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PRENATAL GROWTH OF THE PIG

by

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## PRENATAL GROWTH OF THE PIG.

### I.

#### Introductory.

Numerous observations on various phases of growth are to be found in the biological literature. Most of those concerning prenatal growth are upon the human embryo; although scattered observations are also recorded on other mammals, and a few on the lower vertebrates. The work presented in this paper was done in the attempt to trace, in the pig, the course of the prenatal growth of the body and of the various organs. The results are also compared with the course of growth in the human species and in the lower mammals, so far as data are available. The work was done in the Anatomical Laboratory of the University of Missouri, under the direction of Dr. C. M. Jackson, to whom I am deeply indebted for his interest, aid and valuable suggestions.

### II.

#### MATERIAL AND METHODS.

##### A. MATERIAL.

The material used for this paper consists of 19 litters of pig embryos, comprising about 124 individuals, of which number 89 were used. In some cases all the pigs in the litter were used, in others, three or four of the specimens

about the average of the litter were studied. (Table I.) . These litters of embryos were secured from the Packing Houses in Chicago (Aug.31, 1909), Kansas City (Dec.27,1909), and Columbia (at various times, Spring, 1910). Wherever possible, the litters were worked up in a fresh condition. In the other cases, they were preserved in a 5% aqueous solution of formalin for varying lengths of time. In Table I will be found a summary of the material used, and the condition at the time used.

For the ovum, some fifty adult ovaries were examined fresh. The method used was to open up the large follicles under a dissecting microscope, and measure the ovum (including zona pellucida) with an eye-piece micrometer, whose divisions have a known value. The largest ovum found is considered nearly, if not quite, the size of the mature ovum. No data were found in the literature as to the size of the mature ovum of the pig.

For the data on the adult, a trip was made to the local packing house, and four hogs, about 10 or 12 months old, were examined and weighed. The individual measurements thus secured were averaged, and the averages used in the various curves. The individual data are given in Table XX.

Of the fetal material secured, the litter at 18 mm. was the smallest which could be conveniently dissected and weighed. This leaves quite a gap between this stage and the mature ovum, which I hope to fill at a later time.

The largest litter examined averaged 262 mm. in crown-rump length, and is not quite full-term. However, the changes between this stage and birth are probably slight, except in the matter of absolute weight. That is, the relative size of the various organs would probably not change much, since the changes are relatively slight during the latter part of the fetal period.

#### B. METHODS.

The method used for the fetal and adult material was that of weighing. This is obviously simpler than any other method which could be used, gives a better idea of the relationship of the organs to the whole, and also gives a convenient basis for comparison with other species.

The crown-rump length was also taken in all cases, as it forms another basis of comparison for the individuals and the different stages. It may, to a certain small extent, take the place of the age, which cannot be determined (except for the smallest and largest), in the comparison of one litter with the others. The fetal age, however, is by no means proportional to the increase in crown-rump length.

Each litter is considered as a unit. That is, the individuals in each litter, or three or four average pigs therefrom, are weighed, and individual calculations are made for the percentage of each organ. The average of the percentages for any organ is then taken for the litter, and

this average is used in constructing the tables and curves expressing the growth.

The following measurements were made on each pig: weight and crown-rump length were observed for the whole body; the head, eyeballs, brain, spinal cord, thyroid, thymus, right lung, left lung, heart, liver, stomach and intestines (with mesentery and contents, also without contents where possible), spleen, pancreas, suprarenals, sex glands, kidneys and Wolffian body, were each weighed separately.

The weights were taken carefully, the organs being placed in a closed glass vessel of known weight. For the larger animals, the organs were weighed to .001 g. (1 mg.), the body and head being weighed to .1 g. For the smaller embryos (18 mm., 25 mm., 37 mm., 41 mm.), the body and head are weighed to .001 g., and the organs (except those weighing more than 10 mg. in the 37 mm. and 41 mm. embryos) weighed to .0002 g. (.2 mg.).

The head was divided from the neck on a plane passing just behind the angle of the mandible and the cranium. Variations in this plane (which to a certain extent are unavoidable) lead to variations in the weight, and therefore, in the relative size of the head.

The brain and cord were weighed without the dura mater, but with the pia.



In most cases, the stomach and intestines, after weighing with contents, were emptied of their contents and again weighed. All figures for the stomach and intestines include the mesentery.

The testis was weighed with the epididymis.

The organs were weighed with contained blood; except the heart, which was opened and cleaned of the blood in the cavities.

Since the ages of nearly all the specimens observed is unknown, it is impossible to construct accurate curves of growth either for the body as a whole, or for the various organs. However, by arranging the figures representing the relative size (per cent of the total body weight) according to the crown-rump length, curves can be drawn which give an approximate idea of the relative growth of the various organs during prenatal life. However, no definite conclusions can be drawn from these curves as to the rapidity with which the changes in relative size take place. The only exception to this is in the case of the body as a whole, where some data by Keibel on the age of young pig embryos make it possible to compare the growth in the early part with that in the remainder of the prenatal and with the post-natal period.

A possible source of error lies in the fact that some of the litters were fixed in formalin, while others were studied fresh. It is well known that specimens preserved

in formalin show an increase in total weight, amounting sometimes to 10-15% of the total. It is, however, improbable that this increase will materially affect the relative size of the various organs.

### III.

#### OBSERVATIONS.

The observations have been condensed into twenty tables, from which five plates, containing the curves expressing the growth, have been made. In the following pages will be found a short discussion of, and explanations for, the tables and curves.

##### A. TABLES.

Table I gives a summary of all the different litters used. In it will be found the number of pigs in each litter and the number used; the average, maximum and minimum weights and crown-rump lengths observed in those individuals studied; and the preservation, whether fresh or in formalin.

Each of tables II-XIX gives the observations for one litter of fetuses. Individual observations are given for each specimen examined, and all the observations on each measurement taken are averaged and included in the table. The average relative weight of all the viscera is also given for each litter.

The sex, where determinable, is given for each individual, the abbreviation M. being used for the males, F. for the females. The crown-rump length is given in millimeters: the weight in grams: and all other measurements in per cent of the total weight.

Table XX gives the same things for the 4 adults, with the exception of the crown-rump length, which was estimated by a rough measurement of one hog.

A blank is left wherever, for any reason, any measurement was not secured. However, if a column is not given especially for the empty stomach and intestines, the figures given are for the tract with contents.

Wherever only one pig of a sex was examined in a litter, the

average for the sex glands is given only for the observations on the specimens of the opposite sex.

## B. PLATES.

Plate I shows the curve of absolute growth of the whole body, the average weights for the different litters being arranged according to the corresponding average crown-rump lengths. This, of course, gives no idea of the rapidity of the growth changes. Owing to the large value each division must have in order to get the whole curve on one page, the lower end of the curve will be found magnified in the upper left hand corner. The adult weight is not represented.

In the remaining plates, containing the curves expressing the relative prenatal growth for the various organs and the viscera as a whole, the size is given in per cent of the total body weight, and represents the average of the individual observations of each litter and of the adults. The average crown-rump length for the corresponding litter is used for the abscissa. The dotted portion to the right indicates the trend of postnatal growth to the adult relations. These curves give no idea of the rapidity of the changes.

Plate II contains six curves: one each for the head, brain, all the viscera, the liver, stomach and intestines with contents, and the last empty.

Plate III contains five curves:—one each for the heart, lungs, kidneys, spinal cord, and Wolffian bodies.

Plate IV contains three curves:—one each for the eyeballs, pancreas, and thymus.

Plate V is divided into two parts to avoid confusion, the value

of the divisions being the same in both cases. On it will be found the curves for the spleen, thyroid gland, suprarenal glands, and the male and female sex glands. As indicated by the curves for the last two, the sex was not determined at 25 mm.

TABLE I.  
SUMMARY OF MATERIAL USED FOR OBSERVATIONS.

LOT NO. NO. PIGS.	NO. USED. SEX.	CROWN-RUMP LENGTH.			TOTAL WEIGHT.			PRESERVATION.	
		AV. MM.	MAX. MM.	MIN. MM.	AV. G.	MAX. G.	MIN. G.		
13.	8.	8.---	13.6	15	13	.25	--	--	Form.2Mo.
14.	1D.	56.---	18	19	17	.70	.812	.636	Form.6Mo.
24.	10.	6.---	25.4	26	25	1.70	1.828	1.572	Fresh.
17.	8.	3F. 2M.	37	39	35	3.25	3.47	2.92 <sup>5</sup>	Fresh.
21.	2.	2M.	41.5	42	41	4.96	5.17	4.66	Fresh.
8.	6.	5M. 1F.	59 <sub>8</sub>	60	57	10.66	10.88	9.52	Form.4Mo.
2.	?	2M. 2F.	82	85	80	28.17	29.2	26.8 <sup>9</sup>	Form.2Mo.
5.	10.	7M. 3F.	86	101	70	36.5	46.4	22.3	Form.4Mo.
4.	?	1M. 2F.	108 <sup>4</sup>	110	105	97.	116.5	82. <sup>4</sup>	Form.4Mo.
16.	5.	1M. 3F.	107.5 <sup>4</sup>	110	105	74.85	83.2	69.6	Fresh.
23.	8.	2M. 1F.	113	115	110	113.3	116.	110.4	Form.3Mo.
18.	12.	3M. 1F.	126	134	121	145.6	157.6	136.3	Fresh.
3.	?	1M. 3F.	131	135	127	116.2	124.7	107.9	Form3Mo.
1.	?	2M. 1F.	139	141	135	152.	162.5	141.9	Form.2Mo.
11.	5.	3M. 2F.	156	160	145	288.6	309.6	265.1	Form.1Wk.
10.	5.	3M. 2F.	191	202	178	395.	442.	335.2	Fresh.
19.	6.	2M. 1F.	215	220	205	465.	532.5	348.1	Fresh.
9.	5.	2M. 3F.	242	255	224	730.8	782.5	661.	Fresh.
20.	?	-- 3F.	262	265	260	745.1	825.	692.7	Fresh.
ADULTS.	2M. 2F.	1050.				104538.	123614.	91018.	Fresh.

Form. Refers to a 5% solution of Formalin in water.

The total number of pigs in a litter not known for certain wherever a question mark appears.

TABLE II.  
 TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
 VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
 LITTER 14.

NO.	1.	2.	3.	4.	5.	AVERAGE.
CROWN-RUMP LENGTH.	18mm.	17mm.	18mm.	18mm.	19mm.	18mm.
TOTAL WEIGHT.	.636g.	.668g.	.687g.	.700g.	.812g.	.700g.
HEAD.	33.49%	29.34%	30.00%	28.14%	27.36%	29.67%
BRAIN.	7.42	8.50	9.78	---	10.32	9.01
EYEBALLS.	.094	.15	.20	.17	.17	.16
SPINAL CORD.	--	--	--	1.43	2.31	1.87
LUNGS.	.094	--	--	--	.61	.35
HEART.	2.73	3.23	2.85	5.71	3.03	3.51
LIVER.	12.78	12.90	13.59	9.23	9.41	11.58
STOMACH AND INTESTINES.	.18	--	.17	--	.46	.27
WOLFFIAN BODY.	6.60	7.84	8.15	7.60	7.07	7.49
ALL VISCERA AVERAGE	-----					34.24
Sex not determined for these specimens.						

TABLE III.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 24.

NO.	1.	2.	3.	4.	5.	6.	AVERAGE.
CROWN-RUMP LENGTH.	26mm.	25mm.	25mm.	25mm.	--	26mm.	25.4mm.
TOTAL WEIGHT.	1.572g.	1.622g.	1.627g.	1.760g.	1.791g.	1.828g.	1.70g.
HEAD.	27.98%	29.83%	29.56%	28.41%	28.25%	29.65%	28.95%
BRAIN.	4.83	7.58	6.94	6.87	6.81	5.68	6.62
EYEBALLS.	.41	.43	.32	.42	.31	.41	.37
SPINAL CORD.	1.71	1.22	1.72	1.19	.98	1.04	1.31
LUNGS.	.48	.56	.82	.43	.49	.42	.53
HEART.	3.49	3.39	3.25	3.07	3.23	3.11	3.26
LIVER.	17.23	16.39	12.53	14.83	16.91	17.66	16.60
STOMACH AND INTESTINES.	1.52	1.61	.95	1.08	1.24	1.20	1.27
SEX GLANDS.	.13	.13	.11	.13	.13	.15	.13
KIDNEYS.	.25	.29	.24	.18	.20	.26	.24
WOLFFIAN BODY.	5.03	4.37	4.97	4.03	5.41	4.54	4.73
ALL VISCERA AVERAGE-----							35.06

Sex not determined in these individuals.



