valley of the Missouri in Iowa a bed of coal, similar in all respects to this one, occurs, and is probably a part of the same bed. The evidence from deep wells at Omaha, Nebraska City, Beatrice and Lincoln, the last named well being 2,463 feet deep, points to beds of coal but a few inches in thickness and thinning rapidly to the westward.

For a number of years coal has been mined in various places in the southeastern, or carboniferous portion of this state, as at Nebraska City, Rulo, South Fork and elsewhere, but the thickness of coal in each case scarcely equaled eighteen inches and there was no profit in mining such coal. The best efforts of a Lincoln company headed by Mr. Bullock, a man of ability and experience, failed to make the mine at Rulo profitable, and the undertaking, like that of others, was abandoned at the end of two years as unprofitable.

Although considerable amounts of coal were furnished at one time by the South Fork Mine to the neighboring towns, Table Rock, Humboldt, Salem, Dawson and Seneca, the bulk of coal mined thus far has been used by those mining it. Farmers and others often dig out their own supply of winter fuel. A vigorous effort was made to develop a bed, said to be eighteen inches thick, in northeastern Nebraska, it being a lignitic coal in the Cretaceous and in no way related to the coal recently discovered. Simultaneously with the discovery of coal at Peru come reports not yet verified of a bed equally thick at Falls City. It has certainly been the opinion of geologists at large that commercial coal was not to be expected in Nebraska, and the occurrence of a workable bed in Peru does not materially change this opinion, for at the best it must be local, as shown by surrounding deep wells. Though limited to a square mile or so it is of importance to this commonwealth.

The owner of the land on which the bed of coal was found leased the mine at the rate of fifty cents on every ton of coal sold for three dollars, and one dollar on every ton sold at four dollars, which may be an item of interest to those regularly engaged in mining.

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April 5, 1906.

THE RELATION OF PRESSURE IN THE CORONARY VESSELS TO THE ACTIVITY OF THE ISOLATED HEART, AND SOME CLOSELY RELATED PROBLEMS.[1]

The data recorded in this note were obtained in a series of experiments on the excised hearts of turtles, and on the hearts of guinea-pigs, rabbits, cats and dogs, both excised and in situ. The object was to study the effect of various artificial nutrient solutions under different conditions of temperature and pressure with a view of determining their efficiency in restoring cardiac activity. By efficiency is meant the capability of the heart of maintaining an adequate blood pressure.

Defibrinated blood, blood dilutions, Locke's, Ringer's, Howell and Greene's two solutions, 0.9 per cent. sodium chloride, paraffin oil and hydrogen gas were employed.

The animals were etherized and rapidly bled to death, and the blood collected and defibrinated. In isolated preparations, the hearts were rapidly removed and suspended by the base. Cannulæ were inserted and the pericardium removed. Ventricular tracings were made by connecting this portion of the heart to a simple lever which recorded the contractions on a drum. Auricular tracings also were made in some experiments. In all cases of isolated preparations, before the injection was begun, the hearts were bathed in the solutions to be employed. With all the solutions except blood, or blood dilutions, oil and hydrogen, a short series of more or less rhythmical contractions, similar to those evoked by simple mechanical stimulation, promptly followed their application to the heart. In the course of the experiments with the hearts in situ, a constant parallelism was observed between the aortic pressure and the rate of the heart. In order to determine whether this result was

[1] All references to literature have been purposely omitted.

due to intraventricular or to coronary pressure, the heart was excised and the ventricles slit open; injections under pressures varying from 44 mm. to 200 mm. of mercury were then made through the aorta and also directly into the anterior coronary artery. On cessation of the contractions following the external application of the solution to the heart, perfusion through the coronary arteries was begun, and with blood and its mixtures, oil, hydrogen gas, and all solutions, rhythmical beats followed, the magnitude and rate of which varied with the pressure. The evidence seems conclusive that there exists for each solution a certain optimum pressure which produces the maximum rate without a diminution of the amplitude, and that this optimum changes with the condition of the heart. With hearts from the same species of animals, the optimum pressure for each solution may vary widely at corresponding periods of the experiment. The actual change in rate for a given change in pressure may not be constant for different hearts under similar conditions; nor for the same heart under different conditions. The rate may change three hundred per cent. within the limits of the pressure used, variations occurring when the pressure is changed (1) from low to high, or (2) from high to low. Increase in pressure may be considered as a stimulation in the ordinary sense of the term, for the reason that an increase above the optimum causes an increase in rate, and that delirium cordis may be produced if the pressure be raised sufficiently high. If the pressure now be gradually lowered a regular rhythm returns, which becomes slower concomittantly with the fall in pressure. With the same heart, several successive increases and decreases of pressure may cause nearly identical rhythms at corresponding pressures, the gradual increase or decrease of pressure being attended by a fairly constant change in rate for corresponding changes in pressure. A sudden and profound fall in pressure may cause either (1) an immediate increase in rate succeeded by a decrease to the rate previously observed for that pressure, or (2) a slowing of the rate, even to total cessation, succeeded by a return to the rate previously observed for that pressure. The first phenomenon bears some resemblance to that following a sudden fall of blood pressure in the intact animal, *i. e.,* acceleration, and the second bears a striking resemblance to vagus inhibition in the intact heart. In the preliminary experiments with the heart in situ the higher cardiac nerve centers were inactive. When the animal is under light anæsthesia, the changes in rate produced by changing the pressure, both before and after section of the cardiac nerves, are not the same as in the isolated heart, or in the resuscitated heart in situ. The changes in the rhythm are not due to alterations in intraventricular pressure. If, in the turtle, the cannula is introduced directly into the ventricle the beat may be practically stopped, owing, presumably, to distention of the ventricle. Free incision of the ventricles in the excised mammalian heart precluded any distention.

