Studies on the Mechanism of the Stimulation of Polymerase II-catalyzed RNA Synthesis by Mercury Compounds*

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The specific stimulation of α-amainit-sensitive RNA synthesis in isolated nuclei by methyl mercury (Frenkel, G. D., and Randles, K. (1982) J. Biol. Chem. 257, 6275–6279) has been further investigated. Using the method of alkaline hydrolysis/uridine analysis to determine the number of RNA chains growing in vitro, it was found that the stimulation could not be accounted for by an increase in the number of growing chains. The stimulatory effect of heparin (Coupar, B. E. H., and Chesterton, C. J. (1977) Eur. J. Biochem. 79, 525–533), was found to be additive with that of methyl mercury at saturating concentrations of the latter. Various detergents were found to affect RNA synthesis per se and to modify the stimulatory effect of methyl mercury, suggesting that the stimulation by methyl mercury requires a degree of structural integrity of some nuclear components. The ability of a number of other mercury compounds to stimulate RNA synthesis was investigated. None of the inorganic compounds examined, i.e. HgCl₂, HgSO₄, and Hg(ClO₄)₂, stimulated synthesis. Among the alkyl organic compounds tested in addition to methyl mercury, ethyl mercury also stimulated RNA synthesis, but dimethylmercury did not. Among the aryl compounds tested, phenylmercury did not stimulate synthesis whereas p-hydroxymercuribenzenzoate and p-hydroxymercuribenzenesulfonate did.

N-Ethylmaleimide, a nonmercurous sulphydryl reagent, was found to have only weak ability to stimulate RNA synthesis, compared to a comparable mercury-containing sulphydryl reagent, p-hydroxymercuribenzoate. The stimulatory effect of the latter was, however, effectively competed out by the former, indicating that sulphydryl binding is necessary for the stimulation but not sufficient. This conclusion was reinforced by experiments which utilized a model system to measure the ability of various mercury compounds to compete with N-ethylmaleimide in binding to cytoeine. The results showed that even compounds such as phenylmercury and the inorganic mercurials, which are unable to stimulate RNA synthesis, are able to bind to a sulphydryl group.

Because of the importance of mercury compounds as toxic environmental pollutants (1–3), there has been a great deal of interest in the nature and mechanisms of the biological effects which these chemicals produce (3–4). One area which is of particular interest is the potential of these compounds for producing genetic effects. This question has been approached by direct assessment of their ability to cause chromosomal alterations (5–10) and cellular mutations (11–14), as well as by studies on their effects on nucleic acid structure and metabolism (15–22).

During the course of experiments on the effect of MeHg⁺ on DNA and RNA synthesis in vitro in isolated nuclei, we observed that this compound causes a specific stimulation of the rate of α-amainit-sensitive RNA synthesis (i.e. catalyzed by RNA polymerase II) (23). In contrast, RNA synthesis which is catalyzed by polymerases I and III was inhibited by MeHg. Since under normal circumstances initiation of new chains does not occur in isolated nuclei (24), we felt that most probably the stimulatory effect of MeHg is on chain elongation. However, significant stimulation of elongation by MeHg, such as occurs in isolated nuclei, does not occur with purified polymerase II (23). It thus appeared likely that the stimulation phenomenon was related to some feature(s) of elongation which exist(s) during synthesis in isolated nuclei but not during synthesis with the purified enzyme. For this reason, it was of interest to examine the stimulation phenomenon in nuclei more closely, from the point of view of its relevance to an understanding of the biological effects of mercury compounds as well as a possible probe of the process of chain elongation during transcription.

This paper describes some of the studies which have been carried out to this end. While no definitive description of the details of the mechanism of this phenomenon can yet be given, these studies have provided some insight into the nature and requirements for this unusual and interesting effect of mercury compounds.

MATERIALS AND METHODS

Chemicals—All mercury compounds were obtained from Alfa, except for pHMB which was purchased from Calbiochem, and pHMBS which was purchased from Sigma. Stock solutions of phenylmercuric acetate, ethynylmercuric chloride, methymercuric chloride, and diethymercury were prepared in ethanol and diluted in H₂O such that the final concentration of ethanol in any reaction was never greater than 1%. This concentration of ethanol was found to have no effect on RNA synthesis in nuclei. Stock solutions of HgSO₄ and Hg(ClO₄)₂ were prepared in 0.1 N HCl, and of pHMB in 0.05 N NaOH, and diluted in H₂O such that the final concentration of HCl or NaOH in the reactions was negligible.

