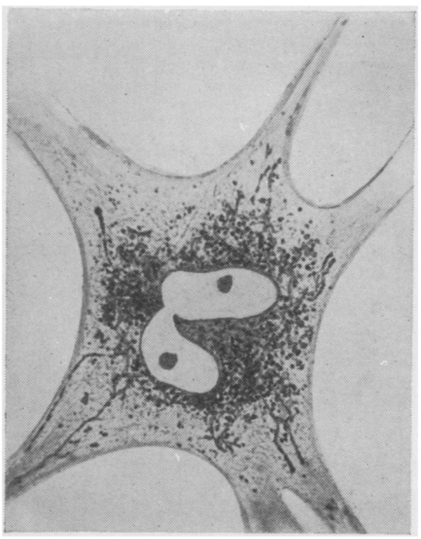


Living Cells Enact In Motion Pictures the Drama of Life and Death

Physiology—Photography

A remarkably clear micro-photograph of a cell from a chick embryo, showing a dividing nucleus, granules of cytoplasm.

By Jane Stafford

MOVIES of the fundamentals of life itself, microscopic dramas of living cells, flash upon the screen in a Baltimore laboratory. It is an endless, unfinished scenario of tragedy and conflict among the smallest of living organisms, the living single cells and their products that make up your body and the bodies of all other animals.

There on the motion picture screen are enacted the existences of all-controlling bits of protoplasm. There may be seen the terrific drama of conflict between life and death engaged in by the millions of cells of your own body during each fleeting moment of your existence.

No movie director engaged in entertaining the pleasure-loving millions is Dr. Warren H. Lewis, the friendly grey-haired exhibitor who has applied motion picture photography to the living world of sizes below the range of the unaided eye. For he is a cytologist who, with his colleagues of the Department of Embryology of the Carnegie Institution of Washington, is engaged in a life-long study of the beginnings and vicissitudes of life.

The cell contains the secret of the cancer and other medical enigma. To advance human knowledge of bodily growth in health and disease, Dr. Lewis has developed a special motion picture camera for microscopic cell photography.

One of the greatest achievements to date has been the photographing, with the cooperation of Dr. P. W. Gregory, of the dividing mammalian egg cell, with its numerous granules and food globules portrayed in the gelatine and silver of the film as they have never been recorded before.

With the aid of these films of cell activity and by other means Dr. Lewis and his associates hope that some day they will have learned all the secrets of the cancer cell and will know enough about it to be able to cure and to prevent this dreaded disease.

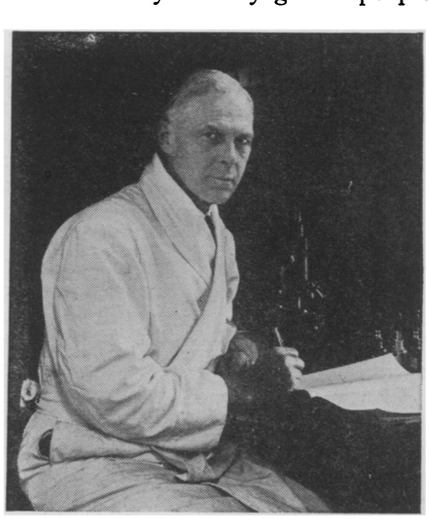
Cancer cells start out in life like other normal cells, but irritations, possibly, or some other cause modifies them so that their multiplication becomes uncontrolled. They run wild, invading tissues made of normal cell, and causing disease of various parts of the body.

To get at the cause of this change in the cells, thousands of them will be observed on the screen. Normal cells and tumor cells will be studied, until the scientists know every faintest motion characteristic of normal cells and just how the motions of the cancer cells differ from the normal. Cells multiply by division of various kinds. The way in which the nucleus and other parts of the cell are arranged just before the cell divides may disclose the factor that starts normal cells on the abnormal path that ends in cancer. Thus the living cells as they move across the motion picture screen are expected to reveal their own secrets.

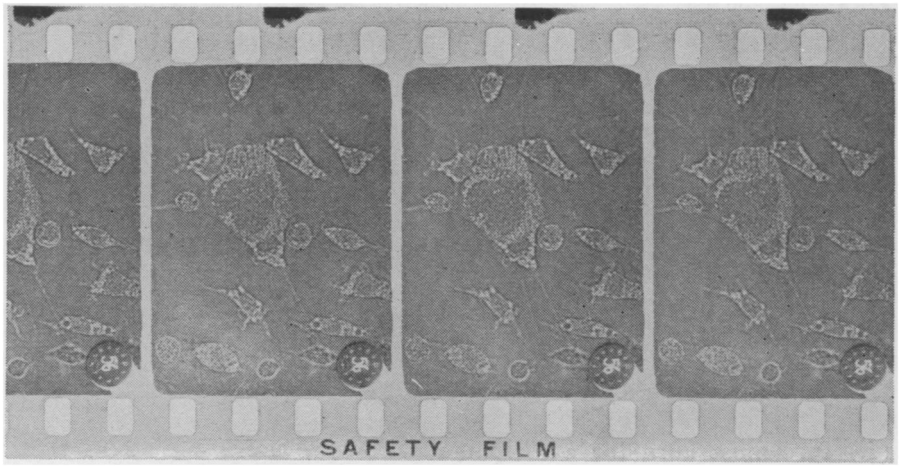
Meanwhile, the scientists at the department of embryology of the Carnegie Institution, under the direction of Dr. G. L. Streeter, hope to learn other vital facts from their study of the cells. One of them is the secret of longevity.

