drastically impaired the survival of neurons cultured in the presence of optimal numbers of glial cells, Varon thinks that NGF is involved. The antiserum was active either when it was added directly to the cultures or when the glial cells were treated with it before being added to the cultures. This raises the possibility that the antibody interacts directly with the nonneuronal cells by combining with NGF-like antigens on their surfaces. According to Varon, glial cells could either be the source of NGF required by neurons or the NGF could somehow facilitate the activities by which glia support and maintain neurons.

Fibroblasts also secrete NGF, according to Young and Arnason. Their original observation was serendipitous. They attempted to use mouse L cells—a line of malignant fibroblasts—as a control in an experiment with NGF and unexpectedly found that the L cells themselves stimulated neurite outgrowth (Fig. 1). They determined that these cells secreted a material immunologically similar to, if not identical with, the NGF of male mouse submaxillary glands. Another line of fibroblasts, 3T3 cells, stimulated formation of neurites; 3T3 cells transformed by a oncogenic virus had the same effect.

Since all of these cell lines are in some way abnormal, Young and Arnason tested a primary culture of normal chick embryo fibroblasts. These too secreted a biologically active NGF that reacts with antibody to pure mouse NGF. Consequently, the investigators have proposed that secretion of NGF may be a general property of fibroblasts and that these cells may be a physiological source of the polypeptide.

Young and Arnason are now investigating whether NGF has more general effects in addition to those on nervous tissue. Mouse L cells secrete chemical factors that confer on the culture medium the capacity to stimulate the growth of other, unrelated cells such as baby hamster kidney cells or macrophages. (Macrophages are cells that are involved in inflammation, infection, and wound healing, and that may have a role in immune defenses against cancer.) Young and Arnason are attempting to determine whether NGF is one of the chemicals producing these growth effects.

Fibroblasts are prominent cell components of granulation or wound-healing tissue. Levi-Montalcini and Pietro Angeletti observed that granulation tissue produces a substance—probably NGF—that promotes nerve growth in vitro. If fibroblasts in wound-healing tissue release NGF as they do in culture, then NGF might be involved in wound healing. Proof that NGF activates macrophages, which are necessary for wound healing, would support this hypothesis.

Wound healing and tumor growth have a common requirement for increased blood supplies to meet their heavy energy requirements. According to Judah Folkman of Harvard Medical School, tumors can enhance their own vascular supply by secreting tumor angiogenesis factor (TAF) to stimulate the formation of blood vessels. Young and Arnason think that there could be a relationship between NGF and TAF. They found that cultured human glioblastoma cells (a glioblastoma is a tumor containing immature glial cells) produced a substance that reacts with antibody to mouse NGF. This tumor is known to secrete TAF. Young and Arnason are now investigating whether NGF has the capacity to stimulate the growth of blood vessels. Their early results look promising. If these results are confirmed, they will show that NGF participates in a number of processes involving growth and development, both in the nervous system and out of it.

—JEAN L. MARX

!Kung Hunter-Gatherers: Feminism, Diet, and Birth Control

If results from recent studies of the !Kung* people apply to other societies, anthropologists may now have some new clues as to the social, dietary, and demographic changes that took place during the Neolithic Revolution when people forsook lives of hunting and gathering and began to farm and to keep herds of domestic animals. The !Kung have lived as hunters and gatherers in the Kalahari Desert of South Africa (Fig. 1) for at least 11,000 years; but recently they have begun to live in agrarian villages near those of Bantus. Investigators who are documenting this change find that, among other things, the settled !Kung women are losing their egalitarian status, the children are no longer brought up to be nonaggressive, and the size of the !Kung population is rapidly increasing rather than remaining stable.

The !Kung's very existence is anomalous since they have lived by hunting and gathering since the Pleistocene. In his archeological studies, John Yellen of the Smithsonian Institution in Washington, D.C., finds artifacts from Late Stone Age hunter-gatherers, of about 11,000 years ago, at the same water holes where modern !Kung set up camp (Fig. 2). According to Yellen, these prehistoric hunter-gatherers even hunted the same animals as the contemporary !Kung, including the nocturnal springhare which must be hunted by a special technique because it spends its days in a long deep burrow.

As recently as 10 years ago, many of the !Kung still lived by hunting and gathering. Now, however, less than 5 percent of the 30,000 !Kung live in this way; the remainder live in agricultural villages. This period of rapid social change coincided with extensive study of these people by numerous investigators throughout the world and from many disciplines.

