13. A. Rich, *Proc. Natl. Acad. Sci. U.S.* 38, 187 (1952).
14. H. M. Ranney, *J. Clin. Invest.* 33, 1634 (1954); H. Lehmann, personal communication.
15. J. V. Neel, *Blood* 6, 389 (1951).
16. ———, *Genetics* 32, 38 (1947).
17. E. Silvestroni and I. Bianco, *Blood* 7, 429 (1952).
18. K. Singer *et al., ibid.* 9, 1047 (1954).
19. In deciding on this notation, I have had the benefit of discussions with E. B. Ford and H. A. Itano. Other comments and suggestions would be welcomed.

3 June 1955

Natural Redistributon of a Quahog Population

It has been characteristic of intertidal quahog (*Venus mercenaria*) sets in Maine that they are of commercial importance only at infrequent intervals and that survivors that reach market size are generally poorly distributed over the available flats. Approximately 95 percent of the fishery is intertidal, and whenever there are sets of commercial importance —as there were in 1938, 1939, 1947, and 1952—they usually occur in limited areas and in very dense concentrations. Although mortality rates are high and invariably exceed 90 percent by the end of the second season, it has been assumed by shellfish biologists working in Maine that the concentrations—sometimes as high as 25,000 quahogs per square foot—take place shortly after setting, probably as the result of involuntary redistribution (*1*).

The actual process of redistribution has not been observed, nor, heretofore, has its extent been measured. Since concentrations made up of individuals as small, on the average, as 3 mm in diameter have been observed, it has also been assumed that redistribution takes place only among the smaller sizes and does not occur on an involuntary basis among adults.

In November 1949 the residue of two widely separated concentrations from the 1947 year-class was discovered in Maquoit Bay, Maine. Because it has been customary during the past decade to transplant overcrowded quahogs to adjacent barren flats to resupply the commercial fishery, salvage operations were carried on from May to December 1950, using quahogs from the more unfavorably located of these two concentrations.

Similar operations for the other area had to be postponed until the spring of 1951. It was decided, in the meantime, to use this remaining concentration as a study area, to survey its geographic limits, to estimate its population and the volume of that population, to measure winter survival, and to make other related observations and determinations during the cold-weather period.

A plane table survey using a telescopic alidade was made during daylight low-water on 17 and 18 Oct. 1950. A flat ledge outcrop within the concentration served as an excellent station for setting up the instrument. The purpose of using a plane table (*2*) for the survey was to insure a high order of accuracy in determining the limits of the occupied area (a reconnaissance of this concentration had indicated that it was surrounded by barren flats several hundred feet in width) and to locate as accurately as possible the sample plots that had been selected for measurement of density and size distribution.

Horizontal stadia to 11 critical points on the perimeter of the concentration were measured. These points were selected wherever a marked change in direction occurred. The remainder of the perimeter was interpolated between these established points. Within the perimeter, 35 sampling stations were surveyed and plotted. The lateral error did not exceed 0.1 ft, and it was estimated that horizontal error, since the longest stadia measurement was only 478 ft, did not exceed 1.0 ft. The population density of the concentration averaged 79.5 per square foot, with a size range from 27 to 56 mm and a median diameter of 43 mm. After the survey had been completed, the area of the concentration was determined by planimeter to be 3.28 acres, more or less.

The concentration remained under periodic observation during the winter and, following the discovery of mass mortalities that took place between 24 Dec. 1950 and 4 Feb. 1951—apparently as the result of gales that removed the sediment (*3*) cover and that were followed by alternate freezing and thawing air temperatures, during low-tide periods—a resurvey to assess the damage was made (*4*). Reconnaissance of the concentration before resurvey indicated considerable displacement and dispersal of the population during the winter. This observation was confirmed by the resurvey made on 29 Mar. and 20 Apr. 1951 in which the procedure of the initial survey was duplicated, except that the sampling fraction was increased from 1/4080 to 1/2895 for greater accuracy.

The redistribution of the population, in general, followed the expected pattern. The storms that had the highest wind velocities, one of a recorded 76 mi/hr, were from the southeast, and the greatest displacement was toward the northwest for a maximum distance of 387 feet, although some redistribution had taken place all around the old perimeter of the concentration, except at the southwestern end. In a small tip at the southwestern end, which had previously had an average density of 23 per square foot, the quahogs had been completely displaced. On the other hand, one previously barren area, the center of which was 182 ft northwest of the old perimeter, had acquired a living population density of 36 per square foot.