Men no longer expect to find a miraculous Fountain of Youth, but they would like to live out their allotted three score and ten years in health and vigor. Science is trying to lengthen and broaden human life by overcoming disease and by improving human dietary and other habits. These efforts have undoubtedly added years to the length of man's life. However, the secret of a long healthy life is not to be found in a particular brand of cigar, or in abstinence from alcohol or tobacco or meat, nor in any of the various health fads.

About 74 of every 1,000 infants that are born die during their first year of life. About half as many more fail to be born alive. Yet at 89 years Oliver Wendell Holmes is fulfilling the arduous duties of Justice of the U. S. Supreme Court and Elihu Root is active and healthy at 85 years. Many children never reach maturity. Many grown people



Dr. Warren H. Lewis of the department of embryology, who devised the new moving picture camera by which cell movements are being studed.



A strip of film showing a tumor cell and blood cells.

who lead temperate lives succumb to disease in the prime of life and die an untimely death. Others of us, exposed to the same diseases and conditions of life, perhaps far more careless about our health, live out our allotted life spans in vigor and health.

The explanation is to be found in the single cell from which each human being develops, Dr. Streeter said.

Each of us starts from a single, microscopic cell, the fertilized ovum or egg. But in each of these tiny living organisms is contained the germ of every part of the complex organism that is a human being. Every structure of the body and every organ develops from this one small cell. To the untrained, those cells may look exactly the same, but in reality no two are alike, any more than any two human beings are alike. It is precisely the differences in these single cells that the Carnegie Institution scientists are studying now, using the moving picture apparatus to help them, because in the difference in these cells is the reason for the difference in vitality and resistance to disease found in human beings. It is probably the vitality of the egg cell that determines the length of the individual's life.

For example, while disease of the heart and blood vessels is the leading cause of death today, the material from which heart and blood vessels develop is present in the single egg cell. If the egg cell is not perfect in this respect, the heart and blood vessels will probably not be able to stand the strain of life and will break down, resulting in the individual's untimely death from heart disease.

Sometimes these egg cells are so imperfect or so lacking in vitality that the baby does not survive the first year of life. Others do not mature fully. Even under normal conditions, one out of every five of the egg cells is lost. When conditions are not normal, the proportion rises till four out of five or even all the egg cells are lost, that is, fail to develop into living infants.

Resistance to infections, or germs, is known to vary considerably in different people. This resistance, or lack of it, probably started in the single cell from which each person developed. It is largely a hereditary feature, as are the color of the eyes, skin and hair, and the general body stature. Resistance to disease is doubtless a matter of chromosomes and scientists hope to learn more about the chromosomes as a result of studies of cell movements.

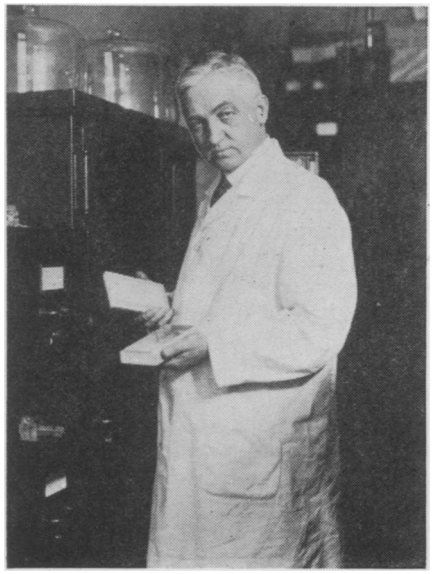
Observation of those cells may reveal the reasons why some develop into healthy infants and others do not. The scientists have already studied thousands of embryos in different stages of development. They have found that every one is different. They are trying to determine just when and how the various organs and parts of the body develop from the egg cell, both normally and abnormally. In this embryology laboratory there is a collection of human embryos in nearly all the different stages of development, from the age of 8 days up. The 8-day one is the youngest human embryo ever obtained. Records of all the available information about each one are carefully kept in the files of the laboratory.

The study has progressed to the point where the scientists can examine an embryo or fetus and state that even if it had developed into a living child, its heart or kidneys would not have been perfect, or it would have been deformed or crippled in some way; or for some reason it could not have lived long. Death before birth was Nature's way of avoiding an imperfect creation.

But there is a gap between the single cell and the 8-day human embryo. In those significant 8-days much has already taken place which scientists need to know. The gap has been filled by the study of rabbits' or pigs' or other mammalian eggs.

