Life's Greatest Miracle (2001), by Julia Cort and NOVA [1]

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The Public Broadcasting Station (PBS) documentary Life's Greatest Miracle (abbreviated Miracle, available at http://www.pbs.org/wgbh/nova/miracle/program.html [4]), is arguably one of the most vivid illustrations of the making of new human life. Presented as part of the PBS television series NOVA, Miracle is a little less than an hour long and was first aired 20 November 2001. The program was written and produced by Julia Cort and features images by renowned Swedish photographer Lennart Nilsson [5]. It comes as a sequel to the award-winning 1983 NOVA production, The Miracle of Life, which exhibits Nilsson’s photography as well. The program showcases a combination of graphic animation, endoscopic and microscopic footage, as well as the story of a couple who are expecting a child. It features a number of new technological and scientific developments not present in its prequel, providing additional relevant information. By depicting human development in a clear and fresh manner, Miracle helps shed light on this indispensable aspect of life. Following is a description of the documentary, highlighting the key points of the film and explaining images featured in it.

Miracle is divided into eight sections. Section one, titled ?Passing on Your DNA,? opens with a discussion of the prodigious natural drive to reproduce. This universal drive is recognized as a unifying theme for life on earth, and DNA is identified as the four-billion-year-old mastermind behind the entire operation. Sexual reproduction, unlike asexual reproduction (cloning [6]), practiced by most bacteria, results in gene shuffling and produces crucial variation. The discussion of the biological benefits of sexual reproduction is accompanied by the depiction of various organisms going about their reproductive processes. Recognizing the complexity of such processes, the film poses the question of what happens, and how? How, from such humble beginnings, do such complex and functional living systems arise? A closer look at the human testis begins to answer this question; detailed photographs reveal the tiny, coiled tubes that make up the male organ. These tubes produce about a thousand new, genetically unique sperm [7] every second through meiosis [8], which is digitally animated in Miracle and explained in the context of its significance to sexual reproduction.

After discussing the process of gamete production and the importance of sexual reproduction, Miracle takes a closer look at mating and the female reproductive system in section two, ?The Egg's Journey.? This section opens with Melinda Tate Iruegas and Sergio Iruegas, a couple expecting their first child. Intermittently throughout the film, the couple discuss their experiences, hopes, and feelings during the various stages of Melinda’s pregnancy [9]. Miracle then explains the significant differences between male and female reproductive systems. While Sergio, like all other healthy males, has been producing sperm [7] continuously since puberty, Melinda’s eggs all formed when she was a fetus [10]. A woman Melinda’s age (early thirties) has a few thousand left of her original millions of eggs, but normally only one is capable of fertilization [11] each month. Vivid video illustrates how a single egg [12] is selected, pampered by support cells in the ovary [13], and ushered into the fallopian tube where it awaits fertilization [11] by sperm [7]. Before any male may mate with a female and fertilize her egg [12], however, he must earn mating rights. Here, Miracle depicts the struggle between males as
they vie for the chance to mate with a female, essentially competing for a chance to pass on their genetic material. The film explains that when a male succeeds in wooing a female and proceeds to mate with her, a series of chemical changes take place, culminating in the ejaculation of sperm [7], which allows for fertilization [11] of the egg [12]. The course of the sperm?s voyage is covered in the following segment.

Section three, ?The Sperm?s Journey,? describes just that. Though the sperm [7] encounter a number of obstacles on their adventure, their ultimate success is largely dependent on the woman?s body. Once ejaculated into the vagina [14], the sperm [7] strive to escape the acidic environment; about 40% of the sperm [7] of a healthy male will be able to propel themselves toward the cervix [19] using their flexible, whip-like tails. Around the time of ovulation [16] each month, the protective mucus cap of the cervix [15] liquefies, creating channels that allow any present and able sperm [7] to enter. In addition, the uterine muscles contract in a wave-like fashion to help the sperm [7] progress into the fallopian tube. If the female has ovulated and an egg [12] is present, the sperm [7] that have traveled thus far will attempt to fertilize it. As the film points out, however, the sperm [7] that fertilizes the egg [12] is usually not the first sperm [7] there, but rather one of those that were caught in the fallopian cilia, modified, and gradually released. Once these sperm [7] reach the egg [12], they must get past the helper cells and penetrate the thick protein coating of the egg [12], called the zona pellucida [17]. Through animation, Miracle explains that entry into the egg [12] requires chemical forces as well as mechanical ones; that is, the proteins on the surface of the sperm?s cap must match up with the proteins of the zona pellucida [17]. Once this match occurs, the cap disintegrates and the membranes of the two gametes fuse, introducing the sperm?s genetic content into the egg [12] itself.

After capturing fertilization [11] in words and images, Miracle continues with section four, ?The First Two Weeks.? Despite successful fertilization [11], a majority of fertilized eggs still fail to become viable [16] offspring, since a number of additional obstacles lie ahead. During the next five days, the fertilized egg [19], still locked in the zona pellucida [17], makes its way to the uterus [20], undergoing repeated cellular division along the way. Once in the uterus [20], the mass of cells now known as the blastocyst [21] secretes enzymes that break open the zona pellucida [17] and is seen escaping onto the uterine lining. Here, it negotiates with the mother?s immune system, convincing it that it is not a harmful foreign body. After suppressing the maternal immune system response, the blastocyst [21] implants in the rich uterine lining, from which it receives nourishment. Some, like Melinda Iruegas, report experiencing morning sickness and nausea at this stage, as the baby makes a more significant impact on their body. Sergio experiences similar symptoms, even though he has neither uterus [20] nor a baby inside him.

