constant. The writer is not aware of any experimental evidence of the truth of this equation. It affords an opportunity of putting to an important use the methods of measuring low pressures which are being perfected at present.

It is also shown that

$$\frac{dv}{dT} = 0 \qquad (9)$$

$$\frac{d^2v}{dT^2} = 0 \qquad (10)$$

Therefore, if the volume v of the substance or mixture in the condensed state may be expressed in a series of integral powers of T by Taylor's theorem,

$$v = v_0 + a_4 T^3 \qquad (11)$$

near the absolute zero of temperature according to equations (10) and (9), where v_0 denotes the volume of the substance or mixture in the condensed state at the absolute zero of temperature, and a_4 is a constant. The foregoing equation could be tested experimentally without encountering insuperable difficulties, probably best by an optical method.

It will be of interest to point out that if equations (1) and (2) can be proved experimentally for a number of substances—Kammerlingh Onnes's experiments furnish the proof for some substances—equations (6), (7), (9) and (10) can be shown to hold for these substances by means of well-known thermodynamical formulae and the Calculus.

It may also be mentioned that it is shown that equation (1) holds for a mass of matter in the gaseous state at infinite volume at the absolute zero of temperature. The experiments of Scheele and Heuse[3] on the specific heat of helium at constant volume, who found that it decreased with decrease of temperature, support this deduction.

The foregoing results, since they were deduced by the help of thermodynamical formulae, will apply to a substance or mixture only if it is in a state that it can be passed through a thermodynamical cycle, *i.e.*, if it is in perfect thermodynamical equilibrium.

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PROFITS DERIVED FROM SEGREGATING COLLEGE STUDENTS ON THE BASIS OF ABILITY

TWO experiments, to determine both the qualitative and quantitative advantages that may be derived particularly by superior college students when segregated on the basis of ability, have recently been completed at the University of Michigan under the direction of Professor Henry W. Miller, head of the department of mechanism and engineering drawing, of the college of engineering. An exhaustive report has been prepared on these experiments by Professor Miller for the senate of the university, which began consideration several years ago of the question, "What can we do to further benefit our superior students?" A limited number of copies of this entire report are available for distribution to those interested in the more detailed discussions of the procedure in conducting the experiments, the incidental findings, and in the graphs showing the performance of the various classifications of students in all their college work, and in particular subjects. The complete report will be published soon in *School and Society*. A brief description of the experiments and the more pertinent findings are given herein.

The department of mechanism and drawing at Michigan is an independent department of the college of engineering and gives all the general courses in engineering drawing to some eight hundred freshmen and sophomores yearly. The department was in the process of revising all its courses, methods of teaching, etc., and felt that an effort should be made to determine the nature and extent of the benefits that might be derived by the students if they were taught in homogeneous groups made up on the basis of ability, rather than in the usual heterogeneous groups. Interest centered particularly in learning what benefits the superior students might derive therefrom and the extent.

Descriptive geometry was chosen as the best test medium for these experiments, for reasons which those having a knowledge of this subject can readily understand. This subject is given to the freshman class in its second semester. All students being tested had, therefore, completed one semester's work in college and a double test could be conducted, the one to determine the nature and extent of advantages from segregation on the basis of ability, and the other to learn whether the quality of work done on previous college courses can serve as a satisfactory basis of segregation.

METHODS OF CONDUCTING THE EXPERIMENTS

At the end of the first semester and before the beginning of the second, the general averages made by the freshman engineers on all their first semester subjects were computed and the names of the men listed in the order of their averages. In computing these averages the mathematical value of the letter grade for each subject was multiplied by the number of credits for that subject and the sum of all the products divided by the sum of the credits. In general the grade "A" is given for a record of from 90 to 100 per cent., "B" for 80 to 90, "C" for 70 to 80, and "D" for 60 to 70. The university gives a value of 4 to the grade "A," 3 to "B," 2 to "C" and 1 to "D." In computing general averages, then, the four credits for any sub-

[3] *Ann. der Physik.*, 40, p. 484 (1913).

ject on which a grade of "B" had been secured were multiplied by the value "3" of this grade. The general averages ranged from 4 down; very few 4's.

