logical damage on rodent population dynamics has been suggested by Chitty in his studies on *M. agrestis* (*Phil. Trans. R. Soc.*, **B236**, 505; 1952). Lidiker considers that nutritional defects of the vegetation did not cause the delay, since young males increase in weight and recommence growth long before other age and sex groups.

The alternation of overwintering numbers seems to be a normal oscillatory process. High winter numbers damage the habitat and induce low dry seasonal survival the following year and also low winter numbers. This reduction in grazing pressure allows the forage to recover and so better survival is seen in the third year.

When all the many population data Lidiker has amassed are examined it is clear that no single factor emerges as the dominant controlling influence. Lidiker lists six factors—both density dependent and density independent—which interact to provide control. If any one factor must be singled out as having a more direct effect on the population than any other, then it must be the pattern of rainfall.

The regular pattern of population dynamics could be modified into the 3 or 4 year cyclical pattern (for example, Krebs, *Tech. Pap. Arct. Inst. N. Am.*, No. 15; 1964) regarded as 'normal' for small rodents by (1) the action of predators responding to the build-up by increased breeding (there were no predators on Brooks Island); (2) delay in the onset of breeding due to physiological damage after a 'crash'; (3) emigration occurring; and (4) a rapid build-up when (1), (2) and (3) have all had their effects.

The Brooks Island study shows that the dynamic pattern is neither controlled exclusively by extraterrestrial phenomena, interpopulation phenomena nor intrapopulation phenomena, but by a complex interaction of factors. Lidiker has done rodent population biology a real service by pointing out that at least one natural population behaves according to the complex dictates of the whole environment of which it is a part.

PURPLE MEMBRANE

Light-driven Pump?

from a Correspondent

THE purple membrane is a specialised area of the cell membrane of the bacterium *Halobacterium halobium*. Recently the vivid colour of this membrane fragment was shown to be due to a complex of protein with retinal, the aldehyde derivative of vitamin A. The protein is the only species in the membrane and is packed in a crystalline array (Oesterhelt and Stoekenius, *Nature new Biol.*, **233**, 149; 1971; Blaurock and Stoekenius, *ibid.*, 152). Since retinal also gives the

visual pigments their characteristic colours, it was suggested that the purple membrane might be a photoreceptor. Oesterhelt and Stoekenius, however, now summarise experiments done by themselves and several coworkers which lead them to suggest that the membrane pumps protons out of the bacterial cell by using light energy. The resulting gradient may be a source of metabolic energy (*Proc. natn. Acad. Sci., U.S.A.*, **70**, 2853; 1973).

The purple membrane forms in the cell envelope if a growing culture is aerated with oxygen-poor air, whereas if the culture is vigorously aerated with normal air the membrane fails to form in significant amounts. If aeration of a growing culture is stopped altogether, the total cell protein fails to increase further but the purple membrane increases fifty times. Illuminating an oxygen-poor culture can increase the proportion of the purple membrane to half the total membrane area. Moreover, growing cells from a late-log phase culture use less oxygen when illuminated than when in the dark; one less oxygen atom is consumed for about every thirty photons absorbed by the purple membrane in the cells (*FEBS Lett.*, **36**, 72; 1973). Starved cells, which consume reduced amounts of oxygen, similarly use even less oxygen while in the

light. These results taken together indicate that the purple membrane compensates for a lack of oxygen. By what means?

When isolated purple membrane fragments in an unbuffered medium are exposed to a bright light, the pH drops, and it recovers the original value in the dark. Correspondingly, a 'bleached' form ($\lambda_{\max}=412\text{ m}\mu$) of the purple protein is found during the illumination, and the normal form ($\lambda_{\max}=568\text{ m}\mu$) is recovered in the dark. The time courses for bleaching and recovery are the same as for the pH effects (*Eur. J. Biochem.*, **37**, 316; 1973). The starved cells similarly make the medium more acid as long as the light is on, and anaerobic cells also cause a net drop in pH in the light. The net increase in proton concentration when whole cells are illuminated is said to be at least twenty times that for the same amount of purple membrane after isolation. It is therefore suggested that the membrane protein may operate in a cycle, repeatedly picking up a proton from within the cell and ejecting it when light is absorbed. Thus the purple protein may be the first membrane pump to be isolated.

The authors refer to Mitchell's chemiosmotic theory (*J. Bioenergetics*, **3**, 5; 1972) and suggest that a resulting electrical potential across the membrane is

FOOD BIOCHEMISTRY

Fragrance of Bread

from our Soviet Correspondent

AT present approximately 100 compounds are known to contribute to the characteristic fragrance of baking bread. These include, in particular, carbonyl compounds such as furfural and oxymethylfurfural, and also fermentation products such as organic acids, complex ethers, acetaldehyde.

A recent study, carried out by a team from the "A. N. Bakh" Institute of Biochemistry of the Soviet Academy of Sciences and the All-Union Research Institute of the Bread Industry, studied how the formation of these aroma-producing substances depends on the thermal and time regimes of baking. It was found (see Kretovich *et al.*, *Prikladnaya Biokhimiya i Mikrobiologiya*, **9**, 5; 1973) that the fragrance is essentially due to chemical changes within the crust, little contribution being made by the soft crumb, the chemical composition of which remains relatively stable. The decisive role in the formation and accumulation of carbonyl compounds within the crust is played by the formation of melanoidine during the baking process.

This process falls into three stages. During the first stage, which lasts for about 25% of the baking time, the

temperature of the crust rises from 20 to 90–100° C, while the temperature of the crumb rises to 38° C. During this stage there is a certain loss of volatile carbonyl compounds, notably acetylene, from the crust.

In the second stage (the middle 50% of the baking time), the crust temperature rises to 130–140° C and intensive melanoidine formation occurs, accompanied by a build-up of carbonyl compounds in the crust as a result of melanoidine reactions. In particular, the furfural content of the crust, especially the top crust, increases, and the loaf assumes the characteristic coloration of well-baked bread. At the same time, the content of amino acids (aspartic and glutamic acids, threonine, tryptophan, methionine, valine and leucine) decreases throughout the whole loaf, the decrease being most marked in the crust, due to the consumption of these amino acids in the processes. During the second stage, the rate of reaction depends essentially on the crust temperature.

The third period (the last 25% of baking time) is characterised by an intensive build-up in the crust of compounds with bisulphite bonds, acetaldehyde and furfural. During this period, the temperature may fall slightly, and the chemical reactions, although similar to those of the second stage, now take place at constant rate.