Tests of Other Organs.—Tests for the production of cn^+ substance by wild type salivary glands (one or two, with and without ovaries), brain tissue, gastric caeca and that portion of the hind gut including the imaginal ring (which regenerates a portion of the hind gut of the imago, Robertson[8]) have all given negative results.

Modification of Ocellus Color.—Vermilion and cinnabar flies have white or very pale ocelli while in wild type and brown flies these organs are brown. It has been noted that *cn bw* flies in which the eye color has been strongly modified by cn^+ substance have unmodified ocelli while *v; bw* flies showing a strong modification of eye color also show a strong modification of ocellus color toward brown. This suggests that ocellus color in cinnabar is autonomous in development, but that in vermilion it is not. However, it remains possible that higher concentrations of cn^+ substance will modify the ocelli of cinnabar flies.

[1] B. Ephrussi and G. W. Beadle, *Bull. Biol. Fr. Belg.*, **71**, 54–74 (1937).
[2] G. W. Beadle and B. Ephrussi, *Genetics*, **22**, 76–86 (1937).
[3] A. H. Sturtevant, *Proc. Sixth. Int. Cong. Genet.*, **1**, 304–307 (1932).
[4] K. V. Thimann and G. W. Beadle, these PROCEEDINGS, **23**, 143–146 (1937).
[5] B. Ephrussi and G. W. Beadle, *Genetics*, **22**, 67–75 (1937).
[6] B. Ephrussi, C. W. Clancy and G. W. Beadle, *C. R. Acad. Sci., Paris*, **201**, 1145 (1935).
[7] B. Ephrussi and G. W. Beadle, *Bull. Biol. Fr. Belg.*, **71**, 75–90 (1937).
[8] C. W. Robertson, *Genetics*, **22**, 205 (1937).

THE REGENERATION OF PLATE ROWS IN MNEMIOPSIS LEIDYI, AGASSIZ

BY B. R. COONFIELD

DEPARTMENT OF BIOLOGY, BROOKLYN COLLEGE, AND THE MARINE BIOLOGICAL LABORATORY, WOODS HOLE, MASS.*

Communicated February 3, 1937

The power of Mnemiopsis to regenerate parts of its body that have been injuried in nature or that have been removed during experimentation is remarkable (Mortensen, 1913, and Coonfield, 1936 *a*). The rapidity of regeneration, the exactness reached in regulating the reformed organs, and the transparency of its body makes this animal an excellent one for experimentation. Organs such as plate rows and the apical organ can be observed clearly during their entire period of regeneration. The unusually rapid rate at which these organs reform is interpreted by me as being due either to a rapid movement and realignment of cells from the remaining parts of the removed organs or to the migration of nonspecialized cells into the wound area. This interpretation can be tested in this animal by

removing a part of an organ, leaving thus some of its cells in the animal, and by removing this organ entirely. Therefore the purpose of experiments cited here was to test this interpretation by cutting out a part of a plate row and by removing the whole of a plate row. Histological evidence will not be given since a successful technique for this has not been developed.

Experiments.—The method of keeping and observing the experimental animals that are referred to here was the same as for those reported by Coonfield (1936 *a*). Three types of experiments were performed. In one experiment, a small section of a plate row was removed from the mid-section of the row (Fig. 5), or from near the apical end of the row, or from near the oral end of the row. In the second type of experiment the entire row on which plates normally are found was cut out (Fig. 4). In this experiment a small part of the row canal was left in place both at the oral end and at the apical end of the animal. These parts of the row, however, lie in the mesogleal layer and have no plates above them. In the third type of experiment the two ends of the animal were cut off (Fig. 2) so as to remove the row and canal connections at the infundibulum and those connections at the bases of the auricles. A part of a row or the entire row (Fig. 3) was then removed from the remaining mid-piece of the animal.

In order to understand what is included in the term plate row the following description is given. There are eight plate rows, four adtentacular and four adesophageal, in the body of Mnemiopsis. Each row connects to the infundibulum as a canal at the apical end of the animal. Each passes from within the mesoglea in this region to near the surface of the body. At the oral end of the animal each of the four adtentacular rows passes into an auricle while each of the four adesophageal rows sinks into the mesoglea as a canal. Plates are found on the rows only in the regions where the canals are near the surface of the animal's body. A plate row therefore consists of a canal which is without plates at both ends of the body and which has plates on it between these two ends. The canal sends out a lateral branch on each side to the base of each plate.

