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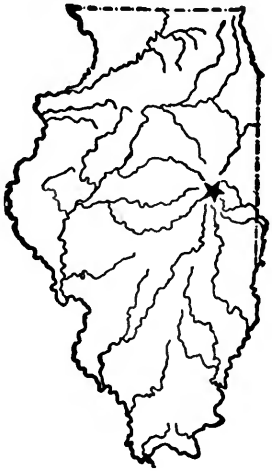
SWINE TYPE STUDIES

III. THE ENERGY AND PROTEIN REQUIREMENTS OF GROWING SWINE AND THE UTILIZATION OF FEED ENERGY IN GROWTH

By H. H. Mitchell and T. S. Hamilton



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THE ENERGY AND PROTEIN REQUIREMENTS OF GROWING SWINE AND THE UTILIZATION OF FEED ENERGY IN GROWTH

By H. H. MITCHELL AND T. S. HAMILTON[1]

A series of investigations relating to the general question of the comparative value of different types of Poland China pigs for market production was started by the Animal Husbandry Department of the University of Illinois in the summer of 1922. The division of Animal Nutrition cooperated in this work during the first two years to the extent of analyzing the carcasses of the pigs individually, analyzing the feeds, supervising the maintenance feeding trials and, in the second year's work, determining the digestibility and metabolizable energy of the ration fed, both at the maintenance level and at the fattening level of feeding.

The large amount of experimental data thus accumulated possesses a significance far more general than the comparison of the different types of pigs used in the work, and in this bulletin the bearing of these data upon the general problems of swine nutrition will be considered.

GENERAL PLAN OF THE EXPERIMENTS

The types of Poland China pigs analyzed in the experiments of 1922-23 and 1923-24 may be described as follows:

Type A, Very Chuffy. The Very Chuffy pigs were extremely short-bodied, low-set, thick animals capable of being fattened at an early age, tho never attaining an extremely large size. Perfection in this type was exemplified by the famous old boar, Chief Perfection 2d. The popularity of the type covered the period from about 1895 to 1908.

Type B, Chuffy. The Chuffy pigs were the same general type of animals as the Very Chuffy, tho they were much less extreme and showed considerably more size and growthiness.

Type C, Intermediate. The Intermediate pigs were longer in both body and legs and lacked the thickness of back and early fleshing qualities of the Very Chuffy and Chuffy types. Animals of this type were popular in the show ring from 1915 to 1917. Some very popular recent show winners (1925-26) have also been of this type.

Type D, Rangy. The Rangy pigs showed still more length of body and leg, were leaner and more growthy, showed a stronger arch to

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their backs, and carried somewhat more bone than pigs of the three types just described. This type is popular in the show ring at the present time.

These four types of pigs are illustrated in Fig. 1. An attempt to measure the type of the experimental pigs was made in the second experiment by a method that will be described later.

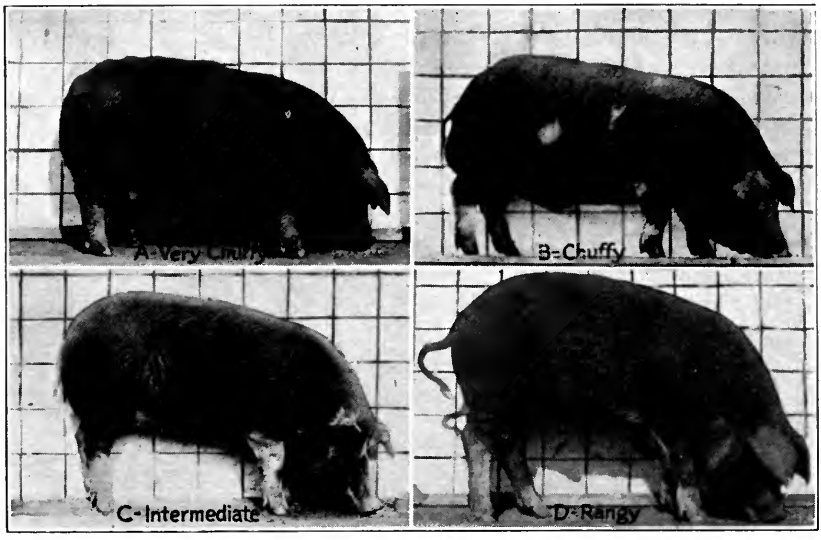

FIG. 1.—REPRESENTATIVE PIGS OF THE VERY CHUFFY, CHUFFY, INTERMEDIATE AND RANGY TYPES AT WEIGHTS OF APPROXIMATELY 225 POUNDS

In the experiment of the first year, 1922-23, Types B, C, and D were investigated; in the following year Types A, C, and D were used. In each year's work five pigs from each type were slaughtered and analyzed at the initial weight of 50 to 70 pounds. At the same time five pigs from each of the three types used were put on a maintenance trial to determine the amount of feed required to maintain constant weight at the initial weight. These pigs were fed individually in dry lot and, in the first year's work, they were slaughtered and analyzed at the end of the maintenance period. Twenty pigs of each type, starting at a weight of 50 to 70 pounds, were hand-fed individually to the limit of their appetites, also in dry lot. In the first year's experiment the pigs on a fattening ration were carried to approximately 225 pounds in weight; within each type 15 of the pigs were slaughtered at this weight and the remaining five pigs were used in a second maintenance experiment at the end of which they were slaughtered. In the second year's experiment it was planned to kill

five of the fattening pigs of each type at a weight of 175 pounds, five more at a weight of 225 pounds, and five more at a weight of 275 pounds, while five pigs of each type were to be used at a weight of 225 pounds in a maintenance feeding period. However, in the experiment of 1923-24 there was considerable mortality among the experimental pigs, due to pneumonia, and the numbers slaughtered at the different weights were necessarily somewhat reduced.

In the experiment of 1922-23 the ration consisted of shelled corn, wheat middlings, and tankage in proportions varying with the growth of the pigs. In the following experiment a small amount of alfalfa meal was introduced into the ration. Only in the experiment of 1923-24 were the digestibility and metabolizable energy of the ration determined.

Because of several important differences in the details of the two experiments, they will be considered at length separately.

FIRST EXPERIMENT

The large majority of the pigs used in the first experiment (1922-23) were farrowed in March; a few were farrowed in late February, and a few in early April. The experiment started July 8, so that the average initial age of the pigs was approximately 3.5 months.

COMPOSITION OF THE CONTROL PIGS

Five pigs from each of the three types, B, C, and D (Chuffy, Intermediate, and Rangy), were slaughtered at the beginning of the experiment at an average live weight of 29.7 kilograms (65.4 pounds). The carcasses were dressed in the ordinary manner and divided into symmetrical halves; one of the halves was then separated with the knife into bone, lean, visible fat, and skin. The bone, lean, and fat of each pig were analyzed separately, but the skin, after being weighed, was ground and composited for analysis for all 15 pigs. Composite samples were also prepared for the blood and for the brain. The thoracic and abdominal viscera of each pig constituted another chemical sample, which included edible as well as inedible organs and the abdominal fats. The tail was also added to this sample. For convenience in the preparation for analysis, the ears and snout were weighed separately for each pig and composited for analysis (for all pigs of the same type); the wet hair as removed after scalding and the toenails of all pigs were composited for analysis. The contents of the intestinal tract unfortunately were not weighed for any of the pigs slaughtered in the first experiment.

The weights of these various parts of the carcass for each of the 15 pigs are given in Table 1, grouped according to type. The most noticeable features of this table relative to type differences are the

TABLE 1.—WEIGHTS OF SAMPLES ANALYZED FROM THE CONTROL PIGS: FIRST EXPERIMENT

Pig No. and sex[1]	Live weight	Fat	Lean	Bone	Skin	Offal and tail	Blood	Brain	Ears and snout	Hair (wet) and toes
					Type B—Chuffy					
	kgs.	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
1b	24.04	5 797	5 720	3 111	1 044	3 345	975	57	212	311
2b	30.84	6 225	7 896	3 848	1 345	4 039	907	71	269	467
3b	28.12	5 169	8 308	3 558	1 414	4 082	1 270	85	241	368
4s	25.40	4 388	7 445	3 110	1 189	2 806	703	57	241	283
5b	31.29	5 454	9 355	3 525	1 727	3 926	1 134	66	269	396
Average	27.94	5 407	7 745	3 430	1 344	3 640	997	67	246	365
					Type C—Intermediate					
6b	27.66	3 922	8 701	3 851	1 216	3 742	1 338	71	212	396
7b	33.11	6 662	10 120	3 952	1 419	4 422	1 156	85	269	425
8b	27.21	3 995	7 869	3 697	1 371	3 883	929	57	241	340
9s	29.93	5 026	9 480	3 979	1 264	3 975	975	71	269	396
10b	32.20	5 699	10 151	4 517	1 343	4 592	1 202	57	354	425
Average	30.02	5 061	9 264	3 999	1 322	4 123	1 120	68	269	396
					Type D—Rangy					
11b	30.39	4 289	8 948	4 820	1 705	4 224	1 179	64	326	340
12b	29.93	3 820	10 378	4 294	1 460	4 110	1 088	71	241	382
13b	37.64	6 895	11 175	5 059	2 002	4 521	1 723	71	340	496
14b	25.85	2 671	6 906	3 983	1 323	3 657	907	57	255	311
15b	32.65	4 326	10 683	4 610	1 691	4 181	1 383	71	283	3 8
Average	31.29	4 400	9 618	4 553	1 636	4 139	1 256	67	289	379
Aver. of all types	29.75	4 956	8 876	3 994	1 434	3 967	1 124	67	268	380

[1] b = barrow; s = sow.

increasing average weights of lean, bone, and blood from the Chuffy, Intermediate, and Rangy animals, and the decreasing weights of fat.

