ENGINEERING, BIOPHYSICS AND PHYSICS AT KING'S COLLEGE, LONDON

NEW BUILDING

THE new physics and engineering laboratories at King's College, University of London, were opened formally by Lord Cherwell on June 27. These laboratories have been built in the only place available, below ground, in the space previously occupied by vaults which had been broken open by bombs during the Second World War. The proximity of Somerset House prevents any part of the building from projecting above ground-level, and the height of the water-table determined by the neighbouring Thames limits extension downwards. Between these levels a two-story building has been constructed, the presence of which would scarcely be suspected by anyone who, entering King's College from the Strand, drives or walks over the asphalt surface of the quadrangle which forms the roof of the building. However, the laboratories are extensive and, being decorated inside in bright colours and lit by fluorescent lighting and by a surprisingly large amount of daylight entering from large windows on one side, suffer relatively little from their subterranean condition.

Both physics and engineering at King's College are distinguished by the antiquity of their foundation. The first professor of natural and experimental philosophy was appointed in 1831. Charles Wheatstone was made professor of experimental philosophy in 1834 and developed the celebrated Wheatstone bridge. The College can claim to be the oldest academic institution in England to teach experimental physics, as the Clarendon Laboratory at Oxford and the Cavendish at Cambridge were founded respectively in 1868 and 1871. Later, Clerk Maxwell was a professor, and the high traditions of the department were maintained by H. A. Wilson, C. G. Barkla, Sir Owen Richardson, Sir Edward Appleton and Sir Charles Ellis, three of whom became Nobel laureates.

The Faculty of Engineering, which dates from 1838, is the oldest university engineering school in Great Britain and Ireland, the first professor (William Hosking) having been appointed in 1840, three weeks before Lewis Gordon became professor in Glasgow.

Department of Engineering

In its beginning, the Department of Engineering at King's College included in its teaching architecture and metallurgy. To-day, undergraduate study covers civil, mechanical and electrical engineering, which are continued in postgraduate work together with chemical engineering. The heads of these departments are, respectively, Prof. A. D. Ross, Prof. S. J. Davies, Prof. J. Greig and Mr. S. B. Watkins. It is of interest that King's College Engineering Society, an undergraduate body, is the oldest engineering society of any kind in Britain and was founded in 1847, six days before the Institution of Mechanical Engineers.

Most of the space for engineering in the new building is devoted to teaching, and comprises a new drawing office, a library, laboratories for soil mechanics and for the study of structures and mechanical vibrations, and for certain branches of electrical engineering. The space in the old building made available through the provision of the new drawing office is now reconstructed as a laboratory for concrete technology.

On the electrical engineering side there are two new teaching laboratories, one for machines and one for light-current work. A new research laboratory is being equipped mainly for work on automatic control systems, and a new workshop and additional photographic facilities have been provided. The research interests of the department lie mainly in the field of electrical measurements, in particular in relation to non-linear phenomena of magnetic origin. The new laboratories include a standards room in which much of the equipment will be associated with this work.

In the Engineering Faculty the research activities are distributed throughout the individual specialist laboratories and will not be concentrated in the new building.

Physics Department : Wheatstone Laboratory

Biophysics Research. The department, under Prof. J. T. Randall, is, of course, responsible for the teaching and research in physics ; but a large part of the research is biophysical, and is concerned essentially with the solution of biological problems. To understand the nature of such biophysical research, which is somewhat unusual in a physics department, it is useful to consider its character and origin. Organization of science (for example, in university departments) naturally requires much modification in order to meet the needs of these new trends.