It is difficult to distinguish between changes due to settling down and changes due to acculturation to Bantu society. Investigators have drawn on extensive long-term studies of the nomadic !Kung in their documentation of the effects of the !Kung's adoption of an agrarian life, but cannot conclusively state the causes of these effects.

One aspect of the settled !Kung society that has aroused considerable interest among social scientists is the role of women. Patricia Draper of the University of New Mexico reports that !Kung women who belong to the nomadic bands enjoy higher status, more autonomy, and greater ability to directly influence group decisions than do sedentary !Kung women. This loss of equality for the agrarian women, Draper believes, may be explained in terms of the social structure of nomadic, as compared to sedentary, groups.

Draper postulates that one reason for the higher status of !Kung hunter-gatherer women is that the women contribute, by gathering, at least 50 percent of the food consumed by a band. Since food gathered by women is so impor-

* The exclamation point refers to an alveolar-palatal click. The tongue tip is pressed against the roof of the mouth and drawn sharply away, producing a hollow popping sound.

tant to the group, the women, of necessity, are as mobile as the men (who hunt), and women and men leave the camp equally often to obtain food. Both the women and men who do not seek food on a given day remain in the camp and share in taking care of the children.

The women in sedentary !Kung societies have far less mobility than the men and contribute less to the food supply. The men leave the village to clear fields and raise crops and to care for the cattle of their Bantu neighbors. The women remain in the village where they prepare food and take care of the shelters. Since the men work for the Bantus, they learn the Bantu language. Thus when the Bantus deal with the !Kung, they deal exclusively with the men. This practice, together with the !Kung's emulation of the male dominated Bantu society, contributes to increasingly subservient roles for !Kung women.

Also contributing to a loss of female egalitarianism is the different way that agrarian, as compared to nomadic, !Kung bring up their children. Draper points out that the nomads live in bands consisting of very few people so that a child generally has no companions of the same age. Thus play groups contain children of both sexes and a wide variety of ages. This discourages the development of distinct games and roles for boys and girls.

Unlike the nomadic children, the sedentary children play in groups consisting of children of the same sex and similar ages. The boys are expected to help herd cattle, so they leave the village where they are away from adults and on their own. The girls, according to Draper, have no comparable experience but remain in the village and help the adult women with chores.

In addition to promoting sexual egalitarianism by their child rearing practices, the nomadic !Kung also discourage aggression among their children. This is no longer the case when the !Kung become sedentary. The nomadic children observed by Draper do not play competitive games. She attributes this to the wide range of ages of children in a group which would make competitiveness difficult. Moreover, since these children are constantly watched by adults, the adults can and do quickly stop aggressive behavior among children. The children rarely observe aggressive behavior among adults because the nomadic !Kung have no way to deal with physical aggression and consciously avoid it. For example, according to Richard Lee of the University of Toronto, when conflict within a group of adults begins, families leave for other bands. Lee observed that the sedentary !Kung, who cannot easily pick up and leave, rely on their Bantu neighbors to mediate disputes.

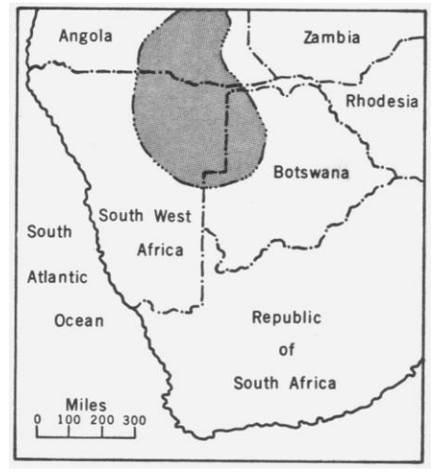


Fig. 1. Location of the !Kung in South Africa.