The percentage composition of the samples of lean, fat, and bone from the control pigs will be found in Tables 2, 3, and 4. In these tables and in all similar computations of this bulletin the crude protein is calculated by multiplying the nitrogen content by 6 instead of the conventional factor, 6.25. This factor was used in view of Armsby's conclusion[1] that the fat- and ash-free dry matter of animal carcasses contains an average of 16.64 percent of nitrogen. The melting points of the fat in the fat samples were determined by the method of Wiley[2] with the results shown in Table 3. The energy value of

[1] Armsby, H. P. The nutrition of farm animals, 204. Macmillan. 1917.

[2] Sherman, H. C. Methods of organic analysis, 2d. ed., 192. Macmillan. 1912.

TABLE 2.—CHEMICAL COMPOSITION OF SAMPLES OF LEAN MEAT FROM THE CONTROL PIGS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type B—Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
1	35.41	15.82	18.32	.93	2 594
2	36.96	14.63	20.18	.90	2 705
3	30.30	16.81	13.42	.94	2 145
4	32.32	15.92	15.03	.94	2 369
5	31.00	15.16	14.18	.94	2 326
Average	33.20	15.67	16.23	.93	2 428
		Type C—Intermediate			
6	32.37	17.03	13.40	.98	2 325
7	34.86	16.12	17.21	.96	2 496
8	30.64	16.21	13.05	.97	2 129
9	30.64	15.71	12.95	.98	2 287
10	29.99	16.03	11.93	.94	2 176
Average	31.70	16.22	13.71	.97	2 283
		Type D—Rangy			
11	30.73	15.68	12.67	.94	2 150
12	28.56	16.13	10.61	.97	1 925
13	29.99	15.45	12.41	.91	2 144
14	28.47	15.89	10.75	.95	1 908
15	28.81	16.34	10.69	.95	2 089
Average	29.31	15.90	11.43	.94	2 043
Average of all types	31.40	15.93	13.79	.95	2 251

these samples, as well as of all other samples in the two experiments, was determined directly in the calorimetric bomb.

It will be noted that for the samples of lean as well as for the samples of fat, the content of fat (ether extract) decreases in the average from the Chuffy, Intermediate, and Rangy pigs, whereas with the samples of bone no such distinction between types exists.

The composition of the offal and of the ears and snout does not possess any particular significance; hence the values obtained will not be given. The composition of the composite samples of blood, skin, and brain, however, may be of interest and is therefore given in Table 5.

Since the composite hair and nails were analyzed in the wet condition as obtained after slaughter, composition on the dry basis only is of significance. The average weight of hair and toenails for each

TABLE 3.—CHEMICAL COMPOSITION OF SAMPLES OF FAT FROM THE CONTROL PIGS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram	Melting point
			Type B—Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*	*°C.*
1	79.06	5.74	67.19	.32	6 873	33.0
2	78.69	4.87	68.04	.32	6 762	34.3
3	75.18	5.82	68.56	.32	6 699	31.6
4	70.41	7.38	60.81	.32	6 370	35.0
5	70.47	6.78	62.77	.32	6 286	36.0
Average	74.76	6.12	65.47	.32	6 598	34.0
			Type C—Intermediate			
6	69.81	6.72	60.79	.38	6 188	39.0
7	74.92	6.36	67.27	.38	6 297	41.0
8	69.18	7.44	62.83	.38	6 065	36.0
9	70.82	6.72	62.54	.38	6 263	39.0
10	71.19	6.96	62.60	.38	6 076	35.5
Average	71.18	6.84	63.21	.38	6 178	38.1
			Type D—Rangy			
11	66.43	7.62	57.23	.39	5 802	31.1
12	61.81	8.46	52.84	.39	5 379	37.0
13	70.51	7.26	62.76	.39	6 005	37.7
14	63.12	8.64	51.40	.39	5 481	31.2
15	65.78	8.22	57.29	.39	5 609	35.0
Average	65.53	8.04	56.30	.39	5 656	34.4
Average of all types	70.49	7.00	61.66	.36	6 144	35.5

pig, as noted in Table 1, was 380 grams. Since this sample contained 28.16 percent of dry matter, the average weight of dry hair and toenails was 107 grams. This dry matter contained 81.2 percent of protein (N x 6.0), and 4.0 percent of ash, and possessed a gross energy content of 5.50 calories per gram.

The nutrients found in the various samples for each pig were summated and expressed as percentages of the live weight of the pig. These percentages were used in computing the initial composition of the fat pigs, an essential step in the estimation of the composition of the gains made. They represent, therefore, the most significant results of the analyses of the control pigs and are summarized in Table 6. The average composition of these 65-pound pigs was 34.00 percent dry matter, 11.61 percent crude protein (N x 6.0), 18.69 percent fat, and 2.28 percent ash; the average gross energy content was 2,474 small

TABLE 4.—CHEMICAL COMPOSITION OF SAMPLES OF BONE FROM THE CONTROL PIGS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
			Type B—Chuffy		
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
1	48.58	17.20	16.36	12.95	2 628
2	50.35	17.57	17.38	13.41	2 648
3	47.26	17.58	14.44	14.77	2 447
4	47.84	18.66	12.40	14.88	2 378
5	43.75	16.74	12.58	12.72	2 267
Average	47.56	17.55	14.63	13.75	2 474
			Type C—Intermediate		
6	46.28	16.86	14.93	13.94	2 198
7	46.73	16.98	14.76	12.96	2 381
8	43.74	17.52	13.11	12.09	2 218
9	46.00	17.28	13.04	14.41	2 186
10	44.56	16.74	13.03	12.24	2 288
Average	45.46	17.08	13.77	13.13	2 254
			Type D—Rangy		
11	45.06	15.30	16.65	10.94	2 475
12	44.20	16.14	14.61	11.50	2 324
13	48.28	17.16	15.37	13.63	2 586
14	43.70	17.10	14.62	11.07	2 347
15	45.86	17.52	13.10	13.58	2 168
Average	45.42	16.64	14.87	12.14	2 380
Average of all types	46.15	17.09	14.43	13.01	2 369

calories per gram. If it may be assumed that these pigs had the same average "fill" as the control pigs of the experiment of 1923-24, that is, 7.49 percent, the average composition of these pigs on the empty-weight basis would be as follows: dry matter, 36.75 percent; crude protein, 12.55 percent; fat, 20.20 percent; ash, 2.46 percent; and gross energy, 2.694 small calories per gram.

TABLE 5.—AVERAGE CHEMICAL COMPOSITION OF BLOOD, SKIN, AND BRAINS OF THE CONTROL PIGS: FIRST EXPERIMENT

Sample	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
Blood	16.79	14.88	.11	1.30	1 069
Skin	48.00	21.00	25.70	.48	3 565
Brains	20.46	9.42	9.09	1.58	1 633

TABLE 3.—CHEMICAL COMPOSITION OF SAMPLES OF FAT FROM THE CONTROL PIGS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram	Melting point
			Type B—Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*	*°C.*
1	79.06	5.74	67.19	.32	6 873	33.0
2	78.69	4.87	68.04	.32	6 762	34.3
3	75.18	5.82	68.56	.32	6 699	31.6
4	70.41	7.38	60.81	.32	6 370	35.0
5	70.47	6.78	62.77	.32	6 286	36.0
Average	74.76	6.12	65.47	.32	6 598	34.0
			Type C—Intermediate			
6	69.81	6.72	60.79	.38	6 188	39.0
7	74.92	6.36	67.27	.38	6 297	41.0
8	69.18	7.44	62.83	.38	6 065	36.0
9	70.82	6.72	62.54	.38	6 263	39.0
10	71.19	6.96	62.60	.38	6 076	35.5
Average	71.18	6.84	63.21	.38	6 178	38.1
			Type D—Rangy			
11	66.43	7.62	57.23	.39	5 802	31.1
12	61.81	8.46	52.84	.39	5 379	37.0
13	70.51	7.26	62.76	.39	6 005	37.7
14	63.12	8.64	51.40	.39	5 481	31.2
15	65.78	8.22	57.29	.39	5 609	35.0
Average	65.53	8.04	56.30	.39	5 656	34.4
Average of all types	70.49	7.00	61.66	.36	6 144	35.5

pig, as noted in Table 1, was 380 grams. Since this sample contained 28.16 percent of dry matter, the average weight of dry hair and toenails was 107 grams. This dry matter contained 81.2 percent of protein (N x 6.0), and 4.0 percent of ash, and possessed a gross energy content of 5.50 calories per gram.

The nutrients found in the various samples for each pig were summated and expressed as percentages of the live weight of the pig. These percentages were used in computing the initial composition of the fat pigs, an essential step in the estimation of the composition of the gains made. They represent, therefore, the most significant results of the analyses of the control pigs and are summarized in Table 6. The average composition of these 65-pound pigs was 34.00 percent dry matter, 11.61 percent crude protein (N x 6.0), 18.69 percent fat, and 2.28 percent ash; the average gross energy content was 2,474 small

TABLE 4.—CHEMICAL COMPOSITION OF SAMPLES OF BONE FROM THE CONTROL PIGS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
			Type B—Chuffy		
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
1	48.58	17.20	16.36	12.95	2 628
2	50.35	17.57	17.38	13.41	2 648
3	47.26	17.58	14.44	14.77	2 447
4	47.84	18.66	12.40	14.88	2 378
5	43.75	16.74	12.58	12.72	2 267
Average	47.56	17.55	14.63	13.75	2 474
			Type C—Intermediate		
6	46.28	16.86	14.93	13.94	2 198
7	46.73	16.98	14.76	12.96	2 381
8	43.74	17.52	13.11	12.09	2 218
9	46.00	17.28	13.04	14.41	2 186
10	44.56	16.74	13.03	12.24	2 288
Average	45.46	17.08	13.77	13.13	2 254
			Type D—Rangy		
11	45.06	15.30	16.65	10.94	2 475
12	44.20	16.14	14.61	11.50	2 324
13	48.28	17.16	15.37	13.63	2 586
14	43.70	17.10	14.62	11.07	2 347
15	45.86	17.52	13.10	13.58	2 168
Average	45.42	16.64	14.87	12.14	2 380
Average of all types	46.15	17.09	14.43	13.01	2 369

calories per gram. If it may be assumed that these pigs had the same average "fill" as the control pigs of the experiment of 1923-24, that is, 7.49 percent, the average composition of these pigs on the empty-weight basis would be as follows: dry matter, 36.75 percent; crude protein, 12.55 percent; fat, 20.20 percent; ash, 2.46 percent; and gross energy, 2,694 small calories per gram.

