THE RELATION BETWEEN BODY AND ORGAN WEIGHTS IN THE RABBIT.

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In the previous paper of this series (1), we summarized the results of that part of our study of organ weights the immediate object of which was to define conditions that obtain in normal stock rabbits with respect to mean weights, the tendency to the occurrence of variations in weight, and the probable limits of variation for different organs. As a further contribution to the general problem of physical constitution and as an approach to the study of conditions that determine or affect the weights of organs, we have undertaken an investigation of the normal relation that obtains between body and organ weight and between the weight of one organ and that of another. The purpose of this paper is to report the relation found between body and organ weight as indicated by correlation coefficients and a comparison of group means.

Methods and Material.

The results to be reported are based on data from 645 male rabbits of various breeds. The series contained a few young and a few old animals but the great majority of the animals were between 6 months and 2 years old with about an equal division between those that were sexually mature but not full grown and those that had attained sexual maturity and full growth. All of the animals were in apparent good health but on postmortem examination many of them showed active or healed lesions of some kind. In the present investigation no discrimination was made on the basis of age, breed, or the presence of lesions.

The actual weight and the weight of organs per kilo of net body weight[1] (relative

[1] Net body weight is the gross weight of the animal minus the weight of the gastrointestinal mass as defined in the first paper of this series (Brown, W. H., Pearce, L., and Van Allen, C. M., *J. Exp. Med.*, 1925, xlii, 69).

TABLE I.

Correlation Coefficients for Actual and Relative Organ Weight with Gross Body Weight.

	Actual	Relative
Net body weight	+0.958 ±0.002	
Heart	+0.755 ±0.011	−0.169 ±0.026
Testicles	+0.555 ±0.019	+0.101 ±0.028
Kidneys	+0.471 ±0.021	−0.443 ±0.021
Gastrointestinal mass	+0.456 ±0.021	−0.311 ±0.024
Brain	+0.451 ±0.025	−0.761 ±0.013
Suprarenals	+0.364 ±0.023	−0.066 ±0.027
Hypophysis	+0.343 ±0.024	−0.402 ±0.022
Mesenteric lymph nodes	+0.307 ±0.03	−0.143 ±0.032
Liver	+0.291 ±0.024	−0.301 ±0.024
Thyroid	+0.248 ±0.025	−0.019 ±0.027
Deep cervical lymph nodes	+0.246 ±0.031	−0.058 ±0.033
Thymus	+0.222 ±0.025	−0.160 ±0.026
Parathyroids	+0.221 ±0.025	−0.174 ±0.026
Pineal	+0.193 ±0.026	−0.316 ±0.024
Popliteal lymph nodes	+0.190 ±0.028	−0.271 ±0.027
Spleen	+0.186 ±0.026	−0.113 ±0.026
Axillary lymph nodes	+0.074 ±0.029	−0.321 ±0.026

TABLE II.

Correlation Coefficients for Actual and Relative Organ Weight with Net Body Weight.

	Actual	Relative
Gross body weight	+0.937 ±0.003	
Heart	+0.739 ±0.012	−0.217 ±0.025
Testicles	+0.493 ±0.021	+0.018 ±0.028
Kidneys	+0.452 ±0.021	−0.473 ±0.021
Suprarenals	+0.415 ±0.022	+0.027 ±0.027
Brain	+0.392 ±0.027	−0.830 ±0.010
Hypophysis	+0.353 ±0.023	−0.449 ±0.021
Thyroid	+0.261 ±0.025	+0.013 ±0.027
Mesenteric lymph nodes	+0.251 ±0.031	−0.222 ±0.031
Gastrointestinal mass	+0.245 ±0.025	−0.448 ±0.021
Parathyroids	+0.242 ±0.025	−0.139 ±0.026
Deep cervical lymph nodes	+0.228 ±0.032	−0.103 ±0.033
Liver	+0.214 ±0.025	−0.417 ±0.022
Thymus	+0.213 ±0.025	−0.171 ±0.026
Pineal	+0.199 ±0.026	−0.323 ±0.024
Spleen	+0.143 ±0.025	−0.166 ±0.026
Popliteal lymph nodes	+0.116 ±0.029	−0.290 ±0.027
Axillary lymph nodes	+0.063 ±0.029	−0.336 ±0.026

TABLE III.

Group Means for Body (Gross) and Organ Weights.

