When the center of the valley had been crossed and soundings became shoaler, the lead was pulled in and the counter checked to see if the depth indications were correct. Then the boat was rowed over to the other side and the other half of the line was run in the same fashion. At the end of the second half of a line there was an opportunity to check the method at the point where the soundings crossed the same position as was obtained on the first half. Till some experience had been acquired it was sometimes found that the soundings did not check. This error was due either to the use of ranges which were either not sufficiently distinct or too closely spaced so that the boat could not be kept on a narrow line or it was due to insufficient backing of the boat before sounding to allow the wire to attain a vertical position. The use of a heavy lead helped eliminate the second of these sources of error and streamlining the lead proved to be some advantage.

The survey was carried on by a crew of three. One took the sextant angles and notes, the second took the soundings and the third rowed and kept the boat on range. The sextant reader increased the speed of operation and obtained some exercise by taking one handle when the sounding wire was reeled in.

*Results of the Survey:* It is not the purpose of the present paper to discuss the scientific results of these detailed surveys, but a few of the outstanding observations will be noted. Very steep slopes were found in both canyons, particularly in the one off La Jolla, where a maximum of 84° was measured on a 200-foot cliff. Outward from the canyon heads each section showed some increase in depth over those inside, so that no evidence of enclosed basins was discovered. Terraces, probably of rock, were found on the sides of the La Jolla canyon, and many ridges and hummocks of rock were detected on the sides of the Carmel Canyon. Tributaries entering at grade were found in both canyons.

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## ACCESSORY HEARTS IN THE OYSTER

IN various animals, notably insects, certain blood vessels are specialized as pulsating organs which serve to pump blood into tissues either too distant from the heart to receive a rapid flow of blood or separated from the arterial system by capillaries. Such accessory hearts apparently have not been described in Lamellibranchs.

In oysters (*Ostrea gigas, O. virginica* and *O. lurida*) such structures may readily be studied, though they appear to have previously escaped observation owing to their location within the walls of the cloacal chamber. In a large specimen of *O. gigas* about 12 to 15 centimeters long they may be seen as a pair of elongated vessels on the inner surface of the mantle lobes which form the lateral boundaries of the cloacal chamber. At the posterior extremity of this chamber the two lobes of the mantle are united, forming a place of attachment for the posterior ends of the paired gills. The accessory hearts in a large specimen may be 2 to 3 centimeters long and extend from the kidneys (organ of Bojanus) almost to the posterior border of the cloacal chamber. At their distal ends each opens into the large blood vessel which runs completely around the corresponding mantle lobe. In the contracted state they have a diameter of about 1 millimeter, but when filled with blood they may be 5 millimeters or more in thickness. The pulsation consists of a wave of contraction beginning at the central, or kidney, end and traveling rather slowly distally.

The activity of these organs was best observed in specimens from which portions of the right valve had been removed, without damage to the underlying tissues. The border of the mantle grew back over the edge of the remaining shell, exposing the cloacal chamber and the accessory hearts. By looking through the cloacal chamber it was possible also to see the pericardium and count the beats of the heart. It was immediately obvious that the rhythmicity of the accessory hearts was entirely different from that of the heart itself, and that the two accessory hearts need not pulsate at the same rate.

The rate of pulsation of the three organs was measured by repeated successive counts of the time required for a given number of pulsations by each and the results for each organ averaged. A typical series averaged as follows: heart, 20.7 pulsations per minute; right accessory, 4.8 per min.; left accessory, 7.6 per min. Generally the left accessory beat more rapidly than the right, possibly due to the fact that the specimen lay in its left valve. It is probable that the rate of pulsation of the accessory hearts depends upon the rate at which they fill with blood. The above measurements show, at any rate, the independence of the three organs in initiation of pulsation.

