cepted by most workers. A few papers were presented which disagreed with some of its finer points and the exact values of the H/e or P/e ratios are still not known. Over the years H. Witt (Berlin) and his colleagues have presented strong experimental support for Mitchell's concepts and again at this meeting, Glaber from Witt's laboratory reported experiments in which ATP synthesis had been induced by creating artificial electrical gradients across chloroplast membranes. A requirement of the chemiosmotic scheme is that there is a membrane-located ATP synthetase or coupling factor able to do work when translocating protons down their electrochemical potential gradient. The coupling factor consists of several subunits and N. Nelson (Haifa, Israel) reported some unique experiments. He seems to have isolated the 'H^+-ionophore' component of the complex and has tested its ability to increase H^+ conductance by incorporating it into artificial membrane systems.

Carbon metabolism

The sessions on carbon metabolism dealt largely with the regulation of CO_2 fixation in C_3 plants and with photorespiration. No great advances in our knowledge of C_4 metabolism were reported, but it is now generally accepted that the Calvin cycle operates only in bundle-sheath cells. CO_2 is fixed in the mesophyll, transferred to the bundle-sheath as malate or aspartate and released again to be refixed by the Calvin cycle.

Regulation of the Calvin cycle is achieved by several mechanisms, one of which is a light-dependent increase in the activity of certain enzymes. Illumination generates dithiol groups within the chloroplast, which then activate the enzymes. L. Anderson (University of Illinois, Chicago) and B. Buchanan (University of California, Berkeley) gave evidence that both membrane-bound dithiol groups and the dithiol protein thioredoxin seem to be involved. A tentative mechanism may be proposed (Fig. 1).

As. H. Heldt (University of Munich) reported, when chloroplasts are illuminated, the Mg^{2+} concentration of the stroma increases by 1–4 mM and its *p*H from 7.0 to 8.0 as H^+ enters the thylakoids and Mg^{2+} moves out. These changes regulate several enzymes of the Calvin cycle, especially fructose and sedoheptulose diphosphatases. Both enzymes work best at high *p*H and Mg^{2+} concentration. Ribulose diphosphate carboxylase requires preincubation with Mg^{2+} and CO_2 to obtain maximum activity *in vitro*: it is not clear if the enzyme is always fully activated *in vivo*. According to D. Walker (University of Sheffield) the kinetics of the activated enzyme can now account for observed rates of CO_2 fixation. J. Preiss (University of California, Davis) suggested that starch synthesis is regulated at the level of ADP-glucose pyrophosphorylase, which is activated at high phosphoglycerate/inorganic phosphate ratios.

Illuminated chloroplasts generate H_2O_2 but contain no catalase activity. Ascorbate peroxidase together with glutathione reductase may remove H_2O_2 *in vivo*, an argument put forward by D. Groden (Bayreuth) and by B. Halliwell (King's College, London).

Photorespiration is caused by the formation of glycollic acid and its subsequent oxidative decarboxylation. G. Lorimer (Munich) reported experiments with $^{18}O_2$ which show that most, if not all, of the glycollate is produced by the hydrolysis of phosphoglycollate generated by the oxygenase activity of ribulose diphosphate carboxylase. U. Heber (Dusseldorf) also carried out other experiments which supported this conclusion. The glycollate so produced is oxidised to glyoxylate and transaminated to glycine in peroxisomes. The glycine is converted into CO_2, NH_3 and serine in mitochondria. As A. Moore (King's College, London) explained glycine oxidation by leaf mitochondria has a P/O ratio of 3; the NH_3 formed is probably a substrate for glutamine synthetase. Several groups of workers have shown that the amount of carbon flowing through glycine and serine in illuminated leaves is more than sufficient for glycine decarboxylation to account for observed rates of photorespiration (D. Canvin, Queen's University, Ontario; C. Whittingham, Rothamsted). However, Canvin also reported that the ^{14}C-labelling kinetics of glycine and serine are extremely complicated and inconsistent with a single origin for these amino acids, so it cannot be clearly stated how much photorespiratory CO_2 arises by glycine decarboxylation.

Refixation of CO_2 released by photorespiration consumes considerable energy within the leaf. G. Krause (Dusseldorf) thought that photorespiration may help to use up 'excess' light energy and protect the chloroplast from damage. As. E. Elstner (Munich) explained, the electron acceptor complex of photosystem I can reduce O_2 to $O_2^{\cdot-}$, the toxic free-radical superoxide (Elstner, Asada). In the absence of CO_2 NADPH/$NADP^+$ ratios in the chloroplast will be high and so electrons should be shunted more rapidly to O_2. Photorespiration, by making CO_2 continuously available for refixation, might help to decrease $O_2^{\cdot-}$ formation to a level that can be dealt with by the chloroplast's protective mechanisms. □

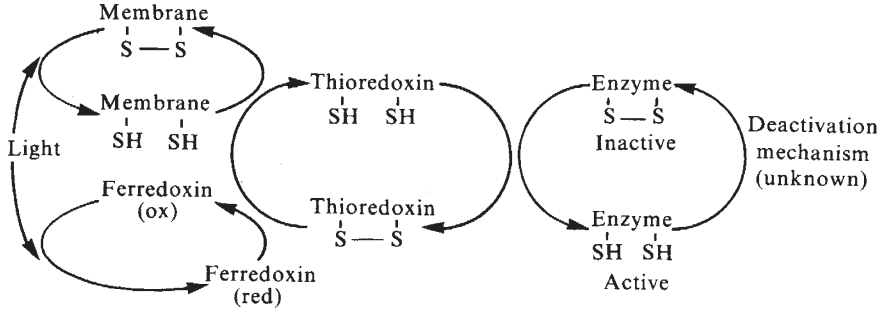

Fig. 1 Tentative mechanism for activation of Calvin cycle enzymes by dithiol groups generated by illumination of chloroplasts.

A hundred years ago

THE chief signal officer of the U.S. army has been urging that physical observations of the sun be made, as of sun-spots, faculae, protuberances &c., in reference to their supposed influences upon terrestrial meteorology, and has offered to publish the results monthly, or such of them as may be considered desirable by the observer, in the *Monthly Weather Review*. The United States Naval Observatory at Washington has already accepted this proposition, and it is considered very desirable that some other observatories in the east and at least one on the western coast, cooperate in this undertaking.

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