Gross body weight	No. of animals	Net body weight	Heart		Testicles		Kidneys		Gastrointestinal mass		Brain	
			Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
kg.		*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*
1.400	1	1175	3.95	3.36	3.22	2.74	20.29	17.28	225.0	191.5		
1.563	2	1245	3.53	2.91	3.74	3.06	11.04	8.87	317.5	261.7	9.38	8.16
1.633	6	1306	3.57	2.74	2.27	1.74	10.44	7.97	327.5	252.9	8.18	6.32
1.750	20	1415	4.08	2.89	3.09	2.20	11.17	7.90	335.7	245.9	8.44	6.04
1.840	36	1472	4.27	2.90	3.80	2.53	11.76	7.99	365.1	250.6	8.60	5.80
1.933	56	1553	4.62	2.98	3.74	2.41	11.98	7.73	380.0	244.4	8.87	5.69
2.033	89	1629	4.86	2.99	4.15	2.53	12.20	7.52	401.6	248.7	8.86	5.46
2.134	83	1717	5.02	2.93	4.16	2.45	12.46	7.26	415.2	243.6	9.23	5.39
2.235	78	1811	5.11	2.81	4.72	2.61	12.71	7.04	420.0	233.9	9.28	5.12
2.338	75	1908	5.37	2.82	5.02	2.60	13.01	6.84	439.0	225.7	9.26	4.87
2.436	59	2005	5.73	2.87	4.99	2.48	13.77	6.88	431.1	217.2	9.27	4.63
2.531	44	2070	5.71	2.76	5.58	2.70	13.68	6.62	457.3	222.2	9.43	4.54
2.638	23	2160	5.94	2.74	5.29	2.40	13.67	6.32	474.3	220.6	9.24	4.29
2.732	25	2272	6.42	2.71	5.87	2.58	14.28	6.27	445.4	197.1	9.76	4.27
2.815	13	2282	6.35	2.79	6.19	2.73	14.43	6.33	527.3	233.0	9.82	4.30
2.936	11	2440	6.85	2.82	6.52	2.66	16.44	6.74	485.0	200.3	9.65	3.91
3.047	9	2562	7.03	2.75	6.43	2.52	15.53	6.11	485.2	187.5	10.06	3.95
3.107	7	2605	7.12	2.97	6.33	2.69	15.81	6.65	497.0	191.9	9.39	4.09
3.200	2	2530	7.45	2.94			16.20	6.41	670.0	265.0	11.30	4.51
3.350	4	2855	7.74	2.72	7.30	2.69	16.48	5.82	470.0	166.3	10.28	3.66
3.450	1	2925	7.20	2.46	8.58	2.93	15.10	5.16	525.0	179.5	11.03	3.77
3.500	1	3010	7.68	2.55	8.98	2.98	15.78	5.23	490.0	162.8		
Correlation coefficient			+0.958 ±0.002	+0.755 ±0.011	−0.169 ±0.026	+0.555 ±0.019	+0.101 ±0.028	+0.471 ±0.021	−0.443 ±0.021	+0.456 ±0.021	−0.311 ±0.024	+0.451 ±0.025	−0.761 ±0.013

TABLE III—*Conclud.*

Gross body weight	No. of animals	Suprarenals		Hypophysis		Mesenteric lymph nodes		Liver		Thyroid		Deep cervical lymph nodes	
		Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
kg.		*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*
1.400	1	0.228	0.194	0.030	0.0255			55.0	46.8	0.175	0.149		
1.563	2	0.505	0.3955	0.0255	0.0208			83.0	68.9	0.1625	0.1311		
1.633	6	0.275	0.2097	0.0237	0.0175	3.03	2.38	61.3	46.8	0.1725	0.1321	0.0988	0.0772
1.750	20	0.3222	0.2259	0.0264	0.0187	2.67	1.92	75.9	54.1	0.2864	0.2024	0.1114	0.0782
1.840	36	0.3285	0.2204	0.0259	0.0176	2.48	1.67	76.5	52.2	0.1866	0.1263	0.1252	0.084
1.933	56	0.3238	0.2083	0.0253	0.0164	3.18	2.05	80.1	51.7	0.1897	0.1216	0.1414	0.0914
2.033	89	0.3239	0.1984	0.0269	0.0166	3.34	2.06	82.3	50.6	0.1944	0.1194	0.1558	0.0959
2.134	83	0.3339	0.1944	0.0273	0.0159	3.26	1.91	82.0	48.0	0.217	0.1266	0.1458	0.0858
2.235	78	0.3694	0.2038	0.0272	0.0150	3.70	2.04	83.4	47.0	0.2079	0.1149	0.1428	0.0785
2.338	75	0.4226	0.2203	0.0282	0.0148	3.38	1.79	92.5	47.4	0.2269	0.1186	0.1484	0.0787
2.436	59	0.4332	0.2164	0.0307	0.0154	3.55	1.79	89.6	44.9	0.2468	0.1221	0.1629	0.0809
2.531	44	0.4358	0.2104	0.0301	0.0142	3.61	1.75	91.0	44.1	0.3095	0.1467	0.1758	0.0851
2.638	23	0.4239	0.1964	0.0311	0.0144	3.95	1.84	84.0	43.7	0.2507	0.1154	0.1678	0.0781
2.732	25	0.4436	0.1947	0.0301	0.0133	4.09	1.79	91.2	40.2	0.2835	0.1239	0.2024	0.0884
2.815	13	0.4117	0.1801	0.0314	0.0138	3.82	1.68	96.9	42.8	0.3202	0.1394	0.2511	0.1108
2.936	11	0.5868	0.2405	0.0319	0.0130	4.19	1.69	92.0	37.8	0.3905	0.1587	0.1969	0.0796
3.047	9	0.5177	0.2006	0.0315	0.0123	4.03	1.57	93.8	36.8	0.2611	0.1019	0.1979	0.0777
3.107	7	0.7000	0.2996	0.0343	0.0142	4.65	1.80	101.6	39.1	0.355	0.1509	0.1238	0.0598
3.200	2	0.475	0.1877	0.0365	0.0144	8.10	3.23	94.5	37.4	0.2075	0.0821	0.185	0.0739
3.350	4	0.436	0.1517	0.0302	0.0106	3.83	1.36	114.8	40.6	0.3775	0.1343	0.2083	0.0753
3.450	1	0.635	0.217	0.032	0.0109	4.00	1.37	120.0	41.0	0.436	0.149	0.225	0.0769
3.500	1	0.590	0.1967	0.030	0.0100	4.85	1.61	90.0	29.9	0.235	0.0784	0.125	0.0416
Correlation coefficient		+0.364	−0.066	+0.343	−0.402	+0.307	−0.143	+0.291	−0.301	+0.248	−0.019	+0.246	−0.058
		±0.023	±0.027	±0.024	±0.022	±0.03	±0.032	±0.024	±0.024	±0.025	±0.027	±0.031	±0.033

