of the developed fields has also been rapid, it has probably not been relatively more rapid. Hence the mathematical investigator of to-day can pursue his work with the greatest confidence as regards his services to the general uplift both in thought and in material betterment of the human race. All of his real advances may reasonably be expected to be enduring elements of a structure whose permanence is even more assured than that of granite pillars.

G. A. MILLER

UNIVERSITY OF ILLINOIS

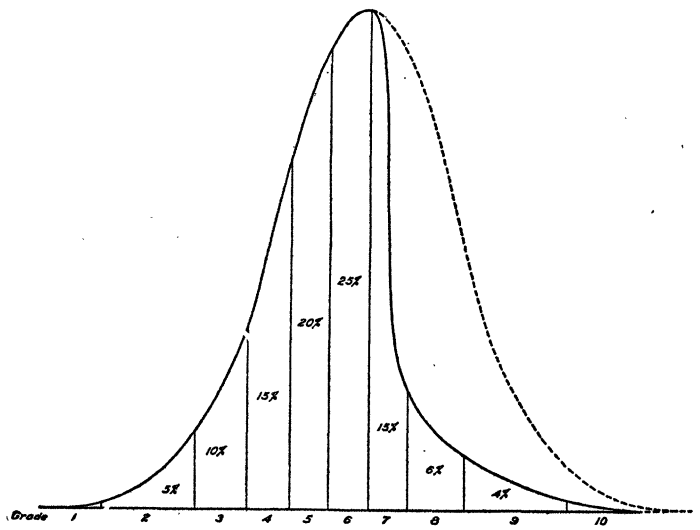
SCIENTIFIC DISTRIBUTION OF GRADES AT REED COLLEGE

A SCIENTIFIC rather than a personal basis for awarding grades in courses of study, if grades are to be used at all, together with definite credit for quality as well as for quantity of work, seems desirable, especially for institutions that are more than theoretically devoted to scholarship, and that are willing to make what sacrifices such ideals may involve.

The common grades *A* to *E* have no defined meaning. To call them such and such a per cent. of an undefined something is to substitute one vague expression for another. Without scientific definition, any set of symbols is inevitably used in personal, variable, erratic ways. To award scholarships, degrees and other honors, as if an *A* in one course represented the same distinction as an *A* in another course is to administer the curriculum on a patently false assumption.[1]

Until all school work can be measured by scales, made up of units that are equal in a defined sense, the best available grading is one of relative position in a series. The nearest approach to such a scientific basis for awarding college credits appears to be a distribution following the normal probability curve, skewed to take account of the effect of selecting the student body.

The Reed College system is shown in the illustration. The outer curve, partly dotted, is the normal probability curve. The inner curve, partly coinciding with the other, shows



[1] It is impossible, here, to give a detailed explanation of the "credit for quality" system and the scientific distribution of grades adopted by Reed College. The underlying principles of both are fully explained in chapters 12 and 13 of the "Administration of the College Curriculum," Houghton Mifflin Company, 1911. "The Distribution of Grades on a Scientific Basis" is presented in *Popular Science Monthly* for April, 1911.

the result of selecting the student body, and would be vertical at the right side if it were possible to perfect the selection so as to exclude all below a certain standard and admit all above that standard.

Reed College uses ten grades. Ten, rather than any other number, are used, because tests by approved statistical and psychological methods show that fewer grades are inadequate to designate readily discernible differences, and many more grades can not be used with intelligent discrimination. The definitions of these grades have a scientific basis. Grades 1–5 indicate that a student stands in the upper half of an average class; grades 6–10 indicate that he is in the lower half. For example, 2 designates the work which will be done (in the long run) by the best 5 per cent. of all students, and 6 the work done by that quarter of an average class standing just below the middle. These particular percentages were chosen somewhat arbitrarily for the sake of convenient round numbers, but they correspond fairly well to the distribution shown in the probability curve as skewed from normal by the selection of students.

Grade 1 is rarely given, representing a degree of excellence attainable by not more than one student in four or five hundred; similarly, grade 10 records correspondingly bad failures. The lowest grade called passable is 8, which covers all cases where credit is granted conditionally or upon the satisfaction of some special requirement; 9 is for ordinary cases of failure.

It will be observed that the symbol 1 of the Reed College scale is a grade of real distinction, as the *A* of the usual scale is not; and that even the 3 of the Reed College scale represents quite as much distinction as the *A* if the latter grade were obtained by 15 per cent. of a class.

The grades, however, can not be interpreted in qualitative terms, as good, poor, *A*, *C*, 90 per cent.; nor do they designate rank in the particular class. They show the group in which the student would appear if the classes of several years were subdivided as indicated above.

Such a definition will not make a "2" = "2" as regards the actual quality of work done by the student, since this is a matter not only of the student's relative standing in the subject, but also of the actual standards set for that subject. But despite this, for courses of the same general sort (as introductory courses without prerequisites, whether coming in freshman or senior year), the relative rank in an average class seems to be the best available criterion of the student's merits.

