seems to be at least one level of organisation between the polypeptide chain and the macroscopic fibre. This level consists of microfibrils the thickness of which varies between 100 A. and 1,000 A. in different proteins; and the microfibrils in turn often appear to consist of assemblies of globular particles; sometimes a simple string of beads; sometimes a more complex pattern as in the paramyosin of clam muscle. The investigation of clam muscle is a striking example of the combined approach of X-ray analysis and electron microscopy. The X-ray pictures of Bear[12] show the typical α-keratin pattern in addition to a low-angle pattern which is resolved into a series of distinct spots. The low-angle pattern can be interpreted in terms of hexagonal array of globular particles of 150 A. diameter, which corresponds exactly with the electron microscope pictures of Hall, Jakus and Schmitt[13]. Another protein, tropomyosin, can undergo a reversible transformation from fibrous to what may prove to be a corpuscular state. The work of Perutz and Kendrew on hæmoglobin and myoglobin[14], both typical corpuscular proteins which have no tendency towards fibre formation in the native state, shows these proteins to consist of bundles of polypeptide chains. It appears that the chains are folded in the α-keratin configuration. Mrs. Hodgkin[15] has recently found evidence of such chain structures in the small peptide gramicidin. Dr. Perutz stressed the importance of further knowledge of the α-keratin structure as basic to the future study of hæmoglobin and myoglobin; this knowledge is not likely to come by model-building alone; more experimental data are required. The recent studies by Elliot, Ambrose and Temple[16] with polarized infra-red radiation on proteins of the α-keratin type have revealed a striking dichroism. Absorption is much stronger (in the neighbourhood of 3 μ) parallel to the fibre direction than at right angles to it. This indicates that the CO—NH bonds are oriented preferentially and parallel to the fibre axis. This observation confirms the old contention that folds in the α-keratin chain must be held together by hydrogen bonds located within each chain.

The use of the reflecting microscope in such studies receives further emphasis from the work of Barer, Jope and Perutz on the ultra-violet absorption of single hæmoglobin and myoglobin crystals. The pronounced dichroic effect in the absorption of the hæm group at 400 mμ shows that this ring is orientated with its plane normal to the *a*-axis of the crystal. The second absorption band shows a maximum dichroic effect at 290 mμ, a region associated with the indol group of tryptophan. Like hæm, this ring system would be expected to show absorption only when the electric vector is parallel to the plane of the ring. The dichroic effect thus indicates that the plane of the indol group is normal to the *a*-axis. X-ray data show the polypeptide chains to be parallel to *a*. Thus, the planes of both hæm and indol rings are normal to the polypeptide chain direction. In tobacco mosaic virus the indol rings are normal to the length of the virus particle.

Dr. Hodgkin stressed the importance of obtaining new information about the region of size to which both X-ray diffraction and the method of electron microscopy might apply; and particularly, the region just below the limit of size where electron micrographs at present show clear detail, say 50 A. or so. X-ray data indicate structure within particles such as the bushy stunt or turnip yellow virus which might be of this order of magnitude. Dr. Hodgkin also discussed the interrelation between information derived from both methods as applied to tobacco necrosis protein.

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[1] See, for example, Randall, J. T., "Diffraction of X-rays by Amorphous Solids and Liquids" (London: Chapman and Hall, 1934).
[2] Riley, D. P., *Brit. Sci. News* (in the press).
[3] Riley, D. P., and Herbert, D., *Biochim. et Biophys. Acta* (in the press).
[4] Bernal and Fankuchen, *J. Gen. Physiol.*, **25**, 111 (1941).
[5] Oster, *Rec. Trav. Chim. Pays-Bas* (in the press).
[6] See, for example, Caspersson in Society of Experimental Biology, Nucleic Acid Symposium (Cambridge, 1947).
[7] See *Proc. Roy. Soc.*, B, **136**, XIV (1949).
[8] Burch, *Proc. Phys. Soc. Lond.*, **59**, 41 (1947).
[9] Seeds and Wilkins, *Nature*, **164**, 228 (1949).
[10] Brown and Randall, *Nature*, **163**, 209 (1949).
[11] Loofbourow, Sinsheimer and Scott, *Science*, **107**, 302 (1948).
[12] Bear, *J. Amer. Chem. Soc.*, **66**, 2043 (1944).
[13] Hall, Jakus and Schmitt, *J. App. Phys.*, **8**, 459 (1945).
[14] Perutz and Kendrew in Barcroft Memorial Volume "Hæmoglobin", 161 (Butterworth, 1949).
[15] Hodgkin and Schmidt, reported in *J. Sci. Instr.*, **26**, 283 (1949).
[16] Elliot, Ambrose and Temple, *Nature*, **163**, 859 (1949). See also Astbury, *Nature*, **164**, 439 (1949) and Sutherland and Darmon, *Nature*, **164**, 440 (1949).

