surface where it awaits another warming the following day." The picture thus offered to the unsuspecting student is so simple—but, as meteorologists have long since recognized, so untrue.

On page 11: "Surface winds are influenced by topography and surface temperature. Winds tend to descend slopes, to follow valleys . . ." The implication of the words as printed surely is that winds do not tend to ascend slopes—an astonishing comment, for example, on the often violent effects of daytime up-slope winds among mountains. The reviewer feels certain that the writer never intended that implication, but clear thinking would have kept such a statement out of print. And one wonders why a publisher should so far fail in the matter of self-protection as not to catch the vacuity of the following (law 81): "Air pressure decreases with increased elevation because the atmosphere envelops the rest of the earth."

"82. There are seasonal and diurnal variations in air pressure related to changes in temperature *but with the opposite sign, falling as the temperature rises.*" (Reviewer's italics.) Now the average elementary student, unwitting victim of mass production in "education," dearly loves to regard his textbook as infallible. At any rate, acting on that assumption helps him to "pass" courses. Therefore it is too much to expect him to wonder whether the spectre of vagueness and half-truth lurks in a statement like the above. The fact is that the diurnal temperature and pressure changes do normally show approximately opposite trends for stations at and near sea level, but that quite the reverse is true for high-altitude stations. It is precisely in this fashion that the spectre bobs up constantly through large sections of the book.

The purpose of the author being to discuss *laws,* it seems unfortunate that he should occasionally (*e.g.,* pp. 25–26) indulge in speculation based too often upon the hypothesis that if such-and-such were the case, the results would be so-and-so. It may be seriously questioned whether it is wise, in a book of this nature, to enter into highly debatable ground—a procedure which can only confound the student for whom evidently the volume is intended.

The bibliographic notes are abundant, and, if used with discretion, will serve a purpose. One becomes skeptical of the author's judgment, however, upon finding that some of the notes refer to text-books (at best second-hand "sources") that are more or less seriously out of date meteorologically. Moreover, one fails occasionally to find references in critical places to the leaders in the particular fields. Thus under "sensible temperature" there is no mention of Leonard Hill, under "cyclones of mid-latitudes" no mention of Bjerknes. Indeed, nothing indicates that the author considers the great conceptions relative to surfaces of discontinuity, warm and cold fronts, etc., to be of any importance to the student of climate who would attempt to keep pace with the development of modern thought in these matters.

Lest the above comments seem too pessimistic, it should be made clear that although the reviewer believes the book *as it stands* could only prove to be an educational pitfall, not alone to the elementary student but to an unwary teacher, nevertheless he also believes that those possessing a sound background of training in meteorology and climatology could find use for the volume. Thus, there is in it abundant statistical and bibliographic material which the teacher of, let us say, geography, could, *if so trained,* use to advantage. But he should, in order to decide whether he is thus trained, first inquire if his knowledge is based upon something more than the outworn conceptions of meteorological processes to be found in the average American "college" text. Then, if he can qualify, and has both time and inclination for the task, let him proceed to select and rearrange from "Climatic Laws" such materials as meet his particular needs.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

APPLICATION OF THE MICROSCOPE TO GALVANOMETRY

THE intention of this note is to draw attention to the possibilities of the microscope as an aid in galvanometer observation. When a galvanometer is used as a null indicator in potentiometer or Wheatstone bridge work the sensitivity of the instrument should be high enough to give an unmistakable change in the galvanometer reading when the slide wire contact is altered by the smallest readable amount. In operations with galvanometers of the portable pointer type it sometimes happens that this condition does not obtain, and it then becomes necessary to turn to the reflection galvanometer, with its more troublesome technique, or to find means of extending the divisions-per-volt sensitivity of the pointer instrument. The latter recourse is to be preferred and is easily affected by bringing a microscope with a power of perhaps a hundred diameters to focus on the tip of the pointer. The eyepiece should be furnished with a scale. It is easy by these means to obtain an increase in apparent sensitivity of sixty to one hundred fold.

The quickness, steadiness and convenience of this arrangement recommend it for use in place of the reflection galvanometer, not only for null indications but also in many cases of current and voltage measurement. Sensitivities of a like order with the more modest wall-type instruments are readily attained.