The students in descriptive geometry are enrolled in six main groups and each of these groups is later subdivided into sections of from twelve to fifteen. On completion of the enrollment, those students of each main group who had a general average on all first semester work of 3 or more were segregated into one section. Those having a general average of less than 1.5 were segregated into another section and the remaining students were divided into sections of from twelve to fifteen. In both experiments it was found that in a group of from sixty to seventy students there were about twelve with averages of 3 or more, and another twelve with averages under 1.5.

In each experiment the low and high sections were given to six instructors with long experience in the teaching of this subject, so that as many as possible of highly trained teachers might have the opportunity to compare results, reactions, necessary teaching methods, capacities, qualities, etc., of the highest and the lowest of the students.

Results and Conclusions

(1) Under the above scheme of segregation about twenty per cent. of freshman engineering students were classed as "high" and another twenty per cent. as "low."

(2) The low students (in the two experiments under discussion) are in the main the children and grandchildren of American-born men and women. They also are the sons of the better educated and more prosperous parents.

(3) A surprisingly large percentage of the high students are the grandsons of foreign-born men and women. They are the sons of parents having either but little education or none. In the main they are the sons of parents whose education does not include the high school. Twenty-four per cent. are the sons of parents who had less than a grammar school education.

(4) The low students had made relatively poor records on their preparatory school work, particularly on mathematics, physics and chemistry. They made poor records also on *reduced* loads of work during both semesters in college.

(5) The high students had made an excellent or good record on their preparatory school work, particularly in mathematics, physics and chemistry.

(6) Outside employment to earn a part of the school expenses, room, board or money seems to have no noticeable effect on scholarship.

(7) Over ninety per cent. of the high students returned for a second year. Only forty per cent. of the low students returned.

(8) The instructors of high and low students learned facts about the qualities, capacities, etc., of such students when segregated that they had not been able to learn when the students were mixed.

(9) Students in low sections quickly develop a confidence in what ability they possess that they do not seem to develop in sections containing appreciably keener men. The idea that they are inspired by more capable men seems to have no support. They do better work when by themselves than when in mixed sections.

(10) The instructor quickly adjusts all discussions and the pace in high sections to the capacities of such men. All discussions are in terms of their keen understanding; the entire class time is spent on just them, all of their time is employed profitably. They are worked at a pace to develop their capacities to the maximum.

(11) Low students are lacking in the quality of vision, powers of analysis and coordination; they are superficially bright and ingenious, but their tenaciousness of purpose and capacity for sustained mental effort are so low that their curve of effort has a steadily downward trend.

(12) High students rate notably high in powers of perception, analysis and correlation, tenaciousness of purpose, capacity for sustained mental effort and inclination to succeed.

(13) The amount of energy required of the instructor of low students to overcome mere friction, to make up for deficiencies, lack of inclination to succeed, etc., is so great that no instructor can gauge it until he has taught a group of such men.

(14) There is no friction to be overcome in getting a group of high men under way. The instructor is constantly exhilarated in keeping up to their pace. He serves for them as a guiding rather than as a driving agent.

(15) High students are able to finish exercises designed to fit a mixed class in about three fourths of the average time of a mixed class.

(16) Low students profit when segregated under three factors: *Intelligence, personal contact* with the instructor and *confidence development.* No measure has yet been effected of the extent of gain under any of these factors.

(17) High students profit when segregated under two factors: *Time,* to the extent of about twenty per cent., and *intelligence,* to the extent of at least ten per cent. They profit also under two other factors: *Content of course,* and *personal contact* with the instructor and a group of men of their own kind, but the extent of this profit has not yet been measured. The measured and agreed upon profit is at least thirty per cent.

(18) The method of segregating students on the basis of the quality of previous college work seems satisfactory because all sections so arranged performed, in the test subject, and in the entire group of second semester subjects, exactly as rated.

(19) No harm is done to any grade of students under segregation and after one trial no instructor objects to at least one section of the low students.