TABLE 5.—AVERAGE CHEMICAL COMPOSITION OF BLOOD, SKIN, AND BRAINS OF THE CONTROL PIGS: FIRST EXPERIMENT

Sample	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
Blood	16.79	14.88	.11	1.30	1 069
Skin	48.00	21.00	25.70	.48	3 565
Brains	20.46	9.42	9.09	1.58	1 633

TABLE 6.—CHEMICAL COMPOSITION OF ENTIRE CARCASSES OF THE CONTROL PIGS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type B—Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
1	40.47	10.84	25.01	2.19	3 080
2	38.50	10.05	23.55	2.15	2 844
3	36.36	11.94	21.31	2.45	2 720
4	33.24	11.17	18.43	2.53	2 482
5	33.16	11.46	18.93	1.97	2 537
Average	36.35	11.09	21.45	2.26	2 733
		Type C—Intermediate			
6	32.97	12.01	17.03	2.52	2 343
7	37.39	11.36	22.69	2.11	2 727
8	31.68	11.65	17.06	2.19	2 271
9	33.89	11.80	18.49	2.48	2 485
10	34.86	12.01	18.79	2.29	2 522
Average	34.16	11.77	18.81	2.32	2 470
		Type D—Rangy			
11	32.68	11.84	16.98	2.28	2 328
12	30.86	12.49	14.74	2.25	2 143
13	34.99	11.69	19.56	2.39	2 540
14	27.61	11.39	12.59	2.21	1 894
15	31.31	12.42	15.15	2.51	2 183
Average	31.49	11.97	15.80	2.33	2 218
Average of all types	34.00	11.61	18.69	2.28	2 474

THE MAINTENANCE EXPERIMENTS

Amounts of Feed and Energy Required for Constant Weight. At the beginning of the experiment five pigs from each of the three types were put upon a maintenance experiment in order to determine the amounts of the ration fed at the beginning of the experiment required to maintain constant weight. Again, at the end of the experiment, when the fat pigs had reached a weight of approximately 225 pounds, five pigs from each type were subjected to a maintenance experiment, the ration being fed to the fat pigs at that time being used in this case.

The ration used for the fattening pigs in this experiment consisted of shelled corn, wheat middlings, and tankage; the proportions fed varied as the experiment progressed, the proportion of corn increasing and the proportions of middlings and tankage decreasing. For the entire fattening period the average ration contained 76 percent of

TABLE 7.—RESULTS OF MAINTENANCE EXPERIMENT ON THE YOUNG PIGS: FIRST EXPERIMENT

Pig No. and sex[1]	Initial weight	Maintenance weight	Average daily feed			Average daily feed per 100 pounds live weight	
			Corn	Tankage and middlings[2]	Total	Weight ratio	Surface ratio
Type B—Chuffy							
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
11b	51	51	.33	.16	.49	.97	.78
12b	40	43	.37	.19	.56	1.31	.99
13b	47	52	.31	.15	.46	.89	.72
14b	64	62	.55	.28	.84	1.36	.73
15b	52	52	.36	.16	.52	1.01	.81
Average	51	52	.39	.19	.57	1.11	.81
Type C—Intermediate							
6b	46	49	.31	.14	.45	.93	.73
7b	50	54	.31	.15	.46	.85	.70
8b	46	52	.36	.19	.55	1.05	.84
9b	47	51	.32	.16	.48	.94	.76
10b	44	51	.35	.17	.52	1.02	.82
Average	46	51	.33	.16	.49	.96	.77
Type D—Rangy							
1b	47	51	.32	.16	.48	.95	.76
2b	44	48	.37	.19	.55	1.16	.90
3b	44	51	.32	.16	.48	.96	.76
4s	49	53	.36	.19	.55	1.04	.84
5b	48	50	.32	.16	.48	.98	.77
Average	46	51	.34	.17	.51	1.02	.81
Average of all types	47.7	51.3	.353	.173	.523	1.03	.797

[1]b = barrow; s = sow. [2]The mixture used was 2 parts middlings to 1 part tankage.

corn, 16 percent of middlings, and 8 percent of tankage. During the maintenance experiment on the young pigs the average ration contained 67 percent of corn, 22 percent of middlings, and 11 percent of tankage, while in the maintenance experiment on the fat pigs the tankage was eliminated and the corn and middlings made up 81 and 19 percent respectively of the average ration fed.

The maintenance feeding continued for 16 to 17 weeks. With the fat pigs a period of at least 8 weeks was obtained in which the pigs were at constant weight on constant feed. In this test, after a sharp initial drop in weight during the first week of reduced feed, the weights of the pigs were maintained at a practically constant level

TABLE 8.—RESULTS OF MAINTENANCE EXPERIMENT ON THE FAT PIGS: FIRST EXPERIMENT

Pig No. and sex	Initial weight	Maintenance weight	Average daily feed			Average daily feed per 100 pounds live weight	
			Corn	Middlings	Total	Weight ratio	Surface ratio
			Type B—Chuffy				
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
6s	223	206	2.06	.50	2.56	1.24	1.58
11b	227	213	1.56	.38	1.94	.91	1.17
13s	225	204	1.63	.38	2.01	.98	1.25
14s	232	229	1.44	.31	1.75	.76	1.01
20b	227	216	1.56	.38	1.94	.90	1.16
Average	227	214	1.65	.39	2.04	.96	1.23
			Type C—Intermediate				
1s	227	221	1.50	.38	1.88	.85	1.11
3b	222	219	1.44	.31	1.75	.80	1.04
14s	227	219	1.75	.44	2.19	1.00	1.30
17b	229	217	1.81	.44	2.25	1.04	1.34
20s	225	219	1.56	.38	1.94	.89	1.15
Average	226	219	1.61	.39	2.00	.92	1.19
			Type D—Rangy				
8b	224	209	1.94	.43	2.37	1.13	1.45
10b	224	217	1.94	.43	2.37	1.09	1.41
11b	225	204	2.06	.50	2.56	1.26	1.59
13b	220	213	1.63	.38	2.01	.94	1.21
17b	224	205	1.81	.43	2.24	1.09	1.39
Average	223	210	1.88	.43	2.31	1.10	1.41
Average of all types	225.3	214.3	1.71	.403	2.12	.99	1.28

for the remainder of the period. With the young pigs, altho the original weight was generally increased slightly in the first few weeks, it was found necessary to reduce the feed gradually over a much longer period than in the second maintenance trial. As a result, a period of only 5 weeks of constant weight on constant feed was obtained. The experiment could not be extended further because of the approach of cold weather, which tended to reduce the weights of the pigs on amounts of feed that had proved adequate for maintenance. The average data for these two maintenance trials are given in Tables 7 and 8. The average analyses of the feeds used are given in Table 9. The corn used in the maintenance experiment on the young pigs is represented mainly by the sample taken from July 1 to September 19,

TABLE 9.—CHEMICAL COMPOSITION OF FEEDS USED: FIRST EXPERIMENT

Feed	Dry substance	N-free extract	Crude protein (Nx6.25)	Ash	Crude fiber	Fat	Gross energy per gram
	pct.	*pct.*	*pct.*	*pct.*	*pct.*	*pct.*	*sm. cals.*
Yellow corn:							
July 1 to Sept. 19.....	90.06	72.63	9.62	1.46	2.09	4.26	4 001
Sept 19 to end of experiment.....	89.41	71.94	9.46	1.30	2.42	4.29	4 041
Average.....	89.74	72.29	9.54	1.38	2.26	4.28	4 021
Tankage.....	91.61	5.21	57.50	19.26	2.00	7.64	4 356
Wheat middlings.....	88.94	65.06	16.17	2.44	2.51	2.76	4 002

while that used in the maintenance experiment on the fat pigs is represented entirely by the second sample taken. The two samples of corn were approximately the same in composition.

The maintenance energy requirements have been expressed as weights of feed required per day per 100 pounds live weight. In reducing to this basis the actual experimental results obtained, two methods have been used, the one involving the ratio of the live weight of the pig to 100 pounds, and the other the ratio of the two-thirds power of these weights. The latter ratio is approximately the same as the ratio of the surface area of the pigs to the surface area of a 100-pound pig. The method involving the surface ratio is apparently the preferable one for the basal metabolism of animals, but in live-weight maintenance, such as obtained in this experiment, the energy requirements of the pigs relate not only to the basal metabolism but also to an unknown amount of muscular metabolism incidental to the muscular activity in the feed lots. It has been well established that the amount of energy consumed in locomotion, either along a level or up an incline, is proportional to the body weight; it bears no evident direct relation to the basal metabolism or to the body surface of the animal. Hence, in so far as the requirement of energy by these pigs relates to the basal metabolism the surface ratio is preferable in equating the experimental results for differences in size, but in so far as the requirement relates to the activity of the voluntary muscles the weight ratio is preferable.

