and, finally, the distribution of spectroscopic binaries as regards the Milky Way.

THE NATURE AND CAUSE OF CEPHEID VARIATION.—Dr. Harlow Shapley, in the December number of the *Astrophysical Journal* (vol. xl., No. 5, p. 448) presents a discussion on the nature and cause of Cepheid variation, in which he investigates the question of whether or not the usually accepted double-star interpretation of Cepheid variation should be abandoned. From the spectroscopic point of view alone, he states, the Cepheids stand out as unexplainable anomalies. There are persistent peculiarities in the spectroscopic elements, a universal absence of a secondary spectrum, and minute apparent orbits. They do exhibit definite periodic oscillations of their spectral lines, as is the case with ordinary spectroscopic binaries, which may be interpreted as periodic orbital motion. In the present discussion, which the author considers only as preliminary, no complete explanation of Cepheid variation is offered as a substitute for the existing inadequate theories, but he points out the direction in which he thinks the real interpretation seems to lie. The sections of the present paper are devoted to the principal results which he has obtained from an extensive investigation, details of which will be published in subsequent papers. The main conclusion which he has reached is summed up by him as follows:—"That the Cepheid and cluster variables are not binary systems, and that the explanation of their light-changes can much more likely be found in a consideration of internal or surface pulsations of isolated stellar bodies."

THE PREHISTORIC SOCIETY OF EAST ANGLIA.

MR. MILLER CHRISTY, in the Proceedings of the Prehistoric Society of East Anglia, 1913–14, discusses the curious engraved shell from the Red Crag at Walton-on-the-Naze, which has formed the subject of much controversy since it was exhibited at the York meeting of the British Association in 1881. It is a crude and inartistic attempt to depict a human portrait. It is much ruder in its execution than the celebrated drawings of the human figure from the French caves and the Bushman drawings from South Africa. It also differs from other drawings of this kind as it represents, not a profile, but a full face. The characteristics of this supposed portrait have been investigated by a special committee, and on the whole Mr. Christy is disposed to agree with its members that the evidence is insufficient to enable us to reach any definite conclusion regarding its age.

Under the title of "An Early Norfolk Trackway: The Drove Road," Messrs. W. G. Clarke and H. D. Hewitt describe a supposed ancient trackway, fourteen miles in length, connecting the fenland at Blackdike, Hockwold, with Peddar's Way on Roudham Heath. There are some indications that this was an ancient route, but the evidence adduced in support of the conclusion that it is of extreme antiquity is not quite conclusive. In its original state it possesses many points of resemblance to known prehistoric trackways in East Anglia and other parts of England; it is subsidiary to Peddar's Way, and it is also connected with the Pilgrim's Walk; in relation to the Fendyke it resembles the Icknield Way, which is certainly prehistoric; roads from Saxon settlements were in some cases diverted from their natural course by the Drove; there are barrows in the vicinity, and flint implements and ancient pottery have been found in the neighbourhood. Another similar road near Norwich is described by Mr. Walter Rye in the same issue of the Proceedings.

ANNUAL MEETING OF THE PARIS ACADEMY OF SCIENCES.[1]

THE year just ended has been broken by a formidable discontinuity. In the first period our work has followed its usual course; in the second, it has been dominated by the constant thought of national defence.

The importance of the rôle of our academy grows from year to year. Nearly all the development of modern civilisation takes its roots in scientific research; that is to say, in the study, the co-ordination and the generalisation of those facts and ideas which lend themselves to exact measurements or precise comparisons. The domain of science thus understood is unlimited; it ranges from the highest abstractions to the most practical applications, from the world of stars and nebulæ to that of atoms and molecules; from the mechanics of worlds to factories, to armoured vessels, and to aeroplanes; from the delicate phenomena of physics and chemistry to the great industries, to telephony, to wireless telegraphy, and to explosives; from the most complex living organisms in the present and the past to microscopic beings; from the experiments of physiology and microbiology to agriculture, medicine, and surgery. If, at all times, the evolution of philosophy has followed that of science, modern work on the principles of geometry and mechanics, the examination of the ideas of space and time, the daring attempts to connect simultaneously these two ideas with the theory of groups of transformations, have opened entirely new paths in the study of the foundations of our knowledge.

The search for scientific truth by a mind enamoured of moral beauty is the noblest aim of mankind. But the study of science, deflected from the steady ideal of right and humanity, confined to the path of a narrow specialisation, disciplined with a view to domination and reduced principally to practical use, leads rapidly to a civilisation of selfishness, hardness, and materialism, to a kind of learned barbarity like that which has gradually overgrown the Germany of the present day. Granted that the acquisition of the scientific spirit is indispensable to education, other elements should be joined to it to form a man worthy of the name, and these are presented to us by the "humanities," which are studied by our colleagues of the other academies; philosophy and history, religious and social science, the rights of individuals or of nations, the creations of thinkers or of artists.

Instruction and erudition must not be confused with education, the laborious work of acquiring knowledge with the development of civilisation. True education ought to create a personal religion, a conscience increasing in sensitiveness and loftiness of ideal, the love of clearness, the power of forming general ideas, devotion to justice, respect for other men.

This is the well-balanced culture after which France has always sought; it is this which is threatened to-day; at the sight of this danger Prof. Murray Butler, of Columbia University, has said:—

"What are we to think? Is science a sham? Is philosophy a pretence? Is religion a mere rumour? Is the great international structure of friendship, good-will, and scholarly co-operation upon which this university and many of its members have worked so long, so faithfully, and apparently with so much success, only an illusion? Are the long and devoted labours of scholars and of statesmen to enthrone Justice in the place of Brute Force in the world, all without effect? The answer is No; a thousand times, No!"

