Table 1. Interplanar separations between the molecules taking part in charge-transfer complexes.

Complex	Distance between molecular planes (Å)
Heterocomplexes	
Anthracene:sym-trinitro benzene	3.28(3)
Phenol:benzoquinone	3.33(3)
Quinol:benzoquinone	3.16(3)
Tetramethyl-*p*-phenylenediamine:chloranil	3.26(3)
Tetramethyl-*p*-phenylenediamine:bromanil	3.31(3)
Perylene:fluoranil	3.23(4)
Self-complex	
Potassium squarate monohydrate	3.24(5)

that 8-azaguanine is incorporated into the bacterial RNA. The cell-poisoning action appears to be associated with such incorporation, since strains of *S. faecalis* resistant to this compound cannot convert it to 8-azaguanylic acid. As a resut of this defect, the 8-azaguanine is not incorporated into the RNA of the resistant cells (*2*). These results indicate that 8-azaguanine exerts its cell-poisoning action only after incorporation into the bacterial RNA.

It is conceivable that the effect of the 8-azaguanine molecule on the RNA molecule arises from some secondary structural feature of the 8-azaguanine. In order to investigate whether 8-azaguanine had any unusual structural features an x-ray crystal structure analysis of 8-azaguanine monohydrate has been carried out. The results of this analysis will be reported in detail elsewhere. However, one observation was made which should be reported immediately.

The 8-azaguanine molecules lie almost exactly in the (102) plane of the crystal. A projection of one molecule in that plane onto a molecule in the plane below is given in Fig. 1. These molecules lie almost directly over one another. The distance between the molecular planes is 3.25 Å ($\sigma = 0.01$). The distances between molecular planes for a number of charge-transfer complexes are shown in Table 1.

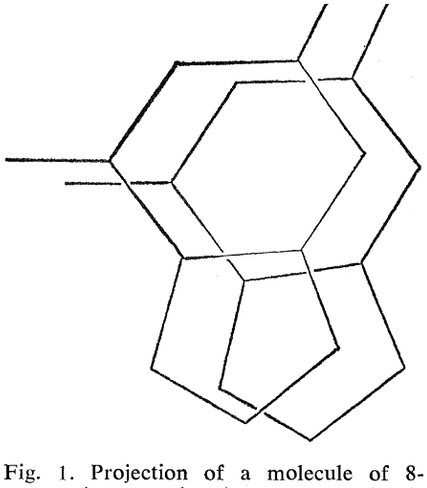

Fig. 1. Projection of a molecule of 8-azaguanine onto the plane of the molecule stacked below it in the crystal of 8-azaguanine monohydrate. The plane of projection is approximately the (102) crystallographic plane.

These complexes are characterized by a rather short intermolecular separation, normal to the molecular plane. The separation between the planes of aromatic molecules, in crystals held together by van der Waals forces only, is about 3.4 Å. As a rule, the formation of a charge-transfer complex is characterized by a reduction in this separation of 0.1 to 0.2 Å.

The distance between molecular planes of 3.25 Å, as in 8-azaguanine, falls into the range of distances in these charge-transfer complexes. This is strong evidence for the formation of a charge-transfer self-complex in the crystal of 8-azaguanine monohydrate.

A second feature of charge-transfer complexes is a slight displacement of the molecules from exact superposition. This is necessary to permit the p_z orbital overlap which provides the binding energy of the complex. The displacement of the two molecules (Fig. 1) is of the type required to permit complex formation (*3*).

A third feature of most charge-transfer complexes, a very strong absorption band in the visible region of the spectrum, is absent in 8-azaguanine monohydrate. The crystals are colorless. However, Mulliken has predicted that in self-complexes, where donor and acceptor molecules are the same, the charge-transfer absorption band should occur at frequencies higher than found in heterocomplexes (*6*). The crystals of potassium squarate monohydrate, which forms a charge-transfer self-complex, are colorless (*5*).

The charge-transfer absorption band for 8-azaguanine may be in the ultraviolet region. Unfortunately this hypothesis has not been checked owing to severe experimental difficulties in obtaining the necessary spectra. However, in potassium squarate monohydrate an appropriate absorption band has been found at 2500 Å (*5*).

The results of the structure analysis then suggest that 8-azaguanine forms a charge-transfer self-complex in the crystals of the monohydrate. At any rate, the close approach of 3.25 Å between neighboring 8-azaguanine planes is evidence of some unusual secondary interaction. This interaction provides a simple mechanism for the lethal effect on bacterial cells of the incorporation of 8-azaguanine into their RNA.

Protein synthesis appears to involve movement of the ribosome along the linear RNA chain which carries the amino acid code (*7*). If a molecule of 8-azaguanine is incorporated into the RNA molecule and forms a complex with another 8-azaguanine base in the same RNA molecule, or perhaps with a natural base, at some distance along the RNA chain, then the molecule will bend over on top of itself to form a loop. The points on the RNA molecule which are connected by the complex between bases can then form an obstruction which will prevent the ribosome from proceeding along the chain. Such an interference with the movement of the ribosome will inhibit protein synthesis, and so arrest the development of the cell.

