The temperature reached at the maximum point depends on the mass of the star: the greater the mass, the higher the temperature and the longer the stellar life. Fig. 3 illustrates the careers of the sun and of stars the masses of which have nearly the extreme values found in Nature. Probably a star having a mass less than one-tenth of that of the sun would not become hot enough to be seen, while Eddington has shown that stars much more than ten times as massive as the sun would be unstable. Only the most massive stars can reach the B and Oe 5 stages of the Harvard spectral sequence. The lighter stars, like the sun, turn back at the A condition, or even at a still lower stage.

Temperature appeared at first, in this great stellar drama, to play a dependent rôle. The star developed heat by contraction, and radiated heat into space. So long as the amount of heat developed exceeded the amount radiated, the temperature would rise, and when, through retardation of contraction and increase of radiation, the conditions were reversed, the temperature would fall. This view is satisfactory in every respect but one—it indicates a length of stellar life far shorter than geological and other evidence makes it possible to admit. In order to account for the amount of heat which a star radiates during its immeasurably long life, it is necessary to suppose that the heat generated by contraction is supplemented by an

enormous supply of energy from some other source. Nothing is certainly known of the nature of this supply. Possibly, as Eddington proposes, it is to be found in the formation of heavier elements from hydrogen. But, wherever the energy comes from, it is difficult to avoid the hypothesis that it can be released only at

FIG. 2.—Diagrammatic representation of the theoretical development of a massive star from an original nebula to a final cold, dense body. The dotted curve is to be regarded as identical with the highest curve in Fig. 3.

the extremely high temperatures attained near the centres of stars. Contraction raises the temperature of a star up to a certain point, and then temperature takes charge and sets free energy from the unknown

FIG. 3.—Curves illustrating the course of evolution of stars of differing mass, showing that, the more massive the star, the longer is its life and the greater is the range of temperature through which it passes.

source at a rate almost equal to the rate of radiation, so that the star is in a condition of approximate equilibrium. It is a problem for the future to determine the origin of the almost inexhaustible supply.

Man and Scottish Animal Life.¹

By Dr. JAMES RITCHIE.

IN the opportunity it affords for the study of the part man plays in the evolution of a fauna, the animal life of Scotland stands alone. This is largely due to a series of geological accidents: the Glacial Period, which made a clean sweep of former faunas; the post-glacial continental land bridge, which allowed immigration from the mainland of Europe, and the subsequent breaking of the continental connexion. Thus there was isolated on the *tabula rasa* of Scotland a fair sample of the post-glacial European fauna, which henceforth was removed from the possibility of subsequent migrations such as complicate the history of continental faunas, and the later evolution of which must in general be due either to the influence of physical and organic changes limited in time and space, or to the interference of man.

The influence of man was itself strictly limited in time, for the earliest human settlements so far recognised in Scotland date back only to Azilian times. It was also unequal in its incidence, gaining in intensity with the passing of time. Thus during the Neolithic, Bronze,

and early Iron Ages only some four of the larger members of the original fauna disappeared—the giant fallow deer, the lynx, the lemming, and the rat vole—and it is doubtful whether the disappearance of any of these was due to man's presence. We may say, therefore, that when the Roman legions followed Agricola northwards through the marshes of Scotland in the early years of our era, they found a fauna which, except for the presence of primitive domesticated animals, differed little in kind from that which greeted man on his first arrival in Scotland some 8000 years before. But the following centuries saw more rapid changes, which so increased that by the sixteenth century many new and important elements had been added, while most of the larger members of the old fauna had been swept away, with the extermination of such as the reindeer, the elk and the wild boar, the brown bear and the beaver, the great bustard, the crane and the bittern. Nowadays the content and assortment of the fauna, the relative numbers of its members and their distribution, show little resemblance to the conditions of the original post-glacial immigrants.

The degree of man's interference may be compared

¹ Summary of an address delivered at the request of the Council to the Royal Society of Edinburgh on July 2.

with the influence of the ordinary forces of Nature which are constantly modifying the animal life of a country. There is a constant ebb and flow within a fauna, a swing of numbers due largely to seasonal changes and fluctuating about a mean—the “balance of life”; and where man’s interference is temporary in its incidence it falls into this category. But there is, besides, a definite faunal evolution, a faunal drift; and where man’s influence is persistent in one direction it must be reckoned as sharing with the great secular forces of Nature in propelling a fauna upon a path along which there is no return.