Unlabeled nucleoside triphosphates were purchased from P-L Biochemicals, and radioactive compounds from New England Nuclear. N-Ethylmaleimide was obtained from Calbiochem. Heparin, actinomycin D, sodium deoxycholate, Triton X-100, and α-amainiti were

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The abbreviations used are: MeHg, methyl mercury; pHMB, p-hydroxymercuribenzoate; pHMBS, p-hydroxymercuribenzenesulfonate; NEM, N-ethylmaleimide; CTAB, cetyltrimethylammonium bromide.
purchased from Sigma. CTAB was obtained from Mann Research Labs.

Cells—HeLa cells were grown in monolayer cultures in Dulbecco's modified Eagle's medium (Gibco) containing 10% heat-inactivated fetal calf serum, or in suspension cultures in Joklik's minimal essential medium (Gibco) containing 5% horse serum.

RNA Synthesis in Isolated Nuclei—Nuclei were isolated and the RNA synthesis reaction carried out as described previously (23). RNA polymerase II-catalyzed synthesis was determined as the difference between synthesis in the absence and presence of α-amanitin at a final concentration of 0.5 μg/ml.

Effect of Growing RNA Chains—The number of RNA chains being synthesized was determined by the UMP/uridine analysis method described by Barry and Gorski (25) utilizing some of the modifications described by Coupar et al. (26), as well as some additional changes. The reactions were carried out on a scale 10-fold higher than the usual reaction (i.e., 2.0 ml) but with all components including [3H]UTP present at usual concentrations (29). The reactions were terminated by the addition of 4 ml of 0.66 M perchloric acid containing 22 mM sodium pyrophosphate. The precipitated RNA was collected by centrifugation for 10 min at 10,000 × g. The precipitate was washed 4 times with 0.55 M perchloric acid containing 18 mM sodium pyrophosphate and redissolved in 1 ml of 0.4 M KOH. After neutralization for 17 h at 37°C, 0.14 ml of 3 M perchloric acid was added, the mixture cooled to −20°C and centrifuged for 10 min at 10,000 × g. To the supernatant, 0.1 ml of a suspension of charcoal (Norit A, prewashed with 0.1 M NaCl, 100 mg/ml) was added and the mixture stirred for 1 h at 0°C. The charcoal was pelleted by centrifugation at 10,000 × g for 10 min. The supernatant was washed once with 2.5 ml of cold H2O, and resuspended in 1.5 ml of 50% ethanol containing 5% pyridine. After incubation for 2 h at 37°C, the charcoal was removed by centrifugation and the supernatant was evaporated to dryness under N2 and redissolved in 0.1 ml of 30% ethanol. The entire sample was spotted in 10-μl aliquots on polyethyleneimine-cellulose plates (20 × 20 cm) (Brinkmann) which had been prewashed with H2O. Markers of UMP (20 nmol) and uridine (40 nmol) were also spotted and the plates were developed first with H2O to 2 cm from the top, then with 2 M sodium formate to 7 cm from the top. The uridine and UMP spots were visualized under UV light, and these regions of the plates were excised and counted in a scintillation vial containing 1 ml of 1 M LiCl.

Table 1

| Experiment | Reaction conditions | Recovery |
|------------|---------------------|----------|
| 1          | −MeHg               | 70 (1.8) |
|            | +MeHg               | 190 (2.9) |
|            | (+/-)               | (2.7) (1.6) |
| 1B         | −MeHg (+postincubation) | 60 (2.1) |
|            | +MeHg (+postincubation) | 170 (3.0) |
|            | (+/-)               | (2.8) (1.4) |
| 2          | −MeHg               | 50 (1.4) |
|            | +MeHg               | 160 (1.9) |
|            | (+/-)               | (3.2) (1.4) |

Effect of Detergents—Although MeHg stimulates polymerase II-catalyzed synthesis in isolated nuclei, it is important to determine whether the stimulatory effect of MeHg is independent of each other, or whether they may involve a similar mechanism. This question was examined by studying the effect of each compound in the presence of the other. The results shown in Table 1 indicate that for the most part the stimulatory effects of MeHg and heparin are unaffected by the presence of the other compound, and that the two stimulatory effects are close to additive at saturating concentrations of MeHg. This suggests that MeHg and heparin are stimulating synthesis by different mechanisms. Furthermore, the fact that heparin does not inhibit the stimulatory effect of MeHg indicates that the effect does not result from increased initiation by free polymerase.

