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Generations of Fertility: A Bioethical and Evolutionary Analysis

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GENERATIONS OF FERTILITY:
A BIOETHICAL AND EVOLUTIONARY ANALYSIS

BY

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THESIS

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ABSTRACT

Influenced by both societal and biological factors, woman play a central role in reproducing offspring for future generations. Because females play such an integral role in reproduction, it is often psychologically difficult for women to cope with infertility that can arise due to a variety of factors: ovarian factor infertility, cervical factor infertility, uterine factor infertility, and peritoneal and tubal infertility factors. As a result, technology has evolved to cater to women's infertility in procedures and treatments regarded as assisted reproductive techniques (ARTs), medical regimens that impose bioethical implications. Examples of ART include therapuetic intrauterine insemination (IUI), in-vitro-fertilization (IVF), pre-implantation genetic diagnosis (PGD) in ART, gamete intrafallopian transfer (GIFT) and zygote intrafallopian transfer (ZIFT), and uterine transplants. Women who face infertility often experience psychological effects as a result, causing stresses for both her and her partner. This begs the question as to why some females are so compelled to have children, or, as of recent years, why they may not be. When a woman enters into the reproductive age she is given the ability to exercise certain reproductive freedoms for family planning as a result of various movements in favor of reproductive rights. These reproductive freedoms can be exercised using birth control (pill, shot, implant patch, or ring), intrauterine device (IUD), diaphragm, condom, sterilization, emergency contraception, and abortion.

Keywords: Abortion, Assisted Reproductive Technology(ART), Contraception, Ethics, Infertility, Motherhood

INTRODUCTION

Women are vital in producing offspring, as their reproductive organs house and nourish a growing fetus—the building block of future generations. Because a female's womanhood is socially tied to motherhood, and has been for centuries, women are often devastated when they are diagnosed with infertility. Female infertility is biologically induced by an assortment of circumstances resulting from ovarian factor infertility, cervical factor infertility, uterine factor infertility, and peritoneal and tubal infertility factors.

With the ability to diagnose women with infertility, assisted reproductive technologies (ARTs) have substantially advanced as a health care regiment to cater to women's infertility. Procedures and treatments regarded as assisted reproductive techniques include therapuetic intrauterine insemination (IUI), in-vitro-fertilization (IVF), pre-implantation genetic diagnosis (PGD) in ART, gamete intrafallopian transfer (GIFT) and zygote intrafallopian transfer (ZIFT), and uterine transplants. Because ARTs alter a women's natural biology, these technologies also impose bioethical implications.

Along with the physical effects of infertility, women who face the condition often experience stress in their personal lives and relationships. Because some women react so negatively to a diagnosis of fertility, it begs the question as to why some females are so compelled to have children, or, as of recent years, why they may not be. In choosing to reproduce, often called family planning, women are able to exercise their reproductive freedoms brought forth by social movements in favor of reproductive rights. These reproductive freedoms can be exercised using birth control (pill, shot, implant patch, or ring), intrauterine device (IUD), diaphragm, condom, sterilization, emergency contraception, and abortion.

The image of women's fertility and reproduction is constantly evolving, largely in part due to the increased recognition of infertility, social pressures of motherhood, and female reproductive rights. For centuries, female reproduction has been affected by a variety biological, social, and cultural influences. Through various advancements in assisted reproductive technologies, development of reliable birth control, and availability of abortion, females have earned reproductive autonomy for the sake of family planning and future aspirations. Though each technology and treatment associated with female reproduction possess a variety of ethical implications, their accessibility have enhanced a female's reproductive freedoms.

BACKGROUND INFORMATION

Reproduction

The male and female reproductive systems have evolved independently over centuries, while maintaining their complementarity. New human life is brought into the world when these two biological systems interact. Although the reproductive system is not essential to live, it is essential for the continued creation of the human race. In the absence of the reproductive system, the cycle of humanity would cease to exist. Each system is comprised of primary and accessory organs, that despite their shared purpose to procreate, and are distinctly different (The Reproductive System 2001).

Humans are able to reproduce sexually through the fusion of two the sex cells, called gametes—the female gamete, the egg, and the male gamete, the sperm cell (Roof 2007). In sexual reproduction the sperm and egg merge, in a process called fertilization, to form a single cell called a zygote, a cell with double the genetic information of either partner's gamete that

ultimately gives rise to a new embryo (Carson-DeWitt 2008). The zygote implants onto the female's uterine lining which provides a nourishing environment to facilitate the zygote's splitting and multiplication through mitosis, a process marked by multiple phases of cell division (Roof 2007). This is the developmental form of the zygote that must implant itself in the uterus to achieve a pregnancy (Carson-DeWitt 2008). The uterus then houses the zygote throughout the gestational period, where continual cell cleavage facilitates the creation of a fully formed organism with gametes of its own—and thus a fetus is born (Roof 2007).

Female Reproductive System. The female reproductive system is notably much more complex than that of the male reproductive system. This system contributes equally to the fertilization of the zygote, but also "provides a protective space for an ovum to be fertilized and to develop until birth" (The Reproductive System 2001). The primary organ of the female reproductive system is the ovary, shown in figure 1 (The Reproductive System 2001). The ovaries produce the female gametes, called ova or eggs (Traub 2010). The ovaries play an integral role producing female sex cells for fertilization in a process called menstruation.

Within the female reproductive system, a woman undergoes a menstrual cycle every 28 days to prepare herself for conception (Menstruation and Menstrual Disorders 2017). The menstrual cycle begins when the hypothalamus, a gland in the brain, secretes gonadotropin-releasing hormone (Menstruation and Menstrual Disorders 2017). This hormone triggers the pituitary gland of the brain to secrete two additional hormones: follicle stimulating hormone (FSH) and luteinizing hormone (LH) (Traub 2010). These hormones stimulate the growth of follicles, pouch like depressions that enclose the ova, within the ovaries (Traub 2010). Once the

follicles have sufficiently matured, they secrete the hormone estrogen, prompting the uterine lining to thicken (Menstruation and Menstrual Disorders 2017).

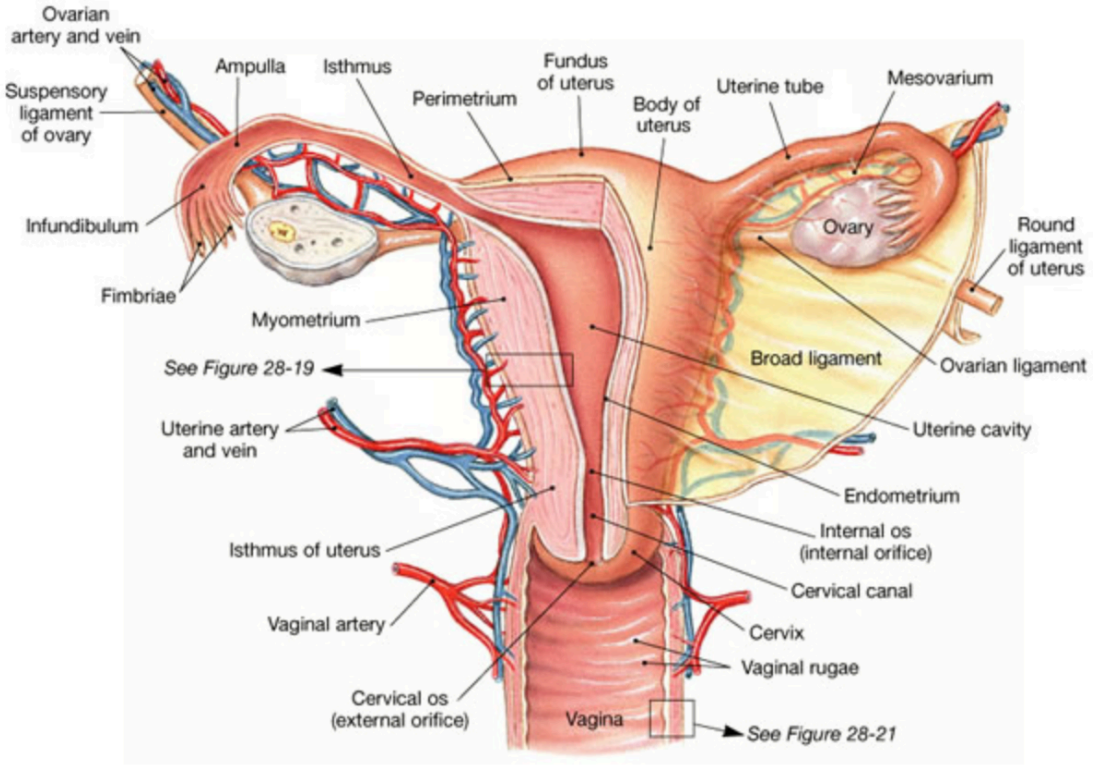

Figure 1 —*The Female Reproductive System:* Image retrieved from *The gross structure of the female reproductive system by Cydney Mellor*. (2019). *Thinglink.com*. Retrieved 14 April 2019, from https://www.thinglink.com/scene/499548973116162050

The release of estrogen also stimulates the pituitary gland to secrete a greater amount of LH, inducing the rupture of a mature follicles in the ovaries to release the ova (Menstruation and Menstrual Disorders 2017). This process is called ovulation, typically regarded as the monthly process by which an ovarian follicle or cyst ruptures and released a mature egg called an oocyte (Menstruation and Menstrual Disorders 2017). The ova are transferred through the fallopian tubes—an accessory organ—to the uterus, a muscular, hollow accessory organ in the female reproductive tract depicted in figure 1. The uterus is essential to childbearing, as it

accommodates and nourishes the embryo and fetus from the time the fertilized egg is implanted onto the uterine walls, until birth (Traub 2010). If the female ovum is not fertilized by the male sex cell, then the uterine lining, along with blood and tissue fragments, shed and exit the uterus through the cervix and vagina as a monthly menstrual period (Menstruation and Menstrual Disorders 2017).

Male Reproductive System. The primary reproductive organs in males are the testes, male sex organs that produce the male gamete called sperm in a process called spermatogenesis (Roof 2007). Sperm cells include spermatozoon, the mature male sex cell capable of fertilizing the female egg (Fallon 2006). With regard to the general morphology of sperm, not all sperm within a specimen of semen have perfectly "normal" biological form and structure (Fallon 2006). Some may be immature, and some may have abnormalities of the head or tail. A normal semen sample will contain no more than 25% abnormal forms of sperm (Fallon 2006). The accessory organs of the male reproductive system (seminal vesicles, prostate gland, and other glands), shown in figure 2, produce a combination of secretions that merge with sperm cells to form semen, the fluid ejaculated by the male during sexual intercourse (Fallon 2006).

Sperm cells are propelled from the testes through the reproductive ducts of the male reproductive system (epididymis, ductus deferens, ejaculatory duct, and urethra), shown in figure 2 (Roof 2007). These cells are propelled into the female's vagina in a process called ejaculation, a spasmodic muscular contraction expelling semen from the penis— the male sex organ (Carson-DeWitt 2008). The sperm the must rely on their ability to propel themselves through the female reproductive tract and cervical mucus to reach the egg and achieve fertilization—a trait described as motility (Carson-DeWitt 2008).

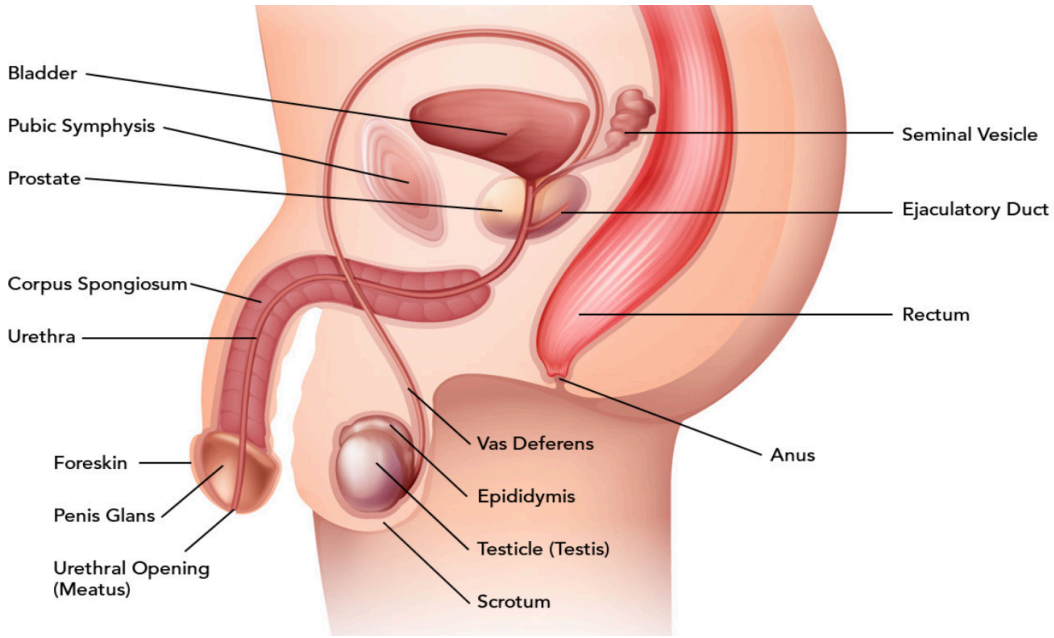

Figure 2 —*The Male Reproductive System:* Image retrieved from *Male Reproductive System – Locations and Functions of the Male Reproductive Organs – Earth's Lab*. (2018). *Earth's Lab*. Retrieved 14 April 2019, from https://www.earthslab.com/physiology/male-reproductive-system-locations-functions-male-reproductive-organs/

In examining a man's fertility capabilities, physicians test not only for sufficient sperm motility, but sperm count as well. Sperm count refers to the number of mature motile male sex cell present in a semen sample (Carson-Dewitt &Odle 2011). The normal, and typically sought after for optimal fertility, number of sperm present in one milliliter (mL) of semen is estimated to be more than 20 million (Fallon 2006). Men who are have an irregular sperm count can be considered subfertile, with only 5 to 20 million sperm per milliliter of semen, or infertile altogether, with fewer than 5 million sperm per milliliter of semen (Fallon 2006).

LITERATURE REVIEW

In the modern age, "infertility is a relatively common health condition, affecting nearly 7% of all couples" (Zorrilla & Yatsenko 2013). Under clinical analysis, infertility is

characterized as a highly heterogeneous pathology with a profoundly complex method in how it originates, stemming from both environmental and genetic factors (Zorrilla & Yatsenko 2013). Studies across the United States have estimated that approximately 50% of infertility cases are a result of genetic defects (Zorrilla & Yatsenko 2013). Although the large majority of genes associated with infertility remain unidentified, there have been immense efforts and clinical research conducted in order to determine any genes linked to infertility. Clinical researchers have determined that only a small quantity of genes, or genetic defects, either directly cause or have an effect on the two types of infertility.

Noted as a remarkably complex reproductive disorder, infertility can present in two forms: primary and secondary. Primary infertility affects the germ cell structure, an embryonic cell with the potential to develop into a gamete, or its physiology (Zorrilla & Yatsenko 2013). With primary infertility, the cell's compromised biology causes an arrest of the germ cell's development and induces cell death (Zorrilla & Yatsenko 2013). In females, the primary form of infertility may present as premature ovarian failure (POF), polycystic ovary syndrome (PCOS), or endometriosis, among other conditions that will be discussed further later on (Zorrilla & Yatsenko 2013). In men, the primary form of infertility affects spermatogenesis, bringing about abnormalities in the semen: sperm counts, morphology, or motility (Zorrilla & Yatsenko 2013). Many times, though, the semen is normal and men experience an unexplained infertility called idiopathic infertility.

Secondary infertility is characterized by systemic or syndromic genetic defects, where some can be identified via known gene associations (Zorrilla & Yatsenko 2013). Secondary infertility can present in both men and women via DNA gene mutations, chromosomes

aberrations, genomic copy number variations (CNV), and infertility disorders specific to biological sex (Zorrilla & Yatsenko 2013). A mutation can be defined as a permanent alteration in genetic material that may induce modifications to a trait or specific characteristic of an individual (Zorrilla & Yatsenko 2013). A mutation may also induce greater effects on the human body by manifesting as a disease or disorder. Since mutations affect the genetic makeup of an individual, they have the potential to be transmitted and passed onto offspring.

One way a DNA gene mutation can arise is from a base substitution, a type of nonsense mutation. A nonsense mutation is characterized by the substitution of one DNA base pair (a DNA building block) for another, altering the amino acid expressed and its coded molecular protein. Another type of DNA mutation arises from either an insertion or deletion, where a DNA base pair is added or removed, from the DNA sequence. Chromosome aberrations can be characterized by anomalies, abnormalities or disorders caused by an additional, absent or irregular portion of chromosomal DNA (Zorrilla & Yatsenko 2013). Genomic CNV is a biological circumstance in which sections of genomic DNA are repeated across the sequence (Zorrilla & Yatsenko 2013).

Female infertility due to reproductive defects and genital tract developmental defects are relatively common. Although the genetics behind all types of anomalies have still yet to be uncovered, some gene associations have been identified. For example, physical defects, ovulation disorders, or reproductive conditions can be inherited via genetic instructions encoded within chromosomal DNA. In any capacity, the biology a woman inherits or acquires based on environmental circumstances can subject a woman to experience infertility.

