly affect you, decades later, despite your never experiencing these things yourself. And that what you do in your lifetime could in turn affect your grandchildren.” (BBC Documentary)

These are the opening words to this work on decades of epigenetic research. A very short section in this film is about stress on pregnant women during the World Trade Centre attacks. Based on this I searched for the original studies and the popularized articles (The Guardian) and decided to look at stress and the connection of epigenetics as well. At this point I already had the impression that this strong focus on pregnancy could be interesting for my thesis and I read Annie Murphy Pauls book on “How the nine months before birth can change the rest of our lives”. In the book I found a passage also focusing on the World Trade Centre studies and I chose this as my *second case study*.

While looking for further articles on stress I found the “Ice Storm Project” and these articles were chosen for the *third case study* because they attached to the already observed stress during pregnancy and can be seen as a further aim for prove of the before assumed epigenetic effects through prenatal maternal stress.

Throughout this process I was influenced both by looking for scientific articles and their popularization and the other way around, hence I focused in the direction in which my research led me. In terms of popular media I tried to compare more than two articles if possible in order to show the different levels of popularization.

By reading Annie Murphy Pauls book about the importance of processes that happen in the womb, one of the probably most widely discussed pregnancy topic suddenly became interesting for my thesis as well. I could remember that the topic of nutrition was also discussed at the workshop in 2012 and through further research I found that the mouse studies from then have been replicated with women in Gambia which led me to my *fourth case study*.

Finally even though this was not a simply linear process, the publication of Rice et al. in 2012 that was found on many controversial blogs and sites on the internet was chosen as the *fifth case study* because it connects the misinterpretation potential of epigenetic research and

popular media in a final way. It is as well connected to pregnancy and it was important for me to analyse this article for my thesis especially because it was widely popularized.

2.2 Research on case studies

Through the analysis of 5 case studies the difference in the original publications to the popularized articles can be observed. The topics of the case studies have been formed out of the theoretical background around the epigenetic discourse. Through the establishment of categories a comparison between the case studies is possible and the different values that are transported through epigenetic research become visible. These case studies are the following:

1. Giving birth
2. Posttraumatic stress during pregnancy
3. Prenatal maternal stress
4. Nutrition
5. Homosexuality

Through the developed research questions, 5 categories have been formed for the analysis. These categories have evolved out of the observed debates around the area of epigenetics which have influenced me while reading the articles for the first time texts. They should not be seen as rigid however for purpose of the analysis it was important to create some boundaries. I am also aware that motherhood, the female body and women might seem difficult to differ in some cases however I have tried to argue why I believed that certain statements in the analysis belong to the chosen category. These categories are the following:

- Motherhood
- Women
- Female body
- Sexuality
- Social structures

Motherhood

Motherhood was chosen as a category because through reading of the articles it seemed to me as if epigenetic research is very often described through research focusing on mothers. Even though the word 'motherhood' is not used straightforward it is implicitly transported through examples such as 'maternal' or the 'mother's nutrition'. The question that was asked through this category was: How is the concept of motherhood connected to responsibility in epigenetic research?

Women

Most of the studies I have found are focused on women and in most cases pregnant women. The category of women was chosen to identify how women are described through epigenetic research and how men are accounted for epigenetic research.

Female Body

In most of the studies that are concerned with pregnancy or the process of giving birth I had the impression that the female body is seen as a research object for epigenetics. By using the female body as a category I tried to identify the passages that transported this image. The question was how the female body is described in epigenetic research.

Sexuality

The category of sexuality gained in importance when analysing the article on homosexuality and epigenetics. The aim was to identify how sexuality is put into words through scientific and popular literature. It was interesting to use this category in the other articles as well as it could show if or how sexuality was part or not of the discourse of pregnancy and pregnant women.

Social structures

I tried to combine here any parts of the articles that were based on assumptions about societal roles. Of course motherhood, the female body, women and sexuality can also be seen as social constructs however it was important to keep them in separate categories to emphasise their importance in epigenetic research. In this category I wanted to combine certain statements that were based on interpretations through the current socio-cultural environment.

I was thinking of a category of "gender" itself but then I decided to work on this throughout my analysis. I did not want to focus solely on it in order to avoid a blind spot.

2.3 Method

Qualitative content analysis was used in order to establish categories that are connected to the conceptions of epigenetics and are being applied in different media through debates about motherhood and sexuality. Therefore the articles were read and then re-read with the focus on the above mentioned categories. For the scientific articles, in most of the cases, the introduction and discussion were chosen for the categorical analysis. The methodological part and the results were mentioned in the analysis for comprehension of the study, however due to the focus on interpretations of results they were not analysed by categories.

Content analysis has developed from communication research and is potentially one of the most important research techniques in the social sciences. According to Berelson the analysis provides a research technique for the objective, systematic and quantitative description of the manifest content of communication (Berelson 1952, S.18). It seeks to analyze data within a specific context in view of the meanings someone – a group or a culture – attributes to them (Krippendorff 1989). Content analysis was chosen for this work because it provides the tools that were important for the analysis of this kind of literature.

The analysis assures not only that all units of analysis receive equal treatment, whether they are entered at the beginning or at the end of an analysis. Moreover, content analysis allows researchers to establish their own context for inquiry, thus opening the door to a rich repertoire of social-scientific constructs by which texts may become meaningful in ways that a culture may not be aware of (Krippendorff 1989).

According to Krippendorff content analysis commonly contains six steps that define the technique procedurally. The first step is the design phase, a conceptual phase during which the analysts define their context and explore the source of relevant data that either are or may become available. The second phase is described as ‘unitizing’. This is the phase of defining and ultimately identifying units of analysis in the volume of available data. *Sample units* make possible the drawing of a statistically representative sample of potentially available data while *recording units* are regarded as having meanings independent of one another. The third step is the sampling phase where it is important that the hierarchy of the sample units becomes representative of the organization of the symbolic phenomena under investigation (Krippendorff 1989). In the fourth step coding takes place in which the recording units are classified according to categories. In the fifth phase the drawing of inferences takes place

which Krippendorff describes as the most important phase in the analysis. It applies the stable knowledge about how the variable accounts of coded data are related to the phenomena the researcher wants to know about. The final step is the validation; this however is limited by the intention of the technique to infer what cannot be observed directly and for which validating evidence is not readily available (Krippendorff 1989). According to Krippendorff content analysis should not be undertaken without at least the possibility of bringing validating evidence to bear on its findings.

Despite its generality, content analysis has some inherent limitations. The most important one is the replicability requirement. It implies fixed and observer-independent categories and procedures that must be codified. If categories are obtained from the very material being analyzed the findings cannot be generalized beyond the given data. While when they are derived from a general theory findings tend to ignore much of the symbolic richness and uniqueness of the data. Therefore the researcher has to compromise when applying content analysis (Krippendorff 1989).

Following this procedure the analysis of the data started by a conceptual phase of design in which the context was defined of what was not observable directly and thus important for the research. Then the *sample units* were designed which in my case were the chosen articles in the case studies. In my sampling process I searched for *recording units*. The process of coding after Krippendorff is the step in which the recording units are described and classified according to the categories. In my case I searched for citations which were representing my recording units and out of these I extracted, if possible, core terms for my analysis. Then I interpreted these citations according to the categories. The final step was the validation of the content analysis. For my analysis I often observed statement that in my opinion held implicit messages and thus I validated these by interpreting the possible purpose or direction of these statements.

Even though it is stated to be 'objective' I would argue that objectivity in a sense of an undefined individual performing the analysis is not possible.

Each case study can be regarded as a new topic. The beginning introduces the background of the research, the authors and the publications that are mentioned. Then the original publication is analysed and the study is explained. In the following the statements in the popularized articles are analysed. After the introduction to the articles each one of them is analysed according to the categories. The most significant citations are used at the beginning

in order to interpret these in the analysis. In some cases explanations to results are also given in the categorical analysis. Eventually, the results of each case study are combined in a short summary and discussion in the end.

2.4 Language

The consistent use of masculine pronouns leaves the impression that women could not be among the group to which the writer is referring. While some may respond that the masculine pronouns "he" and "his" refer to men and women both, the impression left is in the eye of the reader, not that of the writer. Because many readers read masculine pronouns to refer only to men, the writer, perhaps inadvertently, will have created the wrong impression. In my thesis I will try to avoid using gender-specific language when possible and will overall use gender-neutral language.

3 Case studies

3.1 Giving birth

The first case study in epigenetic research is focused on a recent publication on the implications for future health caused by Cesarean delivery. The original article was published in November 2014 in the American Journal of Obstetrics & Gynecology. I have found out about this study through a popular science blog (www.ifls.com) in an article with the title “Cesarean Delivery May Cause Epigenetic Changes in Babies DNA”. These articles will be analysed through the categories: motherhood, women, the female body, sexuality and the underlying social structures. The analysis focuses on the description of epigenetic research and its popularization.

3.1.1 Primary literature

“Cesarean delivery and hematopoietic stem cell epigenetics in the newborn infant: implications for future health?” Almgren et al. 2014

The authors of this article are a group of scientists and doctors researching at the Karolinska Institute and the Centre for Molecular Medicine in Stockholm Sweden. The work was funded through grants by various Swedish and American foundations.

In the past decade an increase in Cesarean section (CS) has been observed worldwide and CS can be seen as the most common surgical procedure performed in women of child-bearing age (Menacker et al. 2006).

The article focuses on clinical studies that have shown that CS birth is associated with a greater risk of developing diseases later in life, i.e. asthma, allergies, type 1 diabetes, celiac disease, obesity, and malignancies. Taking these studies into account it is still unclear how CS “may compromise health in the offspring”.

Thus 18 babies delivered by CS versus 25 delivered by vaginal birth have been analyzed through their methylation pattern. The researchers have found support for altered epigenetic states in blood cells from newborns delivered by elective CS compared with those vaginally born. The epigenetic states provide mechanisms for the functional genome and mediate adaptations to a dynamic environment. A connection of the epigenetic state and the environment is important because the epigenetic deoxyribonucleic acid (DNA) methylation may last stable for the cell's lifetime, albeit division. Following this connection DNA methylation and epigenetic cell memory associated with the mode of delivery could be mechanisms for later differences in disease risk, especially if these occur in progenitor cells. A progenitor cell is a biological cell that, like a stem cell, has a tendency to differentiate into a specific type of cell, but is already more specific than a stem cell and is pushed to differentiate into its "target" cell. The most important difference between stem cells and progenitor cells is that stem cells can replicate indefinitely, whereas progenitor cells can divide only a limited number of times. Controversy about the exact definition remains and the concept is still evolving (Seaberg et al. 2003).

The researchers call this idea "the epigenetic memory of birth" and thus lead to their research hypothesis and questions focusing on stem cells. They hypothesise that DNA methylation in neonatal stem cells differs in relation to mode of delivery and between different genes/gene regions.

Already it is important to state that in this research the only factor considered is the birth method. Thus the type of question is directly searching for only this difference in the babies observed.

The conclusion out of the research is: "Data presented herein suggest that CS is associated with altered epigenetic states of neonatal CD34⁺ hematopoietic stem cells, involving differential DNA methylation of genes/gene regions relevant for later immune-mediated diseases."

Hematopoietic progenitor cell antigen CD34 also known as CD34 antigen is a protein that in humans is encoded by the CD34 gene. Cells expressing CD34 (CD34⁺ cell) are normally found in the umbilical cord and bone marrow as hematopoietic cells (Satterthwaite et al. 1992).

Hematopoietic stem cells that are described above are the blood cells that give rise to all the other blood cells and are derived from mesoderm. They are located in the red bone marrow, which is contained in the core of most bones (National Institute of Health, 2011).

Through their research they have been able to demonstrate 3 novel findings.

1. The global DNA-methylation in neo-natal stem cells varied in relation to the mode of delivery.
2. Genome-wide methylation analysis identified 343 CpG positions that were differentially methylated in cord blood CD34+ hematopoietic stem cells from infants delivered with CS compared with infants vaginally delivered.
3. They also show the first evidence for a relationship between the duration of birth and the degree of DNA methylation of specific genes in offspring.

In the following analysis the article was analyzed according to 5 categories.

Women

According to the World Health Organization up to 15% of deliveries a CS is recommended however most countries are exceeding this recommendation and women are undergoing CS without a necessary medical indication (Almgren et al. 20014, Menacker et al. 2006). The short –term outcomes of CS have been observed however the long-term consequences remain enigmatic. The researchers consider these increases in CS for a reason to study the effects by mode of delivery. The authors describe this observation also as “global change in childbirth”. Only in the introduction about this development the term women is mentioned, in the further article the women who give birth are always called mothers. Thus motherhood in this example is considered to be starting with the moment of birth.

Motherhood

Motherhood as a category in the analysis has been chosen when certain stereotypes concerning the responsibility of a woman as a mother were provided. This often happens in an implicit and not direct way.

By arguing that CS could “compromise health” this implies that it is the woman that compromises with her child’s health and is implying a negative and harmful act. Some evidence is given for this “compromise”: lack of appropriate gut colonization and microbiome exposure, the lack of the immune-activating effects of labor, and epigenetic changes that may modify the immune system have been related to CS related risks for health and diseases.

Considering motherhood this is clearly an important factor as mothers are through labor apparently activating the children’s immune-activation.

“The hygiene hypothesis postulates that the lack of colonization of the infant with maternal gut flora after CS may prevent the initiation of the immune system of the newborn.”

This sentence in the discussion clearly shows that the “lack” of the maternal gut flora can hold back the child’s immunity thus leading to complications in later life. It is not mentioned that the gut flora itself is activated by colonization of microbes in the first hour after birth and is in any way only developing after birth as the child is born without gut flora (Neu et al. 2011). This is important because by not mentioning this crucial step one could think that again it is only the maternal aspect that is missing. The question that rises here is whether the maternal gut flora is in all the cases as beneficial. If this is the cause of the immune system activation then research should probably also involve the beneficial effects of this aspect.

They did however find a correlation between the methylation of DNA and the duration of labor. This suggests that the findings relate to labor itself because the methylation status at the start of vaginal birth resembles that of CS newborns. Thus it is assumed that the methylation of DNA changes with delivery.

Female body

“The stress of being born during vaginal delivery is suggested to be important for successful physiological transition and survival as the fetus leaves uterine life and enters the outside world. Infants delivered by elective CS before the onset of labor lack this preparation.”

Thus the process of birth is being called a ‘preparation’ that is inevitably important for the future of one’s child. Therefore CS may be maladaptive for newborns as in addition the activation of the adaptive immune system is affected. These experimental data suggest that delivery mode can alter gene expression with a functional significance for the immune system. The authors state that: “...the main idea of our hypothesis is that altered methylation may create poised, replication-heritable epigenetic marks, not immediately influencing gene transcription until a second hit arrives causing disease.” This ‘second hit’ is not further described as it is not clear how this would affect the epigenetic state. This means that through a CS epigenetic marks can be inherited that are described as ‘poised’ however this does not mean that these will lead to the actual development of the disease.

“A major limitation in this study is that causality cannot be established”, because additionally the participants were not randomly assigned to the different delivery modes. This of course leads to a selection bias that should not be neglected according to the authors.

The female body in this context is seen as purely operational and as a vehicle through which the baby's immune system can be activated and the birth process can be optimized if it is performed the most 'natural' way.

Considering vaginal delivery to be the 'normal' way of giving birth this is also connected to the potential of the female body. Thus it strengthens the biological aspect of being female. In considering this to be the only way of a healthy delivery mode these biologically deterministic aspects are underlined.

Sexuality

In this article the focus is strongly on the process of giving birth and all the processes before birth that are relevant only in women. Sexuality is not mentioned nor can it be associated to the article in this context.

Social structures

In the discussion the researchers state that early human living conditions and stress, *in utero* and at and immediately after birth, may affect future health and that these so-called 'imprints' are highly likely to be epigenetic.

"Early epigenetic modifications can poise genes, for future response of a second trigger, like infection, trauma, toxicants, and aging. Thus the limits for cellular and organ functions may be determined long before they are challenged."

It is of importance to highlight the word 'poise' here. These early epigenetic modifications that are caused by different birth conditions are assumed to be as powerful as to actually harm the genes for maybe even a lifetime. Throughout this article the role of the woman in deciding over the choice of birth is implied and it is the woman's body that is at question here.

The word 'poise' implies a clear harmful direction that carries a strong force behind these epigenetic mechanisms. Thus through this description certain societal norms of woman and birth are enhanced.

'Risk' is also an important factor that is repeated very often in the article. Either it is the risk a woman takes when choosing a CS or it concerns the risk of altering the methylation pattern which again holds risks for future life and possible diseases. By reading the article focusing on the word risk it becomes clear that this is a main argument against CS.

However, the authors only state that “a possible interpretation of these discoveries is that the mode of delivery affects the epigenetic state of newborn infants”. Therefore they suggest that their findings might have significant implications for health and disease in later life. CS is increasing and in many parts of the world it is already the most common delivery mode. Even through this research, a direct causal relationship between this increase and increased rates of later immune disease cannot be concluded. For example for asthma an increased incidence in the last decade cannot be associated with the increased rates of CS (Almgren et al. 2014, Bager et al. 2008).

