

dricol piles of coins, and the fretwork, a loose arrangement of membranes which lie over, around and between the grana. There is a clear division of labour between these two types of membrane; the grana are coloured by the photosynthetic pigment, chlorophyll, and all the light reactions of photosynthesis leading to the formation of high energy phosphate compounds and a source of reducing power are located on these membranes. The dark reactions which lead ultimately to the synthesis of carbohydrates seem to be confined to the stroma of the chloroplast, the amorphous matrix in which the membranes lie.

Chloroplasts, however, do not always present this hardly simple but nonetheless organized picture. Sometimes the inside of the plastid appears completely homogeneous under the microscope and no grana can be seen. It is possible to cause this transformation artificially by illuminating plants with red light for several hours (T. Punnett, *J. Cell. Biol.*, **35**, 108A; 1967). It seemed therefore to Dr Punnett that it would be interesting to find out what happens to the photosynthetic functions of the chloroplast after inducing this structural change.

He examined the enhancement of photosynthesis by short wavelength light in homogeneous and granulated chloroplasts (*Science*, **171**, 284; 1971). The reactions which lead principally to the formation of a source of photosynthetic reducing power are currently believed to be initiated by far-red light (700 nm). This light is inefficient in promoting those reactions which lead to the formation of high energy phosphate compounds, however, and for maximum photosynthetic efficiency the far-red light must be supplemented by light of shorter wavelengths. This is termed photosynthetic enhancement.

Punnett found that in homogeneous chloroplasts, enhancement, which is normally about 30 per cent, was reduced almost to zero. Punnett has two theories to account for this; first, there may be a shift in the partitioning of light energy absorbed by the chloroplast pigments so that nearly equal amounts of energy are delivered to the long and to the short wavelength light reaction. In these conditions, photosynthetic enhancement will, of course, approach zero. The second possibility is that the mechanism of photosynthesis switches from a reaction involving two photosystems to a simpler form involving but one photoact. It is impossible to tell at present which of these possibilities is most likely, but it seems certain that light activated ion transport is in some way involved. The eventual elucidation of how ion transport alters as plastid structure changes should add a fascinating chapter to this story.

GRAVITATIONAL CONSTANT

Measurements Refined

THE possibility of the gravitational "constant" G not really being a constant was first discussed by Dirac in 1938 (*Proc. Roy. Soc., A*, **165**, 199). Since that time, there have been several conjectures made on the variation of G , and an estimate for the magnitude of the possible variation with time was given by Dicke in 1962 (*Rev. Mod. Phys.*, **34**, 110; 1962, and *Science*, **138**, 658; 1962). He postulated on theoretical grounds that the value of $\frac{1}{G} \frac{dG}{dt}$ could be decreasing at the rate of 4×10^{-11} per year.

A group at MIT's Haystack Observatory now report a continuing series of measurements that aim at determining the time variation of G (I. I. Shapiro *et al.*, *Phys. Rev. Lett.*, **26**, 27; 1971). A decrease in the gravitational constant implies an increase in the orbital planetary periods and, for six years, the MIT group has been involved in measuring these periods. The group use a planetary radar system and regular measurements are taken of radar-echo time delays between Earth and Venus and Earth and Mercury. The data for Earth and Mer-

cury, which were accumulated chiefly during the past three years, are more significant than the earlier work because Mercury has an average orbital angular velocity five times that of the Earth.

To analyse their data, the MIT group take an *ad hoc* model assuming that each planet obeys the equations of motion that follow from the Schwarzschild metric for the Sun and from Newtonian perturbations attributable to the Moon and other planets. In this model, however, G is

replaced by $G_0 + \frac{dG_0}{dt}(d - t_0)$. A com-

puter program is used to fit the model to the data and to extract values for eighteen variable parameters. Values for seventeen of the parameters (the eight-

eenth being $\frac{1}{G} \frac{dG}{dt}$) were consistent with

previous work at MIT, and statistical tests showed the data to be internally

consistent. The value of $\frac{1}{G} \frac{dG}{dt}$ obtained

was less than the expected standard error, and an upper limit of 4×10^{-10} per year is quoted, an order of magnitude larger than Dicke's prediction.

Because the experiment is still in pro-

Chemistry and Hair Colouring

A GOOD example of some basic research in chemistry which will probably have a definite industrial application in the near future is described in an article in next Monday's *Nature Physical Science*. M. M. Breuer reports work done at the Unilever Research Laboratory at Isleworth, Middlesex, to elucidate the reasons why differing quantities of aromatic and aliphatic compounds are absorbed from solution by human hair. The uptake of aliphatic compounds such as ethanol is found to be at least ten times lower than the corresponding figure for aromatic compounds such as the phenols.

Investigations of this type are of considerable importance in the development of more efficient hair preparations and Breuer reports a systematic study which suggests that aromatic compounds are absorbed more easily because of a dipole-induced dipole interaction between the peptide groups of the hair protein (keratin) and the easily polarized aromatic molecules. The formation of similar association complexes between molecules in solution is already well established (see, for example, Homer and Cooke, *J. Chem. Soc. A*, 2862; 1969).

Breuer's conclusion about the nature of the bonding interaction was reached after a number of other possibilities had been eliminated. Experiments showed, for example, that the aliphatic 1,4-dihydroxycyclohexane is not absorbed by hair even from a saturated solution. If this

behaviour is compared with the known appreciable uptake of hydroquinone (aromatic), several bonding possibilities can be ruled out. The existence of hydrophobic bonds, which are formed by the elimination of a water molecule, would imply that the absorption of the two compounds should be similar—the hydrophobic bond energy is approximately proportional to the number of hydrocarbon groups in the absorbed molecule and this number is the same for both 1,4-dihydroxycyclohexane and hydroquinone. The possibility of the involvement of hydrogen bonds is also negligible, Breuer suggests, because benzene, which contains none of the hydroxyl groups characteristic of the phenols, is also found to bind easily to keratin.

Support is lent to Breuer's proposal by the work of Matson *et al.* (for example, *J. Colloid Interf. Sci.*, **31**, 116; 1969) on the absorption of phenols on activated carbon surfaces. They found that the principal adsorption sites for phenol molecules are the surface carbonyl groups and, by infrared spectroscopy, that the stretching mode of the C—O—H linkage was unchanged after adsorption, thus vitiating the hydrogen bond theory. Breuer completes his article by comparing the calculated binding constants of several phenols to wool with their measured polarizabilities; these turn out to be consistent with his approach to the bonding problem.