Causes of Infertility in Women.

Most couples within the United States are able to conceive a child within the first six months of trying (Carson-DeWitt & Odle 2011). As reported by Mayo Clinic, around 85% of couples typically become pregnant after trying for 12 months of trying (Carson-DeWitt & Odle 2011). Presently in the United States, the approximate 15 to 20% of remaining couples of the reproductive age struggle with infertility at any given time (Carson-DeWitt 2008). Infertility can present itself in many physical and biological forms based on a variety of factors: genetics, environment, lifestyle or trauma. Infertility may arise in women as a result of various causes, but are traditionally categorized into a several categories or factors: ovarian, cervical, uterine, tubal, and peritoneal (Keefe et al 2012).

Ovarian Factor Infertility. There are a range of conditions that elicit infertility in women. Besides the obvious infertility associated with the malady of ovarian cancer, women who face infertility associated with the ovaries cab be a result of an ovulation disorder. The most common ovulation disorder endured by women experiencing infertility are ovarian cysts and polycystic ovary syndrome (PCOS). Polycystic ovary syndrome is a common hormone disorder that affects anywhere from 2-20% of women in the general population (Traub 2010). First discovered by I. F. Stein and M. L. Leventhal in 1935, PCOS is characterized as a disorder where normal ovulation does not occur (Traub 2010). Women affected by PCOS also possess an abnormal production of male hormones (Traub 2010). With PCOS, the egg-containing cysts produced in the ovaries during ovulation do not rupture, leadin to enlarged ovaries containing an abundance of swollen cysts, hence the term “polycystic,” depicted in figure 3 (Traub 2010).

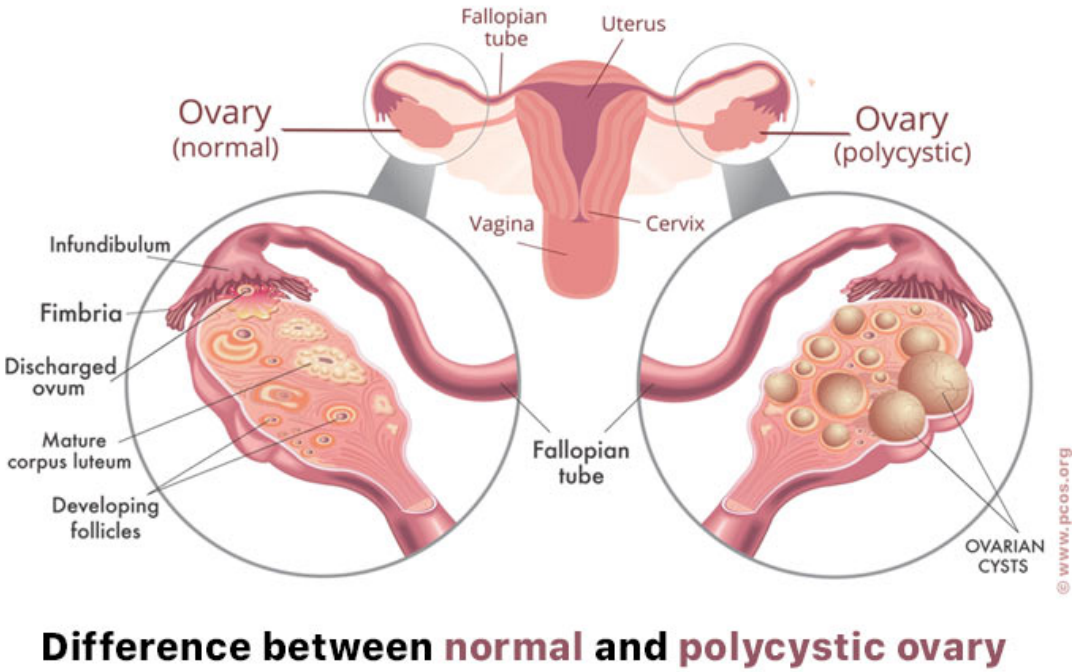

Figure 3 *— A Normal Ovary vs. A Patient with PCOS's ovary:* Image retrieved from *Get info on PCOS symptoms, diagnosis, treatments and management | PCOS.org*. (2019). *PCOS.org*. Retrieved 24 February 2019, from http://www.pcos.org/

During a healthy women's monthly menstruation cycle, the pituitary gland of the brain secretes two hormone types into the blood stream: Lutenizing hormone (LH) and follicle-stimulating hormone (FSH) (Traub 2010). LH and FSH levels increase within the blood, building up to induce swelling and growth of the follicles, creating "cysts" within the ovaries (Traub 2010). Once a certain hormone level accumulates within the blood stream, one of the ovarian cysts will erupt and release a mature egg, or oocyte, in a process called ovulation (Traub 2010). Following ovulation, the mature egg will descend into the fallopian tube and join with sperm cells, if present, for fertilization (Traub 2010). The fertilized egg then migrates into the uterus, where it becomes implanted on its thickened organ walls to continue fetus development. In the absence of sperm cells from a male counterpart, females experience the monthly process of

menstruation, in which the egg remains unfertilized and continues to pass through the cervix and vaginal canal, along with the thickened layer of the uterus.

The exact physiological origin of PCOS still remains uncertain, however there are a variety of abnormalities in PCOS that can be identified within affected individuals. For example, women with PCOS experience a disturbance in their LH and FSH production by the pituitary gland, modifying the presence of LH and FSH in the blood stream (Traub 2010). Additionally, clinical studies have indicated that PCOS effected ovaries do not appropriately respond to LH and FSH, despite their presence in the blood stream (Traub 2010). In addition to complications with ovulation inducing hormones, effected individuals also experience an abnormal over-production of the male hormone androgen from the ovaries and adrenal gland (Traub 2010). Over-production of androgen is the result of another symptom of PCOS, hyperinsulinemia, where there is a surplus of insulin circulating within the bloodstream relative to the level of glucose (Marshall & Dunaif 2012). Women effected by PCOS are also resistant to the effects of insulin and, as a result, often suffer from obesity (Marshall & Dunaif 2012).

Although clinicians are familiar with abnormalities associated with PCOS, there is still speculation as to whether or not the abnormalities are the cause of the disease or the result. In regards to the genetic profile of the disease, researchers have found that women who are diagnosed with PCOS often have relatives who display similar symptoms associated with PCOS (Traub 2010). In clinical research spanning the last few decades, there are circumstances in which PCOS "appears to be inherited with an autosomal dominant or X-linked pattern," although such cases are rare and not applicable to majority of those effected by the disorder (Traub 2010).

Albeit the lack of evidence to support the inheritability of PCOS, current theories surrounding the disorder suggest that there are various genetic alterations and/or genetic factors necessary for PCOS to fully manifest within an individual (Traub 2010). For example, abnormalities in several genes have been associated with PCOS, including mutations in the genes for follistatin, 17-beta-hydroxysteroid dehydrogenase, and a cytochrome P450 enzyme (Traub 2010). These select genes and their mutations affect the functionality of their respective biomolecules: follistatin directly affects levels of FSH production (Meriggiola et al 1994), and 17-beta-hydroxysteroid dehydrogenase and P450 are responsible for the production of testosterone, an androgen (Palermo 2007). Along with the symptoms PCOS present, clinicians estimate that roughly half of the women effected by PCOS will be able to achieve a successful pregnancy (Traub 2010).

Women who experience ovarian factor infertility may also suffer from primary ovarian insufficiency, or premature ovarian failure (POI/POF). POI is a condition characterized as the "cessation of menstrual periods, increased levels of FSH and diminished levels of estrogens before the age of 40" (Sadeghi 2013). In other words, POI referred to as premature menopause, formally named amenorrhea (Sadeghi 2013). POI exists in a very small percentage of the female population: affecting around 1% of women between the ages of 30 and 40, around 0.1% of women under 30 years old, and 0.01% of women under 20years old (Sadeghi 2013). Women diagnosed with POI have very low levels of fertility similar to women in menopause, but unlike menopause, women with POI may experience spontaneous ovarian activity or natural pregnancies (Sadeghi 2013). Typically, women with POI only experience around 5 to 10% rate of spontaneous pregnancies (Sullivan et al 2011). Women who have POI are unable to properly

ovulate due to the loss of eggs (Mayo Clinic 2019). Women with POI cannot release any eggs and as a result cannot achieve fertilization.

Women are diagnosed with POI as a result of a variety of biological factors, such as autoimmune disorders elicited by an antibody attack on ovarian tissue, viral infections, exposure to toxins, or chemotherapy (Mayo Clinic 2019). A common reason a woman may face POI is due to chromosomal defects (Mayo Clinic 2019). With POI, particular genetic disorders are commonly affiliated with the condition, such as mosaic Turner's syndrome (TS) and fragile X syndrome (Mayo Clinic 2019). Turner's syndrome is a condition that affects one in 2000 newborn females (Lunding et al 2015). TS is brought about due to an X-chromosome anomaly and can lead to POI because TS causes "accelerated loss of germ cells before or after puberty" because the women has one altered and one modified X chromosome (Lunding et al 2015).

POI can also arise from fragile X syndrome, where a mutation exists on the Fragile X Mental Retardation (FMR1) gene on the X chromosome, referred to as FXPOI (Sullivan et al 2011). Women with POI who posses the mutation on the FMR1 gene do not have Fragile X syndrome or intellectual or developmental disabilities (Sullivan et al 2011). Instead they have a "permutation" of the gene, meaning that the mutation of the gene is not significant enough to elicit a deficit in intellectual or developmental function (Sullivan et al 2011). Alternatively, the FXPOI permutation compromises ovarian function by inducing amenorrhea (Sullivan et al 2011). Studies show that in general, an estimated 1 in 250 women have the genetic permutation associated to FXPOI (Sullivan et al 2011). Although only a small percentage of the United State's female population is affected by POI, these women are subject to premature menopause, inducing a state of infertility.

Cervical Factor Infertility. In addition to infertility marked by ovarian factor infertility, some women face infertility as a result of cervical factors. The cervix is the opening that leads from the vagina to the uterus, a path through which motile sperm must travel (Carson-DeWitt 2008). Any type of condition that prohibits sperm from swimming through the cervix to fertilize the egg is considered a cervical abnormality. Women can experience cervical factor infertility via any injury to the cervix that may result in a smaller than normal cervical opening (Carson-De Witt 2008). Injury to the cervix can occur during childbirth, surgery from pre-cancerous or cancerous conditions or scarring of the cervical tissue from infection (Carson-DeWitt 2008). A smaller than normal cervical opening often makes it difficult for sperm to effectively enter into the cervix and subsequent fertilization, resulting in bouts of infertility.

In addition to physical anomalies that prohibit motile sperm from entering the uterus, injury to the cervix, or other conditions can lead to the reduction of mucus-producing glands present in the cervix (Carson-DeWitt 2008). The mucus produced by these glands help to transport the sperm through the cervix and into the uterus. In addition to decline of mucus production in the cervix, cervical mucus consistency and composition also play a significant role in a women's fertility. Cervical mucus is critically important in two physiological roles: sperm survival and transport, and serving as a "biological valve" (Keefe et al 2012). With couples who have normal fertility, the window of fertility is 6 days—5 days that the sperm may survive in the fertile-type cervical mucus and the 6th day when ovulation takes place (Keefe et al 2012). In the absence of fertile mucus, "sperm would last only hours in the vagina with little chance of meeting and fertilizing the egg (ovum) (Keefe et al 2012).

Cervical mucus also acts as a "biological valve," in which sperm may be admitted into the uterus at specific times of a women's menstrual cycle, while inhibiting sperm entrance at different points in the cycle (Keefe et al 2012). During a woman's pre-ovulatory phase of her menstrual cycle, where the reproductive organs are under the influence of the hormone estrogen, the cervical mucus becomes watery and orients into parallel channels, allowing sperm to pass through the cervix and swim through the uterus (Keefe et al 2012). This orientation indicates that the "biological valve" is open. When a woman is in the post-ovulatory phase of her menstrual cycle, where the reproductive system is under the influence of progesterone, the cervical mucus becomes thicker, orienting in cobblestone pattern and blocking entry of sperm into the uterus (Keefe et al 2012).

If the sperm cells are immobilized or killed via cervical mucus and exist in large quantities in the cervix, it indicates to the body's immune system that there is a possible antigen (foreign pathogen) present (Keefe et al 2012). Because the female's immune system perceives the sperm as a foreign pathogen, antibodies are secreted by immune cells to destroy male sperm cells (Keefe et al 2012).

Uterine Factor Infertility. A variety of factors can to contribute female infertility beyond chemical or hormonal imbalances or disturbances. For example, uterine abnormalities caused by Müllerian duct anomalies (Chandler el al 2009). A female can experience this form of infertility due to genetic mutations acquired during the gestational period (Chandler el al 2009). The Müllerian ducts are the female's reproductive organs at their earliest stage of development. The ducts—two tube like entities— eventually differentiates to form the fallopian tubes, uterus, cervix, and superior segment of the vagina (Chandler et al 2009). Müllerian duct anomalies can

impede conception and make it difficult to sustain a fetus, for example having higher instances of "infertility, repeated first trimester spontaneous abortions, fetal intra-uterine growth retardation, fetal malposition, pre-term labour and retained placenta" (Chandler et al 2009).

For a female, the typical, healthy uterus is "a hollow, muscular chamber shaped like and upside-down pear" (The Reproductive System 2001). The average uterus will measure around 3 inches in length and 2 inches in width (The Reproductive System 2001). Many times, though, the shape of the uterus varies in relative shape or structure from the defined "norm" which is commonly referred to as an abnormality of the womb (BabyCentre UK 2019). An abnormality of the womb affects an estimated one out of eighteen women, with varying degrees of severity (BabyCentre UK 2019). Dependent on the type of uterine abnormality a female may have, the uterine structure may present obstacles in conceiving a child or carrying the fetus to full term.

There are various general classifications of uterine shapes that deviate from the average shape, as indicate in figure 4: arcuate uterus, septate uterus, bicornuate uterus, uterus didelphys, and unicronate uterus (BabyCentre UK 2019). An arcuate uterus resembles a normal uterus, with the exception of a slight indentation of the fundus. This type of abnormality affects one in twenty-five women and poses an undetectable risk to child conception or miscarriage (BabyCentre UK 2019). Within a septate uterus, the womb is divided by a muscular or fibrous appendage referred to as the septum as a result of an unidentified genetic abnormality (BabyCentre UK 2019). Women with this a septate uterus may have a septum that extends only partially into the womb, or reach as far down as the cervix (BabyCenter UK). A septate uterus generally does not disrupt conception but significantly increases the risk for miscarriage, (Healthline 2019). According to clinical research, the estimated rate of miscarriages amongst

women with a septate uterus may be as high as 40 percent (Selvaraj & Selvaraj 2010). A septate uterus is classified as "the most common congenital uterine anomaly, comprising approximately 55% of mullerian duct anomalies" (Selvaraj & Selvaraj 2010).

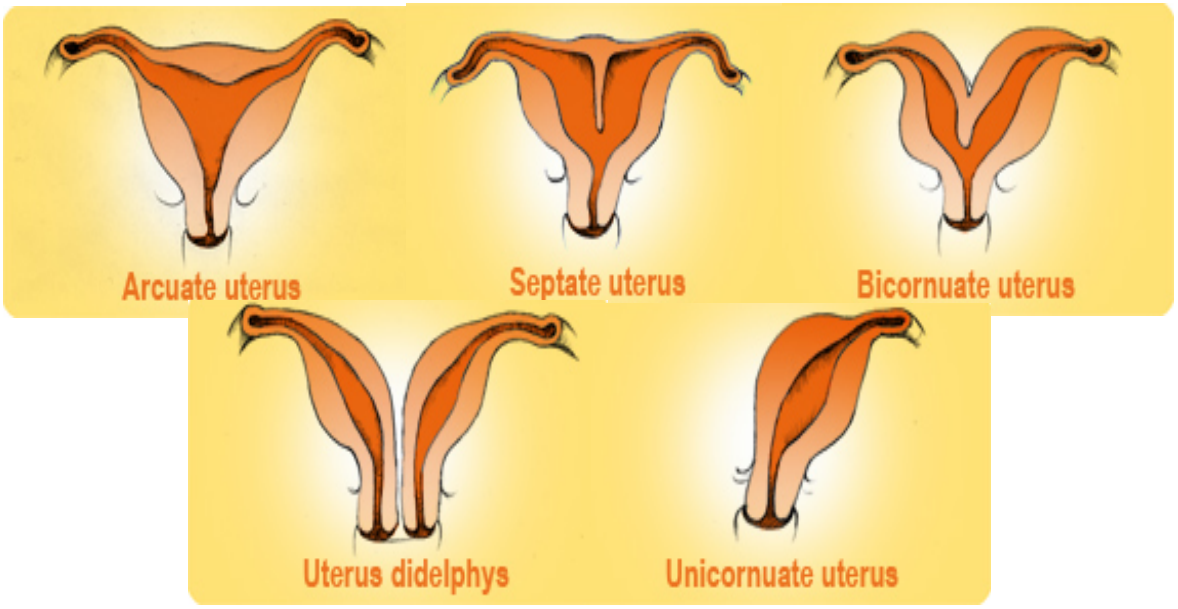

Figure 4 – *Uterine Shapes:* Image retrieved from *Abnormalities of the womb (uterus) in pregnancy*. (2019). *BabyCentre UK*. Retrieved 25 February 2019, from https://www.babycentre.co.uk/a551934/abnormalities-of-the-womb-uterus-in-pregnancy

A bicornuate uterus is structured like a heart, rather than a pear shape, as indicated in Figure 4. Patients affected with what is commonly referred to as the womb with two horns, since the organ is divided by a wedge-like partition of tissue. Patients with a bicornuate uterus have no impairment in regards to fertility, meaning that they can conceive as easily as a woman with a normal uterus, but their gestational capacity is impeded (Maneschi et al 1993). Demographic studies estimate that one in 250 women are affected by this abnormality of the womb (BabyCentre UK 2019). According to clinical research regarding bicornuate uteri, they account for approximately 10% of mullerian duct anomalies (Parmar &Tomar 2014). The uterine malformation from a bicornuate uterus is associated with "spontaneous miscarriages, intrauterine

growth restriction, preterm deliveries, preterm pre-labour rupture of membranes, breech presentation and increased rate of caesarean delivery" (Parmar &Tomar 2014). Frequent complications and adverse reproductive outcomes linked with this form of uterine abnormality reports that 25% of affected patients experience recurrent pregnancy loss, 15-25% experience preterm birth, and 38% experience cervical insufficiency, a weak cervix incapable of deterring dilation (Parmar &Tomar 2014).