Effect of Heparin—Heparin has also been shown to stimulate RNA polymerase II-catalyzed synthesis in isolated nuclei (for review see Ref. 28). Furthermore, this stimulation results from an increased rate of chain elongation, not from an increase in the number of growing chains (28). Since MeHg appears to be similar to heparin in this regard, it was of interest to determine whether the stimulatory effects of the two compounds are independent of each other, or whether they may involve a similar mechanism. This question was examined by studying the effect of each compound in the presence of the other. The results shown in Fig. 1 indicate that for the most part the stimulatory effects of MeHg and heparin are unaffected by the presence of the other compound, and that the two stimulatory effects are close to additive at saturating concentrations of MeHg. This suggests that MeHg and heparin are stimulating synthesis by different mechanisms. Furthermore, the fact that heparin does not inhibit the stimulatory effect of MeHg indicates that the effect does not result from increased initiation by free polymerase.

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ase II-catalyzed RNA synthesis in isolated nuclei, it inhibits synthesis by the purified enzyme (23). In order to examine whether the stimulatory effect requires some form of structural organization in the nuclei, the effect of detergents on the stimulation was studied. Three detergents were examined, deoxycholate, Triton X-100, and CTAB, which are anionic, nonionic, and cationic detergents, respectively. The effect of these detergents on α-amanitin-sensitive RNA synthesis in nuclei was first examined. Fig. 2 shows that each of the detergents has a different effect i.e. deoxycholate stimulates synthesis slightly, Triton inhibits synthesis slightly, and CTAB inhibits synthesis significantly. Similarly, each of these detergents has a different effect on the dose-response profile of synthesis with MeHg (Fig. 3); in the presence of deoxycholate, the stimulation of synthesis of MeHg is virtually identical to the stimulation in the absence of the detergent. The presence of Triton X-100 appears to greatly reduce the stimulatory effect of MeHg. Finally, in the presence of CTAB, MeHg actually inhibits RNA synthesis. It should be noted that these experiments were carried out in the presence of concentrations of detergent which are low enough to have little effect themselves on synthesis (cf. Fig. 2).

Comparison of Various Mercury Compounds—As another approach to understanding the mechanism of the stimulation of polymerase II-catalyzed RNA synthesis in isolated nuclei, a comparative study of the ability of various mercury compounds to effect the stimulation was undertaken. Three major groups of compounds were examined, inorganic, organic alkyl, and organic aryl. None of the inorganics had any stimulatory effect (Fig. 4). It is important to note that the compounds tested differ in that both HgSO₄ and Hg(ClO₄)₂ are extensively ionized to Hg²⁺ in solution, whereas HgCl₂ is not (29).

Three alkyl mercury compounds were tested (Fig. 5). Ethyl mercury stimulated RNA synthesis to about the same degree as methyl mercury. In contrast, dimethylmercury clearly had no stimulatory effect. The results with three aryl compounds examined were of particular interest. As shown in Fig. 6,

![Graph 1](http://www.jbc.org/)

**Fig. 1.** Stimulation of α-amanitin-sensitive RNA synthesis by methyl mercury and heparin. Nuclei were isolated and RNA synthesis reactions carried out as described previously (23) with the indicated concentration of MeHg either in the absence (○) or presence (●) of heparin (1 mg/ml). 100% = 1070 cpm.

![Graph 2](http://www.jbc.org/)

**Fig. 2.** Effect of detergents on α-amanitin-sensitive RNA synthesis. Nuclei were isolated and RNA synthesis reactions carried out as described previously (23), in the presence of the indicated concentration of detergent. ○, Triton X-100; □, CTAB; ▲, sodium deoxycholate.

![Graph 3](http://www.jbc.org/)

**Fig. 3.** Effect of MeHg on α-amanitin-sensitive RNA synthesis in the presence of detergents. △, no detergent; ○, 0.5% Triton X-100; □, 0.01% CTAB;▲, 0.1% sodium deoxycholate.