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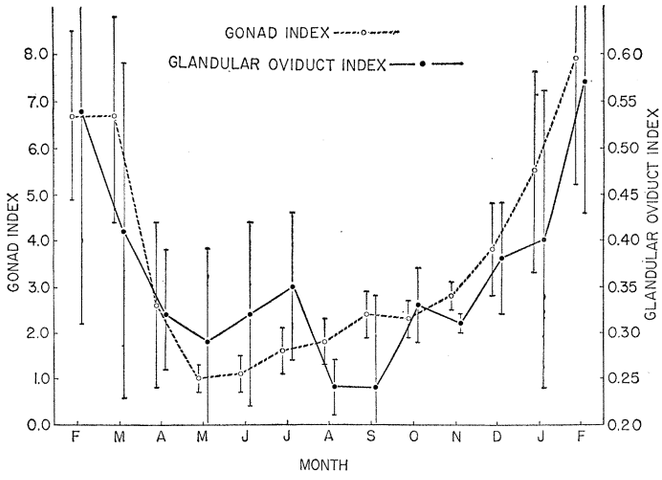
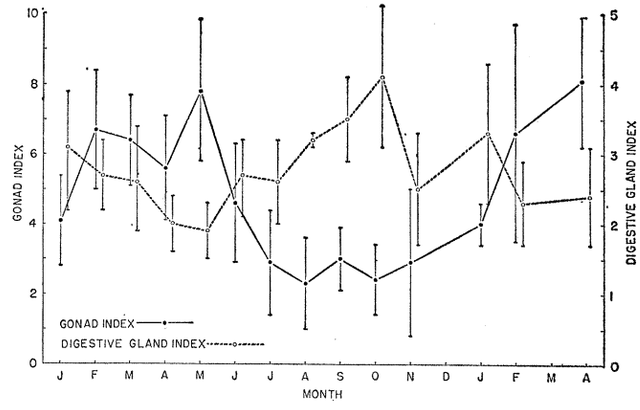
12 November 1964

Cyclic Variations in the Digestive Gland and Glandular Oviduct of Chitons (Mollusca)

Abstract. *In* Cryptochiton stelleri *(Polyplacophora), variation in the size of the glandular oviduct parallels the cyclic variation in the size of the gonad. In* Katharina tunicata *the digestive gland reaches its maximum size in the fall then decreases to a minimum size in the spring when the gonad is at its maximum size. These variations are not due to changes in the water content of the glandular oviduct and digestive gland.*

Reproduction in the chitons *Katharina tunicata* and *Cryptochiton stelleri* is seasonal, an annual reproductive cycle being characteristic in both spe-





Figs. 1 and 2. Fig 1 (left). Seasonal variation of glandular oviduct index and gonad index of *C. stelleri* from February 1963 through February 1964. The points and vertical lines represent means ± one standard deviation, respectively. Fig. 2 (right). Seasonal variation of digestive gland index and gonad index of *K. tunicata* from January 1963 through April 1964. The points and vertical lines represent means ± one standard deviation, respectively.

cies (*1, 2*). The gonad appears to be the only component of the body varying measurably in size with the reproductive season. However, in the previous work with the chitons, other body components were observed in dissection but not measured. In view of the reciprocal relationship between the gonad and the pyloric caecum of the sea stars *Pisaster ochraceus* and *P. brevispinus* (*3*) it seemed of interest to measure the digestive gland of one of the chitons during the course of a reproductive cycle. The glandular portion of the oviduct, whose function is unknown although implicated in spawning (*4, 5*), was also measured. Seasonal changes occurred in both of these organs.

It proved more convenient to remove and measure the digestive gland from the small chiton *Katharina tunicata* than from the large chiton *Cryptochiton stelleri*, but as the glandular oviduct of *Katharina* was too small for accurate measurements, it was studied only in *Cryptochiton*.

Thirteen to twenty *K. tunicata* of both sexes and four to six female *C. stelleri* were collected monthly from the lower intertidal zone near Yankee Point, California (36°33′N, 121°57′W), and Pigeon Point, California (37°11′N, 122°24′W), respectively. After dissection of the digestive gland from each *K. tunicata*, the glandular oviduct from each female *C. stelleri*, and the gonads from both species, the organs were drained of free fluid and weighed. Each organ was then dried and reweighed to determine its water content. The relative weight of the digestive gland, glandular oviduct, and gonad to the total weight of each animal was expressed as the digestive gland index [(wet weight of digestive gland × 100)/wet body weight], glandular oviduct index [(wet weight of glandular oviduct × 100)/wet body weight], and the gonad index [(wet weight of gonad × 100)/wet body weight], respectively.

