CONDITIONS OF FŒTAL RESPIRATION IN THE GOAT.

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As an introduction to the discussion of fœtal respiration it may be desirable to state the essential problem.

(1) In the placenta there is a progressive development of both the maternal and fœtal components [Barcroft and Rothschild, 1932; Hammond, 1934].

(2) The maternal components develop on the whole before the fœtal ones. Thus in the rabbit by the eighteenth day (the period of gestation being 30 days) the stream of blood through the maternal vessels has attained to at least half its maximum volume. On the other hand the embryos are negligible in size. Therefore the maternal blood rushes through the placenta emerging almost as red as when it entered, the amount of oxygen removed for the purpose of fœtal respiration being but trifling[1].

(3) From this point as pregnancy proceeds, the embryos grow apace, denuding the maternal circulation of ever-increasing quantities of oxygen. As the quantity of maternal blood which traverses the placenta does not correspondingly increase, that emerging in the uterine veins becomes progressively darker, and at times may be as little as 25 p.c. saturated with oxygen.

(4) In the absence of any special arrangement to the contrary one must picture the placental circulation somewhat as follows:

Two streams of blood enter the placenta by the uterine (maternal) and umbilical (fœtal) arteries respectively. The former is the red arterial

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[1] The above statements are based on the paper of Barcroft, Herkel and Hill [1933]. As their preparation involved injury to the nerves of the uterus the work has been repeated on preparations not open to this objection. The result was the same.

blood of the mother, the latter is the dark venous blood of the fœtus. In the placenta they come into intimate contact but never actually mix. The limiting condition therefore is that they should emerge in equilibrium, in which case the oxygen pressure in the blood of the umbilical vein (going to the fœtus) and that of the uterine veins (returning to the mother) should be sensibly the same. That being so, and again in the absence of any special mechanism to the contrary, one might expect the hæmoglobin in each to be of the same percentage saturation and the
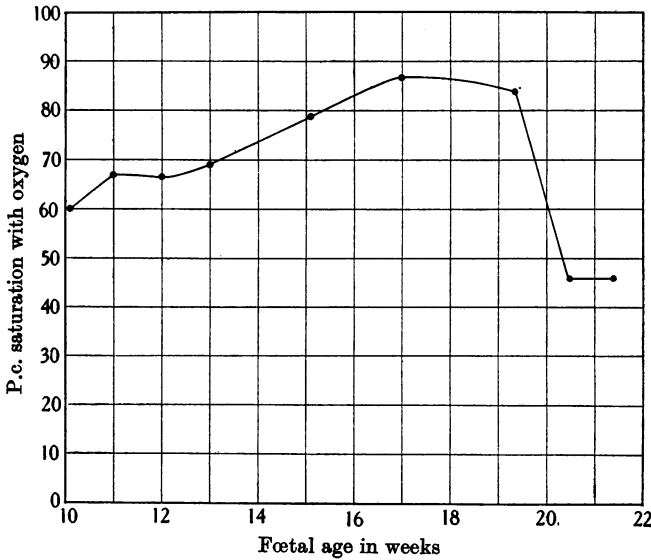

Fig. 1. Superior limit of estimations of percentage saturation of blood
in umbilical vein.

blood in the two vessels to be similar in colour; neither so red as that in the uterine artery nor so dark as that in the umbilical artery.

Moreover, on the above premises one would expect the blood in the umbilical vein to become progressively darker as pregnancy runs its course.

(5) In fact these expectations are not realized, and towards the end of pregnancy the blood in the umbilical vein is often definitely brighter in colour than that in the uterine veins. Indeed in the goat up to the 19th week of pregnancy the saturation of the blood reaching the fœtus tends to become higher (Fig. 1) and that returning to the mother becomes lower. What is the explanation?

(6) Having stated the problem in its general form, some matters of detail may now be mentioned. Paragraph No. (4) above commences,

"In the absence of any special arrangement." In the rabbit the ana-tomical structure of the placenta appears to afford at all events a partial explanation, for according to Mossman [1926] the capillaries in the placenta are so disposed that the blood entering the placenta from the foetus makes its first contact with the maternal blood which is about to leave the placenta, whilst the blood leaving the placenta for the foetus makes its last contact with the maternal arterial blood reaching the placenta from the arteries of the mother (Fig. 2 a).

With such an arrangement clearly the blood in the umbilical vein could be much redder than that in the maternal vein. But this disposition of vessels appears to be a special feature in certain animals only, and therefore it is not a solution of the general problem.
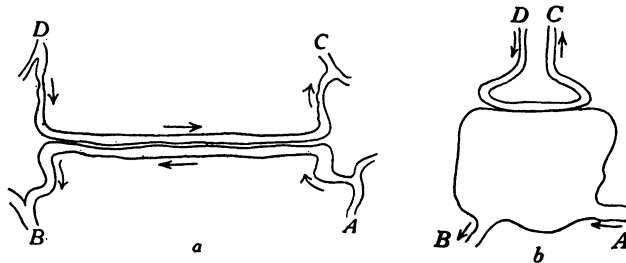

Fig. 2.

Fig. 2. Schematic representation of vessels in placenta (a) of rabbit as described by Mossman, (b) of goat. A, artery carrying blood from mother; B, vein returning blood to mother; C, umbilical vein carrying blood to foetus; D, umbilical artery carrying blood to placenta.

Table I gives data of the age and weight of the foetuses and mothers respectively in the goat. From it growth curves may be constructed as has been done by Huggett [1934] for some of the data given in the table. When the weight of the foetus is plotted against its age a curve of a sigmoid type is obtained. It presents the general appearance to be ex-pected for the growth of an organism which, starting as something very small but growing rapidly, grows at a decreasing rate and ends up as a large organism of slow growth.

Actually the curve when analysed presents some special features. The whole embryo grows from a cell the weight of which is perhaps one millionth of a milligram (*i.e.* ten times the weight of a red blood cor-puscle). If it grew at a uniform rate of sixty-fold increase per week the embryo would be of the order of size which we find it—9 g. at the end of the seventh week. Presumably the growth is more rapid at first and

TABLE I.

Serial No.	Weight kg.	Date of operation	Age of fœtuses weeks and days	Number of fœtuses	Weight of fœtuses kg.
1	32	22. xii. 32	10	2	0·115 0·110
2	40	5. i. 33	12½	2	0·255 0·275
3	28·4	10. ii. 33	16.3	2	1·25 1·19
4	—	23. iii. 33	7	1	0·009
5	—	7. iv. 33	Not pregnant		
6	—	11. iv. 33	10.1	1	0·090
7	—	13. iv. 33	11	1	0·160
8	31·2	18. iv. 33	12	2	0·278 0·254
9	23·1	24. iv. 33	13.2	1	0·374
10	25·8	1. v. 33	14.3	1	0·646
11	36·9	5. v. 33	15.1	2	0·73 0·69
12	—	12. v. 33	16.1	1	1·225
13	24·6	18. v. 33	Not pregnant		
14	37·8	22. v. 33	18	2	1·84 1·43
15	—	31. v. 33	19.6	1	2·00
16	—	31. v. 33	*15–16	1	0·900
17	38·8	31. xii. 33	9.5	1	0·075
18	26·2	22. i. 34	12.5	2	0·228 0·251
19	48·8	1. ii. 34	14.5	2	0·563 0·538
21	40·4	16. ii. 34	19.3	3	0·833 0·960 0·952
22	44·8	19. ii. 34	20.4	2	2·28 2·91

* Inferred from weight.