![Graph 4](http://www.jbc.org/)

**Fig. 4.** Effect of inorganic mercury compounds on α-amanitin-sensitive RNA synthesis. ○, HgSO₄; □, Hg(ClO₄)₂; △, HgCl₂.
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**Fig. 5.** Effect of alkyl mercury compounds on α-amanitin-sensitive RNA synthesis. ○, MeHgCl; □, ethylmercuric chloride; Δ, dimethylmercury.

phenylmercury had no stimulatory effect. In contrast, pHMB and pHMBS both stimulated RNA synthesis significantly. The structures of these three compounds are shown in Fig. 6.

**Fig. 6.** Effect of aryl mercury compounds on α-amanitin-sensitive RNA synthesis. ○, phenylmercuric acetate; □, pHMB; Δ, pHMBS.

In order to determine whether the stimulation of RNA synthesis by pHMB is similar to the stimulation by MeHg, an experiment similar to that described in Table I for MeHg was carried out for pHMB. The results (Table II) showed that the effect of pHMB is similar to that of MeHg in that the increase in synthesis is not attributable to an increase in the number of growing chains.

**Role of Sulfhydryl Binding**—Various mercury-containing compounds are known to bind to sulfhydryl groups in proteins and have been widely used as sulfhydryl reagents. It was thus of interest to investigate the significance of sulfhydryl binding in the stimulation of polymerase II-catalyzed RNA synthesis.

**Fig. 7.** Effects of NEM. A, effect of NEM on α-amanitin-sensitive and -resistant RNA synthesis. The results are expressed as percentage stimulation in the case of α-amanitin-sensitive synthesis (○) and percentage inhibition in the case of α-amanitin-resistant synthesis (□). In the absence of NEM, synthesis was 10,225 cpm for the sensitive and 5791 cpm for the resistant. B, effect of NEM on the stimulation of α-amanitin-sensitive RNA synthesis, and the inhibition of α-amanitin-resistant synthesis by pHMB. Synthesis was measured in the absence or presence of 100 μM pHMB and the indicated concentration of NEM. The results are presented as the percentage stimulation caused by pHMB in the α-amanitin-sensitive synthesis (○) or the percentage inhibition caused by pHMB in the α-amanitin-resistant synthesis (□).

In nuclei. One approach to this question was to examine the ability of NEM, a nonmercurial sulfhydryl reagent, to stimulate RNA synthesis. As shown in Fig. 7A, NEM has only a moderate stimulatory effect (50%). (This should be compared to the large stimulatory effect of 100 μM pHMB in this experiment (210%) which is shown in Fig. 7B at NEM concentration = 0.) Fig. 7A also shows that NEM is only a weak inhibitor of α-amanitin resistant RNA synthesis (which should again be compared to the large inhibition by 100 μM pHMB shown in Fig. 7B at NEM concentration = 0). Thus, in nuclei.

**Table II**

| Reaction conditions | Recovery |
|--------------------|---------|
|                    | UMP     | Uridine |
| --pHMB             | 70      | 1.6     |
| +pHMB              | 200     | 2.3     |
| (+/-)              | (2.8)   | (1.4)   |

A complete description of the effects of various mercury compounds on α-amanitin resistant RNA synthesis will be presented elsewhere (Chao, E. S.-E., and Frenkel, G. D., submitted to Biochem. Pharmacol.).
NEM has relatively low potency in either stimulating polymerase II-catalyzed RNA synthesis or in inhibiting polymerase I- and III-catalyzed synthesis. Fig. 7B shows the effect of increasing NEM concentration on the ability of pHMB to stimulate the former or inhibit the latter. The results clearly show that NEM has no effect on the inhibition of polymerase I and III activity by pHMB, but is able to prevent its stimulation of polymerase II activity.