Failure to observe the pumping activity of these organs has perhaps led to incomplete understanding of the circulatory system of at least some of the Lamellibranchs. These accessory hearts appear to be homologous to the gill hearts of Cephalopods, which are well known and which function to pump blood from the spacious lacunae of the excretory organ to the gills. In this case their function is to complete the circulation of the blood which has lost arterial pressure after having passed through the lacunae of the viscera and into the excretory organ. In the oyster essentially the same condition obtains, save that, as in other Lamellibranchs, the mantle surfaces probably function largely in respiration, while the gills pump the food- and oxygen-bearing water. Thus the gills are primarily feeding organs, rather than respiratory. The gill hearts, in the oyster, pump blood into the highly vascular mantle, where aeration is accomplished, and also, through relatively small vessels, into the gills. The term, *gill hearts,* may be considered to apply to the oyster, in spite of these matters, because of homology with the Cephalopod organs.

The circulatory system of the oyster (*O. gigas*) consists of two parts, very incompletely separated. Blood from the ventricle of the heart is distributed through two large arteries: the posterior aorta, supplying chiefly the adductor muscle; and the anterior aorta, which runs forward, giving off branches into the visceral mass, and at the anterior end opening into a large vessel which divides both dorsally and ventrally into a pair of marginal pallial arteries which run completely around the border of each mantle lobe. That is, the dorsal pallial artery of each mantle lobe is continuous with the ventral pallial artery of the same lobe through the marginal artery. Venous blood from the adductor muscle and viscera is collected in the lacunae of the paired excretory organs, which apparently do not communicate directly with the auricles, as some investigators have thought. From the blood spaces of each kidney a large vessel, the accessory heart, pumps blood directly into the corresponding marginal artery, entering slightly anterior to the posterior insertion of the gills, along which runs a vessel connecting the two marginal arteries together and giving off branches to the gills. Thus the ventricle pumps blood into the marginal arteries from anteriorly while the accessory hearts pump blood into the same arteries near the posterior ends of the gills. The blood in the marginal arteries is subjected to pressure from two directions. In addition, the accessory hearts give off along their course small branches to the adjacent mantle.

The marginal arteries send out branches both distally and proximally into the mantle tissue and the blood is collected by lacunae and veins leading directly to the auricles of the heart. Veins from the gills also empty into the auricles. In this manner the blood returning to the heart, after aeration in the mantle and gills, consists in part of that which has been purified by the excretory organs and in part of systemic blood. The two communicating systems are readily demonstrated by injecting a colored fluid either into the ventricle, from which it goes throughout the marginal arteries, or into one of the accessory hearts, from which it goes into both of the marginal arteries and gills. The marginal artery, then, receives both arterial and venous blood, both purified (by the excretory organ) and unpurified blood.

It is considered possible that the accessory hearts described above may also be found in some other Lamellibranchs, though in most it would probably be difficult to observe the action of the organs.

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## IS THE COLOR OF THE NATURAL RUBY DUE TO IRON?

IT is a well-known fact[1] that synthetic ruby must contain at least 1½ to 2½ per cent. chromic oxide in order to approximate the color of the natural gem; furthermore, it has already been shown[2] that there is not sufficient chromic oxide in natural ruby to account for its depth of color. The literature contains many analyses[3] of both natural and synthetic rubies which show that the two are chemically dissimilar; synthetic rubies contain chromic oxide but no ferric oxide, whereas natural rubies contain significant amounts of the latter in addition to the former; on the other hand, no distinction seems to be made between the two coloring agents in the naturally occurring mineral.

It was accordingly of interest to examine a number of natural rubies for the purpose of determining both the chromium and the iron content of the same specimen, of correlating their color with the amount of pigmenting oxide found and of deciding whether there is a definite ratio between the amounts of iron and of chromium oxides present.

After crushing the rubies to pass a 200-mesh sieve, and fusing them with potassium acid sulfate in the ratio of 15:1,[4] the iron was first separated by means of cupferron[5] and was ignited to the oxide. In order

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