There seems to be no way of deciding which method of equating for differences in size is preferable except by consulting the figures. It will be noted that for the two groups of pigs the maintenance requirements computed from the weight ratio are closely the same, while those computed from the surface ratio are quite dissimilar. From the weight ratio the average requirement of the young pigs was 1.03 pounds of feed per day per 100 pounds live weight and for the fat

TABLE 10.—WEIGHTS OF SAMPLES ANALYZED FROM THE YOUNG MAINTENANCE PIGS: FIRST EXPERIMENT

Pig No. and sex[1]	Live weight	Boneless meat	Bone	Skin	Offal	Blood	Brain	Ears, snout + tail
				Type B—Chuffy				
	kgs.	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
11b.....	21.77	9 944	3 695	1 481	2 900	510	83	204
12b.....	18.28	8 181	2 937	1 484	2 400	624	105	219
13b.....	22.08	9 792	3 862	1 553	2 629	624	81	285
14b.....	27.75	13 510	4 469	1 614	3 435	851	84	368
15b.....	21.43	7 975	3 853	1 630	3 139	851	97	270
Average...	22.26	9 880	3 763	1 552	2 901	692	90	269
				Type C—Intermediate				
6b.....	21.17	7 742	4 369	1 955	2 700	737	77	223
7b.....	22.93	10 634	4 247	1 704	2 850	713[2]	88	257
8s.....	22.56	10 321	4 286	1 832	2 655	624	85	310
9b.....	22.08	10 640	3 585	1 522	2 635	936	85	206
10b.....	21.85	9 101	3 854	1 331	2 800	879	80	242
Average...	22.12	9 688	4 068	1 669	2 728	778	83	248
				Type D—Rangy				
1b.....	21.88	9 425	3 607	1 868	2 606	709	75	250
2b.....	20.69	8 634	4 124	1 538	2 930	539	90	235
3b.....	22.31	9 115	4 213	1 749	2 870	539	95	183
4s.....	22.73	9 790	4 493	1 758	3 102	765	80	226
5b.....	21.31	9 114	4 212	1 506	2 755	794	91	285
Average...	21.78	9 216	4 130	1 684	2 853	669	86	240

[1]b = barrow; s = sow. [2]Sample lost; average of all results substituted.

pigs .99 pound. From the surface ratio these average requirements were, respectively, .80 pound and 1.28 pounds.

Changes in Composition of Young Maintenance Pigs. The determination of the maintenance requirements of animals by feeding experiments involving only live-weight determinations is known to be subject to error since the maintenance of live weight does not necessarily indicate the existence of a condition of nutritive equilibrium. This is especially true of young animals, in which continued subsistence on a ration inadequate for growth will nevertheless not entirely inhibit growth. In such animals body weight may be maintained constant, in spite of an increase in water, protein, and mineral matter, by a corresponding reduction in the content of fat, resulting in a considerable reduction in the energy content of the body. Thus live-weight maintenance trials on immature animals will always under-

TABLE 11.—CHEMICAL COMPOSITION OF BONELESS MEAT FROM THE YOUNG MAINTENANCE PIGS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type B—Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
11	39.16	13.80	22.99	.77	2 992
12	31.60	15.12	16.42	.83	2 231
13	27.66	16.14	10.24	.86	1 984
14	37.00	14.52	20.55	.83	2 909
15	25.75	17.04	7.11	.90	1 726
Average	32.23	15.32	15.46	.84	2 388
		Type C—Intermediate			
6	23.65	16.08	5.43	.85	1 367
7	29.72	15.00	13.08	.84	2 073
8	25.68	16.20	8.27	.89	1 777
9	33.11	16.50	14.58	.88	2 380
10	28.29	16.56	10.25	.88	2 018
Average	28.07	16.07	10.32	.87	1 923
		Type D—Rangy			
1	27.43	17.22	7.01	.86	1 717
2	32.13	16.26	13.12	.84	2 383
3	30.86	16.62	11.68	.81	2 141
4	30.09	15.42	12.67	.77	2 113
5	32.66	14.04	16.78	.75	2 396
Average	30.63	15.91	12.25	.81	2 150
Average of all types	30.31	15.77	12.68	.84	2 154

estimate the energy requirement of maintenance, and the more immature the animal the greater will be this underestimation.

Because of these well-known facts the pigs used in the maintenance trials in this experiment were slaughtered and analyzed at the end of the feeding period. By comparing the composition of the young maintenance pigs with that of the control pigs slaughtered at the beginning of the experiment, an estimate could be made of the change in composition during the maintenance feeding period. On such an estimate could be based a more or less satisfactory correction of the daily feed consumption required for the maintenance of weight, and thus the daily feed consumption required for the maintenance of energy equilibrium could be obtained.

The sampling and analysis of the young maintenance pigs was carried out in a manner essentially the same as that of the control pigs except that the lean and the fat were analyzed together. The weights of samples from these pigs are given in Table 10, and the chemical

TABLE 12.—CHEMICAL COMPOSITION OF BONES OF THE YOUNG MAINTENANCE PIGS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type B—Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
11	51.00	17.34	13.73	16.44	2 469
12	51.70	17.28	14.85	16.97	2 620
13	48.75	17.64	11.66	18.52	2 141
14	54.06	16.92	17.30	17.47	2 619
15	46.90	16.98	10.65	17.22	1 999
Average	50.48	17.23	13.64	17.32	2 370
		Type C—Intermediate			
6	44.76	17.16	9.01	15.45	1 989
7	49.70	16.80	14.52	16.00	2 335
8	45.42	17.40	10.94	15.70	2 072
9	55.48	18.00	16.13	19.29	2 543
10	51.11	18.72	12.00	19.32	2 171
Average	49.29	17.62	12.52	17.15	2 222
		Type D—Rangy			
1	46.61	17.70	10.20	16.60	2 044
2	47.60	16.50	13.89	15.55	2 318
3	45.30	16.26	10.46	15.49	1 999
4	47.97	16.62	13.21	15.79	2 377
5	48.78	15.66	14.58	15.74	2 362
Average	47.25	16.55	12.47	15.83	2 220
Average of all types	49.01	17.13	12.88	16.77	2 271

composition of the boneless meat and of the composite bones in Tables 11 and 12 respectively. The blood, skin, and brain were weighed separately for each pig but were composited for analysis. The results of these analyses will be found in Table 13. The hair and toenails from all pigs were collected and analyzed. It was estimated that each pig contributed to this sample 164 grams of dry matter containing

TABLE 13.—AVERAGE CHEMICAL COMPOSITION OF BLOOD, SKIN, AND BRAINS OF THE YOUNG MAINTENANCE PIGS: FIRST EXPERIMENT

Sample	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
Blood	20.12	15.66	.06	1.56	1 283
Skin	37.36	22.56	14.11	.56	2 491
Brains	21.72	9.90	9.24	1.33	1 481

TABLE 14.—CHEMICAL COMPOSITION OF ENTIRE CARCASSES OF THE YOUNG MAINTENANCE PIGS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (N×6.0)	Fat	Ash	Gross energy per gram
			Type B—Chuffy		
	pct.	*pct.*	*pct.*	*pct.*	*cm. cals.*
11	33.77	13.58	15.06	3.38	2 249
12	30.49	14.65	11.90	3.38	1 962
13	27.70	14.72	8.30	3.86	1 695
14	33.55	13.93	14.78	3.45	2 284
15	25.74	14.43	6.41	3.71	1 494
Average	30.25	14.26	11.29	3.56	1 937
			Type C—Intermediate		
6	25.50	14.54	5.68	3.77	1 389
7	29.99	14.55	10.60	3.60	1 836
8	27.62	15.40	7.73	3.63	1 667
9	32.12	15.43	11.57	3.82	2 012
10	27.68	14.75	8.00	4.10	1 666
Average	28.58	14.93	8.72	3.78	1 714
			Type D—Rangy		
1	26.92	15.15	6.49	3.37	1 543
2	30.17	14.82	10.06	3.71	1 919
3	28.29	14.43	8.68	3.49	1 711
4	29.57	14.60	9.68	3.70	1 837
5	30.62	13.71	11.83	3.67	1 947
Average	29.11	14.54	9.38	3.59	1 791
Average of all types	29.31	14.55	9.76	3.64	1 814

88.5 percent of crude protein (N x 6.0), 5.2 percent of ash, and 902 calories of gross energy. The analyses of the offal sample, consisting mainly of the visceral organs and of the ears, snout, and tail, will not be reported since they possess no particular significance in themselves.

From the weights of samples and their percentage composition the total amounts of the different chemical constituents in the carcasses of the pigs were determined, and from these amounts and the live weights of the pigs the percentage composition of the entire carcass (live weight), exclusive of the contents of the alimentary tract, was determined. The results of these calculations are given in Table 14.

The average analyses for all types of pigs in the maintenance and control groups of the boneless meat (lean plus fat), bone, offal, and entire carcass have been summarized for comparison in Table 15. Evidently during the period of maintenance feeding the growth of the maintenance pigs was not suppressed altho their food consumption

TABLE 57.—A COMPARISON OF PERCENTAGE COMPOSITION OF THE YOUNG MAINTENANCE PIGS AND THE CONTROL PIGS. FIRST EXPERIMENT

Group of pigs	Dry substance	Crude protein (N×6.0)	Fat	Ash	Gross energy per gram
		Boneless meat			
	per cent	per cent	per cent	per cent	cal. calc.
Maintenance	30.32	15.77	12.66	.84	2.558
Control	45.42	12.73	30.34	.79	3.691
		Bones			
Maintenance	48.01	17.13	12.88	16.77	2.572
Control	46.15	17.09	24.42	13.01	2.969
		Offal			
Maintenance	28.10	12.17	4.94	.85	1.352
Control	22.86	12.08	6.20	.85	1.467
		Entire carcass			
Maintenance	28.33	14.55	9.79	3.86	1.854
Control	38.00	11.61	25.49	2.25	2.474

was restricted to the amount needed only for the maintenance of constant weight. In the flesh and adipose tissue, protein and water were being deposited and fat withdrawn, the net change being a reduction in gross energy per gram of tissue of about 41 percent. The bones lost water and fat and gained mineral matter, with only an insignificant loss in gross energy. The offal parts did not change greatly in composition, the the net effect was again a reduction in energy content. The changes in the entire carcass reflect in the main, the changes in the lean and fatty tissues: the water content increased 7 percent, the protein 35 percent, and the mineral matter 60 percent, while the fat content decreased 48 percent and the gross energy content 27 percent. These changes do not, of course, take account of the inconsiderable variations in live weight during the period of maintenance feeding. They clearly demonstrate, however, that the maintenance of live weight in an immature animal is merely the resultant of a number of considerable increases and decreases in the materials of which the animal is composed, and that the quantity of feed or of food nutrients required to maintain weight under these conditions cannot be considered to bear any close relation to the animal's requirements for nutritive equilibrium.