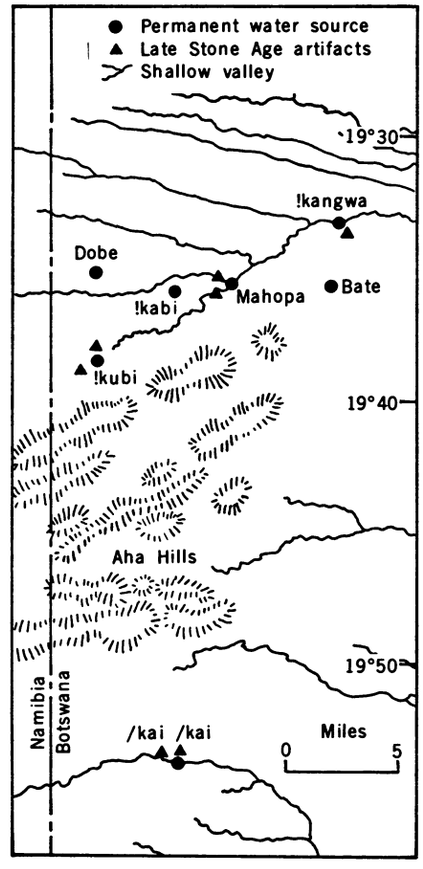


Fig. 2. Distribution of Late Stone Age sites and permanent water sources.

In addition to studying social changes taking place when the !Kung settle down, investigators are studying dietary and demographic changes. The !Kung diet is of interest because the nomadic !Kung are exceedingly healthy and are free from many diseases thought to be associated with the diets of people in more complex societies. The sedentary !Kung have substantially altered their diets, thus providing investigators with a unique opportunity to document the effects of diet on the health of these people. The demographic changes taking place among the !Kung are of interest because the settled !Kung seem to have lost a natural check on their fertility rates.

The diet of the completely nomadic !Kung, which has been analyzed by geneticists, biochemists, and nutritionists, consists of nuts, vegetables, and meat and lacks milk and grains. All the investigators agree that the diet is nutritionally well balanced and provides an adequate number of calories. They found very few people with iron deficiency anemia, even when they included pregnant and lactating women in their sample. They also discovered that the nomadic !Kung have a very low incidence of deficiency of the vitamin folic acid and that the concentrations of vitamin B_{12} are higher in their serums as compared to concentrations considered normal for other populations. These findings led Henry Harpending of the University of New Mexico and his associates to suggest that Stone Age people probably had no deficiencies of these vitamins and that deficiencies first appeared when people settled down into agrarian societies.

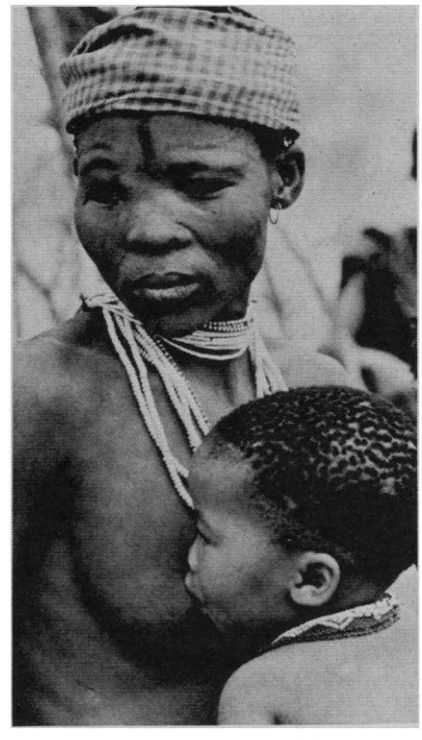
In addition to being well nourished, the nomadic !Kung are free from many common diseases of old age. For example, Lee and others have found little degenerative disease among elderly !Kung, although it is commonplace for these people to live for at least 60 years and some live for as long as 80 years. A. Stewart Truswell of the University of London also finds that the nomadic !Kung are one of only about a dozen groups of people in the world whose blood pressure does not increase as they grow older.

The medical effects of the altered diet and way of life of the sedentary !Kung are not yet well established. In contrast to the hunter-gatherers, these people consume a great deal of cow's milk and grain. In his studies of a generation of !Kung brought up on such a

diet, Lee finds that they are, on the average, taller, fatter, and heavier than the nomadic !Kung. Nancy Howell of the University of Toronto finds that the agrarian women have their first menstrual periods (menarches) earlier than the nomadic women.

The average age of menarche among nomadic !Kung is late—at least age 15.5 according to Howell. Although these women marry at puberty, they have their first children when they are, on the average, 19.5 years of age. This late start to reproductive life helps limit the growth of the population. However, a more significant curb on the size of nomadic populations is the low fertility of the women. Howell finds that the average length of time between giving birth for a nomadic !Kung woman is 4 years. These women have fewer children than any other women in societies that do not practice contraception or abortion. The low fertility of nomadic !Kung contradicts previously held theories that the sizes of hunter-gatherer populations were limited solely by high mortality rates. The !Kung population size remains stable because there are so few children born. Combining her studies of the fertility and mortality rates of !Kung hunter-gatherers, Howell concludes that the long-term growth rate for such a population is only 0.5 percent per year. This is in sharp contrast to the sedentary !Kung whose population is growing rapidly.