Gross body weight	No. of animals	Thymus		Parathyroids		Pineal gland		Popliteal lymph nodes		Spleen		Axillary lymph nodes	
		Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
kg.		*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*
1.400	1	1.280	1.090	0.010	0.00851	0.015	0.01276	0.180	0.1532	1.15	0.978	0.150	0.1276
1.563	2	2.103	1.720	0.015	0.01213	0.0135	0.011	0.230	0.1715	1.165	0.915	0.130	0.097
1.633	6	1.553	1.197	0.0115	0.00887	0.0163	0.01253	0.184	0.1421	0.787	0.603	0.115	0.0891
1.750	20	1.889	1.334	0.0136	0.00952	0.0144	0.01016	0.208	0.1473	0.753	0.528	0.1497	0.1063
1.840	36	1.991	1.291	0.01161	0.00791	0.0153	0.01041	0.232	0.1546	0.925	0.629	0.1667	0.1138
1.933	56	2.110	1.356	0.01141	0.00735	0.0148	0.0095	0.243	0.1565	0.943	0.602	0.1592	0.1019
2.033	89	2.234	1.375	0.01208	0.00744	0.0152	0.00931	0.252	0.1552	0.954	0.590	0.1687	0.1034
2.134	83	2.269	1.334	0.01197	0.00699	0.0155	0.00906	0.256	0.1492	1.042	0.609	0.1646	0.09597
2.235	78	2.240	1.236	0.0119	0.00661	0.0151	0.00828	0.261	0.1435	0.930	0.519	0.1824	0.1034
2.338	75	2.317	1.224	0.01343	0.00705	0.0158	0.00828	0.261	0.1377	1.044	0.550	0.1739	0.0915
2.436	59	2.356	1.175	0.01338	0.00671	0.0159	0.00793	0.263	0.1312	1.061	0.533	0.1805	0.0896
2.531	44	2.527	1.221	0.01495	0.00726	0.0179	0.00871	0.258	0.1254	1.170	0.572	0.1714	0.0832
2.638	23	2.740	1.272	0.01308	0.00607	0.0161	0.00749	0.285	0.1319	1.013	0.469	0.1794	0.0831
2.732	25	2.657	1.172	0.01356	0.00598	0.0163	0.00716	0.250	0.1100	1.181	0.522	0.164	0.0721
2.815	13	2.689	1.181	0.01346	0.00593	0.0155	0.00683	0.272	0.1200	1.249	0.552	0.1646	0.0734
2.936	11	2.599	1.066	0.01454	0.00593	0.0155	0.00632	0.256	0.1039	1.195	0.489	0.1511	0.0614
3.047	9	2.626	1.026	0.01511	0.00592	0.0197	0.00771	0.304	0.1198	1.246	0.487	0.1661	0.0653
3.107	7	2.739	1.054	0.02143	0.00917	0.021	0.00809	0.279	0.1052	1.502	0.574	0.173	0.0664
3.200	2	2.350	0.928	0.017	0.00671	0.022	0.00871	0.250	0.0999	1.895	0.749	0.175	0.0695
3.350	4	2.530	1.094	0.01625	0.00564	0.0205	0.00716	0.338	0.1195	0.995	0.350	0.2217	0.0776
3.450	1	3.100	1.060	0.012	0.0041	0.018	0.00616	0.320	0.1094	1.300	0.445	0.215	0.0735
3.500	1	1.890	0.630	0.032	0.01064	0.025	0.00834	0.470	0.1561	0.930	0.309	0.180	0.0598
Correlation coefficient		+0.222	−0.160	+0.221	−0.174	+0.193	−0.316	+0.190	−0.271	+0.186	−0.113	+0.074	−0.321
		±0.025	±0.026	±0.025	±0.026	±0.026	±0.024	±0.028	±0.027	±0.026	±0.026	±0.029	±0.026

TABLE IV.

Group Means for Body (Net) and Organ Weights.