The increasing size of the body of scientific knowledge and lack of linkage by common theory between its parts has naturally resulted in the separation of science into various subjects, each studied in the universities by specialists in independent departments. Biology, in particular, has developed independently of physics. However, the process of the sciences separating is reversed, and re-integration becomes possible, when an all-embracing fundamental theory is developed. Such theoretical development has enabled chemistry and physics to fuse with parts of biology, thus producing the new subjects of biochemistry and biophysics, which have the complementary aspects of being both new specializations and syntheses of science. Biochemistry is a coherent subject ; but biophysics is heterogeneous and exists in many aspects and more as a trend in certain aspects of biology than as a subject in itself.

The theory behind this biophysical trend is mainly the electron theory of molecular structure, which, having already reduced much of chemistry to physical terms, now, by way of biochemistry, begins to describe and explain in terms of electrons and molecules the properties of living matter and the nature of biological processes. Application of such fundamental theory makes possible the explanation and linkage of phenomena in many fields, and, as a result, it should become easier for a scientific worker to have a measure of real understanding of several branches of science. The effect on the research worker, therefore, is to enable him to return in some ways to the comprehensive view of the natural or experimental philosopher. In fact, progress in biophysics depends largely on the development of such research workers who will have a broad approach resulting from synthesis of the traditions of physics and biology.

Physics finds application in biology, not only in the theoretical approach but also in the use of many new physical techniques. Perfected physical tools (for example, the ordinary compound microscope) may be operated by biologists, but collaboration with physicists is desirable when the information obtained by the method is essentially physical in nature as well as biological; or when the development and operation of the technique requires much physical insight. The aid that physicists can give biologists by providing new techniques is an important aspect of biophysics; but elucidation of biological phenomena in terms of molecular theory has ultimately greater significance.

These trends in certain aspects of biology have developed during the past thirty years—in most cases not under the name of biophysics—in university departments of chemistry, biochemistry, physiology, etc. It has also often been necessary to create new departments of biophysics, research units and research institutes.

Owing to the complicated nature of biophysical problems, it is generally desirable to approach the same subject from many different angles and by use of a wide range of techniques. This is best achieved by mutually sympathetic and understanding specialist biologists, biochemists, physicists and hybrid scientists working in one laboratory and allowing their efforts to unite. A biophysics laboratory will tend to be large because it must contain both a large personnel and an exceptionally wide range of facilities.

To expand a physics department in a biological direction it is necessary to go outside the normal university departmental framework. Biology graduates can scarcely hold posts as teachers of physics, or *vice versa*. At King's College this difficulty is overcome by the inclusion in the Physics Department of a Medical Research Council Biophysics Research Unit, which contains scientists and technicians other than physicists. Apparatus has been provided by King's College, the Medical Research Council, the University Grants Committee and the Rockefeller Foundation. Further staff and apparatus have been provided for by research fellowships and grants from the Nuffield Foundation, the British Empire Cancer Campaign, the Rockefeller Foundation, and Imperial Chemical Industries, Ltd. Research students are physics graduates and biologists, and biophysics is a recognized subject in the University of London for postgraduate study. When physics graduates become research students in biophysics, they are required to attend courses in biology. In order that biophysicists should preserve a rigorous approach to the main branch of science in which they have graduated, the research workers who are not on the physics teaching staff of King's College usually contribute to the teaching in other appropriate departments of the College.

The biophysics research at present involves about twenty-four graduates, including four biologists and two chemists, and there are twenty-seven technicians, both biological and physical. Dr. Honor B. Fell, director of the Strangeways Laboratory, Cambridge, acts as senior biological adviser to the Medical Research Council Unit.

One aspect of the biophysical research of the Department is concerned with the structure and function of various biological fibrous molecular systems. Collagen provides a favourable opportunity of studying the structure of protein in relation to its function and mode of formation. Connective tissue composed of collagen grows with a quasi-crystalline structure from smaller protein units in solution, and the resulting fibres have a very great tensile strength correlated with a highly oriented system of chemical bonds.

