created in 1945 to assist Government departments and industry with advice on mathematical matters and with computational services. The tabulation of mathematical functions of general utility, the application of statistical methods to research problems, and the development of new computing methods and machines are among its activities. A comprehensive range of modern calculating equipment, including Hollerith punched card equipment, is installed at the Laboratory, and the Division has also the use of a differential analyser.

HEREDITY AND VARIATION IN MICRO-ORGANISMS

COLD SPRING HARBOR SYMPOSIUM

WITH the meeting held at the Long Island Biological Laboratory during July 2–12, the series of Cold Spring Harbor Symposia on Quantitative Biology, interrupted since 1941, has started again. This year the theme was heredity and variation in micro-organisms; papers and discussions will be published as volume 11 of the Symposia. The meetings were attended by a number of biologists from Britain, France and Denmark, who joined in discussion with nearly a hundred of their American colleagues.

One of the main objects of the symposium, the finding of common grounds of interest between virologists, bacteriologists, mycologists and geneticists, was fully achieved: indeed, the languages spoken by these formerly distinct groups are gradually merging. It was evident that in a great many fields of research considerable progress had been made since the Missouri Botanic Garden Symposium held in Saint Louis in February 1945 (see *Nature*, January 26, 1946, p. 95).

The work reported at the present symposium may be grouped under three main headings with, of course, much overlapping. The first is the study of the mechanisms of heredity and variation (formal genetics). The techniques and methods of approach of classical genetics are applicable wherever heredity and variation have a particulate basis, irrespective of whether the particles are organised into chromosomes. These possibilities have been skilfully exploited by groups of workers dealing with such suitable material as bacteriophages and their hosts. Among the outstanding results reported at the symposium was the demonstration of exchange of properties between bacteriophage particles belonging to different strains and grown together in the same cell. The number of mutant types known in bacteriophages is still somewhat small, most of them being concerned with host-range and with rapidity of lysis (the latter recognizable from the appearance of the plaques produced). By the use of special techniques it has been possible to determine the mutation-rates for a number of these genetic characters in phages: they seem to be of the same order of magnitude per generation as in higher organisms, although the rate per unit of time is, of course, vastly greater. Where viruses of different genetical constitution are grown together, the results of competition between then can be studied statistically. The size and approximate shape of bacteriophage particles has been investigated by electron-microscopy: some of them appear to be tadpole-shaped, with a 'head' approximately 500 A. in diameter and a 'tail' which may be 1,000–2,000 A. long. Similar studies have been made on animal viruses; but there is still considerable doubt as to the particle-size and shape of even some of the best known plant viruses, such as the tobacco mosaic virus, the difficulty here being to decide what relation exists between the state of the virus in the intact leaf and its appearance in electron-micrographs of particles prepared by different methods of purification.

In bacteria, some work has been done on mutants of visibly different colours, but the most promising line of investigation seems to be the study of bacterial mutants which lack the ability to synthesize some particular chemical substance (for example, an amino-acid) and which consequently will not live on a 'minimal' medium, but will grow on such a medium when the 'missing' substance is added to it. One of the most outstanding pieces of work reported at the symposium was the demonstration that when two bacterial strains which differ in two or more such nutritional requirements are grown together, they may give rise to bacteria having fewer or none of these requirements (that is, able to grow on the minimal medium alone). It does not seem that this result can be explained by the occurrence of multiple independent mutations in the same clone, the probability of such an event, calculated from the known mutation-rates, being far too small. The phenomenon is not yet understood, but its elucidation may open up great possibilities and link up with the analogous discovery in bacteriophages mentioned above. It would not be surprising if this elucidation threw some light on the nature of crossing-over in higher organisms.

It emerged from the discussions that the old alternative between sexual and asexual reproduction may well be a matter of degree, and that new terminologies may have to be developed to cope with the description of the formal genetics of micro-organisms: heredity seems to have a particulate basis in all organisms, but different ways of assorting and segregating particles may operate in different groups. In the higher organisms we have the organisation of such particles into chromosomes and the alternation of meiosis and fertilization. But many other mechanisms may exist, especially in the lowest forms of life, and indeed one of these, known as heterokaryosis (based on segregation and recombination of whole nuclei in multinucleate cells), has long been known in certain fungi (although its genetic significance is only beginning to be apparent), and a similar mechanism may operate in bacteria.