TABLE IV.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 17.

NO. AND SEX.	1-F.	2-F.	3-F.	4-M.	5-M.	AVERAGE.
CROWN-RUMP LENGTH.	35mm.	37mm.	38mm.	39mm.	35mm.	37mm.
TOTAL WEIGHT.	2.925g.	3.287g.	3.305g.	3.385g.	3.47g.	3.254g.
HEAD.	37.11%	25.85%	-----	23.81%	24.98%	25.44%
BRAIN.	5.16	5.41	6.71	6.09	6.05	5.88
EYEBALLS.	.58	.79	--	.61	.66	.66
SPINAL CORD.	1.53	.88	1.15	.45	1.12	1.03
RIGHT LUNG.	--	.72	.73	.61	.43	.62
LEFT LUNG.	--	.36	.39	.45	.28	.37
HEART.	2.25	2.25	2.39	2.03	2.33	2.23
LIVER.	13.67	15.54	15.43	14.85	16.88	15.27
STOMACH AND INTESTINES.	1.77	1.46	1.36	.97	1.06	1.32
SEX GLANDS.	--	.061	.091	.24	.23	(M) .235 (F) .076
KIDNEYS.	.58	.70	.96	.39	.81	.69
WOLFFIAN BODY.	2.59	2.03	2.02	2.49	3.03	2.43
ALL VISCERA AVERAGE-----						31.66

TABLE V.

TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.

LITTER 21.

NO. AND SEX.	1-M.	2-M.	AVERAGE.
CROWN-RUMP LENGTH.	41mm.	42mm.	41.5mm.
<u>TOTAL WEIGHT.</u>	<u>4.66g.</u>	<u>5.17g.</u>	<u>4.97g.</u>
HEAD.	27.89%	25.33%	26.61%
BRAIN.	7.10	6.65	6.88
EYEBALLS.	.64	.59	.62
SPINAL CORD.	1.48	1.41	1.45
RIGHT LUNG.	.77	.73	.75
LEFT LUNG.	.62	.50	.56
HEART.	2.46	2.16	2.31
LIVER.	13.32	14.68	14.00
STOMACH AND INTESTINES.	1.48	1.76	1.62
SPLEEN.	.012	.019	.016
PANCREAS.	.034	.050	.042
SUPRARENALS.	.11	.11	.11
SEX GLANDS.	.24	.26	.25
KIDNEYS.	.60	.65	.63
WOLFFIAN BODY.	2.85	2.86	2.85
ALL VISCERA AVERAGE-----			32.09

TABLE VI.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 8.

NO. AND SEX.	1-F.	2-M.	3-M.	4-M.	5-M.	6-M.	AVERAGE.
CROWN-RUMP LENGTH.	58mm.	59mm.	58mm.	60mm.	60mm.	57mm.	59mm.
TOTAL WEIGHT.	9.52g.	10.1g.	10.26g.	10.36g.	10.88g.	10.88g.	10.66g.
HEAD.	22.22%	24.68%	22.34%	24.73%	24.41%	22.61%	23.45%
BRAIN.	--	7.72	6.55	7.73	7.60	6.49	7.22
EYEBALLS.	1.02	1.03	.82	1.02	.93	.86	.95
SPINAL CORD.	.83	.87	.99	.91	.79	.78	.86
THYROID.	.052	.059	.038	.043	.032	--	.045
THYMUS.	.12	.079	.097	--	--	--	.097
RIGHT LUNG.	1.41	1.64	1.87	1.63	2.05	1.60	1.69
LEFT LUNG.	1.01	1.06	1.25	1.25	1.42	1.12	1.18
HEART.	2.10	2.05	1.87	1.90	2.07	1.61	1.93
LIVER.	16.64	15.39	15.19	14.75	16.86	14.92	15.62
STOMACH AND INTESTINES.	3.11	2.41	2.91	2.70	2.81	2.46	2.73
SPLEEN.	.042	.039	.038	.048	.028	.041	.039
PANCREAS.	.094	.18	.13	.086	.082	.091	.11
SUPRARENALS.	.13	.12	.13	.13	.091	.15	.12
SEX GLANDS.	.094	.16	.17	.16	.15	.17	(M).15
KIDNEYS.	2.39	2.56	2.33	2.89	2.65	2.55	2.57
WOLFFIAN BODY.	1.45	1.29	1.38	1.24	1.29	1.78	1.41
ALL VISCERA AVERAGE-----							36.72

TABLE VII.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 2.

NO. AND SEX.	1-F.	2-F.	3-M.	4-M.	AVERAGE.
CROWN-RUMP LENGTH.	80mm.	85mm.	80mm.	82mm.	82mm.
TOTAL WEIGHT.	26.8g.	29.2g.	27.6g.	29.1g.	28.18g.
HEAD.	23.54%	21.47%	21.63%	21.78%	22.11%
BRAIN.	4.95	4.71	4.86	4.91	4.86
EYEBALLS.	.90	.82	--	.88	.86
SPINAL CORD.	.42	.41	.43	.49	.44
THYROID.	.022	.023	.018	.041	.026
THYMUS.	.044	.075	--	.044	.054
RIGHT LUNG.	1.78	1.66	1.88	2.00	1.83
LEFT LUNG.	1.30	1.10	1.23	1.45	1.27
HEART.	1.46	1.60	1.55	1.46	1.52
LIVER.	10.57	11.27	10.80	9.39	10.51
STOMACH AND INTESTINES.	2.42	2.66	2.54	2.40	2.51
SPLEEN.	.033	.044	.039	.031	.037
PANCREAS.	.078	--	.086	.079	.081
SUPRARENALS.	--	.071	.069	.048	.063
SEX GLANDS.	.044	.11	.097	.10	M. -- .099 F. -- .077
KIDNEYS.	2.66	2.30	2.23	2.91	2.52
WOLFFIAN BODY..	.35	.38	.38	.39	.38
ALL VISCERA AVERAGE-----					27.05

TABLE VIII.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 5.

NO. AND SEX.	1-M.	2-M.	3-M.	4-M.	5-M.	6-M.
CROWN-RUMP LENGTH.	70mm.	84mm.	85mm.	92mm.	101mm.	90mm.
TOTAL WEIGHT.	22.2g.	34.6g.	35.7g.	39.55g.	43. g.	45.25g.
HEAD.	29.95%	22.94%	26.48%	23.39%	25.38%	23.48%
BRAIN.	5.38	5.18	3.33	5.73	6.29	5.24
EYEBALLS.	1.19	1.21	--	--	1.07	--
SPINAL CORD.	.49	.41	.52	.45	.37	.37
THYROID.	--	.040	.047	.045	.046	.031
THYMUS.	--	.13	.12	--	.18	--
RIGHT LUNG.	2.00	1.78	2.46	2.67	2.29	2.41
LEFT LUNG.	1.33	1.48	1.82	1.91	1.50	1.66
HEART.	1.83	1.65	1.31	1.27	1.39	1.31
LIVER.	14.75	11.97	7.91	10.12	10.07	7.02
STOMACH AND INTESTINES.	2.85	2.35	3.11	3.21	3.34	2.46
SPLEEN.	.063	.061	.075	.037	.083	.040
PANCREAS.	.085	.11	.058	.13	.15	.13
SUPRARENALS.	.12	.12	.061	.059	.053	.072
SEX GLANDS.	.094	.095	.072	.060	.048	.071
KIDNEYS.	2.33	2.45	2.32	2.22	2.09	1.74
WOLFFIAN BODY.	.49	.41	.13	.15	.091	.077

ALL VISCERA AVERAGE-----

NOTE. All the pigs of this litter, excepting numbers 1, 2, and 9, were somewhat distorted, so that the crown-rump length could not be accurately determined.

TABLE VIII.  
(CONTINUED).

NO. AND SEX.	7-M.	8-F.	9-F.	10-F.	AVERAGE.
CROWN-RUMP LENGTH.	95mm.	80mm.	78mm.	87mm.	86mm.
TOTAL WEIGHT.	46.4g.	38.8g.	31.4g.	38.5g.	36.54g.
HEAD.	24.81%	26.07%	22.29%	27.11%	25.19%
BRAIN.	5.47	3.12	5.08	5.38	5.02
EYEBALLS.	1.18	1.20	.98	--	1.14
SPINAL CORD.	.25	.59	.45	.32	.42
THYROID.	.032	.045	.038	.059	.038
THYMUS.	.18	.13	.10	.067	.13
RIGHT LUNG.	2.17	2.29	2.09	2.26	2.24
LEFT LUNG.	1.25	1.74	1.41	1.57	1.66
HEART.	1.25	1.42	1.62	1.24	1.45
LIVER.	6.78	8.61	13.16	8.41	9.88
STOMACH AND INTESTINES.	3.19	3.05	2.38	2.83	2.87
SPLEEN.	.064	.065	.060	.14	.069
PANCREAS.	.14	.15	.12	.064	.11
SUPRARENALS.	.075	.047	.082	.085	.077
SEX GLANDS.	.064	.045	.060	.035	M-.072 F-.047
KIDNEYS.	1.79	1.88	2.68	2.26	2.18
WOLFFIAN BODY.	--	.22	.47	.12	.24
ALL VISCERA AVERAGE	-----				27.59

TABLE IX.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 16.

NO. AND SEX.	1-M..	2-F.	3-F.	4-F.	AVERAGE.
CROWN-RUMP LENGTH.	105mm.	105mm.	110mm.	110mm.	107.5mm.
TOTAL WEIGHT.	75.5g.	69.6g.	71.1g.	83.2g.	74.9g.
HEAD.	17.91%	20.95%	---	19.61%	19.49%
BRAIN.	2.65	3.91	---	3.28	3.28
EYEBALLS.	.52	.75	---	.73	.72
SPINAL CORD.	.31	.29	.45	.31	.37
THYROID.	--	.018	.026	.034	.026
THYMUS.	.19	.10	.10	.17	.14
RIGHT LUNG.	1.43	1.71	1.31	1.62	1.52
LEFT LUNG.	.95	1.19	.90	1.19	1.06
HEART.	.84	.85	.74	.84	.82
LIVER.	8.76	8.15	8.22	7.97	8.28
STOMACH AND INTESTINES.	2.82	2.75	2.45	2.91	2.73
SAME-EMPTY.	2.03	1.83	1.70#	2.04#	1.90
SPLEEN.	.054	.070	.053	.072	.062
PANCREAS.	.11	.11	.11	.090	.11
SUPRARENALS.	.039	.027	--	.037	.034
SEX GLANDS.	.083	.034	.022	.045	(F).034
KIDNEYS.	1.71	1.64	1.78	1.85	1.75
WOLFFIAN BODY.	.066	.10	.063	.074	.076
ALL VISCERA AVERAGE-----					21.01

# Weight of the stomach and intestines estimated from the others for these two cases (empty, lose about 30%).

TABLE X.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 4.

NO. AND SEX.	1-M.	2-F.	3-F.	AVERAGE.
CROWN-RUMP LENGTH.	105mm.	110mm.	110mm.	108mm.
TOTAL WEIGHT.	82. g.	92.5g.	116.5g.	97. g.
HEAD.	---	24.54%	20.77%	22.65%
BRAIN.	4.21%	4.42	3.22	3.94
EYEBALLS.	.76	.86	.63	.76
SPINAL CORD.	.25	--	--	.25
THYROID.	---	.033	.029	.031
THYMUS.	.021	.085	.054	.053
RIGHT LUNG.	2.01	2.27	1.97	2.08
LEFT LUNG.	1.38	1.49	1.35	1.41
HEART.	.85	1.02	.74	.87
LIVER.	3.85	5.44	5.61	4.95
STOMACH AND INTESTINES.	2.48	3.06	2.88	2.78
SPLEEN.	.071	.049	.061	.060
PANCREAS.	.068	.093	.082	.081
SUPRARENALS.	.028	.026	.037	.030
SEX GLANDS.	.023	.033	.033	(F) .033
KIDNEYS.	1.65	1.95	1.78	1.79
ALL VISCERA AVERAGE-----				19.10



TABLE XI.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 23.