The results show a differential methylation for at least 1 gene involved in the immune system. This gene has been associated with a genetic predisposition to type 1 diabetes, 1 of the diseases occurring in individuals born through CS. This is strengthening the fact that other factors have been taken into account (e.g.: maternal age, birth order, birth weight, breast-feeding, maternal diabetes, or family history).

A specifically important aspect of the researchers’ conclusion is on the future of individuals born through CS.

“An altered epigenetic profile after CS may be a concern for umbilical cord blood bank, used for transplantation purposes. Mode of delivery affects the banking quality in terms of numbers of cord blood cells. However it is unknown whether delivery mode also affects transplantation outcomes.”

This seems to be a research question of high importance as more and more CSs are performed. It is interesting how this is seen as important as it is not even clear how epigenetics work thus if these could really interfere with transplantations is open to debate. This can additionally be associated with today’s optimization of health in any possible way thus even on the genetic level.

The research on CS associated health risks has many potential confounders. The study presented here has provided evidence of a potential mechanism encoding specific sites in the genome through epigenetic marks. It is important to state that these differentially methylated sites were not only found in gene promoters, a region of DNA that initiates transcription of a particular gene, but also in intragenic regions, a stretch of DNA sequences located between genes, and in regions potentially harbouring enhancers. Thus further shows how very little we know about these methylations and how on different gene expression steps of DNA changes can occur. The question that could also be asked is whether methylation is not as common in

genes that the universality of a certain event cannot really be related to it. I would like to argue that it becomes visible that methylation is seen as an explanatory mechanism, however it is genetically complex and thus not only social structures but also existing biological knowledge are strengthened.

Finally the researchers state that the important task is now to investigate whether any of the differentially methylated positions associated with the mode of delivery retain their epigenetic marks in these CD34+ hematopoietic stem cells into adolescence/adulthood.

3.1.2 Blog article

“Cesarean Delivery May Cause Epigenetic Changes in Babies DNA”.
(www.iflscience.com, retrieved September 2014).

This article is a summary and interpretation of the original publication analyzed before. The results are taken directly out of the research paper. The authors of the article are not mentioned on the blog nor is there a site section where something is described about the writers of the blog. The article begins by explaining the primary outcome of the study, thus that epigenetic changes have been observed in babies born through CS.

The article summarizes the outcome of the research and mentions Professor Ekstrom who has participated in research. Methylation is described here as “the major path through which environment factors can alter the expression of genetic traits”.

According to the article a detailed study of 12 of the babies found statistically significant differences in methylation in almost 350 regions, “many of which are known to influence the immune system.” Even though this analysis does not focus on popularization mechanism of science media it is interesting how out of “at least 1 gene involved in the immune system” many are mentioned in the blog article. This accuracy might not be of significant importance nonetheless it shows that these new findings can be promoted by the popular press in a sensational way. In mentioning ‘many’ possible genes instead of the accurate number which in this case would be ‘at least one’ the epigenetic power over influencing the immune system

is enhanced even more and has tremendous effects in popular literature recently also leading to advice in terms of lifestyle.

Women

In this article women are not explicitly mentioned and throughout the explanation of the study the focus is solely on mothers who will give birth. Thus a pregnant woman is already seen as a mother even before birth.

Motherhood

Even though it is mentioned that the long-lasting effects of the epigenetic changes remain enigmatic the discovery “may explain the relatively poorer outcomes for babies delivered this way”. It is interesting how in comparison to the research paper that mentions other studies with future effects such as diabetes, in the blog article ‘poorer outcomes’ are described without actually explaining what these are. Additionally motherhood is already implicitly described by focusing on ‘poorer outcomes’ with a different birth method. In this way a certain responsibility is generalized and can be projected on to several aspects of motherhood.

Female body

“During a vaginal delivery, the fetus is exposed to an increased level of stress, which in a positive way will prepare the unborn baby for life outside the uterus,” said co-author Professor Mikael Norman (Karolinska University Journal 2014) according to the blog-article (IFLSScience 2014). This sentence must come from an interview as it is not found in the original paper and is also not cited. In this case it is not even necessary to include epigenetics as the simple fact of stress can explain to the popular media why it is more ‘natural’ to give birth through the conventional way. Having a natural scientist say that this is the positive way to prepare the baby for life outside of uterus, which is solely in the responsibility of the woman and her body, is highlighting the importance of this debate. Again it is through the female body that the child is prepared for the life outside the uterus.

“This ‘activation of the fetus’ defense systems doesn't occur when a caesarean section is performed before labour begins, which in turn could be a possible cause for the noticed differences between the groups.”

Human infants born vaginally have a very different succession during the early phases of gut colonization and possibly long-term composition of their microbiota than those delivered by

Caesarean section (Dominguez-Bello 2010). The effects of this difference in infant delivery on adult health remain to be discovered. This could also be an additional effect that could contribute to disease formation. The claimed ‘activation of the fetus’ is purely speculating and strongly implying a directed action in this observed results and additionally this reference is never used in the original article.

CS is described as formerly being a ‘last, desperate option’ where the “mother’s abdomen and uterus are surgically cut open to remove the baby”. Removing the baby means taking it away from the mother. The framing of “removing a baby from a mother” is in a way far more powerful to what it implies than pushing a baby through the birth canal. This form of argumentation implies a negative aspect to the baby as it is taken away from the mother and not pushed through ‘by nature’.

The article then goes into the controversial aspect of CS as it poses problems in terms of diseases attributed to CS for mother and baby.

Social structures

“However, in many countries perverse financial incentives favour the use of caesareans even where a vaginal birth is probably the better choice.”

These ‘perverse financial incentives’ are not mentioned any further in the text nor is it described why a vaginal birth in these cases should be the better choice. In this way a moral judgment is implied without any justification even though when ‘perverse financial incentives’ sounds like a strong argument.

The article concludes that the biological mechanisms predisposing a fetus or a newborn infant to get a certain disease later in life are complex and depend on both genetic and environmental factors during the formative years. This is interesting as in the article itself the biological aspects are the primary focus and it seems as if the complexity is mentioned only in a necessary outlook. Further these epigenetic changes can be either temporary or permanent and there is not enough knowledge available yet to tell whether the observed effects will last.

“However it is particularly concerning that some epigenetic effects are not only permanent, but get passed on to offspring, potentially making the effects of a single birth multigenerational.”

These multigenerational observations are not mentioned in the original text. It is interesting that the popular media has taken this aspect in account. With this additional aspect, the responsibility of the birth choice by mothers becomes an even bigger concern for the long lasting effects over generations.

3.1.3 Discussion of the case study

Both of these articles focus strongly on the consequences of a CS and thus on the responsibility that comes with this decision. This responsibility is inevitably tight to female bodies and the concept of motherhood. Thus not only the female body is seen as the first environment it is also the infant delivery that plays a role in epigenetics contributing further to the creation of responsibility over these actions that could presumably affect our genes.

Environment though itself can have a definition problem as it is unclear whether environment is everything outside of the DNA or everything surrounding the baby (Keller 2010). In the articles the term ‘environment’ is not defined and thus unclear. In the analysis both of the above mentioned definitions of environment have been considered in order to gain a more conclusive image.

An important question that has to be asked in the context of these articles is: Why is epigenetic research focusing on the Cesarean delivery? More often a Cesarean delivery is performed on maternal request which is also known as the “Cesarean delivery on maternal request (CDMR) movement” (National Institute of Health 2006). The popular media suggest that many women are opting for caesareans in the belief that it is a practical solution (Finger et al. 2003). The ethical view that a woman has the right to make decisions regarding her body has empowered women to make a choice regarding the method of her childbirth (Minkoff et al. 2004). Furthermore, with women living longer, concern about damage to the pelvic floor organs by vaginal delivery adds an additional dimension to the issue. Such damage could lead to a relaxation in the ligaments that hold the pelvic organs in place; urinary incontinence can become a consequence.

In this age of career-building the context of environmental epigenetics plays a very important role. Through research conducted only on the factor of birth, and promoting vaginal birth as a preoperational process for later life outside the uterus even more responsibility is pushed on women and their pregnancy. No other factor is observed in this research but the process of giving birth. And even if others are mentioned these are always connected with other conditions that the mother is experiencing. Men supposedly do not play an important role in this situation as they are 'only' the sperm donors. Following Sandra Harding I think it is important to rethink how a question in science can be turned into a problem and where this problem is rooted (Harding 1986). Thus it should also be considered that the long-term effects of differentiated methylation are still to be discovered, however the article imply that children born by CS could be 'poised' by the way they were born, increasing the responsibility of child-bearing even before the birth of the baby. In addition through this new epigenetic research social structures are not only re-determined they are also reinforced. It seems as if epigenetics in this context are used as a powerful tool to strengthen social and gendered norms. By social norms I mean the image that the mother holds a stronger connection to her child by the simple fact that she gave birth to it and in the context of this research men are completely excluded. In terms of gendered norms it becomes visible that medicine and genetics are still in power of deciding over the women's body which is seen as uncoupled from women as individuals but is a vehicle through which scientific questions can be addressed and presumably answered.

In the age of self-entrepreneurship it is not unusual that women choose to give birth in the most convenient way, not only for the benefit of health risks but also in order to plan their maternity as accurately as possible. Therefore I see this debate as an important contradiction and it leads to the subject of responsibility. Modern society has put women in the position where they still need to adapt to masculine work attitude in order to reach the top positions that are so often claimed to be held by men. Thus it is no wonder that strategies empowering women are pushing forward. Facebook is even paying their female employees to freeze their eggs in order to plan their maternity leave more easily into their career (The Guardian 2014).

Eventually with this responsibility there always comes risk. Risk is the potential of losing something of value. Values (such as physical health, social status, emotional well being or financial wealth) can be gained or lost when taking risk resulting from a given action, activity and/or inaction, foreseen or unforeseen. Risk can also be defined as the intentional interaction

with uncertainty (Ricardo et al. 2015). This study imposes that women who go into labor are actively taking risks only by deciding to have a CS. And of course the question remains whether these risks of losing the value of health holds true as the effects are unknown. The factor of risk is permanently present in the area of epigenetics and is strongly used with the methylation patterns that are differentiated through environmental factors.

3.2 Posttraumatic Stress during pregnancy

Through a recent BBC documentary with the name ‘The ghost in our genes’ I found out about the research performed on women that were pregnant during the World Trade Centre attacks. In this case study the focus is on research of transgenerational epigenetics. Several studies point to toxic effects – like exposure to fungicides or pesticides during pregnancy – causing biological changes in rats that persist for at least four generations (Manikkam et al. 2014). The first text is the original publication written by Rachel Yehuda, a psychologist at the Mount Sinai School of Medicine in New York, and colleagues. Produced in conjunction with Jonathan Seckl, an Edinburgh doctor, her results suggest that stress effects can pass down generations. The second text is the popular article in the genetics sections of the Guardian with the title “Pregnant 9/11 survivors transmit trauma to their children”. And the third text is a passage from Annie Murphy Pauls popular science book “How the nine months before birth shape the rest of our lives”.

3.2.1 Primary literature

„Transgenerational effects of posttraumatic stress disorder in babies of mothers exposed to the world trade centre attacks during pregnancy“ Yehuda et al. 2005

The paper was published in the Journal of Clinical Endocrinology & Metabolism in May 2005.

After the tragic events of September 11th of 2001 the effects of stress on a group of women who were inside or near the World Trade Centre and were pregnant at the time were observed in this study. The article starts by questioning why only a proportion of trauma-exposed person actually develop the posttraumatic stress disorder (PTSD). The research is focused on identifying the ‘biological’ basis of the development of this disorder. In a study of Holocaust survivors the prevalence of PTSD in offspring of survivors that have not been exposed to trauma has been observed (Yehuda et al. 1998, Yehuda et al. 2005). This so-called parental-PTSD is related to the reduced cortisol level. In this study the mean 24h urinary cortisol excretion was significantly lower in the offspring of Holocaust survivors with PTSD (Yehuda et al 2002, Yehuda et al. 2005). These lower cortisol levels have also been observed immediately after a trauma event which is described as a ‘PTSD risk factor’. The study was conducted with 38 pregnant women present at or near the World Trade Centre. The researchers report a relationship between maternal PTSD symptoms and salivary cortisol levels obtained at awakening and at bedtime, in mothers and infants of mothers directly exposed to the World Trade Centre collapse on September 2001 during pregnancy (Yehuda et al. 2005).

Motherhood

When the cortisol concentration is associated with a risk for PTSD after trauma exposure, the authors find it reasonable to believe that a contribution of early developmental factors, including *in utero* effects, could be programmed by early life influences.

“Maternal exposure to glucocorticoids during pregnancy can result in lower birth weight and higher glucocorticoid levels in offspring, leading to adult disease (...) and depression.”

The study was focused on the effects of September 2001 exposures on fetal growth and other pregnancy outcomes. In a previous study it was reported that ‘such’ mothers gave birth to smaller babies adjusted for gestational age and delivery, compared to women unexposed to September 2001 during pregnancy (Berkowitz et al. 2003). It is interesting how through these observations these 38 mothers are already combined in a specific group and are then compared to other mothers with similar symptoms. Also there is no definition of PTSD itself other than that it is a traumatic event that channels it. Further it would be interesting to know whether PTSD exists in different forms thus if this level of cortisol decreased, persists

throughout a longer period. If this is the case it would be interesting to know whether the symptoms correlate with the hardship of the ‘disorder’.

“The results of the study report lower cortisol levels in mothers who developed PTSD after exposure to the World Trade Centre attacks on September 2011 compared with similarly exposed mothers who did not develop PTSD. Additionally babies of mothers who developed PTSD also showed lower salivary cortisol levels in the first year of life.”

The question would also be how can ‘similar exposures’ of the attacks be measured in general. How does this become an experimental category when the different influences cannot be grasped? It seems as if this is used in order to reduce and simplify towards the classical symptoms of PTSD.

Also it is visible that the women were mothers before giving birth as this does not focus on women that were pregnant at the time of the attack but especially on the mothers who developed the condition in comparison to mothers who, even while being exposed to the same events did not. These mothers are normalised in the discourse. Basically the ‘cohort’ is used to study an abnormality as if ‘such’ mothers are lacking something to cope with the attack even though not consciously but through their bodies. Thus the category of motherhood and the female body are strongly connected here.

Female body

“These lower levels were most significant in babies born to mothers with PTSD in their third trimester on Semester 11 however the PTSD symptoms severity in the entire sample was correlated with infant cortisol levels regardless of trimester.”

Thus the cortisol levels in babies were unrelated to maternal depression. The researchers claim that the effects of maternal PTSD on cortisol can be observed very early in life of the offspring and underscore the relevance of *in utero* effects as contributors to putative biological risk factors for PTSD. According to the researchers a strong effect of PTSD on cortisol in mothers exposed in the third trimester of pregnancy could implicate the involvement of so-called ‘prenatal factors’. These stress-induced decreases in glucocorticoids during pregnancy influences fetal brain development, “producing permanent changes in glucocorticoid programming in offspring” in both human and animal and are in part dependent on the gestational age of the fetus. Gestational age (or menstrual age) is a measure

of the age of a pregnancy where the origin is the woman's last normal menstrual period and is usually measured in weeks (defined by the American Congress of Obstetricians and Gynecologists 2012). Thus the mothers PTSD can have a permanent effect on the offspring and cause harmful development of the baby's brain. These 'permanent' changes are not defined as the results cannot be correlated to a longer period of time. Still it is interesting how 'prenatal factors' are automatically influencing *in utero* even though it is not clear what these are.

Although the word epigenetics is not used the emphasis on 'prenatal factors' holds the potential of a black box. A description of an underlying mechanism that is taken for granted.

Although the September 2011 exposure overall was related to reduced birth weight for the gestational age this finding did not appear to be related to the presence of PTSD in mothers as hypothesized before. This means that the babies were born smaller but this did not correlate to the PTSD.

The study follows the already obtained results of the research group on Holocaust victims and extends it stating that "extrinsic environmental conditions occurring in offspring later in life cannot fully account for transgenerational transmission of cortisol." Thus it becomes clear that the study on pregnant women during the World Trade Centre attacks is based on the same assumptions as the study on Holocaust victims.

It is important to note that these observations and effects related to *in utero* programming and early stress can change over time because the low salivary cortisol levels in offspring were observed at 3 years but not at 7 years. Thus and this is very important there are contributions to cortisol levels based on the offspring's own development history.

"The current cohort provides an opportunity to examine the longitudinal development in cortisol over time in relation to both remitted or ongoing maternal symptoms and factors related to child development and, accordingly, to disentangle the contributions of genetic, pregnancy, *in utero*, and postpartum influences on offspring cortisol levels in a sample where the intensity, frequency, and duration of the stressor is clearly defined, and the symptoms are clearly quantified in a prospective manner."

This is the last statement of the scientific paper and represents a future outlook on the study. What is unclear to me is how even in the case of already one year old children the future outlook will be on the 'maternal symptoms' even though in the same paragraph it is stated

that other factors need to be considered. However the focus is solely on the mother and how her environment can influence the child *in utero*, the father is never considered.