In normal development of the female reproductive organs, the Müllerian ducts fuse together in order to create one large hollow organ (Chandler et al 2009). In the rare case of uterus didelphys, or a double uterus, the congenital abnormality results from the complete non fusion of the two Müllerian ducts (Chandler et al 2009). The small percentage of women affected by uterus didelphys may experience a variety of possibilities in terms of her reproductive physiology; sometimes there is only one cervix for both uteri, or a cervix for each, or the "double uterus" is simply an opening separated via a thin membrane (Chandler et al 2009). Studies found that they large majority of women who possess the uterus didelphys abnormality have preserved reproductive and gestational performances, although a small fraction did have difficulty sustaining the pregnancy (Maneschi et al 1989).

The final possible uterine structure a woman may have is the unicornuate uterus. The unicornuate uterus can be characterized by a womb that is half the size of a typical uterus, with only one fallopian tube (BabyCentre UK 2019). This uterine abnormality can account for 2.4 to 13% of all müllerian abnormalities (Caserta et al 2014). This type of congenital defect is very rare and affects 1 in 1000 women (Danielsson 2019). With a unicornuate uterus, the incidence of recurrent miscarriage is significantly high, ranging anywhere from 5 to 30% (Danielsson 2019).

The relatively high percentage of miscarriage incidence is associated with several gynecological and obstetric complications, such as infertility and endometriosis among other things (Caserta et al 2014). Women who have a unicornuate müllerian anomaly historically have shown poor reproductive performance: 29.2% live birth rate, 44% rate for premature birth, 4% experience ectopic pregnancies (Caserta et al 2014). Additionally, women with unicornuate uteri have difficulty maintaining pregnancies, where 24.3% of first trimester pregnancies result in abortion, as well as 9.7% of second trimester pregnancies (Caserta et al 2014).

Peritoneal and Tubal Infertility Factors. In addition to genetically acquired cervical and uterine abnormalities, peritoneal factors contribute to a women's infertility. Peritoneal factors of infertility are based on conditions associated with the peritoneum, a silky-like tissue membrane that lines the abdominal cavity and abdominal organs (The Reproductive System 2001). One peritoneal factor that affects women's infertility are pelvic adhesions. Pelvic adhesions arise in a female's reproductive system as thick, fibrous scars that emerge due to various types of trauma such as inflammation, injury, infections (such as pelvic inflammatory disease), endometriosis, or surgery (Alic 2011). The presence of pelvic adhesions, regardless of how they came to be, are a major complication of "many common surgical procedures and may occur in 55% to more than 90% of patients" (Alic 2011). Many times pelvic adhesions create an obstruction or blockage within the female reproductive tract and interfere with the natural function of the ovaries and fallopian tubes (Alic 2011). Due to the healing nature of the peritoneum, peritoneal factors of infertility often lead to tubal factor infertility. Tubal factor infertility is characterized by trauma via disease, obstruction, damage, scarring or other malformations specifically associated with the fallopian tubes (Alic 2011). In either case, these

interferences are noted as common causes of female infertility as infertility can arise from the fact that the mature egg, the oocyte, is unable to descend into the uterus because of the apparent obstruction (Alic 2011).

In addition to pelvic adhesions, endometriosis serves as a peritoneal factor of infertility in women. As previously noted, pelvic adhesions can arise from endometriosis. Endometriosis is a chronic condition characterized by the presence of endometrium-like tissue layers on the outside of the uterine layers: the endometrium and myometrium (Zegers-Hochscild et al 2017). With this condition, the endometrial tissue implants and grows during a woman's monthly menstrual cycle, controlled by a female's hormones (Endometriosis 2017). Reproductive hormones control the buildup of the endometrial lining in preparation for receiving and maintaining a fertilized egg (Endometriosis 2017). With the uncontrolled development and implantation of endometrial tissue on the outside of the uterus, the tissue growth finds its way into other areas of the pelvic cavity, such as attaching to ovaries or intestines (Endometriosis 2017).

As the endometrial tissue permeates other organs, it often causes swelling, inflammation, and pain to the affected tissues (Slon & Davidson 2011) These symptoms arise from implantations on other tissues being stimulated to grow by the estrogens, progesterone, and prostaglandin hormones produced during a women's menstrual cycle (ARC Fertility 2014). The nature of endometrial tissue is to bleed and shed via regulation of reproductive hormones. With the growth of endometrial tissue on the outside of the uterus, or other organs, the bleeding and shedding of tissue does not have a natural passage to exit the body, ultimately eliciting inflammation and irritation of neighboring tissues (ARC Fertility 2014).

As a result of the uncontrolled nature of endometrial tissue growth in endometriosis, in many cases the implanted tissue causes neighboring organs to stick together or to form scar tissue in the form of pelvic adhesions from repeated irritation (Endometriosis 2017). Typically, the endometrial implants "are found most often on the pelvic organs—the ovaries, Fallopian tubes, and in the cavity behind the uterus" (Slon & Davidson 2011). With its natural tendency to target a woman's reproductive organs, the scars, inflammation and irritation caused by the endometrial implants can affect female fertility by interfering with a woman's ability to conceive (Slon & Davison 2011).

The inflammation associated with endometriosis can affect the fimbriae of the fallopian tubes, a factor of tubal infertility, which picks up the egg and transport it into the uterus (ARC Fertility 2014). Inflammation of the fimbria causes swelling and scarring to local tissues and can prevent the egg from entering the fallopian tube and reaching its destination, the uterus, or prevent the ovum from being fertilized by the sperm in general (Carson-DeWitt 2008). Pelvic adhesions developed from endometriosis may also prevent the sperm "from traveling up the fallopian tube from the uterus; or the blastocyst may be prevented from entering into the uterus where it needs to implant (Carson-DeWitt 2008). Inflammation can also expose sperm cells and a women's eggs to an inhospitable environment, where the sperm and egg can be directly damaged (ARC 2014). In more advanced cases of endometriosis, pelvic adhesions or cysts may begin to form and cause neighboring organs, such as the ovaries, to stick together and decrease their relative function, resulting in infertility.

The exact number of women affected by endometriosis is often difficult to determine, due to the fact that as many as 15 to 20 % of women with endometriosis do not present with

symptoms (ARC 2014). Despite the difficulty, studies show that an estimated 6 to 8% of women within childbearing ages, around 5.5 million women, in the United States are affected by this endometriosis (Slon & Davison 2011). Many women are diagnosed with endometriosis between the ages of 25 and 40, although the condition can appear in teenage girls due to the development of a menstrual cycle (Slon & Davidson 2011). In any capacity, endometriosis is a heritable condition that contributes to infertility of women within the United States.

Infertility Treatments and Assisted Reproductive Technology

Human biology is complicated in the way that some women are granted the opportunity to beget a child, while others must cope with infertility. Before the evolution of technology, women dealt with whatever genetic abilities concerning fertility they were born with. Today, medical technologies have evolved to cater to more than just lifesaving procedures. These medical technologies, more often than not, are described as luxury procedures due to the fact that they are not life saving, but elective procedures to satisfy personal and familial aspirations. According to the U.S. department of health and human services, around 10% of women (6.1 million) from ages 15 to 44 in the United States have difficulty getting pregnant and or staying pregnant (Womenshealth.gov 2017). Worldwide, it is noted that around 50 million couples experience infertility (Maternal Health Task Force 2017). Due to the fact that there is a sizeable demographic of women affected by infertility, no matter how it presents, medical professionals and biochemists have produced the means to overcome such boundaries. The types of therapies and medical technologies that improve fertility, as well as increase a woman's odds of bearing a child, fall into a category called assistive reproductive technologies (ART).

According to *The International Glossary on Infertility and Fertility Care, 2017,* assisted reproductive technology (ART) is classified as "all interventions that include the in vitro handling of both human oocytes and sperm or of embryos for the purpose of reproduction" (Zegers-Hochscild et al 2017). These technologies include, but are not limited to: IVF and embryo transfer (ET), intracytoplasmic sperm injection (ICSI), embryo biopsy, pre-implantation genetic testing (PGT), assisted hatching, gamete intrafallopian transfer (GIFT), zygote intrafallopian transfer, gamete and embryo cyropresevation, semen, oocyte and embryo donations, and gestational carrier cycles (Zegers-Hochscild et al 2017). Within the scope of this paper, I will explore intrauterine insemination (IUI), IVF and embryo transfer, pre-implantation genetic testing (PGT), gamete intrafallopian transfer (GIFT) and zygote intrafallopian transfer (ZIFT), and – a more cutting edge technology—uterine transplants.

Therapeutic Intrauterine insemination (IUI). Therapeutic intrauterine insemination (IUI) is an assistive reproductive technology typically used as a first-line treatment method with patients afflicted with ovulatory disorders, as well as cervical or male factor infertility. Typically, IUI is selected as a fertility treatment for patients who suffer from unexplained infertility, a hostile cervical condition—such as cervical mucus problems or cervical scar tissue from past procedures that may inhibit a sperm's ability to enter the uterus (American Pregnancy Association 2012). This form of ART, however, is not recommended for women with a disease of the fallopian tubes, history of pelvic infections, or women with endometriosis. Intrauterine insemination employs a procedure in which a semen sample, washed by a lab, is inserted directly in the women's uterus via a catheter, indicated in figure 5 (Cantineau & Cohlen 2007). One way in which the efficacy of IUI therapies can be enhanced is through sperm washing. The process is

characterized by initially separating the weaker sperm for the stronger and healthier sperm (Attain Fertility 2018). Once the more capable sperm are selected, they are concentrated into high volumes in the insemination sample (Attain Fertility 2018). The sample is then filtered of any toxins, as these toxins may induce an allergic reaction within some women that can affect pregnancy. Inseminating the patient with a washed sperm sample maximizes the number of sperm cells injected into the body, thereby increasing the odds for conception.

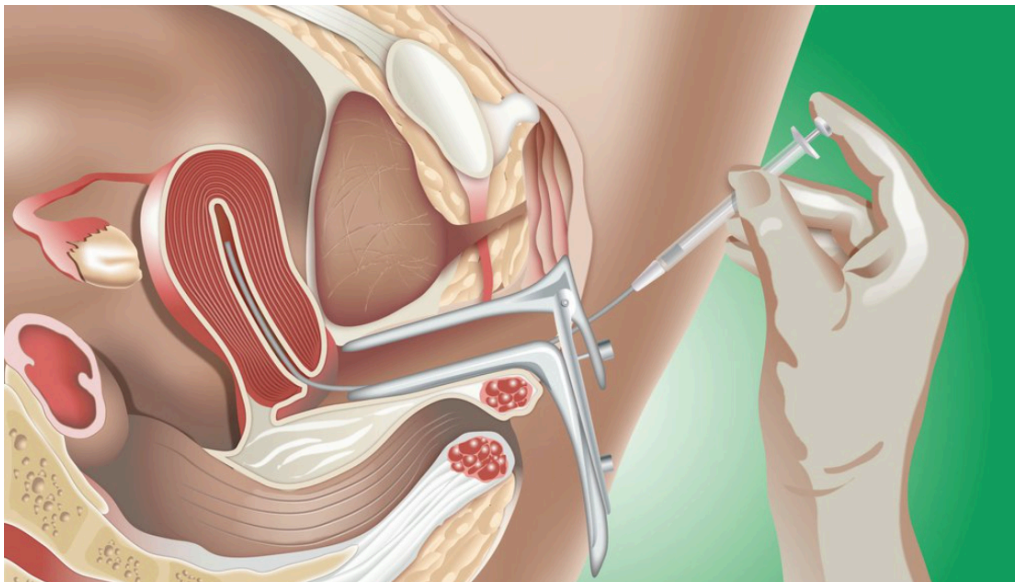

Figure 5— *Intrauterine Insemination (IUI) Procedure:* Image retrieved from *Intrauterine insemination (IUI): Uses, Risks and Success Rate*. (2012). *American Pregnancy Association*.

This type of therapy is employed just before the women ovulates in order to induce a greater ovulatory response. In addition to manual implantation, the patients are given medication (hormone supplements) to hyper stimulate the woman's ovaries in a process called ovulation induction (Cantineau & Cohlen 2007). Patients who are treated with IUI in the absence of ovulation induction show little to no clinical benefit, indicating that ovulation induction is pertinent to IUI pregnancy success.

Ovulation induction serves a pertinent role in ovarian stimulation to produce multiple eggs. Typically, the patient's medical team will administer many different types of medications in order to elicit the production of multiple eggs. Although this process may yield a higher production of eggs from the ovaries, many times doctors like to ensure a higher production of eggs from the patient due to the fact that some eggs may not become fertilized, or develop (Mayo Clinic 2018). Medication regimens typically prescribed for infertile patients look to induce ovulation and consist of general medications for oocyte maturation, a process used to ensure the eggs are mature enough for egg retrieval (Mayo Clinic).

With the additional administration of hormones, more eggs are released from the ovaries to be fertilized. The history of IUI therapy dates back to around the 18th century, when surgeon John Hunter of Scotland performed one of the first effective IUI procedures using the patient's husband's sperm (Putowski et al 2014). Since then, several successful births have transpired due to the creation of IUI therapy for infertility. Though the therapy has been around for many years, the success of the IUI therapy for infertility depends of a variety of variables. For example, if a couple partakes in an IUI procedure conducted each month, the success rate of the procedure may reach success rates as high as 20% (American Pregnancy Association 2012). Additionally, the success of IUI therapy on pregnancy rates are dependent on the women's age, what type of infertility the patient is afflicted by, the longevity of their infertility, the quality and motility of sperm being introduced, and finally the type of ovarian stimulation agent (Gomez et al 2014).

In-Vitro-Fertilization (IVF). IUI is typically noted as a less invasive and economical form of ART, but the pregnancy rates from IUI therapy are notably lower than those of In-Vitro-Fertilization (IVF) treatments. IVF is one of the number one assisted reproductive technologies

used by women struggling with infertility (Bonnicksen 2015). Since the first successful IVF treatment in 1978 in the United Kingdom, over 5 million infants have been born with the help of IVF across the globe (Bonnicksen 2015). Initially, IVF treatments were designed primarily for women with defective or blocked fallopian tubes (Bonnicksen 2012). The IVF treatment was able to bypass these tubes and facilitate natural pregnancy. Today, with current advancements in technology, medical practitioners have, according to Bonnicksen, "extended the versatility of IVF as a method for circumventing infertility" (2015). Women who are unable to ovulate are now able to carry children through term with the use of donated eggs.

The phrase "in vitro" is a Latin phrase meaning within glass, hence the term test tube babies when referring to the *invitro* fertilization, where the joining of the egg and the sperm occurs within a "glass" laboratory culture dish (LaPensee 2012). In IVF protocol, there are 4 main steps: (1) stimulating and monitoring healthy eggs within the ovaries, (2) collecting these eggs and subsequent sperm, (3) combining the eggs and sperm, and (4) providing a hospitable environment for fertilization and promotion of early embryo growth (LaPensee 2012).

In more detail, the process of IVF begins with ovulation induction, in which intravenous injections of medication are given daily in order to increase multiple egg release from the ovaries (LaPensee 2012). The patient is typically advised to undergo ovulation induction treatment for one to two weeks in order to establish sufficient ovarian stimulation for egg retrieval (Mayo Clinic 2018). If overdone, the stimulation can include ovarian hyper-stimulation syndrome in which the ovaries painfully swell and induce nausea and vomiting (LaPensee 2012). Prior to egg retrieval, the doctors monitor the development of follicles in the ovaries via an ultrasound, as well as monitor estrogen levels through blood testing (Mayo Clinic 2018). The eggs are then

collected from the patient's ovaries through follicular aspiration, where an ultrasound and hollow needle is inserted through the abdominal wall to retrieve the eggs, as indicated in figure 6 (LaPensee 2012). The transvaginal ultrasound probe is inserted into the vagina in order to identify the follicles of the ovaries (Mayo Clinic 2018). The thin needle is then inserted into the ultrasound, through the vagina and into the follicles to obtain the eggs (Mayo Clinic 2018).

