as a teaching aid for soil texture that its use is suggested for demonstrating other systems composed of two or more variables. For instance, the addition of more hands and a change of labels will allow the demonstration of the various percentages of protein, fat, carbohydrates, ash and water which distinguish our foods. The proximate analysis of coals showing the percentages of moisture, volatile matter, fixed carbon and ash makes classification of coals a very concrete matter when seen on the clock face. Thus visualizing the nutrient values of feeds becomes simple, and so forth.

JAMES E. CHAPMAN

FARGO, N. D.

SPECIAL ARTICLES

COUPLING OF RESPIRATION AND SYNTHESIS OF PHOSPHATE ESTERS IN HEMOLYZED BLOOD

MAMMALIAN erythrocytes are not able to oxidize carbohydrates but exhibit only glycolysis, the end product being lactic acid. On addition of methylene blue or some other reversibly reducible dye stuff they acquire the property of oxidizing sugar by molecular oxygen as Harrop and Barron have first shown.

On hemolysis, both the faculty of glycolysis and of respiration are lost. Warburg,[1] however, showed that though the hemolyzed blood has no action on glucose or glycogen, it does react with hexose-monophosphate-ester (Robison ester). This carbohydrate ester is oxidized in the air by hemolyzed blood on addition of methylene blue.

It is characteristic of normal respiration that its energy is not entirely liberated as heat but in part utilized for work or chemical synthesis. In the system, hemolyzed blood + Robison ester + methylene blue, however, respiration is not accompanied by any chemical synthesis or work. Runnström, Lennerstrand and Borei[2] found that addition of cozymase from yeast cells to the system mentioned brings about a synthesis of organic phosphate esters coupled with the respiration. We can, now, add the following observation. When pyocyanine is used instead of methylene blue, such a synthesis of phosphate esters takes place without cozymase being necessary.

Though no full insight into the mechanism of this coupled reaction can be obtained as yet, it seems likely that this faculty is correlated with the exceptional property of pyocyanine of accepting either one or two electrons,[3,4] whereas in general dye stuffs can accept only two electrons at once. To be sure, no causal connection between these two properties can be recognized as yet. However, since the reversible two-step oxidation has been recently encountered in other physiologically occurring dye stuffs,[5] especially in Warburg's yellow respiration enzyme, and the flavines or lyochromes, or at least in their prosthetic colored component, according to Kuhn and Wagner-Jauregg,[6] and to Barron and Hastings,[7] the particular behavior of pyocyanine with respect to oxidation and reduction can no longer be considered as a fortuitous property of one special bacterial pigment but as a property of some physiological significance.

J. RUNNSTRÖM
L. MICHAELIS

ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

1 O. Warburg, F. Kubowitz and W. Christian, *Biochem. Zeits.*, 221: 494, 1930.

2 J. Runnström, A. Lennerstrand and H. Borei, *Biochem. Zeits.*, 271: 15, 1934.

3 (a) E. A. H. Friedheim and L. Michaelis, *Jour. Biol. Chem.*, 91: 355, 1931; (b) B. Elema and A. C. Sanders, *Rec. Trav. Chim. Pays-Bas*, 50: 807, 1931.

4 L. Michaelis, E. S. Hill and M. P. Schubert, *Biochem. Zeits.*, 255: 66, 1932.

5 E. A. H. Friedheim, *Biochem. Zeits.*, 259: 257, 1933.

6 R. Kuhn and Th. Wagner-Jauregg, *Ber. Deutsch. Chem. Ges.*, 67: 361, 1934.

7 E. S. G. Barron and A. B. Hastings, *Jour. Biol. Chem.*, 105: vii, 1934.

THE EFFECT OF THALLIUM ON PLANT GROWTH

THALLIUM compounds have proven useful in the control of particularly intelligent rodents, such as the rat (*Rattus rattus rattus*), the Zuni prairie dog (*Citellus gunnisoni zuniensis*), and the California ground squirrel (*Citellus beecheyi beecheyi*). The normal occurrence of thallium in the vegetable kingdom has been reported and possibility suggested that plants may take up thallium from the soil.[1,2] Articles have appeared[3,4] suggesting, apparently without any experimental foundation, that "thallium sulfate has potential destructive effects on vegetation which have not received adequate attention from those advocating its use in vermin control," and predicting "enduring sterility of the soil." McMurtrey[5] suggests that thallium produces symptoms similar to "frenching disease" of tobacco and McCool[6] has conducted some

1 R. Böttger, *N. Jahrb. Chem.*, 21: 148, 1863.

2 J. C. Munch and J. Silver, "The Pharmacology of Thallium and Its Use in Rodent Control," *U. S. Dept. Agr. Tech. Bull.* 238, April, 1931.