Women

In this article women are not mentioned without being mothers. Men suffering from PTSD are also not mentioned. Following the study children are influenced *in utero* by their mother's level of cortisol which is connected to suffering from PTSD. Even though the level of cortisol is connected to the women's body would it not also have an effect if the father suffers from PTSD? It is interesting how prenatal stress is solely fixed on the female body as it seems to be clear that only women experience PTSD that could be harmful for their babies. This reduces the discussion of PTSD to a solely biological deterministic level.

Social structures

“Because adult Holocaust offspring also endorse more childhood adversity and subjective distress to stressful life events, it cannot be ruled out that cortisol levels reflect responses of offspring to their own experience rather than parental PTSD.”

Nevertheless, the researchers state that the extent to which any risk factor for PTSD is associated with parental exposure, including prenatal factors is unknown. These transgenerational effects of trauma have often been attributed to nongenetic, largely postnatal influences such as ‘vicarious traumatisation of the offspring by the parent’s communication of their trauma to the child’ or other consequences of parental symptoms. Here the article mentions ‘poor parenting’ as a parental symptom. This already seems like a very controversial category as the question rises who defines what as poor parenting? No definition to this term is given.

In this study the offspring were only one year old at the time of endocrine testing thus other potential hypothesized mechanisms, related to ‘social regulation’, glucocorticoid programming *in utero*, and/or shared underlying genetic susceptibility are more relevant to the cortisol alterations observed, according to the authors.

Regarding these ‘social regulation’ other studies show that babies being raised under conditions of neglect or abusive care have low ambient cortisol levels (Gunnar et al. 2001). An example of Macaque monkeys is mentioned where offspring exposed to ‘maternal stress’

showed lasting corticotrophin-releasing factor elevations and low cortisol levels which is a profile observed in PTSD. Further Marmoset monkeys exposed to early maternal separations and monkeys exposed to stressful peer-rearing also show reduced basal cortisol (Dettling et al. 2002). In cross-fostering studies even brief exposures in postnatal maternal care during a critical period can have permanent neuroendocrine effects in offspring.

“Thus, mothers with PTSD postpartum may display different or inconsistent behaviour toward their offspring affecting glucocorticoid regulation.”

This paragraph perfectly shows how out of a study performed with pregnant women the effects that have beforehand been observed on monkeys are used as further strengthening proof for the results. Also the final sentence about mothers with PTSD and their behaviour to their children strongly implies a negative effect on the offspring. Which even if it were the case raises the question of what is to be done in this case? Can the mother truly be held responsible for this?

Despite their results the researchers conclude that the contribution of pre-pregnancy or pre-traumatic risk factors, including genetic, cannot be excluded as a mechanism of cortisol transmission to offspring because “PTSD may in part reflect genetic or genetic-environmental interactions regulating individual differences in cortisol or cortisol response to stress that may, in turn, be transmitted.” These factors could also explain heterogeneity in the samples.

I would argue that in this case they are again mentioning genetic or genetic-environmental effects to strengthen their results without a direct link to any sort of genetic data. Only because this has been observed on monkeys as well does not make it transgenerational and therefore it should not be easily generalized.

Sexuality

In this study sexuality is not mentioned in any sort of way.

3.2.2 The Guardian article

“Pregnant 9/11 survivors transmitted trauma to their children”

This is an article focusing on 2 publications of Rachel Yehudas research with an overall summary about epigenetic research. The article was published on the ‘The Guardian’ Genetics/Neurophilosophy section on 9th September 2011. The name of the author is missing. For this case study I have chosen the original publication above for the analysis. The second publication with the title “Gene Expression Patterns associated with posttraumatic stress disorder following exposure to the world trade centre attacks.” was published in 2009 by Rachel Yehuda and colleagues in the Journal of Biological Psychiatry. I will summarize the second article which is important in terms of understanding and can be seen as a follow up study of gene expression after the findings of the previous study. This study has not been analysed through categories as it is only a very short report on the genetic findings with limited information on possible interpretations of the results.

PTSD is associated with enhanced responsiveness of the glucocorticoid receptor and genes involved in the regulation of this receptor may associate with PTSD risk. This study examined risk factors in person exposed to the World Trade Centre attacks from a population-representative sample. Genome-wide expression analysis was used to identify altered gene activity patterns in highly exposed person compared with those without PTSD (Yehuda et al. 2009). In total 40 Caucasians with high-magnitude exposure to 9/11 were chosen of which 20 were suffering from PTSD. The expression levels of one gene involved were in the opposite direction of those observed in recurrent depression (Binder et al. 2004, Yehuda et al. 2009) suggesting that gene expression in PTSD may be regulated “by different mechanisms than in depression, possibly including epigenetic mechanisms.” The expression of several genes was reduced in individuals with PTSD and this therefore may contribute to the high levels of glucocorticoid receptor activity that is consistently observed in the condition.

This is the only time when the term ‘epigenetic’ is used in both of Yehuda’s publication.

The article in ‘The Guardian’ that refers to these two scientific papers describes the transmitted traumatic experiences through the World Trade Centre attacks through the “emerging field of epigenetics”. According to the article psychologists predicted a wave of trauma across the country following the attacks, however it is estimated that about 530,000

New York City residents suffered from symptoms of post-traumatic stress in the months following the attack.

Women

“Among the tens of thousands of people directly exposed to the World Trade Centre attack were approximately 1,700 pregnant women. Some of these women went on to develop symptoms of PTSD, and some of the children have inherited the nightmare that their mothers experienced on that day.”

How many are ‘some of these women’ exactly? Would this not be important when analysing a population-representative? This again would only be possible when PTSD would be a symptom that could be generalized in this way. Using a phrase such as “some of the children have inherited the nightmare that their mothers experiences” a strong responsibility is imposed on these women again as if they are responsible for passing their genetic repertoire to their children.

“Rachel Yehuda, professor of psychiatry and neuroscience in charge of the division, set out to investigate how these women’s experiences might affect their children.”

It is actually very rare that a scientist is mentioned solely when talking about research. However in the case of these studies both in scientific literature and in popular media it seems as if Rachel Yehuda has become the ‘specialist’ when talking about these results.

“They recruited 38 women...” is exemplifying that women are merely objects of research when considered in this context and were ‘recruited’ for the purpose of analysis.

Interestingly the article in The Guardian uses ‘children of women’ and ‘those born to the women who had developed PTSD’ as opposed to the mothers. One could argue that this has no influence on the articles perception however I do think there is a difference in description when talking early on about mothers because the word mother is connected to a strong responsibility of a woman towards her societal role when caring for her child.

Motherhood

“A key study in this emerging field, published in 2004, showed that the quality of a rat mother’s care significantly affects how its offspring behave in adulthood.”

Michael Meaney and colleagues reported in an influential paper with the controversial title “Epigenetic programming by maternal behaviour” that rat pups that have been repeatedly groomed and licked by their mothers during the first week of life were subsequently better at coping with stressful and fearful situations than pups who received little or no contact (Weaver et al. 2004). According to this study these effects are mediated by epigenetic mechanisms that alter expression of the glucocorticoid receptor and this plays an important role in the body’s response to stress. It is quite clear that this study uses the maternal behaviour to emphasise the importance of the traits commonly associated with motherhood in our society thus it is clear that again these results on rats are compared to those of the women of the World Trade Centre attacks. Since this publication in 2004 there has been an increase in scientific studies that investigate how affection, nourishment and abuse in early life lead to epigenetic changes that may remain stable throughout an individual’s life (Kenney & Müller in prep.). I find this very disturbing as gender roles are re-confirmed only by already existing gender roles on a ‘new’ epigenetic level. These new nature/nurture configurations contribute to and change the intertwined scientific and moral discourse about ‘good parenting’, particularly when gendered assumptions about ‘mothers’ and ‘fathers’ can be observed in science literature and media reports on epigenetics. Additionally concepts of ‘good’ and ‘bad’ parenting behaviour are created in the traffic between animal experiments and human categories and these translations influence concepts of parenting as a natural and social phenomenon.

“Specifically, pups that received high levels of grooming and licking had higher levels of methylation within regions of DNA that regulate the activity of the glucocorticoid gene. (...) By contrast, these epigenetic markers, as they are known, were not seen in the ‘low maternal care’ pups, and consequently glucocorticoid receptor levels were reduced in these animal’s brains.”

Examples like these show this dichotomy confirmation very clearly as it is out of our society that ‘low maternal care’ is defined. With the definition of this term a strong moral concept is transported as well. This legitimizes the strong focus on the maternal behaviour towards the child that influences it for a lifetime and thus it is the maternal care that is responsible for the well-being of the child for a life-time. Also it defines maternal care through a complete devotedness to the offspring.

“Similar mechanisms probably account for the transmission of trauma from mother to unborn child.”

It is intriguingly dangerous to use these stereotypes in genetic research as this can lead to assumptions that are very one sided as can be seen in the total exclusion of the figure of the father.

Female body

“Intriguingly, reduced cortisol levels were most apparent in those children whose mothers were in the third trimester of pregnancy when they were exposed to the attack.”

It is the female body that is exposed and that has the impact on the children. Through the exact determination of the momentum in which the correlation seems to be strongest a generalization of the effect on the female body is seen. There is also no data on how many women were at this exact point of pregnancy at the time of the attack.

“Last month, researchers from the University of Pennsylvania reported that epigenetic markers can be transmitted through two generations of mice, suggesting that children who inherited the nightmare of the World Trade Centre attack from their mothers while in the womb may in turn pass it on to their own children.”

This research by the University of Pennsylvania is not mentioned any further and there is no reference to it. I could not find any information on this highlighting the simplicity of the popularization of science. It is also interesting that this research is used as the introduction to the final argument that through these mice results suggest the same mechanism in humans. It is also the first time the expression of ‘the womb’ is used which illustrates again the importance of the female body.

In the animal studies by Meaney et al. the epigenetic modifications were observed in the hippocampus, a brain region that is essential for learning and memory formation. According to the author it is “possible that epigenetic markers are laid down during the formation of traumatic memories.”

Once again the processes in the womb are compared to those in mice and another controversial aspect is discussed, the brain formation. Thus the female body is through the womb connected or also responsible for modifications.

Social structures

“The precise mechanism by which traumatic experiences are transmitted from one generation to the next is still not known, but a picture is beginning to emerge.”

Results on animals again are used as ‘key studies’ when explaining complex process in the female body and are leading to the bigger picture in explaining the transmission of traumatic experiences. This approach of combined results that form a generally applicable conclusion is used by popular media to evoke a complete report on the topic even though this might not be that case. This picture that begins to emerge is one that does not exist and should be found but is constructed by the author in order to sensationalize the story.

“Yehuda’s work established low cortisol levels as a risk factor for developing PTSD and, then taken together with the animal studies, suggests that traumatic experiences can leave epigenetic marks that alter the stress response in offspring.”

Epigenetic factors could also with genetic variation explain why some people are more susceptible to stress than others. This could mean that any sort of event a woman goes through while pregnant can have an effect on the child. The problem with this sort of observation is the definition. Who defines stress? And where is the purely individual experience? Also stress is not a purely female experience thus research should focus on gender as well.

3.2.3 Annie Murphy Paul book passage

“Origins: How the Nine Months Before Birth Shape the Rest of Our Lives (2010)”, Annie Murphy Paul

In this recent popular science book new research concerning a mother’s stress level and dietary habits during gestation are reviewed. The focus is on the influences on the fetus in the future and possible diseases such as obesity, heart disease and diabetes. She is a magazine journalist and book author and her book has been praised as the New York Times Notable Book 2010.

She was writing this book at the time of her second pregnancy and was influenced by all the news she heard about harmful effects from the environment that influence the fetus in the

womb. "...the science of fetal origins is opening up unprecedented possibilities for prevention and intervention, for giving birth to a generation that is healthier and happier than any that came before." This science also "produces new insights" according to her for the most important question on earth: "What makes us the way we are?" For her we must look at where it all began: the womb. The book can be seen as a more scientific version of pregnancy literature primarily written for women who will become mothers in the near future.

The book is divided in 9 chapters each according to one month of pregnancy. Here I will review a part of chapter 3 that corresponds to the scientific article discussed before.

This part of the chapter starts off by describing the events in the morning of September 11th 2001. She describes the people that were on their way to work or the waitresses setting the table all which were nearby the World Trade Centre.

Women

"About 1700 of these people were pregnant women." (Page 42)

The moment the planes crashed into the twin towers these women had to experience the same horrors as others survivors: the chaos and confusion, the clouds of potentially toxic dust and debris and the fear for their lives.

Pregnancy puts women into another category as they are through their body responsible for another being as well. This is why they need to be mentioned especially in experiencing the 'same horrors as other survivors'. Normalization is taking place through the differentiation of other survivors to pregnant women and the combining of all pregnant women to one group.

Psychiatrist Rachel Yehuda was interviewed by the author. At the time of the catastrophe she was arriving at work at the Bronx Veterans Affairs Medical Centre about 15 miles north of New York. She was in a meeting when she got called by her mother asking if she was alright as she had seen the attack on TV. Yehuda and her colleagues then organised a television and watched the events unfold.

"Of course, I was thinking about what the long-term reactions of the survivors would be" (Page 42), Yehuda stated in the interview.

Rachel Yehuda is then described in more detail as 'a leading expert' on post-traumatic stress disorder, a condition that forces survivors of a traumatic event into a state of hypervigilance,

assailing them with nightmares and panic attacks. She is also described as a PTSD researcher who has mostly worked on Holocaust victims and Vietnam War veterans. Even though most of the survivors of the Vietnam War and many survivors of the Holocaust are men this is not differentiated here. She especially worked on those whose trauma happened years or even decades ago.

Motherhood

Since 9/11 Rachel Yehuda has co-authored several articles about the effects on the survivors, including studies of women who were exposed during pregnancy. She was mostly interested in this 'population' as she calls it because she has a long-running interest in the transgenerational transmission of PTSD risk, and the 'handing down' from susceptibility to PTSD from parent to child. She studies this since 1993 when she opened the first clinic in the world devoted to the psychological treatment of Holocaust victims. She was surprised when for every call her clinic received from a Holocaust survivor it got five calls from their grown children. Thus the second generation had symptoms of PTSD, Yehuda observed.

"They reported the same nightmares, the same panics, (...) as their parents did." (Page 42)

Her research confirmed that the offspring of parents with PTSD were more likely to develop PTSD themselves, even though they were no more likely to encounter traumatic events than other people.

Through the use of words as 'population' she clearly combines these women into a special group. Also the term 'handing down' can be interpreted as a directional view of the transmission this implicitly means handing down from parent to child and in this case the mother which enhances the role of responsibility. Who is held responsible when the child is born in times of stress? By studying the female body it is directly held responsible.

Murphy Paul tries to work out how this could happen and explains that the traditional, psychoanalytical explanation would be that the younger generation experienced trauma through the stories of their parents and in observing their struggle. In one case this is even described as "the scar without the wound". Yehuda as well thought that the parent's symptoms in front of their children accounted for the transgenerational effect however she started wondering whether another mechanism before birth could be at work focusing on processes in the womb.

“It would mean that even before birth, mothers are warning their children that it’s a wild world out there, telling them: *Be careful*. It would mean that all of us, no matter how privileged or civilized, are never far from what Rachel Yehuda calls ‘the biology of survival’”(Page 48).

This is the final passage about the research of Rachel Yehuda in the book. The application of studies around the influence of traumatic incidents on pregnant women insofar, that this can be seen as an advice, is pure speculation and the author’s interpretation. Additionally it is probably the most effective way of simplifying these results for pregnant women giving even more power to the prenatal period and the strong meaning of motherhood. Women are not only carriers of the children; they hold a certain power of warning their children through the connection of their body and the womb. Through this statement the society’s importance of motherhood and relationship of mothers to their children as opposed to father to their children is proven through a ‘new’ genetic dimension.

Female body

The categories of motherhood and the female body are strongly connected here as motherhood is defined through processes in the womb and the description of ‘in the womb’ is attached to the female body.

The research of Rachel Yehuda has shown that that low levels of cortisol were a marker of vulnerability to PTSD. Thus people with low cortisol levels were more likely to develop symptoms after trauma. Cortisol is described as a hormone released when the body is under stress and a function of it is to stop the stress reaction once it is finished. When a person has a low level of cortisol the body has a higher state of alarm and thus not subside once the crisis is finished. Another important discovery by Yehuda is that offspring of PTSD patients has lower cortisol levels as well.

“Is this commonality simply genetic? Or could it be passed down *in utero*? Nine-eleven provided an opportunity to find out.” (Page 46)

Women who had developed PTSD after 9/11 had low cortisol levels as well as their babies and this was strongest in infants whose mothers had been in their third trimester during the attacks. The psychoanalytic explanation seems not possible as the children were only a year old. They could have not been “traumatized by their parents’ stories”.

Even though she talks about the parent's stories the question she asks in the book are directed towards the mother. Could this be passed down *in utero*? Again the use of 'passed down' shows a direction that could be willing and holds a different meaning.

The strong effects on babies after exposure in the third semester point to prenatal factors in the transmission of PTSD risks, according to Yehuda.

"It looked like the mothers with post-traumatic stress disorder had passed on a vulnerability to the condition to their children while they were *in utero*." (Page 44)

This is another passage that clearly shows that it is the female body that is concerned when conditions of vulnerability can be transmitted. Vulnerability itself is interesting as it can also be associated with a classical female characteristic in our society. Thus it is through the female body that vulnerability is transmitted.

