

adjacent profiles indicate that the interpretation given is reliable. Full utilization of the reflection data will probably increase the precision of the interpretations somewhat. Table 1 shows the pertinent data for eight similar crustal sections that were obtained during the cruise. [See (2) for parts of the geologic column not of primary interest here and for details of the analysis techniques and results.]

As indicated in Table 1, mantle refractions were clearly obtained with the air gun source. A few arrivals were verified by the use of explosives and conventional records (1, 2).

The somewhat irregular nature of the refraction arrival line suggests that the interface either is irregular or consists of a thin zone of subordinate interfaces rather than a sharply defined plane.

The observations were taken along a thousand-kilometer-long line running roughly northeast from near the Marshall Islands to southwest of the Hawaiian Islands in water depths averaging over 5 km (2). The extent and deep-ocean environment of these observations suggest that the 6.9 to 7.6 km/sec (average, 7.3 km/sec) crustal layer may be fairly widespread throughout the south-central Pacific Ocean. Although similar velocity values have been reported from such oceanic environments as the Caribbean Sea (3) and, in the Pacific Ocean, the Shatsky Rise (4) and the Hawaiian Arch and Deep (5), the layer has not been a generally accepted feature of classical deep-ocean basin structure. For example, Ewing, Raitt, and Shor and Raitt (6) in their reviews of the literature indicate that the deepest oceanic crustal layer has a characteristic velocity of around 6.8 km/sec in the great majority of cases.

If the 7.3 km/sec layer is widely present, as our measurements suggest (7), the implications are several, such as: (i) a widespread change in composition or a polymorphic transition at this interface; (ii) a higher than heretofore accepted mean density of the earth's crust affecting depths determined from gravity anomalies and perhaps density distributions consistent with the moment of inertia; (iii) an effect on the dispersion of seismic surface waves requiring a reconsideration of current interpretations.

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References and Notes

1. This layer was first reported by G. H. Sutton, G. L. Maynard, D. M. Hussong, in paper 15, presented at the April 1969 annual meeting of the Seismological Society of America, St. Louis, Mo. (April 1969); it was discussed further by G. L. Maynard, G. H. Sutton, D. M. Hussong, in paper O132, presented at the annual meeting of the American Geophysical Union, Washington, D.C. (April 1969) [see also *Trans. Amer. Geophys. Union* 50, 206 (1969)].
2. G. L. Maynard, G. H. Sutton, D. M. Hussong, two papers in preparation.
3. C. B. Officer, J. I. Ewing, J. F. Hennion, D. G. Harkrider, D. E. Miller, *Phys. Chem. Earth* 3, 17 (1959); H. W. Menard, *J. Geophys. Res.* 72, 3061 (1967); J. I. Ewing, J. Antoine, M. Ewing, *J. Geophys. Res.* 65, 4087 (1960). A layer with refraction velocity of 7.0 to 7.5 km/sec is a well-known feature of the "mid-ocean" ridges, certain oceanic margin areas, and some trenches and their associated ridges. See, for example, B. C. Heezen and M. Ewing, in *The Sea*, M. N. Hill, Ed. (Interscience, New York, 1963), vol. 3, p. 388; X. Le Pichon, R. E. Houtz, C. L. Drake, J. E. Nafe, *J. Geophys. Res.* 70, 319 (1965); M. Talwani, G. H. Sutton, J. W. Worzel, *ibid.* 64, 1545 (1959); R. E. Houtz and J. I. Ewing, *Bull. Seismol. Soc. Amer.* 54, 867 (1964); E. T. Bunce, D. A. Fahliquist, J. W. Clough, *J. Geophys. Res.* 74, 3082 (1969).
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7. More recent work reveals that the 7.5 km/sec layer is not confined to the area considered here: D. M. Hussong (personal communication) finds the layer in the deep ocean north of Hawaii. D. M. Hussong, A. A. Nowroozi, M. E. Odegard, and G. H. Sutton reported the layer 180 km west of San Francisco in paper S16, presented at the fall meeting of the American Geophysical Union, San Francisco (December 1969) [see also *Trans. Amer. Geophys. Union* 50, 644 (1969)].
8. This work was supported by the National Science Foundation under grant GA 1639 and by the Office of Naval Research under contract Nonr 3748(05). Hawaii Institute of Geophysics Contribution No. 317.