3 S. C. Brooks, "Thallium Poisoning and Soil Fertility," SCIENCE, 75: 105–6, 1932.

4 M. W. Lyons, "Thallium Poisoning," SCIENCE, 75: 381–382, 1932.

5 J. E. McMurtrey, "Effect of Thallium on Growth of Tobacco Plants," SCIENCE, 76: 86, 1932.

6 M. M. McCool, "Effect of Thallium Sulphate on the

laboratory experiments indicating that thallium is toxic to seedlings. On the other hand, Crafts[7] studied the effects of thallium-treated grain under field conditions and concluded that "the possibility of losing agriculturally valuable land through sterilization seems remote."

Experiments were undertaken on a laboratory basis in Denver, Colorado, and on a field scale in Santa Clara County, California. Various amounts of thallium compounds were mixed with loam soil or were applied one or more times to seed beds or to experimental quadrats. The effect of thallium on the growth of vegetables and grasses was followed in the laboratory experiments and on general range vegetation in the field trials. These experiments were conducted over a period of two years. The results obtained in the laboratory and the field studies were harmony and showed that the addition of thallium compounds in amounts up to ten parts per million had no injurious effects, and in many instances appeared to stimulate plant growth. Larger amounts caused some injury, increasing with the quantity applied. Ground squirrels consume thallium-treated grain ("thalgrain") so rapidly that no damage was found o nareas treated nine times. Under the conditions used in the control of rodents by properly trained personnel, no evidence of injury to vegetative growth has been found.

In spite of the various criticisms raised against the use of thallium, these studies under practical conditions have failed to show any decrease in vegetative growth following the use of thalgrain. In fact, large numbers of ranchers have voluntarily advised the writers that the vegetative cover is increased from 10 to 25 per cent. following ground squirrel removal.

E. E. HORN
JUSTUS C. WARD
JAMES C. MUNCH
F. E. GARLOUGH

BUREAU OF BIOLOGICAL SURVEY
U. S. DEPARTMENT OF AGRICULTURE

ON THE DURATION OF SOME IMBIBITION PROCESSES

IN connection with investigations on the time factor in biological problems on penetration, I occasionally determined the length of time during which dry wood absorbs water.

A piece of spruce (*Picea*), 8 cm long, 6 cm broad and 9 mm thick, of a density of .49 (weight: 21.250 gm), cut with its length in the direction of the grain, was held in water, its two large surfaces being horizontal. The two transverse edges were covered with wax so that the liquid could not enter the vessels by their open end but was obliged to penetrate through their walls. To avoid stagnation the water was changed every 3 days.

To determine the rate of imbibition the piece was, at regular intervals, taken from the water, wiped with a towel and weighed. During the 30 to 45 seconds needed for that operation it was possible to observe a diminution of weight amounting to a few milligrams, due to evaporation. Immediately after the measurement the piece of wood was put again into the water. At first the measurements were intervalled at 5 minutes, then at hours, later at days and months.

The intake of water lasted more than 9 months, as is shown in the following table, and the amount of water imbibed was nearly five thirds the weight of the wood.

Time of immersion Min.	Imbibed water gm.	Time of immersion Days	Imbibed water gm.
		2¼	9.44
1	1.16	3¼	11.09
5	1.86	4¼	12.58
10	2.16	10¼	16.78
25	2.49	15	17.30
45	2.92	27	20.11
		43	23.36
Hours		59	24.25
		90	28.86
1¾	3.94	125	31.70
2¾	4.58	161	33.53
3¾	5.10	193	34.69
6¾	6.20	253	35.44
30	8.27	280	35.49

The time factor has been recognized within the last decades as an essential one in problems such as the ascent of sap, but it is probably still underestimated in many problems related to penetration.

BASILE J. LUYET

ST. LOUIS UNIVERSITY

BOOKS RECEIVED

BROWN, HARRY P. and ALEXIS J. PANSHIN. *Identification of the Commercial Timbers of the United States.* Pp. xxvi + 223. 60 plates. McGraw-Hill. $3.00.

CRUM, ROY W., Editor. *Proceedings of the Thirteenth Annual Meeting of the Highway Research Board.* Part I: *Reports of Research Committees and Papers.* Pp. 410. Illustrated. National Research Council.

KRECKER, FREDERICK H. *General Zoology.* Pp. xi + 634. 406 figures. Holt. $3.50.

TOLMAN, RICHARD C. *Relativity Thermodynamics and Cosmology.* Pp. xv + 502. Oxford University Press. $8.50.

Growth of Several Plants and on Nitrification in Soils," *Contrib. Boyce Thompson Inst.*, 5: 289–296, 1933.

[7] A. S. Crafts, "The Effects of Thallium Sulphate upon Soils," SCIENCE, 79: 62, 1934.