Net body weight	No. of animals	Gross body weight	Heart		Testicles		Kidneys		Suprarenals		Brain	
			Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
kg.		*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*
1.163	2	1475	3.89	3.34	3.82	3.30	15.26	13.09	0.264	0.228	9.38	8.16
1.247	4	1681	3.93	3.15	2.94	2.37	10.20	7.91	0.288	0.223	8.34	6.69
1.358	14	1733	3.81	2.80	2.62	1.92	11.14	8.19	0.326	0.240	8.53	6.26
1.443	38	1827	4.33	3.0	4.89	3.34	11.42	8.17	0.308	0.211	8.72	6.06
1.550	87	1964	4.66	3.0	3.92	2.52	12.09	7.81	0.313	0.202	8.85	5.70
1.650	90	2067	4.87	2.95	4.21	2.52	12.62	7.66	0.328	0.200	9.07	5.50
1.745	79	2151	4.98	2.85	4.09	2.34	12.34	6.93	0.349	0.200	8.96	5.13
1.844	87	2260	5.24	2.83	4.96	2.69	13.05	7.07	0.372	0.202	9.46	5.11
1.952	70	2382	5.46	2.79	5.14	2.64	13.02	6.69	0.451	0.232	9.18	4.70
2.046	59	2470	5.72	2.80	5.07	2.45	13.51	6.60	0.434	0.212	9.24	4.53
2.146	44	2596	5.86	2.73	5.48	2.54	13.79	6.42	0.427	0.197	9.41	4.38
2.243	23	2729	6.41	2.85	5.78	2.60	14.10	6.47	0.414	0.185	9.58	4.28
2.350	13	2796	6.86	2.93	6.48	2.76	14.66	6.25	0.559	0.238	9.66	4.10
2.461	12	2945	6.97	2.83	6.72	2.73	16.12	6.53	0.448	0.182	9.95	4.04
2.544	9	3044	6.51	2.77	6.34	2.77	15.55	6.56	0.583	0.254	10.01	4.45
2.655	9	3110	7.11	2.68	6.59	2.48	16.13	6.11	0.681	0.257	9.65	3.62
2.870	1	3300	7.34	2.56	9.12	3.15	18.13	6.31	0.475	0.166	9.70	3.38
2.942	3	3392	7.47	2.54	7.56	2.74	14.30	4.85	0.540	0.183	10.62	3.62
3.010	1	3500	7.68	2.55	8.98	2.98	15.78	5.23	0.590	0.197		
Correlation coefficient			+0.937	+0.739	−0.217	+0.493	+0.018	+0.452	−0.473	+0.415	+0.027	+0.392	−0.830
			±0.003	±0.012	±0.025	±0.021	±0.028	±0.021	±0.021	±0.022	±0.027	±0.027	+0.010

Net body weight	No. of animals	Hypophysis		Thyroid		Mesenteric lymph nodes		Gastrointestinal mass		Parathyroids	
		Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
kg.		*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*
1.163	2	0.029	0.02492	0.1675	0.144			312.0	269.8	0.0125	0.01073
1.247	4	0.0245	0.01858	0.1513	0.1217	3.42	2.73	434.0	348.9	0.0113	0.009
1.358	14	0.0251	0.01849	0.1712	0.1264	2.38	1.74	375.0	276.1	0.0104	0.0077
1.443	38	0.0258	0.01791	0.2343	0.1632	2.97	2.06	381.0	267.2	0.0128	0.0089
1.550	87	0.0254	0.01682	0.185	0.1195	3.20	2.07	412.0	264.8	0.0112	0.0072
1.650	90	0.0274	0.01662	0.2101	0.1273	3.33	2.02	413.0	250.5	0.0129	0.0079
1.745	79	0.0269	0.01544	0.2089	0.1199	3.39	1.94	405.0	232.3	0.0118	0.0068
1.844	87	0.0278	0.01511	0.2096	0.1139	3.53	1.91	414.0	225.1	0.0122	0.0066
1.952	70	0.0286	0.01465	0.2262	0.1151	3.53	1.81	425.0	217.7	0.0137	0.0071
2.046	59	0.0306	0.01496	0.2688	0.131	3.31	1.62	423.0	206.8	0.014	0.0069
2.146	44	0.0303	0.01418	0.3021	0.1406	3.60	1.68	448.0	208.8	0.0139	0.0065
2.243	23	0.0291	0.01299	0.2723	0.1213	4.33	1.93	475.0	211.8	0.012	0.0054
2.350	13	0.031	0.0133	0.2943	0.1679	4.18	1.69	432.0	184.0	0.0125	0.0053
2.461	12	0.0324	0.01318	0.3977	0.1332	4.24	1.72	478.0	192.2	0.0165	0.0067
2.544	9	0.0335	0.0139	0.3733	0.1579	4.42	1.74	504.0	198.2	0.0172	0.0075
2.655	9	0.033	0.01244	0.3272	0.1232	4.14	1.56	448.0	168.7	0.0179	0.0064
2.870	1	0.035	0.0122	0.490	0.1716	2.72	0.95	430.0	149.8	0.016	0.0055
2.942	3	0.030	0.0102	0.3137	0.1067	4.60	1.56	450.0	153.0	0.0166	0.0057
3.010	1	0.030	0.00997	0.235	0.0784	4.85	1.61	490.0	162.8	0.032	0.0106
Correlation coefficient		+0.353 ±0.023	−0.449 ±0.021	+0.261 ±0.025	+0.013 ±0.027	+0.251 ±0.031	−0.222 ±0.031	+0.245 ±0.025	−0.448 ±0.021	+0.242 ±0.025	−0.139 ±0.026