Another study performed by Yehuda and colleagues of Holocaust survivors and their grown children provided another piece of "supporting evidence". In this experiment the offspring were more likely to develop PTSD if their mothers, but not their fathers, had PTSD. This meant for Yehuda that the classic genetic mechanisms are not the sole model of transmission. Yehuda concluded:

"We need to be looking where we hadn't even considered looking before (meaning in the womb)." (Page 47)

The importance of the womb becomes even stronger by differentiating the mothers and the fathers PTSD and correlating these. Also I would argue that as there is no clear definition of PTSD and the strength of the symptoms it is quite impossible to measure these by impact of the father or the mother. Of course through this observation the responsibility on the side of the mother increases and the connection of the concept of motherhood and the female body is visible.

Social structures

There is a last "twist in the story" as the author calls it. Post-traumatic stress disorder appears to be a reaction to stress gone very wrong, causing the victims immense unnecessary suffering. Jonathan Seckl, a collaborator of Yehuda suggests another way of thinking about PTSD. He thinks that this might be a useful adaptation in some circumstances.

“In a particularly dangerous environment, the characteristic manifestations of PTSD – a hyperawareness of one’s surroundings, a quick-trigger response to danger – could save someone’s life.”(Page 48)

Several scientists have elaborated in the same way that “extra vigilance and rapid shifts in attention could be adaptive in an environment full of danger or predators”. Our society might lack the predators but a great effort is put in education of focus and concentration, extra vigilance and rapid shifts in attention can be maladaptive and result in unnecessary anxiety and problems with attention.

“As Yehuda watched in real time as tragedy struck her own city, she was already thinking about how to investigate its impact.” is stated by Murphy Paul in her book.

Of course she is a PTSD researcher thus it is no wonder she sees this as a potential for her studies but on the other hand she interprets this as possibly beneficial because more research subjects will be available. Already scientists are often seen as people who always think about their research and thus a certain truth value is associated with them. Through these citations this belief of the career focused scientist who is disconnected from the wider picture of the attack is constructed.

3.2.4 Discussion of the case study

While reading the articles for the first time I often asked myself why research questions like these were asked and what the purpose of these studies could be.

“How might the traumatic experience of a pregnant woman be transmitted to her unborn children? Research published over the past 10 years or so suggests that this probably occurs by epigenetic mechanisms.” (The Guardian)

What exactly is this research trying to answer? Of course it could be that in future results like these can be used in the therapy of severe cases even though the knowledge is still far from being applicable to everyday psychotherapy. It seems as if epigenetics in this context are used to attach even more responsibility on the female body and the concept of motherhood. I would argue that these results are already in their research question exclusively focused on women

or ‘mothers to be’, and certain ‘blame’ is transported. Throughout history the image of the pregnant women has shifted from having to stay at home from day one and rest to the ultimate self-defined hero women who can work like never before and never skips one yoga class in pregnancy. This development itself is part of a whole debate about pregnancy however with results like these the discussions evolving in popular media need to be considered as well. How could these pregnant women have protected themselves from this stress that was imposed on them and their unborn children? Nobody has an answer to this however the blame is still transmitted with the trauma on their bodies.

Interestingly the scientific publication nor the popular articles never describe how exactly PTSD is defined. It would be crucial to know how a ‘disorder’ which is already very meaningful as word is described in medical terms and to which degree this has an impact on individuals and how long this impact sustains. All of this is important when talking about symptoms on women but is not mentioned nor put into question by the popular articles.

This as well as descriptions of ‘social regulation’ or ‘poor parenting’ can be seen as black boxes. A black box is a metaphor denoting a piece of machinery that "runs by itself". That is, when a series of instructions are too complicated to be repeated all the time, a black box is drawn around it, allowing it to function only by giving it "input" and "output" data. Its inner complexity doesn't have to be known; one only needs to use it in his/her daily activities (Latour 1987). This is something that is constantly done in life sciences and its popularization. I would even argue that ‘stress’ itself when mentioned without context can be regarded as a black box.

Thus cortisol in this research can be seen as a ‘vehicle’ to pin the topic to other factors that could be responsible but are not solved yet. Using the term genetic in this sense is purely speculating as is when talking about ‘genetic-environmental interactions’ as this study did not focus on those but solely on the cortisol level that has been correlated to the mothers and their offspring. There is no doubt that there is a relation between PTSD and environment and most likely the fetus development however in this research the topic is not analysed from the full perspective in order to draw these conclusions.

What is also interesting in this case study is that epigenetics is only mentioned on the side of the original article, the exact words are ‘genetic-environmental interactions’. It is through the popularization that epigenetics are used as the ‘new emerging field’ that could possibly explain the observed results.

Another aspect that is differentiated in scientific literature and popular media is that the expression ‘in the womb’ is never used in scientific context. ‘In the womb’ seems to be a key element for media when attaching these findings to the female body. I would argue that this expression is powerful because it contains the argument that the womb is the beginning of life and thus the most important influence is imposed on this part of the female body.

Throughout two out of three articles the importance of animal studies is visible. Once it is Monkeys in the discussion that lead to expressions such as ‘maternal behaviour’ and the other time it concerns rat mothers and their ‘licking and grooming’ of pups. The comparison of animal and human studies is valid of course as we may not be very far apart on a genetic level. Still these comparisons should be done with care as humans differently experience their social environment thus animal observations cannot hold true for humans, especially mother to child behaviour.

Furthermore in this case study is the homogenization of several aspects in epigenetic research that causes a reduction in the interpretation can be observed. Generally when only focusing on one specific vehicle such as cortisol and in addition the female body. This kind of reduction causes simplification and assumes that processes like these can be explained easily which is actually opposed to the complex reality of epigenetics.

3.3 Prenatal Maternal Stress

This case study focuses on the epigenetic effects of prenatal stress based on the results of a study called “Project Ice storm” published in September 2014 in PlosOne and written by Canadian scientists from the famous McGill working group on epigenetics including, Moshe Szyf. He was one of the pioneers in modern epigenetics through his publication on “Maternal behaviour through rats” mentioned in the previous case study (Weaver et al. 2004). The first article is the original publication, the second article is from the website of a popular epigenetic research site and the third article is from CBC (Canadian Broadcasting Cooperation) news Canada the largest news broadcaster in Canada.

3.3.1 Primary literature

“DNA Methylation Signatures Triggered by prenatal maternal stress exposure to a Natural Disaster: Project Ice Storm” by Cao-Lei et al. 2014

Prenatal maternal stress (PNMS) predicts a wide variety of behavioural and physical outcomes in the offspring (Weinstock 2008, Cao-Lei et al. 2014). Although epigenetic processes may be responsible for PNMS effects, human research is hampered by the lack of experimental methods that parallel controlled animal studies (Charil et al. 2010, Harris 2011, Cao-Lei et al. 2014). Disasters, however, provide natural experiments that can provide models of prenatal stress. In this study women were recruited five months after the 1998 Quebec ice storm who had been pregnant during the disaster and assessed their degrees of objective hardship and subjective distress. Project Ice Storm was conceived following one of Canada's worst natural disasters in history: the January 1998 Quebec ice storm. Between January 6 and January 9, a series of freezing rain storms passed through southern Quebec covering everything in a layer of ice. Resulting power outages ranged from a few hours to as long as 6 weeks for three million people in the province of Quebec (Cao-Lei et al. 2014).

Thirteen years later the researchers observed DNA and methylation profiling in T cells obtained from 36 of the children and compared selected results with those from saliva samples obtained from the same children at age 8.

The objectives of the study were to determine the extent to which objective and/or subjective PNMS from a natural disaster would explain variance in DNA methylation patterns many years after birth and to determine whether these patterns can be discerned in T cells, peripheral blood mononuclear cells and saliva cells. Other tissues such as saliva and whole blood cells are more accessible sources than brain in standard longitudinal behavioural studies in humans (Cao-Lei et al. 2014).

These data provide first evidence in humans supporting the conclusion that PNMS results in a lasting, broad, and functionally organized DNA methylation signature in several tissues in offspring (Cao-Lei et al. 2014).

Motherhood

“Prospective human studies suggest that maternal anxiety and life events in pregnancy predict the fetus’ risk for cognitive and behavioural problems in later life (Talge et al. 2007).”

This citation in the introduction is one of the main arguments for the description of the aim of the research. There are studies that point into this direction and the researchers saw this as an important aspect for this analysis. This suggestion on maternal anxiety and the events in pregnancy focuses exclusively on the mother as the influential factor. Also the degree of maternal anxiety is not defined nor does this explain how anxiety itself can be defined. The same holds true for ‘life events in pregnancy’ as these do not only include the mother.

“Epigenetic modifications of gene function may be one mechanism by which PNMS results in poor outcomes in the offspring. DNA methylation, an intensively studied epigenetic mechanism could be modulated by exposure to a variety of maternal experiences and might participate in processes that “adapt” the genome to stress signals across multiple tissues and explain the broad-ranging effects of early life stress on the fetus.”

In this passage the strong meaning of epigenetic modifications becomes clear when the most important mechanism of DNA methylation is mentioned. First of all, these ‘poor outcomes of the offspring’ are pre-assumed from previous studies mostly conducted on animals. Additionally the connection from an event to the expression of a disease can thus far not be correlated to any cause. Also it is important to state that these ‘poor outcomes’ are purely defined on a genetic level. Thus the definition of poor outcomes comes from the norm of women who apparently do not experience PNMS. This aspect can also be connected to the category of the female body as this is a strong biological view on the female body. Secondly this variety of ‘maternal experiences’ that can possibly ‘adapt’ the genome through these processes describes a strong directional approach. This is a normative explanation of highly complex processes where again the direct link could not be established yet. Also these broad-ranging effects are not explained in detail.

“One approach to circumventing these methodological challenges (...) is to study the effects of exposure to an independent random stressor, such as a natural disaster, on DNA methylation, thereby isolating any effects of the mother’s objective degree of exposure from any genetic predisposition, and from her subjective level of distress.”

The aim was thus to only focus on the mother's 'objective' stress and its effects on the fetus. This implies a normalization of processes during pregnancy, as if the subjective stress would not connect to the objective stress and as if this could be studied separately.

This problematic approach of 'objective' versus 'subjective' stress is the basis of this research and is further discussed in the category of social structures.

In their discussion the authors explain how objective PNMS in Project Ice Storm has shown to be more important and thus they "hypothesize that the effects of objective PNMS on child outcomes may be mediated by these DNA methylation changes which could persist throughout life."

"Unfortunately no biological material was collected from the children of the Project Ice Storm cohort at birth."

This is interesting as it is not clear how differently the methylation has already taken place when talking about changes persisting throughout the life. There is no actual reference for these results.

"By using a natural disaster, this model allows us to isolate the degree of objective exposure of the mother to the ice storm with less danger of potential confounding by family psychosocial characteristics, and allows us to make tentative conclusions that the associations we uncovered are causal in nature."

Apart from mentioning 'family psychosocial characteristics' as a confounding factor by this conclusion of the study the expression of being 'causal in nature' is very unique. How can a representative sample like this with the methodology used and the results obtained, following man-made, rules simply be put into the expression 'causal in nature'? This is also interesting as it is 'nature' itself by definition of the authors that 'created' this representative sample through the disaster. I think that it becomes clear how the researchers are trying to draw a general conclusion with the aim to explain how 'nature' works through epigenetics.

Women

"Project Ice Storm recruited 174 mothers, who were pregnant during the January 1998 Quebec Ice storm or who conceived within 3 months of the storm when stress hormones could still be elevated."

For this study mothers were recruited in order to form a cohort of study objects. Also women who were not pregnant during the storm are still considered to be mothers even if they conceived within these 3 months of the storm. When combining this with the elevated stress hormone normalization again is visible. Thus ‘these’ women are solely measured by their stress hormone level.

“By using a natural disaster model, we can infer that the epigenetic effects found in Project Ice Storm are due to objective levels of hardship experienced by the pregnant woman rather than to her level of sustained distress.”

The question that should be asked here is whether they have even considered the level of sustained distress in comparison to the claimed ‘objective’ stress. As mentioned before this is a problematic description of stress and pervades throughout the analysis. It is also interesting how in their conclusion the researchers use the term ‘pregnant woman’ in singular even though the study clearly does not focus on individual perceptions of stress.

Female body

“The Project Ice Storm cohort provides a unique opportunity to determine whether a direct relationship exists between *in utero* exposure to maternal stress and DNA methylation signatures in the offspring, and to determine the extent to which variance in methylation is explained by objective and/or subjective PNMS.”

By using the term ‘*in utero*’ a certain vehicle is constructed for the connection of environment and the fetus through the female body that is only important in context of the uterus.

“Moreover, our results call for a more careful examination of the interactions between DNA methylation changes in response to stress and health outcomes. Potential confounding variables such as infant stress status need to be taken into account in further studies.”

It can be seen that the female body serves merely as a bridge to the health of the fetus. Thus epigenetics hold the key for these interactions. It is also through the female body that the infant stress is defined which is emphasized to be of importance in future studies.

Social structures

“Thus, both animal and human research suggests that *in utero* exposure to some form of maternal “stress” or mood correlates with the fetus’ epigenome. None of these animal or human studies are capable, however, of determining which aspect of the stress experience is responsible for triggering a biological cascade that will reach the fetus to alter development: Whether the objective hardship experienced by the pregnant female, or her level of subjective distress, or some combination of the two.”

Why are these definitions of maternal mood and the strict distinction of objective and subjective distress of such importance? As seen in the categories of motherhood and women it is problematic to define a certain kind of stress as ‘objective’ as it is not known who defines it as ‘objective’. It is already surprising that it is possible to put such classical descriptions on the stress experience. This biological cascade which already creates a powerful image that again could imply a direction is described as if actively influenced by the mother suggesting again strong responsibility on her side. Furthermore could ‘objective’ stress by this definition not also hold true for the father? Does the father’s contribution not count as ‘objective’ then?

The authors state that through this choice of cohort the research “mimics the experimental control inherent in animal research”. Once again it becomes clear that epigenetic studies need to be based on animal research in order to hold their potential explanatory effect. Also it becomes clear that the experimental design was based on experiments in the laboratory with animals thus the research was trying to ‘mimic’ animal studies rather than trying to analyze these results with the primary focus on humans.

“The personal and financial costs of the disaster left a significant impact on the population. Project Ice Storm has found that maternal objective hardship and subjective distress predict different sets of developmental outcomes.”

This is the only time when the word ‘population’ is used in the whole article compared to pregnant women and mothers. However in the study this significant impact on the population is measured solely by the developmental outcomes influenced by maternal stress.

The effects of external stressor, the “mother’s subjective distress reactions, her trait levels of mood” are difficult to differentiate in PNMS studies. Thus the authors emphasize that “in human PNMS research we need to find a model which could allow us to isolate specific elements of the human stress experience.”

In the discussion the authors do acknowledge that it is difficult to differentiate these levels of stress however they do not put in question their assumptions about women's stress but generalize on the human stress experience. The aim to isolate specific elements of the human stress experience assumes that these were differentiated as such and could be isolated. This human stress experience itself is not defined in any way however it is implicitly powerful and important for their conclusion.

“The 1998 Quebec Ice Storm offered a unique opportunity to isolate objective and subjective aspects of PNMS and their associations with offspring phenotypes given that the objective degree of ice storm exposures was quasi-randomly distributed in the population, as such, the objective PNMS was not confounded by genetic, psychological, or socioeconomic stratification.”

By not confounding their results with these stratifications the authors wanted to enhance their ‘objective degree’. If it is not possible to differentiate as such the level of stress even though they used terms as ‘subjective’ and ‘objective’ how can the authors then assume that psychological or socioeconomic stratification could not play a crucial role in the analysis of ‘subjective’ stress experiences? Would it not be more important to include as many factors as possible and focus more on the individual experiences of stress before drawing conclusion by eliminating those?

Even though through this study it can be assumed that randomly assigned PNMS triggers DNA methylation changes in cells in humans the authors highlight the importance of a bigger sample size in order to further establish the cause and effect relationship between PNMS and DNA methylation. This is a very positive aspect as these results rely on a small cohort and a big sample size should always be emphasized.

3.3.2 What is epigenetics article

“Prenatal Maternal Stress Triggers Distinct DNA methylation Signatures in Ice Storm Babies”

The article was published in November 2014 by Bailey Kirkpatrick on the website www.whatisepigenetics.com. It is based on the original article and has a correct citation of the

PlosOne publication. The article focuses strongly on the scientists Lei Cao-Lei, Moshe Szyf and Suzanne King and the fact that the study was performed by members of McGill University. This highlights the importance of this institute and the scientists in the field of epigenetics.

Women

The article explains that “researchers from McGill University and the Douglas Mental Health University are finding out that the length of time a pregnant woman went without electricity during this time predicts her child’s epigenetic profile.”

It becomes clear that this is less scientific as report than before. In popularization of these findings it seems to be easier to talk about the length of time a woman went without electricity as the sole stress producing element. It is also interesting how this is already put into context with a prediction on the child’s epigenetic profile.

“...women who were pregnant during the storm were recruited and their degrees of hardship and distress were assessed...”

In this article women are again objects of research that have been recruited for scientific purposes. Also their degree of hardship and distress were not actually assessed as this is not possible.

