G. H. Perkins, Professor of Geology.

1. General course. Senior elective. A survey of the ethnological, social, moral and intellectual characteristics of the principal races of the world, followed by a discussion of the origin and development of laws, government, arts, industries, language, literature and religious systems.

Professor Emerson.

1. Social institutions.

UNIVERSITY OF WISCONSIN, MADISON.

Joseph Jastrow, Ph.D., Professor of Psychology, offers one course bearing on anthropology. It is entitled, 'Mental Evolution' and is based on Tylor's Anthropology.

WESTERN RESERVE UNIVERSITY, CLEVELAND, OHIO.

M. M. Curtis, Professor of Philosophy, gives a course of lectures on the history of anthropology, its main problems and bearings.

WILLAMETTE UNIVERSITY, SALEM, OREGON.

President Willis C. Hawley, Professor of Sociology, offers a course in anthropology for juniors and seniors consisting of text, lectures and assigned readings. Two hours a week for the year.

YALE UNIVERSITY, NEW HAVEN, CONN.

William G. Sumner, LL.D., Professor of Political and Social Science.

What Professor Sumner offers is described by himself as follows: "Somatic anthropology has no independent place in the undergraduate curriculum. It is taught as an adjunct to the social sciences by text-books and lectures. Two hours per week. Special students in the Graduate School have lessons in the subject as presented in Ranke's 'Der Mensch,' with lectures, other literature and museum illustrations." The last named course has hitherto been given on alternate years.

E. Hershey Sneath, Ph.D., Professor of Philosophy.

1. Philosophical anthropology. An outline study of man, his body and mind in their relations, his relations to nature, to his fellows, and to God.

Of the thirty-one universities and colleges offering anthropology, it is found to be an adjunct of sociology in nine, of philosophy in five, of psychology in three, of geology and zoology in five, and of medicine in one; while in five instances it stands practically alone and in three it is unclassified.

The process of differentiation has already taken place in the larger institutions and is destined to reach all at an early date. If about four fifths of those who are teaching the subject are impelled to do so because of its important bearing on their chosen field of work and because there is, at present, no one else to do it, they have a right to depend on being relieved of this additional burden by their own students, some of whom will specialize in anthropology and hold professorships where none now exists.

This seems to be the normal line of development and would of itself, in time, suffice to carry instruction in anthropology to every growing college and university in America. But there is evidence of forces at work which will serve to accelerate the general forward movement. An instance of this is the founding of a 'Department of Archæology' at Phillips Academy, Andover, Massachusetts, with two instructors, a collection of 40,000 specimens and funds to carry on the work.

No institution of higher learning, worthy of the name, can long afford to be without advantages which can be had at a first class preparatory school.

George Grant MacCurdy.

New Haven, Conn.

ON THE MEASUREMENT OF TIME.

In the period of the earth's rotation on its axis, called the sidereal day, Nature has provided a convenient, easily determined and, for present purposes, practically invariable unit of time. For the subdivision of the day into the arbitrary units of time called hours, minutes and seconds, recourse is had to artificial mechanical devices known as clocks.

It may perhaps be stated in general, without serious danger of dispute, that the pendulum clock is the most accurate and reliable of all types of timekeeping mechanism. Chronometers have the advantage of portability and often run remarkably well for considerable periods of time, but they cannot compete with the pendulum clock in carrying an even rate during a series of months or years.

Yet a still higher degree of accuracy than that now prevalent in the performance of astronomical clocks is attainable, and is necessary in the present state of astronomy. There seems to be no reason why improvements in timekeeping should not take place along with the general progress in other directions, where scientific results depend on the perfection of mechanical appliances. The sidereal clock is one of the main features of an astronomical observatory, and if it is to continue to be used to measure the angular distance in right ascension between the fixed stars, greater uniformity in its rate than is now usual must be secured. It is also important in time service work to have clocks which will carry time with greater accuracy during long intervals of cloudy weather when observations of the stars cannot be made. The development of the pendulum clock dates from the time of Huyghens, the celebrated Dutch astronomer, who, in 1656, published his theory of the pendulum. From that time until the present the perfecting of the pendulum clock has received the attention of the best mechanical artists in Europe and America. Important improvements in clock-making were made early in the eighteenth century, when the mercurial compensation and dead-beat escapement were invented by Graham, of England. The gridiron pendulum, previously suggested by Graham, was soon after constructed by an Englishman named Harrison.

Excellent practical work was done a century later by a German named Kessels, of Altona, who improved the dead-beat escapement by modifying the form of the 'anchor.' The mechanical work of Kessels is remarkably fine. He made a clock for the observatory at Pulcowa in Russia, and another for the celebrated astronomer, Bessel at Königsberg. Bessel investigated the running of the clock with his usual thoroughness and was much pleased with it. He writes of Kessels as 'der kenntnissreiche und vorsichtige Kunstler.' Kessels also made a clock for the Naval Observatory in Washington, which, after running for half a century, is in perfect condition and is still giving good service.

