Since the 1948 low level of just over 850 million dollars, Federal Government expenditure on scientific research and development has risen steadily, except in 1954, to 2,800 million dollars in 1957, or just over 4 per cent of the total budget expenditure compared with just over 2 per cent, and it is estimated that expenditure on basic research has increased by more than 85 per cent since 1952, although still amounting to only 8 per cent of the total funds for the conduct of research and development, exclusive of the pay and allowances of military personnel. In the same period, allocations for research in the biological sciences also increased by more than 83 per cent. It is estimated that the increases have been greater than the rate of increase in costs for salaries and equipment for scientific work and that accordingly when due account is taken of such rising costs the long-term trend still reflects a steady increase in the provision of Government funds for scientific research and development. Besides the statistical tables, the report includes technical notes on the limitations of the data and definitions and a list of research centres.

PHOTOPERIODISM IN PLANTS AND ANIMALS

An international symposium on "Photoperiodism in Plants and Animals", sponsored by the Photobiology Committee of the National Research Council of the United States, was held at Gatlinburg, Tennessee, during October 29–November 2.

In an introductory session the reversible photochemical properties of certain dyes were described by Dr. G. Oster (Polytechnic Institute of Brooklyn) and problems of energy transfer in photochemical systems were discussed by Dr. Gordon Tollin (University of California, Berkeley). Dr. Stacey French (Carnegie Institution, Stanford) discussed the difficulties of determining action and absorption spectra in living systems.

One session was devoted to the various photoperiodic effects observed in growth and dormancy of plants. Dr. J. L. Liverman (Texas Agricultural Experiment Station) and Dr. W. H. Klein (Smithsonian Institution, Washington) dealt with the interaction between red light and various other factors in the growth of bean leaf disks, and the uncoiling of the bean epicotyl hook, respectively. Both speakers reported that the effects of indole-acetic acid, kinetin, gibberellic acid and the cobaltous ion seem to be independent of those of red light. There appears, however, to be an interaction between adenine and red light in the growth of bean leaf disks. Dr. E. H. Toole (U.S. Dept. of Agriculture, Beltsville) described the responses of various light-sensitive seeds and Dr. P. F. Wareing (University of Manchester) dealt with the photoperiodic control of germination, with special reference to the action of various spectral regions and the possible role of growth inhibitors. Dr. R. J. Downs (U.S. Dept. of Agriculture, Beltsville) discussed the interaction between red and infra-red radiation in relation to various aspects of vegetative growth. The effects of red irradiation on the activity of indole-acetic acid oxidase were shown by Dr. A. W. Galston (Yale University) to be due to the formation of an inhibitor of this enzyme by red light.

Dr. R. van den Veen (Philips' Research Laboratories, Eindhoven) described experiments which involved growing various species entirely under high-intensity monochromatic light. It was found that there are marked differences between species with respect to growth responses, under the various spectral regions. There are complex interactions between blue and red, especially in relation to the control of flowering. Prof. E. C. Wassink (Agricultural University, Wageningen) also described the responses of various species grown under high-intensity radiation in narrow spectral regions.

Two sessions were devoted to the photoperiodic control of flowering. Dr. Ralph Wetmore (Harvard University) and Dr. E. M. Gifford (University of California, Davis) described the structural changes occurring in shoot-apices of *Xanthium* and other species in the transition from the vegetative to the flowering condition. The interaction of red and far-red radiation in the flowering of various species, including *Hyoscyamus*, was dealt with by Dr. H. A. Borthwick (U.S. Dept. of Agriculture, Beltsville). Dr. Roy Sachs (University of California, Los Angeles) discussed the implications of 'long-short' day plants, such as *Cestrum nocturnum*, for general theories of photoperiodism.

Dr. A. Lang (University of California, Los Angeles) read a paper dealing with the general problem of the role of auxin and gibberellins in flowering. Auxin tends to be inhibitory of flowering in short-day plants and promotive in long-day plants, but it appears only to modify the responses. Both gibberellic acid and gibberellin-like fractions from *Cucurbita* endosperm are capable of inducing flowering in some long-day plants, but cannot replace photo-induction in short-day plants. Photo-induction in long-day plants appears to involve reactions other than gibberellin-controlled processes, which may be concerned primarily with stem elongation. The interactions between gibberellic acid and photoperiodic responses were discussed by Prof. Fausto Lona (University of Parma) for a wide variety of species.

The effects of certain synthetic hormones on flowering of *Xanthium* were described by Dr. A. Naylor (Duke University), and Dr. F. Salisbury (Colorado State University) described the interaction between various applied growth substances and the critical dark period in *Xanthium*. Dr. W. Jacobs (Princeton University) discussed the relations between auxin, day-length and compensatory growth in *Coleus*.

In a general paper on the nature of the photoinductive processes in photoperiodism, Dr. James Bonner (California Institute of Technology) outlined the present state of knowledge of the various partial processes involved, and discussed the possible reasons why the 'flower-hormone' has not yet been isolated. Dr. R. B. Withrow (Smithsonian Institution, Washington) gave a general account of the kinetic aspects of the photoreactions. He distinguished between 'graded' responses (for example, of light-sensitive seeds) and 'threshold' responses (for example, photoperiodic phenomena). Dr. S. B. Hendricks (U.S. Dept. of Agriculture, Beltsville) also dealt with kinetic aspects of the photo-reactions of photoperiodism and showed how certain kinetic parameters of the photoreceptor system can be derived. He also described a second photo-receptor system which appears to be involved in anthocyanin synthesis.