NO. AND SEX.	1-F.	2-M.	3-M.	AVERAGE.
CROWN-RUMP LENGTH.	114mm.	110mm.	115mm.	113mm.
TOTAL WEIGHT.	110.4g.	113.6g.	116. g.	113.3g.
HEAD.	20.38%	18.83%	21.03%	20.08%
BRAIN.	3.52	3.16	3.10	3.26
EYEBALLS.	.72	.67	--	.70
SPINAL CORD.	.30	.27	.17	.25
THYROID.	.027	.028	.017	.024
THYMUS.	.19	.19	.18	.19
RIGHT LUNG.	1.48	1.40	1.15	1.34
LEFT LUNG.	1.05	.95	1.02	1.01
HEART.	1.02	.87	.88	.92
LIVER.	5.10	5.83	5.23	5.39
STOMACH AND INTESTINES.	2.31	2.25	2.38	2.31
SPLEEN.	.042	.043	.050	.045
PANCREAS.	.13	.14	.13	.13
SUPRARENALS.	.041	.061	.057	.053
SEX GLANDS.	.022	.081	.049	(M).065
KIDNEYS.	1.36	1.33	1.39	1.36
WOLFFIAN BODY.	.031	--	.052	.042
ALL VISCERA AVERAGE-----				17.03

TABLE XII.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 18.

NO. AND SEX.	1-F.	2-M.	3-M.	4-M.	AVERAGE.
CROWN-RUMP LENGTH.	121mm.	125mm.	125mm.	134mm.	126mm.
TOTAL WEIGHT.	137.5g.	136.3g.	151. g.	157.6g.	145.6g.
HEAD.	-----	23.04%	22.25%	21.05%	22.11%
BRAIN.	3.41	3.63	3.10	3.31	3.36
EYEBALLS.	.69	.67	.72	.62	.68
SPINAL CORD.	.16	.17	.13	.16	.16
THYROID.	.033	.039	.044	.041	.039
THYMUS.	.17	.17	.25	.29	.21
RIGHT LUNG.	1.51	1.43	1.01	1.47	1.36
LEFT LUNG.	.95	1.02	.71	1.10	.95
HEART.	.75	.68	.71	.69	.71
LIVER.	6.43	5.52	5.85	6.79	6.15
STOMACH AND INTESTINES.	3.13	2.89	3.31	4.19	3.38
SAME-EMPTY.	1.74	-----	1.87	2.42	2.01
SPLEEN.	.094	.085	.14	.10	.11
PANCREAS.	.095	.11	.11	.12	.11
SUPRARENALS.	.035	.036	.053	.032	.039
SEX GLANDS..	.024	.041	.064	.053 (M)	.053
KIDNEYS.	1.17	1.23	1.49	1.43	1.35
ALL VISCERA AVERAGE-----					18.66

There were two pathological pigs in this litter (not used).

TABLE XIII.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 3.

NO. AND SEX.	1-F.	2-F.	3-F.	4-M.	AVERAGE.
CROWN-RUMP LENGTH.	130mm.	130mm.	127mm.	135mm.	131mm.
TOTAL WEIGHT.	107.9g.	124.7g.	117.5g.	114.8g.	116.25g.
HEAD.	35.74%	22.67%	24.24%	25.52%	24.51%
BRAIN.	4.82	4.51	4.41	4.29	4.51
EYEBALLS.	--	.84	.92	.92	.89
SPINAL CORD.	.30	.34	.27	.15	.27
THYROID.	.031	.035	.025	.034	.038
THYMUS.	.16	.15	.20	.18	.16
RIGHT LUNG.	1.91	2.11	1.87	2.04	1.98
LEFT LUNG.	1.32	1.65	1.27	1.42	1.42
HEART.	.91	.91	.85	.82	.87
LIVER.	4.39	4.81	4.89	5.55	4.91
STOMACH AND INTESTINES.	3.06	2.74	2.97	2.94	2.93
SPLEEN.	.078	.066	.088	.071	.076
PANCREAS.	.11	.10	.13	.092	.11
SUPRARENALS.	.037	.031	.032	.030	.033
SEX GLANDS..	.041	.031	.044	.046	(F).039
KIDNEYS.	.90	1.00	1.08	.89	.97
ALL VISCERA AVERAGE-----					19.21

TABLE XIV.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 1.

NO. AND SEX.	1-F.	2-M.	3-M.	AVERAGE.
CROWN-RUMP LENGTH.	141mm.	135mm.	140mm.	139mm.
TOTAL WEIGHT.	154.5g.	142. g.	162.6g.	153. g.
HEAD.	22.16%	23.65%	21.79%	22.53%
BRAIN.	3.87	4.62	3.31	3.93
EYEBALLS.	.78	.80	.73	.77
SPINAL CORD.	.21	.23	.28	.24
THYROID.	.030	.032	.031	.031
THYMUS.	.23	.17	.20	.20
RIGHT LUNG.	1.76	2.05	1.95	1.92
LEFT LUNG.	1.28	1.49	1.43	1.40
HEART.	.87	.91	.86	.88
LIVER.	4.45	4.23	4.75	4.48
STOMACH AND INTESTINES.	3.98	3.58	3.53	3.68
SPLEEN.	.093	.073	.092	.086
PANCREAS.	.097	.16	.12	.13
SUPRARENALS.	.032	.026	.020	M- .023
SEX GLANDS.	--	.038	.040	.039
KIDNEYS.	1.63	1.56	1.52	1.57
ALL VISCERA AVERAGE-----				19.48

TABLE XV.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 11.

NO. AND SEX.	1-F.	2-F.	3-M.	4-M.	5-M.	AVERAGE.
CROWN-RUMP LENGTH.	160mm.	160mm.	145mm.	155mm.	162mm.	156mm.
TOTAL WEIGHT.	265.1g.	292.9g.	280.1g.	296.1g.	309.6g.	288.6g.
HEAD.	22.29%	21.27%	24.91%	22.45%	22.77%	22.73%
BRAIN.	3.63	3.62	3.55	3.38	3.48	3.53
EYEBALLS.	.54	.49	.60	.52	.52	.53
SPINAL CORD.	--	.24	.17	.20	.19	.20
THYROID.	.021	.023	.024	.026	.022	.023
THYMUS.	.22	.19	.21	.23	.21	.21
RIGHT LUNG.	1.61	1.43	1.33	1.32	1.23	1.38
LEFT LUNG.	1.06	.92	1.02	.92	.99	.98
HEART.	.71	.82	.65	.71	.67	.71
LIVER.	3.59	3.61	3.45	3.55	2.87	3.40
STOMACH AND INTESTINES.	3.82	4.15	3.34	3.17	3.03	3.50
SAME-EMPTY.	2.5 #	2.78	2.2 #	2.1 #	2.0 #	2.32
SPLEEN.	.092	.092	.095	.092	.083	.091
PANCREAS.	.17	.13	.11	.094	.11	.12
SUPRARENALS.	.018	.021	.018	.020	.021	.018
SEX GLANDS.	.021	.025	.037	--	--	(F).023
KIDNEYS.	1.09	1.10	1.12	.99	.99	1.06
ALL VISCERA AVERAGE	-----					15.81

# The relative weight of the empty stomach and intestines

estimated from the observation on NO. 2.

TABLE XVI.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 10.

NO. AND SEX.	1-F.	2-F.	3-M.	4-M.	5-M.	AVERAGE.
CROWN-RUMP LENGTH.	190mm.	197mm.	189mm.	178mm.	202mm.	191mm.
TOTAL WEIGHT.	364.9g.	435.6g.	335.2g.	397.5g.	442. g.	395. g.
HEAD.	21.70%	21.76%	25.14%	22.70%	20.56%	22.37%
BRAIN.	3.77	3.19	3.64	3.44	3.16	3.44
EYEBALLS.	.56	.44	.61	.56	.47	.53
SPINAL CORD.	.27	.20	--	.24	.20	.23
THYROID.	.027	.014	.019	.024	.018	.020
THYMUS.	.24	.27	.18	.26	.21	.23
RIGHT LUNG.	1.61	1.51	1.57	1.72	1.55	1.59
LEFT LUNG.	1.12	1.07	1.12	1.17	1.11	1.12
HEART.	.68	.61	.63	.72	.64	.66
LIVER.	3.36	3.12	3.29	3.36	3.30	3.29
STOMACH AND INTESTINES.	3.94	3.59	4.16	4.01	3.59	3.86
SAME-EMPTY.	2.79	2.5 #	2.8 #	2.7 #	2.0 #	2.56
SPLEEN.	.15	.13	.15	.14	.12	.14
PANCREAS.	.18	.14	.23	.15	.13	.17
SUPRARENALS.	.014	.015	.020	.017	.014	.016
SEX GLANDS.	.021	.012	.026	.025	.032	(M) .028 (F) .017
KIDNEYS.	.96	.92	.96	.76	.93	.90
ALL VISCERA AVERAGE	-----					16.22

TABLE XVII.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 19.

NO.. AND SEX.	1-F.	2-M.	3-M.	AVERAGE.
CROWN-RUMP LENGTH.	205mm.	220mm.	220mm.	215mm.
TOTAL WEIGHT.	348.1g.	514.4g.	532.5g.	465. g.
HEAD.	23.56%	19.30%	20.47%	21.11%
BRAIN.	4.92	3.69	3.39	3.99
EYEBALLS.	.53	.43	.41	.45
SPINAL CORD.	.31	.26	.19	.25
THYROID.	.038	.037	.027	.034
THYMUS.	.50	.32	.30	.37
RIGHT LUNG. } LEFT LUNG. }-	3.42	2.75	2.73	2.96
HEART.	1.12	.92	.85	.96
LIVER.	3.93	3.66	3.64	3.74
STOMACH AND INTESTINES.	4.92	4.87	4.83	4.87
SPLEEN.	.18	.15	.15	.16
PANCREAS.	.19	.19	.16	.18
SUPRARENALS.	.025	.019	.022	.022
SEX GLANDS.	.021	--	--	(F) .021
KIDNEYS.	1.48	1.04	1.11	1.21
ALL VISCERA AVERAGE-----				19.22

TABLE XVIII.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 9.

NO. AND SEX..	1-M.	2-M.	3-F.	4-F.	5-F.	AVERAGE.
CROWN-RUMP LENGTH.	242mm.	255mm.	224mm.	235mm.	252mm.	242mm.
TOTAL WEIGHT.	705.4g.	774. g.	661. g.	731.1g.	782.5g.	730.8g.
HEAD.	20.98%	22.84%	22.29%	21.13%	22.25%	21.90%
BRAIN.	3.37	3.24	3.63	3.49	3.24	3.39
EYEBALLS.	.32	.32	.38	.36	.30	.34
SPINAL CORD.	.32	.24	.31	.30	.22	.28
THYROID.	.024	--	.027	.022	.019	.022
THYMUS.	.35	.27	.46	.35	.26	.34
RIGHT LUNG.	1.04	1.13	1.43	1.58	1.13	1.26
LEFT LUNG.	.74	.76	1.19	1.17	.79	.92
HEART.	.72	.76	.91	.91	.77	.81
LIVER.	2.45	2.77	2.80	2.67	2.43	2.62
STOMACH AND INTESTINES.	3.89	5.04	5.01	5.17	3.91	4.61
SAME-EMPTY.	2.5 #	3.34	2.68	3.45	2.65	2.92
SPLEEN.	.16	.15	.13	.18	.10	.14
PANCREAS.	.13	.16	.16	.12	.16	.15
SUPRARENALS.	.013	--	.014	.011	.014	.013
SEX GLANDS.	.042	.032	.013	.012	.016	(M) .037
KIDNEYS.	.99	1.02	1.10	.96	.93	(F) .014
ALL VISCERA AVERAGE.	-----					16.92



TABLE XIX.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
LITTER 19.

