

relation. But observation shows that in such pairs the giant star tends to be the more massive component. This is the case, for example, in the three stars  $\nu$  Sagittarius,  $VV$  Cephei and  $\zeta$  Aurigæ. Thus it seems that no matter from what angle we approach the questions raised by the observed properties of binary systems, the paradoxes already recognized by astronomers must remain in one form or another.

However, quite apart from the foregoing objections to the constructive portion of Gamow's article, it is very noticeable that no reference is made to the wide class of dynamical features that is associated with the stars. This, of course, is the direct result of attending only to the internal physical properties of the stars; but the dynamical features we have in mind are altogether too marked to remain unaccounted for in a satisfactory theory. Thus such questions as the formation of individual stars, and of binary and multiple systems, together with the general increase of mass with decreasing separation, and the observed approximation to equipartition of energy among the stars seem to present the real key to any theory of stellar evolution. An internal theory can give no explanation for the correlation between peculiar velocity and spectral class or the observed tendency for massive stars to lie in the galactic plane, features that must be related to the previous history of the stars.

It has been customary during recent years for investigators on stellar evolution to devote attention to internal constitution with little or no regard for the dynamical features. It appears that Prof. Gamow has followed essentially in this tradition and therefore confined his article to the modifications effected by the introduction of modern nuclear theory. Thus, in dealing with the properties of variable stars, no attempt is made to account for the three distinct periodicity groups comprised by stars of periods of order half a day, four days and 300 days. These

variables also show a marked preference as regards spectral class, the first being largely of classes  $B$  and  $A$ , the second of  $F$  and  $G$  and the third of class  $M$ . Moreover, the two short-period groups exhibit a most remarkable property in that none of them, out of more than two hundred available examples, possesses a close companion, whereas about one star in five of normal stars of similar spectral classes does possess a close companion. On the other hand, long-period variables appear to possess a normal complement of companions. The first and third types are stars of moderate luminosity and show no pronounced galactic concentration, whereas the variables of intermediate period, the Cepheids, are strongly concentrated to the galactic plane and are among the most luminous known stars. Thus it is clear that very remarkable dynamical properties are intimately connected with even the different types of variability, and therefore that purely internal considerations are most unlikely to prove capable of elucidating the nature of the connexion.

From these and many other dynamical qualities associated with various types of stars, it appears to us that Prof. Gamow has over-estimated the importance of nuclear theory in the problem of stellar evolution. Indeed, in our opinion nuclear physics has very little to add to the results already conjectured by astrophysicists, and can merely serve to confirm these conjectures, a typical instance being the mass-luminosity relation itself. Finally, we wish to point out that although the present article consists largely of criticism, we have discussed elsewhere a number of the questions raised<sup>2</sup>, and it has been found that purely dynamical considerations may be sufficient to provide a natural explanation of many of the difficulties mentioned in this article.

<sup>1</sup> NATURE, 144, 575, 620 (Sept. 30 and Oct. 7, 1939).

<sup>2</sup> Proc. Camb. Phil. Soc., (4), 35 (1939).

<sup>3</sup> Mon. Not. Roy. Astr. Soc., 98, 646 (1938).

## SCIENTIFIC AND INDUSTRIAL RESEARCH IN CANADA

THE twenty-first annual report of the National Research Council of Canada includes the report of the president, with reports of the various divisions and of co-operative investigations, together with the financial statement and appendixes listing the publications of the Council and papers published by members of the staff and holders of research grants during the year.

Under the Division of Biology and Agriculture a good deal of attention has been devoted to plant hormones, and a simple method of treating seeds with plant hormone chemicals has been developed in which a carrier is utilized, either an inert dust such as talc or a seed disinfectant such as an organic mercurial or copper carbonate. It has also been found that a very small amount of hormone when added to the treated solution greatly reduces or entirely prevents the injury of seed in treatment with formaldehyde for control of smut disease. A joint project with the Dominion Forest Service and the Department of Agriculture dealing with forest tree breeding is to some extent an outgrowth of these plant hormone investigations, since the discovery of a method of inducing wood cuttings to root

more freely has opened up new possibilities in this direction, particularly in the propagation of rapid-growing and disease-resistant trees. Further work on plant hormones has been carried out under an associate committee on this subject, and the Division of Chemistry has given a good deal of attention to the synthesis of a series of homologues of  $\alpha$ -naphthylacetic acid, as well as developing an improved method for the synthesis of  $\alpha$ -naphthylacetic acid itself. Other work under the Division of Biology and Agriculture has been concerned with grain research, including the standardization of an experimental baking test for wheat, experimental malting equipment and methods for barley, food storage and transport, including the effect of freezing treatment and rate of freezing on the quality of frozen poultry, beef, pork and mutton and a survey of packing plants exporting Wiltshire bacon. The Division has also co-operated with the Dominion Department of Agriculture in the development of hybrids between wheat and the Agropyrons or wheat grasses with the object of obtaining large-seeded drought-resistant grasses for western Canada, and some work has been carried out on the effect of phytohormones on bacteria and yeast.