Figure 1 shows that in *C. stelleri* the size of the glandular oviduct increases in parallel with the size of the gonad during the winter and reaches a maximum just before spawning in the spring. Spawning is indicated by the decrease in the gonad index. This change in the glandular oviduct index did not result from changes in its water content which remained at 70 to 75 percent throughout the year. The decrease in the relative size of the glandular oviduct after spawning supports the hypothesis that its greatest size is attained at spawning (*4, 5*). Whether there is also a variation in the organic constituents of the glandular oviduct such as occurs in some of the other organs of the chiton during the reproductive cycle (*2, 6*) has not been determined. Nimitz (*4*) did not find histochemically detectable lipid, glycogen-like material, or protein in the glandular cells of the oviduct. She suggested that the secretion may function to consolidate the eggs during spawning.

The cycles of the digestive gland and gonad of *K. tunicata* are shown in Fig. 2. The change in the digestive gland index did not result from changes in the water content of the digestive gland, since this remained at 64 to 70 percent throughout the year. The inverse relationship between the digestive gland and the gonad cycles suggests that the nutritive demands of gonadal growth might be a factor in the reduction of the size of the digestive gland. Whether growth of the gonad is due to increased uptake and synthesis from precursors in the blood or through direct transfer of material from the digestive gland to the gonad is not known.

The variation of the digestive gland index also could be influenced by a seasonal change in the amount of food ingested. *Katharina tunicata* starved in the laboratory have lower digestive gland indices than those fed continuously on the red alga, *Iridaea*, for the same period; this supports the interpretation that the amount of food ingested by *K. tunicata* is important in determining the size of the digestive gland (*7*). That the lipid content (percentage, dry weight) of the digestive gland declines with starvation along with shrinkage in size has been noted (*6*). These results support the contention that the digestive gland functions as a storage organ (*6, 8*).

It is therefore clear that in some species the size of other organs as well as the gonads vary with the course of the reproductive season. The chemical constitution of the gonad and other organs may also change (*6, 9*). Furthermore, feeding activity varies with the seasons in the sea star *Pisaster ochraceus* (*10*) and in the sea urchin *Strongylocentrotus intermedius* (*11*). Thus it appears that the physiological condition of a marine invertebrate is a function of the seasons and that compari-

son of experimental results gathered at different times must be made with reference to the season, especially the reproductive condition in seasonally reproducing marine invertebrates.

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29 October 1964

Changes in the Tail Feathers of the Adolescent Lyrebird

Abstract. *The changes which take place in the tail of the male lyrebird as it develops to maturity over a period of 7 to 8 years are attributable both to moulting and to processes whereby certain plain feathers are transformed into filamentaries and medians by growth of the rachis and loss of barbs and barbules.*

The tail of the mature male lyrebird (*Menura superba*) consists of 16 retrices which are normally carried extended behind the bird's body, but which are reversed over the body during display (Fig. 1). Each of two of these retrices, known as the lyrates, consists of a quill on the inner side of which is a vane which varies uniformly in width from about 5 to 6 mm at the proximal end to about 19 mm at the distal end. The color is light grey below and brownish-black above. To the outer side of the quill is attached a vane approximately 8 cm wide, which is characterized by a number of apparently transparent V-shaped "windows." This effect is due to the absence of barbules in the V-shaped areas; the thickness of the barbs decreases steadily as the distance from the shaft (rachis) increases. Figure 2 shows a portion of a mature lyrate feather, the detail of the window being illustrated in the inset. The margins of the V-shaped windows are colored yellow-to-orange on the underside, the tips of the vane being dark brownish-black. The end of the lyrate feather is dark brownish-black and club-shaped. Two of the retrices are very narrow, being only about 3 mm wide over the greater part of their length, and practically devoid of vane, especially on the inner side. The vane increases in width to a maximum of about 10 mm. Along the inner side are very fine barbules, ranging in length from about 2.5 to 3 mm over the greater part of the quill to up to about 19 mm over the last 15 to 18 cm distal from the base. These two feathers, generally referred to as the medians, are dark-colored above and silvery-gray on the underside.

Fig. 1. A mature male lyrebird displaying, showing 2 lyrates, 2 medians and 12 filamentary feathers. The bird's body can be seen beneath the tail feathers, facing to the right.

The remaining 12 retrices (known as the filamentary feathers, or filamentaries) each consist of a quill with a "vane" of peculiar design. The proximal portion consists of barbs and barbules which fasten themselves to present a continuous appearance, the length of this part of the feather being greater in the middle than at the extremities of the group (see Fig. 1). The remainder of the feather consists of a number of fine filaments (barbs), up to 20 cm in length, attached to either side of the shaft. The coloring is similar to that of the medians—that is, dark above and light below. Different birds exhibit considerable variation in the length of these feathers (retrices) which range from 70 to 72 cm in some cases and up to over 80 cm in others.

When the young lyrebird leaves the nest at the age of approximately 6 weeks, its tail consists of 16 feathers and is about 12 cm long. At the age of 6 months the tail is similar in length (about 30 cm) and appearance to that of the female; but the juvenile windows in the lyrate are very poorly defined—that is, the lines of demarcation between the vane-like areas are not sharp.

It is difficult to be positive on this point, but observations made on the lyrebirds in Sherbrooke Forest, in the Dandenong Ranges, 48 km east of Melbourne, Australia, suggest strongly that the lyrates are moulted approximately annually and replaced by new ones. Occasionally, immature birds have