With hearts in situ, and in good condition, following injection of blood dilutions into the aorta, the left ventricle got up a pressure greater than that used for injecting. In no instance were efficient contractions obtained by injecting artificial solutions alone. Their use appears to cause a rapid deterioration of cardiac tissue as regards its susceptibility to restoration and efficiency, though complete loss of irritability may not occur for a long time; *e. g.,* from strips of cats' ventricles bathed in Locke's solution, tracings were taken showing contractions for a period of more than six hours, at which time the experiment was discontinued. Efficient contractions, maintained for relatively long periods, followed the injection of defibrinated blood or blood dilutions. If the perfusion with artificial solutions had not been too prolonged, the hearts could be restored to fairly good condition by perfusion with blood mixtures. The optimum pressure for blood and its dilutions was considerably higher than that for the artificial solutions. This difference may be due in part to a difference in viscosity, but it is also possible that artificial solutions increase the excitability of the preparation by direct action primarily on the vessel walls. Two facts lend some support to this view: (1) bathing the hearts with artificial solutions is attended by contractions, while blood and its mixtures produce no such effect; and (2) if two strips of cat's ventricle, one cut so as to include a considerable part of the anterior coronary artery, and the other cut from the anterior lateral margin of the right ventricle so as to include no large vessels, be suspended and irrigated with the artificial solutions, the strip containing the coronary artery soon exhibits strong tonus upon which contractions may be superposed, while a little later the other strip begins to contract more or less irregularly and without any change in tonus. It may be observed in this connection that a strip of thoracic aorta may exhibit a deportment similar to that of the ventricular strip containing the coronary artery.

From these observations we conclude that, with hearts under the conditions of our experiments: (1) It is highly improbable that the production of a rhythmical beat is dependent solely upon the constituents of any one of the artificial solutions employed; that these solutions alone are not sufficient to initiate or sustain efficient beats of the heart. It has been shown in this and other laboratories that such solutions are inadequate to restore or even to sustain the activities of the reflex nervous centers of mammals. We have found the addition of a certain amount of blood necessary to render these solutions efficient. (2) For the production of the efficient rhythmical beat of the isolated heart, pressure or circulation of a suitable medium in the coronary vessels is necessary. Injection of blood or its dilutions into the coronary veins is attended by much the same phenomena as have been recorded for injections into the coronary artery, the principal differences being the somewhat lower optimum pressure and the lower pressure necessary for the production of delirium cordis. The character of the beat may differ somewhat in the two cases. As the pressure in the veins necessary to produce rhythmical beats is in all probability higher than that normally present, the mechanism which initiates the normal rhythmical beat must be sought elsewhere. In further support of this view may be mentioned the fact, as determined by inspection, that, on injecting into the coronary artery, the beat begins before much blood appears in the coronary vein, although the beats are weak before the complete establishment of the coronary circulation. In suitable preparations, in which the rhythm is slow, the coronary artery, or the tissue immediately surrounding it, has been observed to pulsate, and the beat to spread from the coronary vessels over the heart.

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May 25, 1906.

NOTES ON ORGANIC CHEMISTRY.

ESTERIFICATION OF TERTIARY AND UNSATURATED ALCOHOLS.

Not long ago there was given, in this journal, an account of some recent improvements in the methods of preparing esters.[1] Although these are of undoubted value, yet the subject, as a whole, can not be said to be in a very satisfactory state because there are no methods, of general applicability, capable of furnishing a good yield of the esters of tertiary and unsaturated alcohols. The primary cause of the difficulty is the greater sensitiveness of these classes of alcohols, which results in the production from them of other compounds, such as unsaturated hydrocarbons or tarry products, in relatively large quantity. This behavior is further accentuated by the fact that the velocity of their reaction and their equilibrium points are both very low. Whereas, in the case of propyl alcohol, if 46.5 per cent. is esterified in one hour and 66.8 per cent. is esterified before equilibrium is attained, these values become 26.5 and 60.5 per cent., respectively, for secondary propyl alcohol, and for *tertiary*butyl alcohol, 1.5 and 6.6 per cent. The figures speak for themselves and demonstrate how great, relatively, is the opportunity for change to take place in the tertiary alcohol by the action of the high temperature or of the mineral acid or other 'catalyst' that may be present.

[1] Science, XXIII., 712 (1906).