NO. AND SEX.	1-F.	2-F.	3-F.	AVERAGE.
CROWN-RUMP LENGTH.	260mm.	260mm.	265mm.	262mm.
TOTAL WEIGHT.	692.7g.	717.5g.	825. g.	745.1g.
HEAD.	22.59%	21.89%	20.68%	21.72%
BRAIN.	3.91	3.99	3.71	3.87
EYEBALLS.	.45	.42	.34	.40
SPINAL CORD.	.30	.36	.31	.32
THYROID.	.025	.024	.029	.026
THYMUS.	.29	.31	.51	.37
LUNGS.	2.04	1.79	2.18	2.00
HEART.	1.00	.97	1.04	1.00
LIVER.	2.89	2.90	3.19	3.00
STOMACH AND INTESTINES.	5.62	5.90	6.02	5.85
SPLEEN.	.13	.22	.16	.17
PANCREAS.	.14	.13	.21	.16
SUPRARENALS.	.021	.021	.013	.018
SEX GLANDS.	.024	—	.045	.035
KIDNEYS.	1.04	.90	1.02	1.00
ALL VISCERA AVERAGE	-----			18.20

TABLE XX.  
TOTAL WEIGHT IN GRAMS, AND RELATIVE WEIGHT OF THE  
VARIOUS ORGANS IN PER CENT OF THE TOTAL WEIGHT.  
ADULTS.

NO. AND SEX.	1-F.	2-F.	3-M.	4-M.	AVERAGE.
CROWN-RUMP LENGTH.	---	---	---	1050mm.	1050mm?
<u>TOTAL WEIGHT.</u>	<u>91,018g.</u>	<u>102,119g.</u>	<u>101,401g.</u>	<u>123,615g.</u>	<u>104,538g.</u>
HEAD.	6.97%	6.22%	6.27%	4.80%	6.07%
BRAIN.	--	--	--	.085	.085
EYEBALLS.	--	--	--	.011	.011
SPINAL CORD.	.037	.039	.032	.038	.037
THYROID.	--	--	--	.004	.004
RIGHT LUNG.	.51	.38	.35	.42	.39
LEFT LUNG.	.26	.29	.17	.40	.29
HEART.	.31	.30	.34	.28	.31
LIVER.	1.23	1.61	1.36	1.22	1.35
STOMACH AND INTESTINES.	5.82	7.06	6.35	7.46	6.67
SAME-EMPTY.	4.19#	5.02	4.57#	5.37#	4.79
SPLEEN.	.092	.15	.11	.14	.12
PANCREAS.	.13	--	.15	--	.14
SUPRARENALS.	.007	--	--	.003	.005
SEX GLANDS.	.013	.017	--	--	.015
KIDNEYS.	.23	.29	.26	.22	.25
ALL VISCERA AVERAGE-----					9.68

#- Relative weight of the stomach and intestines empty estimated from the one observation on NO. 2.

The length is an estimate from the length in inches.

Plate I.

Curves of Absolute Growth of the Whole Body.  
Length to Weight.

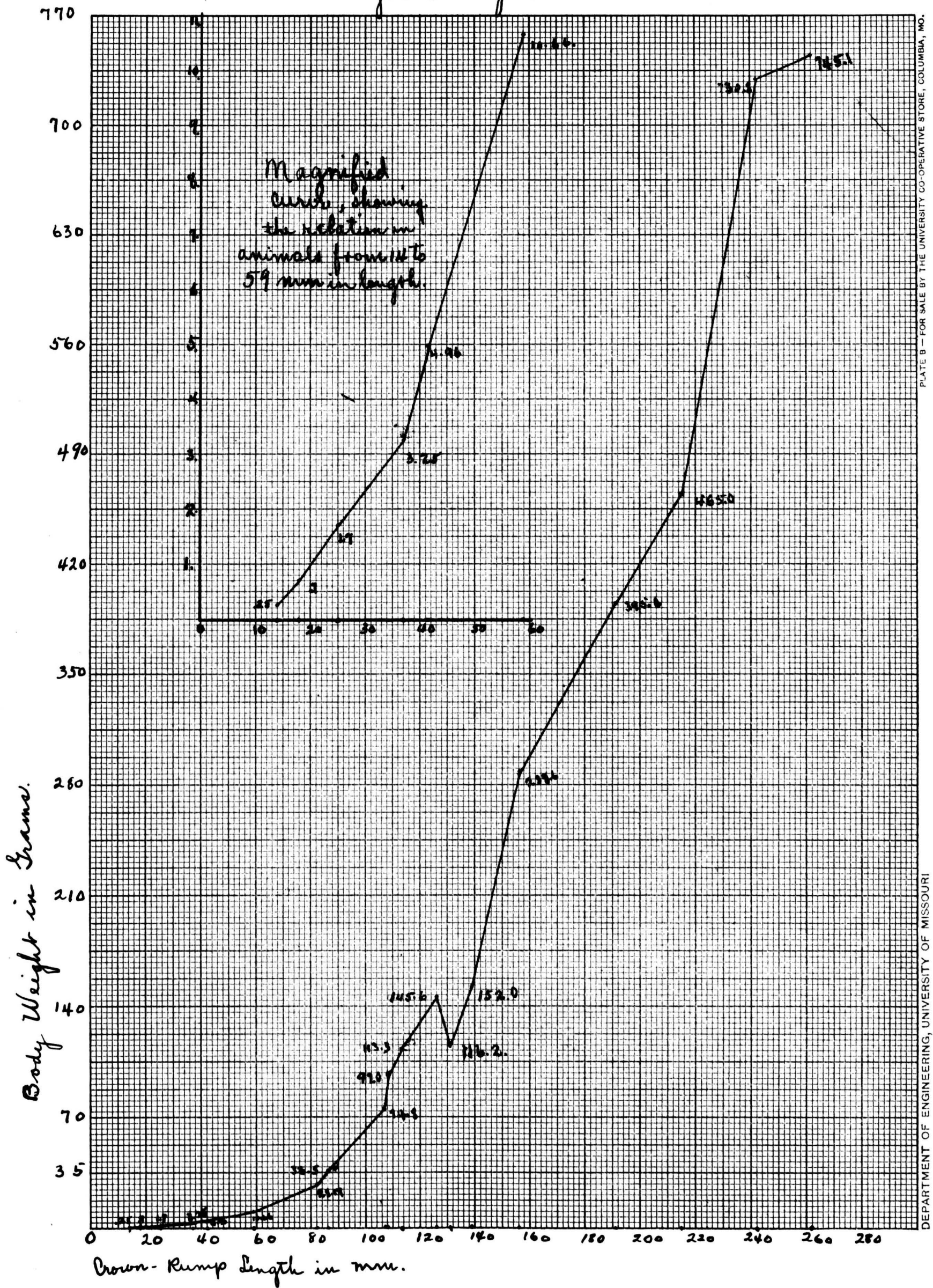


PLATE B - FOR SALE BY THE UNIVERSITY CO-OPERATIVE STORE, COLUMBIA, MO.  
DEPARTMENT OF ENGINEERING, UNIVERSITY OF MISSOURI

Per Cent of the Total Weight.

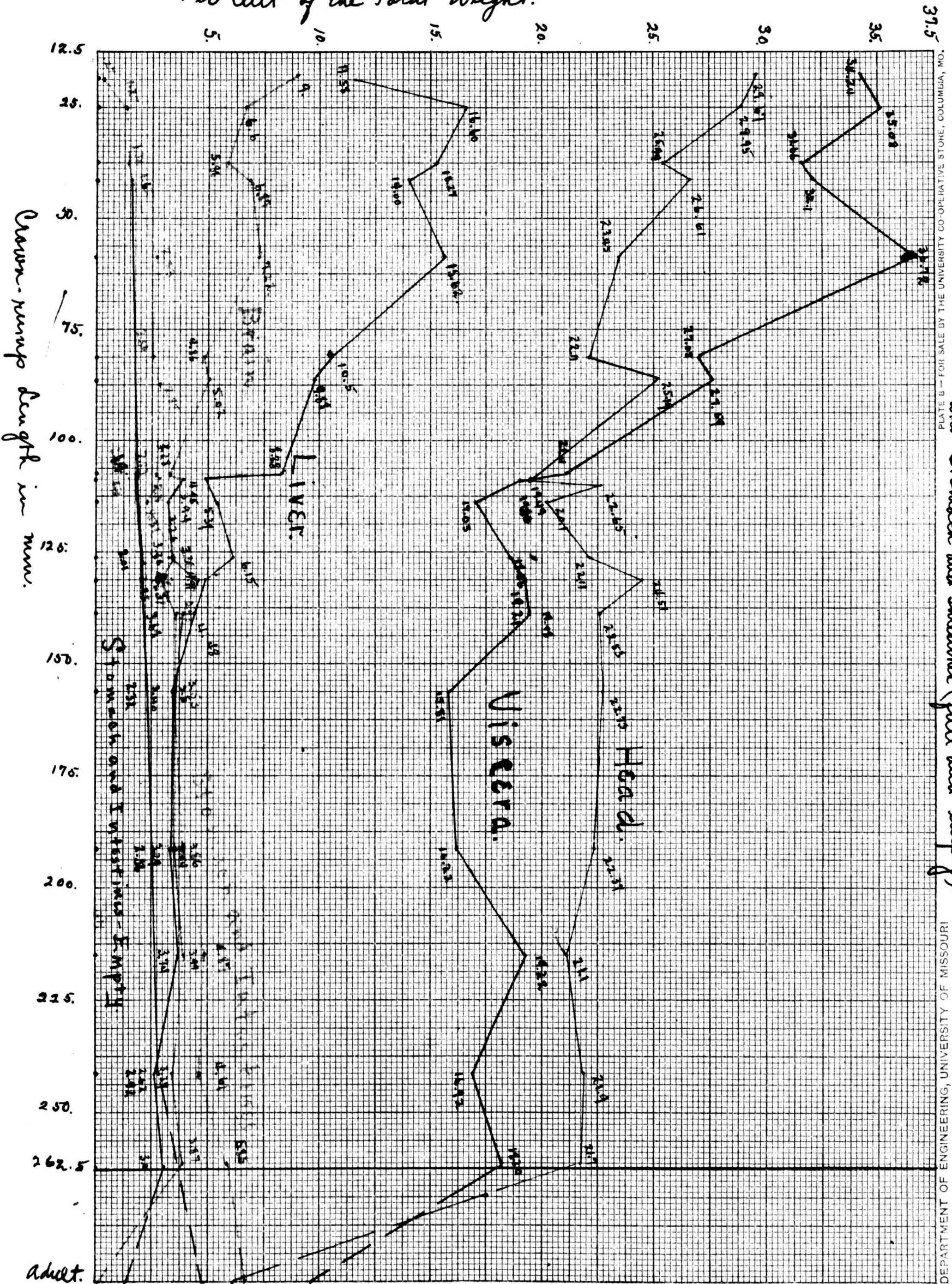


Plate II.  
 known of Relation between pupa length for the viscera, head, brain, liver, and stomach and fatness (full and empty).

DEPARTMENT OF ENGINEERING, UNIVERSITY OF MISSOURI  
 PLATE B - FOR SALE BY THE UNIVERSITY CO-OPERATIVE STORE, COLUMBIA, MO.

9.68 all  
 Viscera.  
 6.67 stomach  
 6.07 head.  
 4.98 stomach  
 and fatness  
 empty.  
 1.35 brain.  
 0.85 liver.

Per Cent of the Total Weight.

