George Otto Gey (1899-1970) [1]

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George Otto Gey was a scientist in the US who studied cells and cultivated the first continuous human cell line in 1951. Gey derived the cells for that cell line, called the HeLa cell line, from a woman called Henrietta Lacks, a Black woman who had cervical cancer. Cell lines are a cluster of cells that continuously multiply on their own outside of the organism from which they originated. Gey developed new techniques for *in vitro* [4], or laboratory-based, maintenance of organs and hormonal tissue, created new methods for cell cultivation, and researched nutritional media, or cell food. Much of his research involved tissue culture, which is the process by which cells are grown under controlled conditions. He also founded what is now known as the Tissue Culture Association, or the TCA, which centered around furthering laboratory research around tissue culturing. By introducing new techniques and methods to cultivate human cells, Gey expanded the laboratory techniques around cell cultivation and helped contribute to a deeper understanding of the human body for future scientific research.

Gey was born on 6 July 1899 in Pittsburgh, Pennsylvania, to Emma and Frank Gey, German immigrants to the US. He had an older brother, Frank, and a younger sister, Henrietta. According to science writer Rebecca Skloot, Gey lived a modest childhood and in his early years would maintain a small coal mine behind his parents' house to keep the family warm. He graduated from Peabody High School in Pittsburgh before earning a Bachelor of Science in biology in 1921 at the University of Pittsburgh [5], in Pittsburgh, Pennsylvania, which he paid for by working as a carpenter and mason. At the University of Pittsburgh [5], Gey spent much of his time in Pittsburgh hospitals where he witnessed the limited treatment options for cancer. During the 1920s, a cancer diagnosis was an almost certain death sentence, a fact that further motivated Gey to study it and find its cure, according to Skloot.

After graduating from the University of Pittsburgh [5], Gey enrolled in the Johns Hopkins University School of Medicine [6] in 1922 in Baltimore, Maryland. However, he needed to defer completing his medical degree until 1929 because of financial constraints. In the years before he resumed his medical degree, he worked as a cancer research fellow from 1923 until 1929 at Columbia Hospital in Milwaukee, Wisconsin. In 1924 at Columbia Hospital, Gey studied the effect of insulin, a hormone [7], in promoting the growth of chicken [8] embryo and explored cultivation of human tissue outside the body which provided the foundation for his later work in tissue culture. At the hospital, he also met Margaret Finney Koudelka, who was working as Head Surgical Supervisor of Nursing Staff while studying clinical lab techniques, and married her in 1926.

In 1929, Gey moved back to Baltimore to continue pursuing his medical degree from the Johns Hopkins University School of Medicine [6]. During his time in medical school, Gey began to explore cell cultures and developed new techniques of filming cell growth. He and his mentor, Warren Harmon Lewis, a professor of physiological anatomy at the Johns Hopkins University [9], fashioned a hybrid device that combined a microscope [10] and motion-picture camera from metal scraps, specialized microscope [10] parts, and a sixteen millimeter camera to film cells' lifecycles including cell growth, division, and death. Using this, Gey made some of the first films capturing the behavior of mitochondria, which are cell organelles that fuel cell function and division. With his camera, Gey created a library of films portraying normal and abnormal cell division. Lewis and Gey were also able to record cell growth, an incredibly slow process. Gey received his medical degree in 1933, after which he served on the faculty of the Johns Hopkins University School of Medicine [6] and School of Hygiene and Public Health.

Beginning in the mid-1930s, Gey and his wife ran the Tissue Culture Laboratory in the Dispensary Building of the Johns Hopkins Hospital [11] Complex. They worked together to develop techniques to film and photograph cell growth within test tubes. The focus of their tissue culture research was growing malignant, or cancerous, cells outside of the human body to be used for cancer research. In 1933, Gey created a new technique for mass tissue culture which he named roller drum technique, which is a cell culture technique still used today. That technique involved a large wooden roller drum, a cylinder with holes for special test tubes called roller tubes, which would roll the tubes in a circular motion. That imitated how blood and fluids would be in constant motion in the body flowing around cells and allowed for the culture to breathe and multiply. Throughout the 1930s, Gey and his wife also tried to develop a culture medium [12], or nutritional liquid used for feeding cells, that could sustain a larger population of cells for long periods of time. They experimented with different ingredients that had been promising in earlier culture experiments to create the Gey Culture Medium. That culture medium [12] includes liquid from the heart of a chicken [8], calf embryo extract, and blood from a human umbilical cord [13]. Gey obtained the umbilical cord [13] blood from the Johns Hopkins Hospital [11] maternity ward and made weekly visits to local slaughterhouses to collect cow [14] fetuses and chicken [8] blood.

In pursuit of his goal of creating a continuous human cell line same goal, Gey continued studying cancer cells. In the 1940s, Gey was one of the first people to grow cancer cells in the laboratory while conducting research on rats. Yet according to Skloot, Gey was most interested in creating a continuous human cell line. Those cells would in theory constantly replenish themselves and never die. Normal cells can only live for a set amount of time because they have internal controls that regulate their number of divisions, but immortal cells like cancer cells can divide indefinitely because they are not subject to the same biological controls.

According to Skloot, Gey even referred to himself as a vulture, starving to get his hands on any human specimens. Although some cells showed promise, all eventually died, until 1951 when Henrietta Lacks arrived at the Johns Hopkins Hospital [11].