Short Section of a Row Removed.—A wedge-shaped piece of a row containing 10–20 plates was cut out of the animal. Such a piece was removed from the mid-part of a row and also from near either end of a row. The ends of the row were observed during the entire period of regeneration, since each had been stained at the time of cutting by Nile blue sulphate in agar blocks. The operations were done on both adtentacular and adesophageal rows with no apparent difference in the results.

Immediately following the removal of a wedge-shaped piece of a row the lateral edges of the wound moved together and fused. Within three hours after the operation a considerable number of cells migrated from within the mesoglea and concentrated at the healed region between the remaining ends of the row. These cells formed a line (cord) in this region and as this

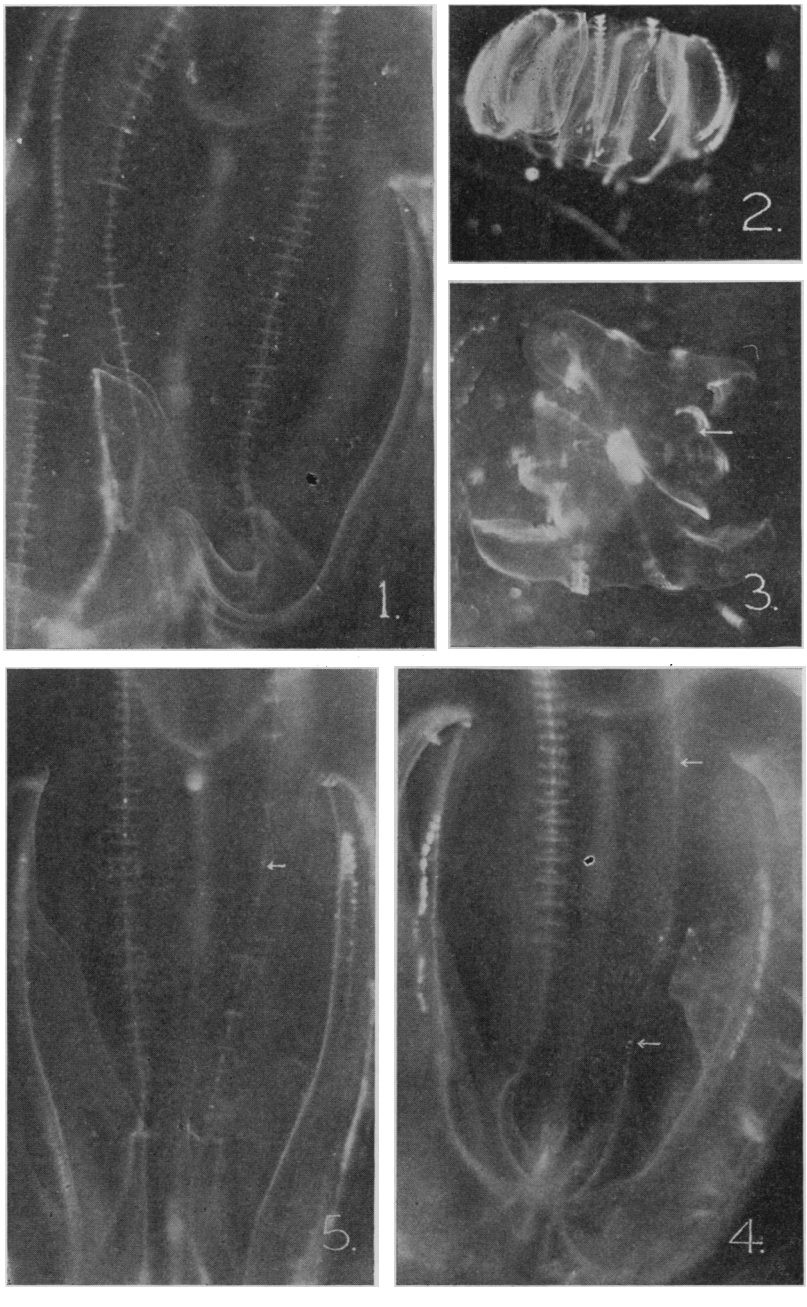

PLATE I

(Description on opposite page.)

was occurring the muscle strands anchored both at the cut ends of the row and deep in the mesoglea beneath contracted to bring the ends of the row gradually together until they fused (Fig. 5). Within an hour after the ends of the row had been brought together, the cellular mass in this region hollowed out to make the canal continuous. Since the ends of the row were stretched as they were pulled together by muscles, the plates of the row were separated from each other. Within about three days after the canal became continuous new plates began to form on the row in between the old plates.