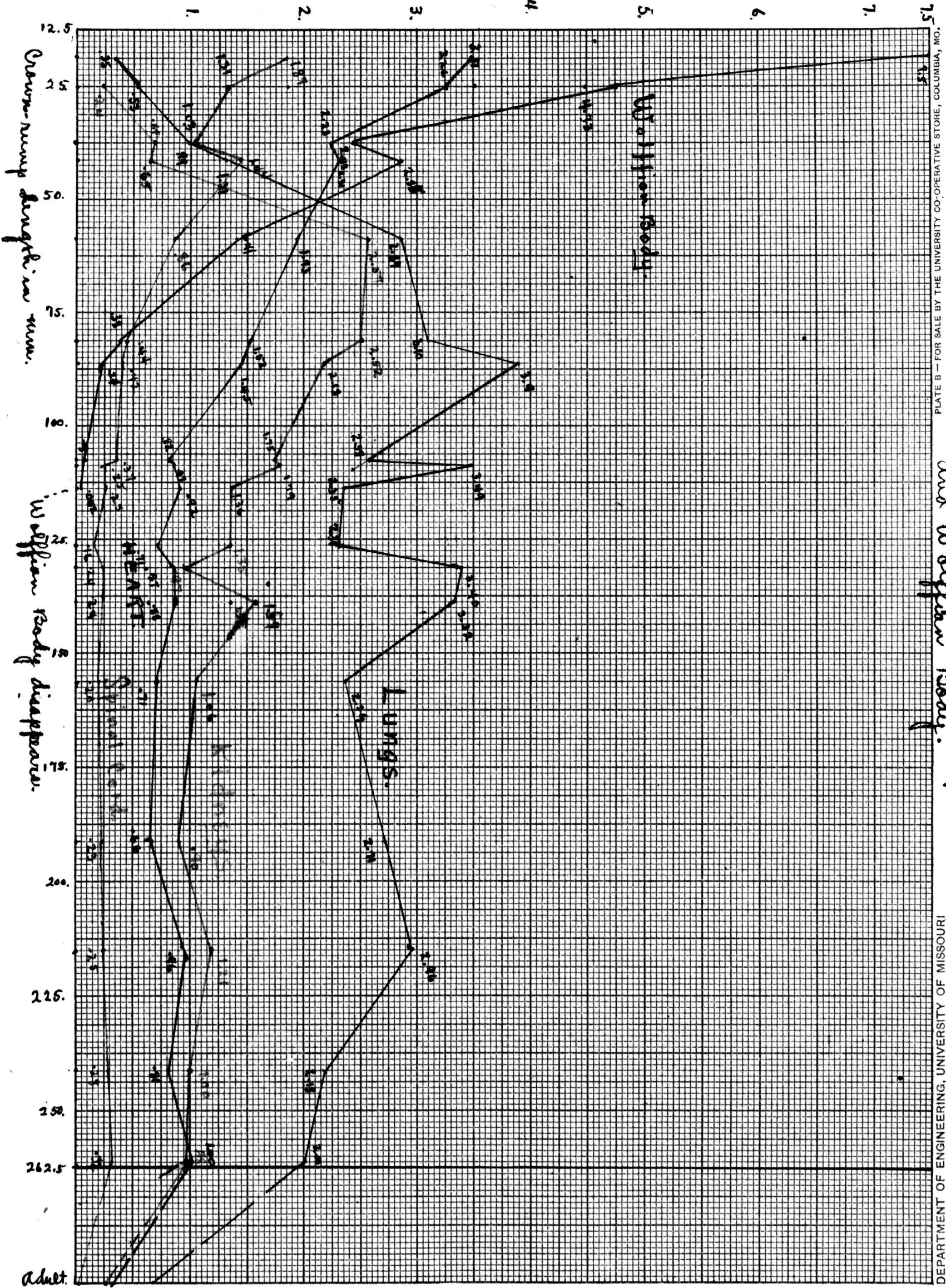
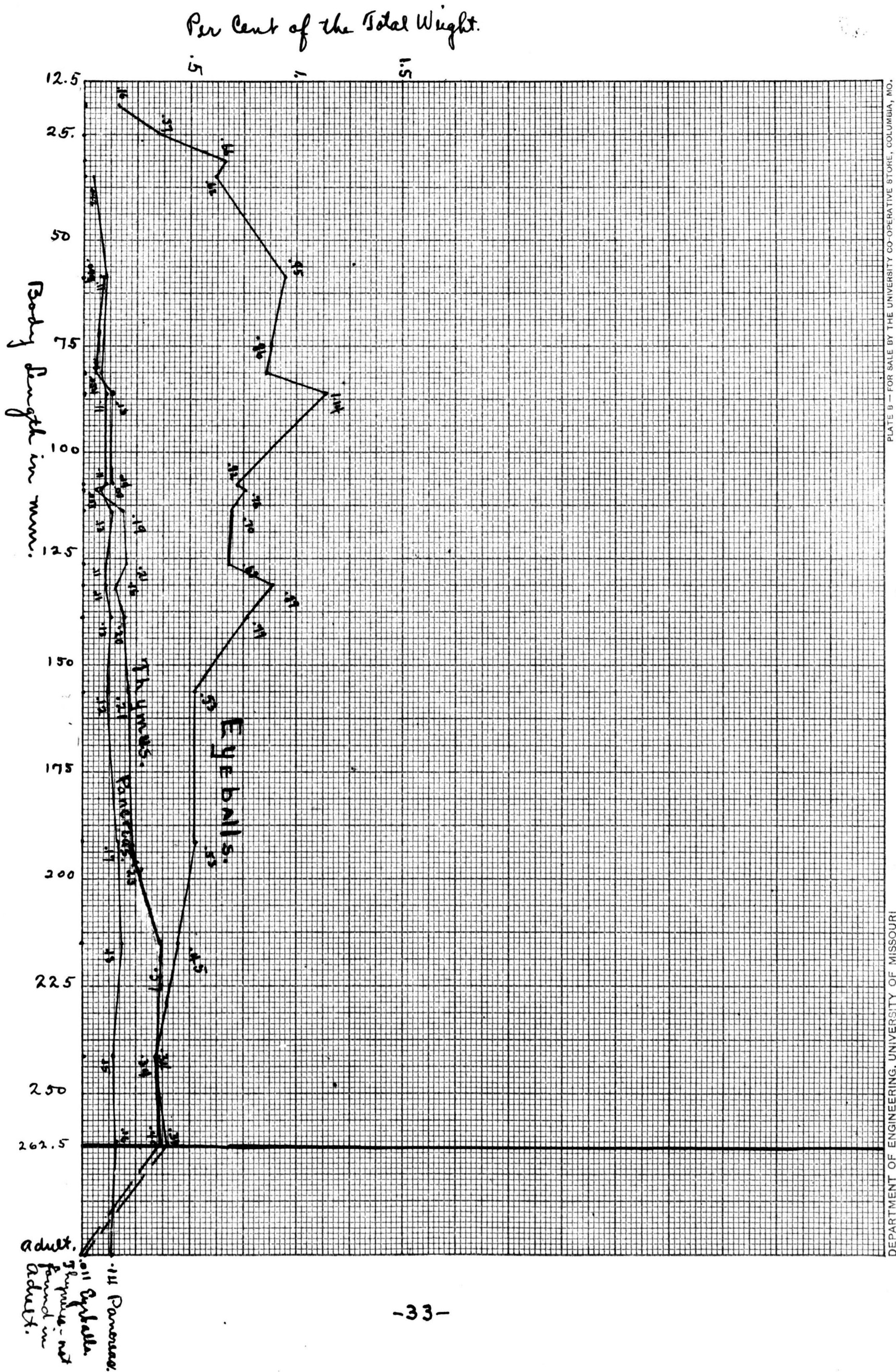


PLATE III.  
 Course of Relative Growth for the Lungs, Kidneys, Heart, Spinal Cord  
 and Wolffian Body.

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Adult  
 .057 Spinal  
 Cord.  
 .25 Kidneys  
 .35 Heart  
 6.8 Body  
 Lungs

Plate IV  
 Curves of growth for the Eyeballs, Thyroids and Pancreas.



Adult.  
 Thyroids - not found in Adult.  
 .11 Eyeballs.  
 .11 Pancreas.

Course of Relative Growth for the Thyroid Gland, Suprarenal Glands, Spleen and Sex Glands (male and female).

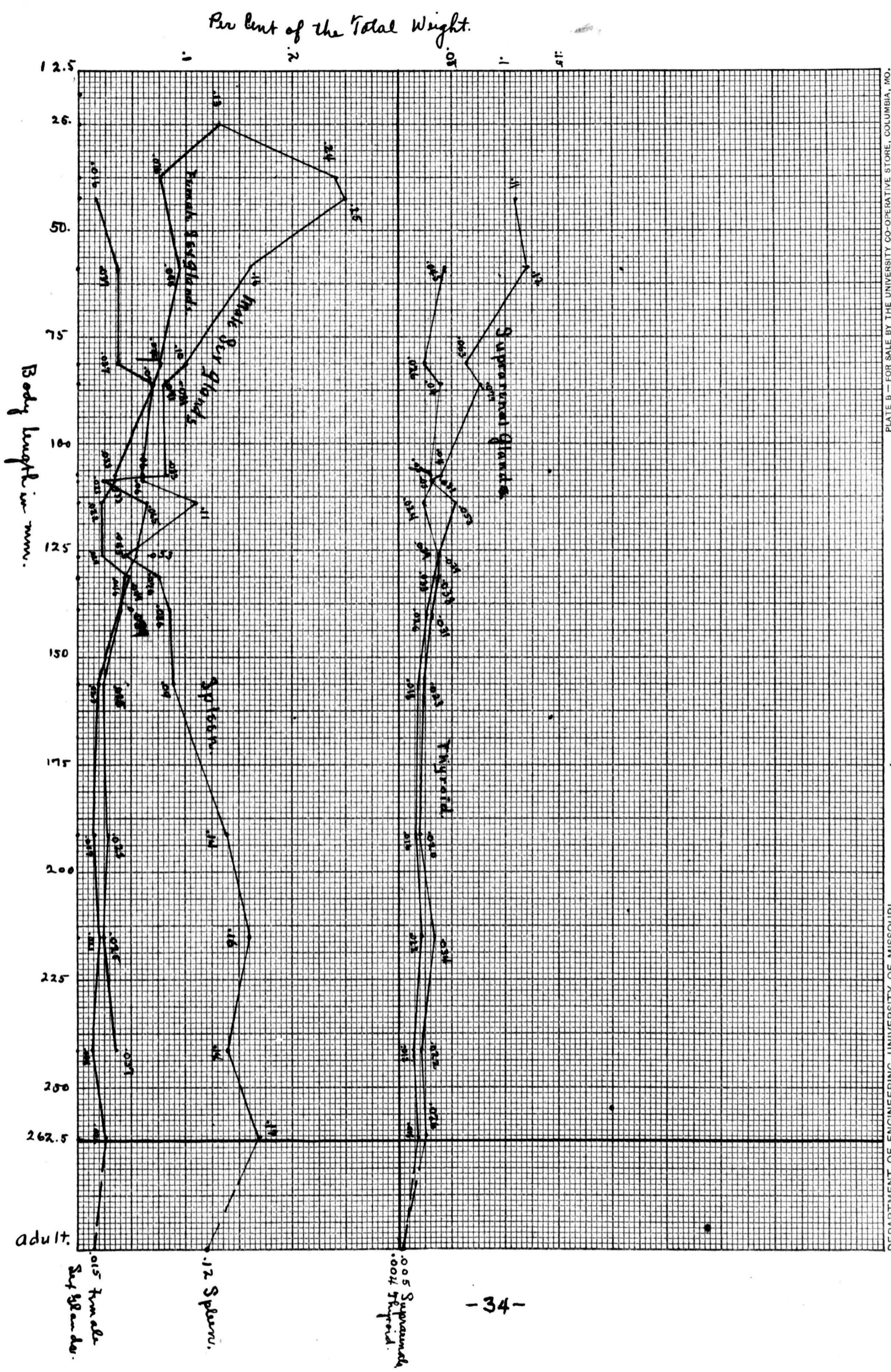


PLATE B - FOR SALE BY THE UNIVERSITY CO-OPERATIVE STORE, COLUMBIA, MO.

DEPARTMENT OF ENGINEERING, UNIVERSITY OF MISSOURI

#### IV.

### DISCUSSION OF THE DATA, AND COMPARISON WITH GROWTH IN OTHER SPECIES.

In the following pages, the body as a whole will first be considered, followed by the discussion of the viscera as a whole, and finally of each individual organ. Comparisons are made principally with the human species, for which the data are fairly complete. The figures for the human embryo are quoted chiefly from Jackson (4), unless otherwise specified. Relatively few observations are available for other animals.

