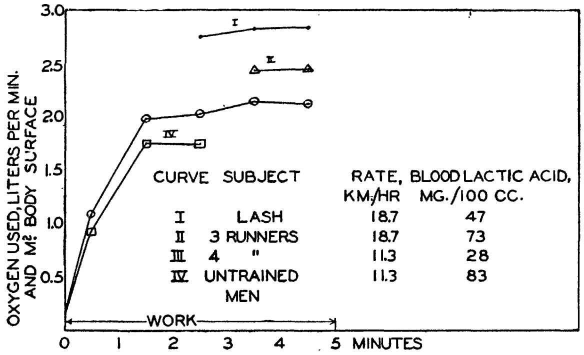

FIG. 1

mal levels of metabolism in all individuals except the runners. Skill is no doubt a factor in the easy adaptation of the runners, but since we did not measure oxygen debt we have no actual measurement of the total energy requirements of the men. When 3 of the runners ran for 5 minutes at 18.7 k.p.h., a task which brought lactic acid up to about the same level as that found in the other men in their maximal work, the runners in all cases elevated their oxygen intake even more, and in 2 of the cases probably reached their maximums. One of the most remarkable observations in the entire experiment was Lash's consumption of 4.96, 5.08 and 5.1 liters of oxygen successively in the last 3 minutes of this run and finishing with a blood lactic acid of only 47.5 mgm per cent. His highest R.Q. in this run was 0.99. In another experiment he reached an oxygen intake of 5.35 liters per minute in a run at 21.6 k.p.h. with no grade. This is approximately the same pace that he runs in his 2-mile race. If related to basal metabolism, this means that he elevated his metabolic rate to 21.4 times its basal level as compared to 14.5, the maximum of the best untrained man. This far exceeds previous records of a similar character, such as those of Henderson and Haggard[2] on Yale oarsmen, Christensen[3] on Danish cyclists and Hill[4] on Cornell runners. The high rate of oxygen intake which can be attained by these men is due largely to extremely high cardiac output, since their blood is normal in oxygen-carrying capacity.

The heart rates were recorded continuously throughout work and recovery by a cardiotachometer. The 5 runners performed the walk with an average pulse rate of 111 per minute, while the other men averaged 134. The average recovery is much quicker in the runners, dropping 34 beats to 77 in the first 30 seconds after stopping work, while at the same time in recovery the other group dropped 19 beats to 115. The next grade of work was hard enough to cause the untrained men to reach their maximum heart rates; they averaged 190, while the 4 runners who went through this run reached an average of 171. The hard work (not attempted by the untrained men) brought the blood lactic acid of the runners up to an average of 73 mgm per cent. and the average heart rate to 189, approximately the maximum of untrained man. The average heart rate for each group after the hardest work attempted is given in Fig. 2. Recovery took place at

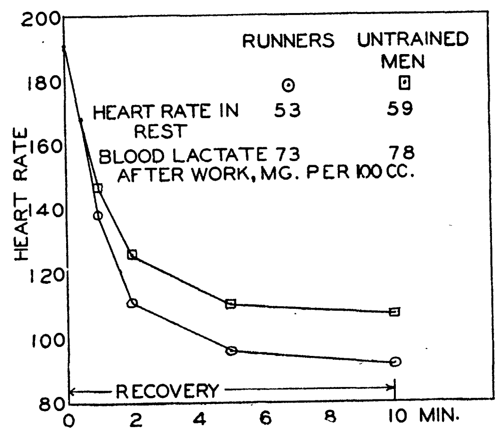

FIG. 2

the same rate in the first half-minute, after which the runners' pulse fell more rapidly.

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2 Y. Henderson and H. W. Haggard, *Am. Jour. Physiol.*, 72: 264, 1925.
3 E. H. Christensen, *Arbeitsphysiol.*, 5: 463, 1931.
4 A. V. Hill, "Muscular Movement in Man," McGraw-Hill, 1927.

THE DIFFERENTIATION OF PANCREATIC TRYPSINS ON THE BASIS OF THEIR SPECIFICITIES

PANCREATIC juice contains at least three enzymes (trypsin, chymotrypsin, heterotrypsin[1]) which are capable of degrading genuine proteins. Synthetic substrates have been obtained recently for each of these enzymes. Thus, chymotrypsin has been found to digest simple derivatives of tyrosine and phenylalanine such as carbobenzoxy-*l*-tyrosylglycine amide and carbobenzoxyglycyl-*l*-phenylalanylglycine amide.[1] The existence of heterotrypsin was discovered because of its ability to split benzoylglycyl-*l*-lysine amide. It has now been found that crystalline trypsin readily hydrolyzes α-benzoyl-*l*-arginine amide.