The population growth among the sedentary !Kung results from both a decrease in the age of menarche and a decrease in the average time between births. Lee has found that the birth intervals drop 30 percent when !Kung women become sedentary. The causes of these reproductive changes are unknown, but some investigators suspect that these decreased birth intervals may result from changes in nursing or dietary habits.

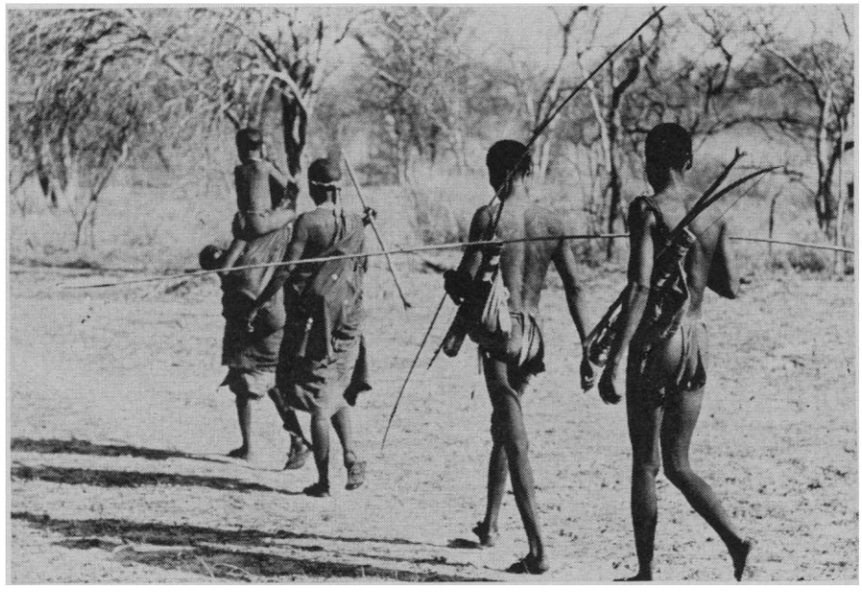


Nomadic mother nursing child who is nearly 5 years old. [Irven DeVore, Harvard University]

Nomadic !Kung women have no soft food to give their babies, and so they nurse them for 3 or 4 years, and during this time the women rarely conceive. Sedentary !Kung women, on the other hand, wean their babies much sooner by giving them grain meal and cow's milk. Irven DeVore of Harvard University believes that a contraceptive effect of the long lactation period is not unexpected, since investigators have observed the same phenomenon in many animals, including monkeys and the great apes. A woman who begins to supplement her infant's diet while the child is very young would not experience this effect because her child would require less and less milk.

Howell and Rose Frisch of the Harvard Center for Population Studies believe that an explanation of the decrease in the age of menarche and in the birth intervals of sedentary !Kung women may involve the diet of the sedentary !Kung. They base this idea on a study by Frisch and Janet McArthur of the Massachusetts General Hospital in Boston. These investigators showed that the amount of body fat must be above a certain minimum for the onset of menstruation and for its maintenance after menarche. Howell points out that the !Kung hunter-gatherers are thin, although well nourished. When women from these bands lactate, they need about 1000 extra calories a day. Thus, during the 3 or 4 years that a woman nurses a baby, she may have too little body fat for ovulation to take place. The shorter birth intervals for sedentary !Kung women would follow from their shorter periods of lactation and larger amounts of body fat. Howell notes that this explanation of the low fertility of nomadic !Kung women cannot be verified until more extensive medical studies are performed with these people.

Although no one claims that the changes taking place in the !Kung society necessarily reflect those that took place when other hunter-gatherer societies became agrarian, studies of the !Kung are providing anthropologists with clues relative to the origins of some features of modern societies. Many findings, such as the social egalitarianism, lack of aggression, and low fertility of nomadic !Kung are leading to new perspectives on the hunting and gathering way of life which was, until 10,000 years ago, the way all humans lived.—GINA BARI KOLATA



Men leaving camp to hunt nocturnal springhare [Irven DeVore, Harvard University]

Additional Reading

1. R. B. Lee and I. DeVore, Eds., *Kalahari Hunter-Gatherers* (Harvard Univ. Press, Cambridge, Mass., in press).