nitrate to nitrite, or the reduction of nitrite to ammonium. In practice it was found that, in *Spirodela,* only the first two processes were affected by the presence of ammonium. Uptake of nitrate was partially inhibited and reduction of nitrate was almost completely inhibited, whereas reduction of nitrite was not affected at all. Looking in more detail at the inhibition by ammonium of nitrate reduction we found, somewhat to our surprise, that *Spirodela* when supplied with both ammonium and nitrate contained high levels of nitrate reductase and high concentrations of nitrate, but yet did not reduce nitrate. Thus it seemed that the presence of ammonium was not affecting the production of the enzyme nitrate reductase but, in some way, was affecting the activity of this enzyme. Thus we have pinpointed, to some extent, the way in which the presence of ammonium regulates the utilisation of nitrate, but we have in no way determined the mechanism of this effect.

Changes in the activities and levels of enzymes are also known to occur in other situations in plants. For example, we have observed marked increases in the activities of certain enzymes as we allow plants to become deficient. If *Spirodela* plants that have been grown in a complete medium are transferred to a medium lacking in nitrogen, for example, then naturally enough those plants soon develop symptoms characteristic of nitrogen deficiency. However, these plants do not stop growth immediately when transferred to deficient media, and will often add considerably to their fresh weight before growth ceases. Even though the new medium may contain no nitrogen, such plants are apparently able to reutilise some of the nitrogen they absorbed when growing on the previous medium. Gradually, however, growth of these plants becomes inhibited through shortage of nitrogen. The reutilisation of reserve nitrogen apparently requires new and different enzymes, for, under these conditions, the plant produces a different array of enzymes. For example, we have found that nitrogen-deficient plants have a marked level of the enzyme urease. Similarly, plants deficient in phosphate have a higher level of the enzyme phosphatase. Such enzymes are apparently produced quite specifically in response to deficiencies of elements. It is natural to suppose that these enzymes are in fact used by the plant in the remobilisation of its reserve nutrients, but direct proof of this has not been obtained.

I have said enough, I think, to demonstrate that plant organisms do exhibit quite marked regulation of their own metabolism. This is one of those aspects of plant growth that have not yet got into the text books. When we read about plant metabolism we are inclined to get the impression that the reactions of metabolism are fixed and unchanging, whereas we now realise that many of these reactions can be inhibited or stimulated in various ways. The actual presence of a compound may induce the production of an enzyme necessary for the metabolism of that compound. The appearance of a specific deficiency may induce the appearance of enzymes that, to some extent at least, can compensate for the deficiency of that element. Again the presence of one ion, such as ammonium, may in some way affect the enzymes that normally metabolise other compounds, in this case nitrate. All of this points to the presence of a most complex and elaborate system of controls in metabolism. We still have much to learn about the actual biochemical pathways of metabolism, but it is also apparent that we have a vast extra amount to learn of the actual regulation of these pathways, their interactions, and how the whole pattern of growth is completely integrated.

CONCLUSION

Man has over the years attempted to improve his ability to grow more food in several different ways. First, he has continually selected the plants he grows—a process that has gone on largely unconsciously down the ages. If one type of wheat plant produced more growth than another or survived a bad year better, man was more likely to use seed from that plant for next season. If an apple tree produced