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Dopamine: Its Occurrence in Molluscan Ganglia

Abstract. *Fluorometric and paper chromatographic evidence indicates that dopamine is the only catecholamine present in the ganglia of a number of lamellibranch and gastropod species.*

Dopamine has been identified in many vertebrate tissues, such as adrenal medulla (*1*), sympathetic nerve (*2*), brain (*3*), and lung (*4*), but it has never been clearly demonstrated in invertebrate animals. In assaying the ganglia of several molluscan species for catecholamines, I found substantial amounts of dopamine with little or no trace of norepinephrine or epinephrine.

The three sets of ganglia of each lamellibranch were dissected free and pooled, and, in gastropods, the entire circumesophageal ganglionic complex was removed. For each species used, the ganglia from several individuals were combined, weighed fresh, and assayed by the fluorometric method of Bertler *et al.* for epinephrine and norepinephrine (*5*); for dopamine, a modification (*3*) of the Carlsson technique (*6*) was used.

Table 1. Estimated concentrations of dopamine in molluscan ganglia. All weights are of fresh tissue. The first three species are gastropods. The others are pelecypods.

Assays (No.)	Av. wet wt. (mg)	Dopamine (μg/g)	
		Range	Av.
	Melongena corona		
3	51	51–82	63
	Lunatia heros		
3	119	12–38	27
	Busycon canaliculatum		
4	310	6–22	14
	Mercenaria mercenaria		
8	31	137–405	261
	Modiolus modiolus		
3	25	35–118	85
	Ensis directus		
3	27	31–49	37
	Mya arenaria		
1	11	—	96
	Mytilus edulis		
1	41	—	35
	Aequipecten irradians		
3	39	60–88	74
	Spisula solidissima		
2	42	26	26

The excitation and fluorescence spectra for the ganglia of every species sampled indicated that a substance fluorometrically identical with dopamine was present, but in no case were epinephrine or norepinephrine peaks clearly evident. In addition, paper chromatography of *Mercenaria* and *Busycon* ganglia, in which the technique of Bertler and Rosengren (*3*) and such solvents as phenol and 0.1*N* HCl or butanol, acetic acid, and water (4:1:5) were used, revealed a spot corresponding to the spot produced by standard dopamine. Again, epinephrine and norepinephrine were not detected. When the three *Mercenaria* ganglia (cerebropleural, pedal, and visceral) were assayed separately, high levels of dopamine were found in each ganglion, while fluorometric assay of other *Mercenaria* tissues such as gill, mantle, heart, and intestine failed to show any appreciable dopamine content. Thus it appears that dopamine, at least in *Mercenaria,* is concentrated in the ganglia and occurs in each of the three ganglia.

The concentration of dopamine can be estimated from microammeter readings taken at the excitation and fluorescence peaks, but these values (Table 1) only indicate relative orders of magnitude. Although the recovery of standard dopamine averaged 90 percent, I found that it could vary widely between the extremes of 68 and 136 percent. Nevertheless, these data demonstrate the relatively high concentrations of dopamine which appeared in the ganglia of every bivalve and gastropod mollusk sampled.

These results are consistent with the reported absence of epinephrine and norepinephrine from *Mytilus* (*7*) and with chromatographic evidence for dopamine in *Helix aspersa* mentioned by Kerkut and Walker (*8*). Östlund's survey of catecholamines in lower animals (*9*) is inconclusive for the mollusks, possibly because he used whole animal extracts.

In the past, dopamine has been regarded as merely the precursor of norepinephrine (*10*), but recent findings have suggested an additional, physiological role for this substance; possibly it is a neurohumor in mammalian brain (*3*) and in *Helix* brain (*8*), and it may function in the regulation of the *Mercenaria* (*Venus*) heart (*11*). This demonstration that dopamine is the principal catecholamine in molluscan ganglia also suggests that dopamine has a function independent of its role as the precursor to norepinephrine.

DARYL SWEENEY
Biological Laboratories, Harvard University, Cambridge, Massachusetts

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Ribonucleic Acid Synthesis in Protoplasts of Escherichia coli: Inhibition by Actinomycin D

Actinomycin D inhibits specifically and effectively DNA-dependant RNA synthesis in mammalian cells (*1*) and in several bacteria (*2*). *Escherichia coli* however, even in the form of spheroplasts, is resistant to the antibiotic (*3*). Since DNA-dependant RNA synthesis by *E. coli* extracts is sensitive to actinomycin (*3*), the resistance of intact *E. coli* bacteria might be attributed to impermeability of this organism to the drug. Because of the relevance of the actinomycin effect to the study of gene action, and in view of the unusual amount of information available about nucleic acid metabolism, phage infection, and the regulation of protein synthesis in *E. coli*, an actinomycin-sensitive *E. coli* system would be useful for studying these problems.

We have prepared protoplasts from