11 December 1969

Bradykinin Inhibition by Butylated Hydroxyanisole

Abstract. Concentrations of butylated hydroxyanisole as low as 8×10^{-9} mole per liter can inhibit detectably the contraction of smooth muscle elicited by bradykinin. The mechanism of the inhibitory effect of this food grade anti-oxidant is apparently complex, and the effect is only partially reversible.

Bradykinin's contractive action on smooth muscle is inhibited by agents generally classed as tranquilizers (1). We now report similar inhibition of bradykinin activity by butylated hydroxyanisole (BHA), an antioxidant widely used for the preservation of foods containing unsaturated lipids.

Assays of this inhibitory effect were made with a 2- to 3-cm section of the terminal segment of a guinea pig ileum suspended in a 5-ml capacity perfusion bath held at 37°C. Changes in length of the ileum were recorded with a standard kymograph. The gut was equilibrated against Tyrode's buffer containing 2 mg of atropine and 40 μ g of pyribenzamine per liter by flowing the solution through the cell at a rate of 15 ml per minute for 1 hour before use.

After equilibration the flow of Tyrode's buffer through the cell was suspended, and a 0.2-ml portion of test solution containing pure bradykinin and the antioxidant were injected into the cell. Test solutions were made from stock solutions of butylated hydroxyanisole (Nutritional Biochemicals) dissolved in water and synthetic bradykinin (BRS 640, Sandoz) dissolved in

Tyrode's buffer. After exposure for 30 seconds to a test solution, the mixture was flushed from the cell, and the entire procedure was repeated with another kinin mixture. The response of the gut to a solution containing only pure kinin was used throughout the analyses as a control. The height of the peak traced on the kymograph chart when the gut was in contact with the kinin-containing solution was taken as

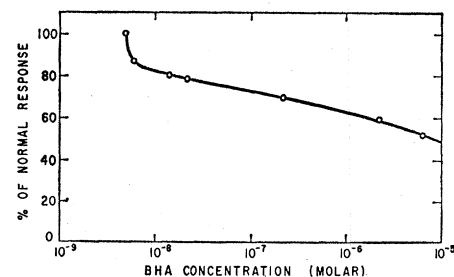


Fig. 1. Suppression of ileum response to test solutions of bradykinin containing increasing amounts of BHA. Gut was freed of reaction mixtures by flushing Tyrode's buffer through the cell at a rate of 15 ml/min for 10 minutes between each point determination. The raw data were corrected for irreversible decreases in gut sensitivity due to exposure to BHA.

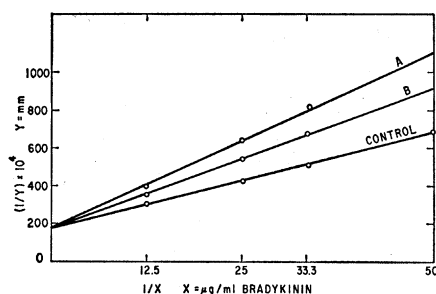


Fig. 2. Drug dose (x)-response (y) plot characterizing suppression of contractile response of smooth muscle (guinea pig ileum) by BHA. Control samples contain no antioxidant. Points on line A were obtained with 7.2×10^{-9} g of BHA per milliliter in test solution, and points on line B were obtained with 3.6×10^{-9} g of BHA per milliliter. All points represent data corrected for loss in gut sensitivity to bradykinin due to exposure to BHA.

being directly proportional to the amount of smooth muscle contraction elicited by bradykinin. Reduction in peak height by added antioxidant was taken as a measure of its inhibitory action.

With this procedure, it was found that the threshold concentration at which BHA began to suppress the ileum's response to $0.04 \mu\text{g}$ of bradykinin per milliliter in the reaction bath was $8 \times 10^{-9}M$. Increasing concentrations of antioxidant depressed gut response (Fig. 1).