TABLE II. Kids.

Serial No.	Date of Operation	Date of "Stocking"	Date of Birth	Age	Weight kg.
20	5. ii. 34	6. ix. 33	4. ii. 34	20 hours	4·8
23	1. iii. 34	1. x. 33	28. ii. 34	1 day	2·34
26	2. iii. 34	1. x. 33	2. iii. 34	Less than 14 hours	—

slows down, but it is not surprising to find that in the eighth week the rate of growth is approximately 120 p.c. reckoned in the following way: if a is the weight at the end of the seventh week and b is the weight at the end of the eighth week, $\frac{(b-a)}{\frac{1}{2}(b+a)} \times 100 = 120$. Beginning at the end of the ninth week and continuing to the end of the sixteenth week there is a period during which the rate of growth is almost uniformly 40 p.c. of the weight of the fœtus. The rate then becomes slower and at last negligible (Fig. 3).

Another interesting relationship is that of the fœtal weight to that of the placenta. Fig. 4 shows this relation for the fœtuses other than triplets. We have never had a case of more than three fœtuses.

The first point to be investigated regarding the conditions which govern fœtal respiration is clearly the exact forms of the oxygen dissociation curves of the maternal and fœtal bloods respectively. Two sets of observations on this subject are to be found in the literature. Huggett [1927] reported that the blood of the fœtus contained less oxygen at given pressures than that of the mother: his observations were made upon goats. Haselhorst and Stromberger [1930, 1931], in an elegant research on the human subject, came to the opposite conclusion. In neither case, however, was the dissociation curve delineated in detail over the whole of its course, nor was it followed progressively during the period of pregnancy. We were fortunate in obtaining from a reliable source a sufficient supply of goats to obtain weekly information from the seventh week onwards, the period of gestation in the goat being 21–22 weeks.

METHOD.

The goat was anæsthetized with urethane 4 c.c. per kg. If necessary it was given some c.e. mixture. The animal was then placed in a saline bath and the abdomen was opened. The fœtal blood for analysis was withdrawn from the umbilical artery or vein (as the case might be) with a hypodermic syringe. The syringe was prepared by filling the dead space with a solution of 3 g. acid potassium oxalate and 1 g. sodium fluoride in 100 c.c. water. Enough of this mixture was placed in the syringe to insure that the blood when drawn would be diluted with the solution in the ratio of 9 : 1. This may conveniently be done by the use of a syringe, with a glass bead of suitable size to ensure thorough mixing.

The samples of blood for determination of the dissociation curves were drawn as described above and were placed in a saturator filled with air to which CO_2 was added to a partial pressure of about 50 mm. Hg.
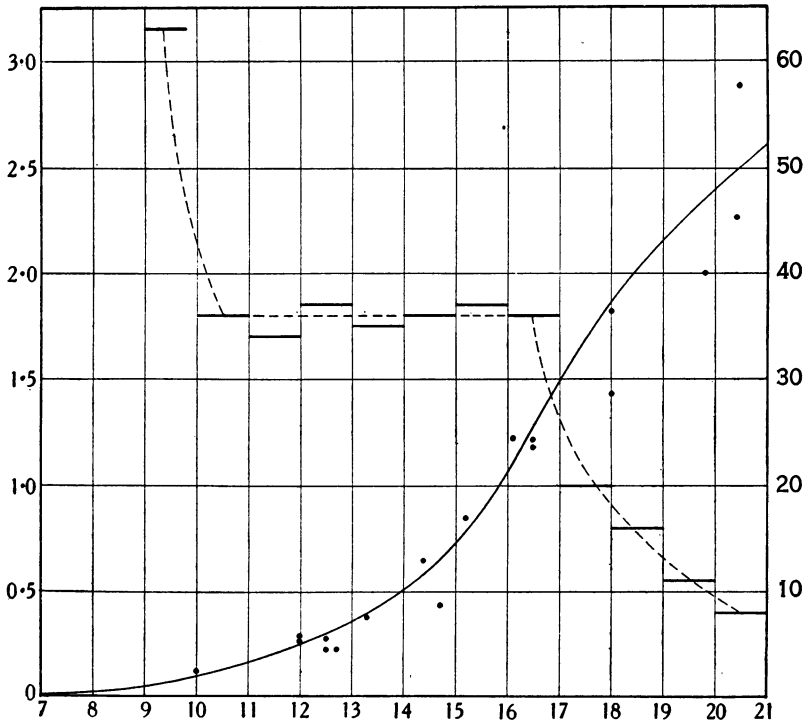
Fig. 3. Abscissa, fœtal age in weeks. Ordinate, left-hand scale weight of fœtuses in kilos, refers to unbroken line; right-hand scale the increment of weight in any week expressed as a percentage of the mean weight for the same week.
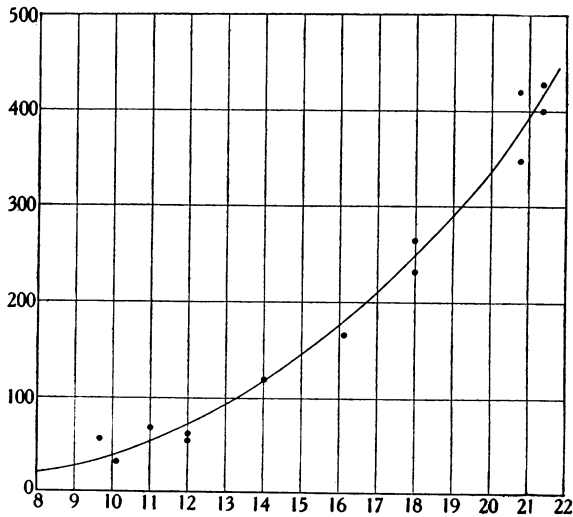

Fig. 4. Abscissa, fœtal age in weeks. Ordinate, weight of fœtus expressed as a percentage of the weight of the placenta.

The equilibration was carried out at 38° C. in the new saturators [Barcroft, 1934]. The blood-gas analyses were made in the van Slyke manometric apparatus. Usually the determination of a single point required the cooperation of four persons, the gas analysis being done in duplicate by two of them, and the blood-gas determination (also in duplicate) by the others. The maternal blood was equilibrated in saturators of about 300 c.c. capacity. The pipette used delivered two blood samples, each of 1 c.c. The saturators used for the foetal blood were varied according to the size of the foetus, *i.e.* according to the amount of blood available. Usually, however, they were of 25–60 c.c. capacity, the pipette delivering 0·2 c.c. samples. The curves, both maternal and foetal, were determined in the presence of 50 mm. CO_2 as nearly as possible, and corrected to that figure. Naturally the smaller the saturator the more difficult it is to hit off the exact CO_2 reading desired.

Care was taken to put the blood into the van Slyke apparatus immediately it was taken from the bath and not to leave it standing in the pipette. The following is a series of readings showing a fair sample of the accuracy obtained with the foetal bloods using the small tonometer saturators:

Goat 14.

	Oxygen pressure mm. Hg.	Percentage saturation
(1)	16·2	22·5
	16·7	22·3
(2)	24·4	52·6
	24·8	52·4
(3)	32·8	80·0
	33·1	81·8
(4)	57·2	83·3
	57·0	83·7

The chief points about the dissociation curves are as follows.