The plane table and alidade provided precise means for defining the limits of the geographic redistribution, and sampling within the area supplied detailed information on the extent of this redistribution. Since all sample plots had been surveyed, it was possible to compare changes in population density within a relatively small subarea before and after redistribution.

One 10,300-ft^2 subarea with its long axis running north and south had in October contained an average population of 116 per square foot, but by spring it had been further subdivided into smaller subareas having average densities from north to south of 19, 40, 21, and 40 per square foot.

The most densely occupied portion of the concentration in October had been one of 38,800 ft^2 that contained an average population of 125 per square foot. By the time of the resurvey, this average had been reduced to 40 per square foot, and in some sections to concentrations as low as 23 per square foot. Even the most densely populated section, one of less than 1000 ft^2, had a population of only 63 per square foot.

Several small colony-like concentrations of 30, 36, and 65 per square foot were discovered during the resurvey northwest of the old perimeter in flats that had been barren the preceding October. These colonies occupied areas from slightly more than 2000 ft^2 to nearly 17,000 ft^2.

Although the concentration at the time of the initial survey occupied an area of 3.28 acres, more or less, the surviving redistributed population, which had been reduced 40.3 percent by winter mortalities, occupied an area of 6.81 acres, more or less, and the physical center of the redistributed population had been displaced northwesterly an average distance of 100 ft. While the resurvey accounted for all animals, living and dead, that had occupied the area at the time of the initial survey, the density per square foot of 79.5 in October had been changed to an average combined living and dead density of 41.7 by the time of the resurvey.

Robert L. Dow
Dana E. Wallace
Maine Department of Sea and Shore Fisheries, Augusta

References

1. J. M. Moulton and G. W. Coffin, "Distribution of *Venus* larvae in Orr's Cove plankton over the tide cycle and during the summer and early fall of 1953," Research Bull. No. 17, Maine Dept. Sea and Shore Fisheries (1954).
2. K. F. Mather and B. Washburn, "Telescopic alidade and the plane table as used in topographic and geologic surveys," *Sci. Labs., Denison Univ. Bull.* 33, 1 (1938).

3. J. M. Trefethen, *Geology for Engineers* (Van Nostrand, New York, 1949), pp. 68–69.
4. R. L. Dow and D. E. Wallace, "Method of reducing winter mortalities of quahogs (*Venus mercenaria*) in Maine waters," Research Bull. No. 4, Maine Dept. Sea and Shore Fisheries (1951).

9 June 1955

Reaction Rates of a Muscle Model with Nucleotides

We have previously reported (*1*) that UTP (uridine triphosphate) might replace ATP (adenosine triphosphate), mole for mole, in eliciting the contractile response that is characteristic of the glycerol-extracted muscle fiber model. The present report (*2*) is an extension of this work to include an analysis of the rates of response of the model to ATP, UTP, and CTP (cytidine triphosphate). In addition, some indirect evidence is exhibited to support the hypothesis that the reaction of these nucleotides with the contractile protein may be a direct one that need not be mediated by a high-energy phosphate group transfer system such as the nucleoside diphosphokinase system identified by Krebs and Hems (*3*) and recently purified by Berg and Joklik (*4*).

The methods were essentially the same as those used in earlier experiments (*5*). Dog or rabbit psoas muscle fiber bundles were extracted at rest length in $2.9M$ glycerol at $-15°C$. A fiber bundle of about 0.1-mm² cross-sectional area was isolated and divided to provide a pair of shorter duplicate preparations, one of which was induced to contract with ATP, and the other of which was contracted in the presence of either CTP or UTP (*6*). The medium in which contraction was induced was phosphate-buffered $5 \times 10^{-2}M$ KCl containing $5 \times 10^{-3}M$ $MgCl_2$, at *p*H 7.8 and ionic strength 0.11 at 25°C. Nucleotides, as sodium salts, were added to the system to make their concentrations 4, 6, or $8 \times 10^{-4}M$. The latter value approximates the minimum amount of nucleotide necessary to induce maximal contraction (*5*). The tension developed by the model in the first minute following nucleotide addition was used as the criterion of the rate of the contractile response.