#### 1. THE BODY AS A WHOLE.

(Tables I-XX: Plate I.)

##### I. The Pig.

Table I gives the average weights observed for the various litters examined. The corresponding curve (Plate I), with the body weights arranged according to the body lengths, shows, of course, that the actual increase in weight is more rapid in the later stages. This cannot be taken as the actual growth curve, however, since the body length does not increase in proportion to the age.

There are, however, two litters for which the age can be approximately estimated. From these may be roughly estimated the growth rate for the earlier and later stages.

The largest ovum found in those pig ovaries examined, measured .177 mm. in diameter. This includes the zona



pellucida, which measures about .020 mm. in thickness (.010 mm. counted twice in measuring the diameter). From this, the diameter of the mature ovum (including zona pellucida) is estimated to be about .18 mm. The corresponding volume would be about .000003 cc., and (assuming the specific gravity as 1) the weight about .000003 g.

Keibel (9) cites 3 pigs, aged 22 days, which varied from 12 to 14 mm. in length. In the smallest litter observed by me, the average crown-rump length was 13.6 mm., and the average weight .25g. (8 specimens). These embryos would not more than 23 days old according to Keibel's figures.

The duration of pregnancy in the pig is given by Coburn (13) as 112 days, by Long (14) as usually 112, varying from 110 to 116 days according to age of the mother, and by Spencer (15) as 16 weeks. This would place the usual time at 16 weeks or 112 days.

Long (14) gives some figures for the weight of litters from 1 year old sows. The litters average 7.8 pigs to the litter, the total average weight being 14.2 lbs., or 6,442 gms. This is an average weight of 826 gms. per pig. For sows 2-3 years old, the pigs average about 1,190 g. For those about 5 years old, the pigs are still larger, weighing about 1300 gms. on the average (individual data not given).

As the hogs which go to market are usually about 10-12 months old, the average weight of the full term fetus would therefore be approximately 826g. The oldest litter exam-

ined in my observations averaged 745 g. These pigs are therefore probably well along in the last month of fetal life.

During the 23 days immediately succeeding fertilization, the weight increases to about .25 gram, an actual increase of about 83000 times the weight of the ovum. Even this is too small, as a part of the ovum goes to form the membranes, etc. But this gives an idea of the enormously rapid growth rate in the early stages. For the whole ensuing fetal period of 99 days, the fetus increases actually in weight from .25 g. to 826 g., an increase of about 3300 times the weight at 23 days. That is, in a period about four times as long, the increase is only about 1/25 as great. If the early rate of increase were maintained throughout the fetal period, the new born animal would weigh about 2 million billion grams.

The weight at birth, 826 g., represents an increase of over 275 million times the weight of the ovum.

The four adult hogs examined (age about 12 months) averaged about 104.5 Kg. in weight. We may safely estimate the average adult weight to be about 100 Kg. The increase from a weight at birth of 826 g. to an adult weight of 100 Kg. represents an increase of only 121 times. Certainly an enormous decrease in the relative growth rate, even when compared with the last 99 days of prenatal life. The total increase from the weight of the ovum to the weight of the

1 year adult (16 months total prenatal and postnatal time) amounts to about 33 billion times the weight of the ovum.

Although these data are limited in extent they show such startlingly enormous differences that we may safely assume the conclusions of Muehlmann (10), strongly emphasized by Minot (6) and Jackson (4), to be true also for the pig; that is, the relative growth takes place most rapidly in the earliest stages, the rate decreasing, at first rapidly, then more slowly, throughout prenatal and postnatal life.

TABLE XXI.

TABLE OF COMPARATIVE GROWTH.

Animal	Ovum	Three weeks	
	Ovum - absol.wt.	absol. g.	no. of times increase
Pig	.000003	.025	83,000
Human	.000004	.016	4,000
Rabbit	.000003	11.7	3,900,000
White Rat	.000003 (?)	5.0	1,670,000
Chick	?( <sup>total egg</sup> <sub>35-40 g</sub> )	30.0	(?)

Animal	112 days		16 months (pre+postnatal)	
	absol.g.	no. of times wt. of ovum	absol.g.	no. of times wt. of ovum
Pig	826	275,000,000	100,000	33,000,000,000
Human	120	30,000,000	8,000	2,000,000,000
Rabbit	1000 (?)	333,000,000?	2,000(?)	667,000,000(?)
White Rat	140	47,000,000	275(?)	92,000,000(?)
Chick	1000 (?)	(?)	2,000(?)	(?)

## II. Comparison of Human Growth.

The human ovum (plus zona pellucida) has a diameter of about .2 mm., and a corresponding weight of about .000004 g. At 22 days the embryo weighs about .016 g. This is an increase of about 4 thousand times the weight of the ovum.

At the end of 112 days (full term for the pig), the human fetus weighs about 120 g., an increase of about 7500 times the weight at 22 days, and about 30 million times the weight of the ovum.

At 7 months of age, the human child averages about 8 Kg. in total weight (Vierordt). This age corresponds to an age of 1 year for the pig, being 16 months prenatal plus postnatal. This weight represents an increase of about 2 billion times the weight of the ovum.

At birth, however, the human averages 3200 g. in weight. This is an increase of about 800 million times the weight of the ovum. At 20 years of age, the average weight is 60 Kg. (Vierordt), which is an increase of about 19 times the weight at birth, or about 15 billion times the weight of the ovum.

If we compare these figures with those for the pig (cf. Table XXI) we find that in the earlier embryonic period (about three weeks) the relative growth rate in the pig is

over 20 times as rapid; for the 4 months period, about 9 times as rapid; and for the 16 months, over 16 times as rapid.

From this, we may conclude that during the first 16 months the relative growth rate is from 9 to 20 times as rapid in the pig as in the human. Although the rate is more rapid in the pig, the human finally reaches a larger relative size at birth, on account of the longer gestation period. That is, it is relatively nearer its adult size when born. In spite of its lower growth rate, however, the human adult approaches the pig in weight, on account of the longer period through which growth extends.

### III. Comparison of Relative Growth in the Rabbit.

The mature ovum of the rabbit has a diameter of .18 mm., according to Waldeyer (16), which, like that of the pig, corresponds to a weight of about .000003 g. At the end of 21 days of prenatal growth, the embryo weighs 11.73 g. (the average of two specimens of Fehling (12)). This represents an increase of about 3,910,000 times the weight of the ovum, as compared with about 83,000 times for the pig at about the same age.

At birth (the period is 30 days), the animal weighs 38.35 g. according to Fehling.

The adult rabbit weighs 1500 to 3000 g. From this we may safely assume (since the rabbit grows very rapidly) that, at 112 days (3 months postnatal), the rabbit would

weigh about 1000 g. This is about 333 million times the weight of the ovum, as compared with 275 million for the pig in the same time.

From these figures, we conclude that, in the earlier stages, the growth rate is far more rapid in the rabbit fetus than in the pig fetus of the same age (cf. Table XXI). After birth, however, the growth rate of the rabbit decreases greatly, so that at the end of 112 days (birth of the pig), the pig has almost overtaken the rabbit, and soon exceeds it. Minot (6), indeed, concludes that at birth the rabbit has lost over 98% of its power to grow.

#### IV. Comparison of Growth in White Rat.

The ovum of the white rat may be assumed to have the same size as that of the pig, with a weight of .000003 g. At 21 days (birth) the rat has an average weight of about 5 gm. (Donaldson (2), average for 57 individuals of both sexes as 5.3 g.; Jackson for 24 individuals of both sexes as 4.58 grams). The increase therefore amounts to about 1,670,000 times the weight of the ovum.

At 92 days postnatal age (113 days prenatal plus postnatal), the average of 11 individuals taken from Donaldson (2), is 139.6 g. This is an increase from the weight of the ovum of about 47 million times.

At 15 months postnatal, corresponding to 1 year postnatal of pig, the weight of the white rat is about 275 g. on the average, estimated from data by Donaldson (2). This

is an increase of about 92 million times the weight of the ovum.

It is therefore evident upon comparison (cf. Table XXI) that during the prenatal period of the rat (3 weeks) the growth rate is much greater than for the pig; but, owing to the longer course of prenatal life the pig finally reaches a greater relative weight at birth than does the rat.

#### V. Comparison of Growth in the Chick.

The egg of the chicken has a weight of about 35-40 g. Its protoplasm (which would correspond to the mammalian ovum), cannot be measured. The egg is, of course, chiefly made up of food material for the chick embryo, and it is probably due to this that the chick has such a rapid early growth rate.

According to Welcker and Brandt (8), the new-born chick weighs about 30 g. This represents an enormous increase in the living protoplasm, but the growth rate cannot be calculated. But, starting from some very small weight, the chicken fetus increases to a weight of 30 grams in 21 days, which is a larger total weight than that reached at the same time by any of the animals yet considered. From incomplete data by Welcker (8) and Davenport (11), the greatest relative growth comes in the earlier fetal stages, gradually decreasing after about the 9th day of incubation.

At 112 days (the end of the prenatal period for the pig), 92 days of postnatal life, the weight of the chick may

be safely assumed as about 1000 g., an increase of about 35 times the weight at birth.

#### VI. General Conclusions on Comparative Growth.

From the foregoing account of the development of these various animals (cf. Table XXI) it will be seen that the general course of relative growth of the pig agrees with that of all the others, in that the rate is very rapid in the early embryonic stages, decreasing at first rapidly, then more slowly, throughout prenatal and postnatal life, until the adult size is reached.

The rapidity of growth, however, is quite different in the various animals at corresponding periods. Thus, at the end of 3 weeks of prenatal life the pig has increased about 20 times as rapidly as has the human embryo, but only about 1/20 as rapidly as the white rat and 1/50 as rapidly as the rabbit. After birth of the rat and rabbit, however, their growth rate is greatly decreased; so that at 112 days the pig (new born) has far outstripped the rat (275 million to 47 million), and is approaching the rabbit, which has reached a weight of about 333 million times the ovum. The human embryo still lags behind (30 million) but is approaching the rat. At one year postnatal (16 months total) the pig has reached 33 billion times the weight of the ovum. Next in order is the human (7 months old) with an increase of 2 billion times, while the rabbit and white rat have been dropped far behind. Thus the animals with a short gesta-



tion period (rabbit, rat) have a more rapid relative growth rate during that period, but are thereafter overtaken and outstripped by those with a longer gestation period (pig, human).

At the time of birth, the growth rate always undergoes a rapid decrease, the prenatal rate always being far more rapid than the postnatal. There seems to be no definite relation, however, between the length of the gestation period and the ratio of new born to adult weight. Of the five species considered, the human is relatively nearer the adult weight at birth, the ratio being about 1:19. The pig is farthest from the adult, the ratio being about 1:120. The rabbit, rat and chick take an intermediate position, their ratio being about 1:60 (cf. Table XXII).

TABLE XXII.

RATIO OF ADULT TO NEWBORN WEIGHT

	: Weight of : Newborn	: Weight of : Adult	: <u>Weight Adult</u> : <u>Weight Newborn</u>
Pig	: 826 g.	: 100,000 g.	: 121
Human	: 3200 g.	: 60,000 g.	: 19
Rabbit	: 38.35 g.	: 2,500 g.?	: 66
White rat	: 5.00 g.	: 300 g.	: 60
Chick	: 30.00 g.	: 2,000 g(?)	: 66

## 2. RELATIVE GROWTH OF THE VISCERA.

(Tables II-XX; Plate II.)

Under this heading will be considered the relative growth of all the viscera, together, (including the brain and spinal cord) which were measured. In a negative way, this gives also the relative growth of the other structures of the body—chiefly skin, skeleton and musculature.

A reference to Plate II will show the general trend of the curve. The maximum relative size occurs in the 59 mm. litter, where the organs form 36.72% of the total. At 18 mm. they form 34.24%, and in the late fetus, 18.20% of the total. In the adult, they form only 9.68% of the total weight.

From this it is evident that the skeleton and musculature are relatively small at first, increasing, at first rapidly, then more gradually, until, in the adult, they form nearly 1/2 more relatively than they did at the fetal maximum for the organs.