As a second approach to the question of the relevance of sulfhydryl binding to the stimulation of RNA synthesis, the ability of various mercury compounds to bind to a sulfhydryl group was determined. A method was devised which is based upon the observation that the characteristic absorbance of NEM at 300 nm is eliminated when it is bound to cysteine (27). As shown in Fig. 8, the absorbance of a solution of 1.5 mM NEM is inversely proportional to the concentration of cysteine added. Thus, the absorbance can be taken as a measure of the concentration of free NEM. The binding of various mercury compounds to cysteine was measured by their ability to compete with NEM; the more mercury compound which is bound to cysteine, the less NEM is bound and the higher the absorbance will be. The results of such experiments with a group of mercury compounds is shown in Fig. 9. The compounds fall into three distinct groups; the inorganic compounds are more effective than the organics at competing with NEM and dimethyl mercury is completely ineffective. The simplest explanation for this grouping is based upon the sites available for sulfhydryl binding; the inorganics can bind 2 mol of cysteine, the R-Hg organics only one, and dimethylmercury none. Although it is not clear that this method actually allows for an accurate determination of relative affinities for the sulfhydryl group, nevertheless it is clear that the ability of a mercury compound to bind to a sulfhydryl group does not correlate with its ability to stimulate RNA synthesis. In addition to the inorganic compounds, phenylmercury is clearly able to bind to cysteine; thus, the inability of phenylmercury to stimulate RNA synthesis cannot be due to its inability to bind to a sulfhydryl group (see “Discussion”).

**DISCUSSION**

The results of these experiments allow certain tentative conclusions to be drawn as to the requirements for stimulation of RNA synthesis in isolated nuclei. It is clear that the inorganic mercury compounds tested are ineffective, as is dimethylmercury. This suggests that one coordination site of the Hg must be available and one must be filled. Two possible reasons for the ineffectiveness of phenylmercury suggest themselves, steric hindrance and hydrophobicity. The fact that both pHMB and pHMBS are effective stimulators of RNA synthesis indicates that hydrophobicity is the more likely explanation. This question is currently being further investigated.

The finding that detergents are able to alter the effect of MeHg on RNA synthesis (Fig. 3) is subject to a number of interpretations. Since it is known that elongation by extracted RNA polymerase II is not stimulated significantly by MeHg (23), it seems clear that the simplest explanation is that there is some structural requirement in the nucleus which is necessary for the stimulation. This structure is not altered by deoxycholate but is by Triton and CTAB, even at concentrations which have little apparent effect on synthesis itself. These alterations could represent disruption of a structural feature of the nucleus, or simply of the conformation of the transcription complex.

All of the mercury compounds examined, except for dimethylmercury, are able to bind to the sulfhydryl group of cysteine, as evidenced by their ability to compete with NEM for binding (Fig. 9). This results does not mean, of course, that they are all able to bind to a sulfhydryl group in a particular protein. Factors such as structure and hydrophobicity could play an important role in the discrimination among the various mercury compounds (30). However, the fact that NEM is able to compete out the stimulation by pHMB in nuclei strongly indicates that sulfhydryl binding is necessary for the stimulation. However, this result also shows that NEM is able to bind to the relevant sulfhydryl group in the nucleus, but is nevertheless only a very weak stimulator of RNA synthesis. Thus, we conclude that, for stimulation of RNA polymerase II-catalyzed synthesis in isolated nuclei, sulfhydryl binding is necessary but not sufficient.

The results which we have obtained do not as yet allow a definite conclusion as to the mechanism of the specific stimulation of polymerase II-catalyzed RNA synthesis in nuclei. Several conclusions can be drawn, however, which allow for a general formulation of some aspects of the mechanism. First, it is important to keep in mind that the phenomenon is specific for RNA polymerase II. RNA synthesis by polymerases I and III in nuclei is inhibited by MeHg (23), and we have recently found that mitochondrial RNA synthesis, both in whole cells and in *vivo* in isolated mitochondria, is inhibited by MeHg (31). Second, the stimulation cannot be attributed to an increase in the number of growing RNA chains.
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Since we have previously shown (23) that the stimulation represents an increase in the initial rate of the reaction, not in its duration, it appears unlikely that the stimulation is due to inhibition of chain termination. Thus, we feel that the most likely explanation is that the mercury compounds cause an increase in the rate of chain elongation. Third, the requirement for sulfhydryl binding indicates the probable involvement of a protein or proteins in the stimulation; these could be part of the transcription complex (e.g. RNA polymerase and/or factors) or template-associated (e.g. histones). In this connection, it is of interest that Otsuki and Gruenwedel (32) and Gruenwedel and Diaham (33) have recently demonstrated that MeHg is able to cause structural alterations in the histone core of chromatin. They reported that MeHg treatment results in a decrease in associated histones with a concomitant decrease in the thermal stability of the chromatin (32). Thus, it is possible that removal of histones results in localized denaturation which facilitates RNA chain elongation. We are currently investigating this question directly.