TABLE IV—*Concluded.*

Net body weight	No. of animals	Deep cervical lymph nodes		Liver		Thymus		Pineal gland		Spleen	
		Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative	Actual	Relative
kg.		*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*
1.163	2			83.5	72.1	1.867	1.613	0.0150	0.0129	0.940	0.806
1.247	4	0.0938	0.0752	74.8	59.5	1.345	1.073	0.0155	0.0124	0.753	0.601
1.358	14	0.1008	0.0745	72.2	53.1	1.744	1.285	0.0138	0.0102	0.848	0.640
1.443	38	0.1285	0.0891	81.2	56.3	2.014	1.392	0.0144	0.0100	0.886	0.613
1.550	87	0.1392	0.090	82.4	53.1	2.024	1.310	0.0144	0.0093	0.955	0.620
1.650	90	0.164	0.0996	83.2	50.3	2.268	1.381	0.0158	0.0096	1.021	0.616
1.745	79	0.1447	0.0833	80.8	46.3	2.245	1.291	0.0159	0.0092	1.022	0.588
1.844	87	0.1437	0.0779	88.2	47.6	2.279	1.242	0.0153	0.0083	0.963	0.525
1.952	70	0.152	0.0777	87.3	44.7	2.334	1.196	0.0161	0.0082	1.053	0.539
2.046	59	0.161	0.0787	89.5	43.8	2.587	1.267	0.0166	0.0081	1.100	0.535
2.146	44	0.1754	0.0817	91.2	42.5	2.526	1.175	0.0164	0.0077	1.140	0.530
2.243	23	0.2196	0.0981	96.0	42.6	2.816	1.255	0.0153	0.0069	1.030	0.458
2.350	13	0.1781	0.0756	86.9	36.9	2.514	1.070	0.0166	0.0071	1.078	0.458
2.461	12	0.2205	0.0895	90.2	36.6	2.648	1.077	0.0188	0.0077	1.058	0.423
2.544	9	0.166	0.0656	90.5	35.6	2.285	0.897	0.0189	0.0074	1.334	0.525
2.655	9	0.1933	0.0726	96.3	36.3	2.282	1.153	0.0184	0.0069	1.551	0.586
2.870	1	0.150	0.0527	115.0	40.1	2.050	0.714	0.0200	0.0070	0.900	0.313
2.942	3	0.1875	0.0639	106.7	36.3	2.763	0.940	0.0210	0.0071	1.093	0.372
3.010	1	0.125	0.0416	90.0	29.9	1.890	0.630	0.0250	0.0083	0.930	0.309
Correlation coefficient		+0.228 ±0.032	−0.103 ±0.033	+0.214 ±0.025	−0.417 ±0.022	+0.213 ±0.025	−0.171 ±0.026	+0.199 ±0.026	−0.323 ±0.024	+0.143 ±0.025	−0.166 ±0.026

Net body weight	No. of animals	Popliteal lymph nodes		Axillary lymph nodes	
		Actual	Relative	Actual	Relative
kg.		*gm.*	*gm.*	*gm.*	*gm.*
1.163	2	0.180	0.1532	0.150	0.1276
1.247	4	0.1725	0.1377	0.1388	0.1109
1.358	14	0.2418	0.1769	0.1527	0.1118
1.443	38	0.2311	0.1569	0.1607	0.1111
1.550	87	0.239	0.1551	0.1568	0.101
1.650	90	0.2546	0.1543	0.1705	0.1033
1.745	79	0.2583	0.1483	0.1659	0.0951
1.844	87	0.2639	0.143	0.1813	0.0984
1.952	70	0.2577	0.1319	0.1756	0.0897
2.046	59	0.2738	0.134	0.1845	0.090
2.146	44	0.2439	0.1135	0.1563	0.0728
2.243	23	0.2264	0.1232	0.1733	0.0773
2.350	13	0.2512	0.1068	0.160	0.0679
2.461	12	0.2845	0.1154	0.1702	0.0694
2.544	9	0.2225	0.0878	0.1292	0.0511
2.655	9	0.2681	0.0997	0.1584	0.0595
2.870	1	0.350	0.122	0.180	0.0627
2.942	3	0.3475	0.1182	0.2775	0.0945
3.010	1	0.470	0.1561	0.180	0.0598
Correlation coefficient		+0.116 ±0.029	−0.290 ±0.027	+0.063 ±0.029	−0.336 ±0.026

weight) were correlated with both gross and net body weight. The correlation coefficients are recorded in Tables I and II in the order of the magnitude of the coefficients obtained for actual weight. Space does not permit the publication of complete correlation tables but a summary of the group means is given in Tables III and IV arranged on the basis of increasing gross and net body weights respectively. The results for gross body weight are plotted in Text-fig. 1; those for net body weight do not differ sufficiently to warrant reproduction. In order to facilitate direct comparison the values for organ weight are plotted on the basis of a percentage deviation from the mean weight of the organ concerned for a given increase in body weight so that the scales of all curves are comparable. The significant parts of the curves are included between heavy perpendicular lines. The groups to the right or left of these lines contained only a few animals but the values are given as they were used in calculating the coefficients.

RESULTS.