Changes in Composition of Fat Maintenance Pigs. The [illegible] maintenance pigs were not analyzed in such detail as the young maintenance pigs and, since the work was completed, it was discovered that some of the data required for an accurate estimate of these [illegible]

TABLE 16.—PERCENTAGE COMPOSITION OF DRESSED CARCASSES OF THE 225-POUND MAINTENANCE PIGS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (N×6.25)	Fat	Ash	Gross energy per gram
		Type B—Chuffy			
	per ct.	per ct.	per ct.	per ct.	mc. calo.
4	449.046	144.367	300.388	4.191	3.6572
11	452.389	144.731	304.195	3.228	4.0229
18	500.810	144.165	351.222	4.116	3.9885
19	422.774	144.390	274.188	3.539	3.9485
20	501.365	144.196	352.365	3.778	3.9899
Average	511.896	144.770	362.146	3.860	3.9922
		Type C—Intermediate			
2	556.320	132.096	422.300	3.226	4.7244
3	559.440	133.457	424.258	3.086	4.8286
14	559.452	131.999	422.365	3.288	4.7231
17	560.080	133.198	424.737	3.426	4.8022
20	560.035	132.770	423.255	3.310	4.7960
Average	559.452	132.296	422.183	3.255	4.7997
		Type D—Hungry			
5	557.306	132.082	422.282	3.109	4.7984
10	558.116	132.366	423.155	3.452	4.8231
12	468.339	135.367	327.322	4.721	3.9458
13	558.080	132.280	422.422	3.105	4.7957
17	468.322	135.779	328.484	4.461	3.9477
Average	542.259	132.855	406.129	3.369	4.7557
Average of all types	537.133	133.641	397.455	3.577	4.7889

composition had unfortunately not been permanently recorded. The dressed carcass of each of the 225-pound maintenance pigs was analyzed as a composite sample of the bone, boneless meat, and skin of which it is composed. The results of the chemical analysis of these samples are included in Table 16. The analyses of the other samples need not be considered since they are in themselves without significance.

A comparison of the composition of the dressed carcass and of the offal of these maintenance pigs and of the fat pigs analyzed at the conclusion of the fattening period will be found in Table 17. Judging from the differences in average composition of these samples from maintenance and fat pigs, the 225-pound pig when put on a maintenance ration, will still change considerably in composition. In spite of inadequate nutrition, growth is not entirely suppressed. Fat is being used up, while water, minerals, and protein are being added, so that the net change in energy is considerable, especially for the Chuffy and Hungry pigs.

TABLE 17.—COMPARISON OF PERCENTAGE COMPOSITION OF DRESSED CARCASSES OF THE 225-POUND FAT PIGS AND THE 225-POUND MAINTENANCE PIGS: FIRST EXPERIMENT

Group of pigs	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
			Carcass composite		
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
Chuffy type					
Maintenance pigs....	51.68	14.79	33.14	3.80	3 932
Fat pigs.....	62.31	13.06	45.12	2.73	5 060
Intermediate type					
Maintenance pigs....	59.42	12.28	43.11	3.25	4 797
Fat pigs.....	64.30	13.34	46.27	2.71	5 108
Rangy type					
Maintenance pigs....	54.29	13.85	36.09	3.66	4 137
Fat pigs.....	62.19	13.59	44.44	2.93	4 960
			Offal		
Chuffy type					
Maintenance pigs....	29.00	13.58	12.60	1.15	1 996
Fat pigs.....	27.79	11.83	12.83	.82	1 960
Intermediate type					
Maintenance pigs....	32.52	13.00	17.28	1.09	2 385
Fat pigs.....	27.90	11.79	12.76	.81	1 991
Rangy type					
Maintenance pigs....	30.78	14.14	13.49	1.10	2 110
Fat pigs.....	27.06	12.18	11.51	.86	1 899

The data are not at hand for an estimate of the complete composition of the entire carcasses of the 225-pound maintenance pigs. However, satisfactory estimates of their total gross energy values will be found in Table 19.

Estimates of Feed Required for Maintenance. There are rather serious difficulties in the way of any method of correcting the food intake records of the two groups of maintenance pigs in order to get a satisfactory estimate of the amounts of food required to maintain a condition of energy equilibrium. The method we have adopted yields the results given in Tables 18 and 19.

Obviously in using the results of the slaughter tests, it is necessary to use the total feed consumption of the maintenance period from the first day of feeding to the day of slaughter rather than the feed consumption found to be best adapted to the maintenance of constant weight, as used in Tables 7 and 8. The estimates of the original energy content of the pigs in each type are based upon the average energy content of the control pigs of that type. The final energy contents

TABLE 18.—COMPLETE DATA FOR MAINTENANCE EXPERIMENT ON THE YOUNG PIGS, 110 DAYS: FIRST EXPERIMENT

Pig No	Initial weight	Average weight	Initial energy content	Final energy content	Loss of energy	Total feed eaten	Feed equivalent of energy loss[1]	Maintenance feed			
								Total	Per day	Per day per 100 pounds live weight	
										Weight ratio	Surface ratio
Type B—Chuffy											
	lbs.	*lbs.*	*therms*	*therms*	*therms*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
15	52	52	65	32	32.5	71	24	95	.87	1.68	1.35
14	64	61	79	63	16.0	93	12	105	.96	1.56	1.33
13	47	51	60	37	22.1	68	16	84	.76	1.49	1.19
12	40	41	50	36	13.8	75	10	86	.78	1.88	1.40
11	51	51	63	49	14.3	71	11	81	.74	1.46	1.17
Average	51	51	63	43	19.7	76	15	90	.82	1.62	1.29
Type C—Intermediate											
10	44	49	49	36	12.9	70	10	80	.73	1.48	1.17
9	47	51	53	44	8.3	69	6	75	.68	1.34	1.07
8	46	50	52	38	14.0	72	10	82	.75	1.49	1.18
7	50	53	56	42	14.0	68	10	78	.71	1.35	1.09
6	46	49	52	29	22.2	65	17	81	.74	1.52	1.19
Average	47	50	52	38	14.3	69	11	79	.72	1.44	1.14
Type D—Rangy											
5	48	49	48	42	6.5	67	5	72	.65	1.32	1.05
4	49	52	49	42	7.6	72	6	78	.71	1.36	1.10
3	44	48	44	38	6.1	68	5	73	.66	1.38	1.08
2	44	47	44	40	4.6	74	3	77	.70	1.50	1.16
1	47	50	47	34	13.6	67	10	77	.70	1.40	1.11
Average	46	49	47	39	7.7	70	6	75	.68	1.39	1.10
Average of all types	48	50	54	40	13.9	72	10	82	.74	1.48	1.18

[1]Assuming all the metabolizable energy, estimated at 1,342 calories per pound, to be net available.

TABLE 19.—COMPLETE DATA FOR MAINTENANCE EXPERIMENT ON THE FAT PIGS, 83 TO 200 DAYS: FIRST EXPERIMENT

Pig No.	Initial weight	Average weight	Initial energy content	Final energy content	Loss of energy	Total feed eaten	Feed equivalent of energy loss[1]	Maintenance period	Maintenance feed			
									Total	Per day	Per day per 100 pounds live weight	
											Weight ratio	Surface ratio
Type B—Chuffy												
	lbs.	*lbs.*	*therms*	*therms*	*therms*	*lbs.*	*lbs.*	*days*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
6	223	210	400	275	125	284	94	113	378[2]	3.35[2]	1.60[2]	2.04[2]
11	227	214	407	337	70	258	52	119	310	2.60	1.22	1.57
13	225	208	403	306	97	260	73	120	333	2.77	1.33	1.70
14	232	228	416	349	67	246	50	119	296	2.49	1.09	1.44
20	227	217	407	332	75	288	56	131	344	2.63	1.21	1.57
Average	227	215	407	320	87	...	..	...	...	2.62	1.21	1.57
Type C—Intermediate												
1	227	221	418	408	10	256	8	125	267	2.14	.92	1.26
3	222	219	409	420	−11	253	− 8	125	245	1.96	.90	1.16
14	227	218	418	403	15	223	11	99	234	2.36	1.08	1.40
17	229	218	422	424	− 2	225	− 2	97	223	2.30	1.06	1.37
20	225	219	414	418	− 4	239	− 2	118	237	2.01	.92	1.19
Average	226	219	416	414	2	...	..	...	....	2.15	.98	1.28
Type D—Rangy												
8	224	210	396	366	30	205	23	83	228	2.75	1.31	1.68
10	224	217	396	365	31	274	23	113	297	2.63	1.21	1.57
11	225	206	398	270	128	334	96	125	430[2]	3.44[2]	1.67[2]	2.13[2]
13	220	213	389	397	− 8	242	− 6	111	236	2.13	1.00	1.29
17	224	209	396	276	120	496	90	200	586	2.93	1.40	1.79
Average	223	211	395	335	60	...	..	...	...	2.61	1.23	1.58
Average of all types	225	215	406	356	50	...	..	...	...	2.44	1.13	1.46

[1]Assuming all of the metabolizable energy, estimated at 1,337 calories per pound, to be net available. [2]Not included in the average.

of the pigs were directly determined as explained above. The estimated losses (or gains) in energy during the maintenance period are converted into terms of feed on the somewhat dubious assumption that the metabolizable energy of the rations consumed, as estimated from results obtained in the next year's experiment, would be utilized to the extent of 100 percent in preventing a loss in body energy.

Some estimate of this sort is required in order to make the correction desired, and the selection of this ideal percentage was based upon the following considerations. Armsby[1] has estimated from available data that on fattening rations swine utilize over 78 percent of the metabolizable energy of their rations for maintenance and gain. Furthermore, Forbes, Fries, Braman, and Kriss[2] have presented evidence to show that the metabolizable energy of the feed is utilized to a greater extent when fed at the maintenance or submaintenance level than when fed at the supermaintenance level. This is quite in agreement with the observation of Benedict and Benedict,[3] on human subjects, that the ingestion of a small breakfast does not appreciably affect a basal metabolism determination that is made immediately afterward.