The significance of the stimulation phenomenon is 2-fold. First, the effect is clearly of importance in the characterization of the toxicity of organomercury compounds. Second, it is clear that this specific effect of some mercury compounds is indicative of both structural and enzymatic features of the process of chain elongation during transcription by RNA polymerase II. Mercury compounds will thus serve as important probes in the study of the biochemistry of this process.

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REFERENCES
1. D’Itri, P. A., and D’Itri, F. M. (1977) Mercury Contamination, John Wiley & Sons, New York
2. Harada, M. (1978) in Toxicity of Heavy Metals in the Environment, (Oehme, F. W., ed) pp. 261-302, Marcel Dekker, New York
3. Nriagu, J. O. (ed) (1979) The Biogeochemistry of Mercury in the Environment, Elsevier, Amsterdam
4. Gatti, G. L., Macri, A., and Silano, V. (1979) in Trace Metals: Exposure and Health Effects (Diferrante, E., ed) pp. 73-98, Pergamon, Oxford
5. Ramel, C. (1967) Hereditas 57, 445-447
6. Skerfving, S., Hansson, K., Mangs, C., Lindstén, J., and Ryman, N. (1974) Environ. Res. 7, 83-98
7. Ramel, C. (1972) in Mercury in the Environment (Fiberg, L., and Vostal, J., eds) pp. 169-181, CRC Press, Cleveland
8. Mathew, C., and Al-Doori, Z. (1976) Mutat. Res. 40, 31-36
9. Fiskejö, G. (1970) Hereditas 64, 142-146
10. Jenson, D., and Ramel, C. (1980) Mutat. Res. 75, 191-202
11. Nakai, S., and Machida, I. (1973) Mutat. Res. 21, 348
12. Fiskejö, G. (1979) Hereditas 90, 103-109
13. Bruce, W. B., and Heddie, J. A. (1978) Can. J. Genet. Cytol. 21, 319-334
14. Kanematsu, N., Harai, M., and Kada, T. (1980) Mutat. Res. 77, 109-116
15. Gruenwedel, D. W., and Davidson, N. (1966) J. Mol. Biol. 21, 129-144
16. Gruenwedel, D. W., and Davidson, N. (1967) Biopolymers 5, 847-861
17. Gruenwedel, D. W., and Lu, D. S. (1970) Biochim. Biophys. Res. Commun. 40, 542-548
18. Chrisman, R. W., Mansy, S., Peresie, H. J., Ranade, A., Berg, T. A., and Tobias, R. S. (1977) Bioinorg. Chem. 7, 245-266
19. Clegg, M. S., and Gruenwedel, D. W. (1979) Z. Naturforsch. Sect. C: Biosci. 34c, 259-265
20. Anderson, R. R., Maki, A. H., and Ott, C. M. (1980) Biochemistry 19, 4412-4418
21. Nakazawa, N., Makino, F., and Okada, S., (1978) Biochem. Pharmacol. 24, 489-493
22. Gruenwedel, D. W., and Cruikshank, M. K. (1979) Biochem. Pharmacol. 257, 6275-6279
23. Frenkel, G. D., and Randles, K. (1982) J. Biol. Chem. 257, 6275-6279
24. Udvardy, A., and Seifart, K. H. (1976) Eur. J. Biochem. 62, 353-363
25. Barry, J., and Gorski, J. (1971) Biochemistry 10, 2384-2390
26. Coupar, B. E. H., Davies, J. A., and Chesterton, C. J. (1978) Eur. J. Biochem. 74, 611-623
27. Roberts, E., and Rouser, G. (1978) Anal. Chem. 50, 1291-1292
28. Coupar, B. E. H., and Chesterton, C. J. (1977) Eur. J. Biochem. 79, 525-533
29. Carty, A. J., and Malone, S. F. (1979) in The Biogeochemistry of Mercury in the Environment (Nriagu, J. O. ed) pp. 433-479, Elsevier, Amsterdam
30. Webb, J. L. (1966) Enzyme and Metabolic Inhibitors Vol. II, pp. 643-650, Academic Press, New York
31. Frenkel, G. D., and Harrington, L. (1983) Biochem. Pharmacol. 32, 1454-1456
32. Otani, L. G., and Gruenwedel, D. W. (1980) Z. Naturforsch. Sect. C Biosci. 35c, 605-610
33. Gruenwedel, D. W., and Diaham, B. (1982) Mol. Pharmacol. 22, 121-126
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