

the cost of food in the already developed areas of the world. The best advice for the developing countries still seems to be "Produce more of the foods that you are currently growing" (here the agronomists and plant geneticists can offer practical help with new strains giving higher yields of protein) and "Try by social measures to distribute available protein-rich foods among the population according to needs". This in practice means a recognition that protein deficiency strikes primarily at the very young and at pregnant and nursing mothers, and the production and distribution of protein-rich foods in the form of special mixtures suitable for weaning must be one of the primary objectives of food scientists and governments.

## DNA

### Okazaki Fragments

from our Cell Biology Correspondent

EVIDENCE is steadily accumulating to suggest that DNA synthesis in bacteria and bacteriophages involves the production of short chains by discontinuous synthesis and that these are then covalently linked by DNA ligase (see *Nature*, **219**, 17; 1968). In the latest issue of *Proc. US Nat. Acad. Sci.* (**61**, 1129; 1968), Hurwitz's group reports results which can be interpreted as showing that both DNA strands are made in this way, and Hosoda and Mathews (*ibid.*, 997) report similar conclusions. The snag is that of the experiments so far, neither those of Okazaki himself nor anything which has followed prove that DNA synthesis is discontinuous.

Okazaki's original observation, in 1965, was that newly synthesized DNA, labelled with a pulse of radioactive precursor for a few seconds, can be extracted as short fragments which, in alkaline sucrose gradients, have a more or less unimodal distribution and a sedimentation coefficient of something between 8S and 16S. Virtually ignored for a while, his experiments have now become the theme of several variations, involving pulse chase experiments or conditional lethal mutants, which implicate DNA ligase and the Kornberg DNA polymerase in DNA replication. Hosoda and Mathews, for example, have shown that a temperature sensitive mutation in the DNA ligase gene of phage T4 blocks DNA replication and that newly made DNA accumulates as short pieces. When ligase activity is restored, by lowering the temperature of the culture, the short pieces are joined to yield high molecular weight DNA. The pulse chase experiments with wild type *E. coli*, with or without infecting T phage, reported by Hurwitz's group suggest the same mechanism. And as more than half the radioactive label appears in the short fragments, the argument goes that both strands of a DNA molecule are replicated discontinuously even though the Kornberg DNA polymerase, if that is the *in vivo* replication enzyme, could make one strand continuously.

But as everyone admits, this sort of observation cannot rule out the possibility that the short strands are the result of endonuclease activity—the DNA at the growing point might well be more susceptible to degradation than the rest of the chromosome—and the fact that fragments can be joined by ligase is no proof that they are the normal intermediate precursors during replication. Making elegant variations on

Okazaki's theme is one thing, devising a test of his hypothesis another.

And apart from DNA polymerase and ligase and a pool of precursors there must, as Hurwitz's group point out, be additional factors involved in DNA replication. For one thing, some mutants of DNA replication have apparently normal polymerase and ligase. For another, there is no evidence that polymerase can initiate new DNA chains once it has started synthesis, whereas Okazaki's model implies multiple initiation of DNA chains in the replicating region.

## ARCHAEOLOGY

### Evolution of a Roman Villa

from our Archaeology Correspondent

THE complete excavation during the past six years of a Roman villa in Gadebridge Park, Hemel Hempstead, has produced a remarkably detailed picture of its changing economy and architectural development from the second half of the first century to well into the fifth century. The excavation was directed by Mr D. Neal of the Ministry of Public Building and Works but was financed independently, chiefly by Hemel Hempstead Borough Council.

The earliest building on the site, dated by Samian and coarse pottery to about the last quarter of the first century, was a timber house with a fairly simple detached stone bath house. Virtually nothing remains of the timber building apart from ditches and traces of



Looking south over the outer western wing of the villa.  
(Photograph by Mr J. Brown.)

floors. During the second phase early in the second century, the bath house was enlarged to include hot and cold plunge baths. Then, with increasing prosperity in the middle of the second century, the wooden house was replaced by a sophisticated stone villa built on the usual truncated U plan, with at least one two-storeyed wing. Mr Neal interprets a series of robust stands on the ground floor of this building as supports for wine presses, and there are also traces of iron working of a purely domestic nature and some crucibles for bronze working. But at this stage the only hypocaust was in the bath house.

The boom conditions went on, and by the late second century the baths had been extended again and prob-