The Division of Chemistry has examined the factors involved in the preparation of rennet casein suitable for the manufacture of plastics, particularly buttons, and the highly efficient packings for fractionating columns and scrubbing towers designed in the laboratories are now being developed in forms specifically suited for larger scale operations. Active contact has been maintained with the laundry and cleaning industries of Canada, and the Division has also co-operated with the Sub-committee on Textile Specifications of the Canadian Government Purchasing Standards Committee. An investigation of the laundry cleaning process with sodium hypochlorite has been concluded, and work carried out on the efficiency of wetting compounds and mixtures for use in the first or 'break' operation where thorough wetting of the fabrics is of importance. The magnesian products laboratory of the Division has made available to the Canadian metal industry better refractories and a wider range which can be obtained from Canadian materials, notably the product of high-grade refractories from dolomite.

Various barks have been investigated as a source of tannin for the leather industry, and in the rubber laboratory much work has been done on bonding rubber to leather, particularly the application to the manufacture of automobile engine mountings of a bonding material previously developed in the laboratory. Numerous tests have been made of such materials as paints and textiles on behalf of the Canadian Government Purchasing Standards Committee, while a process for the preparation of organic mercury derivatives, particularly alkyl mercuric halides and other salts used for seed disinfection, has been developed. Use of the disinfectants in the form of a dust consisting of an inert carrier adapted to adhere to the seed has also been studied, and Canadian bentonites and talc proved satisfactory as carriers, the dust being equal in disinfecting power to the best imported products. Work on synthetic resins has been extended to cover the formation of polymers from chloromethyl compounds.

The Division of Chemical Engineering has a wind tunnel for testing aeroplane models and streamlined locomotives and other equipment in which air resistance is important, and a model-testing basin in which similar problems in regard to water can be investigated. Safety tests are continually made of domestic oil, gas- and gasoline-burning appliances. Five ship models were tested during the year in the towing basin in connexion with the design of private and Government vessels. Numerous aircraft instruments, gasoline and lubricating oils have been tested for various branches of the Government service.

In the Division of Physics and Electrical Engineering an increasing amount of standardization and testing work of all types has been carried out. In addition to studies of the heat insulation properties of building materials, the development of a suitable thermostat for refrigerator cars has received much attention. Thousands of aircraft castings have been examined by X-ray methods; and the cathode ray compass and direction finder, detection of fire through haze, estimation of forest fire hazards, vibration in aircraft and ultrasonic generators for depth sounding are other problems under investigation.

Steps were taken during the year to reorganize the Division of Research Information and establish a Section of Research Plans and Publications, one function of which is to provide technical secretarial services for the president and some of the associate committees. Stress is laid in the report on the organization of an Associate Committee on Medical Research. The Associate Committee on Grain Research has outstanding achievements to its credit in the solution of problems relating to bread wheat. Studies of the drying of tough and damp wheat have established the conditions under which this can be done without injury to the milling and baking quality of the grain. Other investigations dealt with seed injury by fungicidal treatments, effect of formaldehyde treatment on the growth of wheat and prevention of heating of damp grain in storage.

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## R. H. THURSTON: ENGINEER CENTENARY CELEBRATIONS

THE celebration of the centenary of the birth of the distinguished American engineer, Robert H. Thurston, held at Cornell University on October 25, was the occasion for the delivery of several addresses in which tribute was paid to the great influence Thurston had on engineering education and progress, and also reference was made to the part the engineer should take in the solving of social and economic problems. The addresses were given in the Bailey Hall before an audience of more than a thousand persons, which included many of Thurston's old students and delegates from no fewer than sixty universities and institutions in the United States, Great Britain, Canada, France and Germany.

When inaugurating the proceedings, Dr. E. E. Day, president of the University, said that in the tense and hurried living of this twentieth century of ours, it is difficult and at times well-nigh impossible to keep in clear view the importance of the really durable values of life. No corrective for this difficulty is so sure as the occasional review of the qualities of

leadership in great men. War-racked and depression-ridden though this world may be, the force of individual character remains undiminished. As the years of Thurston's active service recede, his contributions to the upbuilding of Cornell lose none of their impressiveness, while the lives of the men who went out from his tutelage continue to attest the strength of his mind and spirit.

After speeches in which Thurston's training at Brown University, and his work as a naval engineer and as an instructor at the United States Naval Academy had been recalled, Dr. H. N. Davis, president of the Stevens Institute of Technology, Hoboken, dealt with "Pioneering in Engineering Education at Stevens". Thurston had joined President Henry Morton at Stevens in 1870, when thirty-one years of age, and he brought to bear upon the problem of an engineering curriculum an original mind, a wide outlook and great force of character. There were two aspects of his work at Stevens, said Dr. Davis, that seemed likely to be permanent parts of the Thurston