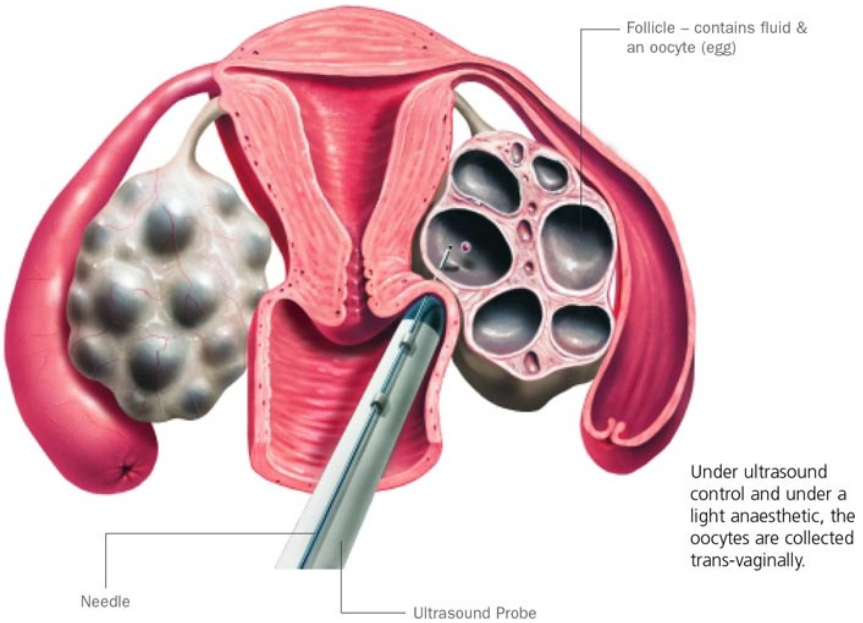

Figure 6—*Follicular Aspiration***:** Image retrieved from *Egg pick up and embryo transfer*. (2018). *Coastalivf.com.au*

The eggs are suctioned out of the follicle through the needle, where several eggs can be retrieved within a 20 minute time span (Mayo Clinic 2018). The mature eggs are placed into a culture medium and incubated until the healthy and mature eggs can be identified for further use (Mayo Clinic 2018). With the collection of the women's eggs, this also elicits the collection of the sperm, generally by ejaculation, or extracted by microsurgical sperm aspiration (MESA), brought on by a defect or absence of the vas deferens in men (LaPensee 2012). Additionally, in special cases the sperm can be frozen cryogenically and then thawed at the time of preferred use.

Upon collecting the eggs and sperm, the two cell types are unified for insemination in vitro. For the best rate of success with IVF, the sperm sample is typically "washed". The process of sperm washing ensures the removal of any mucus or immobile sperm that may disrupt the process and success of IVF. Additionally, if the doctors foresee there may be obstacles in attaining a successful pregnancy through the normal process of IVF, they may use intracytoplasmic injection (ICSI) (LaPensee 2012). Intracytoplasmic injection is the procedure by which one sperm is systematically injected into a specific egg (LaPensee 2012). In both cases, no matter how fertilization takes place, the eggs are observed until cell division takes place (LaPensee 2012). Upon doing so the eggs are then considered embryos.

Up to six days after the egg is fertilized, the embryo is transferred from the petri dish to the patient's uterus using a catheter connected to a syringe (LaPensee 2012). Prior to embryo transfer, the patient is typically prescribed medications to prepare the lining of the uterus in order to ensure that the uterus is more receptive to implantation (Mayo Clinic 2018). The catheter is inserted into the vagina and through the cervix as depicted in figure 7. The syringe contains one or more embryos suspended in a small amount of fluid (Mayo clinic). The nurse then expels the contents of the syringe into the patient as method of embryo transfer (Mayo Clinic 2018). Following the embryo transfer, the patient is observed via blood tests and frequent ultrasounds to determine whether or not implantation and pregnancy have been attained. In participating in IVF

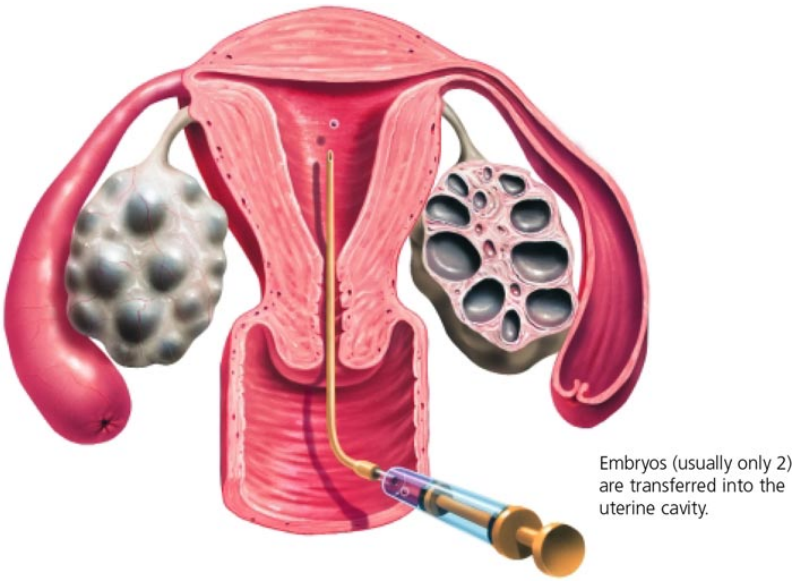

Figure 7 —*In Vitro Fertilization (IVF) Procedure:* Image retrieved from *Egg pick up and embryo transfer*. (2018). *Coastalivf.com.au*

treatments, the patient ultimately faces many cycle carrying risks. In this case, according to Mayo Clinic, "IVF increases the risk of multiple births if more than one embryo is implanted into your uterus. A pregnancy with multiple fetuses carries a higher risk of early labor and low birth weight than pregnancy with a single fetus does" (2018). Along the same lines, patient who participate in IVF treatments may experience premature delivery of their babies, which establishes a low birth weight for the child (Mayo clinic 2018). In terms of technical risks, the patient may face: ovarian hyperstimulation syndrome via ovarian induction medications, miscarriage, egg-retrieval procedure complications, or ectopic pregnancy—which affects around 2 to 5% of women who use IVF, ovarian cancer, and overall stress (Mayo Clinic 2018).

Pre-Implantation Genetic Testing (PGT) or Pre-Implantation Genetic Diagnosis (PGD) in ART. With the constant development of modern medicine, assisted reproductive technologies are evolving in order to offer infertile women the opportunity to have a child. Modern medicine, though, is not complacent with the technological advancements already

employed, instead scientists aim to push the envelope and revolutionize existing technologies. A newly developed technique called pre-implantation genetic testing (PGT), or pre-implantation genetic diagnosis (PGD) does just that when used in conjunction with IVF treatments (Bonnicksen 2015). Pre-implantation genetic testing is an umbrella term for the clinical techniques "used for the genetic profiling of embryos prior to implantation or of the oocytes before fertilization" (Larson 2016). This technology is available to patients and couples who are known to be at high risk for passing on severe genetic diseases.

PGD technology emerged in the age of the human genome project, when powerful molecular diagnostic methods were established and refined clinical techniques on embryos surfaced (Franklin & Roberts 2006). Up until the early 1980's, the only available prenatal diagnosis technology included amniocentesis, analyzing an amniotic fluid sample, and chorionic villus sampling (CVS), analyzing a small tissue same of the fetal segment of the placenta (Antonios 2011). The first successfully performed PGD test occurred in October of 1989 by Alan H. Handyside, a clinician who subsequently became a pre-implantation genetics consultant (Antonios 2011). Handyside was able to effectively detect the genetic indicators for cystic fibrosis, an X-linked disease, within the embryo (Antonios 2011). In its early applications, PGD was used as a method of gender selection, a way for parents to evade the possibility of having a child with a sex-linked disease (Antonios 2011). Families who chose PGD for gender selections often chose only to have girls, as males are naturally more prone to having an X-linked genetic disorder (Antonios 2011). Since its creation, PGD has been used to identify three major groups of inherited disease: "single-gene mutations such as cystic fibrosis and sickle cell anemia, sex-

linked disorders such as hemophilia, and chromosomal abnormalities such as Down syndrome" (Antonios 2011).

PGD technology is used in tandem with assistive reproductive technology (ART), typically IVF (Larson 2016). In conducting PGD, a woman must undergo superovulation to increase the number of eggs present in a single reproductive cycle (Press 2014). Superovulation is generally induced by a strict regime of administered reproductive hormones, often prescribed by the patient's doctor (Press 2014). The eggs are harvested for fertilization and subjected to IVF to produce anywhere from six to eight embryos (Press 2014). These embryos are left to develop until they are deemed mature enough to undergo genetic analysis, a stage where the embryo has anywhere between eight to twelve cells (Press 2014). One or two cells are then removed from each embryo and subjected to genetic analysis (Press 2014). The genetic analysis can be performed at various stages of embryo development, but geneticists often conduct the analysis on unfertilized oocytes, fertilized embryos and polar bodies, three-day cleavage-stage embryos, and blastocysts (Larson 2016). PGD tests performed in the early stages of the embryo can only indicate the maternal contributions to the embryo, while in later stages maternal and paternal contributions can be assessed (Larson 2016). Embryos that bear genetic defects are then discarded, while the unaffected embryos are chosen and implanted (Press 2014).

With regards to the technical side of PGD, the diagnosis may employ fluorescent in situ hybridization (FISH), a technique that detects chromosomal abnormalities in the embryo (Larson 2016). FISH utilizes a fluorescent probe to identify whether or not the embryo possesses any genetic diseases by binding to specific chromosomes (Larson 2016). The probes are synthesized with short sequences of DNA that bind complementarily to the DNA removed from the embryo

(Larson 2016). The probes visibly mark the target DNA sequence after being exposed to a particular wavelength of light, as the binding between the probe and target DNA sequence will induce fluorescence (Larson 2016). If the probe binds to a specific gene, or gene sequence, within the embryonic genome, the binding location indicates where the target genetic disorder is on the genome. Once the location is established, the embryo's genome is analyzed for the presence of genetic anomalies or mutations (Larson 2016).

PGD may also be established by employing the polymerase chain reaction (PCR) technique, a method developed to replicate target DNA sequences in vitro and examine single-gene mutations (Larson 2016). Through PCR, a single molecule of DNA, a target sequence, in an embryo can be amplified (replicated) thousands of times over using thermo-stable DNA polymerases, a primer, and template DNA (Larson 2016). The amplification process allows geneticists to produce many copies of the targeted DNA sequence to be further analyzed. These geneticists examine the target DNA at particular locations across the embryonic genome, sequences associated with genetic disorders noted in published literature, to identify anomalies or gene mutations that would elicit a genetic disorder.

Gamete intrafallopian transfer (GIFT) and Zygote intrafallopian transfer (ZIFT). IVF is noted as having one of the highest success rates in treating infertility. Since the year 1978, there have been more than 5 million children born as a result of IVF treatments (Bonnicksen 2015). Despite its numerical successes, IVF is noted as a highly invasive process and procedure with an expensive protocol. IVF ultimately enhances the patient's probability of becoming pregnant by taking control of the fertilization process. Zygote intrafallopian transfer (ZIFT) and

gamete intrafallopian transfer (GIFT) are considered to be modified versions of the IVF assistive reproductive technology (WebMD 2019).

Similar to IVF, GIFT and ZIFT are assistive reproductive procedures that involve the transfer of freshly recovered ova from a women, subsequently combined with conditioned spermatozoa (Mastroianni & Cohen 2014). Prior to treatment, the patient is prescribed reproductive hormones to stimulate the development of ovarian follicles to increase the number of eggs produced in one reproductive cycle, thereby increasing the odds of becoming pregnant (Silber 2019). There are two significant difference between IVF treatment, GIFT, and ZIFT procedures: where fertilization takes place, and how long the oocyte and sperm are left to achieve fertilization to mature (Saylor 2007).

In terms of the technical aspects of performing a GIFT procedure, the oocytes are retrieved via a transvaginal needle aspiration with an ultrasound guide; the semen sample is collected from the male, washed and prepared, and loaded into the same catheter in which several of the female's best oocytes will go (Silber 2019). To achieve fertilization via the GIFT procedure, the implant is a mixture of the female's retrieved ova and a concentrated sperm sample (Saylor 2007). The sperm and egg mixture is then released into the patient's fallopian tube through a small surgical procedure using laparoscopy or a small incision in the lower abdomen (Silber 2019). With GIFT, once the oocytes and sperm are retrieved they are implanted into the fallopian tubes within 24 hours, compared to being placed into a petri dish for three to five days with IVF (Saylor 2007). The advantage to GIFT is that the process introduces the embryo into the female's reproductive system in a very similar fashion to natural conception (WebMD 2019).

In regards to ZIFT, the procedure is a variation of the methods previously discussed with GIFT, where a zygote is implanted into the female fallopian tube (Silber 2019). Women who choose ZIFT often do so as a result of damaged or blocked fallopian tubes. The ZIFT procedure allows women with obstructed tubes "to become pregnant by introducing the developing embryo into an area past the blockage or occlusion" (Saylor 2007). ZIFT, like GIFT, is an advantageous infertility treatment for females, as it introduces the embryo to the reproductive system in a minimally invasive and seemingly natural method of conception.

It is important to note with the IVF, GIFT and ZIFT assisted reproductive technologies that the women receiving this treatment are using their own eggs. With age, specifically past the age of 35, a women's egg quality and quantity begin to decline (WebMD 2019). For the year 2017, the Center for Disease Control noted that "29.3% of all cycles that used the woman's own eggs or embryos led to successful pregnancies," and the remaining 70% did not (WebMD). Women in their upper thirties and early forties who choose to undergo IVF, GIFT and ZIFT choose to use donor eggs, as their own eggs have a lesser chance of resulting in pregnancy or healthy baby (WebMD 2019).

Uterine Transplants. Women who lack a uterus due to either a birth defect, hysterectomy or by other means are affected in a way that they are unable to experience what most women can—child birth. Other forms of assisted reproductive technologies used to treat infertility in modern medicine rely on the presence or general function of a female's existing reproductive organs. Without the fundamental organ to house and facilitate gestation, the uterus, childbearing becomes physically impossible for women afflicted with this form of infertility. Current technology has bridged this gap in biology and provided an opportunity for women to

have children through an assisted reproductive technique (ART)—uterine transplantation (UTx). Although a uterus transplant may fall under an assisted reproductive technique, it is fundamentally an organ transplant. With organ transplants, comes its own set of risks; factoring in the possibility of another potential being presents further risks and complications.

Although a sparse amount of uterine transplant cases have surfaced, the procedure remains highly experimental and is practiced in only a handful of clinical trials across the globe. Presently, a continued research regimen of uterine transplants has begun, constituting various animal trails utilizing sheep, dogs and genetically identical mice (Catsanos, Rogers, Lotz, 2013). Although these efforts yielded some success with live births, the relevance of these studies to human anatomy is minimal (Catsanos, Rogers, Lotz, 2013). In studies conducted on higher level primates, the results were less than ideal; "Auto-transplanted uteri functioned normally, but no pregnancies resulted; and transplants with donor uteri failed" (Catsanos, Rogers, Lotz, 2013).

Despite the limited success with animals, a procedural protocol for uterine transplants has been created in order to establish structure to an otherwise controversial topic already being carried out. To begin, a screening process is conducted in which the patient must meet the following criteria in order to be considered a candidate:

> Is a genetic female of reproductive age with no medical contraindications to transplantation, has documented congenital or acquired UFI which has failed all current gold standard and conservative therapy, (1) has a personal or legal contraindication to surrogacy and adoption measures, or (2) seeks the UTx solely as a measure to experience gestation, with an understanding of the limitations provided by the UTx in this respect, has not had her decision to undergo UTx deemed as irrational expert psychological evaluation, does not exhibit frank unsuitability for motherhood, and is responsible enough to consent, informed enough to make a responsible decision and not under coercion (Lefkowitz, Edwards, Balayla, 2012).

Following the screening process, biological tests are performed in order to determine the compatibility between the donor, either a deceased or living donor, and the recipient. These tests include "ABO blood compatibility, human leukocyte antigen (HLA) tissue matching, and negative cytotoxic antibodies in the recipient" (Lefkowitz, Edwards, Balayla, 2012). Once these tests are concluded, it is possible to go forward in the transplant process. The organ recipients must undergo In Vitro Fertilization (IVF) preceding the transplant in order to increase the odds of success and decrease the possible exposure the embryo may have to the immunosuppressant drugs (Catsanos, Rogers, Lotz, 2013).

