ence for any month does not exceed 1° F. Comparing corresponding slopes of the two watersheds, the mean temperature is substantially the same. (2) Precipitation occurring as rain is practically equal on both watersheds. If the soil is saturated, as small a rain as 0.01 inch may cause the streamflow to respond; but ordinarily rains of 0.10 inch or less in summer merely replenish losses due to evaporation or transpiration, and do not affect streamflow appreciably. Most of the summer rains are not in excess of 0.25 inch, hence it is seen that summer rains are not, in general, of great importance. (3) A little less than 50 per cent. of the precipitation is snow, but it yields more than half the runoff. The average depth of snow per season is 113.3 inches. The maximum observed was 149.7 inches and the minimum 80.7 inches.

Interesting features of the streamflow records are: (1) Stream *A* rises more rapidly than *B* and reaches a maximum sooner than *B*, but before the flood has subsided a secondary maximum with a steadier flow may occur at *A*. This feature, as mentioned above, is easily explained by topography. (2) Winter and autumn show very little diurnal variation of streamflow; summer is more marked, with a maximum in the early morning hours and a minimum between 1 and 2 o'clock in the afternoon; spring, however, with the great amount of melting snow, has a pronounced diurnal period owing to alternate freezing and thawing. The amplitude of variation is greater at *A* than at *B*, and the *A* maximum and minimum are more pronounced. (3) An estimated disposition of 21.00 inches of precipitation, the average annual amount for eight years observations, is shown for *A* as follows:

Evaporation	7.39 inches
Transpiration	3.91 inches
Interception	3.62 inches
Runoff	6.08 inches
Total	21.00 inches

It is clear that the objective of all these studies is an accurate estimate of the relations between the various factors on *A* and *B* in order that, in the years following denudation, the conditions on *A* can be used as an index to what would have occurred on *B* had denudation not been effected. It is only in this way that the effect of the presence or absence of trees can be ascertained. Much of the paper, therefore, is devoted to these relations in too great detail for abstracting. Thirteen "rules" are developed as statements of these relations to be used in the later discussions. These concern ratios of discharges in different periods and at different times, time intervals between crests, probable height of crests, and the deposition of silt.

This experiment is of great practical importance with respect to hydrological problems—floods, irrigation, etc., and its outcome will doubtless be watched with the greatest interest by those who are concerned with these problems.

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SPECIAL ARTICLES

AN EARLY STAGE OF THE FREE-MARTIN AND THE PARALLEL HISTORY OF THE INTERSTITIAL CELLS

THE theory that the intersexual condition of the free-martin depends upon hormones secreted by interstitial cells of the testis of the male twin and distributed by its blood to the female depends primarily upon the demonstrated connection between fœtal vascular anastomosis and the intersexual condition of the female twinned with a male calf, and secondarily on comparative data. The time of effective action of the male hormone has been presumed to be very shortly after the beginning of sex-differentiation in the embryo (Lillie, '17) owing to the known normal condition of the embryonic membranes in such stages, which renders vascular connection possible, and the very profound nature of the effect. The earliest stage of the free-martin hitherto described is 7.5 cm greatest length (Lillie, '17; Chapin, '17). Sex-differentiation begins at approximately 2.5 cm. The gap thus indicated in our knowledge of this phenomenon is now largely filled up by study of a free-martin of 3.75 cm greatest length, and of the complete history of the interstitial cells of the testis and ovary from 2.5 cm throughout life.

In the 3.75 cm free-martin the gonad is much less than half the bulk of those of normal males and females of corresponding age. The germinal epithelium (cortex of ovary) is only about one fifth the thickness of that of the normal female of corresponding age and less developed than a female of 3 cm greatest length. The blood of the male has already operated to inhibit growth of the entire gonad and to stop the differentiation of the cortex. The specific male sex-hormone is thus demonstrably present in the blood at this stage.

Interstitial cells appear in the testis of the normal calf embryo between the stages of 2.7 and 3 cm greatest length. At the latter stage they are identical in size and histological structure with those of later stages and the adult; they have a continuous history up to adult age. In the female, on the other hand, comparable cells do not appear in the ovary until about the time of birth.

The following conclusions may be drawn:

1. The appearance of interstitial cells in the testis at the very time that a male hormone may be demonstrated by its physiological effects (free-martin) is strong evidence that these cells secrete the sex-hormone.

2. The absence of such cells in the female and the corresponding lack of effect of the female blood on the male twin argue in the same sense.

3. In the female of cattle sex-differentiation before birth is apparently due to genetic factors exclusively; in the male the genetic factors are intensified by the production of a hormone.

The detailed data will be published shortly by the authors separately, Mr. Bascom dealing with the interstitial cells.

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THE EFFECT OF ACID ON CILIARY ACTION AS A CLASS EXERCISE IN pH

THE effects of changes in hydrogen-ion concentration have received so much attention in the recent literature that it has become desirable to incorporate some exercise into laboratory courses in physiology which will illustrate the principles by which the p_H of a solution is determined. For the majority of college laboratories "gas chain" apparatus, potentiometers, etc., are out of the question for student work. The colorimetric method, however, which is very simple and sufficiently accurate for general laboratory problems, can be used to good effect at very little expense.

For our class in general physiology consisting of some twenty students in their second and third college years, we have outlined an experiment on the stopping of ciliary movement in the epithelium of the frog's esophagus by acid which has proved most successful. The experiment is in the form of a problem, and is stated thus: "Find the concentration of acid which will stop ciliary action within approximately three minutes." The students work in pairs. A small bit of ciliated epithelium is placed on a slide, and while one student observes this under the low power of the microscope, the other places upon the tissue a few drops of acid, and records the time. When the concentration has been found which stops the movement of cilia in three minutes, an indicator is added in the correct proportion (Clark, '20, p. 40) and the p_H determined by matching the resulting color with the appropriate color in the color chart.

When acetic acid diluted with distilled water was used with brom phenol blue as indicator, the following answers were handed in by the class:

Motion stopped in less than 2 min., $p_H = 3.4$, 2 groups of students.
Motion stopped in 3 min., $p_H = 3.5$, 6 groups of students.
Motion stopped in 3½ min., $p_H = 3.6$, 1 group of students.
Motion stopped in 9 min., $p_H = 3.8$, 1 group of students.

The agreement between these results is, we think, very good for an ordinary class exercise.

It should be noted that ordinary distilled water is decidedly acid, $p_H = \pm 6.3$, and that cilia cease to beat in it within approximately half an hour. In 0.7% NaCl, the beating continues for a day, and in Ringer's solution for three or four days at room temperature. For