Figures for the viscera (including brain and spinal cord) of the human fetus are as follows:

Second month	--35.98%	of the total body.
Fifth	" --27.89%	" " " "
Eighth	" +-26.95%	" " " "
(Still-born) Tenth	" --26.33%	" " " "

From data by Welcker (8) (5 males, av. weight 58.2 Kg.)

the average total of the viscera is 13.07% for the adult. This is <sup>much more</sup> slightly less than that found in the pig for the adult. The total relative weight of the viscera is apparently about the same for the pig and human in early fetal life; but at birth that for the pig is much below the human. The decrease for the viscera and the increase in relative size for the remaining structures are very marked between birth and the adult, both in the pig and the human.

According to Jackson, the brain and spinal cord in the human embryo, at the beginning of the second month, have nearly 3 times the volume of the organs lying ventral to the body axis: at birth they are about equal; while in the adult, the ventral organs are 6 times as large as the brain and cord. In the pig, the nervous system is relatively much smaller. In the 18 mm. pig embryos, the ventral organs are more than twice as large as the brain and spinal cord: at birth they are more than three times as large; while in the adult, they are about 100 times as large.

### 3. THE RELATIVE GROWTH OF THE VARIOUS ORGANS.

The relative growth of the organs considered together having been shown, it is now necessary to take up the growth of each individual organ separately, as their growth is by no means uniform.

## THE HEAD.

(Tables II-XX; Plate II)

Table II and the head-curve in Plate II, show that the head was found relatively largest in the earliest stage examined (18 mm.), forming, on the average, 29.67% of the total. Throughout the earlier fetal stages it forms from 20-25% of the total, and in the later, averages about 21 to 22%. Its minimum relative size is 19.49% at 107 mm. In the nearly full term fetus it averages 21.7% of the total. In the adult it forms 6.07% of the total body weight. The decrease in the relative size of the brain is much larger than that of the head, so that the facial structures form an increasingly larger portion of the head in the later fetuses and in the adult.

In the human, the head reaches a maximum relative size of 45% during the second month. It then decreases gradually in relative size, forming about 26-27% of the total at birth. The adult human head forms 6-9% of the total body weight.

The head of the pig at no stage observed reaches as large a relative size as does the human at a corresponding stage, having, for the most part, a relative size about 2/3 that of the human. In the adult, the relative size is more nearly equal in the two species.

In all vertebrates, from the fishes upward, the embryonic head is relatively large, especially in the early stages.

The extent to which this is true varies in the different forms, the head being in general best developed in the amniota. It is perhaps largest in bird embryos, where it may form more than half of the entire body (chick). There is also variation in different species of mammals, as shown by the difference between pig and human.

#### BRAIN.

(Tables II-XX- Plate II)

The maximum relative size of the brain (Table II) was found at the earliest stage examined (18 mm., accompanying the maximum relative size of the head). It then forms, on the average, 9% of the total body weight. The relative size then decreases, rapidly in the earlier stages, then more slowly until, at 113 mm., it has a minimum prenatal relative size of 3.26% of the total. In the fetus nearly full term, it forms 3.87% of the total, and in the adult, .085%.

A comparison of the relative size of the head and brain shows that, in the first stage examined, the brain forms about one-third of the head; at 82 mm. about one-fifth, and throughout the later part of fetal life and at birth, about one-sixth. In the adult it forms only about one-seventieth of the head.

This is a very small relative size when compared with the human, both in prenatal and postnatal stages.

The maximum relative size for the human occurs during the second month (at the same time as for the head), when the brain forms about 20% of the entire body. This is about one-half the entire head. At birth, the brain forms about 12.8% (still-born), or 14.6% (live born), which is about one-half the entire head. Vierordt (7) estimates the adult human brain at 2.16% of the total body, forming about one-third to one-fourth of the head.

The human brain, therefore, is relatively much larger than that of the pig, in percentage both of the head and of the entire body.

Donaldson (3) gives some figures for new born rats, showing that the brain forms about 5.18% of the total weight (both sexes). Figures for adult rats, over 10 months old, from the same source, show that the brain forms .714% of the total (an average of eight large male and female rats being taken). This is almost nine times the relative size of the adult pig brain.

In the dog-fish, data compiled by Kellicott (5), show that at birth the brain forms 1.11% of the total, while in the large adult it forms only .085%, or about the same relative size as the pig.

Some observations on the chick, recorded by Welcker and Brandt (11), indicate that, at the ninth day of incubation, the brain forms 28.2% of the body; newly hatched,

3%; adult, less than .5%. Other observations from the same source indicate that the brain is relatively larger in the embryo or new born than in the adult, for the dog, shrew, salamander and stickleback.

These observations show that the brain is relatively large in the vertebrate embryo, usually at a stage comparatively early in prenatal list, diminishing afterward throughout pre-and post-natal life. The brain also forms a larger proportion of the head in prenatal than in postnatal life.

#### SPINAL CORD.

(Table II-XX; Plate III)

The spinal cord in the pig embryo has its maximum relative weight (of the stages observed) at 18 mm., where it forms 1.87% of the total. Decreasing, at first rapidly, then more slowly, at 126 mm. it reaches its minimum relative size, about .16% of the total. Throughout the remainder of the stages examined, it averages about .25%. In the late fetus, however, it forms .32%; while in the adult it forms .037% of the total.

In the first stage, its weight is about one-fifth that of the brain, later in the fetal period about one-twelfth to one-fifteenth, in the late fetus reaching one-tenth. In the adult the weight of the cord is between one-half and one-third that of the brain. Its relative growth rate must be much greater in postnatal life than is that of the brain; or, otherwise expressed, the decrease in relative

size of the brain is much greater than that of the cord. On the other hand the prenatal growth rate of the brain is much larger than that of the cord.

The cord is relatively larger in the human fetus than in the pig in the earlier stages, but smaller in the later stages. Its maximum in the human embryo is 4.85% in the fifth week, and 3.43% at 17 mm., in comparison with 1.87% at 18 mm. in the pig. At birth, the human cord forms about .15% of the total weight, which is only one-half the relative size of the pig's cord. In the human adult, the cord forms .06% of the total (Vierordt), which is almost twice that of the pig. The conditions regarding comparative prenatal and postnatal growth of brain and cord are similar in both human and pig; that is, the brain has the more rapid relative growth rate in prenatal life. In postnatal life the relative growth rate of the cord is the more rapid, as Donaldson has pointed out for the human.

Figures from Donaldson (3) show that at birth the spinal cord in the white rat forms, on the average, .73% of the total, while in the adult (10-12 months), it forms .20%. The decrease is therefore similar to that in the pig and human. Data by Welcker (8) indicate a similar decrease in the chick, but not in the dog.



TABLE XXIII.

Showing the approximate relations of weights of the Brain and Spinal cord at different times in the Pig, Human and White Rat.

	Pig			Human			White Rat	
	Fetal max.	birth	adult	Fetal max.	birth	adult	birth	adult
Brain weight								
Spinal Cord wt.	5	12	2	4	90	36	7	3.5
Brain % Birth	45			6			7	
Brain % Adult								
Sp. Cord % Birth	9			2.5			4	
Sp. Cord % Adult								

THE EYEBALLS.

(Tables II-XX; Plate IV)

The eyeballs (Tables II and VIII and curve on Plate IV), starting with an average relative size of .16% of the total at 18 mm., increase rapidly to a maximum of 1.14% at 86 mm. From this stage, they decrease slowly until, at birth, they form .40% of the total. In the adult they form only .011% of the total weight.

From a few scattering observations on the human eyeballs, it seems that they are relatively smaller than those of the pig in the early stages; about the same relative size in the later stages of prenatal life; relatively smaller at birth, and about twice as large relatively in the adult.

Welcker and Brandt (8) record some observations on the chick embryo. At the 11th day of incubation, the eyeballs form nearly 25% of the total body. At birth they form about 3%, and in the adult about .3%. Other data indicate that the eyeballs are smaller in the adult shrew, salamander, stickleback and dog than they are in the embryo or new born.

#### THYROID GLAND.

(Tables VI-XX; Plate V)

The thyroid makes its first appearance (being too small for accurate dissecting earlier) in the 59mm. litter, when it has its maximum observed relative size of .045% of the entire body weight. From then until the end of the prenatal period, it averages from .02 to .03%, forming .026% at birth. In the adult it forms only .004% of the total.

The individual measurements are rather variable for this gland, but it averages very regularly throughout. It more nearly keeps pace with the body growth than any other organ observed.

The human thyroid, forming .035% of the total at 2 months, increases to .111% (still born) or .125% (live born). In the adult it forms .05% of the total, according to Vierordt. It is therefore, at all stages, a larger and probably more important organ in the human than in the pig.

## THYMUS GLAND.

(Tables VI-XX; Plate V)

The thymus is liable to a considerable amount of individual variation, and shows a gradual increase in relative size throughout prenatal life. Where first measured, at 59mm., it forms almost .1% of the total weight. Near full term, it forms .37% of the total. It was not found in the adult, though it may possibly have been overlooked.

In the human, the thymus forms .008% of the entire body at the end of the second month; and about .3% at birth. Vierordt gives the adult size as .04% of the total weight.

In general, the relative size and course of growth of the thymus appears similar in the pig and in the human.

## THE LUNGS.

(Tables II-XX; Plate III)

The lungs are considered together because, while there is a difference in size, their ratio to each other if fairly constant, the right lung being to the left approximately as 7:5. The curve for both lungs together is given in Plate III. Forming .53% of the total weight at 25 mm., the lungs increase rapidly in relative size until, at 86 mm., they form 3.79% of the total body weight. From here the decrease in relative size is somewhat irregular to the late fetus, where they form 2% of the total body weight. In the adult they form only about .68%. In the smallest litters examined,

there is apparently no appreciable difference between the two lungs. The difference between the two lungs in the larger stages, while holding fairly well to the ratio of 7:5, is liable to considerable individual variation, as is the relative size of the two lungs.

Approximately the same course of growth occurs in the human. There is an initial rise, the maximum occurring in the fourth fetal month, when the lungs average 3.29% of the total weight. In the still-born they average 1.7%, in live born, 2.18%. In the adult, they form 1.5% of the total (Vierordt). In relative size, therefore, the human lungs are approximately equal to those of the pig during prenatal life, but are about twice as great in the adult. In both the maximum relative size occurs in early fetal life.

The right lung in the human is also larger than the left, averaging about 20% larger. In the adult, the right lung is usually stated to be only 10% larger than the left. In the pig, however, the right lung averages about 40% greater than the left, both in the fetus and in the adult.

#### THE HEART.

Tables II-XX; Plate III)

The heart has its greatest observed relative size in the earliest stage examined (18 mm), forming 3.51% of the total weight. An examination of earlier stages would probably show a still larger maximum. It decreases rapidly at first, then more slowly, until, at 119 mm., it forms only .65% of the total body weight. In the later fetuses, there

is a gradual rise, the heart forming 1.00% of the total weight in the 26mm. fetus (nearly full term). In the adult it forms .31%, about one-third that of the late fetus.

In the human, the heart also has its maximum early, being estimated at more than 5% in a four week embryo; 3.64% in the fifth week (11mm.) and .85% in the third month. At birth it forms .7% to .77% (still- and live-born). Vierordt estimates the adult human heart to form .46% of the total weight.

The heart is, therefore, similar in relative size in pig and human during fetal life. It appears, however, to be relatively smaller at birth, and larger in the adult in the human.

#### STOMACH AND INTESTINES.

(Tables II-XX; Plate II)

The stomach and intestines (including mesentery) differ from all other organs observed, in that they increase greatly in relative size in the adult. This is the case, whether they are considered with, or without, contents.

At 18 mm., they form .27% of the total body weight, after which they increase, at first very rapidly, then more slowly (and with considerable individual variation) to a maximum (for prenatal life) of 5.8% in the late fetus. In the adult they form 6.67% of the total weight. These figures are for stomach and intestines plus contents, which, especially in the later stages, present a great deal of variation.