The medical protocol of a uterus transplantation procedure does not constitute the connection of nerves to the transplanted uterus, as it is not fundamentally important in the performance of gestational function (Catsanos, Rogers, Lotz, 2013). This in turn affects the transplanted uterus in the way that the patient will not perceive any sensation; for example, they will be unable to feel a moving fetus or contractions (Catsanos, Rogers, Lotz, 2013). Assuming the transplant is successful, the patient must take immunosuppressant medication in order to prevent the body from rejecting the transplanted uterus. The individual must remain medicated through all three trimesters of pregnancy to ensure that the body continues to accept the organ among their other body systems. It is vital to take the immunosuppressant medications throughout pregnancy, not only to safeguard the state of the transplanted uterus, but to protect the developing fetus within the transplanted uterus as well. In taking these immunosuppressive medications, the fetus will also be exposed to the drug.

If the woman is able to carry the fetus to term, the remainder of the process will be completed post birth. The prospective mother, hoping to deliver naturally with the uterus

transplant may encounter certain obstacles. With a lack of nerve sensation, it is possible that the vaginal function will be compromised, resulting in a caesarean delivery (Catsanos, Rogers, Lotz, 2013). Following the child's birth or the caesarean delivery, the transplanted uterus is removed. The transplant removal allows the patient to cease the immunosuppressant drug use, as it is no longer necessary. After the personal screening, uterus transplantation, a possibility of nine months of pregnancy, and the removal of the transplant, the patient may deliver a child into the world.

Psychological Effects of Infertility on Couples

Although a diagnosis of infertility elicits physical deficits, infertility also impacts the relationship between partners and induces emotional distress on each individual. When partners choose to get married or establish a long term relationship, this arrangement implies that they are looking to start a family, spend the rest of their lives together, and support one another. This marriage, or a long term relationship, is two individuals looking to create a familial unit to support one another in the future, often times this includes children. Because there is such a close connection to between marriage and having children, couples who face infertility often are rendered vulnerable to divorce. Compared to couples who have no difficulty reproducing, couples who experience infertility are three times more likely to get divorced (Pearce 2017). When a couple is diagnosed with infertility, experienced by either one partner or both, this causes a significant impact on a relationship. Part of the reason in which couples may feel a strain on their relationship is due to the expectations they set out for themselves. When a couple makes the decision to begin a family, it can be noted as a way to take control of the future.

Infertility ultimately undermines a family's choice to make decisions for the future, a stressor that often causes partners to place blame on one another and conflict within the relationship.

The psychological effects of infertility on couples can arise from a variety of factors. Women diagnosed with infertility often become fixated on conceiving and, as a result, have trouble focusing on completing daily tasks. With regard to an initial diagnosis of infertility, women may face feelings of shame, guilt, and low self-esteem. This arises as a result of being confronted by a subconscious rejection of motherhood, feelings of immature femininity, or from sexual identity conflicts (Thorn 2009). On a social level, women have historically been expected to produce children and fulfill the role of motherhood. When faced with infertility, affected patients are confronted with the social stigmas and taboo essence of being unable to reproduce naturally. Due to the socially imposed gender-roles placed on women, infertile women experience an alteration in how they perceive themselves, put in place by the strong link emphasized between a woman's femininity and motherhood (Thorn 2009).

The internal conflict arises between the ideal sense of self as a woman, who has the ability to bear a child, and their real self, being infertile (Thorn 2009). Similarly, men who face infertility can experience paralyzing effects, which is why many men would rather end their marriage, then seem like less of a man in his relationship. The efficacy of couples coping with involuntary childlessness depends on objective characteristics of the situation: personal, family, and behavioral stress that affect the emotional capabilities of an individual (Sabatelli et al 1988). When confronted with infertility, males and females face different implications for a life without children.

In regards to women though, the experience is different due to the fact that a women's "role" is more closely tied to the role of motherhood (Thorn 2009). Additionally, a women's social life may change as her female friends transition into motherhood and refocus certain priorities in their life (Thorn 2009). This transition often impacts the quality of friendship between a fertile and infertile woman, as many times infertile women isolate themselves from friends who have become mothers (Thorn 2009). Experiencing infertility affects both partners within a relationship, each individual must adapt and integrate infertility into how they perceive their sense of "self." According to previously studies, men and women differ in how they manage the stress induced by the diagnosis; "men tend to benefit from information and often prefer a pragmatic and aim-oriented approach whereas women find it helpful to share their emotional reactions" (Thorn 2009). Although these claims are largely based on gender bias, the societal constructs that go along with gender bias play an influential role in how men and women react to such a diagnosis.

Infertility is regarded as a prevalent condition throughout the United States, but many times women who struggle with infertility do not share their sentiments with friends or family. Women who struggle to reproduce naturally can become isolated because they feel they are alone in experiencing infertility. With the absence of an emotional outlet, infertile women increase their vulnerability to psychological deficits. Infertility is often a silent struggle where women who have trouble naturally reproducing experience feelings of depression, anxiety, isolation, and loss of control (Rooney & Domar 2018). Women with infertility can experience depression to an extent that is often compared to magnitude at which cancer patients experience depression (Rooney & Domar 2018). Continual exposure to these types of negative feelings puts

infertile women at high risk to become subject to depression, anxiety, distress, and poor quality of life (Rooney & Domar 2018).

Diagnosis related enhanced stress between partners and pressures of societal constructs often inflict strain on a couples' relationship. The stress can manifest in many different ways, and induce burdens on a partnership. One example would be strains on a relationship's intimate life. In general, couples experience natural sexual stress when trying to conceive a child; the proposition "let's make a baby" alone is enough to impose increased levels of stress on either partner under normal biological conditions. When partners are faced with infertility, there is additive pressure to these intimate interactions due to the fact that they perceive intercourse as futile. Instead of focusing on the connection and intimacy between one another, couples struggling with infertility may neglect its pleasurable and intimate aspects, viewing sexual intercourse as a duty set forth by societal expectations to conceive a child. In some cases, the emotional stress is so great that it may affect a partner's biology. For example, the stress reaction to infertility can induce sexual dysfunction (Thorn 2009). Although typically noted as temporary conditions, "up to 60% of all couples suffer from a loss of libido or erectile dysfunction" (Thorn 2009). The stresses brought about by infertility not only affect a man or woman's physiologically, but also impose detrimental emotional burdens upon a partnership.

EVOLUTION OF SEX AND REPRODUCTION

Due to a variety of social, political and economic factors, the cultural landscape of sex and motherhood in the modern world has drastically changed. Contemporary expectations for relationships and having children are no longer centered around medieval concepts but rather for the empowerment of women and individuality. Less than a century ago, sexuality was considered

a private matter—it was highly inappropriate to openly discuss the subject in public. Not only was it taboo discuss sexual matters, but it was described as unacceptable for anyone to express any form of sexual desire through physical contact in public, such as kissing or embracing (Attitudes toward Sexuality 2004). Parents deliberately avoided any conversation about sex or sexual pleasures until their child was ready to marry (Attitudes toward Sexuality 2004).

Once young women were biologically mature enough to develop a menstrual cycle, contact with men was severely restricted (Attitudes toward Sexuality 2004). These restrictions stemmed from the initiative to preserve a young women's virginity, a concept glorified by religious institutions and archaic ideologies. Young women were told that menstruation was "the work of evildoers or 'witches' and inspired fear in young women" (Attitudes toward Sexuality 2004). Additionally, young women who were menstruating were under strict care; the mother would employ magic or medicine men to expunge evil spirits from the daughter (Attitudes toward Sexuality 2004). In general, women who were menstruating were confined and subjected to social and physical isolation, so as not to "spread their evil" (Attitudes toward Sexuality 2004).

Because a female's natural biological processes were seen as historically wicked, societies aimed to counteract a women's natural uncleanliness by maintaining a young women's virginity. Virginity, both in the past and present day, has been regarded as extremely important for young women. Traditionally, unmarried women were prohibited from engaging in sexual intercourse until the first night of her married life (Attitudes toward Sexuality 2004). On the first night of her marriage she had to prove to her husband that she was chaste and pure (Attitudes toward Sexuality 2004). If a young woman could not prove to her husband that she was "untouched"

then she not only brought immense shame unto herself, but her family as well (Attitudes toward Sexuality 2004). Females who engaged in premarital sex were disgraced, so much so that they women remain single for the remainder of her life, or become a concubine (Attitudes toward Sexuality 2004).

Since then, though, American sex culture has come a long way. Beginning during the sexual revolution of the 1960's, when the FDA approved the first oral contraceptive, America presented a greater social acceptance of sexual intercourse beyond the confines of the marriage. Whether or not the approval of oral contraceptives can take responsibility for broadening sexual activity and fluidity, there has been a notable shift in American sex culture. In modern society, individuals often have multiple sexual partners prior to committing to marriage, or not marrying at all. Individuals across the nation are more open to discussing and exploring the bounds of sex, as there is a growing emphasis on the fluidity of sex and sexual orientation. As a result of societal demand, dialogue is being had across the country concerning LGBTQ+ community recognition, as well as supporting women's rights. With the development of social movements across the United States, reasons behind having sex have changed. Women are embracing their individuality and breaking away from conforming to gender roles. Instead of having sex to have children, women are having sex because they can.

Reproductive Rights and Relevant Legislature

Countries across the globe have long histories of regulating the reproductive rights of their citizens, particularly those of women. Despite the fact that women are the individuals who carry, give birth to, and rear children, government agencies and other groups, such as insurance

companies, often take on the responsibility of regulating female reproductive rights (Reproductive Rights 2018).

For thousands of years, early civilizations practiced a variety of contraceptive methods in order to control reproduction. For example, "Ancient Egyptians, Greeks and Romans used various herbs, plant extracts, and other ingredients as spermicides, substances that kill sperm" (Reproductive Rights 2018). For centuries women took varied herbal mixtures to prevent pregnancy or induce abortion. According to early literature, abortion was not a crime in the United Kingdom or the United States and could be carried out so long as the women couldn't feel the fetus moving (Reproductive Rights 2018). Prior to the 19th century, merchants would journey through various towns and sell herbs and drugs that could induce abortion, some even posted advertisements for such services in the newspaper (Reproductive Rights 2018).

With the advancement of contraceptives rapidly increasing during the 19th century, the topic in itself was considered "sordid and unsuitable for public discourse" (Contraception 2008). At that time, the United States enacted a law to declare all contraceptive devices were obscene, called the Comstock Law of 1873 (Contraception 2008). This law ultimately prohibited the mailing, interstate transportation, and import of any and all contraceptive devices (Contraception 2008). The Comstock Law of 1873 was enacted in order to eliminate the distribution of contraceptive devices, as well as literature including such topics sent through the mail (Contraception 2008). Social movements for the legalization and availability of birth control opposed the legislation in place at the time in efforts to regain control over their reproductive rights(Contraception 2008).

Margaret Sanger, a birth control activist, played a fundamental role in changing the law

and negative perceptions surrounding contraception (Contraception 2008). Fueled by movements in the previous century, where women fought for the right to vote, admittance into higher education, or access to careers outside the home, Sanger was determined to fight back against the administration (Reproductive Rights 2018). In 1916, Sanger opened the first ever birth control clinic in the United States, in hopes that researchers may develop practical and effective alternatives to the contraceptives available at the time (History.com). Sanger and her sister Ethyl Byrne, a nurse, owned operated the clinic, providing care to 464 patients local patients in the district of Brooklyn (Feldt 2006). The clinic only remained open for 10 days, at which point the police arrived and forced the women to close the clinic (Feldt 2006). Although authorities deterred Sanger, who would later go on to establish the Planned Parenthood Federation of America, she successfully ignited a movement for reproductive freedom (Feldt 2006). These initiatives effectively challenged the Comstock Law and, by the 1930's, it was no longer illegal to distribute contraceptive devices or contraceptive based literature (Contraception 2008).

Reproductive rights remained a concern for many for centuries, but the fight to attain the autonomy for these rights emerged during the mid-20th century (Reproductive Rights 2018). In the early 1950's, Gregory Pincus, a biochemist at the Worcester Foundation for Experimental Biology, and John Rock, a gynecologist at Harvard Medical School, began work on a hormonal based oral contraceptive called Enovid, commonly referred to as the Pill (History.com 2018). Following clinical tests of the Pill initiated in 1954, the FDA approved the Pill on May 9, 1960 and allowed women better control of their reproductive freedom (History.com). Although the drug was approved in 1960, some states, such as Connecticut, did not legalize birth control for

prescribed use (Planned Parenthood 2015). Estelle Griswold, Planned Parenthood executive director in Connecticut and activist for birth control, also opened a local clinic which provided birth control to the local women (Planned Parenthood 2015). Griswold was subsequently arrested, and her case, *Griswold v. Connecticut* of 1965, reached the United States Supreme Court, where birth control was made legal for married women (Planned Parenthood 2015).

Although *Griswold v. Connecticut* of 1965 granted the legalization of oral contraceptive to married women, millions of unmarried women were still refused the reproductive freedom to oral contraception (Thompson 2013). In the year 1970, women involved in the feminist movement began to push back against the political administration in office, and in 1972, in the case *Baird v. Eisenstadt*, the Supreme Court ruled in favor of legalizing birth control for all female citizens –regardless of marital status (Thompson 2013). The invention of the pill initiated other advancements in the medical field in terms of forms of contraception: safer and more effective IUDs in the manufactured in the early 2000's, the first birth control implant in carried out in 2002, the synthesis of emergency contraceptive pills in the 2010's, and availability of the emergency contraceptive pill (Plan B One-Step) without a prescription in 2013 (Thompson 2013). These technologies served as pivotal points in reproductive rights, as women were gaining greater autonomy over their bodies and their futures.

A century after the Comstock Law of 1873 was enacted— and subsequently repealed— and one year after the nationwide legalization of birth control, abortion was legalized for American women in the United States Supreme Court ruling of *Roe v. Wade* in 1973 (Brown 2019). The case arose when Texas law against abortion was challenged, where the laws in place denied women their constitutional rights (Reproductive Rights 2018). The Supreme Court

decided that many of the Constitutional amendments protected an individual's right to privacy, (Reproductive Rights 2018). The justices proclaimed that an abortive procedure fell under a woman's right to privacy, and as a result, the Supreme court ruled in favor of legalizing abortion (Reproductive Rights 2018). Under this Supreme Court case, states were not able to outlaw abortion in the first trimester of pregnancy (Reproductive Rights 2018). Additionally, *Roe v. Wade* established that abortion in the second and third trimesters must be reasonable and and consider the protection of the female's life (Reproductive Rights 2018).

Following *Roe v. Wade*, some states made efforts to make abortion procedures increasingly difficult for women to obtain. For example, in the reproductive rights case *Whole Woman's Health v. Hellerstedt* in 2013, Texas law required that abortion providers must possess surgical-grade facilities to be considered a licensed abortion provider (Reproductive Rights 2018). This law meant that doctors would need to admit clinic patients to the hospital, an initiative which caused many clinics to close. Women's rights activists contended that this left women "without access to safe and legal abortions" (Reproductive Rights 2018). Ultimately, the court ruled in favor of the female activists, declaring that Texas was imposing unnecessary burdens on women who sought out abortions (Reproductive Rights 2018). Although the women advocating for this case won, various states across the nation continue to pass laws, like that of *Woman's Health v. Hellerstedt,* to limit female access to abortion procedures. State laws regulate abortion by controlling various stages of the process: physician and hospital requirements, gestational limits, "partial-birth," public funding, coverage by private insurance, refusal, state-mandated counseling, waiting periods, and parental involvement for minors (Guttmacher Insitute 2016).

More recently, modern reproductive laws made further efforts to regulate contraceptives. For example, "In 2014 the US Supreme Court Ruled in the case *Burwell v. Hobby Lobby* that 'closely-held corporations,' such as family-owned companies did not have to provide insurance coverage for contraceptives for employees" (Reproductive Rights 2018). The decision was based on the idea that requiring companies to provide contraceptive coverage could infringe on the owner's freedom of religion (Reproductive Rights 2018). This initiative elicited worry amongst women who used birth control, as the decision would affect their access to the contraceptives in the future. Additionally, women who were on the Pill for reasons other than pregnancy, such as ovulatory disorders or hormonal imbalances, would also lose their coverage as well (Reproductive Rights 2018).

In October 2017, "the administration of the US President Donald Trump announced that it was rolling back health insurance requirement on birth control" (Reproductive Rights 2018). This initiative permits exemptions for any employer to deny coverage for a no-cost birth control for all employees based on the employer's religious or moral beliefs (Reproductive Rights 2018). The Trump administration announced that this new rule eliminates "the Affordable Care Act's requirement that all insurance plans must cover birth control coverage without a co-pay or otherwise ensure access to birth control coverage for women whose employers of schools can legally opt out of providing coverage" (Planned Parenthood 2017). According to Planned Parenthood, this alteration of the Affordable Care Act affects coverage for an estimate 62 million women (2017). Despite the ever changing laws regarding women's reproductive rights, women across the country are exercising their reproductive freedoms in efforts to fulfill their physical, personal, and emotional needs.

Deterring Pregnancy— Contraception, Abortion and Other Methods

Women are establishing an increased awareness of their needs and wellbeing, for this reason, society has created medical advancements necessary to meet the demand for casual sex or family planning with contraception and other methods of birth prevention. Contraception is defined as "the process of preventing pregnancy by interfering with the normal process of ovulation, fertilization, or implantation" (Contraception 2008).

