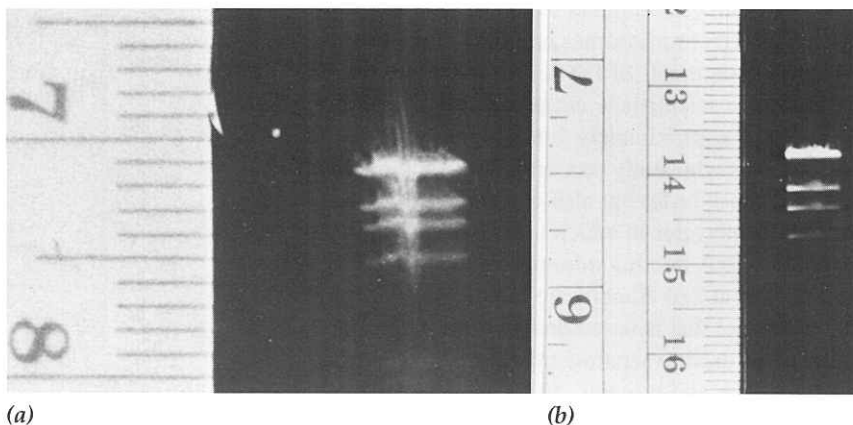


# Fast Agarose Gel Electrophoresis (FAGE)

Inventor: Frederic R. Fairfield,\* Theoretical Division



(a) The electrophoresis of Lambda DNA fragments with the FAGE System lasted for four minutes. (b) The electrophoresis of Lambda DNA fragments with conventional techniques lasted for ninety minutes. The rulers in the two pictures show that, during electrophoresis, the DNA fragments have moved approximately the same distances.

When DNA or deoxyribonucleic acid—originally called “nuclein”—was discovered in 1869, scientists were unaware of its essential role in genetic inheritance. Until the early 1950s, biologists generally maintained that proteins were the chief carriers of heredity because proteins appeared to have a greater diversity of structure than nucleic acids did, a feature that made them more likely to be responsible for the diversity of the genes. But then, in the early 1950s, firm evidence was obtained that DNA, rather than proteins, serves as the physical basis of heredity.

Now scientists and lay people alike know that the basic material constituting the gene is made up of chainlike molecules of nucleic acids—DNA in most organisms and RNA (ribonucleic acid) in some viruses. Each human being carries an amazing amount of DNA that is coiled and folded inside cells; it has been estimated that if all the DNA in a human were stretched out, it would extend from the Earth to the Sun and back again. And it is in the molecules of DNA that the human genome resides and encodes chemical instructions for the production of thousands of proteins, which are largely responsible for the body’s structure, functions, and development as well as for maintaining its biological systems.

Molecular biologists study DNA samples for such diverse purposes as genetic screening, forensic medicine, research in genetic diseases ranging from cancer to manic depression, and mapping of the

entire human genome system. One analytical technique—gel electrophoresis—is dominant in all these studies; it allows scientists to separate different-size fragments of DNA by their movement through a gel under the influence of an electric field. However, this operation can take a long time, sometimes too long for the purposes of the specific run (in some cases it takes as long as 36 hours). The Fast Agarose Gel Electrophoresis (FAGE) System, developed in part at Los Alamos, dramatically shortens the time needed for the run (it can be ten to one hundred times faster than runs performed with other, similar techniques) and will therefore most likely become an indispensable tool of research worldwide. For developing this technology, the inventor won a 1990 R&D 100 Award; the awards are given each year by *Research and Development Magazine* for the one hundred most significant technical innovations of the year.

## The FAGE System

The FAGE System includes the apparatus in which the electrophoresis is performed, the method for preparing the DNA and the gel, and the method for running the electrophoresis. The three components of the system are interconnected; a change in the apparatus implies a change in the gel that is produced in the apparatus as well as a change in the method for running the electrophoresis. The system separates DNA fragments by size when the fragments are placed in and then driven through a gel by an electric field that measures 20 to 40 volts per centimeter across the gel. During the experiment, the gel is thermostated to 4 degrees Celsius by a copper cooling plate and an insulating layer of polyethylene to prevent it from getting burned. After 4 to 60 minutes, depending on the experiment, the voltage is turned off and the gel is removed from the apparatus. The gel contains the DNA fragments, which are not visible; a dye is then used to stain the fragments and thus make them visible, and the result is photographed. This separation of the fragments provides a means for distinguishing among various types of DNA.

In aqueous solutions, the movement of the DNA is independent of the size of the fragments because

\* Frederic Fairfield started developing this technology while working at the University of Tennessee in Knoxville.