A series of papers dealt with photoperiodism in animals. Dr. A. D. Lees (A.R.C. Unit of Insect Physiology, Cambridge) reviewed the phenomena of photoperiodism in insects and mites, particularly in relation to the onset of diapause. Photoperiodic responses appear to be widespread in Lepidoptera. Dr. C. E. Jenner (University of North Carolina) dealt with photoperiodism in an aquatic midge, the larval stage of which is found in the 'pitchers' of pitcher plants. Reproduction in certain snails and freshwater shrimps appears to require long-day conditions. Photoperiodism is also of importance in many marine invertebrates, including crustaceans, molluscs and echinoderms, as was shown by Dr. A. C. Giese (Stanford University).

The general problem of the seasonal control of reproductive cycles in vertebrates was discussed by Dr. W. S. Bullough (University of London), who emphasized that photoperiodism constitutes only one aspect of a highly complex system. In vertebrates, photoperiodic perception appears generally to be mediated through the eyes. In carp and related fishes, courtship and breeding appear to be induced by increasing day-length in the spring, as shown by Dr. R. W. Harrington (Florida State Board of Health). Photoperiodic effects have also been reported in certain reptiles, including the pond-turtle, the American chameleon and certain lizards. Dr. G. A. Bartholomew (University of California, Los Angeles) emphasized, however, that in the latter the importance of photoperiodic responses is probably over-ridden by behavioural patterns in relation to diurnal temperature changes.

Endogenous rhythms in the ovulation cycle of hens were described by Dr. R. M. Fraps (U.S. Dept. of Agriculture, Beltsville). Dr. D. S. Farner (State College of Washington) showed that in certain birds day-length controls a variety of physiological responses including the male gonadal cycle, fat metabolism, vernal migration and probably moulting. In the white-crowned sparrow the most effective spectral region controlling development of the testes appears to be in the red. Dr. A. Wolfson (North Western University, Evanston) described photoperiodic control of migration in the juncos of Alberta, in which fat deposition appears to be an important factor. The responses in these birds appear to be determined by the duration of the daily dark period. Photo-periodic responses in other bird species were described by W. L. Engels (University of North Carolina), Dr. C. M. Kirkpatrick (Purdue University) and Dr. W. O. Wilson (University of California, Davis).

A further series of papers was devoted to endogenous rhythms in plants and animals. Dr. E. Bünning (University of Tübingen) gave a general account of endogenous rhythms, and discussed some general properties of the 'timing mechanism' in such rhythms. Dr. K. C. Hamner (University of California, Los Angeles) described the results of experiments with 'Biloxi' soybean, in which it was found that flowering occurred with cycle-lengths of 24 hours or of multiples thereof, whereas with cycles of intermediate duration flowering was partially or completely inhibited. These results are held to indicate an endogenous rhythm in photoperiodic sensitivity. Dr. F. W. Went (California Institute of Technology) showed that certain species, notably the tomato, made favourable growth on 24-hour cycles but showed reduced growth and other adverse symptoms on other lengths of cycle. These effects are exhibited in both photoperiodic and thermoperiodic phenomena.

Dr. C. S. Pittendrigh (Princeton University) discussed the possible nature of the clock mechanism in endogenous rhythms and postulated that two types of 'oscillator' may be involved, namely: (1) a primary light-sensitive oscillator which is temperature-independent, and the phase of which is determined by external light conditions; (2) a temperature-sensitive oscillator which can 'entrain' oscillator (1). Endogenous rhythms of activity in the hamster, and of bioluminescence in *Gonyaulax polyedra*, were described by Dr. K. S. Rawson (University of Wisconsin) and Dr. J. W. Hastings (Northwestern University) respectively.

Three evening sessions were devoted to sixteen short papers, including seven dealing with interactions between gibberellic acid and various light-controlled processes.

This highly successful meeting is believed to have constituted the first international symposium devoted specifically to photoperiodism in plants and animals. Biologists working in this field are indebted to the Photobiology Committee for organizing the meeting and especially to Dr. R. B. Withrow and Dr. N. E. Tolbert, chairman and secretary of the Committee respectively.

P. F. WAREING

FARMING HISTORY

THE joint annual conference of the British Agricultural History Society and the Association of Agriculture was held on December 7 at the Institute of Education, University of London. Three papers were read. Mr. George Ordish discussed the "History of Crop Pests, and the Measures taken to overcome them". After lunch, two papers on horticultural history were presented. Dr. L. G. Bennett, Department of Agricultural Economics, University of Reading, spoke on the "History of the Development of Market Gardening", and Mr. Eric Hobbis, of Long Ashton Research Station, University of Bristol, on the "History of Soft Fruit Growing".

Pests and diseases of plants are as ancient as the cultivation of crops for food, and the uncultivated flora that flourished before man was probably also afflicted. Mr. Ordish showed by exhaustive references to Pliny that pests and diseases were well known in classical times. Apples and pears were affected, and the olive fly was prevalent. It is still a trouble. There were cereal pests, wireworm and the cabbage flea beetle, but there was no phylloxera, nor the two mildews that were introduced from America much later.

Methods of protection were then of four kinds: religious, superstitious, mechanical and chemical. Though some of the first two were peculiar, it is not advisable to dismiss them out of hand. The superstition of yesterday often turns out to be the science of to-day. Achilles barley, presumably an immune variety, was recommended by Pliny when rust was very bad. Treating with burnt ash, steeping seed in