Later Tiede, of Berlin, and Hohwü, of Amsterdam, attained great success in making astronomical clocks, and there are now two or three English and American makers who are doing work of great merit.

The Dennison gravity escapement, which has recently come into use, is supposed to be an improvement on the dead-beat escapement, because any small irregularity in the action of the train of wheels should theoretically have little or no effect on the pendulum. It should, for this reason, be better adapted for use in clocks provided with an electric contact, worked, as is usually the case, by a toothed wheel on the seconds arbor for transmitting signals for record on the chronograph. This is an important practical advantage, and to more certainly secure it, American clocks are usually made strong and heavy and are run with heavy weights. The relative merits as timekeepers of the best American and

German clocks is an interesting subject for investigation.

Within the last ten years a clock by Riefler, of Munich, having certain novel features, has come into notice. In the Riefler clock the pendulum rod is a tube filled with mercury by which the compensation is effected. The pendulum is perfectly free, except that it receives its impulse from the spring by which it is suspended. The Riefler clocks have given good results, and one of them has been adopted as the standard clock of the Pulcowa Observatory at Odessa in Russia.

Various devices have been used with success at Greenwich, Pulcowa and elsewhere for compensating clocks for variations of barometric pressure. A newly discovered alloy of 36 per cent. nickel with 64 per cent. steel, which has a remarkably small coefficient of expansion, makes it possible to compensate clocks more perfectly for changes of temperature.

The astronomical clock is a simple piece of mechanism and the perfection of design, excellence of workmanship and the efficiency of the various contrivances for compensating for variations of temperature and barometric pressure seem to have been developed to a point beyond which no great advance is to be expected along present lines. Even if the effects of change of temperature and air pressure on the pendulum could be perfectly eliminated by compensation, we should still have their effects on the clock train as well as the harmful influence of dust and moisture, unless the clock-case affords protection from the latter.

The most obvious chance for future progress seems to lie in securing the greatest possible uniformity of conditions. With a clock securely mounted, enclosed in an air-tight case and kept at an invariable temperature and barometric pressure, the only conceivable cause for variations in its rate would be perhaps the imperfections in the mechanism of the clock itself. It is necessary for obvious reasons that the sides of the air-tight case should be rigid. A constant pressure cannot be maintained without constant temperature, as may be seen from the well-known formula connecting the pressure, volume and temperature of a body of gas,

$$pv = kt,$$

in which, for our present purpose, v may be regarded as constant. We may therefore write,

$$p = k't.$$

In an air-tight case filled with air the change of pressure due to a change of temperature of 1° Centigrade is between 2 and 3 millimeters for pressures of 650 to 750 millimeters.

The first successful attempt to mount a clock in an air-tight case seems to have been made by Tiede, of Berlin, who in 1865 installed for Professor Foerster in the basement of the Berlin Observatory an electric clock in an air-tight glass cylinder. This clock, the escapement of which is a very simple piece of mechanism, is described by Professor Foerster in the 'Astronomische Nachrichten,' Nr. 1636. The impulses given to the pendulum are independent of the strength of the current, since they are produced by the falling of weights which are lifted each second by an electromagnet. The reason for adopting the electric clock was that the winding of a clock run by weights is attended by difficulties when the clock is enclosed in an air-tight case. While this clock does not run under ideal conditions, being subject to a gradual change of temperature and a consequent slight variation of barometric pressure during the year, it is probably the best time-keeper in the world. It has frequently run for periods of two or three months with such accuracy that the average deviation of the mean daily rates for the whole period is only $0^s.015$ and with a maximum deviation of $0^s.03$. The clock was dismounted for cleaning in 1894 after running continuously for eight years. The pressure of the air in the case has been kept below the normal atmospheric pressure, and mention is made of the pressure having been made at one time as low as 180 mm., about 7 inches. Little difficulty seems to have been found in keeping the cylinder air-tight. Indeed a slight progressive diminution of the pressure in the cylinder has been observed, and is attributed by Professor Foerster to oxidation of the metal parts of the clock and to absorption by the glass walls of the cylinder of particles of moisture from the air within. This clock has been for thirty-six years the normal clock of the Berlin Observatory.