Despite its controversy, methods to prevent pregnancy have been sought after for many millennia and across many cultures. Some of the early methods ancient civilizations employed were foolish and ineffective, such as the ancient Greek physician Dioscorides, who proposed wearing cat testicles or asparagus would prevent pregnancy (Contraception 2008). Some early methods, though, were used as the basis or inspirations for contraceptive techniques practiced in the 21st century. For example, in ancient Egypt—circa 1550 BC—women used tampons made of lint soaked in an herbal spermicide of honey and tips of the acacia shrub (Contraception 2008). The acacia shrub contains gum arabic, "a spermicidal agent used in modern contraceptive jellies and creams" (Contraception 2008). The Romans also made efforts to control pregnancy through varied practices: sterilization (performed on slaves), or prolonged nursing of infants—methods that are still in use today (Contraception 2008). Additionally, oiled Bamboo tissue paper discs, created and used by China and Japan, were used as barriers to the cervix, a technique that influenced the modern day diaphragm contraceptive device (Contraception 2008).

Contraception of any form was regarded as controversial, and still is. For centuries religious, political and familial institutions preached to women of all ages that they must remain

abstinent and pure for the sake of their image—how they were perceived socially and in the eyes of God. This concept was, and still remains, a heavily pursued endeavor. Around the dawn of the 20th century, as birth control was becoming more accepted, many notable controversies developed because of it (Contraception 2008).

Despite being a heavily debated topic amongst social, political, and religious institutions, the use of contraceptives has increased more than 10-fold from the year 1963. According to the Guttmacher Institute report "Contraceptive Use in the United Sates," there are around 61 million women of the childbearing age, around which 43 million are sexually active but do not want to become pregnant (Brown 2019). In the modern age, research has shown that 62% of women of the childbearing age use some form of contraception, effective methods outside of practicing abstinence. Of this 62%, 72% of women practice nonpermanent methods of contraception (the pill and its offspring, IUDs, and condoms), while the remainder use sterilization—22% for females and 7% of males (Guttmacher Institute 2018).

Birth Control Pill. The first oral contraception, Enovid, was submitted to the FDA in the year 1957, "as a treatment for menstrual disorders and infertility, not as a contraceptive" (Junod 1998). Three years later in 1960, with the launch of the sexual revolution, the drug Enovid, or the Pill, was submitted to the FDA for the its approval to function specifically as an oral contraceptive (Junod 1998). This medical endeavor received a lot of skepticism, as many voiced concerns about the safety and effects of the drug on a women's ability to conceive a child in the future (Junod 1998). Despite the controversy, the pill was FDA approved on May 9, 1960, granting American women greater reproductive freedom (Junod 1998). As reported by the National Center for Health Statistics, the birth control pill is the leading contraceptive method in

the United States for women of the childbearing age, and has been since the year 1982 (Contraception 2008).

The birth control pill employs the use of steroids to alter a women's basic reproductive cycle (Contraception 2008). The majority of birth control pills in circulation use a combination of synthetic estrogen and progestin, or just progestin, to manipulate the natural ovulatory process (Contraception 2008). Through taking a daily oral contraceptive, steady levels of progesterone and estrogen are maintained (Contraception 2008). Unchanged levels of theses hormones in the body naturally inhibit the secretion of gonadotropins, FSH and LH associated with ovulation (Hormonal Contraception 2019). In the absence of surging FSH and LH levels, follicle development and selection is not initiated so ovulation will not occur (Hormonal Contraception 2019). The pill also initiates changes in the cervical mucus, where it becomes thicker and relatively impenetrable to sperm cells (Contraception 2008). The efficacy of pregnancy prevention with the Pill is dependent on how strictly the patient adheres to the schedule of taking the oral contraceptive. Women who take the Pill at the same time everyday have are estimated to experience 99% effectiveness; if the patient deviates from the schedule, the pill becomes 91% effective (Planned Parenthood 2019). Although highly effective in preventing pregnancy, the Pill does not protect women against sexually transmitted diseases (STDs) because it does not prevent contact between sexual partners.

Birth control shot. After oral contraceptives were introduced to the medical market, other forms of contraceptives have been developed in favor of convenience. Although birth control pills are the leading form of birth control, some women find the daily obligation of taking a pill to be burdensome. For this reason, a long-term injectable form of contraceptive was generated by

scientists in which progestin is injected into the body to inhibit ovulation in the same mechanism previously discussed with the Pill (Contraception 2008). Approximately 3.5 million women choose this form of contraception worldwide; the shot is used in more than 90 countries, but less frequently in the United States (Contraception 2008). The most common type of this contraception is Depo-Medroxyprogesterone Acetate, known more commonly as Depo-Provera or DMPA (Contraception 2008). For women who choose this form of birth control, they must get an injection of Depo-Provera, a depo shot, every three months in order to maintain its efficacy in pregnancy prevention (Planned Parenthood 2019). Women who receive the depo shot regularly as recommended will prevent pregnancy with 99% effectiveness, those who forget to get the shot on time decreases the shot's effectiveness to 94% (Planned Parenthood 2019).

Birth control implant. The birth control implant was created for similar reasons as the creation of the birth control shot. In the year 1991, the FDA approved the birth control implant, "a hormone based contraceptive which is surgically implanted in the arm and lasts approximately five years" (Contraception 2008). The implant is a small, thin bar the size of a match that allows for a steady delivery of a progestin dose into the blood stream and throughout the body (Contraception 2008). The progestin is administered throughout the body and elicits the same ovulatory inhibition response and changes to cervical mucus as the Pill and Depo-shot. The birth control implant is regarded as highly effective, although it does not prevent STDs, the implant is effective up to 99% (Planned Parenthood 2019). The birth control implant is often compared to the intrauterine device (IUD), as they offer similar contraceptive benefits. The birth control implant can last for up to 5 years and is convenient with little to no upkeep (Planned Parenthood 2019).

Birth Control Patch. The transdermal contraceptive patch, or birth control patch, was introduced to the medical market in 2002 (Contraception 2008). This form of contraception is a patch that women wear on the skin of the belly, upper arm, butt, or back (Planned Parenthood 2019). The birth control patch works in the same way as methods previously discussed; the patch contains estrogen and progestin that are absorbed by the skin to prevent egg ovulation from occurring, in addition to the thickening of cervical mucus (Planned Parenthood 2019). In order to achieve effective pregnancy prevention, the patient must apply a new patch to the skin every week for three weeks, taking the fourth week off prior to repeating the cycle (Planned Parenthood 2019). Just like other hormone based forms of contraception, the birth control patch does not prevent STDs, but effectively prevents pregnancy up to 99%, 91% if the patient is not diligent with applying the birth control patch (Planned Parenthood 2019).

Birth Control Ring or Vaginal Ring. The birth control ring was first developed and used in the Netherlands prior to its arrival in the United States in 2001 (Contraception 2008). The birth control ring is a small, flexible ring inserted into the topmost most part of the vaginal canal near the cervix, as depicted in figure 8 (Planned Parenthood 2019). The ring contains the hormones estrogen and progestin and functions like most hormonal birth controls by inhibiting monthly ovulation and causing cervical mucus to thicken. The hormones are able to effectively

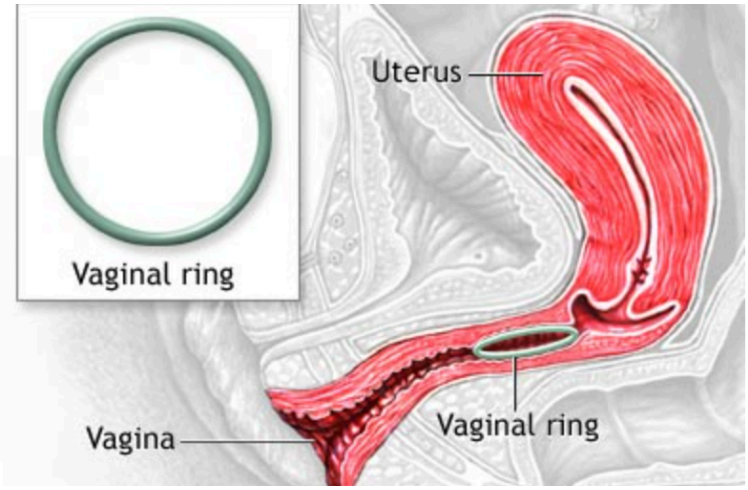

Figure 8— *Birth Control Ring or Vaginal Ring:* Image retrieved from *Vaginal ring (2019). Vaginal ring: MedlinePlus Medical Encyclopedia Image. Medlineplus.gov. Retrieved 14 April 2019, from https://medlineplus.gov/ency/imagepages/19704.htm*

inhibit the release of the gonadotropins necessary to initiate ovulation because the hormones are absorbed directly into the body through the vaginal lining (Planned Parenthood 2019). To achieve effective pregnancy prevention, up to 99% in the case of birth control rings, the patient must leave the ring in for three weeks and remove the ring for the last week of the cycle (Planned Parenthood 2019). Women who choose to skip their menstrual period using the birth control ring have the option to do so, as the ring can be worn for up to four weeks straight (Planned Parenthood 2019). The ring must be changed every four weeks in order to be effective, whether the patient chooses to have their menstrual period or not, failure to do so lowers the effectiveness of the birth control ring to 91% (Planned Parenthood 2019).

Intrauterine Device (IUD). The first intrauterine device (IUD) was designed in 1909, but "was not used widely in the United States until the 1960's when new models were introduced" (Contraception 2008). The IUD is a device manufactured with a small piece of flexible plastic formed into a T shape. The two IUD models offered today may either be wrapped in copper, called a copper IUD, or made to administer the hormone progesterone to the female's

reproductive organs, called a hormonal IUD (Planned Parenthood 2019).

After being inserted by a physician, both the copper IUD and hormonal IUD act as a physical barrier to prevent sperm cells from reaching a female's eggs, as indicated in figure 9 (Planned Parenthood 2019). Aside from physically disrupting conception, both the copper and hormonal IUDs elicit biological responses to reinforce pregnancy prevention. The copper IUD works by inducing a local inflammatory response within the uterus (Contraception 2008). The inflammatory response initiates an increase in leukocytes, white blood cells, present in that area in response to inflammation (Contraception 2008). When the leukocytes break down, the reaction reduces the risk of pregnancy because it kills off nearby sperm cells (Contraception 2008). Women with a copper IUD do not experience any alterations in hormone levels,

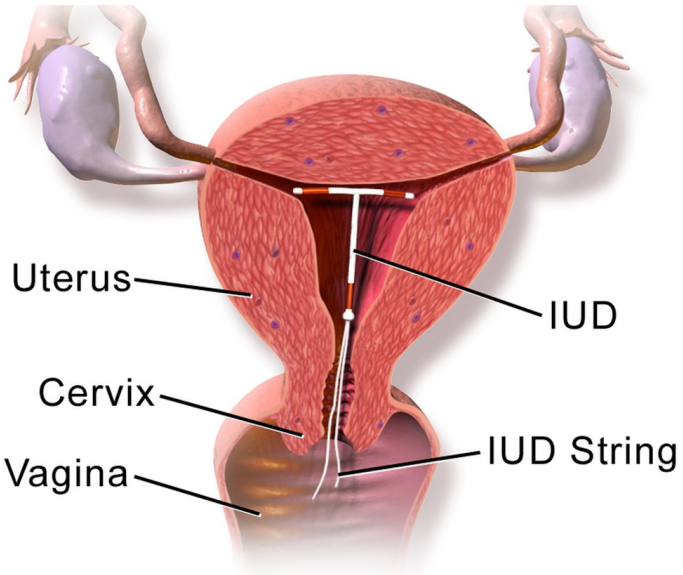

Figure 9— *Intrauterine Device (IUD:* Image retrieved from *The best contraceptives for teens are IUDs and implants. (2015). The Verge. Retrieved 14 April 2019, from https://www.theverge.com/2015/4/7/8364721/best-teen-birth-control-iud-implant-cdc*

so ovulation is unaffected. As a result, these women will still have a menstrual periods (Contraception 2008). The hormonal IUD uses progestin, a synthetic steroid hormone, to prevent

a fertilized egg from implanting in the uterus as a secondary mechanism of pregnancy prevention, eliciting the same process that the birth control pills employs. Progestin also facilitates the thickening of cervical mucus, in addition to inhibiting a women's ovulatory cycle— with no egg to fertilize, pregnancy cannot occur (Planned Parenthood).

When cervical mucus thickens, it creates a naturally occurring barrier to sperm because it is too thick to travel through (Keefe et al 2012). As previously noted, steady levels of progesterone and estrogen naturally inhibits the secretion of gonadotropins (Hormonal Contraception 2019). With out the rise in FSH levels and LH levels, there is nothing to initiate the follicular development and selection of ovulation (Hormonal Contraception 2019).

IUDs are recognized as one of the most effective forms of birth control, where fewer than 1 of 100 people will get pregnant with an IUD— meaning IUD's are 99% effective (Planned Parenthood 2019). IUDs are shown to be very effective forms of pregnancy prevention because the human error is significantly minimized with this form of contraception compared to others. IUDs are implanted one time by a physician and offers pregnancy prevention all day, everyday, for anywhere between three to twelve years (Planned Parenthood 2019). IUDs are unlike contraceptive pills because once the device is inserted, there is no upkeep until the patient chooses to remove it (Planned Parenthood 2019). There are two disadvantages women face when they choose an IUD as their primary form of contraception: women may face anywhere from 3 to 6 months of pain and discomfort induced after the device is inserted, and there is no protection for women from contracting an STD (Planned Parenthood 2019). Typically, an estimated 14% of women choose an IUD as their primary form of birth control out of the 62% of women who use nonpermant methods of birth control (Guttmacher Institute 2018).

Diaphragm. The diaphragm was influenced by Chinese and Japanese cultures who prevented pregnancy using an oiled Bamboo tissue paper disc to prevent sperm from reaching the cervix (Contraception 2008). The earliest model of the diaphragm was developed in the 19th century and made with rubber (Contraception 2008). Since then, the diaphragm has evolved into a shallow, bendable soft silicon cup shaped like a saucer, inserted into the vagina to cover the cervix during sexual intercourse, indicated in figure 10 (Planned Parenthood 2019). The diaphragm is folded and inserted inside the vagina to cover the cervix, acting as a physical

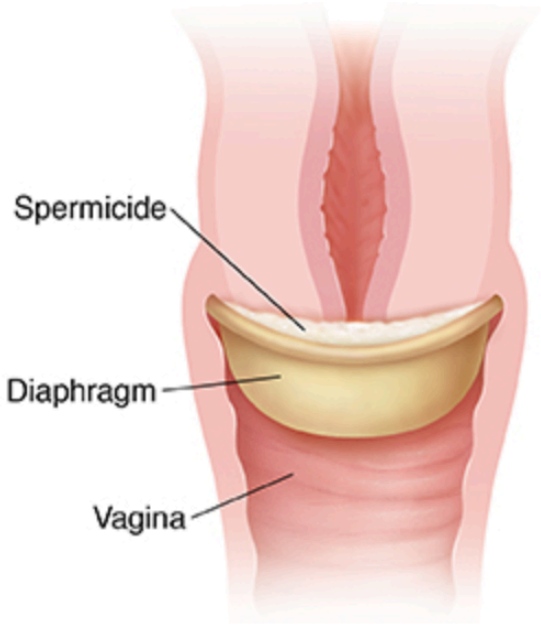

Figure 10— *Diaphragm:* Image retrieved from *Birth Control: Diaphragm and Cervical Cap. (2019). Fairview.org. Retrieved 14 April 2019, from https://www.fairview.org/patient-education/85688*

Barrier between the sperm and egg. In order to get optimal pregnancy prevention, the diaphragm must be used in tandem with a spermicide, a substance developed in the late 1880's to kill sperm cells (Planned Parenthood 2019).

Upon perfect use of the diaphragm, properly inserting the device and using it in addition to spermicide, it is 94% effective (Planned Parenthood 2019). If perfect use is not reached, then

the diaphragm is only 88% effective—meaning that around 12 of 100 women will get pregnant annually (Planned Parenthood 2019). Women who choose to use diaphragms as their primary form of birth control have the advantage of how durable the device is: the device can with stand multiple uses over a two-year period with proper care, and it can be inserted up to several hours prior to engaging in intercourse (Planned Parenthood 2019). The disadvantage to using the diaphragm is that it does not offer women any protection against contracting an STD (Planned Parenthood 2019). Contemporary use of this form of contraception is very uncommon, as "the diaphragm was used by less than 2% of American women who used contraceptives in 2005," a percentage which has since continued to drop (Contraception 2019).