In adopting the Reed College System, we attempted to divide the base line of the normal probability curve into equal parts; but we found this awkward, as grade 2 would then fall to but 1½ per cent. of the students. We then tried (each side of the median) a distribution of 20 per cent., 15 per cent., 10 per cent., 5 per cent., which corresponds to equal bases for grades 4, 5, 6, 7 with somewhat longer bases for 3 and 8, and much longer ones for 2 and 9. This distribution seemed more convenient. We changed the distribution on the lower side, however, to 25 per cent., 15 per cent., 6 per cent., 4 per cent., to allow for skewing of the curve due to the influence of selection. What sort of divisions of the base line this requires no one can say without knowing the exact shape of the skewed curve (which depends on how effective the selective cut is), and knowing also how far the new median has been moved above the median in the normal curve (which depends on what area was cut off, according to the standard of selection). In using unequal divisions of the base line, therefore, we make a choice of percentages which is somewhat arbitrary, except that it follows roughly the sort of distribution in the skewed curve with equal base divisions.

With such a basis for grading students in their college courses, it is possible to give a definite and just reward for high scholarship by allowing a course completed with high credit to count more toward a degree than a course completed with lower credit. Such a plan for counting quality has the great advantage of enabling the students who do the best work to graduate in less than the normal

time, without tempting them to take more subjects in a given year than they can creditably pursue.

WILLIAM T. FOSTER

SCIENTIFIC NOTES AND NEWS

BY the untimely death of Wilbur Wright the country loses an inventor of distinction, whose great achievement in the development of the aeroplane gives him high rank among those who have contributed to the practical applications of science.

DR. WILLIAM MCMICHAEL WOODWORTH, of the Harvard Museum of Comparative Zoology and the author of important contributions to zoology, has died at the age of forty-eight years.

VICE-PRESIDENT THOMAS JONATHAN BURRILL and Comptroller Samuel Walker Shattuck, of the University of Illinois, will retire from active service at the end of the present academic year, having been granted special retiring allowances by the Carnegie Foundation for the Advancement of Teaching. Both of them have been with the university since its foundation in 1868, and have been potent factors in its upbuilding. Dr. Burrill has served as professor, dean, vice-president and acting president and has done notable research work in botany and bacteriology. Professor Shattuck has served as professor of mathematics, vice-president and comptroller.

DR. HENRY T. EDDY, head of the department of mathematics and mechanics at the University of Minnesota and dean of the graduate school, will retire from active service under the terms of the Carnegie Foundation.

PROFESSOR THEODORE W. RICHARDS, of the department of chemistry of Harvard University, lectured at the University of Michigan upon "Atomic Compressibility" on May 16. On May 17 he was awarded the Willard Gibbs medal by the Chicago Section of the American Chemical Society, and delivered an address upon "Atomic Weights."

THE death of Lord Lister having created a vacancy in the membership of the Royal Society of Science, Upsala, Sir Victor Horsley, F.R.S., has been elected his successor.

THE Société Astronomique de France has, says *The Observatory*, lately taken advantage of two anniversaries to pay honor to the founder and past-president of the society. January 28 last was the twenty-fifth anniversary of the founding of the society, and this year is the fiftieth of M. Flammarion's career as an astronomical writer, for his first great work, "La Pluralité des Mondes habités," was published in 1862. The actual ceremony took place in the large hall of the Sociétés Savants on the evening of February 26, which happened to be M. Flammarion's seventieth birthday, so that three anniversaries were celebrated.

AS a memorial of Professor Ralph S. Tarr a volume is to be published consisting of essays on physiographic and geographic subjects, the work of men trained by him. A committee has been named to take charge of the preparation and publication of the volume. This committee has asked Dr. Frank Carney, professor of geology in Denison University, to edit the work.

THE completion by Rudolf von Jaksch of twenty-five years as professor of internal medicine at Prague was celebrated recently. The *Prager med. Wochenschrift* issued a special number in his honor and a *Festschrift* was presented to him.

COLONEL SIR DAVID BRUCE, C.B., F.R.S., has been promoted to the rank of surgeon general in the British Army, in consideration of his eminent services to the cause of science. Sir David Bruce is at present at the head of the Sleeping Sickness Commission appointed by the government, with the advice of the Royal Society, to continue the study of the disease in Nyasaland.

A GRANT of $140 from the C. M. Warren Fund of the American Academy of Arts and Sciences has been made to Professor Arthur B. Lamb for work upon the rhodiumamines.

HARRY MILES JOHNSON, Ph.D. (Hopkins '12), has been appointed psychological assistant in the physical laboratory of the National Electric Lamp Association, Cleveland, Ohio.

THE American Road Builders' Association gave a dinner at the Hotel Astor, New York