The average estimate of the feed equivalent of the energy losses of the young maintenance pigs, according to the data obtained in this experiment (Tables 18 and 19), is equal to 14 percent of the total feed consumed and to 13.5 percent in the case of the 225-pound maintenance pigs. If it had been assumed that the metabolizable energy of the feed were only 78 percent net available for maintenance, instead of 100 percent, these percentage feed corrections would be increased to approximately 18. Evidently, therefore, any likely error in the feed correction for losses of body energy would not greatly affect the final estimate of the feed required for maintenance per 100 pounds live weight.

Among the young maintenance pigs the energy content of the body decreased on the average 31 percent for the Chuffy type, 28 percent for the Intermediate type, and 16 percent for the Rangy type during the maintenance feeding period of 110 days. Among the 225-pound maintenance pigs the average percentage losses of body energy were 21, .5, and 15 respectively. The differences between the average type values are not readily explainable on the basis of differences in rate of growth or in the attainment of maturity. The consistently larger

[1] Armsby, H. P. The nutrition of farm animals, 288.

[2] Forbes, E. B., Fries, J. A., Braman, W. W., and Kriss, M. Jour. Agr. Res. 33, 483. 1926.

[3] Benedict, C. G., and Benedict, F. G. Boston Med. and Surg. Jour. 170, 849. 1923.

percentage losses in body energy for the Chuffy type on a ration adequate for the maintenance of body weight may indicate a growth impulse for these pigs that is less readily inhibited by restrictions in the amount of feed consumed.

Before considering the final estimates of the amount of feed required for maintenance, it is necessary to decide which method of reducing these amounts to 100 pounds of body weight is preferable—that involving a ratio of weights or that involving a ratio of surfaces (two-thirds powers of the weights). The average estimates for all types by the weight ratio are 1.48 pounds of feed for the young pigs and 1.13 pounds for the older pigs; the estimates obtained by the surface ratio are 1.18 pounds and 1.46 pounds respectively. In neither case do the values agree well. Using the weight ratio one would infer that the maintenance requirements are more intense (greater per unit of weight) for the young pigs than for the older pigs; using the surface ratio, the opposite would be inferred. However, where differences in maintenance requirements with age have been measured, it has been invariably found that, per unit of weight, the basal metabolism of the younger animal is greater than that of the older; and per unit of surface, where a difference exists, the younger animal again has a higher basal heat production.[1] The activity factor, which is of course involved in live-weight maintenance, is probably affected by age and also by seasonal factors[2]; it is probably fair to presume[3] that, except for the very young animal, increasing age is accompanied by decreasing spontaneous activity.

Therefore, with respect to basal metabolism as well as spontaneous activity, one would expect a greater energy requirement per unit of size for the young animal than for the old. Since this relation is shown by the estimates of maintenance requirements per 100 pounds of body weight obtained by the weight ratio and is not shown by those obtained by the surface ratio, it is perhaps fair to assume that the former method is more satisfactory than the latter in varying such estimates for variations in size and age. This is probably due to the fact that spontaneous activity plays a large part in determining the feed requirements for live-weight maintenance. In assuming that the energy equivalent of this activity varies with surface rather than weight, the estimate for a 100-pound pig from results obtained on a 50-pound pig would be too low, while that made from results on a

[3] This does not apply to the very young animals. The new-born animal has a very low basal metabolism per unit of weight or surface, but very quickly attains a level considerably higher than the adult level.

[1] Hitchcock, F. A. Amer. Jour. Physiol. 75, 205. 1925.

[2] Armsby, H. P. The nutrition of farm animals. 307.

225-pound pig would be too high. In this connection it may be recalled that Armsby, Fries, and Braman[1] found that the basal catabolism of cattle of different weights, indirectly determined, was as well correlated with body weight as with body surface.

The estimated feed requirements for the young maintenance pigs per 100 pounds weight, it is interesting to observe, are not distinctly different for the different types. For the older maintenance pigs, however, the Intermediate type appears to have a distinctly lower requirement of feed for energy equilibrium.

THE FATTENING EXPERIMENT

Composition of the Fat Pigs. When the 20 pigs of each type that were grown out and fattened reached a weight of approximately 225 pounds, they were withdrawn individually from this feeding experiment; 15 in each type group were slaughtered and analyzed immediately and 5 were placed upon a maintenance feeding test described in the preceding section. The slaughter data and the weights of samples taken for analysis for the 45 fat pigs are given in Table 20; the analyses of the more significant of these samples will be found in Tables 21, 22, and 23. Table 24 contains the analyses for the composite samples of blood, brains, hair, and skin to which all pigs in all types contributed.

The average weight of brain for these 45 pigs was 89 grams, as compared with 67 grams for the 15 control pigs. The average weight of air-dried hair (plus toenails) was estimated to be 318 grams.

From the weights of samples and their chemical composition the percentage composition of the entire carcasses (live weight) was computed, with the results given in Table 25. The weight of "fill" in these carcasses was not determined. If it is assumed to be 5.6 percent of the live weight, or the average of the 225-pound fat pigs of the experiment of the following year, the average percentage composition of these 45 fat pigs, on the empty-weight basis, would be as follows: 52.3 percent dry substance, 11.9 percent crude protein (N x 6.0), 36.7 percent fat, and 2.2 percent of ash. The gross energy value on the same basis would be 4.17 calories per gram, or 189 therms per 100 pounds.

The average percentage compositions of the more important chemical samples and of the entire carcass for the three types of pigs are summarized for comparison in Table 26. In spite of the very obvious differences in the conformation of the three types of pigs and in their market condition at the time of slaughter, their chemical composition did not vary greatly. The Intermediate-type pigs proved to be some-

[1] Armsby, H. P., Fries, J. A., and Braman, W. W. Jour. Agr. Res. 18 43. 1919.

TABLE 20.—WEIGHTS OF SAMPLES FROM THE FAT PIGS: FIRST EXPERIMENT

Pig No. and sex[1]	Live weight	Total fat[2]	Total lean	Total bone	Skin[3]	Offal	Blood
			Type B—Chuffy				
	kgs.	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
1b	104.3	29 600	34 239	8 741	4 153	7 700	2 665
2b	102.1	31 645	32 038	8 842	3 780	7 990	2 864
3b	98.9	29 718	30 674	9 656	2 898	8 149	1 871
4s	99.8	24 729	32 519	9 406	3 800	9 650	1 588
5s	102.1	31 591	30 884	9 072	3 981	8 606	2 239
7s	101.5	30 361	33 051	7 902	3 473	8 593	2 665
8b	101.2	26 806	31 957	8 846	3 808	8 865	1 559
9s	101.2	32 093	27 653	9 654	4 300	9 130	1 899
10b	103.4	29 737	32 287	8 399	3 234	8 800	1 814
12b	99.8	27 624	32 051	8 348	3 752	9 747	2 580
15b	98.4	27 127	28 283	8 987	3 446	9 915	1 701
16b	101.2	30 157	29 633	8 395	3 799	8 695	2 608
17b	105.2	30 376	33 093	9 393	3 261	8 800	2 183
18b	103.9	32 315	29 845	8 406	3 871	9 110	2 268
19b	104.8	34 015	29 702	8 953	3 704	8 950	1 814
Average	101.8	29 860	31 194	8 867	3 684	8 847	2 155
			Type C—Intermediate				
2s	104.3	29 555	33 545	9 248	4 194	6 655	2 098
4b	101.6	28 654	32 909	9 692	4 274	7 286	3 062
5b	101.3	29 068	32 345	10 210	4 150	9 670	2 239
6b	102.5	30 816	31 422	8 944	4 181	9 000	1 956
7b	102.1	27 672	35 139	9 438	4 022	8 134	2 211
8b	100.7	28 558	33 854	8 644	3 629	8 454	1 956
9s	100.2	27 680	32 691	9 415	4 014	7 552	2 098
10b	99.3	28 977	32 141	9 334	3 770	8 145	1 927
11b	104.3	27 837	33 856	10 673	4 991	8 656	2 069
12s	102.5	30 704	30 115	8 738	3 459	9 414	2 268
13s	104.3	28 736	31 235	9 493	4 050	10 570	2 183
15s	104.3	28 418	33 916	9 066	3 898	9 527	2 523
16s	104.3	28 274	34 580	9 685	3 982	7 922	1 701
18b	101.6	32 385	31 740	9 526	3 840	8 107	2 154
19b	98.9	28 024	32 263	8 785	4 330	7 945	2 041
Average	102.4	29 024	32 783	9 393	4 052	8 469	2 166
			Type D—Rangy				
1b	99.3	29 958	31 190	9 974	4 026	8 514	1 474
2b	101.2	26 694	34 970	10 122	4 118	8 537	1 927
3b	102.5	27 115	33 243	9 307	4 785	8 920	2 268
4b	105.2	25 055	31 796	12 770	5 027	9 965	1 531
5b	103.9	27 114	33 097	10 327	4 730	8 980	2 353
6b	104.3	28 062	32 591	11 001	4 949	10 015	1 588
7b	107.0	24 603	36 393	11 442	5 111	10 500	2 239
9b	100.7	23 787	33 969	10 856	4 086	9 785	2 098
12b	101.2	29 257	31 501	10 107	4 441	8 500	2 012
14b	101.6	30 079	32 821	9 206	4 798	7 893	2 665
15s	103.4	25 064	33 916	11 315	4 276	8 852	2 523
16b	102.1	31 006	32 858	10 128	3 934	8 645	2 381
18b	101.6	30 342	29 228	10 552	4 306	8 165	1 474
19s	99.3	23 665	35 312	10 820	4 027	7 785	2 183
20b	100.2	27 094	32 914	10 033	4 042	8 876	2 722
Average	102.2	27 260	33 053	10 531	4 444	8 929	2 096
Average of all types	102.1	28 715	32 343	9 597	4 060	8 748	2 139

[1]b = barrow; s = sow. [2]Including the caul and mesentery fats. [3]Including snout and ears.