A better index of the growth is shown by the figures for the stomach and intestines without contents. In the stages to and including the 41 mm. stage, there would seem to be no appreciable contents, and here the stomach and intestines amount to 1.6% of the total body weight. They gradually increase throughout fetal life, forming, at 241 mm. 2.85% of the total, being about 40% less than the same with contents (4.75%). In the adult they form (empty) about 4.79% of the total weight, about 28% less than the tract with contents (6.67%).

The range of variation is large, due to the extreme variations in contents, but the tract empty is, in later prenatal life, about 35-40% less than the tract with contents.

In the human the intestinal tract is small in the early stages, increasing rapidly to full term, when the tract (empty) forms 1.03% of the total weight. The contents here are about twice as great as the empty intestinal tract. Vierordt estimates 2.06% of the total body weight for the adult tract (empty).

The empty intestinal tract of the pig is therefore relatively much larger than that of the human, both in later fetal stages, and in the adult, while the contents are smaller.

#### THE LIVER.

(Tables II-XX; Plate II)

In the earliest stage examined (18 mm.), the liver forms 11.58% of the total weight. In the next succeeding

stages, it forms the most prominent organ. It has an early maximum, reaching 16.6% of the total body in the 25 mm. stage. From here, it decreases sharply and somewhat irregularly, forming 4.95% at 108 mm. The smallest relative size observed was not in the largest fetus examined, however, but in the 241 mm. litter, where it forms only 2.62% of the total weight. In the late fetus it forms 3% of the total weight. In the adult it forms only about 1.35% of the total body weight. The maximum relative weight may be somewhat more than 16.6% and come somewhere about the 30 mm. stage.

In the human fetus, the liver never reaches more than 7.5-10% of the total body, and this maximum size occurs during the second and third months. During the fourth month, the liver drops to an average of about 5%, which it maintains throughout fetal life, averaging 5.23% in live-born infants. This is almost twice as much as the average relative size in the pig at the same stage. Vierordt gives the average for the adult human at 2.75%. Therefore, in the earlier fetal stages, the liver has a much greater relative size in the pig than in the human, but in the later fetal stages and in the adult, it is relatively much smaller..

As in the case in the pig and human, the liver is smaller in the adult than in the embryo or new born in the chick, dog, stickleback and shrew (Welcker). But it is relatively larger in the adult for the salamander and dog-fish (Kellicott).

## THE SPLEEN.

(Tables V-XX: Plate V)

The spleen is liable to very great individual variation in relative size. First observed in the 41 mm. litter, it there has a relative size of .015% of the total body weight. It gradually increases in relative size, until in the 260 mm. fetuses, it forms on the average .17% of the total weight. In the adult it forms about .12%.

Practically the same course of growth is found in the human, although here the spleen is relatively larger than in the pig. The maximum is over .4% in the 8th and 9th fetal months; .43% in live-born infants, and .25% for the adult (Vierordt). The individual variations would seem to be greater in the human than in the pig.

## THE PANCREAS.

(Tables V-XX: Plate IV.)

Starting with a relative size of .042% of the total body weight at 41 mm., where it was first observed, the pancreas increases, at first rapidly, then more slowly to a maximum of .18% at the 215 mm. stage. At 260 mm., it forms .16% of the total weight; in the adult, .14%. In the pig, the variations in individual size are very great, due perhaps in part to difficulty in dissecting it out perfectly. During the greater part of fetal life, the pancreas averages about .1-.13% of the total weight.

Judging from the data available for comparison, the



pancreas is slightly heavier in the pig than in the human throughout the greater portion of fetal life, and has about the same relative size in the adult.

#### SUPRARENAL GLANDS.

(Tables V-XX: Plate V.)

At 25 mm. the suprarenal glands can be readily detected with the dissecting lens, but, owing to their position and attachments, cannot be readily dissected out and weighed.

At 41 mm., the suprarenal glands form about .11% of the total weight. At 59 mm., they form .12% of the total, which is the maximum observed relative size. Throughout the latter part of fetal life, they average about .015-.025% of the total, forming .018% in the largest stage examined. In the adult they are very small organs, forming about .005% of the total. There is no marked difference between right and left in size.

In the human fetus, the left suprarenal is usually the larger of the two. During the second month, the suprarenals form about .3% of the total body volume, increasing to a maximum of .46% in the third month. At full term they form about .24%. In the adult they form .01% (Vierordt).

The suprarenals, therefore, have a much larger relative size in the human than in the pig, both in prenatal and post-natal life.

## SEX GLANDS.

(Tables III-XX: Plate V.)

The sex glands were first accessible by dissection at 25 mm., when they average .13% of the total weight. From this point there is considerable difference in the two sexes, the male sex glands averaging much heavier relatively than the female. Rising rapidly to a maximum, they form .25% at 41 mm. At 59 mm. the female sex glands have their maximum size of .094% of the total. At 260 mm. (average of three females), the sex glands form .026% of the total weight, and in the adult (2 f.) .015% of the total weight. (Data for males incomplete).

This is also the case in the human--the sex glands being relatively larger in the earlier part of prenatal growth, the male glands being relatively heavier than the female. In an embryo of the fifth week (11 mm.), the anlagen for the glands form .085% of the total volume. In the later fetal stages, the human testes are about twice as large as the ovaries, a relation similar to that in the pig.

## THE KIDNEYS AND WOLFFIAN BODIES.

The kidneys (Tables III-XX: Plate III) were first measured at the 25mm. stage, when they average .24% of the total body weight. They increase rapidly to a maximum relative size of 2.57% of the total weight at 59mm. At 191mm. they form .90%, which is the minimum of later fetal life. Near full term they

form .98% of the total, and in the adult, .25%. There is apparently no constant difference in size between right and left.

In the human, the kidneys form about 1% in the later fetal stages. Vierordt gives .46% as the size in the adult. The kidneys first appear in the second month, and, from that time onward, the left kidney is quite usually larger than the right.

It would appear from this that the kidneys, throughout the later part of fetal life, have about the same relative size in the pig and human, but are larger relatively in the human adult.

Agreeing with the pig and human, the kidneys appear relatively smaller in the adult than in the embryo shrew, dog and chick; but they are relatively larger in the stickleback and salamander (Welcker and Brandt).

The Wolffian bodies (Tables II - XI, Plate III) of the pig have their maximum very early in fetal life, probably at an earlier stage than can be readily dissected. At 18 mm. they have by far the largest relative size observed-- 7.5% of the total weight. From this stage the decrease is rapid. In the 25 mm. pigs, they form only 4.73%; 37 mm., 2.43%; 59 mm., 1.48%; 82 mm., .38%; disappearing at about 115 mm.

The Wolffian body presents a very interesting case, as it is the only structure observed (except postnatal thymus?) in which a decrease in absolute weight takes place.

The following table expresses the relations for this organ:-

TABLE XXIII.  
SHOWING THE ABSOLUTE WEIGHT, AND PER CENT  
OF TOTAL OF THE WOLFFIAN BODY IN  
SOME OF THE OBSERVED CASES.

Litter	Weight Wolffian Body	Per Cent of Total
14. (18mm.)	.0522 g.	7.49%
8. (58mm.)	.148 g.	1.42%
2. (82mm.)	.107 g.	.38%
16. (107mm.)	.052 g.	.076%
23. (113mm.)	.047 g.	.028%

Coincident with the decrease in relative size of the Wolffian body, one might expect an increase of the kidneys in about the same proportion. This is partly true. The first record of the kidney (.24%) corresponds to a relative size of 4.73% for the Wolffian Body. The maximum relative size of the kidney (2.57%) corresponds to a size of 1.48% for the Wolffian Body. At the time of disappearance of the Wolffian Bodies, the kidneys form 1.35% of the total weight. Shortly after this, the kidneys increase to 1.57%. (See Plate III).

In the human, the Wolffian bodies form .6% of the total volume in an embryo of the fifth week (11 mm.), in which the

renal anlagen are just appearing. From this time onward, they become both absolutely and relatively smaller, just as in the pig.

The Wolffian bodies in the pig, therefore are relatively very much larger than in the human embryo, and persist for a longer time.

#### 4. DIFFERENCES ACCORDING TO SEX.

The data from the various litters were sorted out and grouped according to sex, the averages being calculated for each sex in each litter. The results were of little value, however, on account of the small number of specimens; only five litters having two or more of each sex. Although, therefore, it was not thought necessary to reproduce this table, certain indications which it showed are worthy of mention.

In the first place, the total weight almost constantly averages higher in males than in females of the same litter. This was true in four of the five litters mentioned. It is known that the human males average heavier than the females of the same age in prenatal life, and at birth.

The liver in the pig fetuses was found relatively heavier in the female in most cases where a comparison was possible. This is also almost constantly true in the human species.

The sex glands, beginning with the time when the sexes are first distinguishable are found relatively heavier in the male than in the female pig, as already mentioned. This also is in agreement with the human species.

For other organs, no definite conclusions concerning sexual differences could be drawn, and even those mentioned rest upon a very uncertain basis. Many more observations are necessary, in order to distinguish variations due to sex from accidental variations.

#### V. SUMMARY.

The general conclusions concerning the growth of the pig may be summarized as follows:

1. The weight of the ovum is about .000003 g. The increase in weight is at least 83,000 times during the first 23 days. At the end of 112 days (full term) the increase is 275 million. The weight of the adult hog is about 333 billion times that of the ovum. Comparative figures are also given for the human, rabbit, rat and chick. All these forms agree with the general law that the rate of growth is by far most rapid at the beginning of prenatal life.

2. The viscera of the pig embryo (including brain and spinal cord) have their maximum relative size, about 36% of the whole body, at an early stage (59mm.), decreasing to about 18% at the end of the fetal period. In the adult, they form about 9.68% of the whole body.

3. The head attains its maximum observed relative size at 18mm. (earlier stage not examined) forming 29.66% of the total, decreasing to 21.7% before birth, and to 6.07% in the adult. It is always relatively smaller than the human head at corresponding stages.

4. The brain also attains its maximum observed relative size at the same time as the head, forming about 9% of the total body and about one-third of the head. In later stages it decreases until, near full term, it forms 3.86% of the total, and about one-sixth of the head. In the adult it forms about .085% of the total. The brain of the pig is at all stages relatively much smaller than the human.

5. The spinal cord has its maximum relative weight at 18mm., 1.87%, decreasing at first rapidly, then more slowly, and forming .32% of the total before birth. In the adult, the cord forms about .037% of the total.

6. The eyeballs attain their maximum relative observed size at 86mm., forming 1.14% of the total, decreasing to .40% of the total before birth. In the adult, they form only .011% of the total.

7. The heart forms 3.5% of the total weight at 18mm., decreasing to a size of about 1.00% before birth, and averaging about .70% during the greater number of stages examined. In the adult hog, the heart averages .31% of the total weight.

8. The lungs increase to a maximum of 3.8% at 86mm., decreasing irregularly thereafter to about 2% before birth. The right lung is larger than the left in the approximate proportion of 7-5. The lungs in the adult form only about .68% of total.

9. The liver increases to a maximum relative size of 16.6% of the total body at 25mm., decreasing to 2.9% before birth. Its maximum relative size is over twice as large as that of the human. In the adult the liver of the pig averages 1.35%, being only about half that of the human.

10. The kidneys increase rapidly to a maximum relative size of 2.57% of the total body at 59mm., decreasing thereafter to an average of .98% before birth; and forming about .25% in the adult.

11. The spleen, pancreas and thymus increase gradually from the beginning, averaging about .17%, .16% and .37%, respectively, near the end of fetal life. In the adult, the figures are .12%, and .14%, for spleen and pancreas respectively.

12. The thyroid decreases slightly throughout prenatal growth, averaging about .026% of the total at the close of the fetal period, and .004% in the adult. It more nearly keeps pace with the growth of the body than any other organ.

13. The suprarenals form about .12% of the total at 59mm., decreasing thereafter to about .018% before birth, and about .005% in the adult.

14. The stomach and intestines increase gradually throughout the period, forming about 4.6% at 241 mm. (with contents), or 2.9% (without). Near full term (261 mm.) they form 5.85% of the total (with contents). In the adult, they increase to 4.79% without contents or 6.67% with contents.

15. The total weight of the body and the relative weight



of the sex glands are greater in the male, while the relative weight of the liver is usually greater in the female.



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