Soon after, Tiede succeeded in mounting a clock run by weights in an air-tight glass cylinder, and it was exhibited at the Paris Exposition of 1867. In his report of the Pulcowa Observatory for 1867 Otto Struve, the director, announced, with enthusiasm, Tiede's success, and stated that a clock run by weights and enclosed in an air-tight case had been ordered for that observatory. It appears subsequently that much difficulty was experienced from various causes in getting the clock into working order. But it was finally set up, about the year 1880, in the basement of the Pulcowa Observatory, where the temperature changes only four or five degrees a year, and was found to run with a satisfactory rate. This was for many years, and presumably is still, used as the principal clock of that observatory, which is an institution widely known for the high quality of its work. The pendulums of these clocks at Berlin and Pulcowa were compensated, of course, for change of temperature.

The Riefler clocks mentioned above are constructed so as to be easily mounted in air-tight cylinders, which together with the clock itself rest on a shelf bolted to the clock pier. There is one of these clocks mounted in the usual way at the Georgetown University Observatory at Washington. It is run by a weight which is wound up every few minutes by electricity. But it is not found practicable, under the conditions there, to keep the temperature strictly constant.

The standard clock of the Greenwich Observatory by Dent, of London, is mounted in the basement of the observatory, where the temperature changes are small and very gradual, and is fitted with an electrical device for barometric compensation.

The standard clock of the Paris Observatory, by Winnerl, enjoys the unique distinction of being mounted in a vault at a depth of 27 meters underground. The temperature changes at that depth are of course very small, being, according to Tisserand, not more than one or two hundredths of a degree during the year, but the effect of barometric changes on the rate of the clock has been found to be serious.

There seems to be no case where an attempt has been made to keep both temperature and barometric pressure strictly constant. There is, I think, no doubt that it is entirely feasible to maintain a suitably constructed vault at a practically constant temperature throughout the year by artificial means. Then, with an air-tight case, the barometric pressure could be kept practically uniform and the clock would be completely protected from dust and moisture. Even if it were not practicable to get the case perfectly air-tight, a practically uniform pressure could be maintained by exhausting the air from time to time, provided that the leakage is very small.

Accurate comparisons of clocks running

under such uniform conditions would be exceedingly valuable, not only in giving the highest order of results in timekeeping, but also in developing the peculiarities and comparative merits of the clocks themselves. The extreme accuracy with which two clocks, one keeping sidereal and the other mean time, can be compared by coincidences of the beats, which take place every six minutes, is familiar to every astronomer. Again, the more rapid minor variations in the rates of clocks could perhaps be detected and their periodicity determined by comparison with the vibrations of a pendulum swinging in vacuo.

Improvement in performance of astronomical clocks is of special importance in fundamental astronomy. An independent redetermination of the positions of the fundamental stars is necessary, and for this the most accurate possible timekeeping is needed because, in order to be of value in the present state of astronomy, such work must be of the highest degree of accuracy. All this has long been recognized by astronomers, and during the past forty years efforts in the direction of improved timekeeping have been made in all the principal observatories of Europe where fundamental work is attempted.

Commenting on the bad effect of variations in the rates of astronomical clocks due to the diurnal changes of temperature, Professor Foerster, the distinguished astronomer, who has been for 38 years director of the Royal Observatory at Berlin, wrote in 1867:

"How detrimental to accuracy such a large and changeable irregularity is, is evident since it operates like a variable division error.

"It is therefore necessary, in order that a clock may be of service in absolute determinations of star places, to have it protected from the daily temperature change, and also from all sudden changes of temperature. That is, it should be mounted in a place of nearly constant daily temperature so that it will remain for the compensation of the pendulum to effect only the last remaining fine adjustment.

"The air-tight confinement is safe in underground rooms or in heavy masonry against injury to the clock-work, because in the hermetically enclosed space any moisture present can be done away with by known means and the coming in of new moisture is impossible."

MILTON UPDEGRAFF.
U. S. NAVAL OBSERVATORY,
WASHINGTON, D. C.

SCIENTIFIC BOOKS.

The Stars, A Study of the Universe. By SIMON NEWCOMB. Pp. v+333. New York, G. P. Putnam's Sons; London, John Murray.

This is professedly a book written to order, as a part of the science series now appearing under the editorial supervision of Professor Cattell, and its author states plainly in his preface that he has found the task, 'to sketch in simple language for the lay as well as the scientific reader the wonderful advances of our generation in the knowledge of the fixed stars,' much more onerous than he had anticipated, on account of 'the extent and complexity of the subject and the impossibility of entering far into technical details in a work designed mainly for the general use.'

If one may judge the extent of systematized knowledge concerning the fixed stars by the space allotted to its presentation in the most approved text-books of general astronomy, from that of Arago to the present time, it appears that this branch of astronomy has grown during the century from about one eighth to one sixth part of the entire science. But the indexes to recent volumes of the principal astronomical periodicals show that about one-third of the articles there appearing relate to problems of stellar astronomy and thus mark an accelerated growth of interest in and knowledge of the remoter parts of the visible universe. The author who attempts to digest