TABLE 21.—PERCENTAGE COMPOSITION OF LEAN SAMPLES FROM THE FAT PIGS: FIRST EXPERIMENT

Pig No.	Dry substanee	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type B—Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
1	39.68	16.74	22.32	.86	3 088
2	40.90	16.68	20.57	.89	2 852
3	41.06	16.50	23.71	.85	3 263
4	39.90	16.50	21.24	.88	3 017
5	41.70	16.98	22.70	.88	3 038
7	38.06	16.86	20.48	.89	3 071
8	40.93	16.14	22.66	.93	3 102
9	40.66	17.82	20.76	.86	3 068
10	35.21	18.18	16.29	.87	2 715
12	40.69	16.62	23.41	.85	3 059
15	40.78	15.72	22.94	.83	3 229
16	38.19	16.80	19.80	.85	2 934
17	35.45	16.74	16.91	.87	2 626
18	40.10	16.38	22.05	.91	3 025
19	38.01	17.40	19.16	.90	2 866
Average	39.42	16.80	21.00	.87	2 997
		Type C—Intermediate			
2	43.56[1]	16.61[1]	23.59[1]	.87[1]	3 188[2]
4	42.84	17.10	21.88	.92	3 001
5	45.32	16.98	21.23	.91	3 024
6	44.98	15.72	28.04	.84	2 440
7	43.36	16.56	22.80	.90	3 085
8	42.35	15.84	25.40	.89	3 232
9	47.36	16.56	22.11	.89	3 039
10	43.30	16.50	24.57	.85	3 210
11	41.68	16.02	23.55	.87	3 067
12	41.10	17.22	22.55	.87	3 140
13	47.51	16.80	22.92	.85	3 136
15	43.93	16.38	25.91	.84	3 382
16	40.12	16.68	22.36	.81	3 318
18	42.60	17.04	22.49	.85	3 077
19	43.41	17.16	24.42	.83	3 439
Average	43.56	16.61	23.59	.87	3 119
		Type D—Rangy			
1	43.56	15.42	24.54	.80	3 122
2	44.39	16.44	23.44	.98	3 116
3	40.48	17.40	20.56	.95	3 030
4	45.36	16.20	25.60	.96	3 326
5	40.80	16.38	22.64	.92	3 200
6	40.83	15.78	22.58	.81	3 227
7	44.43	16.44	21.32	.89	2 971
9	44.65	17.04	22.89	.98	3 196
12	41.97	16.20	24.68	.80	3 166
14	45.84	16.98	22.35	1.01	3 085
15	42.07	16.32	22.80	.83	3 004
16	37.08	16.62	19.61	.88	2 913
18	39.77	16.02	22.00	.89	2 972
19	39.82	17.04	21.03	.95	3 069
20	38.52	16.56	21.28	.93	3 004
Average	41.97	16.46	22.49	.91	3 093
Average of all types	41.65	16.62	22.36	.88	3 070

[1]This sample was accidently thrown out before it was analyzed. The percentages given are the averages for that type. [2]Calculated using 5.7 calories per gram of protein and 9.5 calor es per gram of fat.

TABLE 2.—PERCENTAGE COMPOSITION OF FAT SAMPLES FROM THE FAT PORTS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (N×6.0)	Fat	Ash	Gross energy per gram
		Type B—Chatky			
	per.	per.	per.	per.	cal.
1	94.26	3.90	89.40	.16	9 [illegible]
2	95.85	3.84	91.78	.16	9 [illegible]
3	96.58	3.96	91.80	.16	9 [illegible]
4	96.56	3.80	92.80	.16	9 [illegible]
5	96.56	3.84	91.20	.16	9 [illegible]
7	95.21	4.02	90.40	.16	9 [illegible]
8	95.25	3.46	92.10	.16	9 [illegible]
9	94.86	4.06	90.10	.16	9 [illegible]
10	93.24	4.50	91.30	.16	9 [illegible]
12	95.94	3.78	90.90	.16	9 [illegible]
15	94.89	3.84	90.20	.16	9 [illegible]
16	94.91	4.44	91.30	.16	9 [illegible]
17	96.56	3.72	92.60	.16	9 [illegible]
18	95.25	3.78	91.70	.16	9 [illegible]
19	94.94	3.78	91.40	.16	9 [illegible]
Average	94.24	3.90	91.04	.16	9 [illegible]
		Type C—Intermediate			
2	96.16	4.56	91.4	.14	9 [illegible]
4	94.31	3.66	91.5	.14	9 [illegible]
5	96.34	3.72	92.1	.14	9 [illegible]
6	95.76	3.30	92.6	.14	9 [illegible]
7	96.67	3.56	91.9	.14	9 [illegible]
8	97.02	3.42	92.2	.14	9 [illegible]
9	97.70	3.36	92.5	.14	9 [illegible]
10	95.84	3.46	92.0	.14	9 [illegible]
11	97.36	3.30	92.9	.14	9 [illegible]
12	96.16	3.24	91.3	.14	9 [illegible]
13	96.52	3.46	92.5	.14	9 [illegible]
15	96.36	3.42	91.4	.14	9 [illegible]
16	97.10	3.30	92.5	.14	9 [illegible]
18	97.12	3.24	92.4	.14	9 [illegible]
19	96.40	3.16	92.0	.14	9 [illegible]
Average	96.32	3.40	92.1	.14	9 [illegible]
		Type D—Range			
1	92.80	3.36	90.89	.13	9 [illegible]
2	93.10	3.26	91.36	.13	9 [illegible]
3	92.30	3.26	92.20	.13	9 [illegible]
4	93.40	4.02	91.30	.13	9 [illegible]
5	92.40	3.66	91.27	.13	9 [illegible]
6	92.10	3.66	91.25	.13	9 [illegible]
7	93.60	3.96	91.45	.13	9 [illegible]
8	94.35	3.66	91.60	.13	9 [illegible]
9	93.48	4.32	91.40	.13	9 [illegible]
10	93.20	3.48	91.62	.13	9 [illegible]
11	92.22	4.20	91.38	.13	9 [illegible]
12	92.26	4.02	91.18	.13	9 [illegible]
13	93.25	4.32	91.25	.13	9 [illegible]
14	93.82	3.96	91.31	.13	9 [illegible]
15	94.02	3.72	92.01	.13	9 [illegible]
Average	93.12	3.79	91.42	.13	9 [illegible]
Average of all types	95.23	3.72	91.89	.14	9 [illegible]

[illegible] determinations were made. The [illegible] given is the average value for the type [illegible] using 9.7 calories per gram of protein and 9.3 calories per gram of fat.

TABLE 23.—PERCENTAGE COMPOSITION OF BODY SAMPLES FROM THE FIVE PIGS FIRST EXPERIMENTS

Pig No.	Dry substance	Crude protein (N×6.0)	Fat	Ash	Gross energy per gram
		Type B—Chubby			
	per ct.	per ct.	per ct.	per ct.	cal.
1	60.498	19.724	35.385	5.060	3.1136
2	60.220	19.022	35.719	5.060	3.2286
3	58.220	18.722	34.685	5.351	3.0922
4	60.386	19.220	32.422	7.667	3.2283
5	57.440	18.380	30.102	8.111	3.1446
7	61.980	18.448	33.590	8.980	3.1960
8	61.980	19.336	29.194	8.457	3.2244
9	60.680	18.422	30.380	8.440	3.2240
10	62.580	18.380	30.580	9.680	3.2255
12	60.770	19.336	37.857	4.086	3.1580
15	59.110	19.194	34.055	5.580	3.1524
16	62.597	18.384	30.128	9.338	3.1465
17	63.220	18.136	32.726	8.755	3.3084
18	59.770	18.080	30.531	7.886	3.1931
19	60.350	17.888	31.997	7.444	3.2055
Average	60.722	18.738	30.387	8.444	3.1936
		Type C—Intermediate			
2	59.980	18.584	31.380	7.122	3.2467
4	62.155	18.584	30.467	8.580	3.1941
5	60.080	19.382	31.580	7.130	3.1924
6	60.580	19.088	32.387	7.122	3.1965
7	61.110	19.322	32.331	7.280	3.2180
8	60.980	19.002	30.194	9.722	3.2231
9	61.538	19.986	31.355	8.486	3.2280
10	60.280	19.002	31.380	8.700	3.1988
11	60.380	18.680	33.596	6.980	3.4431
12	61.680	19.022	31.277	8.581	3.2100
13	60.440	18.722	32.467	7.086	3.3538
15	59.980	18.584	32.186	7.110	3.2941
16	62.110	18.086	32.331	7.580	3.3984
18	59.982	19.022	30.194	7.867	3.1984
19	62.580	18.286	29.139	7.137	3.2289
Average	60.944	18.986	31.382	7.696	3.2962
		Type D—Blocky			
1	60.980	17.522	33.381	7.465	3.2968
2	59.188	19.442	28.382	8.684	3.0965
3	60.448	18.122	31.128	7.384	3.0968
4	60.155	18.422	28.778	8.384	3.2980
5	62.259	18.980	32.107	7.367	3.3277
6	57.380	17.184	30.776	6.666	3.0942
7	56.580	18.186	27.122	7.256	3.1284
9	62.357	18.380	28.224	8.367	3.1788
12	59.270	19.580	29.100	7.429	3.1157
14	61.440	19.380	30.440	8.258	3.1188
15	56.580	18.186	27.186	6.584	3.1112
16	59.680	19.380	32.482	6.666	3.2477
18	60.124	18.380	28.324	8.480	3.1488
19	62.256	18.422	34.119	7.774	3.1422
20	58.380	19.380	29.380	6.484	3.1910
Average	60.112	18.680	31.778	7.259	3.1958
Average of all types	60.760	18.884	31.183	7.777	3.1982

