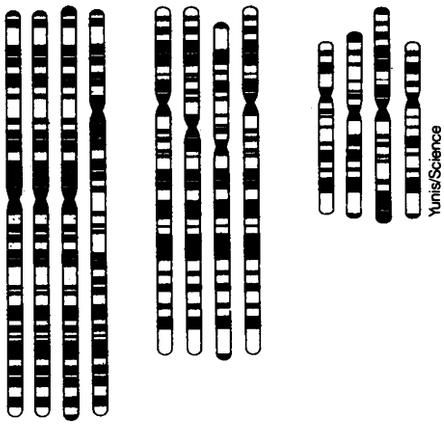
Human Evolution: Chromosomes as Legacy

The family tree of the primates is being worked out with a variety of tools. Rare fossils give one set of clues, and variation in particular proteins and genes provides another. Now Jorge J. Yunis of the University of Minnesota Medical School describes a different, "very powerful tool to trace evolutionary trees." He and colleague Om Prakash have examined the detailed banding pattern of chromosome preparations from a variety of primate species. "We use the whole genome [the genetic endowment of a species] as footprints of evolution to see an overall pattern of what has happened," Yunis says.

Man, chimpanzee, gorilla and orangutan are remarkably similar in their chromosome patterns. A few simple changes are sufficient to explain the variation in pattern of the 1,000 bands Yunis and Prakash observe, looking at one chromosome of each pair. "We have been able to work backward in evolution to suggest likely karyotypes [chromosome sets] for three presumed common ancestors of apes and man," the scientists report in the March 19



Few and simple changes can explain the differences in chromosome bands between human, chimpanzee, gorilla and orangutan (left to right in each set).

SCIENCE. They suggest that 18 of the 23 pairs of chromosomes are virtually identical in modern man and the "common hominoid ancestor."

The evolutionary scheme they propose has three branch points between a hominoid-orangutan precursor and man. The orangutan line was the first to diverge, leaving the hominoid ancestor, which evolved into the gorilla and a human-chimpanzee progenitor. Finally the paths of man and chimp part.

Yunis and Prakash point out that this scheme conflicts with the view that man diverged separately from the evolutionary line leading to the great apes. However, J. Lawrence Angel, curator of physical anthropology at the Smithsonian Institution, says that most anthropologists already agree that gorilla, chimpanzee and man are quite closely related, with man and chimpanzee diverging most recently. "This is the current, but very new belief," Angel says. It is based in part on earlier, less detailed analysis of chromosome patterns.

Every band found in the human chromosomes can be identified in each of the three great ape species (and in some other primates), Yunis and Prakash report. "It is approximately the same genome but with some rearrangement," Yunis says. By far the most common rearrangement is the inversion of a segment within a chromosome (for example, the difference between orangutan and the other chromosome 3 patterns). More rarely, pieces are moved from within one chromosome to another, or exchanged between the ends of chromosomes (for example, between gorilla chromosomes 5 and 17). Yunis disregards differences in the "junk" DNA (heterochromatin) that does not contain genes, such as the dark bands at the ends of gorilla chromosome 3.

Newer methods of preparing and staining chromosomes, developed to diagnose medically important abnormalities (SN: 10/31/81, p. 278), allow an even finer pattern of up to 2,000 bands, each representing, on the average, only fifteen genes. Yunis now plans to apply these techniques to the comparison of primate chromosomes. —*J. A. Miller*

Nerve electricity studied *in vitro*

A biological system, a sequence of nerve cells for instance, will often take a certain stimulus at one end and produce a certain action at the other end. It is the task of biophysicists particularly to figure out the physical details of what happened in between. This is nearly always extremely difficult to do and especially so if the experimenter has to deal with the system *in vivo*.

Speaking at last week's meeting of the American Physical Society in Dallas, Tex., Paul Mueller of the University of Pennsylvania in Philadelphia pointed out that a human brain has about 10 billion neurons. Through their contacts with each other these cells can add together about 100,000 simultaneous inputs in real time by way of small electrical impulses. The way these impulses are generated is the key to the operation of the whole system, but studying it in the complexity of the living system is a formidable if not impossible task.

Mueller described a recently developed method for studying the mechanism *in vitro* by setting up what amounts to a single artificially assembled nerve cell membrane. The surface membrane of a nerve cell is a bilipid layer, two lipid molecules back to back. (Lipids are similar to fats or soaps.) The thickness of the bilipid is about 50 angstroms.

The bilipid is an electrical insulator. If there is a difference between the concentrations of electrical charges inside and outside the cell — usually there is — there will be a corresponding electric potential or voltage difference across the membrane. It is a sudden reversal of the polarity of this voltage that causes the electric discharge. A cell can fire in this way as often as 500 times a second.

The changes in potential are managed by channel molecules, proteins that are embedded in the membrane. These channels can pass ions back and forth across the membrane and alter the electrical balances. At least two kinds of channels are necessary to make the system work. In evolutionarily primitive cells they pass either cations or anions; in more advanced cells they select potassium chloride or sodium chloride. Either type may be open or closed at a given time and how and when they open and close are controlled by the potential that they themselves alter. Thus the system interacts with itself in complicated ways.

What Mueller and his associates have shown is that it's not necessary to dissect a brain to study this. Lipid material taken from nerve cells will assemble itself into a bilayer across a hole in a glass septum that separates two halves of a small tank. An electric potential is established across the membrane by electrodes in the two sides of the tank connected to a voltage source. Channel material drawn separately from nerve cells is added and inserts itself into the membrane spontaneously. The resistance across the membrane falls as channels open. Then, when a certain level is reached, channels begin to close and the resistance shoots back up again. "The system behaves like a tunnel diode," Mueller says.

Now the experimenter can alter ion concentrations on either side of the membrane by adding small amounts of this or that and observe how the channels and the potential respond. A situation can be reached in which the membrane acts like a flip-flop switch. It flips transiently from one polarity to the other and then flops back. This is the action that produces the nerve impulse. The details of this mechanism and the exact structure of the channel molecules that control it are now the main subject of study. —*D. E. Thomsen*