Supposedly the mechanism of this inhibition can be ascertained from a standard study of the relation of drug to dose response as described by Roche e Silva (2). Here the reciprocals of effects ($1/Y$), where Y is peak height in millimeters, as measured on the kymograph chart are plotted against the reciprocals of the doses ($1/X$), where X is equal to the concentration of bradykinin in the reaction chamber. Our data in this form are presented in Fig. 2. From the relatively straight line plots and the common intercept shown in Fig. 2 it can be inferred (2) that BHA acts as a competitive inhibitor of bradykinin. Likewise, from the second plot, the relative inhibitor strength of BHA can be derived (2) as its inhibitory potency (pK_i). The value ascertained by this procedure, $pK_i = 7.9$ g/ml, indicates that BHA is a relatively strong inhibitor.

The validity of this relation may be questioned since the inhibitory action of BHA is not completely reversible. After four 30-second exposures to solutions containing $1 \times 10^{-6}M$ BHA stock solution, only 92 percent of normal brady-

kinin response could be recovered by flushing with buffer for 15 minutes. The reason for this loss in sensitivity has not been established. It probably involves very strong or irreversible binding of the antioxidant on some bradykinin receptor sites since the smooth muscle contracts normally in response to $0.40 \mu\text{g}$ of histamine per milliliter in the presence of $10^{-5}M$ concentrations of BHA in the reaction bath. Regardless, our data demonstrate that relatively low concentrations of BHA can inhibit the contractile action of bradykinin on smooth muscle. The higher BHA concentrations used in these experiments approach the concentrations of BHA permitted in foods under present Food and Drug Administration regulations. The significance of this finding in regard to the widespread use of this antioxidant in food manufacture remains to be established.

The possibility that an impurity in the commercial BHA sample used in our study could have given rise to the described results has been considered.

Catch Property in Single Mammalian Motor Units

Abstract. *The tension output of single motor units in the cat triceps surae muscle was studied during patterned stimulation of the innervating motoneurons. With repetitive stimulation within a rather narrow frequency range, the tension output of slow-twitch (type S) motor units may be quite sensitive to the pattern of stimulus intervals in the train. The presence of only one stimulus interval that is much shorter than the others in the train can cause marked, long-lasting tension enhancement, provided that the stimulus repetition rate in the basic train is within certain limits.*

A motor unit in skeletal muscle consists of a neural component, a motoneuron with cell body in the spinal cord and axon in a particular muscle nerve, and a muscle component, the bundle of muscle fibers innervated by that motoneuron (1). Motor units may be regarded as the indivisible functional elements of skeletal muscle action. Much work on the production and maintenance of muscle tension has involved whole muscle, with all motor units activated simultaneously (2). However, such simultaneous activation is rare in normal movement; usually, muscle tension is produced by motor units acting asynchronously and independently (3). Moreover, motor units in a given muscle may differ from one another in contractile properties (4). For these reasons, we have recently begun a study of the production and maintenance of tension by single motor units in the

Standard gas-liquid chromatographic analysis of the antioxidant used showed it to be essentially 7 percent 2-BHA and 93 percent 3-BHA. Only two volatile contaminants in trace quantities could be found on the chromatogram. A sample of BHA further purified by sublimation also has the same inhibitory power as the commercial sample. Furthermore, we have some data that indicate other phenolic antioxidants similarly inhibit the response of smooth muscle to bradykinin.

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20 November 1969; revised 12 January 1970 ■

cat triceps surae muscle. In the course of this work we have observed a phenomenon similar to what has been termed the "catch property" of certain invertebrate muscles (5).

When a single motoneuron can be stimulated in isolation, the mechanical response produced in a muscle by one active motor unit can be studied (4). In these experiments adult cats, anesthetized with pentobarbital, were maintained with normal blood pressure and body temperature. The tendons of the three heads of the triceps surae muscle, medial gastrocnemius (MG), lateral gastrocnemius (LG), and soleus (SOL), were separated from one another and arranged for independent connection to a strain gauge myograph through a stiff link. The hind limb was rigidly fixed to a frame with drills through the femur and ankle. The strain gauge, mounted on a rack and pinion that permitted