phorus." Thus, when the muscle is allowed to stand outside the body, the "labile phosphorus" content progressively diminishes at a fairly rapid rate (it is entirely gone in less than twenty minutes), and at the same rate creatine is set free, as indicated by its failure to be thrown down by copper. If the trichloroacetic acid filtrate prepared from a sample of fresh muscle is kept (unneutralized) for several hours, the "labile phosphorus" has completely disappeared, and the copper precipitate is then virtually free from creatine. The same parallelism holds for muscle which has been stimulated, showing that the liberation of inorganic phosphate during stimulation is associated with the conversion of the creatine to a form in which copper will not precipitate it. Finally, in case the muscle has been stimulated with the blood supply cut off—a procedure which, as stated, leads to the loss of all the "labile phosphorus"—and then permitted to recover, the reappearance of "labile phosphorus" is accompanied by the return of an equivalent quantity of creatine to the condition in which precipitation by copper does take place. Direct evidence for the synthesis of a creatine-phosphoric acid compound during recovery is thereby attained.

Quite aside from its obvious bearing on the mechanism of muscular contraction, the demonstration of "phosphocreatine" in muscle should go far towards providing an explanation for a number of matters which in the past have been obscure. Among these may be mentioned the passage of administered creatine into muscle in spite of the large quantity already there, and the striking difference between resting (living) muscle on one hand and fatigued or dead muscle on the other in their capacity for retaining both creatine and phosphate, as shown by perfusion and dialysis experiments.

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ON THE UPPER LIMIT OF VIBRATIONAL FREQUENCY THAT CAN BE RECOGNIZED BY TOUCH

IN relation to experiments on the transmission of speech instrumentally to organs of touch in the skin and to end organs of the sense of vibration it is of more than ordinary interest to discover what is the upper limit of vibrational frequencies that can be felt through these senses.

Landlois (*Lehrbuch d. Physiol. d. Menschen,* 1880) states that vibrations of strings are recognizable at a frequency of 1552 a second. This is the highest figure that has been published hitherto.

Dr. V. O. Knudsen, of the Department of Physics of the University of California, reports in a paper that is about to be published that his subjects reached no higher than 1600 d.v. a second. The stimulus was furnished by an oscillator and was applied through a reed slapping near the tip of the subject's middle finger.

In my experiments the stimuli are the vowel qualities *e, er, oo, o, ah* and *aw,* spoken into a high-grade microphone. A modified 25 B (Western Electric) two tube amplifier is in circuit. An electrical filter has been introduced also, and a five unit receiver or teletactor. Each of these instruments has been made for my use by the Bell Telephone Laboratories. The filter analyzes the speech frequencies into five bands: 0–250; 250–500; 500–1000; 1000–2000 and 2000 plus vibrations a second. Each band is led into one unit in the receiver and into no other. In the course of the experiments that are reported here connections have been broken so as to eliminate all but the highest band of frequencies—2000 d.v. and above.

When the vowel qualities already mentioned are pronounced into the microphone the subject feels the fifth reed that remains connected through the filter when it is in vibration. The figures below indicate the degree of the subject's accuracy of detection. He reported "yes" when he felt a vibration; otherwise he was silent. The stimulus is received through the finger nail or through the skin—preferably the former.

Total impressions—75
C. Subj.; G. Exp.

e	total	19	Vibrations.	Felt	15
er	"	13	"	"	0
oo	"	12	"	"	1
o	"	8	"	"	0
ah	"	10	"	"	3
aw	"	13	"	"	6
		75			25

O. Subj.; G. Exp.
Total impressions—74

e	total	18[1]	Vibrations.	Felt	18
er	"	13	"	"	7
oo	"	12	"	"	12
o	"	8	"	"	2
ah	"	10	"	"	3
aw	"	13	"	"	11
		74			53

The subjects in this test are both deaf. They can not hear speech. The experimenter, while the test

[1] Missed one *e*; finger off receiver.

was going on, was thirty-five feet from the subjects, behind two closed doors and standing upon a pile of papers and magazines to damp vibrations that may otherwise be assumed to reach the subject through the floor from the experimenter's body.