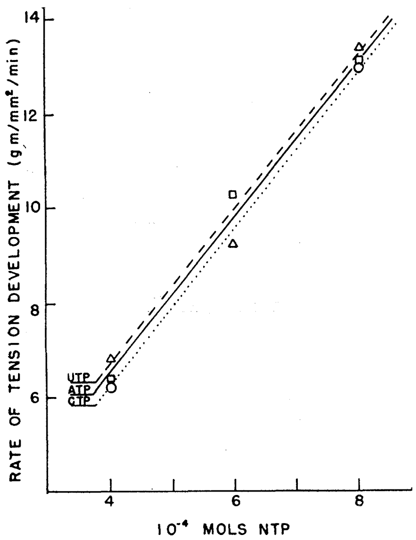

Fig. 1. Rate of tension development of the muscle model system when either ATP, CTP, or UTP was used as the stimulating nucleotide. Each point is the mean response of three or more fiber preparations. ATP, △——△; CTP, ○·····○; UTP, □-----□. The abbreviation NTP stands for any one of the three nucleotides tested.

The rates of tension development in a rabbit psoas model system are shown in Fig. 1. As nucleotide concentrations were increased toward the value necessary for maximal contraction, the rate of contraction increased linearly. It would appear that there was no significant difference in the model responses to either ATP, CTP, or UTP. Through accident the data for CTP at $6 \times 10^{-4}M$ were useless. Limited amounts of this material prevented complete repetition of the experiment, but a second comparison at this concentration alone showed no significant difference in the rates of tension development when either ATP, CTP, or UTP was used to stimulate contraction of the model system.

It is of interest that preliminary experiments employing guanosine triphosphate or adenosine tetraphosphate (*7*) as the nucleotide in this model system showed greatly reduced rates of tension development when they were compared with ATP-stimulated responses. Confirmation of these observations would indicate that a certain degree of specificity exists in the nucleotide-actomyosin reaction that might be related to nucleotide structure.

In order to elucidate further the similarities of the reaction of these nucleotides with the contractile proteins, the rates of tension development were diminished by employing several nonspecific inhibitors of the contractile response. Table 1 shows the similarity in degree of inhibition of the ATP or UTP response achieved by (i) aging the fibers 21 days at $-15°C$; (ii) partial sulfhydryl-group blockade with *p*-chloromercuribenzoate; and (iii) two intensities of trypsin digestion. These data have been interpreted as indicating that even when some essential sulfhydryl groups were blocked or when partial denaturation was achieved either by aging or by digestion, no significant differentiation in the model response to these two nucleotides was effected.

Table 1. Nonspecific inhibition of the model response to ATP or UTP addition. (Dog psoas fibers extracted for 7 days were treated with each inhibitor and the rates of contraction of duplicate fibers were measured when either $10^{-3}M$ ATP or $10^{-3}M$ UTP was used to stimulate tension development)

Treatment	Percentage inhibition	
	ATP	UTP
Fibers aged 21 days at $-15°C$	58	62
p-Chloromercuribenzoate ($10^{-4}M$)	46	59
Tryptic digestion (trypsin concentrate, 2μg/ml, 5 min at 25°C)	34	50
Tryptic digestion (trypsin concentrate, 2μg/ml, 10 min at 25°C)	73	72

In certain energy-transfer systems (*4*), only one of the purine or pyrimidine nucleotides reacts directly with its acceptor substance. We must conclude from the present evidence, however, that for the muscle model system utilized in this investigation, three constituents of the "nucleotide pool," ATP, CTP, and UTP, may be equally available for direct and independent reaction with actomyosin to effect the molecular rearrangement that is the essence of muscular contraction.

R. E. Ranney*
Department of Physiology, University of Colorado School of Medicine, Denver

References and Notes

1. R. E. Ranney, *Am. J. Physiol.* 178, 517 (1954).
2. Supported in part by research grants H1821 and H1218C2 from the U.S. Public Health Service.
3. H. A. Krebs and R. Hems, *Biochim. et Biophys. Acta* 12, 172 (1953).
4. P. Berg and W. K. Joklik, *J. Biol. Chem.* 210, 657 (1954).
5. R. E. Ranney, *Am. J. Physiol.* 179, 99 (1954).
6. Cytidine triphosphate was generously provided by the Pabst Laboratories, Milwaukee, Wis., through the kindness of S. H. Lipton. Adenosine and uridine triphosphates were purchased from the same concern.
7. These nucleotides were obtained from Sigma Chemical Co., St. Louis, Mo.
* Present address: G. D. Searle and Co., P.O. Box 5110, Chicago 80, Ill.

7 June 1955

North-South Asymmetry of the Pleistocene Ice Sheet

Geologists have long considered the great continental ice sheets of Pleistocene time to have been more or less symmetrical. An examination of the meteorology involved, however, does not lead to such a conclusion.

The cold winds that sweep across the Northern Hemisphere land masses may be described as polar air moving south-