PREPARATION AND INSECTICIDAL ACTION OF *BIS* (*BIS*-DIMETHYLAMINO)-PHOSPHONOUS ANHYDRIDE

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IT has been reported by Schrader[1,2] and other German workers that certain organo-phosphorous compounds have strong insecticidal properties. They act as contact insecticides, but also, in a less familiar manner, as 'systemic' insecticides, that is, they are absorbed by the roots or the leaves of a plant and render it toxic. The effect may be very persistent and this mode of action would be of considerable economic interest were it not for the fact that, with compounds tested to date, the treated plants are also toxic to mammals.

In order that biological tests may be definitive, it is necessary to work with pure materials. This is especially so with the synthetic organo-phosphorous compounds, which differ widely in insecticidal activity. The *bis* (*bis*-dimethylamino)-phosphonous anhydride used in the present investigation has been prepared with great care, and the steady boiling point and satisfactory analysis suggest that the material was pure.

Preparation. Purified starting materials were employed and the intermediate compounds were all fractionated carefully one or more times through a 24-in. column packed with glass helices and with a variable take-off stillhead. The method of synthesis used was based on that outlined by Schrader[2] and was briefly as follows:

Methylaminehydrochloride and excess phosphorus oxychloride were refluxed for 20 hours and fractionated to give dimethylamino-dichlorophosphine oxide (I), NMe_2POCl_2 (b.p. 88°/18 mm.; 94 per cent yield). Treatment of I (1 mol.) with methylamine (2 mol.) in ether at room temperature yielded *bis* (dimethylamino)-chlorophosphine oxide (II), $(NMe_2)_2POCl$

(b.p. 102°/6 mm.; 84 per cent yield). Ethyl *bis* (dimethylamino)-phosphonite (III), $(NMe_2)_2PO(OEt)$, was made by reaction of II with an equimolecular amount of sodium ethoxide in alcohol (b.p. 93·5°/8 mm.; 88 per cent yield). When II and III were heated together in equimolecular amounts in boiling xylene for 20 hours, ethyl chloride was evolved and, after fractionation, *bis* (*bis*-dimethylamino)-phosphonous anhydride, $(NMe_2)_2PO.O.PO(NMe_2)_2$, was obtained in 81 per cent yield as a colourless, almost odourless liquid, b.p. 98°/0·002 mm., 102°/0·003 mm., or 106°/0·004 mm. Analysis gave C, 33·9; H, 8·5 and N, 19·8, while the formula $C_8H_{24}N_4P_2O_3$ requires C, 33·6; H, 8·4 and N, 19·6 per cent.

Biological tests with Aphis fabœ. For the biological tests the material, prepared as above, was diluted to a 10 per cent v/v solution in distilled water and stored to be diluted further as required.

Broad beans were infested with *Aphis fabœ* and kept in a greenhouse at 16–26° C. The relative humidity and light conditions varied greatly. The results of the observations made to date may be summarized as follows.

Contact action. The day after the plants have been dipped in a 0·05 per cent v/v solution of the insecticide containing 0·1 per cent 'Teepol' as a wetting agent, the colonies of aphids are very much reduced in numbers. The young die first; but the plant is not entirely free from aphids for about three or four days. A 0·1 per cent solution acts rather more quickly and a 0·025 per cent solution more slowly. The leaves retain their toxicity to new infestations of aphids for about three days only. The action is slow on aphids arriving on the third day and the colonies take about six days to die out. Necrotic areas develop on the leaves after about fourteen days with concentrations of 0·05 per cent and more. 'Teepol' alone, at the stated concentration, is somewhat toxic to aphids, but the colonies survive and no necrotic areas develop on the plants.