Entire Row Removed.—The entire length of a row on which plates regularly grow was removed. By this operation the two ends of the canal were left in place. Thus some of the endodermal part at each end of the row was left in place after the operation. The wound healed soon after the operation and within three hours cells migrating from the mesoglea concentrated at the healed region and formed a cord between the remaining ends of the canal. The ends of the canal were pulled toward each other to some extent, due to the contracting muscle strands of the row. These ends, however, did not move entirely across the wound area (Fig. 4). The cord which had been formed by the mesogleal cells hollowed out and became a canal connecting the two ends of the old canal. Food was seen to pass through this canal, proving thus that it was continuous. Three days after this time plates began to form above this canal.

Row Removed from Mid-Piece.—The mid-piece of the body of Mnemiopsis was obtained by cutting the animal across just below its infundibulum and above its auricles (Fig. 2). Thus all canal connections were parted by two cuts. By cutting out the entire remaining portion of a plate row from this mid-piece the endoderm in this particular region was removed. Either a portion of a row or an entire row was removed from the mid-piece. These operations were done on both the adtentacular and the adesophageal rows.

DESCRIPTION OF PLATE I

Fig. 1. Part of the adtentacular surface of an injured specimen collected in its natural habitat. The two rows at the left of the photograph show regenerating plates.

Fig. 2. The mid-piece of a specimen immediately after its apical and oral ends have been removed.

Fig. 3. Photograph of the apical end of a mid-piece healing at its cut surface. The arrow indicates the region from which an adtentacular row had been removed completely. Photographed 24 hours after the operation.

Fig. 4. A regenerating adtentacular row following its complete removal is shown on the right of this photograph. The new canal can be seen and it occupies the region between the two arrows. Mid-way between these two arrows a mass of materials can be seen. This mass of materials was produced by the migrating cells within the mesoglea. Photographed 12 hours after the operation.

Fig. 5. Photograph of the pulling together of the two cut regions of the remaining ends of an adtentacular row following the removal of its mid-part. The fusing cut regions are indicated at the arrow. Photographed 12 hours after the operation.

The wound made by the removal of a row healed quickly and soon afterward the healing at the cut ends of this mid-piece was complete (Fig. 3). When a portion of a row was left in place a new row regenerated from this remaining part. There was considerable stretching of the part of the old row and at the same time many of the cells within the mesoglea concentrated at the wound. These cells probably contributed to the formation of the new canal and row. The new row was complete except for its plates within three days. Following the removal of the entire row, new row canals which originated at the two ends of the mid-piece were complete at the end of four days. New plates began to form on the regenerated canal one day after the canal was formed, following the removal of a portion of the row and also following the removal of an entire row. The time and procedure of regeneration of part and whole rows were the same in the adtentacular and adesophageal regions.

In order to ascertain whether the line (cord) formed by the migrating cells of the mesoglea which followed the removal of a part or the whole of a row was only a part of the mechanism of ordinary wound healing, the following experiment was executed. A wedge-shaped piece of the body involving both ectoderm and mesoglea was removed from between the plate rows. This was done between the adtentacular and the adesophageal rows. The wounds healed promptly and without any line (cord) formation and also without any visible migration of the mesogleal cells.

Discussion.—Records of experiments cited in this report and evidence brought out previously (Coonfield, 1936 *a*) show that regeneration in Mnemiopsis is quite rapid. I have described experiments which were designed to test the hypothesis that rate of regeneration as well as the process itself in Mnemiopsis depends either on migrating cells from the remains of extirpated organs or on migrating nonspecialized cells. It is quite possible that regeneration in Mnemiopsis is due to both of these processes.