When connection was broken between the microphone and the receiver and the experimenter continued to pronounce as usual the subjects gave no sign of knowledge that anything was going on.

What the subjects felt may have been far above a frequency of 2000 a second. It was at least as high as that. High frequencies in the male voice run up as follows: *e,* 2987; *oo,* 3700; *er,* 3050; *o,* 3475; *ah,* 3683; *aw,* 3612, (Crandall, Sounds of Speech; *The Bell System Technical Journal,* IV, 4). In fact these figures are *next* above 1965 in Crandall's table. It is highly probable that our subjects are sensing vibrations that occur with a frequency approximating 3000 a second.

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POSSIBLE SOURCES OF SOME BOULDERS IN THE GLACIAL DRIFT OF MISSOURI

THE writer realizes that it is not an entirely safe procedure to identify a rock specimen, found in glacial drift, as having come from a certain locality, by comparing the megascopic characteristics of the specimen with the recorded descriptions of rocks from various localities. With a full realization of this uncertainty, the writer has endeavored to locate the original sources of some of the glacial boulders in the vicinity of Columbia, Missouri.

A large variety of rocks has been identified in the glacial drift in the vicinity of Columbia. These rocks include granites of various colors and varying coarseness of texture, dolerites, hornblendites, basalts, gneisses, both hornblende and mica schists, anorthosites, quartzites of various colors, conglomerates and a quartzose-looking rock. For most of these rocks, the writer has been unable to locate successfully their original sources. The last four rocks above mentioned are the ones about which the writer wishes to make a few remarks.

Anorthosite is not a common rock, being known to occur in relatively few places in North America. It is known to occur in the following localities: Adirondack Mountains, in Wyoming, several places in Canada, such as in the region of the headwaters of the Saguenay River, and north of Montreal, in the Lake Superior region in localities as Carlton Peak, Shingle Cove and other places. The writer believes that the anorthosite found in the glacial drift in the area under consideration came from the anorthosite localities along the west shore of Lake Superior. This is the only probable locality from which the anorthosite could have come.

The quartzites in the drift are largely the Sioux quartzite, which is the hard, red quartzite found in Minnesota, Iowa and South Dakota.

The conglomerate, which is of much interest locally, is a jasper conglomerate. The jasper pebbles are the red-banded and black-banded varieties. These pebbles, along with quartz pebbles, are firmly cemented with a siliceous cement. The conglomerate closely resembles a portion of the Ogishke conglomerate, of Huronian age, found in the Vermilion Range of Minnesota.

The "quartzose-looking" rock is a dark red, fine-grained rock containing sandy granules of red jasper. Grout,[1] to whom a sample was sent, says of it, in part—"I have never seen (it) in place anywhere except on the Mesabi range, as a part of the iron-bearing formation." It agrees with the description of the ferruginous chert which makes up a part of the iron-bearing formation in the Mesabi range.

The direction of movement of these rocks, if their original localities as stated be granted, was therefore from the north directly to the south, in almost a north-south line. The post-glacial movement, due to running water, is believed to be slight.

In the vicinity of Marysville, Nodaway County, Mo., and at Green City, Sullivan County, Mo., there have been found several pieces of native copper in the glacial till,[2] the age of the till being unknown to the writer. According to W. A. Tarr, one of the pieces of copper weighed about twelve pounds. The only logical locality from whence this copper could have come is the copper country of Upper Michigan.

Upham[3] states, "In Lucas County, of southern Iowa, a mass of drift copper weighing more than thirty pounds undoubtedly was borne by the currents of the ice-sheet about six hundred miles, from the present copper-mining region south of Lake Superior or from Isle Royal, first southwestward and later southward through eastern and southern Minnesota, passing west of the Wisconsin driftless area. Its journey probably was accomplished mostly during Nebraskan time."

The writer believes that the copper found in the northwestern part of Missouri was carried by the same currents of the ice-sheet that carried the copper to southern Iowa.

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[1] Personal communication with Dr. F. F. Grout.

[2] Personal communication with Dr. W. A. Tarr.

[3] Upham, W. "Stages of the Ice Age." Bull. G. S. A., Vol. 33, 1922, p. 501.