The American conscience has thus formulated the

[1] Translation of the main part of the address delivered on December 21, 1914, by the president, M. Paul Appell.

universal reply, which is a certain proof of victory for our ideal.

Amongst the scientific events of the year, prominent mention is due to the unveiling of the monument of our colleague Marey, one of those men to whom modern physiology owes so much. As M. Richet has said ("Inauguration du monument élevé à la memoire de Etienne Jules Marey, au Parc des Princes, à Boulogne-sur-Seine, le mercredi 3 Juin, 1914"; Paris: Gauthier-Villars), he is one of those who leave a work so firm, so fruitful, so perfect that every year adds to its renown. In fact, time takes no toll on a well-founded scientific work. The pages of Descartes on "la Géométrie analytique," of Harvey on "the contractions of the heart," of Lavoisier on "les combustions respiratoires," remain intact and intangible, like the Greek marble statues, the beauty of which remains unchanged after a lapse of twenty centuries. The idea conceived by Marey in his youth and realised by him in his work was the creation of methods permitting the direct and precise inscription of motion, either by graphical records, or by photographs taken at intervals so short as to appear continuous. A running man, a galloping horse, a flying bird, a beating heart, execute movements only a confused average of which can be seized by the eye. The photographs of Marey give an exact analysis of them; it is only necessary to realise the synthesis of the successive images by the aid of a method employed a long time ago in certain toys to obtain a kinematograph. This apparatus, possessing innumerable scientific applications, has then its origin in the work of Marey.

It presents the great philosophic interest of giving control of the time, which, until then, had been the one independent variable. Once a phenomenon is recorded it can be repeated in its successive phases, accelerating or retarding at will. Thus deceleration permits the study at leisure of the beats of the heart, the movements of a bird's wings, and acceleration shows in a few minutes the germination of a plant or the hatching of an egg. It is even possible to change the sign of the variable and reverse the order of events. Marey then was an inventor of genius, a man who extracted something from nothing; the improvement of a discovery is a small matter, the essential point is to make it.

This year French physicists have been actively occupied with the construction of a huge electromagnet, in which the intensity and dimensions of the field were to be much greater than those of the most powerful apparatus in current use. A magnet of this nature would permit of absolutely new researches on the magnetic properties of matter at different temperatures, on the constitution of crystals, on Zeeman's phenomenon, rotatory magnetic polarisation, and, in another order of work, on modifications of vital phenomena under the action of the magnetic field. The council of the Faculty of Science of Paris, struck with the importance of these researches, had reserved from the funds placed at its disposition by the liberality of M. Commercy for the advancement of science a sum of 50,000 francs, as a first contribution, although small, to the total expenditure required for the realisation of the scheme. Prince Bonaparte, who is always ready with active generosity to support great French scientific enterprises, has taken an active interest in this question. At his request an official committee, composed of the most competent members of our academy, was constituted, in order to study under what conditions France could be endowed with an instrument that should be unique in the world. This committee has held numerous meetings to discuss the various suggestions and hear the best-known specialists; its results have been published in a pamphlet which is a credit to our academy. Without quoting any names, the conclusions may be summarised thus: it is desirable that an important laboratory of magnetic research should be created; this laboratory should be placed under the patronage of the academy, and administered by the University of Paris; in this laboratory should be installed the most powerful electromagnets of the types chosen.

While we are thus dreaming of a gigantic magnet destined to enlarge the field of human knowledge, Germany, carried away by its dream of world-domination, prepared in secret enormous mortars in view of a sudden overwhelming attack on Belgian and French fortresses; when the time was thought favourable, war was declared against Russia and France, and Belgian neutrality was violated. Since the first days in August our academy has had but one thought, to assist the Government in the defence of the country and liberty.

At the meeting of August 3, the academy notified the Government that all its members who were not mobilised in the public service held themselves in readiness to aid in the national defence, each according to his speciality. After the meeting six large committees were constituted under the following denominations:—(1) Mechanics (including Aviation); (2) Wireless Telegraphy; (3) Radiography; (4) Chemistry (including Explosives); (5) Medicine, Surgery, Hygiene; (6) Food. All these committees have worked their hardest; the time has not come to speak of the reports which they have presented and the results they have obtained.

On August 10 the academy addressed to its correspondants in Belgium, M. Boulvin at Ghent, and M. Francotte at Brussels, the expression of its brotherly friendship and its profound admiration for the Belgian people and army. We solemnly renew to-day the expression of these sentiments, adding our indignant protest against the destruction of the treasures of art and science; the acts of violence on the liberty, life, and property of the non-combatants, committed deliberately in order to punish noble nations because they did not hesitate in their choice between the laws of honour, the respect for treaties, the love of independence, and the base suggestions of material interest or of fear.

MATHEMATICS IN ARTILLERY SCIENCE.

SIR GEORGE GREENHILL, president of the Mathematical Association, delivered an address upon "Mathematics in Artillery Science" at the annual meeting of the association on January 9. We have been unable to obtain a copy of the address from the officials of the association, though we think that one of the chief purposes of a scientific society should be to secure as wide a publicity as possible for its papers and addresses. Sir George Greenhill's remarks have, however, been summarised in the daily papers, and from the *Times* report the subjoined abstract has been derived. We may add that as Sir George was formerly professor of mathematics in the Artillery College, Woolwich, his opinions upon the position which science occupies in our technical training for modern warfare must be given careful consideration.

Six months ago artillery officers would have said there was no such thing as mathematics in artillery science; but that outlook was now ancient history, for at the present time we are engaged in what is, in fact, a mathematical war. Drawing upon his experience as a professor of artillery theory for in-