strongly that the controlling factor is the amount of air dissolved in the water; when this amount is known to be large, the bubble grows, and when the water has been degassed before use, the bubble shrinks. Guild appeals to physical chemists to "determine the laws governing this phenomenon and to work out the true explanation of it."

We think that the phenomenon is much less obscure than Guild supposes. In fact, his own experiments are extensive enough to show that there are no very obscure factors operating. It is merely necessary to suppose that a collodion membrane is permeable to air. Tap water is commonly saturated with air at a pressure greater than atmospheric; that is, the partial vapor pressure of the dissolved air is greater than one atmosphere. Then if the membrane is permeable to air (that is, nitrogen, oxygen, etc.) air will pass through until the water on both sides contains air at the same partial pressure. But if this partial pressure is greater than the mechanical pressure on the water, which is, of course, one atmosphere, then the system is unstable, air will be evolved more or less rapidly and a bubble will form. Once the bubble is started, the rate of growth will be proportional to the interface, that is, to the surface of the bubble. When we have the bubble in the sac and flow degassed water past it, the same processes occur in the reverse direction. The water inside the sac is saturated with air at a pressure greater than that outside, so that air is lost to the running water and the bubble shrinks.

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HISTORY OF THE DISCOVERY OF PERIODIC REVERSAL OF HEART-BEAT IN INSECTS

SUPPLEMENTARY NOTE

IN a recent paper[1] I have traced the early history of the discovery of periodic reversal of peristalsis of the heart in Lepidoptera, a phenomenon which accompanies metamorphosis and continues to the end of life, resembling in certain respects a similar phenomenon in ascidians. Periodic reversal in Lepidoptera, discovered by Malpighi in 1669, expressly denied in the first half of the nineteenth century by such excellent observers as Herold (1823) and Verloren (1844), confirmed for the chrysalis (silkworm) by Cornalia (1856), was first adequately described by Bataillon (1893, 1894).

In writing this historical review I was unaware of the second paper on the subject by Bataillon,[2] in which he extended his observations to the adult silkmoth and found, as I have done recently, that periodic reversal in the direction of the heart-beat is not a temporary phenomenon connected with metamorphosis but, in confirmation of Malpighi's observations, is characteristic of the adult moth. I will here briefly summarize and translate Bataillon's later conclusions.

He states that, having regarded the phenomenon as connected with disturbances in nutrition during metamorphosis, he had been skeptical of Malpighi's observations on the adult, especially in view of the fact that they were made on the eviscerated insect under obviously abnormal conditions. Continuing he says:

> If the dorsal integument is carefully shaved and the median line smeared with glycerine to make it more transparent, the heart becomes visible, and its movements can be observed until death. Here, again, in spite of the defects of his technique, Malpighi was right. The circulation takes place sometimes in one direction, sometimes in the other.

On the basis of experiments upon full-grown larvae, he concluded that pupation and periodic reversal of circulation in the dorsal vessel depend upon three factors which presumably reduce internal pressure, *viz.*, elimination of the contents of the intestine, transpiration and spinning.

Of the adult insect he says:

> There are, at first, successive periods of direct or of reversed circulation every one or two minutes; then these periods are longer, especially while the individuals are in copulation. Finally, the contractions of the dorsal vessel succeed each other regularly and alternately, from in front backward and from behind forward, becoming less and less marked at the approach of immobility and death.

Thus he calls attention to the comparatively short periods of forward and backward peristalsis in the young moth, to the longer phases sometimes induced by copulation and to the reduction of the successive alternating phases in old age to single beats, observations similar to those which I have made.[3]

Hypodermic injection of saline solution (seawater) into the blood of the adult moth caused an immediate cessation of reversal; forward beating alone occurred for several hours. The employment of suction, on the other hand, was followed by long periods of backward beating. By the injection of air into the hemolymph, the forward flow of the blood

[1] J. H. Gerould, *Biol. Bull.*, 56 (3): 215–225, 1929.

[2] E. Bataillon, "Nouvelles recherches sur les méchanismes de l'évolution chez le Bombyx mori," *Revue bourguignonne de l'enseignement supérieur*, 4: 1–16, 1894.