The condom. In it's earliest stages, the condom was not developed for the use of contraception or prevention of STDs—as we understand it today—but for a variety of other reasons. Early Egyptian males used condoms as a form of protection against water parasites, or as a decorative piece to indicate their social standing in a hierarchal society (Contraception 2008). It wasn't until the 16th century, when a widespread outbreak of virulent forms of syphilis spread throughout Europe, that condoms began to take on the role they serve today (Contraception 2008). The earliest developed condoms were made of linen and were only used as weapons against sexually transmitted diseases (Contraception 2008). By the 18th century, condoms were being made from animal membrane, making them water resistant and an effective form of pregnancy prevention (Contraception 2008). A pivotal point in the development of condoms followed the Industrial Revolution; in the year 1837, "condom manufacturers took advantage of the successful vulcanization of rubber, a process in which sulfur and raw latex were combined at a high temperature" to synthesize condoms (Contraception 2008).

The modern condom is a small, pliable pouch made of a variety of materials to accommodate both men and women's biology, personal preferences, and health concerns. The condom can be made of latex rubber, soft plastics (polyurethane, nitrile or polyisoprene) or lambskin (Planned Parenthood 2019). Male condoms are able to prevent pregnancy by creating a physical barrier that captures the sperm ejaculated from the penis and prevents sperm from reaching the female's egg. Internal condoms, also called female condoms, can be used as an alternative to the traditional condom. Internal condoms are small nitrile pouches that can be inserted into the vagina or anus, for partners having anal sex. With vaginal use, the internal condom works similarly to the traditional condom by prohibiting the interaction between the egg and sperm. Condoms, in general, are the only existing method of birth control that protects and reduces a sexual partner's odds of contracting an STD by preventing contact between semen and vaginal fluid, as well as limiting skin to skin contact between partners (Planned Parenthood 2019).

The efficacy of condoms in preventing pregnancy and contracting an STD, depends on the attentiveness of the user. If a traditional condom is used perfectly each time partners engage in sexual intercourse (wearing the condom from start to finish, putting it on an erect penis, and leaving room for semen to collect at the end), then they are 98% effective (Planned Parenthood 2019). Because of human error, though, condom use is rarely "perfect," so efficiency of pregnancy prevention is around 85% – meaning "about 15 out of 100 people who use condoms as their only birth control method will get pregnant each year" (Planned parenthood 2019). The efficacy of pregnancy prevention with internal condoms exhibits the same type of tendency as the traditional condom with regard to attentiveness. If the internal condom is used perfectly

(inserting the condom into the vagina as far as it can go, maintaining the condom isn't twisted, and holding the condom in place during sex), then the condom is 95% effective (Planned Parenthood 2019). If the necessary precautions aren't taken into account, the effectiveness of the internal condom is around 79% (Planned Parenthood 2019).

Male or Female Sterilization. According to the National Center for Health Statistics, male or female sterilization is the second leading form of birth prevention in the United States behind the Pill (Contraception 2008). This method blocks reproductive function altogether, effectively preventing pregnancy. Among the population of individuals who use use sterilization as contraception 22% are females and 7% are males (Guttmacher Institute 2018). Generally, women tend to undergo sterilization more often than men due to the imposition they feel to carry the responsibility of pregnancy prevention. In fact, female sterilization is recognized as "the world's most popular form of family planning. In 2009, 223 million women used sterilizations as birth control," and today this number is still on the rise (Klibanoff 2014). Young women who start their families earlier will often complete the desired amount of children they want. As a result, women undergo sterilization procedures so that they do not have to worry about unwanted pregnancies later on in life.

When a woman is sterilized she undergoes tubal ligation, also referred to as a woman getting her tubes tied. Female sterilization is an hour long procedure that effectively seals a woman's fallopian tubes (Bartz & Greenberg 2008). A small incision is made with the use of laparoscopy in order to access the oviducts and conduct tubal occlusion, the closing of a hollow organ (Bartz & Greenberg 2008). Women who undergo tubal ligation are still able to ovulate and produce eggs, but the eggs are blocked from passage through the fallopian tube (Contraception

2008). As a result of the intentional blockage of the fallopian tubes, the sperm are unable to access the eggs for fertilization so the egg eventually deteriorates (Contraception 2008). It is said that immediately after the procedure, the contraception takes place (Bartz & Greenberg 2008). Women who withstand sterilization often feel a sense of empowerment, as they are able to take on challenges with confidence without the threat of unwanted pregnancy. Because of this, sterile women often take on a renewed sense of empowerment.

The male sterilization procedure is called a vasectomy "in which the doctor seal, ties or cuts the vas deferens (the tube which carries the sperm from the testicle to the penis)" (Contraception 2008). Sterility in men does not take effect immediately following a vasectomy, due to the fact that some mature sperm may still exist in the reproductive tract (Contraception 2008). Sterility in men must be evaluated 12 weeks after the vasectomy or after an estimated 20 ejaculations (Bartz & Greenberg 2008). After being evaluated, partners who undergo sterilization achieve around 100% effectiveness of pregnancy prevention (Planned Parenthood 2019).

Emergency Contraception. The morning after pill was deemed safe and effective by the FDA in February of 1997 (Contraception 2008). Women are typically subject to some form of emergency contraception following unprotected sex. The morning after pill is a drug used to prevent a possibly fertilized egg from reaching the uterus and implanting on the uterine lining (Contraception 2008). It is recommended that women who need to take a morning after pill do so within 72 hours of the unprotected sex in order for the drug to be effective (Contraception 2008). Women who take the morning after pill within this time frame decrease the probability of an established pregnancy by 89 to 95% (Contraception 2008). This percentage effectively decreases when a woman takes more time between taking the morning after pill and the unprotected sex.

The exact mechanism of the morning after pill is still debated, but scientists suspect that large doses of hormones are administered into the body prevents the uterine lining from thickening and impeding implantation (Contraception 2008). Scientist also speculate that the up regulation of hormones may interfere with ovulation and slow the egg's travel through the fallopian tube (Contraception 2008). In some cases, where emergency contraception is necessary, doctors may prescribe their patients with a higher dosage of combined oral contraceptives to elicit the same response as the morning after pill (Contraception 2008). An alternative to the morning after pill is inserting an IUD, specifically a copper IUD (Planned Parenthood). The copper coil of the IUD is able to work as emergency contraception because it elicits an inflammatory response strong enough to kill off cells in the surrounding area (Planned Parenthood 2019). If the IUD is inserted within 5 days of having unprotected sex, it's estimated as 99.99% effective as a method of emergency contraception (Planned Parenthood 2019).

Abortion. Contraceptive methods are never 100% effective, whether it's due to defects in the device, or incorrect or inconsistent use. As a result, unplanned pregnancy can occur, putting partners in the position to decide to carry the baby to term or terminate the pregnancy. Women who choose to terminate the pregnancy must seek out a medical professional who is a licensed abortion provider. In 1973, the United States Supreme Court effectively legalized abortion across the nation in the case Roe v. Wade (Reproductive Rights 2018). The legalization of abortion divided the nation between pro-choice and pro-life supporters, a dichotomy that has influenced state legislature concerning abortion. Prior to getting an abortion, some states require mandatory waiting periods, parental involvement for minors, or that doctors must present graphic material to the mother in efforts to discourage abortion (Contraception 2008).

If an unwanted pregnancy occurs, the mother has two options on how they want to terminate the pregnancy: medical abortion or surgical abortion (Contraception 2008). With a medical abortion, the abortion is triggered by the use of drugs, specifically mifepri-stone approved by the FDA in 2000 (Contraception 2008). This form of abortion is typically used at the earliest stages of the gestational period when pregnancy is initially established (Contraception 2008). Mifepri-stone uses molecules called antiprogestins that inhibit the natural biological effects of progesterone (Contraception 2008). If prosterone's effects are inhibited, the uterine lining is no longer biologically supported—the uterine lining softens as degrades leading to menstruation (Contraception 2008).

According to the Gale *Encyclopedia of Science,* "A surgical abortion is the only type of FDA-approved abortion currently available in the United State; in some states it is very difficult to obtain" (Contraception 2008). This type of abortion service is offered only in hospitals and clinics to mothers who have not developed past the 12-week gestational period (Contraception 2008). A surgical abortion most commonly enlists a suction technique called vacuum aspiration to remove the contents of the uterus (Lohr et al 2014). If a woman reaches the gestational period beyond 15 weeks, the process becomes increasingly complicated due to the size of the fetus in the uterus (Contraception 2008). Women who have an abortion generally experience post-procedural bleeding for up to seven days following the procedure, as well as cramping (Contraception 2008).

Maternal Instinct.

It can be said for many women that experiencing pregnancy is an important aspect to their gender identity (Catsanos, Rogers, Lotz, 2013). The ability to bear a child is central to a woman's biology; as women, they carry the responsibility to bring a child into the world. Although childbirth is significant to a woman's identity and an important experience to some, it is easy to become distracted by the idea of an opportunity at the unattainable. This is supported in the way that "Research indicates that patients seeking innovative surgery or treatment typically focus on the perceived benefits rather than the possibility of complications or failure, particularly when the stakes are high" (Catsanos, Rogers, Lotz, 2013).

In some cases, "…gestational ties play a significant role in forming motherhood. For many women parenting without pregnancy will leave a significant void" (Orentlicher, 2012). This strong emotional drive to fulfil the journey of motherhood often acts as a hindrance to understanding the reality of the physiological and emotional risks and failures associated with assisted reproductive technologies. Many women place a large emphasis on becoming a mother and beginning a family without providing more background as to why. Is the simple response "Because I want kids" sufficient enough to answer the question as to why so many women feel the obligation to have children? Is maternal instinct an ideology that is biologically driven, or a result of societal influence? It may be safe to say that both biology and culture make contributions to female reproductive behavior.

At present, Earth is compromised of 99% of multicellular organisms that reproduce sexually (Cumming 2016). All organisms have the inherent drive to obtain a sexual partner, posing the question as to why the process has evolved the way it has. The relationship between

sexual intercourse and the preference to have a child posed a challenge even for Charles Darwin, the father of evolution. His confusion was evident when in 1862 he wrote, "We do not even in the least know the final cause of sexuality; why new beings should be produced by the union of the two sexual elements. The whole subject is as yet hidden in darkness" (Cumming 2016). All sexually reproducing organisms, no matter what species, all share the same goal evolutionarily speaking—two members of an identical species will merge their DNA and produce offspring with an entirely new genome (Cumming 2016). Sexual reproduction allows multicellular organisms to create variability in genetics and biological traits for future generations— an idea essentially describing the basis for Charles Darwin's theory of evolution. Although humans could be considered animals on a fundamental basis, we are intellectual beings who, for the most part, act based on logic rather than biological urges.

As far as modern scientists know, reproduction is not an inheritable trait; there is no gene, or set of genes, within our genetic makeup that code for whether an individual inherits the preference to have children. Historically, sex and reproduction have been shown to go hand in hand. However, with the developments in contraceptive technology, humans are able to have sex with their partners without having children. As a result, biological evolution is being challenged by contraceptives, as sexual activity is no longer considered tied to the maternal instinct to have children (Elgar 2015). Now that sex and reproduction can be viewed independently of one another, it is easier to observe whether or not women choose to become mothers or not; what pressures, if any, influence a woman to have children? It can be said that females posses a type of maternal instinct that ensures a mother's ability and need to nurture the child, a trait that is "facilitated by the release of certain hormones and other necessary biological changes" (Elgar

2015). Although women have an inherent nature to nurture, there isn't an associated biological trait that pushes mothers to have children (Elgar 2015). The two biological traits that have ensured reproduction are the biological urges to have sexual intercourse and subsequently nurture their offspring, the preference to have children thereby lies between, but is not encoded in our genetic makeup.

So if it it is not biological urges that indicate a woman's preference to have children, the influencing factors must result from social impacts. Simone de Beauvoir, a French writer, contended that "women are repeatedly told from infancy that they are 'made' for childbearing" (Singh 2005). The "splendors of maternity" are continually reinforced in which societal and familial institutions portray motherhood as the end all be all (Singh 2005). Maternal ideals are valorized in patriarchal societies, upholding the idea that a woman's central purpose is to bear children—as a result, mothering becomes entwined with female identity. This type of pervasive socialization frames a young women's state of mind to desire, and choose the path of, motherhood.

Throughout the course of history, patriarchal culture has defined, influenced and determined a women's maternal experience, regarding motherhood as a sacred and powerful path for women to take. Through a variety of institutions created by male authority, such as religion, art, medicine and psychoanalysis, motherhood is often objectified. Instead of having true autonomy over their future, the voice of the mother is often silenced (Singh 2005). Women were not included in established cultural institutions, and as a result they experienced an absence of subjectivity (Singh 2005). For example, religious scriptures sentimentalize and idealizes motherhood. Cultural and societal institutions built on male authority have defined a women's

femininity, where women women must have the instinct make themselves nurturers. Under this definition, the assumptions associated with femininity ultimately shape a women's social practices to automatically assume the responsibility of being a caregiver.

According to the *Encyclopedia of Children and Childhood: In History and Society*, "In 1800, the average family raised seven children to adulthood; by 1900, that number had shrunk to three or four" (Grant 2004). Because there were fewer children in the home, as well as fewer productive responsibilities, child rearing became the primary focus of a women's work in the home (Grant 2004). Within Western societies, specifically after postwar years, women were encouraged to conceive large families—a task intended to award women with satisfaction and pride in motherhood. Women who chose to be full-time mothers were associated with the highest nobility and respect, but still deemed inferior to male pursuits (Singh 2005). Ultimately, the institution of motherhood was both idealized and vilified by the society establish by men.

Because women were forced to succumb to the gender roles imposed upon them by male authority figures for generation after generation, the definition of mothering and its associated assumptions were intersected with womanhood (Singh 2005). This intersection is drawn from the notions conceived by the nature and culture of society. These notions ultimately unify certain aspects of motherhood with a women's virtue and authenticity (Singh 2005). The entanglement between womanhood and motherhood can be proven in how some stay at home fathers are recognized in the home. Typically, "men who undertake basic childrearing and caretaking activities are in some ways 'mothers' rather than 'fathers'" (Singh 2005). Rather than defining childrearing simply as parenting, it becomes gendered to align with societal constructs.

Presently, one largest contributing factor to the pressures women face is the media. The media reinforces the old age "happily ever after" idea, and as a result, women often find themselves equating their sense of womanhood with motherhood (Ashouri 2013). Pop culture reinforces the expectation of women to have children, as many times movies, television programs, and literature, among other things, demonstrate having children is the key to happiness (Ashouri 2013). The linkage between motherhood and womanhood is an age old habit set for the by the archaic practices and traditions of hierarchal societies. Because of this, women have adhered to social traditions and expectations for centuries out of habit, succumbing to the responsibilities of motherhood without considering if childbearing is actually a priority.

Because early American societies used motherhood as an index to define "real" women, the cultural expectations and assumptions associated with motherhood have generated intense contemporary social pressure for women to conform to them. In many ways, motherhood is regarded as a prerequisite for social acceptance. When women choose not to have children, or can't have children due to problems with infertility, women experience feelings of rejection and low-self esteem (Singh 2005). Despite the historical tendencies, 21st century motherhood has taken on a new meaning, as women are reclaiming their sense of self and individuality. With the advancements in modern day medicine, such as the Pill and other methods of contraception, the legalization of abortion, and feminist movements arising abundantly across the nation, some of the most extensive developments have taken place in present-day American society. These movements and technologies contribute to and preserve a women's ability to decide when, if at all, they want to have children and under what circumstances.

Putting Off Having Children

Now that contraception (birth control, condoms, and morning-after pills) has been made more accessible to across the nation, in addition to the legalization of abortion, women can test whether maternal instinct is strong enough to influence them to have children. Because these advances in medical technology have been made available, women are able to effectively put off having children. In analyzing the demographics of women giving birth in today's age, there are notable trends across various age groups who are giving birth. For example, according to the CDC's *Births: Provisional Data for 2017*, for women ages 15-19 the birth rate has decreased substantially, more than likely due to the prevalence of birth control and other methods of contraception. Specifically, "The rate has declined by 55%, or nearly 8% per year, since 2007" (Hamilton et al). As the number of teen pregnancies have significantly decreased over the past decade, the number of provisional birth rates rose for women aged 35 to 39 as well as 40 to 44 (Hamilton et al). For the age group of women between the ages of 35 to 39, the birth rate for this age group has risen each year, from the year 2011 to 2016 (Hamilton et al).

Entering into motherhood has stood as a significant milestone in a women's life for many centuries. In analyzing the last several decades, the age range of childbearing women of the United States has shifted significantly from primarily early to mid twenties, to an even distribution of of childbearing women between the ages of early twenties to mid thirties shown in figure 11 (Bui & Miller 2018). Modern studies show that first-time mothers are of an older demographic in large cities and on each coast, but of a younger demographic in rural areas, the Great Plains, and the southern states (Bui & Miller 2018). For example, in San Francisco the average first-time mother is 32 years old, and in Todd County in South Dakota it is 20 years old

(Bui & Miller 2018).