The movements of a cell are often too slow to be detected by the eye. Anyone who has looked at objects through a microscope for even a few minutes knows how tedious it quickly becomes. It is easy to see that the job of watching a single cell for many hours would involve a tremendous strain, even if one could thereby see its movements. But such slow movements really cannot be seen directly, but must be speeded up in order to be detected by the human eye. This is what Dr. Lewis' camera does.

The movements of the cells have only just begun to be studied, although scientists have been studying cells for years, and learned their shapes and relative (*Turn to page* 220)



Dr. George L. Streeter, director of the department of embryology of the Carnegie Institution, holding the box of microscope slides on which are preserved sections of the famous Miller Ovum, the earliest-stage human embryo so far discovered. It is kept at the Johns Hopkins University in Baltimore.

Motion Pictures Of Living Cells—*Continued*

sizes and the changes they undergo in multiplication and during the life of the animal and during disease processes. Studies of cells have been made with the aid of powerful microscopes which magnify the tiny organisms that would be too small to be seen with the naked eye. Now comes the moving picture camera with a quick-motion device that makes it possible to see the movements of the cells readily. As a result new and unsuspected facts about cells have been discovered.

For instance, it has been found that certain cells of the blood which act as scavenger cells, change their shapes when they get into the tissues. In the blood stream they are round and of fairly uniform size, but in the tissues they spread out into every conceivable shape and wave long veil-like appendages or branches about in all directions, gathering in globules of liquid, fragments of cells and proably other foreign particles.

These scavenger cells, which are called monocytes, rush to the site of a bruise, or a black and blue spot, and clean up the mess. After they have gotten filled up with dozens of red blood cells and other debris they become many times larger than they were and are usually called macrophages. The macrophages are grown-up monocytes. The change in size is very striking. The monocyte may take in as many as 50 cells the size of its own self.

These monocytes are also found together with cancer cells, but the monocytes are much more active than the malignant cells. In fact, the moving pictures have shown that the blood cells are the most active of all the cells. On the screen this is very clear. The monocytes or macrophages are seen to wave their veils and move rapidly about, but the tumor cells move very much slower.

The apparatus with which Dr. Lewis takes his pictures of living cells consists essentially of a microscope, a motion picture camera and a timing device. The cells themselves are on a slide under the microscope. A light reflected by a mirror illuminates the field. The chamber containing the microscope and specimen is kept at the uniform temperature best suited to cell life and activity. The camera is mounted above the microscope with a thin cover glass placed between at an angle of 45 degrees. This allows 95 per cent. of the light to pass through to the exposed film of the camera, while 5 per cent. of the light is deflected to an observing eyepiece through which Dr. Lewis or his associates can observe directly the material under the microscope while pictures of it are being taken.

The timing device consists of a series of interchangeable pulleys driven by a constant speed motor. This device regulates the number of exposures per minute, which can be varied from 1 to 60.

The image of a watch projected into one corner of the film enables the observers to determine the time at which various events occur when the film is projected onto the screen at the normal rate of 960 pictures per minute. It really times the cell movements. Watching the films, Dr. Lewis can see that a particular cell he is observing started dividing at 10 o'clock and is through dividing at, say 10:30.

A strip of test film is taken and developed first. When this test shows that the time of exposure is correct, the camera is allowed to run hours, even all night if necessary.

The outlines of the living cells seen on the motion picture screen are not so sharp as those of fixed and stained cells when viewed on a slide under the microscope. The activity, however, has shown many things that were not seen before. The scientists are in the position of a man who is looking across a field and sees no sign of life until suddenly some bird or animal moves. Even then he may not clearly see the outlines of the animal, seeing chiefly the motion, but the motion reveals the presence of the animal and probably its kind. So to the scientists the quickened motion of the cells shows many things that they had not seen before in the field they observed through the microscope.

One of the things that has been seen most clearly with the aid of the cell movies is the waving veils of the monocytes. Another is the fact that the nucleus of the cell rotates, sometimes as much as 180 degrees, without disturbing the cytoplasm, which surrounds the nucleus and is intimately connected with it. The significance of this new discovery is not yet clearly understood, but it is one of the many new facts about cells which are being learned with the aid of the motion picture. Probably it has some relation to cell division.

This division is one of the most fundamental things in all life, because the way in which cells divide regulates the way in which organisms grow and develop. Also, cell division has a vital bearing on the concer problem. In this condition there is greatly increased cell multiplication, hence increased cell division. Possibly the manner of division is changed as well as the rate.

Another of the things that the cell movies have shown is the great activity of the chromosomes in going from the prophase to the metaphase. These are respectively the first and second broad stages of cell division. In the metaphase the chromosomes split longitudinally into exactly similar halves. In the prophase a preliminary arrangement of the chromosomes takes place. The amount of chromosome activity accompanying the changes was viewed on the motion picture screen.

We do not yet know much about cell division. It needs much more study to determine its why and how. However, each new fact discovered, each bit of information gathered from such investigations as are being made at the Carnegie Institution's embryology laboratory add to our knowledge of the fundamentals of life itself.