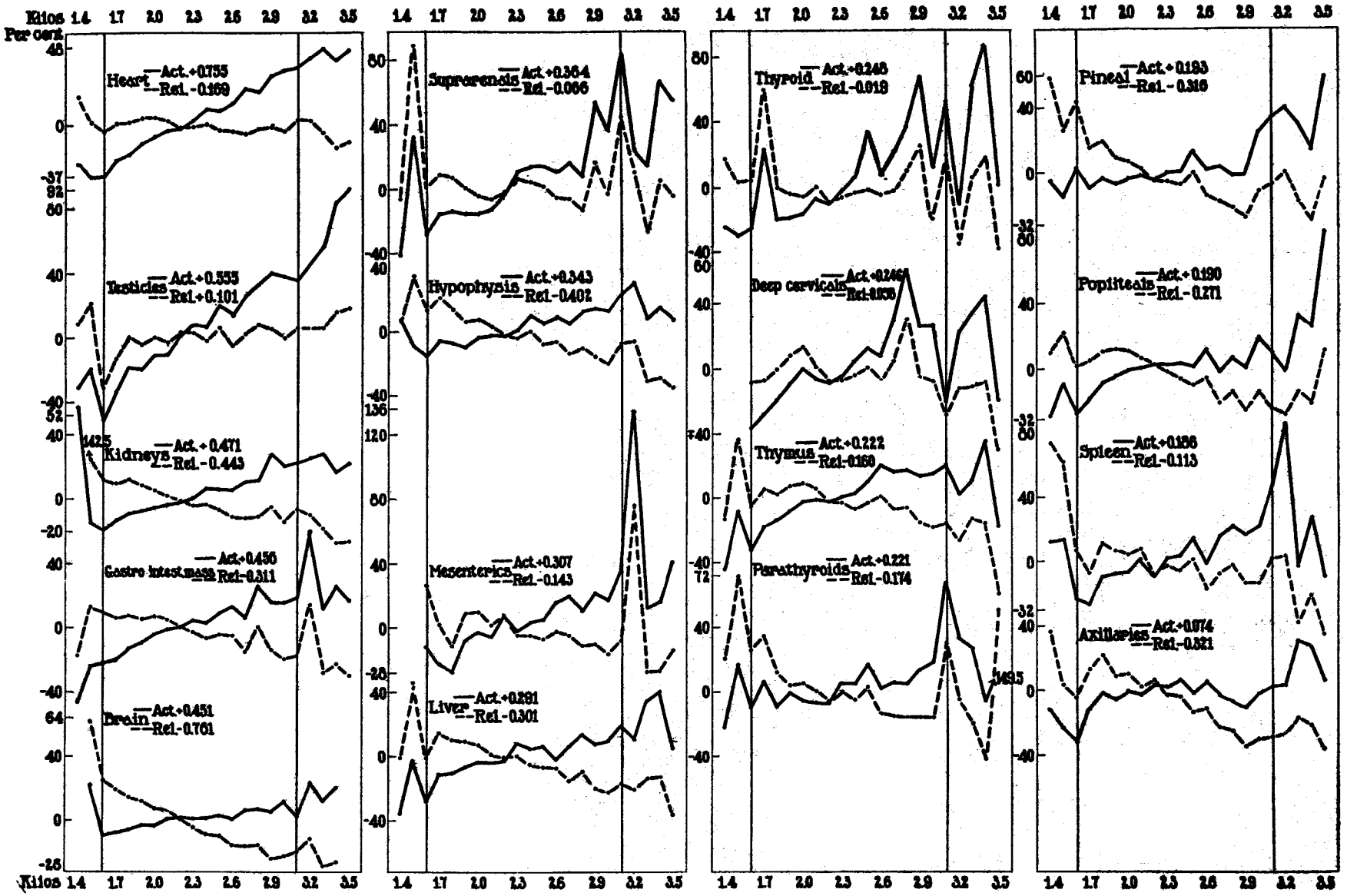
The relations found between body and organ weights are presented in Tables I to IV and Text-fig. 1.

DISCUSSION AND CONCLUSIONS.

The results presented in Tables I to IV and Text-fig. 1 bring out a number of important points concerning the physical constitution of mature and apparently healthy stock rabbits. With very few exceptions, the ratio of the correlation coefficients to their probable errors (Tables I and II) is sufficiently large to warrant acceptance of the results as valid measures of the relation existing between body and organ weight, irrespective of the magnitude of the coefficients.

The coefficients show a great diversity of relations. In the first place, it will be seen that there is a *positive* relation of some kind between the actual weight of all organs and the body weight of the animal while the coefficients for relative weight are either *negative* or *approach a zero order*. That is to say, there is evidence of a common tendency on the part of all organs to weigh more or less according to the weight of the animal but, in only a few instances, is the difference in weight of such an order as to maintain a constant relation between body and organ weight; the weight of the organ per kilo of body weight varies and, as a rule, diminishes as the weight of the animal increases.

In estimating the degree of the correlation there are two values to



TEXT-FIG. 1. Relation of actual and relative organ weights to body weight plotted as a percentage deviation of the group means for organ weight from the mean values for all animals. (Act. = actual organ weight, Rel. = relative organ weight.)

be considered, first, the direct correlation between the actual weight of the organ and that of the body and, second, the inverse relation between the weight of the organ per kilo of body weight and the weight of the body. By reference to Tables I and II, it will be seen that there is no constant relation between these two values. The ideal condition of a high positive and a low negative coefficient, or a coefficient of the zero order, is shown by very few organs. In some cases this relation is reversed while in others the two sets of coefficients are of a comparable magnitude. If, however, we arrange the organs according to the magnitude of the correlation coefficients for actual weight with gross body weight, as in Table I, it will be seen that in general the so called major organs of the body show the highest values and the lymphoid organs the lowest with the endocrine glands occupying an intermediate position.

The situation presented by correlating relative organ weight with either gross or net body weight is entirely different. The coefficient obtained in this way serves as an inverse measure of the extent to which the increase in the actual weight of different organs approximates the ideal condition of the maintenance of a constant ratio between body and organ weight. In most instances the magnitude of the coefficient for relative weight is smaller than that for actual weight.