“...assessing the effects the stressful ice storm has had on the children of women who were pregnant during or became pregnant shortly after the disaster.”

In this article women are not immediately seen as mothers and thus the concept of mothers before conceiving is not prevailing here. This is important because it has an implicit value when talking about pregnancy.

Motherhood

“...it was found that maternal hardship could predict the amount of DNA methylation in the babies’ T cells.”

This article uses the expression ‘maternal hardship’ from the study above and this is not explained in any detail. It is only clear that maternal hardship seems to be more important than paternal hardship as the father is not mentioned in any way. Also this is a simplification

as maternal hardship cannot ‘predict’ the amount of DNA methylation. In the original article there is correlation however no quantification of such data is yet possible.

“It’s also the first time a study has showed that enduring changes to the babies’ epigenome occurs due to a mother’s objective exposure to stress and not the level of emotional distress she experiences.”

This is interesting as it is the first time the word ‘emotional’ is used in context of motherhood. I would argue that this is again another mechanism of popularization as it is easier to describe maternal stress by stereotypes such as ‘emotional’.

In the article the term “prenatal maternal objective hardship” is described as the amount of time a pregnant woman went without electricity, any injury she experienced as a result of the storm, the extent of damage that was done to her house. This was positively correlated to the DNA methylation levels. Thus an injury a woman occurred while pregnant is seen as an objective hardship. This sort of generalization asks for a clear positioning of the authors in order to fully understand these observations. Also only because the injury was experienced through the storm it is still a personal, individual stress experience.

Female body

“Scientists have discovered a unique DNA ‘signature’ of children who were in the womb while the massive ice storm occurred.”

The use of the word signature as such is implicitly explaining some sort of negative effect on these children through the experiences ‘in the womb’. In the womb again is used in popularization which as ‘*in utero*’ stands for a vehicle through the female body and the environment.

Social structures

The scientists do state that the long-term changes through DNA methylation are poorly understood. However “the epigenetic signature” may put these teenagers at risk for developing health complications according to the article. This conclusion highlights again how epigenetic research is always directed at future developments of ‘these’ children who have been exposed to some sort of stress. Again risk becomes a very powerful word which

also raises the question of who put whom at risk and how could these women have protected themselves from this sort of stress in the first place?

3.3.3 CBC article

“Ice storm stress affected pregnant women’s offspring, study suggests”

The third article has been published on CBC News Canada on September 29th 2014. It is a very short summary of the above mentioned results. It is not clear who wrote this article as there is no Journalist name mentioned. In this article the “stress and hardship faced by pregnant women” is mentioned at the beginning that through the Quebec Ice storm in 1998 may have affected the health of the children these women gave birth to. Another difference to other articles is that the researchers have been interviewed.

Motherhood

Again the Universities are mentioned (as these are well known) and that 150 families were followed in which “the mother was pregnant during the natural disaster”.

In this article it is interesting that the focus is again on the mother not on the woman that was pregnant. This is probably because in popular media it is important to create certain images such as the ‘mother’.

“The goal of the study was to see if maternal stress affects the health of children.”

This again shows a simplification of the results as the ‘maternal stress’ is not explained by the study’s aim of subjectivity and objectivity stress differentiation. However it becomes clear that it was only the maternal stress that was the objective of the study.

Female body

Once again in a popular article the importance of an advice that can be taken out of the research is visible.

“Szyf says the research needs to be replicated in a larger study, but that it highlights how important it is to keep a non-stressful environment for pregnant women.”

This again is focused on the female body exclusively which should not be stressed. Of course it is important to keep women during pregnancy at a low environmental stress level however this is subjective and individual. Also pregnant women are emphasized to work long into their pregnancy and thus it becomes unclear why this sort of stress is neglected by defining it as ‘subjective’ in the study.

Women

“Szyf says this study is the first to show that objective stress, such as the number of days a woman went without electricity, is what causes long-lasting changes in genetic expression and not the degree of emotional stress.”

This is an interesting statement as it compares the different sorts of stress on a new level. It is not clear if the objective stress is actually what causes ‘long-lasting’ changes however for popular science purposes it seems to be easier to explain it in this way. Also it is important to state that in this phrase the sole focus is on the woman and not even on the pregnant woman.

Social structures

“We have evidence in animals that if you stress an animal during the pregnancy that will have long-term effects in the way the DNA is programmed and the way their health shapes up later in life. But we didn’t know if this can happen in humans... because it’s unethical to stress little babies,” said Moshe Szyf.

I find this statement very disturbing because first of all yes it is ‘unethical’ but however already the idea of it based on animal studies is questionable. Who defines what is unethical and what not? Is it not also unethical to stress animals? Furthermore can this ‘natural disaster’ really be taken as the same study design used for animals?

“The health effects of the change in genetic expression aren’t clear, but researchers say it could put children at a greater risk to develop asthma, diabetes or obesity.”

Again ‘risk’ is used when talking about genetic expression and the outcomes for children. If these health effects are not clear yet then why do the researcher claim there is a higher ‘risk’.

It seems as if in popularization it is important to construct certain strong statements about these effects in order to highlight the importance of the findings and make them accessible to the widest audience.

3.3.4 Discussion of the Case study

In this case study it can be seen how definitions such as stress carry strong social connotations. It is thus interesting how stress is also only important for women and how stressful events are seen as crucially important when talking about the health of the offspring.

The definition of the term stress as objective versus subjective in terms of a natural disaster is problematic as can be seen in the appearance throughout several categories. The question is the legitimization of this study through identifying an ice storm as an occurrence that has objective stress on pregnant women. Of course the authors do not state that every pregnant woman has the same reaction to this event nonetheless through this approach the 'subjective' stress which is not measurable before this event is reduced. A pregnant woman's subjective stress is not subject of research before the definition of the objective stress. This objective stress is for the researchers triggered by a catastrophic event and described by this event. Thus already this cannot be objective. This dual definition simplifies stress to a solely triggering momentum and the researcher do not even discuss this problematic.

Another aspect is the expression 'causal in nature' which appeared in the original article. Through this sort of explanation the importance of the value of the research is demonstrated. This means that the researchers believe that these are processes causal in nature and ready to be inspected by them rather than mentioning how our social environment and perceptions of stress influence how we do research on these subjects.

Several mechanisms of popularization are visible as well. For example the definition of subjective and objective is not at all mentioned in popularization but is described through emotional stress. This is probably due to the easier way of explaining the results.

Another aspect that becomes clear in popularization is the advice value. Once again in epigenetic research results are taken for granted and changed into a sort of advice for a

healthier sort of life for the pregnant woman and unborn child. This is stated in the same article that described how knowledge on genetic expression is still limited.

3.4 Nutrition

Very few topics have been as widely discussed when talking about pregnancy as women's nutrition. The following articles focus on a study of epigenetics that for once could show evidence for the assumed influence of women's nutrition on the genetic repertoire of her unborn baby. The first article is the original scientific publication, the second article is from a popular scientific internet site and the third article is the BBC News coverage about the story.

3.4.1 Primary literature

“Maternal nutrition at conception modulates DNA methylation of human metastable epialleles” Dominguez-Salas et al. 2014

The article was printed in November 2014 in the magazine Nature Communications. The main author is Paula Dominguez-Salas with further 15 co-authors. It is based on the study of environmental influence on Agouti mouse performed in 2003 by Waterland & Jirtle (see also Figure 1).

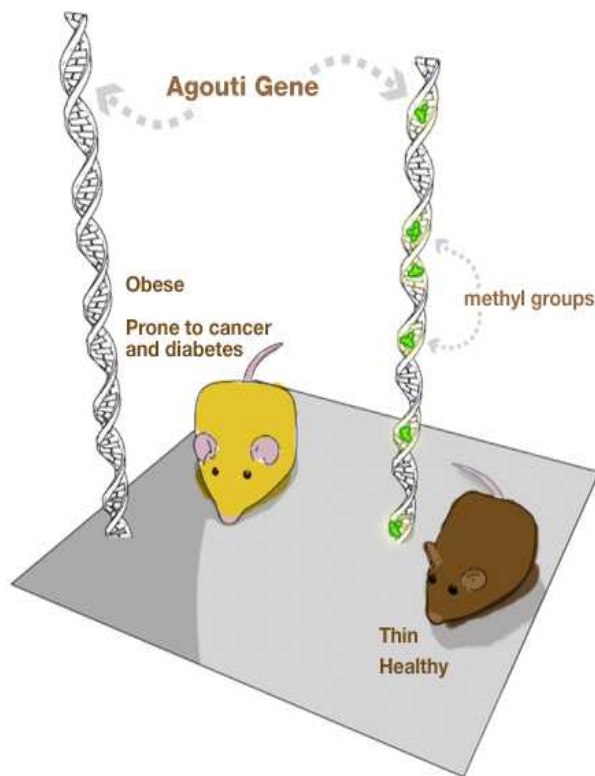


Figure 1: Agouti mice. All mammals have a gene called *agouti*. When a mouse's *agouti* gene is completely unmethylated, its coat is yellow and it is obese and prone to diabetes and cancer. When the *agouti* gene is methylated, which is the case in most mice, the coat colour is brown and the mouse has a low disease risk. Fat yellow mice and skinny brown mice are genetically identical. The fat yellow mice are different because they have a different epigenetic profile. When researchers fed pregnant yellow mice a methyl-rich diet, most of her pups were brown and stayed healthy for life. These results showed that the environment in the womb influences adult health. Early nutrition affects adult metabolism in humans and other mammals, potentially via persistent alterations in DNA methylation. These findings suggest that dietary supplementation, long presumed to be purely beneficial, may have unintended deleterious influences on the establishment of epigenetic gene regulation in humans (Waterland & Jirtle 2003; Figure retrieved May 26 2015, University of Utah).

The study focuses on metastable epialleles which are alleles that are variably expressed in genetically identical individuals due to epigenetic modification established during early development and are thought to be particularly vulnerable to environmental influence (Rakyan et al. 2002, Dominguez-Salas et al. 2014). The experiments in agouti viable yellow mice have demonstrated that maternal dietary changes affecting methyl-donor availability alter epigenetic development at metastable epialleles and that this is causing permanent phenotypic variation among isogenic offspring (Waterland & Jirtle 2003, Waterland et al. 2006, Dolinoy et al. 2007). These metastable epialleles can be seen as epigenetic polymorphisms. The methylation of these in accessible cells can provide a readout of the epigenetic state in other tissue and thus makes them attractive for epigenetic epidemiological studies (Waterland & Michels 2007, Harris et al. 2013, Dominguez-Salas et al. 2014).

The original publication as well as the popular article have been analysed according to the five categories.

Women

In this previous study the percentage of DNA methylation was higher in children conceived in the protein-energy-limited rainy ('hungry') season than in those conceived in the dry ('harvest') season. The terms 'hungry' and 'harvest' have been used by the authors and are problematic due to the limited definition as they do not explain why a rainy season leads to hunger and moreover who the hungry ones are. However it is still implicitly understood showing a supremacy view on the topic. In this study they propose that other nutrients critical to methyl-donor metabolic pathways may have a limiting role. They report a prospective study that replicates the season of conception effects on the epigenotype and extends the findings to additional human metastable alleles.

“Exploiting an experiment of nature that determines seasonal fluctuations in the dietary intake and nutritional status of rural Gambian women, we previously demonstrated that seasons of conception significantly influence the methylation of candidate metastable epialleles in children.”

The term “exploiting an experiment of nature” seems disturbing as nature itself is not at all explained and for me it is not clear how through the argument of epigenetic research on Gambian women this is an experiment of nature. Additionally, I see the exploitation behind it not as a very suiting word for an already controversial attentive to study nutritional patterns through Gambian rural women. Women in the explanation of the study are merely a vehicle to ‘exploit an experiment of nature’.

Motherhood

“We further show that DNA methylation is predictably influenced by periconceptional maternal plasma biomarker concentrations of key micronutrients involved in one carbon metabolism. This represents a demonstration in humans that a mother’s nutritional status at the time of conception can influence her child’s epigenome, with likely lifelong implications.”

The time around the moment of conception is defined as periconceptual. Thus the word ‘maternal’ is already used before the conception has even taken place. When the moment of conception is concerned it is not only about the mother, it is about women and men. It is also not only ‘her’ child. By applying this periconceptual importance motherhood is assumed to

begin even before conception thus the question can be asked: When does motherhood begin? This causes for certain problems as it can also not be seen as the moment when 2 people decide to have a baby because then every conception would provide for a wishful experience of motherhood. Nonetheless it seems easy in terms of biological explanation to use results with the notion of motherhood even though it evokes social and gendered roles because only the woman is considered.

“Our data represent first-in-human confirmation that the maternal blood biomarker status of substrates and cofactors required for methyl-donor pathways, measured around the time of conception, predicts the methylation patterns of metastable epialleles in offspring.”

These ‘maternal blood biomarkers’ around the time of conception are important. I would argue that the term maternal differentiates from the mother’s blood biomarkers. A mother, even though the question again would be when one does become a mother, is a woman with a relationship to a child that does not necessarily have to be her own while the adjective ‘maternal’ also depicts a moral responsibility behind someone with a child. Often women are also described as maternal because of their affinity to care about others. Thus it is as if a moral concept lies already behind blood biomarkers. Also through focusing on the maternal here the paternal blood biomarkers are completely left out as if not important even around the topic of conception.

Female body

In addition the increased maternal body mass index was also predictive of decreased systemic infant DNA methylation in metastable epialleles. This could potentially be of global significance and further research will focus on different effects driven by total adiposity and/or dynamic changes in energy balance. Additionally the research is continuing on infants from these studies to observe long-time effects.

If this is of global significance it would mean that the body mass index which already is one measure of judging the body will be understood differently as it can have a genetic effect on unborn infants. I find it interesting that a study in a small group of women can lead to strong conclusions such as global significances.

In the discussion of their results the authors mention that evidence is accumulating that environmental factors during early-life have long-term effect on later health outcomes and

that these processes reflect epigenetic responses to ‘periconceptual exposures’. This kind of exposure is describe as the environment before conception, of the not yet conceived child, thus practically speaking the women’s body can already influence the life of her child for a lifetime. I find this problematic as only nutrition was concerned and is also seen as an exposure.

Sexuality

It is interesting that even though the study surrounds the topic of conception sexuality is not part of this research in any way.

Social structures

“Our experimental design (based on random distribution of conceptions to different seasons) eliminates many possible confounders and, because our data corroborate prior knowledge from controlled supplementation studies in animal models, a likely causal effect can be inferred.”

Animal studies are taken as a basic underlining of epigenetic studying when performed with humans. In a sense this is an accepted fact in modern society that animals are taken as reference to explain biological processes and environmental effects on humans. If the experimental design eliminates confounders why does the argument have to be held by the previous animal study? It should speak for itself. Also this experimental design has been applied in the same way as from animal studies thus again the question was answered before posed, as the problem itself was pre-determined.

Even though the phenotypic consequences of these variations in methylation are not yet known the “possible implications of tissue-wide epigenetic variation at Metastable epialleles induced by subtle differences in maternal micronutrient status and body mass index at the time of conception are far reaching.”

The authors state that the result are still not enough to form a conclusive understanding and describe that even subtle differences in maternal micronutrient status and body mass index at the time of conception are crucial. Once again women, and not men, are the ones that primarily influence their children. This is confirming societal norms through epigenetic results.

In this study nutrition is the only factor that is observed when considering pregnancy and epigenetics. Thus the social in the maternal behaviour is reduced to solely nutrition and the focus is on identifying the 'right' nutrition from the 'wrong'. The description of only 'dry' and 'rainy' seasonal states gives no definition on the kind of food that these women are eating and simplifies the results. Thus social factors are only described through the nutritional values.

3.4.2 The Scientist article

"Epigenetic effects of Mom's Diet" by Emily Willingham

The article was published in April 2014 on the Scientist.com a popular science magazine and is reporting on the above mentioned study. Overall it is summarized with the sub-headline "Molecular markers of a mother's nutrition around the time of conception can be found in her child's DNA", which already introduces the topic with a certain force on the importance of the mother.

Motherhood

"Maternal nutrition around the time of conception can affect the regulatory tagging of her child's DNA from the earliest embryonic stages, according to a study (...)" is the first sentence describing that the focus was on a population of women and children in Gambia. The focus here lies on the earliest embryonic stages. Also the word maternal enhances the importance of the mother versus the father and through this the responsibility of motherhood is directly transported.

One scientist says in the interview that "the real advance of this study" is that the metastable epialleles have been identified.

"Not only does (the variation) occur stochastically and is influenced by maternal nutrition before and during pregnancy, but also it occurs systemically throughout the embryo."

The results show “associations between maternal biomarkers and increased or decreased methylation in infant DNA and that all of the maternal biomarkers together explained about 10% of the variation in these infant DNA methylation patterns.”

What is interesting is that these 10% are not further discussed. It is not clear whether a 10% influence is a strong variation or how many percent of methylation are ‘normal’ according to other results. It seems to me that numbers are again used to build a stronger argument around the results of the research.