Fig. 5 shows an area between two dotted lines. These are the limits of the curves which we have plotted for normal female goats, *i.e.* goats which are not, and have not recently been pregnant. We have ascertained that (1) the curve is not appreciably altered by the anæsthetics which we have used, (2) the points fall on the same curve whether the blood is defibrinated by whipping or drawn into a syringe with a tenth of its volume of oxalate fluoride mixture, and (3) the sample of blood gives points on the same curve whether equilibrated in the large or the small saturators.

Fig. 6 (goat 4, seven weeks pregnant) shows the points obtained from the earliest pregnant goat which we studied, and they are all within the normal area.
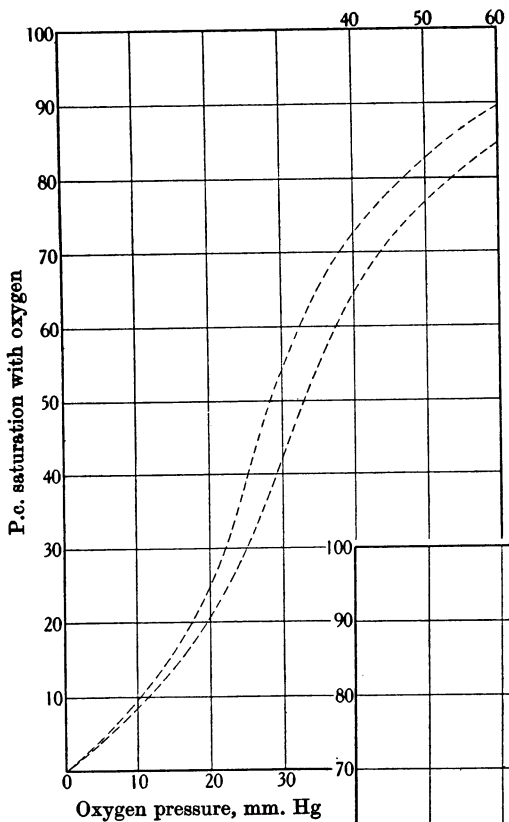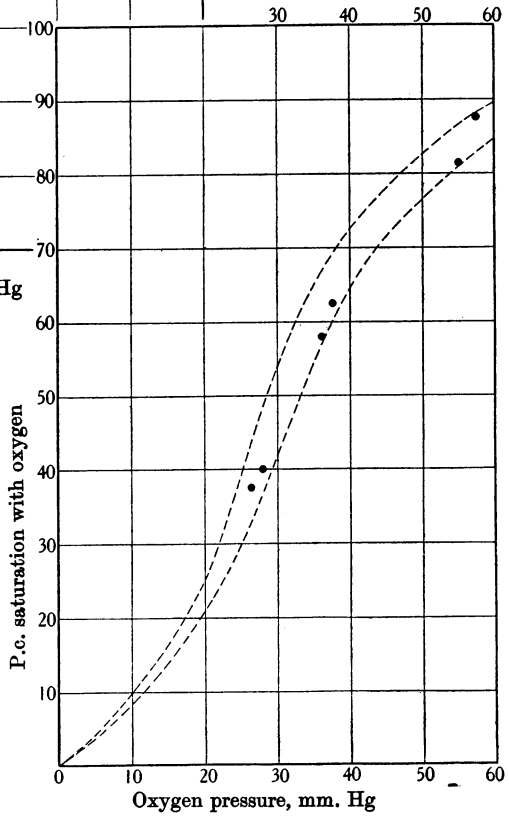
Fig. 5.

Fig. 6.

Fig. 5. Limits within which fall the oxygen dissociation curves of normal female goats not recently pregnant. CO$_2$ pressure 50 mm., temp. 38° C.

Fig. 6. Goat 4, pregnant 7 weeks; points on dissociation curve of mother.
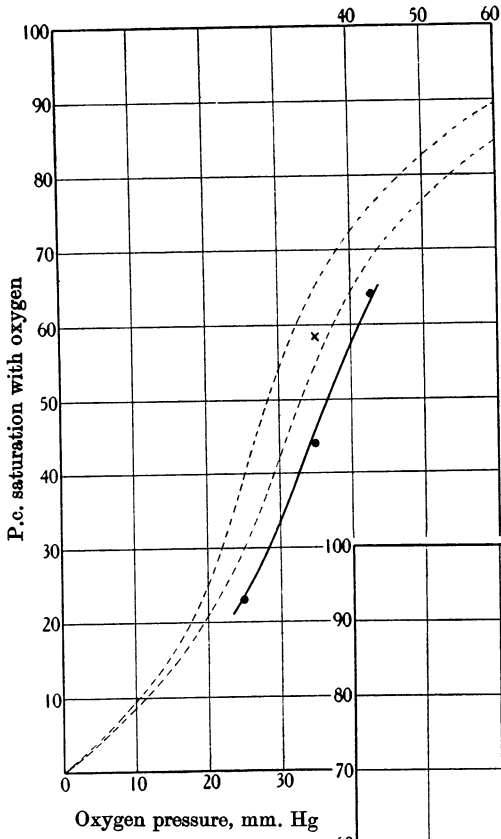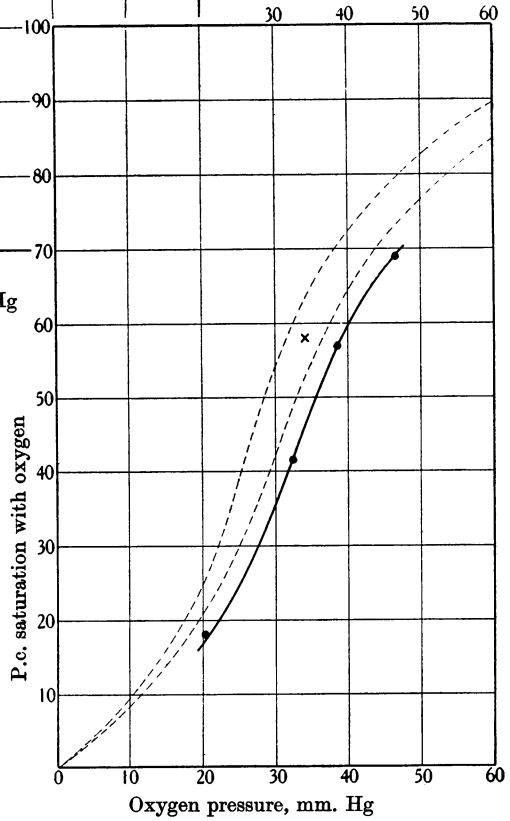
Fig. 7.

Fig. 8.

Fig. 7. Goat 1, pregnant 10 weeks. • maternal blood; × fœtal blood, CO_2 pressure 50 mm.,
temp. 38° C.

Fig. 8. Goat 6, pregnant 10 weeks 1 day; notation and conditions as in Fig. 7.

Figs. 7 and 8 show maternal curves (10 weeks and 10 weeks 1 day). They are now definitely to the right of the normal area. One point only in each case has been obtained for the fœtal blood; it lies within the normal maternal area.