Similar conditions obtain when the weights of organs are correlated with net instead of gross body weight (Table II). The chief difference between the two sets of results is in the magnitude of the correlation coefficients for different classes of organs. By correlating actual organ weight with net body weight, the coefficients for the endocrine glands are increased while those for all other organs are either diminished or unaffected; in the case of relative weights, all values are increased with the exception of those for the thyroid, parathyroids, suprarenals, and testicles. While in most instances the change in the magnitude of the coefficient is comparatively small, the effect of this method of correlation is to strengthen the direct correlation of the endocrine glands and to weaken that of other organs.

A clearer conception of the form as well as the measure of the relation between body and organ weight may be gained by an examination of the curves in Text-fig. 1 which give the results obtained by

plotting the group means for actual and for relative organ weight against the corresponding values for gross body weight (Table III). These curves show three distinct forms of relation: first, a linear increase in actual weight which is directly proportional to body weight; second, a straight line increase in actual weight which is of such an order as to produce a linear decrease in the weight of the organ per kilo of body weight; third, an increase in the actual weight of the organ over the lower ranges of body weight with the maintenance of a constant or diminishing level of actual weight over the middle and upper ranges which produces first an increase and then a decrease in the weight of the organ per kilo of body weight (popliteal and axillary lymph nodes).

Other curves appear to be modifications or combinations of these with the possible exception of the curve for the suprarenals. There is some indication that the change in the weight of the suprarenals is not of the order of a uniform progression but shows a diphasic condition characterized by stabilization of actual weights at successive levels or by a succession of increases and decreases in relative weight. It may be that this condition is referable to some factor other than body weight which, in the case of the suprarenals, is sufficiently potent to obscure the influence of the body weight factor.

Analyzing the results obtained from the standpoint of the correlation coefficients and the form of the relation shown, it will be seen that there are comparatively few organs the weights of which are closely related to body weight. The heart shows the closest correlation from every point of view. The coefficient for actual weight is much larger than that of any other organ while the coefficient for relative weight is comparatively small. This, in itself, suggests that there is a constant ratio between the weight of the heart and the weight of the body which holds for practically all ranges of weight within the limits of these observations. This conclusion is borne out by plotting the mean values for actual and relative weights (Table III) against body weight. The curve obtained (Text-fig. 1) shows a linear increase in the actual weight of the heart which is of such an order as to maintain the weight per kilo at a practically constant level. This may be taken as an example of almost perfect physical correlation between the weight of an organ which performs a mechanical function and that of the body which it serves.

The testicles show a similar relation to body weight, giving a high correlation coefficient for actual weight and a small positive coefficient for relative weight, while the mean values (Table III) form a curve which shows the same relation between actual and relative weights on the one hand, and the weight of the body on the other, as the curve for the heart. This result may be regarded as highly significant and indicates that the generally recognized relation between testicular development and growth is of a very high order.

Among the organs studied, the testicles and the heart are the only ones that show a high correlation of this type. The kidneys, the gastrointestinal mass, and the brain come next in the order of magnitude of the correlation coefficients between actual and gross body weight. But, these organs show a negative coefficient for relative weight of a high order which would lead one to infer that the rate of increase in the actual weight of the organ is not proportional to the increase in body weight. By plotting the mean values (Table III, Text-fig. 1), we find that, within the limits of these observations, the increase in the weight of the kidneys is fairly uniform but the rate of increase is such that the weight per kilo of body weight diminishes at a rate which is approximately equal to that of the increase in actual weight, giving correlation coefficients of essentially the same magnitude ($+0.471 \pm 0.021$ and -0.443 ± 0.021). The gastrointestinal mass behaves in much the same manner but the coefficient for relative weight is smaller ($+0.456 \pm 0.021$ and -0.311 ± 0.024), and the regression in the weight of the mass per kilo of body weight is correspondingly less.

The coefficients for the liver ($+0.291 \pm 0.024$; -0.301 ± 0.024) are of a lower order than those for the kidneys and gastrointestinal mass but they show a similar relationship to body weight with a suggestion of a tendency toward an accentuation of the inverse relation which is brought out so strikingly in the case of the brain. The condition presented by the brain is the reverse of that shown by the organs mentioned above. The coefficient for actual weight is $+0.451 \pm 0.025$ while that for relative weight is -0.761 ± 0.013. These values would lead one to expect a very uniform but very small increase in the actual weight of the brain with increasing body weight. The curve formed by the group means (Table III; Text-fig. 1) shows

a slight and very uniform increase in the actual weight of the brain for animals weighing between 1500 and 2000 gm.; from 2000 to 2500 gm. it is doubtful whether there is any change but in still heavier animals there is apparently a second increase of the same order but less uniform than the first.

The organs considered above form a small group with comparatively close and clearly defined relations to body weight. At the opposite end of the scale, we find such purely lymphoid organs as the popliteal and axillary lymph nodes with negative coefficients that are distinctly larger than the positive coefficients for actual weight. The relation shown by these organs is of a comparatively low order and even this may be an effect of age rather than weight.

It will be seen that the mesenteric and deep cervical lymph nodes differ from the popliteal and axillary nodes; the coefficients for actual weight are larger and the negative coefficients are smaller so that the relation of these two masses of lymphoid tissue to body weight is not only closer than that of the superficial lymph nodes but is also of a different character (Text-fig. 1).

The conditions shown by the spleen and thymus are of especial interest. Their weights appear to be only slightly affected by body weight; the coefficients for actual weight are comparatively small but are slightly larger than those for relative weight so that the results agree with the superficial lymph nodes in one respect and with the deep lymph nodes in another. The closest analogy, however, is with the parathyroids which have coefficients that are almost identical with those of the thymus. This is of interest as we have additional evidence of a relation between these organs.