In 1951, Gey received a sample of cancer cells that would eventually lead to the first human cell line. Those cancer cells came from a Black woman named Henrietta Lacks who was diagnosed with cervical cancer at the Johns Hopkins Hospital [11]. In her first procedure for cancer treatment, the surgeon stuffed her cervix [15] with tubes and pouches filled with radium, a standard procedure for invasive cervical cancer. At the same time, the surgeon took a sample of her tumor from her without her knowing, a move that the medical community widely condemns as unethical as of 2021. The surgeon provided the cells to Gey, who at the time was the director of the Tissue Culture Laboratory. By the time Gey had received Lacks's cells, thirty specimens of cervical cancer had already been sent to the laboratory. Gey then tasked his research assistant Mary Kubicek with culturing samples of Lacks's cells. According to Skloot, neither Gey nor Kubicek expected Lacks's cells to hold any more success than previous patient cells they had attempted to culture. However, Lacks's cervical tumor cells continued to proliferate at twenty times the speed her normal cervical cells grew. Because the Gey culture medium [12] provided an optimal growth environment for Lacks's cancer cells, the cells did not stop dividing as long as they had access to food and warmth. Gey had successfully created the first immortal human cell line. According to John R. Masters, a researcher at the University College London [16], Gey named it HeLa after the first two letters of Henrietta Lacks's first and last name. After successfully proliferating the HeLa cell line in 1951, Gey began to share vials of Lacks's cells with his colleagues. He sent shipments of HeLa cells to researchers in Texas, India, New York, the Netherlands, and many other places. As Gey flew from one lab to another, he demonstrated his culturing techniques and helped set up new laboratories.

Gey's development of the HeLa cell line also allowed for advancements in the creation of the polio vaccine. At the end of 1951, the world was facing a poliovirus epidemic. Poliovirus induces a disease that causes paralysis. Jonas Salk, a vaccine researcher in France had developed a polio vaccine in 1952 but not yet declared it was safe and effective. Salk worked in close collaboration with the National Foundation for Infantile Paralysis, or NFIP, to plan a study to evaluate vaccine efficacy from health outcomes of enrolled participants. However, testing the vaccine was expensive since it would need to test and culture cells on an industrial scale. HeLa provided a cheap solution to testing the vaccine. HeLa also was a more ethical option since it would curb the need to recruit thousands of human subjects to be in an experiment to test possible side effects of the vaccine. In 1952, Gey and William Scherer, a colleague from the NFIP infected HeLa cells with poliovirus for the first time and proved that HeLa cells had an innate characteristic that led them to be more susceptible to the virus than any other cells tested before them . Skloot claims that with HeLa, scientists helped prove the effectiveness of the Salk vaccine since results showed up quicker than they would in normal cells.

After Gey's success with the HeLa cell line and the development of the poliovirus vaccine, more scientists began to cultivate their own cell lines from tissues taken from patients. According to Skloot, researchers would come to Gey's lab to learn his techniques, and Gey would travel to labs around the world to set up cell culture facilities. However, in the 1960s, Stanley Gartler, a researcher who studied genetics and cell biology in the twentieth century, found evidence that HeLa cells may have contaminated many of what were thought to be original cell lines. Those cell lines were ones that researchers had been conducting experiments with. That would mean the results of experiments that had unknowingly utilized HeLa cells were unverifiable because the wrong type of cell was used, making the results of many cell line experiments essentially useless. If HeLa contamination had taken place in cell-specific research, scientists would have made experimental conclusions based on incorrect assumptions on the identity of the cells and wasted thousands of research dollars. In the 1950s, scientists had no concept that cells could travel from one culture to another and only tested cells lines to see whether they were human cells. Despite Gartler's findings, many researchers ingored or denied the risk of cross contamination until the 1970s. In the 1970s, Walter Nelson-Rees, a geneticist at University of California, Berkeley, in Berkeley, California, further investigated the problem of cross-contamination with HeLa. He identified biological markers unique to the HeLa cell line and used them to expose many cell lines that researchers used as contaminated, and therefore not usable.

While Gey impacted the field of cell culture with his development of tissue culture techniques and his accomplishments with time-lapse phase motion photography, the ethics behind the origin of the HeLa cell line are still heavily debated. According to Skloot, neither Gey nor the lab personnel who worked with the HeLa cell line ever asked for Lacks's permission for usage of her cells. In this time, the idea of informed consent [17] had not been popularized yet and Lacks never knew that her cervical cells were being used for research. In 1974, almost 20 years later after Gey had used Lacks's cells in his research, new federal law went into effect requiring informed consent [17], or permission for conducting medical research and treatment, for all federally funded research.

Throughout his career, Gey continued his involvement in cell culturing and education. He served as a founding member and first president of the Tissue Culture Commission, or TCC in 1946, which, in 1949, became the Tissue Culture Association. Gey also served as a lecturer at the Johns Hopkins University [9]. In the late 1950s, Gey's health began to decline, but he continued to advocate for tissue culture research into the 1960s and helped found the W. Alton Jones Cell Science Center which opened in 1971 in Lake Placid, New York. Gey was the recipient of many honors including speaking at a Harvey lecture series in 1955, where biomedical researchers around the world speak, and receiving the Katharine Berkan Judd Award for Cancer Research in 1954, which is awarded to individuals who have made great advancements in the understanding of cancer through basic discovery. Gey was also a member of seventeen learned societies throughout his career, which are organizations promoting an academic discipline.

On 8 November 1970, Gey died from pancreatic cancer in Baltimore, Maryland, less than a year after his initial diagnosis.

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