Fig. 9 (11 weeks and 2 days) shows the maternal blood much as in Figs. 7 and 8, but two points were obtained for the fœtal blood. These show a new feature, namely that they lie on a curve which tends to cross the normal area. A single case of this kind might naturally be discounted on the ground that one or other observation was erroneous; its importance, however, is evident from the fact that all the fœtal curves up to Fig. 15 show the same characteristic.

Fig. 10 (13 weeks 3 days) again shows a new character, namely that the fœtal curve is drifting farther away from the maternal one, as the pressure becomes lower.

For instance, at half-saturation the gap between the maternal and fœtal curves in Fig. 9 corresponds to 7 mm. pressure: in Fig. 10 it is 10 mm. or estimating in terms of the difference of saturation at a given pressure, in the same region:

	Maternal blood	Fœtal blood	Mean	Difference
Percentage saturation: Fig. 9	43	56	$49\frac{1}{2}$	13
„ 10	40	59	$49\frac{1}{2}$	19

Fig. 11 (14 weeks and 1 day) shows much the same features as Fig. 10 (13 weeks). In the region of 50 p.c. saturation the difference is 17 p.c. The maternal and fœtal curves are both more to the right than in Fig. 10. To this we ascribe no special significance, it probably means that before pregnancy the curve in the case of goat 10 (Fig. 11) was near the right of the normal area and that of goat 9 (Fig. 10) was near the left.

In Fig. 12 (15 weeks and 2 days) the gap between the fœtal and maternal curves has increased and now corresponds to difference of saturation of 25 p.c. at 31 mm. oxygen pressure.

This may be a suitable point to emphasize the relative properties of the maternal and fœtal curves which are found at this stage: all our estimations of the percentage saturation of oxygen in the blood of the umbilical vein, *i.e.* the fœtal blood leaving the placenta, show a considerable degree of unsaturation. They vary very much, which perhaps indicates that the last word has not yet been said as regards technique, but broadly speaking they lie between 80 and 40 p.c. (see Fig. 1) saturation, which is roughly the region covered by the fœtal curve in Fig. 12. What
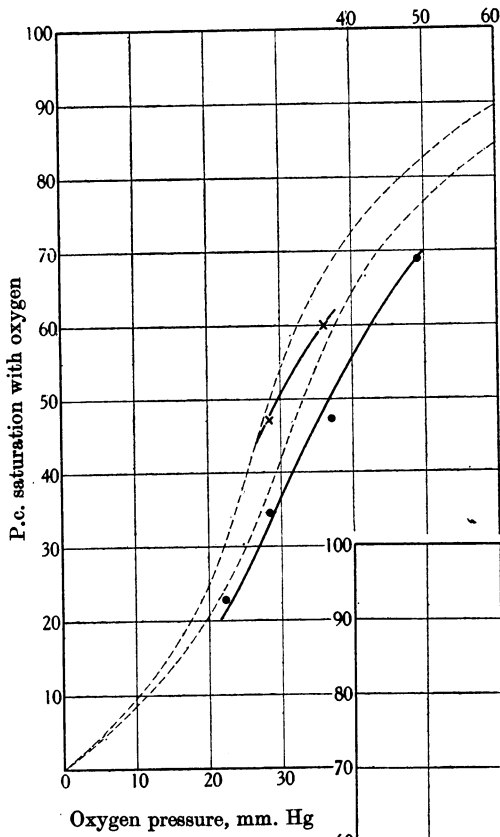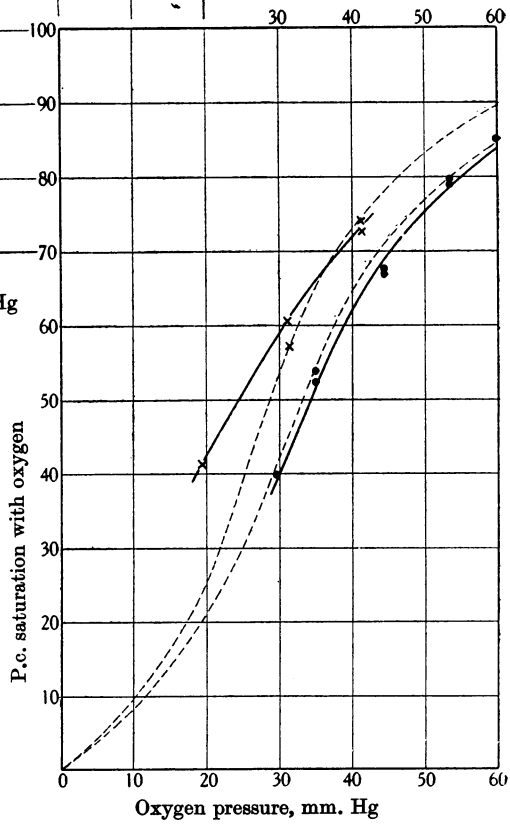
Fig. 9.

Fig. 10.

Fig. 9. Goat 7, pregnant 11 weeks 2 days; notation and conditions as in Fig. 7.
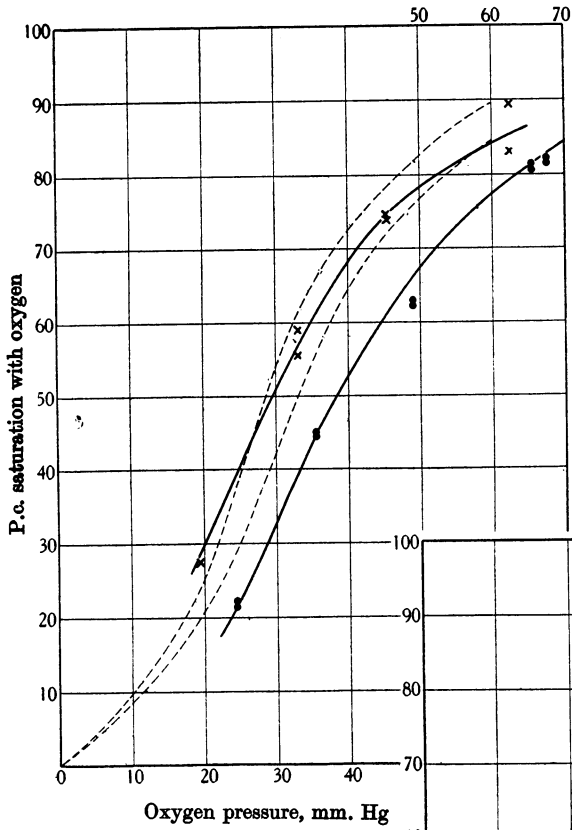Fig. 10. Goat 9, pregnant 13 weeks and 3 days; notation and conditions as in Fig. 7.
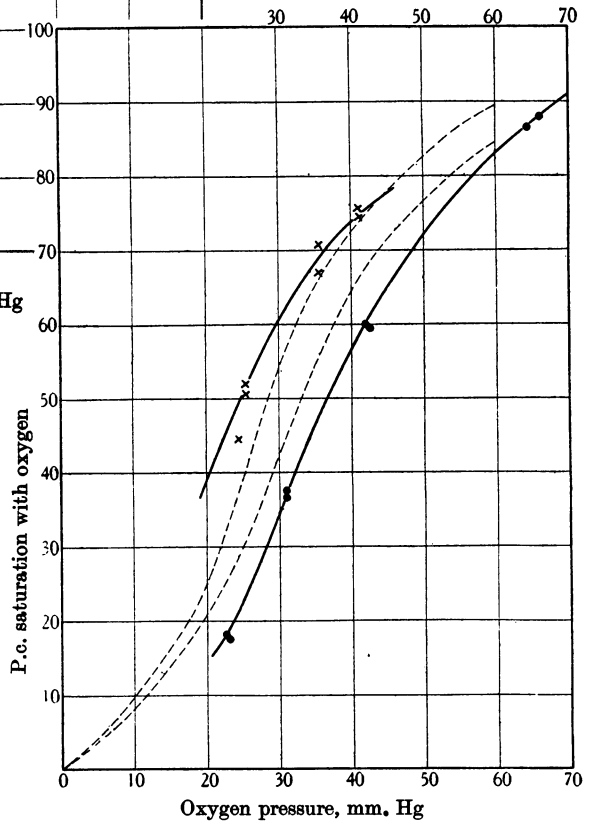
Fig. 11.