The endocrine glands show a variety of conditions. The suprarenals and the thyroid give results which differ chiefly with respect to the magnitude of the coefficients. The coefficients for the actual weight of the suprarenals are comparatively large while those for relative weight are very small giving a value for the direct relation which is considerably higher than that of any other organ in this group. The significant feature of the relation shown by these two organs is, however, the constancy of the weight per kilo of body weight within certain limits (Text-fig. 1).

The hypophysis and pineal gland show a relation to body weight

which is the reverse of that shown by the suprarenals and thyroid. In the case of the hypophysis, both sets of coefficients are large but the negative value is larger than the positive so that the reduction in the weight of the organ per kilo of body weight is more clearly defined than the increase in the actual weight of the organ. The pineal gland exhibits a similar tendency with an even greater discrepancy between positive and negative values. The brain and the superficial lymph nodes are the only other organs that show such a decided preponderance of the inverse over the direct relation between body and organ weight.

As has been pointed out, the parathyroids give results that are more nearly comparable to those of the thymus than to other endocrine glands so far as correlation coefficients are concerned. Both sets of coefficients are small and, while the curves for mean weights are decidedly irregular, neither the actual nor the relative weight of the organs appears to be materially affected by body weight. In fact, if we disregard the upper and lower ends of the curve, the results obtained show the nearest approximation to a neutral equilibrium that is given by any of the organs studied.

The significance of the points brought out by this discussion may be made clearer by tabulating the results for gross body weight in the following manner:

Organ	Coefficient		Organ	Coefficient		Organ	Coefficient	
	Actual	Relative		Actual	Relative		Actual	Relative
Heart.....	+0.755	−0.169	(Testicles)	+0.555	+0.101	Deep cervicals..	+0.246	−0.058
(Testicles).	+0.555	+0.101	Thyroid..	+0.248	−0.019	Mesenterics....	+0.307	−0.143
			Suprarenals...	+0.364	−0.066			
Gastrointestinal mass....	+0.456	−0.311	Parathyroids....	+0.221	−0.174	Spleen....	+0.186	−0.113
Kidneys...	+0.471	−0.443				Thymus...	+0.222	−0.160
Liver.....	+0.291	−0.301						
Brain.....	+0.451	−0.761	Hypophysis...	+0.343	−0.402	Popliteals..	+0.190	−0.271
			Pineal....	+0.193	−0.316	Axillaries..	+0.074	−0.321

This arrangement of organs takes into account structural and functional relationships as well as the correlation between body and organ weight. The organs studied are divided into three main groups; each of these groups contains three subdivisions, which differ with respect to the relative magnitude of the coefficients for actual and relative weights, arranged in the order of a diminishing direct or increasing inverse relation. The table may be read in any direction. In general, it will be seen that the magnitude of the coefficients for corresponding subdivisions, and hence the closeness of the relation between body and organ weight, diminishes from left to right; in like manner, the direct relation, which is strongest in the first subdivision of each group, diminishes and then changes to an inverse relation. The extreme conditions are represented by the upper left and the lower right divisions.

Tabulation of the results on the basis of the coefficients for net body weight, as has been pointed out above, merely accentuates the direct relation of the endocrine glands and the inverse relation of other organs with only a few minor changes in the actual arrangement of the organs in any given subdivision.

A number of interesting deductions may be drawn from this study. As has already been pointed out, the relations between body and organ weight are diverse. There are a number of organs that show a comparatively high and undoubtedly significant correlation with body weight but only a few that show a correlation of a very high order. In some cases it is the direct relation that is significant, in others, the indirect relation overshadows the direct and, in still other instances, the two are of about equal rank. There are only two clearly defined instances, however, of a direct relation between the actual weight of an organ and that of the body which is sufficiently close to maintain a constant ratio between body and organ weight. In most cases, the relations are such as to favor a diminishing weight per kilo of body weight. For animals weighing less than 2200 to 2300 gm., the weight of the organ exceeds the mean value for animals of all groups while beyond this point the weight becomes less than the mean (Text-fig. 1) so that, as a rule, the larger the animal the smaller the mass of organ tissue per unit of body weight that is available to perform a given function. The amount of the reduction in propor-

tion to body weight varies with different organs, but, as a matter of interest, it may be pointed out that, in several instances the correlation coefficients for actual weight give a rough approximation of the part of the organ that is supposed to be essential to the performance of its function, so far as such information is available, or that the coefficient is the reciprocal of the fractional part of the organ or tissue that may be removed without causing serious impairment of function.

Finally, attention should be called to the fact that the results reported above do not represent conditions that obtain in strictly normal rabbits of a given age and breed. They are reported with a realization that not only these but still other factors may have affected the values obtained. There is, however, substantial evidence that the relations found between body and organ weight have an important bearing on the problem of physical constitution and that the results have both an anatomic and a functional significance. In general, it appears that organs that are related anatomically or that may be supposed to perform analogous or related functions give results of a comparable nature, both with respect to the magnitude and the form of the relation shown.

SUMMARY.

Data from 645 normal rabbits were used as the basis of an investigation of the relation existing between body and organ weights. Actual and relative weights were correlated with both gross and net body weight.

The results obtained varied with different classes of organs but it was found that, in general, there was an agreement between the form and degree of the correlation shown and the structural and functional properties of the organs concerned.

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