The accessibility of synthetic substrates, the structure of which may be modified almost at will, makes it possible to perform comparative studies of the specificities of the various trypsins. The following table indicates the wide differences in chemical speci-

1 M. Bergmann and J. S. Fruton, *Jour. Biol. Chem.*, April, 1937.

TABLE I
HYDROLYSIS OF SYNTHETIC SUBSTRATES BY PANCREATIC TRYPSINS

Substrate	Crystalline trypsin	Crystalline chymotrypsin	Hetero-trypsin
Benzoylarginine amide ...	+	−	
Carbobenzoxytyrosylglycine amide	−	+	
Benzoylglycyllysine amide.	−	−	+

ficity among crystalline trypsin (Northrop), crystalline chymotrypsin (Northrop) and heterotrypsin.

It may be mentioned that the substrates of trypsin and heterotrypsin both contain basic amino acid groups; nevertheless, this basicity is in itself not decisive for the specificity, since trypsin does not split the substrate of heterotrypsin. It has been reported[2] that chymotrypsin attacks the highly basic protamines which are extremely rich in arginine. This is of interest, since the artificial substrates of chymotrypsin do not contain a basic group and since chymotrypsin is unable to split either of the synthetic basic substrates of heterotrypsin and trypsin.

With the aid of the synthetic substrates exact estimations of each of the trypsins in the presence of each other become possible and their respective activities in various biological systems may be determined. Such an investigation of commercial pancreatin showed that this enzyme preparation splits benzoylglycyllysine amide much more rapidly than benzoylarginine amide. Therefore, pancreatin must contain a large amount of heterotrypsin and the activity of pancreatin toward genuine proteins must, to a large degree, be due to heterotrypsin.

The physiological rôle of the pancreatic trypsins is generally considered to be one of preparing the food proteins for a complete breakdown. If this be the only physiological function of the trypsins, it is difficult to understand why they exhibit such pronounced and narrowly limited specificities.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

IGNEOUS ROCK TEXTURE DEMONSTRATION FOR STUDENTS OF ELEMENTARY GEOLOGY

THE study of igneous rocks by students of elementary geology is greatly facilitated by laboratory demonstration of the various types of texture, namely granitic, felsitic, porphyritic and glassy.

To demonstrate those textures in which either macroscopic or microscopic crystals are present to give a grained appearance to the rock, it is first necessary to prepare a supersaturate solution of sodium thiosulfate ($Na_2S_2O_3 \cdot 5\ H_2O$) by heating 100 cc tap water to boiling, then dissolving 200 grams sodium thiosulfate in the boiling water. The test-tube and its contents are cooled to or below room temperature by placing the test-tube and contents in cold running water. The cooled sodium thiosulfate solution is supersaturated.

For the formation of a granitic texture, place approximately 20 cc supersaturated sodium thiosulfate solution in a test-tube and inoculate the solution with a small particle of foreign material to start the crystallization. Crystals begun by the introduction of foreign material form aggregates which in arrangement of the individual crystals have the same arrangement as the crystals observed in igneous rocks of a granitoid texture.

The fine, almost microscopic, size crystals characteristic of felsitic textures may be obtained by violently shaking a test-tube containing 20 cc supersaturated sodium thiosulfate solution. The agitation of the supersaturated solution causes the formation of large numbers of minute crystals which accumulate on the bottom of the container. The crystalline character is distinctly seen when the accumulation at the bottom of the container is examined with a hand lens.

Two distinct sizes of crystals may be obtained in a single test-tube by first inoculating 20 cc supersaturated solution of sodium thiosulfate with a particle of foreign material and allowing the crystal aggregate to become well developed. The container with the developing crystal aggregate should be violently agitated by shaking so as to cause the formation of minute crystals, which in falling to the bottom of the container mix with the larger crystals of the aggregate to form porphyritic texture.

Glassy texture, such as is represented in obsidian, can be demonstrated by placing a 250 cc beaker half filled with granulated sugar over a Bunsen burner and heating slowly. The heating must be slow enough that the sugar melts without burning. If the melted sugar is poured into a beaker of cold water or on a cold surface, the resulting rapid cooling will form glassy textured masses.

The procedures mentioned above are not in themselves new but merely represent an application of elementary chemical and physical principles in experiments that can be conducted as classroom demonstrations to aid the student of elementary geology in

[2] E. Waldschmidt-Leitz and S. Akabori, *Z. physiol. Chem.*, 228: 224, 1934.