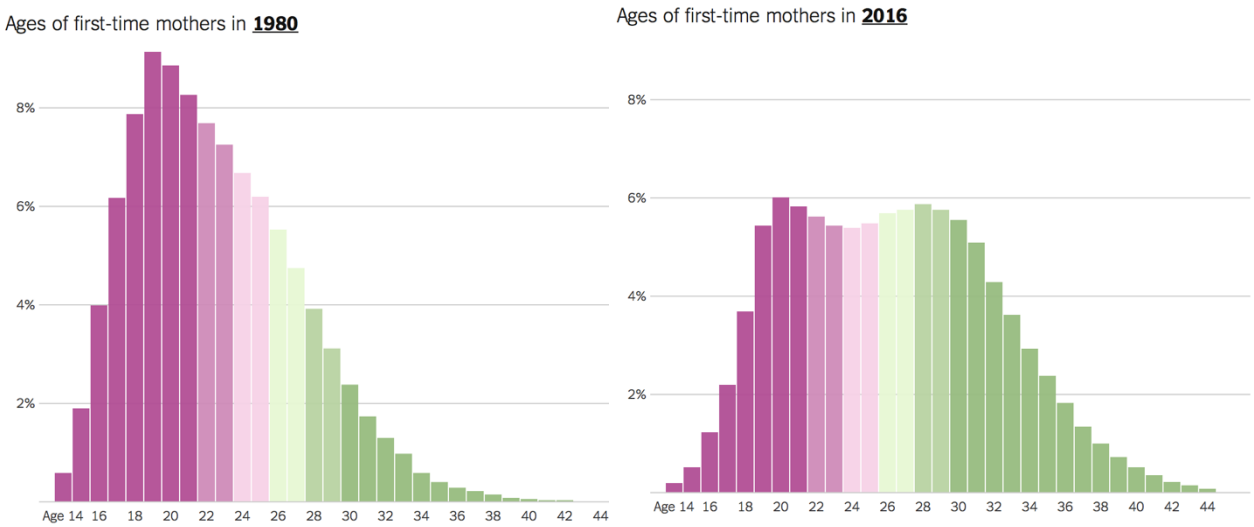

Figure 11—*First time mother age demographic 1980 vs 2016:* Image retrieved from Bui, Q., & Miller, C. (2018). *The Age That Women Have Babies: How a Gap Divides America*. *Nytimes.com*.

The age demographic of first time mothers has adapted to the modern state of differing socioeconomic statuses across the United States. Researchers have found that the difference in age of first time mothers is attributed to the nation's inherent inequality (Bui & Miller 2018). It is becoming increasingly difficult in today's labor industry to move up the economic ladder, an element that mother's must consider due to the fact that socioeconomic circumstances play a large effect on the prosperity of their child's future. Prior to entering motherhood, mothers often speculate how ready they are to support a child, both financially and otherwise. Presently, a college degree is viewed as increasingly essential to earning what is considered as a middle-class wage (Bui & Miller 2018). According to the New York Times, college is considered a stronger factor in affecting a women's age when she has her first child, more than geography or home prices (Bui & Miller 2018).

In present-day, married couples of the United States have very similar educational and

career backgrounds, more now than ever. Although the husband typically earns more in the work force than his wife as a result of the gender wage gap, immediately after a woman gives birth to her first born, the pay gap between spouses doubles (Miller 2018). This increase in wage gap is due entirely to a substantial hit to the mother's salary, as the husband's wages continue to rise (Miller 2018). Economist Danielle Sandler, a senior economist of the Census Bureau reports that "women earn $12,600 less than men before children are born and $25,100 less afterward" (Miller 2018). This increase in wage penalty is largely attributed to the amount of time that having a child requires, as mothers have historically spent disproportionately more time childrearing compared to the. As a result, mothers are more likely to reduce their work hours, take time off, turn down a promotion or quit their jobs to care for a family.

Additionally, the U.S. does not require that employers offer paid parental leave to mothers, so for the weeks that a new mother is tending to her newborn, she is being penalized for her time away. Women face a large disadvantage in family planning as they are forced to choose between success and wage equality in the work place, and building a family. Because mothers face such a tremendous wage penalty, many pursue advancing their careers prior to giving birth, as recent studies have indicated that between the years of 25 to 35 are "prime career-building years and the years when most women have children" (Miller 2018).

In the fight to earn financial equality, more and more women are attending institutions for higher education, such as community college, 4-year colleges, graduate school, or pursuing a doctorate degree. Recent studies have indicated "where men once went to college in proportions far higher than women – 58 percent to 42 percent as recently as the 1970s—the ratio has now almost exactly reversed" (Marcus 2017). According to the U.S. Department of Education, is was

determined that in the fall of 2018, 56% of students on campuses for higher education were women (Marcus).

In many ways a degree is the golden ticket into the labor market. Presently, Americans place a very high value on completing a degree, but 66% of Americans also believe that receiving a post secondary education can reap benefits even if the education does not result in a degree (Trostle 2016). This claim can be supported by recent research, which shows that for every one year of education attended beyond the high school level, the college wage premium (individual earnings receive after a collegiate level education) increases by 4 to 8 percent (Oreopoulous & Pertronijevic 2013). By attaining a degree and overall extension of secondary education, women are able to maximize their lifetime earnings by delaying motherhood. Typically parents who have attended college are older, have more years of education, and more time to earn money that may ultimately be invested in extracurricular activities, tutoring opportunities, access to quality education, and college savings accounts for their children. The availability and access to such resources and how heavily a parent can invest into them can set children on very different paths towards a multitude of fates (Bui & Miller 2018).

Presently, more women are choosing to pursue their education and careers, delaying motherhood so that they may be successful and financially stable for their first born. This choice is regarded as a social phenomenon described as the tendency for modern Americans to commit to marriage and/or only childbearing at a later age in life (Carson-DeWitt 2008). Women are putting off this chapter of their lives in order to prioritize other facets of their life. Scientific studies conducted during the 2000s indicated that infertility has increased a whopping 177% since 1982, primarily due to this social phenomenon (Carson-DeWitt 2008).

Women who make their first attempts at pregnancies at older ages, 35 years old or above, face increased health risks associated with pregnancy: gestational diabetes, high blood pressure, preeclampsia, placenta previa, miscarriage, premature birth, stillbirth, need for cesarean delivery, heavy bleeding after delivery, infant low birth weight and/ or chromosomal abnormalities (Watson 2018). Despite the associated health risks older mothers face, more women are choosing to delay motherhood. Even so, some women may feel the effects of the social phenomenon and do not choose the path of motherhood at all— a decision typically based on their aspirations for successful careers and higher education, among other reasons.

Childless Women

According to the CDC's *Births: Provisional Data for 2017*, "The provisional number of births for the United States in 2017 was 3,853,472, down 2% from the number in 2016 (3,945,875) (Hamilton et al 2018). Although 2% could seem relatively insignificant and rather the natural fluctuation of birth rate from year to year, 2017 was the third year in a row that the overall number of births have declined, after a small increase of the birth rate in the year 2014 (Hamilton et al 2018). This is significant data point because 2017's number is the lowest provisional number of births in 30 years from 1987 (Hamilton et al 2018). This indicates that over the last three decades, women are making the conscious choice not to have children.

With the help of contraceptive methods and the legalization of abortion, women have more control over their family planning. There are a variety of factors that influence women and families to not choose motherhood. In today's society women are prioritizing their careers and educations. This social phenomenon could be enough to deter women from becoming mothers

altogether. The New York Times quotes Heather Rackin, a sociologist who studies fertility at Louisiana State university, that women of a higher socioeconomic status "have more potential things they could do instead of being a parent, like going to college or grad school and having a fulfilling career. Lower-socioeconomic status people might not have as many opportunity costs – and motherhood has these benefits of emotional fulfillment, status in their community and a path to becoming an adult" (Bui & Miller 2018).

For some women, having a child just isn't feasible. The U.S. Department of Agriculture reports that the average cost of raising a child between birth and 17-years-old is $233,610 (Smith 2018). However, this number does not account for inflation costs caused by economic variation. When inflation is taken into account, the amount increases to $284,570 (Smith 2018). This price tag only accounts for mothers who are capable of naturally reproducing. The cost for mothers who struggle with infertility carry a larger economic burden due to the considerable financial obligation associated with ART. For many, this economic responsibility can infringe upon the quality of life of either parent, as well as the child. If the family does not have sufficient means to provide and support both themselves and a child, this can ultimately determine family planning for the parents. Additionally, some couples may find love later on in life or choose not to marry at all. Partners who get married or enter into a long term relationship at older ages not only affects if the women can conceive her first child, but also whether or not the couple will have children altogether.

Presently, a significant percentage of American women are choosing childlessness. For example, 53.8% of women between the ages of 25 to 29 years old were childless in 2016, compared to 30.8% in 1976 (Brown 2019). Women between the ages of 30 and 34 exhibited a

similar increase in childlessness between 2016 and 1976, 30.8% and 15.6% respectively. These statistics, though, are beginning to prove that the universality and glorification of motherhood is a myth. Women across the globe are proving themselves to exist as indivuals, independent of the image bestowed upon them by societal constructs. Women are multidimensional beings who embody their individuality and defy the super-construct placed upon them. In the modern era, women are fulfilling other roles and self-perceptions aside from being a mother, shuffling their priorities in spite of the societal pressures that culture, climate and class have established for motherhood. In surveying the social landscape of the modern era, feminist movements have become more prevalent in efforts to effectively combat this gender associated myth.

ETHICAL IMPLICATIONS

At present, millions of people are affected by infertility worldwide. Infertility can affect both men and women, serving as a source of psychological and social suffering. Such a diagnosis can induce stresses and challenges fore a partnership. People with who are diagnosed with infertility perceive their biological suffering as very real pain, compromising to both their mental and physical health (Schenker 2011). As a result of the advances made in medical technology, specifically ART, couples who previously wouldn't know the joys of being biological parents are now able to bring home healthy newborns. Although these technologies and techniques are both impressive and cutting edge, ART possesses many ethical dilemmas that can be analyzed through the four principles of principlism: autonomy, nonmaleficence, beneficence, and justice.

Assisted reproductive technologies have been in practice as a medical treatment for over 25 years (Schenker 2011). Infertility treatments provided through ART have redefined what it

means to be a parent, as the process of building a family becomes increasingly complex. Despite a women's preference to beget a biological child, ART is regarded as ethically controversial due to the harmful consequences it poses for children in need of adoption. In funding and supporting assisted reproductive technologies, it fails to prioritize the needs of the most vulnerable—children without parental caretakers (Leighton 2014). When indivuals, partners, or families choose ART over adoption, they are breaching the ethical principle of beneficence, the moral obligation to do good for the greater good.

According to the Children's Rights, an organization for the cause of children in the foster care system, "On any given day, there are nearly 443,000 children in foster care in the United States" (2019). In the year 2017, the number of young people "aged out" of foster care without permanent families exceeded 17,000 individuals (Children's Rights 2019). Choosing ART over adoption is viewed as ethically problematic because families are choosing methods and procedures that are "medically unnecessary" and a "luxury service" to produce offspring that is not guaranteed, over providing a home to an existing and disadvantaged children (Ryan 2003). Research has shown that individuals who leave the welfare systems without being adopted experience an increased likelihood of encountering homelessness, unemployment and incarceration as adults (Children's Rights 2019). Instead of being adopted into a nourishing familial environment, children of the welfare system may not reach their full potential.

Partners who choose ART over adoption are reinforcing the socioeconomic gap between classes. If indivuals have the economic means to choose ART, they also have the means to adopt from the welfare system. Offering a home to a child without one contributes to beneficence by doing good for the greater good: offering better opportunities to the disadvantaged and

maintaining the children do not enter into poor socioeconomic status. Choosing ART over adoption also breaches nonmaleficence, the moral obligation to do no harm, for the same reason that it breaches beneficence; children who are not adopted are already at a disadvantage when entering into the general population. Nonmaleficence goes hand in hand with the violation of beneficence because by not doing good, we are inflicting harm. Many times children in the welfare system are bounced from foster home to foster home, ultimately being abused by the system put in place to protect these children. In the absence of a stable family and environment, children in the foster care system can suffer psychological effects, ultimately inflicting harm. Along the same lines, ART breaches the ethical principle justice. Justice is the granting and fulfilment of legitimate rights of others, or, in simpler terms, equality. Without a parental caretaker, these minors have limited rights. They are subjected to adhere only to the authority of the welfare system, which limits certain freedoms other children can experience.

ART may be as be regarded as unethical outside of its comparison to adoption because it breaches beneficence, nonmaleficence and justice. Women with infertility may be diagnosed as a result of a medical condition. Because these women are biologically compromised, it can expose similar or other health related risks to their child if they choose to undergo ART, breaching nonmaleficence as it will disadvantage the fetus. Additionally, treatments associated with ART are, in most cases, invasive so it inflicts physical harm on the female patient.

Although some insurance companies can cover certain ART procedures, only individuals of a higher socioeconomic status will be able to afford these “luxury procedures. This negatively affects society in that it would be funding a technology devoted to promoting social hierarchy. With ART in circulation, those of a higher socioeconomic status will be the only ones with

access to this revolutionary technology. This presents problems, as the disparity in classes will become larger and create an irreparable divide.

Under the principlistic lens of beneficence—do good for the greater good— allowing ART such as PGD to extend beyond just eliminating genetic conditions may, in theory, benefit society as a whole. Embryos with problematic conditions, whether they be chronic genetic conditions or terminal genetic illnesses, would benefit from the constant treatment.

On the other hand, though, IVF used with PGD implores the morality involved, without the regard of how it may affect society in the long run. If scientists allowed the commercial use of these technologies and used it as a means to select for physical and intellectual traits, these designer babies would become a prevalent issue by reinforcing the class system. PGD presents the largest ethical issue because it presents the idea that researchers are "playing God"; the science of PGD can manipulate the body for the intention of creating the ideal child. This type of control may lead to a slippery slope in which we may try to enhance humans beyond "normal" human ability and reach a super human level. PGD begs the question of where researchers should draw the line; this predicament ultimately places those in charge of the IVF/PGD movement, as well as the citizens of society, at a greater risk for problems in the future.

Despite the fact that ART is not ethical when compared to adoption or other societal establishments, there are other ethical implication still to consider. In 1948, the United Nations Universal Declaration of Human Rights proclaimed that the right to procreate is a basic human right, "men and women of full age, without limits due to age, race, nationality, or religion, have the right to form a family" (Schenker 2011). With this declaration, ART is ethical under the scope of autonomy, the recognition and acceptance of the free choice of an individual. Women

should be granted the right to use the technologies available, as all persons have rights to biologically reproduce if their bodies see fit.

Employing the right to take control and choose what you can and cannot do to your body is a central and important idea in present day society. Autonomy is especially essential for women who are trying to reclaim their reproductive rights. Assisted reproductive techniques offer more than just the outcome of genetic offspring, but an achieved desired identity. These medical treatments are prime examples of individuals exercising their autonomy to achieve a certain level of emotional wholeness associated with conceiving a biological child. Breaching the right to access viable technology violates the justice aspect of principlism. Since ART procedures and treatments have reached circulation as viable medical options, every individual should have the opportunity to seek out and acquire its benefits.

LIMITATIONS

This study has various potential limitations, largely in part due to the time constraint of one year. For this reason, many of the topics did not get as much attention as some deserved. Such topics include specification of reproductive rights set forth by state laws, further exploration of the health risks associated with older pregnant women, discarding unused embbryos, and the bioethical analysis of the various forms of contraceptive, abortion, and fertility treatments discussed in the second section of this study. In the future I would hope to overcome these limitations by exploring the ethical implications of each form of contraception, abortion and infertility treatment, as they each pose their own benefits and disadvantages.

Additionally, I spoke generally about women, and in the future would like to examine how infertility affects women based on race, as well as socioeconomic status. Throughout the study I largely focused on presenting overarching concepts and pivotal moments in reproductive history in order to provide a well-rounded analysis of Infertility

CONCLUSIONS

Over the course of millennia, female reproduction tendencies have adapted to fit the social, political, and familial environment. Due to the fact that a women's identity has since changed from the dawn of early civilizations, sex is no longer just a means to a child, but an empowering act for women. Various changes in reproductive rights for women throughout history have since allowed women to exercise their reproductive freedoms. Contemporary women are able to use the resources at their disposal to plan their families as they see fit. This can be accomplished using revolutionary forms of contraception such as the birth control (pill, shot, implant patch, or ring), intrauterine device (IUD), diaphragm, condom, sterilization, emergency contraception, and abortion.

For women who struggle with fertility, society has also evolved in their favor, as clinicians have invented innovative and advanced treatments and technologies to treat women with various forms of infertility. Infertility can be challenged and overcome through procedures and treatments under ART. Such procedures include therapuetic intrauterine insemination (IUI), in-vitro-fertilization (IVF), pre-implantation genetic diagnosis (PGD) in ART, gamete intrafallopian transfer (GIFT) and zygote intrafallopian transfer (ZIFT), and uterine transplants.

Women who cannot conceive and subject to ART are often met with feelings of shame and depression, since they lack the ability to naturally reproduce. Whether their distress arises from the failure to meet a social expectation or from an inherent maternal instinct, many women experience various detrimental effects following episodes of infertility. Women who seek out ART due so in order to obtain the ability to naturally reproduce. In choosing to participate in ART treatments and technologies, women, partners and families must consider the ethical implications ART poses. These treatments ultimately alter a women's natural biology for the benefit of her right to autonomy. Despite the ethical drawbacks of ART with regard to society as a whole, ART offers a promising future in the medical field and should be permitted, along with other reproductive treatments and technologies to maintain a woman's right to her body.

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