

X. "An Experimental Inquiry into the alleged Sugar-forming Function of the Liver." By F. W. PALVY, M.D. Communicated by Dr. OWEN REES. Received May 26, 1858.

(Abstract.)

The author commenced by stating that the question to be discussed in his communication was, not whether sugar was to be found in the animal system independently of a saccharine alimentation, for that he considered to stand upon irrefutable ground; but whether the sugar encountered in the liver *after death* was a natural representation of the condition during life, or was only the result of a *post mortem* occurrence. He had noticed as early as February 1854, that the blood removed by catheterism of the right ventricle during life, was almost completely destitute of saccharine impregnation. The observation did not then, however, receive the attention it deserved; but on repeating the experiment at a later period, and meeting with a similar result, an investigation was made which has led to the conclusions advanced in his communication.

From upwards of sixty observations, it is asserted that the condition of the blood after death can no longer be taken as indicating its state during life. For, if blood be withdrawn from the right ventricle of the living animal in a natural or tranquil state, there is scarcely an appreciable amount of sugar to be discovered, whilst, if the animal be afterwards sacrificed and blood collected from a fine incision of the ventricle, it will be found to present a strong indication of the presence of sugar. In one of the experiments quoted, there was a barely appreciable reaction in the blood removed during life, and nearly 1 per cent of sugar in the blood collected after death, the animal having been sacrificed immediately after catheterism has been performed.

Observing this striking contrast in the blood abstracted from the right ventricle *before* and *after* death, the possibility occurred that there might be a corresponding contrast in the organ that was considered to be specially endowed with a sugar-forming function. The recent researches of Bernard had taught us that a material naturally existed in the liver which was extremely susceptible of conversion into sugar. It was this material, in fact, which was looked upon as

giving rise to the sugar thought to be largely present in the liver during life. At the outset of the inquiry, an agent was sought for which would check the transformation of the sugar-forming material after death, and thus present the liver in a condition as near as possible to that which existed during life. Potash was found to possess this effect without destroying the principles concerned. A strong solution of it was then injected, as instantly after death as practicable, through the portal vein into the liver; and, as the result, the organ presented scarcely any appreciable trace of the presence of sugar. A liver similarly treated when it had been allowed to remain a short period after death, gave the usual strong reaction of sugar that has been hitherto noticed. By injecting only a part of the organ with the alkali, it is most strikingly susceptible of demonstration, that the presence of sugar is in reality due to a *post mortem* occurrence, and can therefore be no longer looked upon as a representation of the natural *ante mortem* condition.

The sudden abstraction of heat from the liver instantly after death, leads to a similar arrest of the production of sugar, and thus enables us likewise to represent the real condition of the organ belonging to life. In one of the experiments mentioned, where a dog was sacrificed, and a piece of the liver instantly sliced off and thrown into a freezing mixture of ice and salt, the absence of sugar was almost complete; the amount at least was so small, that it was found impossible to arrive at a quantitative determination with a concentrated spirituous extract, notwithstanding the process is susceptible of so great a delicacy. The portion of the liver which was not submitted to the action of cold, and which was allowed to remain a short time in the animal, yielded on analysis an indication of 2.96 per cent. of sugar.

Division of the spinal cord in the lower part of the cervical region, the effects of which have been noticed by Bernard, but differently interpreted, leads to a corroboration of the deductions drawn from the preceding experiments. When the weather is cold or moderate, the operation is followed by a gradual reduction of temperature; and if the animal be sacrificed when its body has cooled down to about 70°, the liver is found free from sugar, upon an ordinary immediate examination, because at such a degree the *post mortem* transformation is not effected with sufficient rapidity to lead to our deception.

Placed aside, however, it soon becomes strongly saccharine. Should the operation of division of the cord be performed, and the temperature of the animal be afterwards maintained at about the ordinary height by exposure to external warmth, then the liver is as strongly saccharine upon ordinary examination after death, as if the animal had been taken and simply sacrificed.

By oiling the coats of rabbits and exposing them to cold, the temperature of the body falls, and precisely the same phenomena are noticed as after division of the cord.

With frogs in a vigorous condition, the presence or absence of sugar in the liver submitted to the ordinary process of examination after death, is dependent upon the temperature of the animal at the time of the destruction of life. This fact was independently noticed by myself about the time that it was mentioned by Bernard in a communication to the Parisian Academy of Sciences. Bernard's interpretation of it is connected with the relative activity of the abdominal circulation; but, for myself, I bring it forward as strongly supporting the views that have been advanced, and consider it to be explained by the influence of temperature on the *post mortem* production of sugar.

The material which occasions the presence of sugar in the dead liver, has been called by Bernard "Glucogenic matter,"—a term which, being only specially applicable after death, it is suggested should be abandoned, and replaced by Hepatine.

The amount of hepatine in the liver of the dog is much greater under a vegetable than an animal diet. The amount is also increased by mixing sugar with animal food. From the examples given, it is shown likewise that the relative weight of the liver presents a proportionate variation, according to the quantity of hepatine present. In eleven dogs taken indiscriminately, that had been restricted to an animal diet, the weight of the liver was one-thirtieth that of the animal. The average per-centage of hepatine yielded by eight livers, also taken indiscriminately after an animal diet, was 6.97. Five instances have been collected of dogs restricted to a vegetable diet for some days prior to death. The average weight of the liver was one-fifteenth that of the animal. In only three of the examples was the actual amount of hepatine determined, but in the other two it was noticed to be exceedingly large. The average given by the

three was 17·23 per cent. Four dogs were placed upon an animal diet, and about a quarter of a pound of ordinary cane-sugar administered daily for a short period. The average weight given by the four livers was one-sixteenth and a half that of the animal, and the average amount of hepatine yielded was 14·5 per cent.

The natural destination of hepatine in the living body remains to be determined. It has also to be shown how it resists transformation into sugar during life, when it is so rapidly changed at an elevated temperature immediately after death. A possible analogy may be presented by the following occurrence :—When a solution of hepatine, *in a neutral state*, is placed in contact with saliva, an almost instantaneous transformation into sugar takes place; but if a little acid alkali or carbonated alkali be added, scarcely a trace of change is for some time discoverable.

Under normal circumstances, rarely an appreciable amount of sugar is encountered in the circulatory system—only, according to my analyses, from about ·047 to ·073 of a grain in 100 grains of defibrinated right-ventricular blood; and this would appear to result rather from a simple escape of a small amount of hepatine from the tissue of the liver into the blood whilst circulating through the capillaries, than from a special functional operation of the organ; for when a disturbance of the circulation, whether by congestion or the opposite, is occasioned, sugar makes its appearance to a considerable extent in the system, because the admixture of hepatine with the blood is favoured. It can be easily shown by experiment, that on introducing hepatine into the circulatory system, a saccharine state of the blood is induced, and if enough have been employed, a strongly marked diabetic condition of urine is established.

Sacrificing an animal and maintaining the circulation by performing artificial respiration, occasions a well-marked diabetes. With the destruction of life, the transformation of hepatine into sugar takes place, and this, being carried away by the blood, is eliminated by the kidneys, and thus renders the urine strongly saccharine.

Many phenomena which were before obscurely explained, receive a lucid interpretation from the new facts which have now been brought to light.