Female body

The article then focuses on the Dutch Hunger winter, which included mothers who lived through the Dutch famine in the World War II and their children born during that period (Roseboom et al. 2006, Schulz 2010). This study is described as the first “hints” at a maternal dietary influence. The Dutch Hunger winter is also a problematic case on a social level which is often not anticipated as such. How could the mothers have feed themselves differently when there was nothing else to eat? In this case the female body is a vehicle for the health of the fetus. In the grey-zones between heredity and transmission numerous historical, social and cultural experiences are translated into physiological traces. In this translation epigenetics occurs as a discipline that verifies causalities and promises final explanations (Richter 2015).

According to the co-author Andrew Prentice this study shows something the Dutch Hunger Winter study could not. They “recruited mothers prospectively” and through their focus on metastable epialleles they were able to “identify the critical period when maternal diet has affected this process”. This moment is “either occurring in the mother’s ovary some two weeks prior to conception or within the first two days or so of conception.”

Again the influence is occurring even before conception, however the women are already considered to be mothers.

The co-author also advised women to take folic acid supplements before conceiving to prevent fetal neural tube defects; however he stated that “our results suggest that a cocktail of nutrients in addition to folic acid is needed.”

This is an example of how epigenetic research holds power over future health enhancement. Results from only one study with a group of women, that are not profound enough to be applied on any level to how influence can be positively changed e.g. by vitamins, are used as

health advice for women to influence their bodies before conception. It is also interesting that the researcher states this in the interview but there is no passage similar to this in the original publication. It seems as if results are made more accessible by adding an applied touch which is probably not necessary in the scientific community.

Social structures

“The study extends upon previous reports linking maternal nutrition with epigenetic tagging in both mouse and human offspring.”

Once again the previous animal study is mentioned as it is the only other study performed with these aims.

Another scientist who was not involved in the study was interviewed and was more cautious about the study’s results and any other advice gained from it, noting that a separate replication sample is needed in order to verify the seasonal differences.

To this critique the author prompted that for similar studies with mice “a relatively large phenotypic effect was explained by a rather modest increase in DNA methylation.” It is interesting that studies on animals are not only used as precursors for humans but also for a direct link and justification when studies on humans are criticised. Basically as if animal and human genetics were underlying the exact mechanisms. This again shows how in our society experiments on animal are seen as valid for results for humans.

Women

The distinct rainy or dry season influences the inhabitants’ diets, and thus makes it easy to track their nutrition. Therefore the researcher “sought to determine whether Gambian women’s nutrition at conception affected their infant’s patterns of DNA tags, or methyl groups.” Maternal blood samples were profiled for nutrients linked to methylation and infant hair and blood DNA methylation patterns were observed focusing on metastable epialleles. These are described as “sequences where methyl groups appear to be added randomly, compared with the more-predictable patterning of much of the rest of the genome.” Again the distinction of rainy and dry season is not put into question and ‘easy to track’ is enough argument for such a study.

The authors also conclude that the study replicates a previous study from the research group in a separate population of women in Keneba and they thus “feel very secure that it is a genuine finding.” The question that can be asked is: What is genuine in this context? They have basically only looked at nutrition thus it is not surprising that they found a correlation. It would be more interesting to question their strategy.

3.4.3 BBC article

“Pre-pregnancy diet permanently influences baby’s DNA”

This is a third article published on BBC Online in April 2014. It was written by Helen Biggs.

Already the headline points to a more popularized version of the above mentioned study and a difference from the previous popular article is evident.

Motherhood

“A mother’s diet around the time of conception can permanently influence her baby’s DNA, research suggests.”

The first paragraph starts off with this phrase which immediately describes motherhood as a momentum starting not only long before birth but even before conception. Otherwise it should focus more on the women’s diet influencing conception. Also by using the word ‘permanently’ the study has a sensational aspect.

The last paragraph has the headline “Genes ‘unknown’” starting once again by citing another author who stated that the published results “were a proof in principle that a mother’s diet can have epigenetic effects.”

Following this interview he thinks that the research is showing that a mother’s nutrition can leave permanent marks on her child’s genome and on all the cells of the body.

It can be seen that in comparison with the previous article, describing 10% variation in methylation, for this article the results are permanent and possibly influence all the cells of the

body. Responsibility in motherhood becomes even more connected through this interpretation.

Women

In the study the infants from rainy season conceptions had consistently higher rates of methylation in all six genes that were studied. These were then linked to various levels of nutrients in the mother's blood. Epigenetic research with these women leads to a genetic responsibility that is carried by women. This responsibility over the offspring is a repeating element in this research.

Social structures

The study is described as the first 'human evidence' of previous studies on animals where the diet in pregnancy can 'switch on or off' genes. This simplification even though useful in explaining the process breaks everything down to the pregnant women as the only one responsible for changes in genetic repertoire.

“Experiments in mice show diet during pregnancy can have a life-long impact on the genes of offspring.”

This is explained through 'epigenetic effects' that are described as modifications to DNA that can turn genes on and off such as the process of methylation.

“The research followed women in rural Gambia where seasonal climate leads to big differences in diet between rainy and dry seasons.”

This is a very simple description of the study's objective especially because it is not clear whether there are really 'big differences' between the diets of those seasons. There has not been a complete analysis of the food that the women ate.

Also the article describes that the study emphasizes “the need for a well-balanced diet before conception and in pregnancy.” Again epigenetic results are regarded as a health advice for the future. The lead scientist Dr. Branwen Hennig told BBC News that their results have shown that maternal nutrition pre-conception and early pregnancy is important and may have implications for health outcomes of the next generation.

“Women should have a well-balanced food diet prior to conception and during pregnancy.” Here the scientist does mention women and not mothers as is more logical in this case. The article does not mention epigenetics in the first paragraph but goes into the explanation of the previous assumptions through epigenetics. Thus the most important message in the article is the well-balanced food diet in order to give birth to the healthiest baby.

“But it is not yet known what the genes do, and what effect the process might have.”

By writing this sentence it becomes unclear how the before mentioned importance of these findings of maternal nutrition can be interpreted as advice for pregnant women.

Female body

“Our ultimate goal is to define an optimal diet for mothers-to-be that would prevent defects in the methylation process.”

This sentence is at the end of the article and cites another Co-author of the research. This is the first time the term ‘mother-to-be’ is used in the article. Thus the diet which influences the female body is crucial for epigenetic reasons the moment when women become ‘mothers-to-be’.

3.4.4 Discussion of the case study

The main aspect that is definitely a critique on the article is that the only factor considered was the nutrition. Through this exclusive focus nutrition during pregnancy becomes even more important. Also this implies that there is a ‘right’ and ‘wrong’ way of feeding when one is a pregnant woman. What can a woman do if she cannot feed herself differently at the time of conception? Who is then to blame? These questions result inevitably from my analysis and I find it important to state again that in the article no other background information about the situation of the women is given nor about the authors definition of ‘hungry’ and ‘harvest’ which can be interpreted as ‘right’ or ‘wrong’.

Why are socio-cultural factors not considered in this epigenetic research? It seems as if epigenetics are focusing strongly on several aspects concerning the body (e.g. nutrition)

however not embedded in a wider picture such as the living conditions of the women. There could be many factors responsible counting as ‘environment’ such as social, individual, and political that possibly influence methylation in a certain period of time. Nonetheless in this study only nutrition is considered leading to results of ‘global significance’.

Throughout these articles it seems as if it is especially important to emphasize how women should control themselves and thus their body even before pregnancy. Epigenetic research in this context is more of a bridge or vehicle in order to build this already existing assumption and the female body is to blame. There is a strong moral interpretation behind these arguments. In addition a strong invocation on the behaviour of the mother is proclaimed. In a sense of governability the mother is subject to a strong self control, she is responsible and thus has to optimize her behaviour herself (Foucault 1991). She is not discussed as an actor of a political and agricultural system in which she may have to survive losses such as food inequality. I don’t want to argue that the women of Gambia are victims of the Gambian state but with the situation of the pregnant women this should be questioned in context of participation, agriculture and nutrition.

The sentences “The team enrolled 167 women in a prospective study.” and “Because he and his colleagues recruited mothers prospectively” are passive phrases with respect to the recruited study participants. These lead to the impression that women are merely objects of research and less research partners. “Prentice noted the advice for women to take folic acid supplements...” there is no consideration of the social situation of women in Gambia or the political and agricultural factors of a West African state. Instead the possible nutrients for pregnant women are discussed and supplements that could change those methylation patterns. Who is considering for these women to take vitamins? I would argue that educated researchers in the developed world that are holding the power to impose what is best, not only for pregnant women in Gambia, but based on those for all women around the world. Researchers also control the female body in the epigenetic discourse and it is the female body that is considered as a medical condition.

A constant comparison with animal studies and justification through those can be observed on all 3 types of articles. How much difference on the genetic level is tolerable to still make comparisons like these? On the other hand are not epigenetic studies showing that environment thus also sociology and nurture have a huge effect? However the research still

focuses on these comparisons. If nurture and the social surroundings are important for socially highly developed human beings can these studies be compared so easily?

The word 'offspring' does give the impression that there has to be a biological father as well but he is not considered in the texts. This very exclusion is repeatedly occurring in epigenetic research which may or may not underlie a certain systemic pattern. In the original publication only once the word 'inhabitants' is used in addition to the often used terms 'mothers' and 'Gambian women'. The image is formed that through epigenetic research everything that is connected to child bearing is a woman's responsibility. This aspect is especially interesting as not only the moment of conception which already includes male genetics as well is analysed but also the period before conception. Thus there is an exclusion of men even before conception and motherhood begins prior to conception. It becomes clear that social structures are attached on the bodies as identities. A woman is defined through her body and the pregnant body is defined as a mother.

3.5 Homosexuality

In this final case study the study on epigenetics by William R. Rice is analysed. It is based on the assumption that homosexuality is a consequence of epigenetic mechanisms. Homosexuality has been subject of scientific research in more than decades however a simple and singular determinant for sexual orientation has not been conclusively demonstrated (Frankowski et al. 2004, Långström et al. 2008). In addition to the original scientific publication two popularizations of this article will be analyzed. I read about the original article in the German newspaper DIE ZEIT which interpreted the results through biological theories on sexual orientation. Following this article I searched for the original and looked for other interpretations of this study. The second article is from a popular science site 'Science Daily' and the third is a review article based on these findings on 'the evolutionary puzzle of homosexuality' from the BBC Magazine.

3.5.1 Primary literature

“Homosexuality as a consequence of epigenetically canalized sexual development” Rice et al. 2012

The paper was published in December 2012 in The Quarterly Review of Biology by William R. Rice, Urban Friberg and Sergey Gavrilets.

The article explains at first that the existing genetic models for the evolution of human homosexuality can be separated into two major classes. One is based on kin selection (Wilson 1975) and the other on sexually antagonistic alleles and/or over dominance (Camperio-Ciani et al. 2004, 2008; Gavrilets and Rice 2006, Rice et al. 2012). An importance in these models is that they are all based on special cases of selection that directly, or indirectly, maintain genetic variation at loci contributing to the homosexual phenotype. Even though numerous studies over the last decade have focused on polymorphisms associated with homosexuality, no convincing molecular genetic evidence has been found despite the fact that pedigree and twin studies show that homosexuality is familial (Ngun et al. 2011, Rice et al. 2012). Another hypothesis is that homosexuality is caused by non-genetic factors such as maternal antibodies against male-specific antigens (Bogaert and Skorska 2011). According to the authors this could be the explanation for some “cases of homosexuality” but not for all (Rice et al 2012).

Given these different stances a new conceptual framework to understand the evolution of homosexuality is asked for. In their paper the authors integrate theory from evolutionary genetics with recent developments in the regulation of gene expression and 50 years of research on androgen-dependent sexual development.

Hormonal influences of androgen in fetal stages, specifically testosterone, cause feminine qualities in regard to sexual development in females and masculine qualities in males. According to this observation during sexual development, females are exposed to minimal amounts of testosterone, thus feminizing their sexual development, while males are typically exposed to high levels of testosterone, which masculinize their development (Rice et al. 2012).

They argue that the existing paradigm of mammalian sexual development is incomplete, with the missing component being a system to canalize androgen signalling during fetal development (Rice et al. 2012).

In their study they integrate data with the recent findings from the epigenetic control of gene expression, especially in embryonic stem cells, to develop and empirically support a mathematical model of epigenetic-based canalization of sexual development. The model predicts the evolution of homosexuality in both sexes when canalizing epi-marks carryover across generations with nonzero probability (Rice et al. 2012).

They use the term epi-marks to describe changes in chromatin structure that influence the transcription rate of genes, including nucleosome repositioning, DNA methylation and/or modification of histone tails, but not including changes in DNA sequence (Rice et al. 2012).

Sexuality

“The common occurrence of homosexuality is perplexing from an evolutionary perspective. Simple logic suggests that a fitness-reducing phenotype should be selected against, but homosexuality is nonetheless surprisingly common in human populations.”

With this introductory statement it becomes clear that from the point of the researchers they are observing homosexuality from a scientific perspective and that this is seen as being out of the heterosexual norm. Also the definition of ‘simple logic’ that would suggest that it should be selected against is defined from the researchers ‘simple logic’.

“Our study examines the ramifications of transgenerational epigenetic inheritance to the phenomenon of human homosexuality.”

Homosexuality is described as a ‘phenomenon’ something that can be observed and studied and that typically is unusual or difficult to understand or fully explained. The definition as a phenomenon strengthens the assumption that it is not within the societal norm.

“By homosexuality we mean any same-sex partner preferences, spanning all Kinsey scores >0 (e.g., including bisexuality). Our model of homosexuality may also apply to transsexualism, but we do not develop this application here.”

Kinsey scores are a metric attempt to classify homosexuality in scores from 0-6, 0 meaning fully heterosexual and 6 fully homosexual (Kinsey et al. 1948). Thus homosexuality includes bisexuality and even transsexualisms. Sexuality is put in scores and defined thereafter, these are strict boundaries and the sole focus is on these scores. This implies that homosexuality is

influenced by only biology or defined from the body, as social development is not at all considered in this definition.

“...our model and its predictions are consistent with the major empirical patterns associated with male and female homosexuality and other common gonad-trait discordances.”

It is important to state that the research is solely based on a model thus it is basically generating a hypotheses based on mathematics. It is interesting that the researchers managed to integrate these ‘major empirical patterns’ that are apparently associated with male and female homosexuality as these patterns are not described in any detail.

Social structures

“Epigenetics is a relatively new subdiscipline in genetics and its importance in evolution, especially as a major contributor to realize heritability, is currently being developed and debated (Slatkin 2009, Furrow et al. 2011).”

Describing epigenetics as a new discipline is a powerful instrument especially when put in context with its importance in evolution. The authors state that this is under debate however the description of a ‘major contributor to realize heritability’ strengthens the important focus on epigenetics. Not only are epigenetics mentioned as a novelty, the potential of a realization of heritability is forced onto this field.

In the article the mechanisms of canalization are described as “occurring when a developmental endpoint is reached despite environmental interference that can potentially disrupt it (Waddington 1942).” This is only one of many descriptions that seem to operate on a simply directional level. I would argue that this is also how our society perceives life sciences as it is taught this way in school. In this way processes always seem to have and need a cause and effect relation.

The study focuses further on the so-called epi-marks and the heritability of those.

“A consequence of epi-marks being laid down at the stem cell stage of development (...) is that such epi-marks have the potential to be transmitted across generations, but only when the cycle of epi-mark erasure and renewal, within and between generations, is somehow

circumvented. Studies in both mice and humans clearly demonstrate that transgenerational inheritance of epi-marks occurs at nontrivial rates.”

There is a strong homogenization and mechanization in ‘erasure and renewal, within and between generations’. Broken down to this simple mechanistic understanding it seems as if these processes always occur in the same way.

“In this case, epi-marks that sometimes carryover across generations would contribute to the causation of homosexuality and its observed heritability while de novo epi-marks produced independently in each monozygotic twin would account for the low observed concordance for homosexuality between monozygotic twins.”

This is the most important message that the results of the study depicts. In the passage epi-marks are described as the final missing link in order to explain the ‘causation of homosexuality and its observed heritability’. In addition, two crucial processes in this theory are described, transgenerational inheritance of an epi-mark and its penetrance once inherited (Rice et al. 2012). Here again it becomes visible that the ‘causation of homosexuality’, if even existing, is simplified in order to explain it by putting it in a scientific order and by describing these processes through several seemingly logical steps. What is lacking is the observation from more than only a biological point of view. I think that this represents a common occurrence in our society to search for these causations when something is out of the ordinary ‘norm’. This is probably due to the fear of difference.

“Here we provide evidence that the prenatal androgen paradigm is missing a major component. This conclusion is based on our reanalysis of studies of circulating prenatal androgens in human and rat fetuses.”

The conclusion that the prenatal androgen paradigm is missing a component is based on a reanalysis of human and rat fetuses. It seems as if this is a logic conclusion however far rats and humans may be in terms of social upbringing.

“Studies with rhesus monkeys clearly demonstrate that sex-specific behaviour and the genitals can be masculinised or feminized during different gestational time periods.”

This is another example how studies on animals can ‘clearly’ demonstrate how sex-specific behaviour can be modified and why this needs to be studied in humans. Additionally the terms masculinised and feminized taken as traits that are easily described even though it is

known that there are several characteristics influencing the biological sex thus using masculinised and feminized is simplifying to the existing dichotomy.