Fig. 12.

Fig. 11. Goat 10, pregnant 14 weeks 1 day; notation and conditions as in Fig. 7.

Fig. 12. Goat 11, pregnant 15 weeks 2 days; notation and conditions as in Fig. 7.

then is the difference of oxygen saturation between fœtal and maternal blood at a given pressure as one passes down the fœtal curve?

	Oxygen pressure mm.				
	50	37	30	25	21
Saturation of fœtal blood	80	70	60	50	40
Difference of O_2 saturation between maternal and fœtal blood	8	20	26	28	25

Thus down to a low point (that at which the dissociation curve of the mother begins to curl inwards towards the origin) the lower the oxygen pressure at which the maternal blood yields its oxygen the greater the amount which can be transferred to the fœtus at a given pressure.

At this point we may suitably consider Figs. 13 and 14. They are the dissociation curves of two goats which were members of the series and were operated upon on the assumption that they were pregnant but which in point of fact contained no embryos—that of Fig. 13 had gone 17 weeks from "stocking," Fig. 14 had gone 9 weeks. The points obtained in both cases fell in, or on the edge of, the area for normal goats. Whether these animals never were pregnant or whether they had contained fœtuses which had been reabsorbed, we do not know. They appeared to us to be rather satisfactory controls.

We may now pick up our survey of the general progress of events, which we had brought up to the fifteenth week. Goat 3 (Fig. 15) had gone 16 weeks and 3 days. In its essential points the curve does not differ from that of Fig. 12.

Fig. 16 (18 weeks and 2 days) shows a remarkable change. The dissociation curve of the fœtus is altering in shape. The general nature of the alteration is in the direction of increased adaptability to take up oxygen at high oxygen pressures, and this without any sacrifice at low ones (20 mm. and the like). The question may be asked, what does the fœtus gain by this increased ability to take up oxygen at low oxygen pressures? A partial answer may perhaps be found in Fig. 1. None of our observations has given us more solicitude than those of the direct records of the percentage saturation of the blood taken from the umbilical vein. The results vary greatly, but the curve shown in Fig. 1 gives the upper limit. Often the points are much lower. At present we have not sufficient information fruitfully to discuss whether these lower observations are due to experimental procedure, *e.g.* constriction of the uterine vessels when
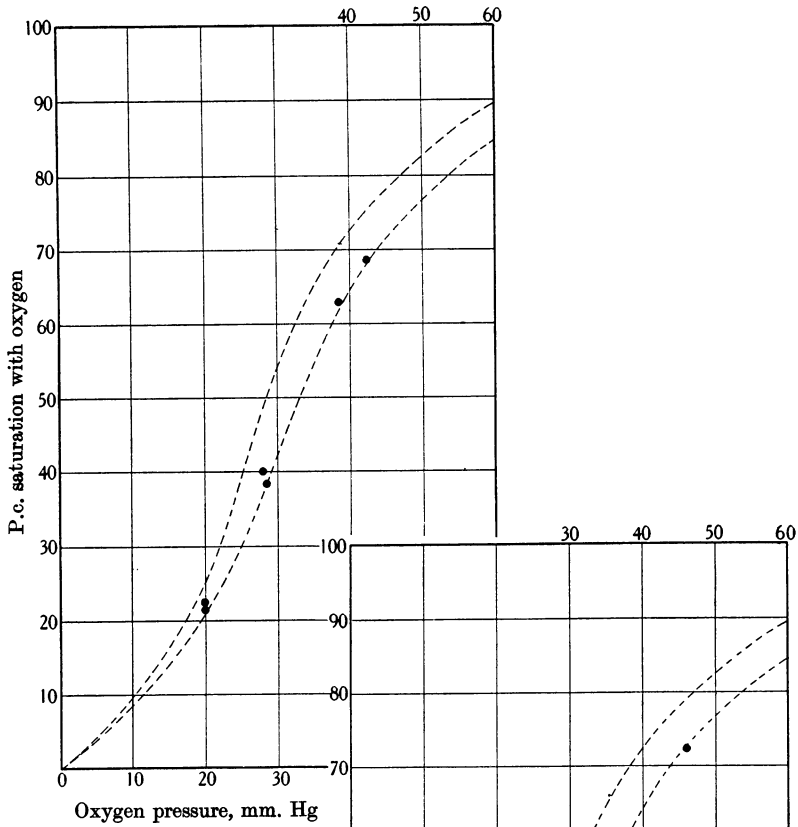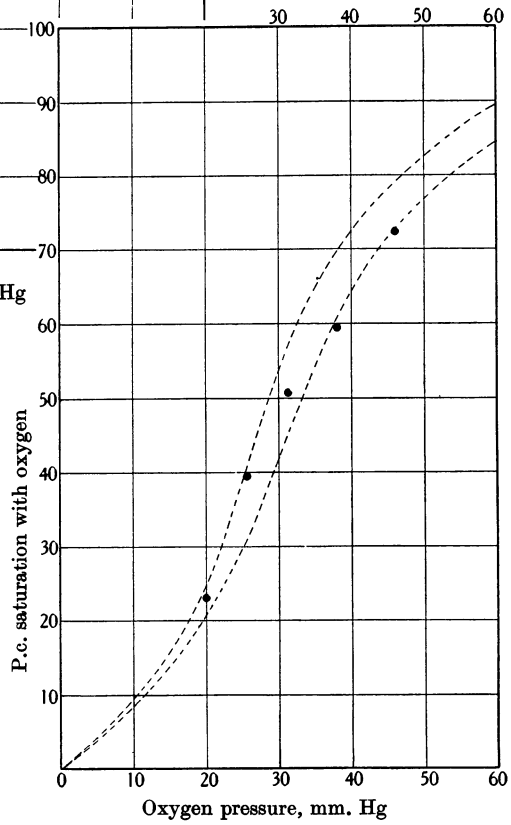
Fig. 13.

Fig. 14.

Fig. 13. Goat 13, not pregnant 17 weeks from presumed fertilization; notation and conditions as in Fig. 7.

