than nutrients, which in small amounts promote, inhibit, or otherwise modify any physiological process in plants". He also mentioned that compared to auxins or hormones, the term regulator had the widest of boundaries and could be applied to materials that modify any physiological process in plants.

Personally, I prefer the broadest interpretation of the term "growth regulator" as it applies to plant propagation. Under this heading, we can then discuss everything from florigen to kinetin, from 2,4,5-T to vitamin B, from traumatic acid to "accelerator A", and from Chloromone to co-factors. And, should boron be found to aid rooting, it too could be included in the list, perhaps not as a nutrient, but as a regulator playing a far different physiological role.

Who knows what substances will serve to answer some propagation questions we have at present? For example, why do etiolated stems root better than normal stems; why does juvenile wood root more readily than the adult type; who do pendant branches root better than erect ones; why does a light interruption during the night have an influence on rooting; and lastly, why does Bartlett pear, which normally doesn't root at all, produce a fair stand when the source of cutting wood comes from trees grafted on quince? When these questions, and many others are answered, we may have some surprising new growth regulators on the books.

An excellent example of what lies in the future can be drawn for the work of Dr. Hess at Purdue University. He has isolated four substances he calls co-factors, since they do not function alone, but only in the presence of IAA. Co-factor #4 appears in the largest quantity in juvenile or easy-to-root cuttings. This is the co-factor Dr. Hess is presently trying to identify. He has located a very similar compound, a reducing agent commonly used in photography. While this substance is not identical to co-factor #4, it still is very active in promoting rooting when combined with IAA. It is the ultimate aim of Dr. Hess to identify all four co-factors. Once this is done, a difficult-to-root variety need merely be analyzed to determine which co-factors are missing or in low supply. The right co-factor could be supplied and rooting would be achieved.

Now that the future and the past have been briefly investigated, let us see what the present holds in respect to Growth Regulators in Relation to Plant Propagation. Our first speaker will be Dr. J. van Overbeek, Chief Plant Physiologist, Shell Development Co., Modesto, California. Dr. van Overbeek --

Plant Hormones

J. van Overbeek

Shell Development Company, Agricultural Research Division

Modesto, California

In the plant, as well as in the animal, minute amounts of chemicals regulate the growth process. These compounds are called growth regulators, and if they are naturally-occurring, they are spoken of as plant hormones. At present we recognize three major classes of plant regulators:

The Auxins.
The Gibberellins.
The Kinins.

We will discuss what they are, how they regulate the plant's physiology, and to what practical uses they have been put.

The Auxins

The prototype of the naturally occurring auxins is indoleacetic acid (IA). It is formed from tryptophan via indoleacetaldehyde in young growing tips. If these courses of IA are cut off, the remainder of the plant ceases to grow. However, growth is resumed when IA or another synthetic auxin is applied to the cut stump.

Plant cells grow by taking up water osmotically. Auxins promote this process by softening the cell walls. This leads to cell enlargement.

A general characteristic of hormones is that they affect a multitude of processes. Thus, auxins not only promote growth of stems and fruits, but they promote the formation of roots on cuttings and the formation of flowers on pineapple plants. Not only do auxins promote growth, but sometimes they inhibit it. Lateral buds, for instance, are prevented from growing out of the leaf axils because of the auxin produced by the terminal bud. When we cut the terminal bud off, as in clipping a hedge, these lateral buds then grow out.

The major practical use of auxins is as selective weed killers. A synthetic auxin, principally 2,4-dichlorophenoxyacetic acid (2,4-D), is sprayed on plants in such relatively large amounts (yet only one pound per acre!) that it "drowns" the natural regulating system, and the plant dies a slow death. Cereals, such as wheat, can inactivate the synthetic regulator, while broad-leaved plants, such as wild mustard cannot. Thus, 2,4-D sprays have effectively removed broad-leaved weeds out of wheat, thereby making grain production more efficient.

Synthetic auxins are also universally used for plant propagation. Most modern nurseries treat the base of cuttings with indolebutyric acid before these are placed in the propagating frame. Root formation is accelerated in this way and, in addition, a "bottle-brush" type of root system develops which facilitates transplanting.

In boysenberry culture "king-sized" fruits are produced by application of synthetic auxins; and in the citrus industry 2,4-D in small amounts is a standard ingredient to increase the size of oranges.

The Gibberellins

The structure of these plant regulators is far more complicated than that of the auxins. Man has not yet synthesized them. Their existence was known in Japan long before the western world became aware of them. The gibberellins promote shoot growth dramatically. These chemicals can give dwarf plants the appearance of normal, tall plants. They promote flower formation in many species. Growth of lateral buds is promoted by gibberellins, but curiously the presence of auxins prevents the gibberellins from exercising this power.

Gibberellins are beginning to find practical uses. In the culture of table grapes of the Thompson Seedless variety, gibberellin is used to make larger bunches with larger berries. Celery is made larger after gibberellin application. Gibberellins speed up malting in beer brewing. In the seed industry, gibberellin is used to make head lettuce produce seed stalks.

The Kinins

These are the most recent discovery. Structurally they are related to the nucleic acids, but man has made synthetic kinins. In nature they are found in tissues that nourish the plant embryo. It was first discovered in coconut milk. Kinins promote cell division in very low concentrations; a few parts per billion is enough.

Adenine is the essential ingredient which gives a kinin molecule its biological activity. Adenine is an essential ingredient of nucleic acids. Nucleic acids control important processes such as protein synthesis. It is not surprising, therefore, that kinins promote both nucleic acid and protein synthesis. Kinins appear to do this especially well in leaves, even in the dark and in leaves which have been removed from the plant. Kinins, therefore, may be called maintenance hormones. Kinins maintain normal biochemistry in the leaf. Kinins, therefore, keep green produce healthy after harvest, a feature which is being exploited commercially at present.

REFERENCES

van Overbeek, J., Auxins, The Botanical Review. Vol. 25, No. 2, pages 269-350, April-June, 1959.

Phinney, Bernard and Charles A. West. Gibberellins and the Growth of Flowering Plants. Developing Cell Systems and Their Control. Pages 71089. New York: The Ronald Press Company, 1960.

Strong, F. M., Kinetin and Kinins. Topics in Microbial Chemistry. Pages 98-157. New York: John Wiley and Sons, 1958.

Recent Books: Plant Growth Regulation, Fourth International Conference on Plant Growth Regulation. Ames, Iowa: The Iowa State University Press, 1961.

Gibberellins, Symposium, 138th National Meeting of the American Chemical Society, New York, N. Y. Advances in Chemistry Series Number 28, American Chemical Society, Washington, D. C., 1961.

MODERATOR LAGERSTEDT: Thank you, Dr. van Overbeek. Our next speaker on this evening's program will be Dr. Hudson T. Hartmann Professor of Pomology, University of California at Davis. Dr. Hartmann --

The Use of Growth Regulators in Propagating Clonal Rootstocks for Several Tree Fruit Species

H. T. Hartmann

Dept. of Pomology, University of California

Davis, California

Clonal rootstocks are becoming more important each year in propagating many kinds of fruit trees. Such stocks have the advantages of uniformity, perpetuation of specific, desired characteristics without change, and often result in more rapid propagation time than when seedling stocks are used. They have the disadvantage, however, of perpetuating diseases -- so the use of initially clean stock is very important.

During the past few years in California, a definite need for clonal rootstocks, and rapid methods of propagating them, has arisen in several tree fruit species.

As a rootstock for the English walnut, Paradox walnut seedlings (*Juglans hindsii* x *J. regia*), resulting from natural crossing, have