The nature of man’s interference, directly or indirectly exercised upon the animal life of Scotland, is of great complexity, but it may be conveniently grouped according to results. In some ways man has reduced the numbers of animals, in some ways he has increased their numbers, and in some ways he has modified their habits and even their structures. Reduction of the fauna, which, commencing with a mere cutting off of the numbers of a species, may proceed to a marked limitation in the range of distribution and finally to extinction, has been brought about directly by deliberate destruction, as in the cases of the polecat and the urus, and indirectly by cultivation, which has destroyed feeding grounds and breeding haunts, driving away such as the great bustard and the bittern, as well as by destruction of the forest, with which disappeared the capercaillie and the red squirrel, both since reintroduced. Increase in the quantity of the fauna is largely due to an intensive cultivation which has provided bounteous food-supplies for such as rabbits and sparrows, and to deliberate protection of other creatures for food, sport, or amenity. The quality of the fauna has been increased by the addition of new elements from other

lands, either introduced deliberately, like pheasants and the common rabbit, or carried hither by mischance of international commerce, like the black and brown rats and many an insect pest. Habits have been changed: the one-time cliff-dwelling swallow has been converted into an inhabitant of houses; and structures have been changed in converting wild into domesticated animals, and by the alteration of habitats, whereby the red deer has lost many points from its antlers and several cubits from its stature.

It must not be imagined, however, that a simple enumeration of first effects exhausts the tale of man’s interference. The story of the effect produced, by protecting a few black-headed gulls, upon the vegetation of a heather moor and its fauna (which I have described elsewhere) illustrates how the slightest interference with wild life may produce complicated and far-reaching results, and that in a remarkably short space of time.

A final comparison of the modern fauna of Scotland with that found by Azilian man on his arrival on these shores, shows that the modern fauna is much more rich in numbers than the old fauna, and that in addition, in spite of the extermination of many forms, it is also more varied in species. The consistent tendency throughout the period of man’s presence has been for the larger animals, which formed the most impressive contingent of the wild life, gradually to be rooted out; while the additions consist largely of lesser creatures, many of which have gained entry only because their minuteness has enabled them to escape detection. The great change therefore has been a notable diminution in the standard of size of the wild fauna, and this tendency is still strongly marked in the evolution of the Scottish fauna at the present day.

Obituary.

MR. S. S. HOUGH, F.R.S.

MR. SYDNEY SAMUEL HOUGH, H.M. Astronomer at the Royal Observatory, Cape of Good Hope, died on Sunday, July 8, at Gerrard’s Cross. He had visited Europe last summer and had attended the meeting of the International Astronomical Union at Rome, but after his return to South Africa he was in poor health and ultimately cancer was diagnosed. He came back to England under the care of a nurse in the spring of this year and succumbed to the disease after a painful illness.

Mr. Hough was born at Stoke Newington on June 11, 1870. After distinguishing himself at Christ’s Hospital School, he proceeded to St. John’s College, Cambridge, as a foundation scholar. At Cambridge he had a brilliant career and graduated as third wrangler in 1892. He was awarded the first Smith’s prize in 1894, and soon after was elected to an Isaac Newton studentship and to a fellowship at his college.

After taking his degree, Mr. Hough devoted himself to research work in astronomy and geophysics. It had recently been found by Küstner and Chandler that the free period of the variation of latitude differed from that predicted by Euler, and the investigation of this subject was undertaken by Mr. Hough. He passed on under the guidance of Sir George Darwin to an investigation of the tides on dynamical prin-

ciples, and succeeded in deriving a more complete solution of the tidal problem than had been previously obtained, and indeed in making the most important contribution to this theory since Laplace. In his work he introduced the mutual gravitation of the water, and he determined the periods of free oscillation of the ocean. At this time he also did some work on periodic orbits.

When Mr. Finlay, chief assistant at the Cape Observatory, retired in 1898, Sir David Gill, who was then H.M. Astronomer, pointed out to the Admiralty the importance of selecting as his successor a man with the highest scientific qualifications who might be expected ultimately to become director of the observatory. In accordance with this plan Mr. Hough was selected for the post and he proceeded at once to take up his duties. He became H.M. Astronomer in 1907.

Mr. Hough threw himself into the work of the observatory and made valuable contributions to astronomy in organising and discussing observations, particularly those relating to the exact positions of the stars. This work is of a kind which does not attract much public notice, but it is absolutely fundamental to astronomy. Soon after his arrival at the Cape he was entrusted with the reduction of a triangulation of close circumpolar stars made with the