Female body

“Nonetheless, there is now clear evidence that environmentally induced epigenetic modifications of genes expressed in male mice (e.g. DNA methylation, Franklin et al. 2010) that feminize their brains and behaviour can be transgenerationally inherited by their offspring (Morgan and Bale 2011).”

This ‘feminization of the brains’ that is not explained in detail occurs in male mice and is then transgenerationally inherited by their offspring. According to this statement the research is based on the assumption that there are strict definitions of a male and a female brain thus male mice brains are feminized. Through these assumptions a biological determination for the differentiation in gendered brains is imposed. There is a difference in describing a result as comparison to non-environmentally induced epigenetics than to describe difference as ‘feminized’ without characterizing these traits.

“...a long succession of studies have consistently and unambiguously demonstrated that sexual dimorphisms of the genitalia and brain of mammals are strongly influenced by androgen exposure during fetal development. The foundation for this conclusion is that XY fetuses experimentally exposed to androgen antagonists during gestation develop feminized genitalia, brains, and behaviour, whereas XX fetuses exposed to elevated androgens develop masculinized phenotypes for these same traits.”

According to the authors the fetal development seems to be the crucial point in the influence of epi-marks. This is strongly linked to the female body as is it the environment around the fetal development. Furthermore the description of feminized genitalia, brains and behaviour in mammals is problematic. The authors state that this is simply mediated through these ‘androgen antagonists’ and that it depends on the chromosomes in which phenotype this will lead. These traits are not described in detail and neither is it explained how feminized or masculinised behaviour was observed.

“From these examples it is clear that the substantial prevalence of homosexuality (...) is not unusual for a phenotype strongly influenced by fetal androgen exposure.”

The subject of fetal-androgen signalling seems to be one of the most important factors in the heredity of homosexuality and this emphasizes the importance of *in utero* processes.

“Many environmental agents can potentially reduce androgen signalling and these could episodically affect some periods of fetal development and not others.”

The study is based on existing data incorporated into a mathematical model. The researchers have not performed any other study themselves and by solely claiming that ‘many environmental agents’ are responsible the focus is shifting from inheritance to exposures during the fetal development. Also it is not clear how these different periods of fetal development are meant. This only enhances the responsibility on the female body that through these claims is also the space in which sexuality can be modified.

Motherhood

“In aggregate, these studies are consistent with an SA-epi-mark causation of homosexuality because they indicate that homosexual men have more fecund mothers and/or female relatives on the maternal, paternal, or both sides of the family.”

Such sex-specific epi-marks are sexually antagonistic (SA-epi-marks) because they canalize sexual development in the parent that produced them, but contribute to gonad-trait discordances in opposite-sex offspring when not erased (Rice et al. 2012).

By foremost mentioning that ‘homosexual men have more fecund mothers’ after then claiming that other relatives are responsible as well a simple explanation is provided through fertility. Additionally a certain implicit message is transported with these results that homosexuality is based on several factors in fetal development, thus the female body, in combination with the fertility of the mother.

Women

“It may be feasible to readily test the second prediction with current technology in the case of female homosexuality. Our hypothesis predicts that differences will be found when comparing the genome-wide epigenetic profiles of sperm from fathers with and without homosexual daughters.”

Female sexuality seems to be more complex and even less understood than male homosexuality according to the current state of research. In addition in the study female sexuality seems to be less important as the focus is in explaining male sexuality. Even though processes associated with fetal androgen signalling are occurring for both sexes women's sexuality is problematic.

3.5.2 The Scientist article

“Epigenetics may underlie homosexuality, study finds”

This article was published online in December 2012 on Science Daily. A citation to the original article is given and no author mentioned.

“Is homosexuality genetic? It's a long running debate.” This question introduces to the topic mentioning the study that “found a clue that may unlock the mystery.” This clue seems to be epigenetic research. The article mentions that the researchers used mathematical modelling and observed that the transmission of sex-specific epi-marks may signal homosexuality.

Sexuality

The co-author Sergey Gavrilets is interviewed noting that the occurrence of homosexuality in families leads most researchers to believe that there is a genetic underpinning of sexual preference. Despite this no major gene for homosexuality has been found even though numerous studies have tried to find a genetic connection.

“Epi-marks may be the trigger they've been searching for.”

A trigger is something that can cause the start of a reaction or be the missing element to this start. Epi-marks are thus seen as in the original publication as the last missing link in this so-called ‘mystery’ of homosexuality. In popular media the definition of these as a trigger is important as it describes how homosexuality in the public space needs to be explained through a biological meaning.

The article explains that the researchers used evolutionary theory with the recent advances in molecular regulation of gene expression to “produce a biological and mathematical model that

delineates the role of epigenetics in homosexuality.” This role of epigenetics is important as it is seen as the missing link even though other missing links such as social upbringing are not at all discussed when mentioning sexuality.

“The study solves the evolutionary riddle of homosexuality, finding that ‘sexually antagonistic’ epi-marks, which normally protect parents from natural variation in sex hormone levels during fetal development, sometimes carry over across generations and cause homosexuality in opposite-sex offspring.”

In the popular media article homosexuality is not differentiated for male and females however the results from the Rice et al. paper are only for male homosexuality. The description of ‘solving the evolutionary riddle’ further strengthens the view that homosexuality is a phenomenon that needs to be explained. In addition epi-marks are simply described as ‘normally protecting’ parents and that these can cause ‘causing homosexuality’. These terms clearly demonstrate that homosexuality is seen as something out of the ‘norm’ and apparently caused by a process that ‘normally’ should not occur.

“Transmission of sexually antagonistic epi-marks between generations is the most plausible evolutionary mechanism of the phenomenon of human homosexuality.”

In conclusion the article as well as the original paper seeks to explain the ‘phenomenon of human homosexuality’ through evolution as this seems to be of importance because of its definition as a ‘mystery’.

Social structures

“According to the study, published online today in The Quarterly Review of Biology, sex-specific epimarks, which are “erased” and thus normally do not pass between generations, can lead to homosexuality when they escape erasure and are transmitted from father to daughter or mother to son”.

There is strong implicit meaning in erased thus when they ‘escape’ erasure, this leads to homosexuality. Erasure in this case is seen as the normality.

“Epi-marks constitute an extra layer of information attached to our genes’ backbones that regulates their expression. While genes hold the instructions, epi-marks direct how those

instructions are carried out. They are usually produced anew each generation, but recent evidence demonstrates that they sometimes carry over between generations.”

I would argue that this is as before a simplistic version of how genetic processes are described in our society and how science is often represented. It becomes clear that epigenetics are used as the next way of determining processes that could not be explained by genes only. Genes are ‘holding the instructions’ and it is important to highlight this as the entities we call genes do not act and do not have agency. Thus epi-marks are the new powerful research tool as these seem to be able to ‘direct these instructions’ although the principle is the same as epi-marks also do not act. It is only through the description of genes and epi-marks that images of ‘active’ and ‘self-directed’ are constructed.

Female body

“Sex-specific epi-marks produced in early fetal development protect each sex from substantial natural variation in testosterone that occurs during later fetal development. Different epi-marks protect different sex-specific traits from being masculinised or feminized.”

The use of ‘protect’ in these cases raises the question: Protecting from what? And also who is protecting whom? The fetal development is of importance such as in the original publication even though here it seems as if there is a difference in the early and later stages. These processes are strongly linked to the female body that implicitly holds the power to protect other processes from happening. In this article the environmental influences are not mentioned.

Women

According to the article the researchers found that homosexuality can occur in opposite-sex offspring when the sex-specific epi-marks are carried on to another generation.

“We discovered when these epi-marks are transmitted across generations from father to daughters or mothers to sons, they may cause reversed effects, such as the feminization of some traits in sons, such as sexual preference, and similarly a partial masculinisation of daughters.” said Gavrillets.

By mentioning a ‘feminization of some traits in sons’ and the sexual preference it is not clear whether these are connected. If so why does a feminization also contribute to the sexual preference? Additionally this process does not occur in the same way for daughters but a ‘partial masculinisation’ takes place. A clear differentiation is visible between descriptions of sexuality for men and women.

3.5.3 BBC article

“The evolutionary puzzle of homosexuality” by William Kremer.

The article was published online on BBC News Magazine on the 8th of February 2014. It is not only about the study Rice et al. but it reviews several aspects of explanations of homosexuality.

Social structures

“In the last two decades, dozens of scientific papers have been published on the biological origins of homosexuality – another announcement was made last week. It’s becoming scientific orthodoxy. But how does this fit with Darwin’s theory of evolution?”

In describing homosexuality as scientific orthodoxy and putting this into question with Darwin’s theory of evolution a common societal phenomenon can be observed. Despite the success that Darwin’s theory has had since its publication 1859 several aspects are not yet completely understood. However in the public space through education, the general perception is that any process based on inheritance needs to be completely verified by the concept of the theory of evolution. This may be an important position nonetheless it should not hold this power in the contemporary scientific discourse.

Sexuality

“Since the early 1960 researchers have shown that homosexuality is more common in brothers and relatives on the same maternal line, and a genetic factor is taken to be the cause. Also relevant – although in no way proof – is research identifying physical

differences in the brains of adult straight and gay people, and a dizzying array of homosexual behaviour in animals.”

In this popular article the genetic factor is mentioned but the lack of results over the past decade for this assumption is left out. Looking for differences in brains is as well controversial as it has become clear that brain research has been biased for claiming differences in male and female brains even though these can often be neglected. Furthermore the occurrence of homosexuality in animals is pointed out in order to ‘normalize’ it. In this case the comparison to animals comes out of an attempt to contextualize it in ‘nature’.

“But since gay and lesbian people have fewer children than straight people, a problem arises.”

The authors asks how a trait like male homosexuality, which has a genetic component, persist over evolutionary time if the individuals that carry the genes associated with that trait are not reproducing. This is also described as the ‘Darwinian puzzle’.

According to the article in the US about 37% of lesbian, gay, bisexual and transsexual people have a child and about 60% of these are biological.

“These figures may not be high enough to sustain genetic traits specific to this group but the evolutionary biologist Jeremy Yoder points out that for much of modern history gay people haven’t been living openly gay lives. Compelled by society to enter marriages and have children, their reproduction rates may have been higher than they are now.”

In this popular media article the subject of homosexuality is described in context of society thus not purely on the biological level. It is interesting that although both articles before focus on heredity this aspect of genetic transmission and reproduction was not mentioned especially when the original paper used statistical analysis.

Women

“Most of the theories relate to research on male homosexuality. The evolution of lesbianism is relatively understudied – it may work in a similar way or be completely different.”

In this case female sexuality is mentioned as a different subject of research and this is the only article that states that most of the research is on male homosexuality. Why female homosexuality is less researched than male homosexuality is not clear through these studies.

“We know that women tend to like more feminine behavioural features and facial features in their men, and that might be associated with things like good parenting skills or greater empathy.”

These are generalizing assumption about what women search for in men. It is not mentioned which representative sample is taken to ground these statements. Furthermore the term ‘good parenting’ is mentioned for the first time in this context and points to classical gender stereotypes about male and female characteristics. When a review on homosexuality is written from this sort of perspective it is likely that classical assumptions on male and female behaviour are transported.

“Rice believes that female fetuses employ an epimark that makes them less sensitive to testosterone. Usually it’s not inherited, but occasionally it is, leading to same-sex preferences in boys.”

This result is not described in this way in the original publication. It is basically the same as before as it concerns the un-erased epi-marks. It is interesting how it is the female fetuses that are sensitive to testosterone and in inheritance can then cause same-sex preferences in boys.

Motherhood

“Andrea Camperio-Ciani, at the University of Padova Italy, found that maternal female relatives of gay men have more children than maternal female relatives of straight men. The implication is that there is an unknown mechanism in the X chromosome of men’s genetic code which helps women in the family to have more babies, but can lead to homosexuality in men.”

This is another way of describing the mother’s responsibility in the homosexuality discourse as it seems to be connected with the mother’s fertility. An implicit meaning of this is that women who have more babies risk homosexuality in sons. I am using the term ‘risk’ as I think that this is how the statement can be interpreted. With this risk the mother can be held responsible in cases of homosexuality.

Female body

In the paragraph ‘It’s not all in the DNA’ the importance of “other, naturally varying biological factors” is described.

“Exposure to unusual levels of hormone before birth can also affect sexuality. For example female fetuses exposed to higher levels of testosterone before birth show higher rates of lesbianism later on.”

The importance of the female body and the early stages of development are also mentioned in the final article as it seems to be crucial. The focus is strongly on processes *in utero*.

3.5.4 Discussion of the case study

Even though the study of Rice et al. (2012) mentions the lack of results for a ‘gay gene’ it is hard to understand how their results on epi-marks should be able to solve this so-called ‘mystery’. Furthermore it is important to state once more that their study is based on a mathematical model. The idea of heritable traits due to results from studies on twins and brothers could have other explanations as well. For examples it could be easier for a child to identify with its homosexuality when there is already a child in the family that has done so. Social stigmata are still highly pervasive on homosexuality. This would of course cause for an observation of society and its discriminations or alternative appreciations of sexuality and how this influences humans. However these aspects have not been subjects of research.

Additionally by searching for hereditary explanations, homosexuality is implicitly described as not ‘natural’ such as other diseases that are associated with epigenetic research.

In the BBC article Dr. William Byne, Director of the Laboratory of Neuroanatomy and Morphometrics at Mount Sinai School of Medicine, notes that the heritability of homosexuality is similar to that for divorce but “social science researchers have not searched for ‘divorce genes’. Instead they have focused on heritable personality and temperamental traits that might influence the likelihood of divorce.”

This statement brings the debate of heritability of homosexuality to a precise point and demonstrates how this discourse is treated differently.

Through this study and the constant context of evolution the question is why heterosexuality is defined as advantageous in evolutionary terms to homosexuality and why the research does not involve a different approach towards heterosexuality as well. Why does homosexuality need to be defined by genes or epigenetics and heterosexuality remains unquestioned through its ‘natural’ occurrence and reproductive legitimation?

The problematic of the Kinsey scores is also of importance. When is a person homosexual? The Kinsey test is based on decisions in biology and medicine that are correlated with how often a person engages in homosexual actions and their frequency. The idea of Rice et al. that this frequency of actions has a biological basis seems to be more prevalent than the possibility of a personal decision. The study of Rice et al. is only an interpreted connection between epigenetics and homosexuality based on theoretical reflection rather than an empirical hypothesis. Androgens are hormones that can alter the sexual phenotype. The meaning of androgens on an epigenetic basis concerning homosexuality is presupposed even though there are no clear results on this debate which are not criticised in the scientific community (Voß 2013). Furthermore the focus on fetal androgen signalling clearly enhances the role of the female body in this context. It is through *in utero* processes and the early fetal environment that these epi-marks are described.

I would like to argue that in the debate about sexuality the field of epigenetics is constructed as novel to further strengthen biologic and deterministic views. This can be seen through the above mentioned description of genes and epi-marks as self-directed entities.

“Just as epigenetics is a probable etiological agent (...) so too is it a probable agent contributing to homosexuality.” (Rice et al. 2012)

In defining epigenetics as an etiological agent, thus an agent that can give reason to a certain process, a powerful mechanism is described in epigenetics. In order to talk about epigenetics we need to talk about a cellular matrix and DNA thus the search of an etiology through only one aspect of a cellular complex is simplifying these mechanisms to the most possible.

Finally what is also visible through this research is how studies on homosexuality are mostly focused on male sexuality and a social dichotomy is reproduced. Can it be that male homosexuality holds a different kind of role in our society? It is not clear why this is the case and if female homosexuality is, as stated in the article, more complex or simply no knowledge about it is available.

4 Conclusion

The main question I was addressing in my thesis was how scientific literature is used in popular media and how scientific facts are popularized.

Throughout the analysis the succession of scientific knowledge in the realm of popular media was observed. Mechanisms such as the simplification of scientific facts or the exclusion of results are often practised. Often results are described in a sensational way in order to attract readers even though the science itself does not precisely explain the claims. For example, when out of one gene in the original publication, many genes are described in the popular article (case study on giving birth). Through popularization scientific facts are depicted in a reductive and homogenizing way and are categorized according to existing norms of motherhood and giving birth, in order to simplify these further. In the case studies this can be well observed when for example, The Guardian article on the World Trade Centre attack starts with the headline on how mothers transmitted the tragic events to their babies. This is a simplified statement, as found in the case study on nutrition when, in the title, “Epigenetic effects of mom’s diet” are concerned. This is taken out of the context of the original study as the pregnant women’s diet in Gambia cannot be homogenized in a general description of ‘mom’s diet’. This is problematic when the impact of popular media is concerned. Additionally in the case studies it is visible how through simple phrasing of results in popular media, a completely different meaning can be ascribed to the original results. When, for example, to the results of epigenetic effects the word ‘permanently’ is added in the case study on nutrition, this changes the consequences of the report in the media. This is dangerous, as it evokes the image that epigenetic research leads directly to health advice which was the case in the results on nutrition, prenatal stress and giving birth. These results should be concerned with caution in order to avoid such claims in popular media. Furthermore, the attempt to generate ‘truth’ through these claims should be avoided. The discussion of scientific facts in the public sphere through popular media targets the question of objectivity, which is also embedded in the epigenetic discourse. Several claims have been made in the case studies imposing a scientific objectivity. One particular case was the separation of ‘subjective’ and ‘objective’ stress in the ‘Ice Storm Project’ study. The problem with these concepts is that the researchers do not define their descriptions. In order to explain subjective or objective the authors would need to work on their own perception of these terms. Although this was heavily

criticised by feminist scholars (Haraway 1988, Harding 1991), objectivity still remains to be important in life sciences. In comparison of scientific and popular media throughout the case studies the transmission of scientific facts could be observed. The generalization of results to a kind of advice was observed as a popular mechanism. These statements are then discussed in popular media by the researchers, as could be seen in the case of nutrition. Through popular media the results are transmitted back to those who performed the research, thus the public sphere can have an impact on the scientific knowledge production and should not be neglected (Felt et al. 1995). Since the gap between science and the social surrounding is increasing, the transmission and translation of science should be intensified (Weingart 2003). Especially when the media coverage on epigenetic research can shape future research through the discourse that evolves in the public sphere.