Fig. 14. Goat 5, not pregnant 9 weeks from presumed fertilization; notation and conditions as in Fig. 7.
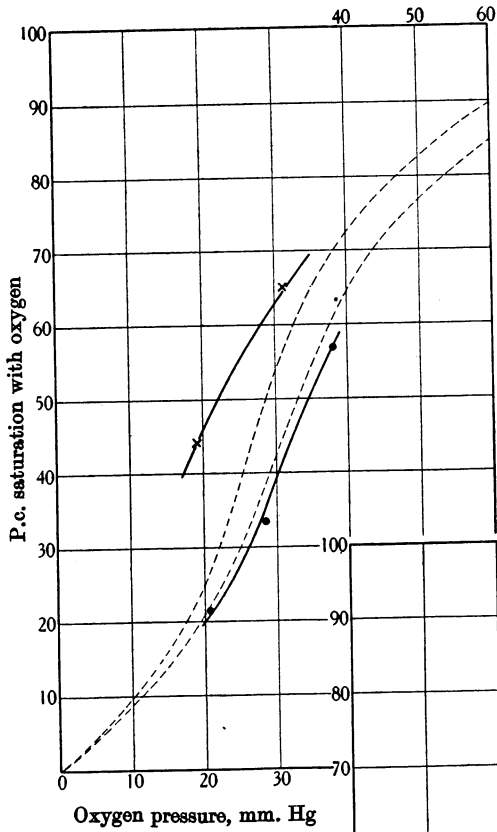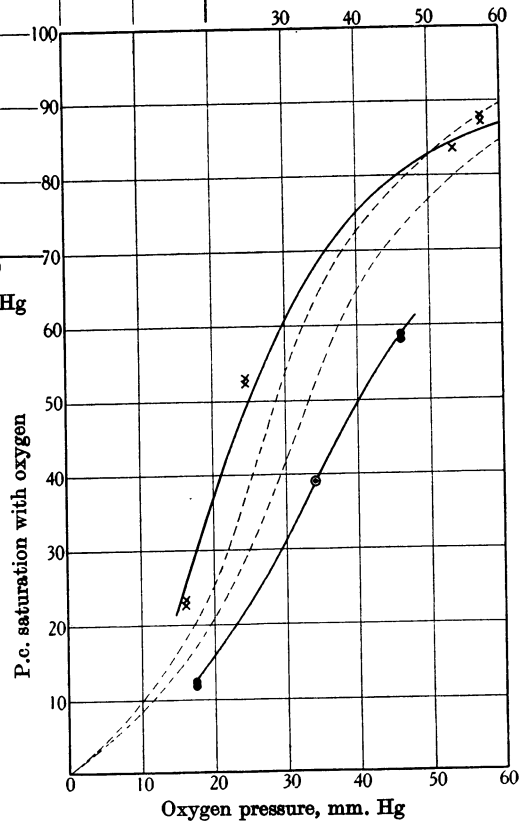
Fig. 15. Goat 3, pregnant 16 weeks 3 days; notation and conditions as in Fig. 7.

Fig. 16. Goat 14, 18 weeks 2 days; notation and conditions as in Fig. 7.

the uterus is opened. The highest ones seem to be as high as is consistent with the existing anatomical conditions in the placenta of the goat (see Fig. 2b). It is not easy (short of some form of oxygen secretion) to see that the oxygen pressure in the blood which leaves the placenta for the fœtus can be much higher than that which leaves the placenta for the mother. If then in goat 14 the curves for the mother and fœtus are substantially as in Fig. 16, and if the fœtal blood is 83 p.c. saturated, that would correspond to a pressure of 50 mm. O_2. This pressure indicates a saturation of 60 p.c. or over in the blood of the uterine vein, which is as high as can be expected, perhaps higher.

These considerations, with some others of a like nature, form as we have said "a partial answer," but it is difficult to escape the feeling that there is something prophetic about the change in the shape of the dissociation curve. It is acquiring the degree of inflection typical not of fœtal but of ante-natal existence. Indeed the eighteenth week is a period at which many alterations take place. Fig. 3 indicates that about this time the embryo ceases to grow at a uniform rate, and the dissociation curve takes on its ultimate degree of inflection whilst the blood in the umbilical vein reaches its maximum saturation (Fig. 1). It is natural to ask, why is the fœtus not born at this point? Why does it carry on a lingering existence in the uterus, growing at a reduced rate and straining the conditions of respiration till the blood which supplies it is not 80 p.c. but perhaps 50 p.c. saturated? The answer is probably to be found in the extent to which three or four extra weeks of intra-uterine life enables the newly born kid to fend for itself. On the day that it is born it can walk. At a stage of maturity probably corresponding to the eighteenth week in the kid, the human fœtus is born.

The curves for goat 21 (19 weeks and 3 days) do not differ in any essential point from Fig. 16. It happens that the maternal and fœtal curves are a little to the left of their position in Fig. 16, but this is probably unimportant, the relation of the curves to one another is essentially the same, but in Fig. 18 (goat 22, 20 weeks and 4 days) there is a marked change. The maternal and fœtal curves are drawing towards one another: the conditions are becoming less favourable to fœtal respiration at a time when the embryo is still growing and requiring more oxygen. It is not surprising then to find a large drop in the percentage saturation of the blood in the umbilical vein of goat 22 as compared with goat 21 (Fig. 1). But the curves draw still closer. Fig. 19 (goats 25 and 26) shows those of the mother and kid at the birth of the latter which took place after a pregnancy of 21 weeks and 4 days. The birth occurred during the night
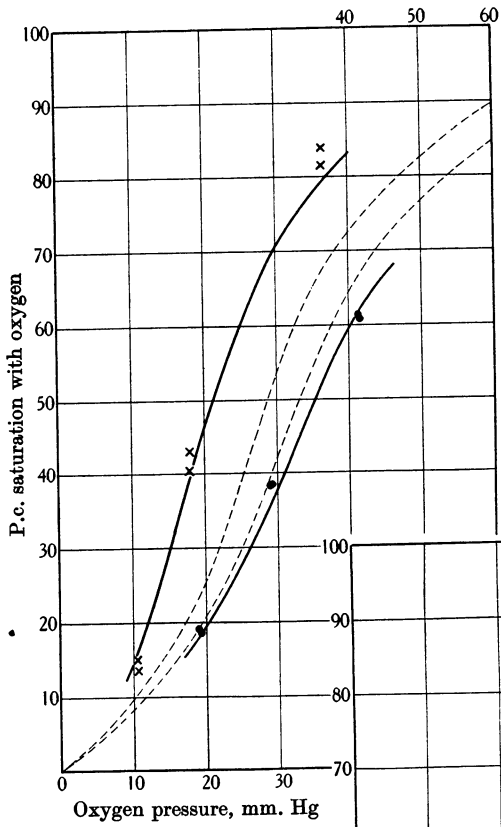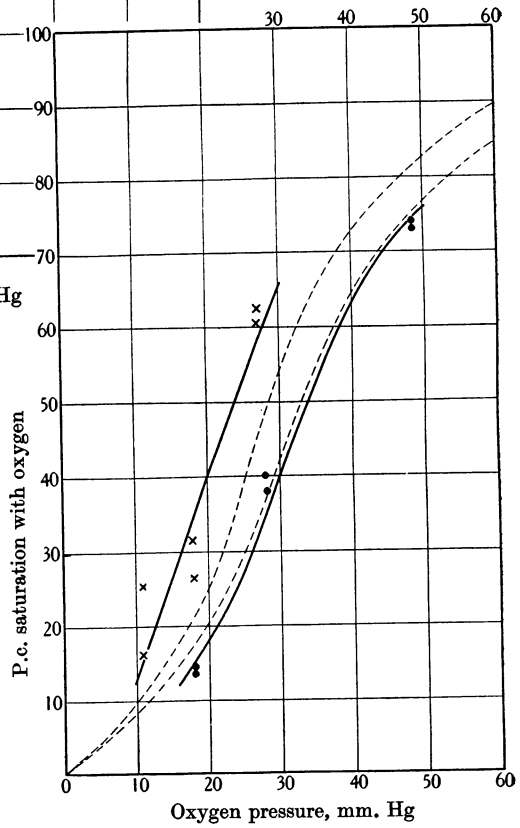
Fig. 17.