Once implantation [22] has occurred, the blastocyst [21] undergoes a number of transformations through the process of gastrulation [23]; this is the beginning of section five, ?The Embryo Takes Shape.? While Miracle is able to depict frog [24] gastrulation [23] since it occurs in a transparent egg [12], human gastrulation [23] remains invisible and is explained through animation. The formation of the three germ layers [25] and an explanation of their future structures serve as a prelude to a more in-depth examination of differentiation [26]. In utero photos of a three-week-old embryo show the beginnings of the neural tube [27], and subsequent photos of a four-and-a-half-week old embryo show early development of the brain. Other developments around this time, such as the formation of blood vessels, a beating heart, the primitive backbone, and appendage buds, are also depicted. Recognizing the incredible complexity of such a cascade of events, Miracle once again turns to the micro?the DNA?to explain the macro?the formation of a complex organism. The film explains that
various cells in the body are different because different genes turn on; the turning on of genes by certain proteins is animated for clarification. It is thought that once a basic body plan has formed, the cells develop in accordance with their location in this layout. The cells communicate with each other using chemical signals, and the resultant gene expression allows for the production of different proteins that serve various functions in the body; an explanation of some of these proteins is also provided.

The next section, ?Messages in the Genes,? highlights the importance of the genes to the development of various features of the embryo, including its sex. An ultrasound of the Iruegas? fetus shows it moving around and its heart beating, while the couple discusses their decision not to find out the sex of their child. At this early stage of development, males and females are anatomically identical. In fact, before the formation of distinct sex organs, the only way to tell is by looking at the twenty-third pair of chromosomes: if both are X chromosomes, it?s a girl; if an X and a Y, it?s a boy. Miracle demonstrates how the SRY gene, which is found on the Y-chromosome and is only active for a couple days during the sixth week of development, initiates a cascade of reactions that produce a male child. If the Y chromosome?and thus the SRY gene?is not present, the embryo will develop into a female. Other genes, such as those directing growth or cell death, are also described. By the end of section six, two months have passed since fertilization and the embryo is now considered a fetus. It has taken shape, but still needs to grow and develop into a full-fledged baby.

As the fetus continues to mature, section seven, ?Feeding the Growing Fetus,? discusses the nutrition of both the mother and the fetus. Melinda describes her need to smell and approve of any food before she consumes it, making it somewhat difficult to make dinner plans. Meanwhile, the fetus gets all of its nutrients and oxygen from its mother?s blood, via the placenta and umbilical cord. Images of the placenta?s villi, which absorb materials from pools of enriched maternal blood, help explain how the fetus is fed without contact between its own blood and the mother?s.

Bone replaces some of the fetus?s cartilage during the fourth month of development, and the fetus also begins to hear sounds. Melinda and Sergio Iruegas therefore take pleasure in playing different types of music and sounds to their child and gauging its reactions. The final part of this section consists of a succession of photos of the developmental process, documenting various features from different angles. This timeline intricately illustrates the unfolding human form and emphasizes the details of each stage.
The final section, "The Third Trimester," details the progression of events leading up to birth, and the "miracle" of birth itself. By the third trimester, the fetus has formed all of its organ systems and is primarily growing in size. In preparation for birth, fat reserves are established throughout the fetus's body, and myelination (deposition of myelin on the axons of the nerve cells) begins. Myelination greatly increases the speed and efficiency of brain and nerve impulses. Miracle points out that as the third trimester nears its end, the baby's hunger for fat becomes so great that the supply coming through the placenta becomes inadequate. It is at this point that the baby needs to leave the womb; in other words, to be born. The film shows the birth of Melinda's baby and explains the process. It also states that since human births are extremely dangerous due to the size of the baby's skull and the narrowness of the birth canal, humans are the only mammal that regularly gives birth in the company of others. In showing the birth, Miracle involves the viewer in the emotion and joy felt by the family upon the arrival of their child.

Life's Greatest Miracle is available on the PBS website, along with a number of other related resources. These include "Windows on the Womb," a discussion of the various modern screening techniques used by medical professionals to assess the progress of the baby while in the uterus; a discussion of the stem cell debate; an explanation of how cells divide and how sex is determined; and a journal by a woman describing the various aspects of her pregnancy. The companion website to the film also provides other resources for curious minds.

Miracle's prestige comes not only from its content, but also from its being a NOVA production. It has earned countless awards, among them numerous Peabody and Emmy awards. Julia Cort, the writer and producer of the documentary, won the 2001 Science in Society Journalism Award for her work on it. Since it follows the entire process of human procreation, Life's Greatest Miracle is a useful resource, providing the public with accurate information about what goes on in the world of the embryo and fetus.

Sources


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