Absorption from the roots. When applied to potted plants about six inches high in quantities ranging from 0·2 to 0·05 c.c. per 400 gm. soil, there is little apparent effect for three to five days, depending on the dose, but all aphids are killed in six to eight days. The plants are still toxic three weeks later, but at doses of 0·05 c.c./400 gm. soil and more, necrotic areas develop after about ten days.

In culture solutions, a 0·5 per cent concentration of insecticide frees the plant from all aphids in twenty-four hours, but necrotic areas develop in five days. A 0·05 per cent solution produces the same effect in four days, and necrotic areas appear about the fourteenth day. A 0·005 per cent solution kills the aphids in about nine days, and necrotic areas only begin to appear about the twentieth day. At this time the plants are still toxic to aphids.

If the plants are allowed to absorb 6–10 c.c. of a culture solution containing 0·1 per cent v/v of the insecticide, they remain toxic to aphids for at least twenty-one days. They develop necrotic areas after about fourteen days.

Concentration in the plant necessary to kill the aphids. A dose of 1 c.c. of a 0·1 per cent v/v solution gives a 99 per cent kill of aphids in two days when absorbed totally and rapidly (about three hours) by the cut main root of a plant weighing 10–15 gm. If it is assumed that the insecticide is absorbed and translocated unchanged, this dose would represent a concentration of insecticide of about 60–100 mgm./kilo in the plant tissue. When the absorption is slower (several days), the kill is delayed and may be incomplete.

Absorption from the leaves. When 0·5 c.c. of a 0·2 per cent v/v solution of the insecticide is applied to the upper surface of a pair of bean leaves, the aphids feeding on the lower surface are killed, but on the other parts of the plant they are unaffected. Absorption and translocation does not follow applications made to the undersurfaces of the leaves, either.

Mode of action on the insects. It is reasonable to suppose that the insecticide is absorbed by the roots and carried in the transpiration stream, and that the sap on which the insects feed becomes poisoned. Experiments in which the transpiration of certain leaves is depressed by enclosing them in a saturated atmosphere tend to confirm this. There is no evidence with this material that any vapour action is involved.

Tests against other insects. The material does not appear to be highly toxic to the stored-product insects *Ptinus tectus* and *Tribolium confusum*, which have been placed on surfaces treated with it. In this respect it is less toxic than O, O-diethyl O-*p*-nitrophenyl thiophosphate (*E*605).

It is hoped to publish a more detailed account of this work at a later date.

[1] Martin, H., and Shaw, H. Developments in methods and materials for the control of plant pests and diseases in Germany. Rept. No. 1095. British Intelligence Objectives Sub-Committee. (London, 1948.)

[2] Schrader, G. Rept. No. 714, *ibid.* (1948.)

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PROGRESS OF CANCER RESEARCH

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THE British Empire Cancer Campaign (11 Grosvenor Crescent, S.W.1) has now supported cancer research for a quarter of a century. The twenty-sixth annual report, edited by Sir Heneage Ogilvie, is a weighty volume of 320 pages where the reader will find that the Campaign finances, wholly or in part, nine centres of research in London and twenty-eight in the provinces, and co-ordinates, or is affiliated to, other centres in Canada, Australia, New Zealand and South Africa; that the Campaign's income was more than £300,000 in 1948, and that it is administered by more than a score of committees and sub-committees. The Campaign supports three types of investigation and development, namely, radiological, clinical, and a composite group, mainly biochemical.

The accompanying table shows the subject and number of investigations which are described in the report:

Radiology; biophysics	26
Carcinogens; carcinogenesis	12
Chemotherapy	8
Biochemical	7
Hormones	6
Clinical (excluding the Clinical Committee Report)	5
Pathology	4
Genetics; mutation	3
Virus tumours	3
Cytology	2
Tissue culture	2
Social incidence	2
Effect of diet on growth of tumours	1
Milk factor for mouse mammary carcinoma	1

The ever-increasing prominence of physics-inspired research and development expresses not only the