Fig. 18

Fig. 17. Goat 21, 19 weeks 3 days; notation and conditions as in Fig. 7.

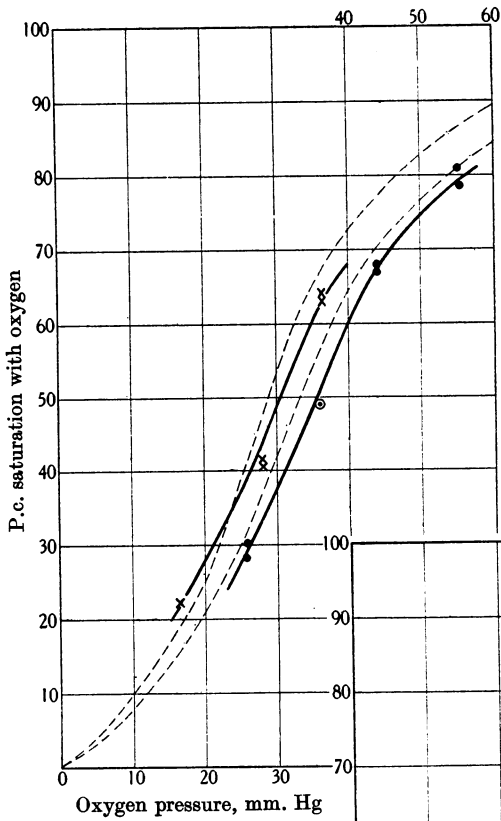Fig. 18. Goat 22, 20 weeks 4 days; notation and conditions as in Fig. 7.
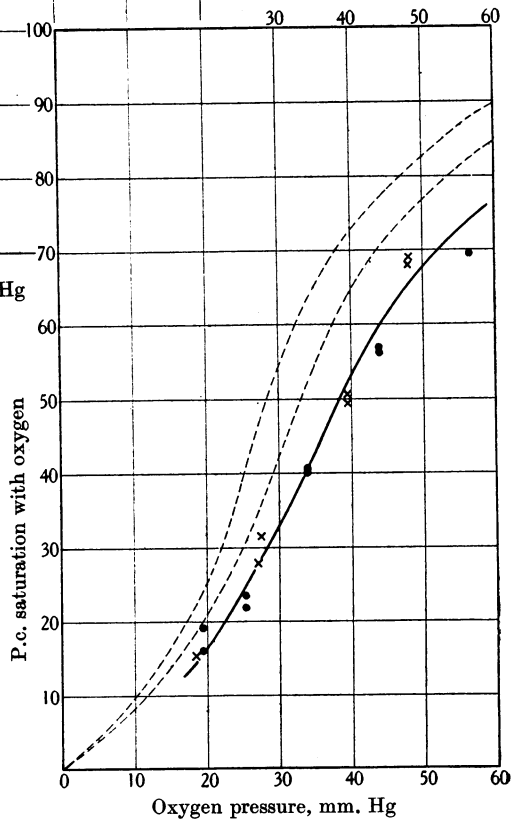
Fig. 19.

Fig. 20.

Fig. 19. Goat 25, and its kid 26 at birth; notation and conditions as in Fig. 7.

Fig. 20. Goat 25, and its kid 26, 18 days after birth; notation and conditions as in Fig. 7.

14

and the blood was withdrawn at 10 a.m. next morning so that the exact age of the kid in hours from birth is not known. This picture is of interest as showing the same general features as those figured by Eastman, Geiling and de Lawder [1933] for man, *i.e.* a gap between the maternal and fœtal curves, the maternal curve definitely to the right of the normal, fœtal curve not definitely to the left of the normal and both of the normal degree of inflection.

The curves of goats 25 (mother) and 26 (kid) were determined again 18 days later (Fig. 20); by that time they were indistinguishable—though both to the right of the normal area, possibly because they were both rather anæmic.

We have had the opportunity of determining the curves of two other kids, which were sent to us by Mr T. R. Egerton, the well-known breeder of pedigree goats at Rushmere, Ipswich. We would like to take this opportunity of thanking him for the very great trouble he has taken in diverting his organization from its usual business to that of securing that kids born on his farm were in our hands at the earliest possible moment. In the case of kid 20 (Fig. 21) the data for the curve were obtained about 20 hours after birth and before the kid had been fed, while in the case of kid 23 (Fig. 22) the curve was obtained on the day after birth, the kid having had milk. In both these cases the curve had the adult degree of inflection but was slightly to the left of the normal area. Having stated the facts something must be said about the mechanism which lies behind them. This can be treated very shortly because already, both in the case of the maternal and fœtal bloods, researches in this series have been published dealing with the matter not merely in a general way but with the actual goats under discussion. There is no element of doubt therefore as to the legitimacy of transferring results obtained upon one species or even one individual to another.

The cause of the shift in the maternal blood is simple; it is due to increased hydrogen-ion concentration. The *p*H was calculated from CO_2 dissociation curves by A. B. Keys [1933, 1934], and similar curves from which the *p*H may be calculated are given by Eastman, Geiling and de Lawder [1933]. The hydrogen-ion concentration was also measured directly with the glass electrode, by Dr R. E. Havard and Mrs S. Dickinson. The table on p. 212 is quoted from Keys' paper [1934]. Thus the maternal bloods taken during experiment ranged in *p*H from 7·22 to 7·33, whilst controls taken under similar circumstances, after some considerable period of anæsthesia, were 7·35 and 7·41 respectively. These results agree in general with those of Eastman, Geiling and de Lawder [1933].
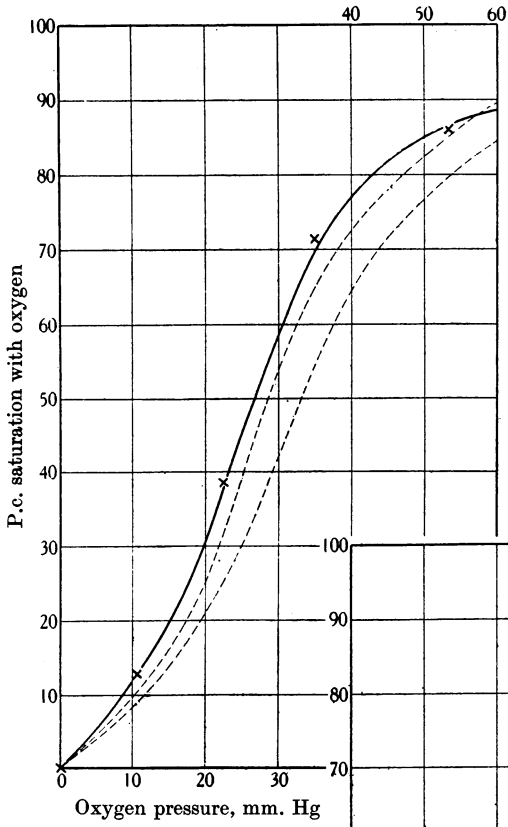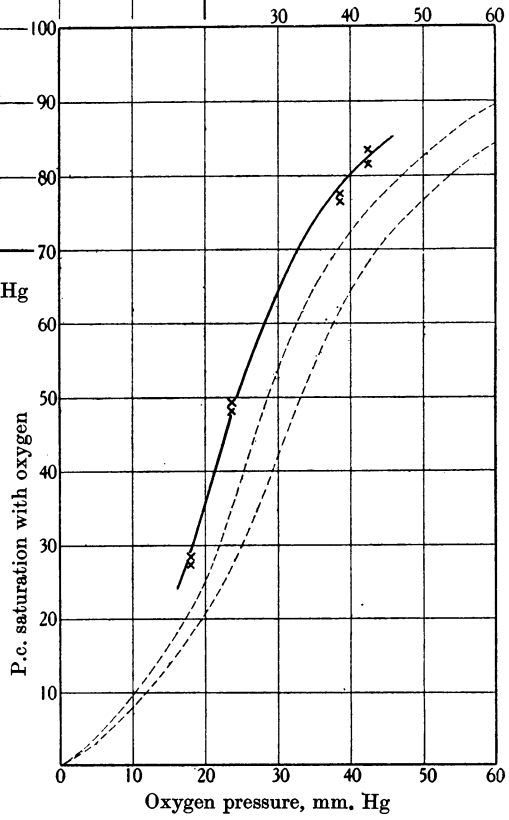
Fig. 21.