The second stimulating topic of the symposium was that of the nature of cytoplasmic 'self-duplicating' particles ('plasmagenes') and their relations to the nuclear genes. Most of the evidence continues to come from studies of 'adaptive' enzymes in yeast and bacteria and from work on plasmagenes in *Paramecium*, particularly those responsible for the 'killer' reaction. An interesting recent advance is the discovery that an extract of yeast cells adapted to ferment a particular sugar will increase specifically the speed of adaptation in non-adapted cells. The similarity between this result and the transformations of pneumococci studied by Avery and McCarty is evident. Another important advance is the discovery that the rate of multiplication of the plasmagene responsible for the production of the 'killer' substance in *Paramecium* is to a considerable degree independent of that of the nuclear genes and of the cell, so that by varying experimentally the rate of division of the cells the number of particles per cell can be controlled. Studies such as these have provided material for various working hypotheses on the relationships between genes and plasmagenes, and a good deal of discussion took place on these matters. Without going into details, it seems to be very significant that the study of the cytoplasm is no longer 'taboo' for the geneticist. On the contrary, he now approaches it with the feeling that from it classical genetics can be broadened and completed in precisely that part where an impasse had been reached, namely, the relations between the activities of the genes and the biochemistry of the cell as a whole.

A third topic of the symposium was the genetical control of biochemical reactions. To the great amount of work done in recent years on the fungus *Neurospora*, mainly by Beadle, Tatum and others at Stanford University, closely parallel results with bacteria have now been added. The technique of 'blocking' chemical reactions at specific points by means of specific mutations (so as to produce strains deficient in the ability to synthesize a particular substance) proves to be a tool of increasing usefulness in the analysis of these reactions. The synthesis in the cell of most types of organic compounds takes place in many steps, each of which may be 'blocked' by a mutation leading to the loss or inactivation of a specific enzyme. Thus many mutations leading to the same end-result (a particular 'nutritional deficiency') may exist, each acting on a different step in the same biochemical synthesis. Very large numbers of such mutations have now been obtained in *Neurospora* by the use of X-rays, ultra-violet radiation and chemical agents. Many of these are undoubtedly 'point-mutations' at a single locus, but others with complex effects may be structural chromosomal changes such as small deletions, which cannot as yet be distinguished with certainty from the former category. Whether this type of biochemical genetics will only be, from now onwards, a tool for the biochemist, or whether it will also produce fundamental results in genetics and cell physiology, is a matter for the future.

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TORPEDOES: THEIR USE AND DEVELOPMENT DURING THE WAR*

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THE torpedo designer has in some ways an even harder task than the aircraft designer. He must produce a propulsive system that is completely self-supporting and self-contained; in other words, he must carry all the air with him that he wishes to use: this problem is unique—an aircraft engine, a steam engine, a marine steam or diesel engine can and does draw unlimited quantities of air from the atmosphere, as it were for nothing. In very round figures, for each ton of fuel consumed, be it petrol, oil or coal, these engines use at least 15 tons of air. The torpedo designer, on the other hand, has to carry all this air with him. So his problem is more conditioned by the amount of air he can carry than the amount of fuel. Furthermore, the torpedo designer is very restricted for space, the weapon must be small and easily maintained, and by reason of his special problems the torpedo designer cannot draw to any very great extent for technique on the general engineering industry of Great Britain.

* From a discourse at the Royal Institution on June 14.

In a nutshell, the problems confronting the designer of torpedoes are as follows:

(i) He must increase the chance of his weapon hitting its target by reducing the time which it takes to reach the target—in other words, it must be very fast. The latest British torpedo engine develops 465 h.p. and can drive the torpedo at 50 knots. Its weight is only 223 lb.

(ii) The torpedo must be capable of going great distances, as the farther away you are from your enemy at the moment of attack the less likely he is to see your torpedo and destroy you before it has been launched. This is particularly important in the case of submarines, the purpose of which is to deliver an unseen attack. Therefore the torpedo must have a considerable endurance. If the designer achieves this, he can make use of additional devices, such as patterning devices, which will enable the torpedo to turn and recross the track of the convoy a number of times, thus much enhancing the chance of a hit.

(iii) The torpedo must be trackless, so that the ship does not see the torpedo in time to avoid it.

(iv) The torpedo must carry as big an explosive as possible to ensure that one hit will either sink outright any vessel or very seriously damage it.

(v) The torpedo must be accurately controllable in depth and direction. A few feet error in depth might cause the torpedo to pass harmlessly under the ship attacked, and a few degrees error in bearing at long distances would cause it to miss by many yards.

(vi) Finally, what is perhaps most important of all, the torpedo must be simple, easy and safe to maintain, easy to use and robust. This is particularly important as at sea in small ships it gets rough usage, and when used from aircraft it must withstand the shock of entry into the water. An aircraft torpedo weighs nearly a ton, and it will be appreciated there is considerable shock when it enters the water at something like 300 knots or more.

Developments

How, then, have we and other nations tackled these problems?

How has the inherent disadvantage of this weapon, namely, the long time of flight, been tackled? The ideal is for the torpedo to travel at very great speed in the air like a shell and then plunge into the water just short of the target and hit it underwater. The Germans had done some preliminary work on a flying torpedo—it was propelled in the air by rockets for a predetermined distance and then dived into the water. They had not, however, got very far, and it is evident that it would not have reached fruition for some years. We in Britain had realized this was more of a long-term development and consequently guided our developments on improving the underwater speeds. The chief limiting factor in speed is