Through the categories that I established before the analysis I tried to extract the elements that are repeatedly found in the scientific literature and popularized in the media. Female bodies, women and motherhood are prevalent in this work on epigenetic research. The explanation of sexuality was also a research focus in all of the case studies.

A major focus of this work was the description of female bodies, women and motherhood through epigenetic research. When the prenatal period is described as crucial for ‘epigenetic programming’, the concept of motherhood is defined before birth and, in the case study on nutrition, even before conception. Additionally by explaining certain aspects of epigenetics through ‘the womb’ thus through the female body these are simplified on a purely biological level. It became visible that through epigenetic research the ‘natural’ belief of childbirth is enhanced through results on negative aspects of Caesarean sections. Through the category of the female body it was possible to identify the biological determinism that is reconfirmed in epigenetic research. The measure of a babies’ weight and the comparison to certain norms such as shown in the case studies on PTSD and nutrition can be connected to what Michel Foucault defined as ‘biopolitics or biopower’. Behind these politics lies a control apparatus exerted over a population as a whole (Foucault 1997). Examples for biopolitics are the ratio of births to deaths, the rate of reproduction, the fertility of a population that are always attached to the body and in the case of this epigenetic research the female body (Foucault 1997). The regulation of the female body is emphasized in these studies. Michel Foucault developed his thoughts on biopolitics when the progress in genetics was just about to set off. However, the current developments are still part of the biopolitical context that Foucault drew attention to, but in the current debate the focus has shifted from the population to the individual and

his/her own responsibility. The change comes in the way the body is visualized and acted upon. The form of the body as a “whole” is about to change as was predicted by the move into the age of “molecular biopolitics/biopower” (Rose 2007) performed on the individual in accordance to maximize life and health. This molecular biopolitics can be observed in the case studies in the category of the female body and its importance in epigenetic expression. The focus is only on *in utero* processes which seem to be crucial as they can minimize health in the offspring and thus research aims at female body in order to prevent these health problems in future life (case study of nutrition, giving birth, prenatal stress and post-traumatic stress).

Through the category of ‘women’ statements were extracted to show how and if women are differentiated from mothers and from men. It was observed that men are excluded in these epigenetic researches as they are mostly not mentioned when the studies concern the future of the child. Even though the maternal phenotype has substantially greater capacity to shape the offspring’s phenotype, through the processes of pregnancy and lactation, this does not fully explain the neglect of research on parental effects in this field. This lack of men can be observed in most of the studies concerning pregnancy contributing to existing societal norms. In her analysis on the science and politics of male reproduction political scientist Cynthia Daniels notes:

“Despite evidence that paternal behaviours and life experience such as the use of alcohol, smoking and pesticide exposure can impact the health of offspring from conception, scientific research and public health interventions on fetal harm consistently focus on the mother and minimize paternal effects.” (Daniels 2006)

This asymmetry in epigenetic research originates in longstanding Western culture and ideological convictions (McMahon 1995). This includes, on the one hand, a belief in the vulnerability of female bodies and the primary liability of the mother for infant care and development, and on the other, a resistance to notions of male reproductive vulnerability and to paternal responsibility for the development of embryos and infants (Richardson 2014).

The categories of women and motherhood are strongly connected to responsibility. Throughout the articles this responsibility is implicitly transported through the ‘maternal diet’ or the ‘maternal stress’ and this is problematic in terms of blame. In a short article on the problematic of epigenetic research Sarah S. Richardson claimed that scientist should be

careful not to “blame the mothers” (Richardson et al. 2014). A mother’s individual influence over a vulnerable fetus is often emphasized in this field while the role of societal factors is not at all emphasized, which was also demonstrated in the case studies. The behaviour of the mother has ever since been discussed as crucial in the development of the child, however through epigenetic studies women are even more the focus of critique connected to their bodies (Phoenix & Woollett 1991; MacMahon 1995). Epigenetics are a further vehicle to strengthen stereotypic views of motherhood and a woman’s responsibility when conceiving and giving birth to a child is shifted to a ‘new’ genetic level. The blame that is transported is not put into question. For example in the case studies on prenatal stress and post-traumatic stress the circumstances for the pregnant women could not have been altered as these were sudden catastrophic events. Thus the question arises of how these women could have ‘protected’ their children from environmental epigenetics if this is at all the aim of the researchers? It is obvious that these sorts of observations were not part of the studies. The same holds true for results on the case study on nutrition which did not at all emphasize the women’s situation in Gambia but only focused on the nutrition as the only factor of influence.

Sexuality was observed to be less important as category in epigenetic research concerning pregnancy even though conception was a major focus. This can be connected again to the category of women and the exclusion of men. Epigenetic research thus starts off from the female body. Even when homosexuality is concerned these processes are tracked back to the mother. Through the analysis, it became clear that, in the case of homosexuality, male homosexuality is more researched than female homosexuality. The researchers used an explanation of higher complexity or simply the lack of knowledge when concerning female homosexuality. However by highlighting the dominance of epigenetic research in male homosexuality the dichotomy of gender is reproduced by epigenetics and homosexuality.

Another important aspect that can be observed in all of the studies is the transmission and generalization from animal studies to human studies. From a strictly biological or genetic site this might not seem as problematic as rats and monkeys can be associated with the human genome. Researchers reported that, at approximately 2.75 billion base pairs, the rat genome is smaller than the human genome, which is 2.9 billion base pairs, and slightly larger than mouse genome, which is at 2.6 billion base pairs. However, they also found that the rat genome contains about the same number of genes as the human and mouse genomes (Gibbs et

al. 2004). Even if the differences might not seem as significant these are still distinct species. When talking about an environmental factor like stress, which is already hard to define, it is challenging to use animal studies as explanations for human studies. Furthermore, as can be seen in the behaviour of rat mothers to their pups classical societal norms are only reproduced through epigenetic mechanisms in animals (Weaver et al. 2004). This is a crucial point in life science research concerning animal studies that should be considered in the future interpretation of epigenetic results.

In the context of the nature versus nurture debate the question was whether the post-genomic research field of epigenetics truly offers an appreciation of complexity to the alternative old, deterministic explanatory paradigms of genetics as Evelyn Fox-Keller proposed (Keller 2010). Grey-zones between heredity and transmission are visible and numerous historical, social and cultural experiences are translated into physiological traces. In this translation epigenetics occurs as a discipline that verifies causalities and promises final explanations (Richter 2015). The case studies on epigenetics demonstrate that it is impossible to understand biology outside the context of the environment. Through certain statements such as ‘etiological agent’ in the study on homosexuality, epigenetics are described as a vehicle that carries a precise purpose.

“By themselves the entities we call genes do not act, they do not have agency. Strictly speaking, the very notion of a gene as an autonomous element, as an entity that exists in its own right is a fiction. In order for a sequence of nucleotides to become what is conventionally called a gene, requires that the sequence be embedded in a cellular complex that not only reads, translates and interprets that sequence, but also defines it, giving it its very meaning.” - Evelyn Fox-Keller (2010)

The same observation holds true for epigenetics even though as described before agency is connected to epi-marks (Rice et al. 2012). Therefore claims that used to be underlined by genes are in a new way attached to epigenetics. This is a powerful reinforcement of existing purely biological understandings rather than the ‘key’, as often claimed in epigenetic research, to solve these. It is important to emphasize that genes are neither unchangeable nor inevitable. The results from epigenetics may show a predisposition through methylation of DNA however this does not represent a predetermination of these. In the epigenetic discourse the focus is strongly on transgenerational effects and several studies have emphasized this (for example case study on PTSD, prenatal-stress). In the popular media the ‘permanent’ changes

were observed as well (BBC article on maternal diet). It seems as if the reversible effect of epigenetics is not as important as it does not hold as much power of novelty as the connection to a disease. Although this debate on the power of genes is not a new one, it is reproduced in epigenetic research showing further that the construction of it as a novel field is only shifting the attention from classical genetics. In situating epigenetics as a form of biomedical novelty, claims-makers must overcome the regularly expressed doubts of their colleagues who argue that it is simply a variant of established research on gene expression (Niewöhner 2011, Pickersgill et al. 2014). Through the description of the results in popular media the actuality of the topic is also enhanced. In the debate on nature versus nurture in this work epigenetics tend to fall into the old, deterministic explanatory paradigms of genetics rather than to cope with the complexity of the environment as a reduction of social factors is taking place.

In context of epigenetic research motherhood represents gender as an analytical frame for examining epigenetics. Gender analysis of science, however, offers insights that extend beyond investigation of the consequences of scientific research for women. By attending to the production of embodied differences, gender analysis can help to reveal theoretical shifts instantiated in the postgenomic age and not apparent through standard analytical frames (Richardson 2014). Gender is highly differentiated in parenting as the concept of motherhood is associated with the female sex based on the social dichotomy. The studies were thus based on this dichotomy. Factors such as paternal contribution, family life and social environment receive less attention in the epigenetic research. Epigenetic science merely reproduces and subtly reformulates determinist strategies and reductive methods of life science research. Additionally epigenetic explanations combine elements of deterministic or anti-deterministic frameworks in ways that transcend received conceptual dichotomies (Niewöhner et al. 2011).

These observations call for a new analytic approach on epigenetics. Future studies should also recognizing that fathers and grandparents also affect descendant's health when heredity is concerned. Eventually, scientists and educators should anticipate how this work is likely to be interpreted in popular discussion as this is influencing the production of scientific knowledge as well, which should generally not be from only a partial perspective but focus on as many perspectives as possible.

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6 Abstract

This thesis performs a content analysis based on five case studies in the field of epigenetics, each within a different area of research. The case studies reviewed cover the following topics: (1) the process of giving birth, (2) post-traumatic stress disorder, (3) prenatal stress, (4) nutrition, and (5) homosexuality. Scientific literature and popular media articles were critically analysed based on the categories of motherhood, women, the female body, sexuality and social structures.

The field of epigenetics has been described as the study of how exogenous factors contribute to genetic expression. These modifications do not take place in the genome, but rather on various levels above it, and thus the DNA sequence is not changed. Epigenetics has, in recent years, received much attention in the field of molecular biology, as well as in the wider scientific community and in popular media. The social implications of environmental epigenetics- the part of the epigenetics study that concerns itself with how environmental factors can cause changes in the genome- has grown in prominence within the wider discourse. Such studies focus on potential (epigenetically-determined) health consequences.

In the analysis for this thesis it became clear that the concept of motherhood is, especially, re-established by epigenetic research. This is strongly linked to the female body. An almost complete exclusion of the role of men was observed, even in studies concerning conception. Additionally conception was rarely connected to sexuality. In these studies epigenetics was also seen as the “missing link” for biological explanations of homosexuality. Interestingly, homosexuality among males was specifically highlighted in this case study, as homosexuality among females appears to be subject to more complex mechanisms.

The analysis demonstrates that it is impossible to understand biology without accounting for environmental influences. Furthermore, the analysis shows that epigenetic research often neglected to depict the role of the father, family life and the social environment; the focus within the body of literature reviewed is primarily aimed at the mother and the female body.

In biology itself, the mechanisms of epigenetics are not yet fully understood. Thus the question arises: how should such research results be used by both scientists, and the popular media? Different perceptions of epigenetic research can have controversial consequences, especially in the public sphere.

7 Deutsche Zusammenfassung

In dieser Masterarbeit wurde anhand von 5 Fallstudien im Bereich der epigenetischen Forschung eine Inhaltsanalyse durchgeführt. Die Thematiken der Fallstudien waren: Die Geburt, Posttraumatischer Stress, Pränataler Stress, Ernährung und Homosexualität. Anhand der Kategorien Mutterschaft, Frauen, der weibliche Körper, Sexualität und vorherrschende soziale Strukturen wurden wissenschaftliche und populärwissenschaftliche Texte kritisch behandelt. Die Popularisierung von wissenschaftlichen Ergebnissen wurde herausgearbeitet und zu der originalen Primärliteratur verglichen.

Die Epigenetik befasst sich mit der Frage, welche Faktoren die Aktivität eines Gens und damit die Entwicklung der Zelle (dauerhaft) festlegen und ob bestimmte Festlegungen an die Folgegeneration vererbt werden. Grundlage sind Veränderungen an den Chromosomen, wodurch Abschnitte oder ganze Chromosomen in ihrer Aktivität beeinflusst werden. Man spricht auch von epigenetischer Veränderung bzw. epigenetischer Prägung. Die DNA-Sequenz wird dabei jedoch nicht verändert. In der molekularen Biologie hat Epigenetik in den vergangenen Jahren sehr viel Aufmerksamkeit auf sich gezogen und zwar nicht nur auf biologischer Ebene, sondern auch in der weiteren Wissenschaftsgesellschaft sowie in popularisierenden Medien. Durch kontroverse Ansichten und Diskurse wurde ein sehr heterogenes Bild von Epigenetik geschaffen. Epigenetik wurde durch diverse Medien sowohl als ein weiterer Aspekt der Genregulation gesehen als auch als ein Paradigmenwechsel in der Entwicklungsbiologie.

Beachtenswert ist in diesem Bezug die soziale Implikation von Umwelt-Epigenetik, der Teil der Epigenetik der sich mit Umwelteinflüssen beschäftigt, die Veränderungen im Genom hervorrufen können. Studien beschäftigen sich in diesem Fall mit den potenziellen (epigenetisch determinierten) Gesundheitskonsequenzen.

Im Verlauf der Analyse wurde klar, dass vor allem das Konzept der Mutterschaft durch epigenetische Forschung neu begründet wird. Dies wird am weiblichen Körper festgemacht, der als Vehikel dient, um klassische Vorstellungen von Mutterschaft zu bestärken. Bemerkenswert ist auch der fast vollständige Ausschluss der Rolle des Mannes, auch wenn es in Studien um Konzeption ging. So wurde auch das Thema der Sexualität selten in Verbindung mit Konzeption gebracht. Andererseits, wenn es um Homosexualität geht, wird

epigenetische Forschung als die fehlende Verbindung zu dessen Erklärung gesehen. Interessanterweise wurde in dieser Fallstudie vor allem die männliche Homosexualität hervorgehoben, denn weibliche Homosexualität scheint komplexeren Mechanismen zu unterliegen, wodurch es wiederum zu biologisch determinierten Dichotomien kommt.

Bei Epigenetik handelt es sich um eine weitere Schnittstelle zwischen Soziologie und Biologie. Durch die Analyse zeigte sich, dass es nicht möglich ist, die Biologie zu verstehen ohne die Umwelt-Einflüsse einzubeziehen. Da in der Biologie selbst noch sehr wenig über die vorliegenden Mechanismen bekannt ist, stellt sich die Frage, wie mit solchen Forschungsergebnissen von den Wissenschaftlern und populären Medien umgegangen werden soll, ohne ein Verschulden zu implizieren. Denn die unterschiedlichen Auffassungen von epigenetischen Forschungsergebnissen können, soziologisch gesehen, kontroverse Folgen haben.

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gefördert.

Curriculum Vitae

Persönliche Daten

Name	Pavla Debeljak
Geburtsort	Zagreb, Kroatien
Nationalität	Österreich

Bildung

2014	Masterstudium Ökologie mit Auszeichnung bestanden
2011 – 2014	Masterstudium der Ökologie mit Schwerpunkt Meerebiologie an der Universität Wien
seit 2012	Masterstudium Gender Studies
2011 – 2012	Erasmus Austauschsemester in Rennes, Frankreich
2007 – 2011	Bachelorstudium der Biologie an der Universität Wien
2007	Erfolgreich bestandene Matura am BG & BRG Baden Biondegasse

Berufserfahrung

2013 – 2014	Angestellte der Universität Wien als Tutorin für „Einführung in die Ökologie“
2013 – 2014	Geringfügig angestellt beim Bürgerservice des Gesundheitsministeriums Österreich
2010 – 2011	Laborarbeit an der Universität Wien im Department für Chemische Ökologie

Seminare

June 2012	Workshop “Epigenetics, Society and Gender”, Universität Wien
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Sprachenkenntnisse:

Deutsch	Muttersprache
Kroatisch	Muttersprache
Englisch	Sehr gute Kenntnisse CAE, Cambridge Certificate of Advanced English
Französisch	Sehr gute Kenntnisse (Europäisches C2 Niveau)
Italienisch	Grundlagen Kenntnis (Europäisches A2 Niveau)