Fig. 22.

Fig. 21. Goat 20, 20 hours old; notation and conditions as in Fig. 7.

Fig. 22. Goat 23, 1 day old; notation and conditions as in Fig. 7.

Whilst the divergence from the normal of the dissociation curve in the maternal blood is accounted for by change in reaction, that of the fœtal cannot be so explained. In the cases quoted above the fœtal bloods,

Blood hydrogen-ion concentrations at 37° C.

Goat No.	Blood	pH calculated	pH observed by Havard and Dickinson
11	Maternal	7·26	7·26
	Fœtal	7·34	7·38
12	Maternal	7·22	7·25
	Fœtal	7·30	7·31
14	Maternal	7·23	7·14
	Fœtal	7·27	7·30
16	Maternal	7·33	7·33
	Fœtal	7·35	7·34
Control C_3	Before anæsthesia	7·37	
	15 min. after	7·31	
	75 min. after	7·35	
Control 13		7·35	
Control	Before anæsthesia	7·50	
	90 min. after	7·41	

whether estimated by the glass electrode or by the CO_2 method, fall within the pH range 7·27–7·38. Though more alkaline than the maternal bloods they are not more alkaline than the normals. Moreover, the position of the fœtal curve is associated with a greater or less difference from the normal in the inflection of the curve.

The position and shape of the fœtal curve are governed by conditions other than the hydrogen-ion concentration. The pH indicates greater alkalinity in the fœtal than the maternal plasma, but the fœtal plasma is not more alkaline than that of the normal controls. Moreover, a change in the hydrogen-ion concentration would not in itself produce the less S-shaped type of curve which is portrayed especially before the eighteenth week.

Two researches have been carried out on this subject, by McCarthy [1933] and Hall [1934a, 1934b] respectively. The former liberated and purified the hæmoglobin from the animals used in several of the experiments already quoted. He found that, working with the purified hæmoglobin, the curves for the maternal pigment were indistinguishable, under identical conditions, from those of the controls. Those from the fœtal blood, however, were definitely to the left, over the major portion of the curve. The only thing to be added to McCarthy's published work is that, since his paper was written, he has investigated the hæmoglobin of a kid, which he found to be like that of a normal goat and therefore unlike the hæmoglobins of the fœtuses.

The general coincidence between data obtained from purified hæmo-globin by McCarthy and data obtained from blood by ourselves is well shown in Fig. 23. In Fig. 23(a) we give McCarthy's points for goat 12 (16 weeks 1 day) as accurately as we can read them from curves 2 and 3, Fig. 1 of his paper, together with our curves for the blood of the same goat, while the points for goat 14 (18 weeks), taken from his curves 4 and 5, are similarly shown in comparison with ours in Fig. 23(b).
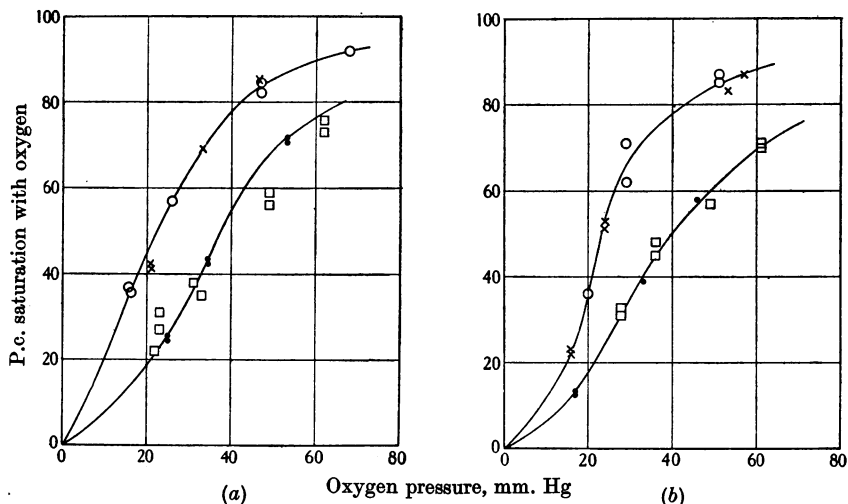

Fig. 23. (a), goat 12; (b), goat 14. □ McCarthy maternal hæmoglobin, pH 6·8; o McCarthy fœtal hæmoglobin, pH 6·8; × fœtal blood $CO_2 = 50$ mm.; • maternal blood $CO_2 = 40$ mm.

The dissociation curves proper to the hæmoglobins of the mother and fœtus respectively have also been investigated by Hall [1933, 1934a, 1934b] by the method which he recently described. The investigation, unlike that of McCarthy, was on dilute solutions and by spectroscopic methods, but the result was essentially the same, namely that the fœtal curve was to the left of the maternal and on the whole less inflected, though not actually hyperbolic. Hall [1934c] has also found differences between the hæmoglobins of the embryo chick and its mother similar to those which he observed between the fœtal and maternal hæmoglobins in goats and rabbits.

SUMMARY AND CONCLUSIONS.

1. The problem of fœtal respiration is that of an organism growing in mass, at a much greater rate than the machinery for its supply.

2. Oxygen dissociation curves are given for the blood of the mother

and the fœtus, making a complete series from about the tenth week till birth.

3. The curve of the mother moves to "the right" of the normal, that of the fœtus being for the most part to the left.

4. The maximum divergence is about the eighteenth to nineteenth week, after which the curves draw together.

5. The movement on the part of the curve of the mother is due to increased hydrogen-ion concentration.

6. The fœtus contains hæmoglobin, the properties of which differ from that of the mother. It gives a less inflected curve, as well as one which is situated "to the left" of the normal.

7. So is explained the gap between the maternal and fœtal dissociation curves noted by other observers [Haselhorst and Stromberger, 1930; Anselmino and Hoffmann, 1931; Eastman, Geiling and de Lawder, 1933].

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