detected a colorimeter may often be employed for the determinations. But when a colorimeter is prohibitive, a series of tubes ranging by the smallest perceptible variations in color may prove satisfactory.

One difficulty in preparing a set of tubes in this fashion lies in the fact that to the unaided eye a change in color is less noticeable between deep colors than the same change between diluted ones. This is apparently a geometric relationship, as demonstrated in an article[1] recently published by the author.

This finding is not at variance with that of Lovibond.[2] But it is not necessary to have recourse to a "specific color factor" for practical purposes, as it is only essential to dilute the colored solution sufficiently to ascertain roughly the number of tubes required for a geometric series that will fulfill the requirements at hand.

Having a colored solution that matches the heaviest shade of the substance to be estimated, we dilute an aliquot with an equal volume of water, part of this we dilute again, etc., till there is but a perceptible difference in shade between our last two dilutions. We can then calculate the number of tubes required for the series and may ascertain the factor for the set, using the formula

$$r = \sqrt[n-1]{\frac{1}{a}}$$

Of course, the number of tubes required to complete a series graded by the nearest perceptible change in color will vary as the intensity of the terminal solution and in the case of a very weak solution many less tubes will be necessary than in a strong one. Then, too, if the grading is through a definite number of tubes rather than by intensity of color and the tubes are too few in number, these large jumps in color by reason of their geometric relationship may give rise to errors when interpolating, especially in the deep colors. The size of the factor rests somewhat on the degree of accuracy desired in reading between tubes.

It is suggested that color standards may be more easily and reliably prepared in the manner outlined above than by matching or diluting by the unaided eye.

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BUREAU OF PLANT INDUSTRY

1 "Geometric progression in optically prepared standards," *J. Amer. Op. Soc.*, May, 1923.

2 Lovibond, J. W., "Light and color theories," 1915, Appendix II, p. 77.

A FACTOR CAUSING THE ASSIMILATION OF CALCIUM

IN the work of Dr. Forbes, formerly of this station and the earlier work of Hart and his associates and of Meigs and his associates it has been demonstrated that milking cows receiving a ration of grain and dry hay, with and without mineral supplements, are brought into a decided negative calcium balance. Hart has also shown that goats, after a period of negative calcium balance, have been able to produce a positive calcium balance when placed on green feed. He states that apparently there is something having its source in fresh green material which controls or assists calcium assimilation.

Working on the hypothesis that most of the calcium, in whatever combination it may be, in the cells of green plants is in a highly dispersed form and hence better assimilated than the calcium in the dry plant, the drying of which no doubt causes a change in the physical properties of the cell and its content, we set about to imitate, in a rough way, the cell content as far as it represents our idea of the highly dispersed form in which the calcium exists in green plants. A starch paste was made up with a known solution of $CaCl_2$ (2 Molar). Then an equal volume of Na_3Po_4 of the same strength as the $CaCl_2$ was added. The starch acted in a slight degree as a protective colloid for the calcium ion and the final product, Ca_3 (Po_4) was left in a highly dispersed form. This starch paste was added to the ration of grain and dry timothy hay, which in turn was fed to two milking goats.

The goats were mature animals in their third and fifth months of lactation and weighed 30 and 40 kilograms respectively.

This test was carried on for a period of 26 days preceded by a preliminary period of 10 days. The 26 day period was divided into three periods of 7, 7 and 12 days respectively. The calcium intake was from 5 to 6 grams per day. Out of the six complete accountings of the calcium five were positive, the sixth showing a negative balance of 0.32 grams calcium for the 12 days. This was a little surprising to us after we had failed, in a previous trial, to obtain a positive calcium balance on a dry ration and a mineral supplement. We realize that the goats were in a later stage of lactation in this trial than in the one two months previous, when a negative calcium balance was obtained, with practically the same intake, yet we do not believe that this difference can be entirely attributed to this factor.

A vitamin or the vitamins of green plants may play an important part in the assimilation of calcium, yet we do believe the difference between green (fresh) and dry plants in causing the assimilation of calcium is partly due to the difference in physical properties of the cell wall and the cell content.

Our data are not yet inclusive enough to substantiate our hypothesis or to draw definite conclusions.

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TRABECULAE OF SANIO IN ANGIOSPERMS

THE occurrence of "Trabeculæ of Sanio" has been noted previously only in Gymnosperms but their discovery in an Angiosperm at the Forest Products Laboratories of Canada demonstrates a wider distribution than hitherto has been credited to these rod-like structures which extend across the lumina of cells.

Typical trabeculæ—homologues of those common to Gymnosperms—were observed extending radially throughout a series of tracheids in secondary wood from the stem of *Alnus oregona,* Nutt. One section of this alder shows a series of trabeculæ which, as well as crossing a number of tracheids, traverses the lumen of a wood parenchyma cell.

Generalizations regarding a primitive position for the Betulaceæ which are based on the occurrence of trabeculæ in members of this group must be hazardous as the ubiquitous distribution of these typically rod-like structures in the Gymnosperms leads to the presumption that they may be of widespread occurrence in the Angiosperms as well.

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A COURSE IN PHYSICAL MEASUREMENTS FOR STUDENTS IN OTHER SCIENCES

IN the issue of SCIENCE for August 29, 1919, a plea was made by Dr. Paul E. Klopsteg for courses in physical measurements for students of chemistry and related sciences. In view of the inherently physical nature of almost all quantities which can be observed and evaluated, the reasonableness of such a plea seems obvious. The emphasis of the writer was upon the need of training in physical measurements as differentiated from "physics."

During the past semester we have offered a course of this type and it seems advisable to add our experience to the plea made by Dr. Klopsteg. The section has consisted of ten men, seniors and juniors, whose major interests have been in astronomy, chemistry, engineering and mathematics. All have pursued a course in general physics which included a year of laboratory practice of the ordinary college type. Each one has had laboratory experience, more or less extended, in some other science.

The material for the course was determined by choosing from the instruments commonly employed in the physical laboratory those which were judged to have application in other fields. Opportunity was given for becoming familiar with each instrument by using it for some particular determination. The method of its use was stressed rather than the quantity which was being determined. For instance, the potentiometer was studied in principle and one was used in calibrating a thermocouple. The choice of instruments has been influenced by the resources of the laboratory and the list here given is not to be taken as a final selection. In each case the particular use to which the instrument was put has been indicated.

1. The Pulfrich refractometer for the index of pure liquids, solutions and solids.
2. The prism spectroscope with photographic registration of an "unknown" and a comparison spectrum, measured with a comparator.
3. The alternating current bridge and galvanometer for electrolytic conductivity, using an electrically controlled thermostat.
4. The Carey-Foster bridge for the checking, coil by coil, of a decade box against a standard.
5. The potentiometer in the calibration of a base metal thermocouple.