[3] J. H. Gerould, "Periodic Reversal of Heart Action in the Silkworm Moth and Pupa," *Jour. Morph. and Physiol.*, 48: 385–430, 1929.

was enormously stimulated and became even tumultuous; this was seen in marked degree in old individuals which were decrepit and motionless. Such a moth, for example, injected in the morning, immediately was thrown into a state of intense activity which continued during the rest of the day, followed by death a few hours later.

In conclusion Bataillon says:

> The entire life of *Bombyx* from the spinning to death presents constant physiological characteristics: lowering of internal pressure; respiratory and circulatory disturbances, and histolysis. . . . The circulatory disturbances . . . are merely the permanent index of more profound disruptive changes.

Both Bataillon in his earlier paper (1893)[4] and Fischer (1918)[5] suggested that periodic reversal may be due to increased acidity of the blood accompanying metamorphosis. This idea is supported by a recent paper in Japanese by Yokoyama[6] who has succeeded in bringing about periodic reversal prematurely in the larva by blocking the abdominal spiracles with enamel paint or by injecting into the hemolymph of the abdomen (at the eighth abdominal segment) weak solutions of lactic or acetic acid.

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THE CHEMICAL CONSTITUTION OF PECTINATELLA

IN searching for material in order to study the synthesis of protein, Pectinatella was examined. The thought was that here was a source of rapidly formed gelatin, or its precursor collagen. A mass weighing from 2 to 5 kilos is formed within a few weeks, comparable to the growth of certain tumors. The fact that investigation reveals that the jelly-like secretion is not of the nature of collagen but of true protein of a fairly high order does not rob the study of its interest or importance, for the organism stands as a readily available source of study of extremely rapid synthesis of protein.

The material was supplied by Professor Raymond C. Osburn, director of the Stone Laboratory, Put-in-Bay, Ohio. Pectinatella is available in large quantities during the summer and autumn. It may be preserved in fresh water, and sampling is possible from the growth, the remainder proceeding with its growth without detriment.

The water content is high. A specimen weighing 1,200 grams gave, on drying, 5.0 grams dry weight. Protein, etc., therefore make up about 0.5 per cent. of the normal body.

The protein reactions were typical of such proteins as ovalbumin, serum albumin, etc. The biuret reaction was positive and typical, that is, like that of white of egg and not like that of gelatin or peptone.

The following amino-acids were demonstrated: tyrosin, tryptophane, cystin. In a cold extract of the dried material all three were positive, but the reactions were intensified after acid hydrolysis. This was especially true of cystin. The protein was heat coagulable.

Of the inorganic substances, sodium chloride was demonstrable. Phosphorus was negative before hydrolysis, and after boiling with equal volumes of sulphuric and nitric acids, none was demonstrable. Calcium is present in copious amounts, as one would suspect from the calcareous nature of the body and statoblasts.

Characteristic of these organisms is the supporting structure composed of chitin. In the specimens examined chemically, glucosamine (galactosamine?) was readily demonstrable after hydrolysis. This amino-sugar has extensive distribution through the animal kingdom and in man occurs in cartilage.

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JANUARY 3, 1930

REPORTS

THE TEACHING OF HYDROBIOLOGY AND AQUICULTURE IN AMERICAN UNIVERSITIES

THE committee on aquiculture of the Division of Biology of the National Research Council has had a subcommittee engaged in gathering data on the teaching of hydrobiology and aquiculture in American universities. This committee has consisted of James G. Needham, A. G. Huntsman, Chancey Juday and E. N. Transeau. A report has recently been submitted, embodying the following data.

Sixteen institutions in the United States and Canada give courses in these subjects. These institutions and their undergraduate courses are listed in the accompanying table. These courses are called by various names, as indicated in the footnotes to the table.

[4] E. Bataillon, *Bull. Sci. France et Belgique,* 25: 18–55, 1893.

[5] E. Fischer, "Eine bei Raupen und Puppen beobachtete Umkehrung der peristaltischen Herzbewegung," *Entom. Rundschau. Stuttgart,* 35: 9–10, 1918.

[6] T. Yokoyama, "Notes on the Periodic Reversal of Heart-beat in the Silkworm *Bombyx mori* L.," *Dobutsugaku Zachi* (*Zool. Mag.*), 39, No. 459, Suppl.: 45–51, 1927.