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ON VALONIA AND HALICYSTIS IN EASTERN AMERICA*

THE use of large coenocytic algae in the study of protoplasmic permeability and the accumulation of salts in the vacuolar sap has proved so valuable that a note on certain distinctions with regard to them may be of interest. The best known species is *Valonia macrophysa* Kütz., of Bermuda, where it is widely distributed, but reaches large size only in favorable situations. It then occurs in branching clusters, which often are very tight and force the individual "cell" to grow into an elongated or tapering cylindroid. The separated "cell" is dark green and firmly turgid while alive and sinks in sea water. Its specific gravity is correlated with its sap content, as shown by Osterhout and Dorcas,[1] the solution of (chiefly) potassium chloride in the vacuole having a higher density than the sea water.

This cell contrasts markedly with the other Bermuda coenocyte studied, the one known locally as "sea bottles," washed ashore during part of the year on exposed beaches of the south shore. These are invariably single, pear-shaped cells up to an inch or more in diameter, and never clustered. These cells have not yet been found *in situ,* but when the stranded ones are carefully gathered many are found to live in the laboratory for a week or more. During this time they remain a pale to medium green in color, and have a distinct turgor, though the cell is much more resilient than that of *Valonia macrophysa.* Most marked of all, these cells continue to float in the sea water and only sink when the protoplast disorganizes and the green color disappears. This flotation during life is again correlated with the sap constitution (Osterhout and Dorcas, *loc. cit.*), the predominating salt being sodium chloride, and the solution slightly less dense than the sea water. Sulphate ion is excluded, and potassium is not markedly accumulated. On death, of course, all the salts of the sea water diffuse in, and the sap no longer remains light enough to float the protoplasm and cell wall.

These "sea bottles" of Bermuda have long been considered as *Valonia ventricosa,* a common species of the West Indies.[2,3] It was remarkable, of course, that two species of the same genus should differ so widely in fundamental character as to exercise such different selectivity with respect to salts. This distinction, together with differences in the cell wall, chloroplasts, distribution of nuclei and absence of lenticular or holdfast cells raised the suspicion that the floating form might not be *Valonia* at all, but *Halicystis,* a somewhat similar genus, known in the North Sea, the Mediterranean and the Pacific.[4] The occasional appearance of radiate and stellate markings quite similar to those figured by Kuckuck[5] in connection with zoospore formation in *Halicystis* strengthened this suspicion.

Further evidence was afforded the writer this summer, during a stay at the Carnegie Institution's marine laboratory at Tortugas, Florida. On the reefs surrounding those keys the cells of *Valonia ventricosa* J. Ag., are found *in situ,* and may be gathered for laboratory study. These cells are, again, always single, never in clusters or branching, and are usually almost spherical. They are, however, but slightly resilient, are dark green in color, and immediately sink in sea water, floating neither in the ocean nor while kept in sea water in the laboratory. The electrical conductivity of the sap indicates it to be chiefly potassium and not sodium chloride solution and is almost the same as that of *Valonia macrophysa,* gathered at Fort Jefferson, in Tortugas. Chemical analysis will be reported elsewhere in detail.

It is evident that this Florida species, morphologically similar to the *Valonia ventricosa* widely distributed in the West Indies, is something quite distinct from the Bermuda "sea bottle." It is therefore gratifying to report that specimens of the latter (and of one of three cells found floating at Tortugas, closely resembling the Bermuda form) were submitted to Dr. Marshall A. Howe, of the New York Botanical Garden. Dr. Howe has very kindly identified the floating cells as being indeed *Halicystis.* The species remains in doubt, *H. ovalis* (Lyngb.) Aresch. being evidently a smaller plant.

The conclusions we may draw are: (1) Physiological differences may be useful in taxonomic diagnosis,

* Contributions from the Bermuda Biological Station for Research. No. 155.

[1] Osterhout, W. J. V., and Dorcas, M. J., *J. Gen. Physiol.,* 1924–25, vii, 633.

[2] Collins, F. S., and Hervey, A. B., *Proc. Am. Acad. Arts and Sc.,* 1917, liii, 51.

[3] Britton, N. L., "Flora of Bermuda," New York, 1918, p. 494.

[4] Setchell, W. A., and Gardner, N. L., *Univ. California Pub., Botany,* 1920, viii, 154–5.

[5] Kuckuck, P., *Bot. Ztg.,* 1907, lxv, 139.