In the experiments wherein parts of a plate row were left in place, I am certain that cells migrated from these parts into the wound gap and contributed to the regeneration of the removed part. This conclusion is based on results of the experiments where a portion of a row was removed from the whole animal and from an isolated mid-piece. The cut ends of the row were stained with Nile blue sulphate to enable me to observe any change in their location. These ends moved toward each other until fusion occurred. During the migration the ends of the old row were pulled by the mucle strands. This resulted in a thinning out of the stretched canal. While this was taking place a great many cells within the mesoglea concentrated to form a definite line between the ends of the old row. Whether these cells actually contributed to the new canal I cannot be certain. In the experiment where a portion of a row was cut out of a mid-piece of the animal, the new canal formed from the remaining end of the row. Here too

a considerable stretching of the remaining end of the row occurred. Regeneration actually began at this end and continued along the region occupied previously by the removed section of the row. In the experiments in which the whole row was removed from a mid-piece of the animal, regeneration of this row began at each end of this piece. Since the wound at the two cut surfaces of the mid-piece healed within three hours, and since the ends of the other seven canals were brought together before the rows started to regenerate, I assume that endodermal cells from these canals contributed to the formation of the new canal and row. Here again cells within the mesoglea were seen to move and then concentrate to form a line in the area from which the row had been cut. The results therefore show that cells from the remaining parts of an extirpated plate row and cells in the mesoglea were active in the regeneration of the lost parts of the row.

The experiments, in which an entire row on which plates usually grow was extirpated, left a small amount of the canal in place in the mesoglea. These remaining parts of the canal stretched to some extent but failed to cover the operated region completely (Fig. 4). Cells from the mesoglea were seen to migrate into the wound area and to form a definite line between the two ends of the canal. This line of concentrated cells hollowed out to form a canal continuous from end to end. The lining up of these cells in the exact region occupied previously by the removed section of the row contributes further to the evidences of polarity within Mnemiopsis (Coonfield, 1936 *b*). The evidence based on the results of these experiments shows that the nonspecialized cells in the mesoglea migrate to the wound area following the removal of a row and form a new canal. Later plates were formed along and above this new canal to complete the regeneration of the extirpated plate row. It is interesting to note further that as the plates formed along this new canal and also along the regenerated canal following the removal of parts or the whole of a row, as described in the other experiments in this report, these plates regenerated first at the apical end of the row.

In conclusion the experiments discussed here show that when a portion of a plate row was removed from a whole Mnemiopsis, or when a portion of a row or the whole of a row was removed from a mid-piece of this animal, regeneration is due primarily to the migrating endodermal cells from the remaining parts of the canal or from neighboring canals. These experiments show further that when the entire canal above which plates grow was removed from the whole body of Mnemiopsis, regeneration is due primarily to the migrating nonspecialized cells from the mesoglea. Therefore these two processes account in part for the rate of regeneration as well as for the mechanism itself in this animal.

Conclusions.—1. A plate row regenerates following its removal in part or as a whole.

2. The sequence in the regeneration of a plate row is as follows: healing, stretching of the remaining part or parts of the canal and concentration of mesogleal cells at the wound area, fusion of parts of the canal, hollowing out at the region of fusion and formation of plates above the new canal.

3. Cells from the remaining part or parts of a row or from neighboring rows and also nonspecialized cells in the mesoglea take an active part in the regeneration of plate rows.

4. Contracting muscle strands which are anchored to the plate row and also in the mesoglea aid in the reformation of a row following its removal in part or as a whole.

* Contribution No. 18 from the Department of Biology, Brooklyn College.

B. R. Coonfield, "Regeneration in Mnemiopsis leidyi, Agassiz," *Biol. Bull.*, **71**, 421 (1936 *a*).

B. R. Coonfield, "Apical Dominance and Polarity in Mnemiopsis leidyi, Agassiz," *Biol. Bull.*, **70**, 460 (1936 *b*).

Th. Mortensen, "On Regeneration in Ctenophores," *Videnskr. Meddel. fra Dansk naturh. Foren.*, **66**, 45 (1913).

IMMERSION OF THE FOURIER TRANSFORM IN A CONTINUOUS GROUP OF FUNCTIONAL TRANSFORMATIONS

BY E. U. CONDON

DEPARTMENT OF PHYSICS, PRINCETON UNIVERSITY

Communicated January 20, 1937

The Fourier transform $g(u)$ of a function $f(x)$ is defined by

$$g(u) = \frac{1}{\sqrt{2\pi}} \int f(x) e^{iux}\, dx \qquad (1)$$

where $\int$ means integration from $-\infty$ to $+\infty$. This possesses* the inversion formula

$$f(x) = \frac{1}{\sqrt{2\pi}} \int g(u)\, e^{-iux}\, dx. \qquad (2)$$

Evidently if we write F for the operation performed on f in (1) then (1) and (2) can be written

$$g(u) = Ff(x), \quad f(-x) = Fg(u) = F^2 f(x),$$

from which it follows that

$$f(x) = F^4 f(x) \qquad (3)$$