The very highest sensitivities are to be obtained of course with reflection galvanometers, and here too the microscope may be employed to extend the range of the instrument to much smaller currents and voltages than those ordinarily observed. Light from a vertical lamp filament, passing through a convergent lens, falls upon the galvanometer mirror and comes to focus before the objective of a horizontal comparator microscope instead of upon the customary scale. The observer uses the comparator in the usual way, setting the cross-hair or index upon the edge of the filament image and taking readings at the micrometer head.

On an ordinary scale one would perhaps be able to detect an image shift of one fifth of a millimeter. With a comparator suitably arranged a displacement one one hundredth as large is definitely observable. In a recent test a filament of a 40 watt tungsten lamp was used as source, while a lens of 60 cm focal length produced the image. The mirror was of good quality, plane and circular, and had a diameter of 1.1 cm. At a distance of 200 cm from the mirror a comparator with a magnification of thirty diameters was located. The definition of the image was greatly improved by the insertion of a green Wallace filter at the comparator objective. With the mirror in a fixed position the comparator index was set upon the edge of the image ten times and the micrometer head readings recorded. The average deviation of these readings from their mean was .0001 cm, which shows that any rotation of the mirror, so long as the image remained within the range of the comparator, could by a single setting be measured with a probable error of 1/20 second of arc.

With the galvanometer before me at present—a style to be found in most university physical laboratories and one without claims to high sensitivity—these figures suggest the possibility of measuring currents of the order of 10^{-11} amperes. Unfortunately, however, the perturbations to which these types are subject prevent making full use of this unusual magnification.

The angular sensitivity described is due in part to the use of the comparator screw, by which the observer is relieved of the task of estimating the precise position of the image with respect to a series of scale rulings. It is well not to forget that this objectionable operation, which limits the accuracy of scale measurements of all kinds, may generally be avoided, if the ends justify the effort, through mechanical devices such as we have considered here. The ordinary vernier supplies the simplest and best illustration.

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SPECIAL ARTICLES

AN HYPOTHESIS ON CELL STRUCTURE AND CELL MOVEMENTS BASED ON THERMODYNAMICAL CONSIDERATIONS[1]

ALL living matter is principally built up of aqueous solutions of substances which have the property of lowering substantially the surface tension of water. It is known that these substances will tend to reach an equilibrium by accumulating at interfaces. This is just a consequence of the application of a well-known thermodynamical law: a system always tends towards a state of equilibrium where the free energy will be the minimum compatible with its total energy. If a droplet of such a solution is abandoned in a small hollow in a rock, or sprayed into the air, under any circumstances where it will be momentarily separated from the bulk, its constituents in solution will concentrate in the surfaces, the solubility of some of them, in case of a complex solution, will be affected by the presence of salts and of CO_2, coagulation will follow, and it will be surrounded by a membrane. On the other hand, since the works of Gibbs and Boltzmann, we know that the state of equilibrium predicted by thermodynamics for any material system is always "the most probable state compatible with its total energy, potential and kinetic." Hence, we may say that "the most probable equilibrium configuration of such a system is the cell form," which is equivalent to saying that the state of thermodynamic equilibrium of a system composed of proteins[2] in solution with salts, under the conditions stated above, is the cell form. However, the size of the original droplet is not indifferent, and the foregoing observations, based on experimental evidence[3] and theoretical considerations, are only likely to be applicable in the case of droplets small enough to coat themselves with an adsorbed layer of protein of sufficient thickness in a very short time. The smaller the droplet, the more rapidly its surface layer will be saturated with protein.

1 From the Laboratories of The Rockefeller Institute for Medical Research.

2 Or any other organic substance of high molecular complexity endowed with the same properties with regard to surface tension. The term "protein" is used throughout this paper for the sake of brevity, but the experimental facts and the hypothesis may apply as well to other compounds found in the cells and in the plasma, for instance, or to a combination of them.

3 du Noüy, P. L., *J. Exp. Med.*, 1922, xxxv, 575, 707; SCIENCE, 1924, lix, 580.