The fibrous molecule of deoxyribonucleic acid is often supposed to have a special function in relation to protein synthesis. It has been found possible to crystallize the pure substance in the form of fibres and then to determine, by X-ray diffraction, many of its structural characteristics, which can also be shown to exist in living sperm cells and in the nuclei of growing cells. The structural relation of protein to nucleic acid is also being elucidated, and this may cast light on the mutual role of nucleic acid and protein in growth, and the relation of these molecular patterns to specific chemical differences associated with gene action.

The other main aspect of the biophysical research is the development and application of physical methods to determine the distribution of chemical substances in growing cells. Ultra-violet, infra-red and interference microscopes are used to measure the concentrations of nucleic acid, protein and other substances. Thus, from the cytochemical side, the functional relationship of nucleic acid and protein is studied, and this connects with the molecular structure approach to the same question. The development (by use of a microscope interferometer) of successful reflecting microscopes for this work has involved much physical study.

On the biological side, the department has all usual facilities, including an animal room and tissue-culture laboratories. There are two time-lapse phase ciné-microscopes in 'hot-boxes'; a 35-mm. camera on each biologist's microscope; cytological freeze-drying equipment; several ultra-violet microscopes; a high-power ultrasonic generator; and a flying-spot microscope.

On the more physical side, there are two electron-microscopes and a 400-kV. instrument nearing completion. Three ultra-violet and two infra-red microspectrometers together with five reflecting microscopes are at present in use. A semi-fine-focus X-ray tube and two fine-focus tubes are used in conjunction with several microcameras and a long-spacing diffraction camera.

Biochemical facilities include cold rooms at 0° C. and −20° C.; an ultracentrifuge; electrophoresis apparatus; and a 12-litre centrifuge, ultra-violet spectrophotometers, etc.

Theoretical Physics. A strong theoretical group of about twelve workers has been engaged under the direction of Prof. C. A. Coulson on applications of wave mechanics and statistical mechanics. The theory of the chemical bond has been developed and applied to questions of the chemical reactivity of molecules, the stability of crystal structures, biological properties of molecules such as cancer-producing chemical compounds, electrical and magnetic properties of metals, etc. A second aspect of the work concerns properties of electrolytes and colloidal solutions, including the theory of electrophoresis. The activity of the theoretical physics group at King's College may be judged from the fact that more than one hundred papers have been published during the past five years.

Experimental Physics. Apart from biophysics, there are several distinct physics research groups in the Wheatstone Laboratory.

One group is studying effects produced by nuclear radiations and light on various crystalline insulators such as diamond. Variations in the texture of diamonds have been shown to cause wide changes in some of their physical properties. This work has the dual purpose of developing radiation detectors which utilize such effects, and of increasing knowledge of how energy is transported and converted in insulators and semi-conductors.

Another group is concerned with the temporary distortions produced in the earth's electric field due to thundercloud disturbances. The relation of the propagation of this field distortion, the wave-form, and its frequency analysis are studied by means of multi-tube cathode-ray wave-form recorders and radio spectrometers installed on the roof of the College.

An electronics group is concerned with the development of high-speed electronic-analogue computing techniques and their applications to a variety of physical and biophysical problems. Two high-speed computing instruments have been built. Techniques are also being developed for the study of the central nervous system from the point of view of information theory.

In connexion with biophysical applications of spectroscopy, investigations of the fundamental relation of optical properties to molecular structure are being made by a spectroscopic group. The ultra-violet and infra-red absorption of small molecules and crystals of known structure is being measured by means of high-dispersion equipment using polarizers, reflecting microscopes and automatic recorders. Fundamental studies in the vacuum-ultra-violet are also in progress. M. H. F. Wilkins

LONG ASHTON RESEARCH STATION

OPEN DAY

At the University of Bristol Agricultural and Horticultural Research Station's Open Day on July 15, several items of particular scientific interest were demonstrated. In the Pomology Section, Dr. L. C. Luckwill dealt with fruit-thinning sprays containing α-naphthalene acetic acid. These, applied to apples within three or four weeks of petal-fall, induce seed abortion, and consequently an increased drop of young fruits. The concentration required to give satisfactory thinning is affected by the variety, the initial set of fruitlets and the stage of development at the time of spraying. The method, therefore, cannot yet be safely recommended in commercial apple growing.

Paper chromatography is being employed at Long Ashton in the study of the natural auxins controlling fruit development. An exhibit showed some of the biological tests employed for locating the position of the auxins on the chromatograms. These include a modification of the coleoptile cylinder test and the *Coleus* petiole abscission test.

In the plant nutrient investigations under the direction of Dr. E. J. Hewitt, specific visual symptoms on the cauliflower plant were used to demonstrate its molybdenum requirements in the presence of nitrogen applied respectively as nitrate, nitrite, ammonium or urea. Nitrate consistently induced a characteristic mottling, absent from plants given the other treatments.

A survey of the copper, zinc and molybdenum requirements of large-seeded legumes demonstrated that the seed reserves in dwarf, runner and broad beans and in peas could provide sufficient molybdenum for one year's growth but rarely for two. Seed reserves of these crops also mitigated the effects of copper and zinc deficiencies. In comparative trials of water purification methods in the study of molybdenum, copper and zinc requirements, the behaviour of test crops showed that rainwater demineralized by a suitable ion-exchange resin was similar to glass-distilled water.

Iron deficiency was induced in sugar-beet by excess of copper, zinc or manganese. The degree of chlorosis produced was increased by extra molybdenum and, outstandingly, by copper.

The exhibits dealing with insecticides included a demonstration by Mr. S. H. Bennett (working in collaboration with Dr. W. D. E. Thomas) of biological methods using chrysanthemum plants infested with *Macrosiphoniella sanborni* for tracing the movement of octamethyl pyrophosphoramide (schradan) through the plant. This method used in conjunction with radioactive tracer techniques permitted accurate study of the translocation of the insecticide.

Dr. R. J. W. Byrde, of the Mycology Section, demonstrated the effect of winter spray treatments in inhibiting sporulation by *Nectria galligena* (causing apple canker) and *Sclerotinia fructigena*, the brown rot fungus. The effect on *Nectria galligena* was sufficient to reduce subsequent leaf scar infections; but in *S. fructigena* the supply of spore inoculum could be built up sufficiently quickly to outweigh the effect of the winter treatment.

In an exhibit illustrating improvements in spray nozzles, Mr. N. G. Morgan and Dr. H. G. H. Kearns showed two standardized designs. The first was a light-weight all-purpose ¼-in. B.S.P. nozzle, with interchangeable parts for high- or low-volume spraying at low pressures (30–75 lb./sq. in.), suitable for light lances, ground-crop booms or air-flow machines. The second was a ⅜-in. B.S.P. nozzle intended mainly for high-pressure (200–400 lb./sq. in.) spraying of fruit trees by means of hand lances or spray masts.

The exhibits of the Cider and Fruit Juices Section (under the direction of Dr. A. Pollard) were concerned both with the practical aspects and with some of the more fundamental work at present being undertaken on cider and apple juice production. In an exhibit emphasizing the microbiology of cider making, photomicrographs illustrated the yeasts and bacteria capable of giving rise to disorders of cider. The latter included 'sickness' bacteria and lactic rods responsible for the condition known as 'ropiness'. The use of acetic bacteria in the production of cider vinegar was the subject of a practical demonstration.

An exhibit of unfermented apple juices illustrated oxidation phenomena during processing and storage. The addition of small amounts of sulphur dioxide at the time of milling the fruit was shown to inhibit the initial rapid oxidation of polyphenolic components which normally occur, the amount required exhibiting wide variation according to fruit variety. Adequate exclusion of oxygen from the bottled and pasteurized product was shown to inhibit the slower oxidative changes which occur on storage.

The result of field trials with selected varieties of cider apples grown as bush trees was illustrated by