TABLE 25.—PERCENTAGE COMPOSITION OF ENTIRE CARCASSES[1] OF THE FAT PIGS: FIRST EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type B—Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
1	44.81	11.30	30.20	2.01	3 586
2	50.91	11.05	35.34	2.07	4 055
3	50.13	10.86	35.33	1.98	4 034
4	46.71	11.13	32.17	2.11	3 677
5	50.73	11.07	36.01	2.06	4 055
7	48.26	11.15	35.24	1.94	3 917
8	47.05	10.70	33.53	2.08	3 824
9	50.80	11.19	36.40	2.17	4 091
10	45.97	11.16	32.29	2.10	3 733
12	49.14	11.24	34.95	2.05	3 938
15	47.37	10.40	33.78	2.14	3 872
16	48.28	10.99	33.91	2.04	3 864
17	47.86	10.75	34.11	2.13	3 831
18	49.00	10.41	35.01	1.89	4 042
19	49.42	10.53	35.45	1.92	4 017
Average	48.43	10.93	34.25	2.05	3 902
		Type C—Intermediate			
2	49.17	11.40	34.44	1.95	3 893
4	50.19	11.66	34.66	2.23	3 888
5	51.10	11.47	34.84	2.13	3 941
6	51.21	10.77	38.70	1.92	4 234
7	50.46	11.62	34.20	2.09	3 928
8	50.85	10.94	36.73	2.15	4 071
9	51.52	11.38	34.55	2.19	3 972
10	50.83	11.22	36.22	2.20	3 988
11	50.33	11.52	34.86	2.07	3 845
12	49.49	10.69	35.12	2.00	3 971
13	49.90	11.00	34.34	1.98	3 883
15	49.17	11.19	34.87	1.94	3 873
16	49.08	11.07	34.65	2.05	4 017
18	53.29	11.33	38.84	2.10	4 242
19	51.72	11.40	36.94	1.96	4 196
Average	50.55	11.24	35.60	2.06	3 996
		Type D—Rangy			
1	51.27	10.72	37.51	2.19	4 179
2	49.76	11.62	34.84	2.38	3 972
3	48.03	11.58	34.36	2.10	3 824
4	48.34	11.50	33.35	2.40	3 821
5	48.21	11.35	31.91	2.22	3 811
6	48.49	11.20	34.52	2.18	3 902
7	49.02	11.77	32.85	2.34	3 738
9	48.85	11.91	32.25	2.51	3 783
12	50.56	11.53	35.38	2.17	4 022
14	52.95	11.69	36.50	2.16	4 144
15	46.99	11.77	31.79	2.28	3 656
16	50.18	11.68	35.61	2.02	4 084
18	49.28	10.92	35.78	1.97	3 947
19	47.75	12.12	32.53	2.44	3 786
20	48.09	11.64	33.03	2.18	3 852
Average	49.18	11.53	34.15	2.24	3 901
Average of all types	49.39	11.23	34.67	2.12	3 933

[1]On live-weight basis.

TABLE 24.—PERCENTAGE COMPOSITION OF COMPOSITE SAMPLES FROM THE FAT PIGS: FIRST EXPERIMENT

Sample	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
Blood	19.80	17.82	.04	1.22	952
Brains	21.50	10.44	9.69	1.38	1 523
Hair[1]	93.19	83.58	2.49	5.64	4 868
Skin[2]	90.00	37.08	51.85	.35	7 816

[1]On the air-dry basis. This sample includes the toenails. [2]This sample includes the ears and snout.

what fatter on the average than the other types, a distinction evident for all samples except the offal, but the differences are slight and of doubtful significance. The Rangy pigs, because of a slightly larger proportion of bone, contained a higher average percentage of ash in the entire carcass. While this is very probably a significant type difference, it is not important quantitatively.

TABLE 26.—COMPARISON OF THE AVERAGE PERCENTAGE COMPOSITION OF DIFFERENT TYPES OF FAT PIGS AND OF PRINCIPAL ANALYTICAL SAMPLES: FIRST EXPERIMENT

Type	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
			Lean		
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
Chuffy	39.42	16.80	21.00	.87	2 997
Intermediate	43.56	16.61	23.59	.87	3 119
Rangy	41.97	16.46	22.49	.91	3 093
			Fat		
Chuffy	84.24	3.90	78.64	.16	7 585
Intermediate	86.12	3.49	81.10	.14	7 795
Rangy	84.11	3.78	79.92	.15	7 688
			Bone		
Chuffy	60.72	18.73	21.04	19.10	3 118
Intermediate	60.94	18.98	22.48	17.68	3 262
Rangy	60.13	18.80	21.75	17.20	3 195
			Offal		
Chuffy	27.79	11.83	12.83	.82	1 960
Intermediate	27.90	11.79	12.76	.81	1 991
Rangy	27.06	12.18	11.51	.86	1 899
			Entire carcass		
Chuffy	48.43	10.93	34.25	2.05	3 902
Intermediate	50.55	11.24	35.60	2.06	3 996
Rangy	49.18	11.53	34.15	2.24	3 901

The absence of marked type differences in the composition of the carcasses of pigs is very strikingly shown in the case of the dressed carcasses. In Fig. 2 longitudinal sections of three typical carcasses of the Chuffy, Intermediate, and Rangy pigs are pictured. They differ distinctly in appearance and in market finish, but when they are dissected with a knife into lean, fat, and bone and analyzed chemically, no pronounced differences are evident except possibly with respect to

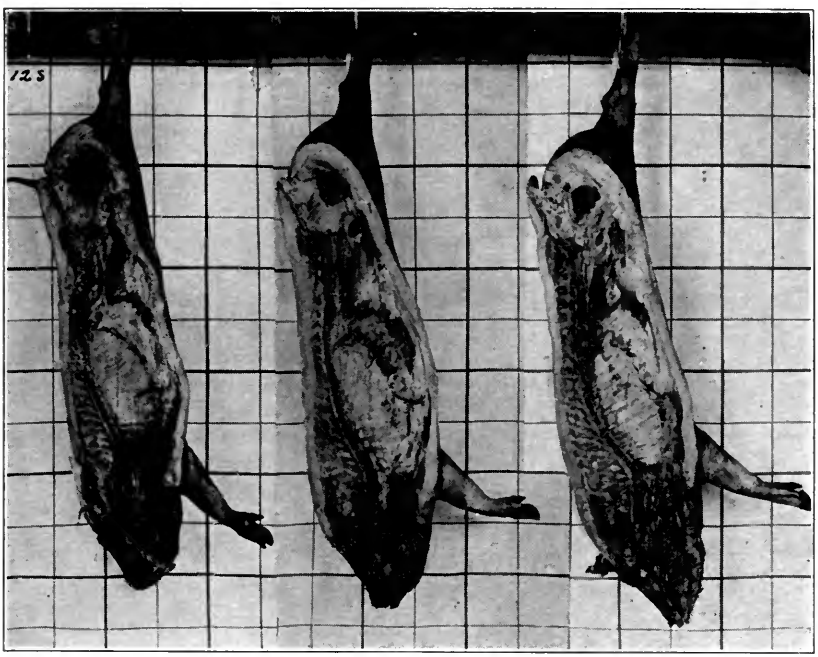

FIG. 2.—REPRESENTATIVE CARCASSES OF CHUFFY, INTERMEDIATE, AND RANGY PIGS SLAUGHTERED AT APPROXIMATELY 225 POUNDS LIVE WEIGHT: FIRST EXPERIMENT

While the pigs of these types differed distinctly in appearance and market finish, the carcasses did not differ much in chemical composition.

the bone and ash content of the Rangy pigs (Tables 27 and 28). Apparently these carcasses differed in their *distribution* of tissues and of nutrients but not in their *content* of them to any but an inappreciable extent.

Composition of Gains. The amounts of organic and inorganic nutrients contained in the carcass of an animal measure the amounts of food nutrients that have been used for growth and fattening;

TABLE 27.—AVERAGE PERCENTAGES OF LEAN, FAT, SKIN, AND BONE IN DRESSED CARCASSES OF THE FAT PIGS: FIRST EXPERIMENT

Type	Average weight of dressed carcass	Lean	Fat	Bone	Skin
	kgs.	*pct.*	*pct.*	*pct.*	*pct.*
Chuffy	71.82	43.45	39.06	12.36	5.13
Intermediate	73.45	44.64	37.00	12.79	5.52
Rangy	73.61	44.92	34.74	14.32	6.01

TABLE 28.—AVERAGE PERCENTAGE COMPOSITION OF DRESSED CARCASSES OF THE FAT PIGS: FIRST EXPERIMENT

Type	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per pound
	pct.	*pct.*	*pct.*	*pct.*	*cals.*
Chuffy	62.31	13.06	45.12	2.73	2 297
Intermediate	64.30	13.34	46.27	2.71	2 319
Rangy	62.19	13.59	44.44	2.93	2 252

hence, they are measures of the requirements of nutrients, for these purposes, from the time of conception to the time of the examination of the carcass, due consideration being given to the interchangeability of foods in metabolism. It follows, therefore, that increases in the amounts of nutrients contained in older, as compared with younger, animals measure the amounts of nutrients used between those ages for growth and concomitant fattening and measure also the corresponding requirements. The composition of the gains put on by growing and fattening animals is a most important and fundamental consideration to a study of their food requirements.

In computing the composition of the gains in weight of the fat pigs during their feeding period some estimate must be made of their composition at the beginning of the experiment. Such an estimate may be made on the assumption that the fat pigs in each type possessed the same composition at their initial weights as the control pigs of that type slaughtered and analyzed at the beginning of the experiment. In Table 29 will be found the estimates of the percentage composition of the gains put on by the fat pigs from initial weights averaging 72 pounds to final weights of 225 pounds.

In this table the pigs in each type have been arranged in the order of decreasing rates of gain during their feeding periods, for the purpose of determining whether the composition of the gains was related to the rate at which they were made. It is conceivable that the slower gains would represent more growth and less fattening than

TABLE 29.—PERCENTAGE COMPOSITION OF GAINS OF THE FAT PIGS: FIRST EXPERIMENT

Pig No.	Average daily gains	Percentage composition of gain				
		Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
Type B—Chuffy						
	lbs.	*pct.*	*pct.*	*pct.*	*pct.*	*sm. cals.*
1	1.22	49.0	11.4	34.4	1.90	4.00
18	1.20	53.6	10.1	40.1	1.72	4.53
4	1.18	50.5	11.2	36.1	2.07	4.03
12	1.18	54.8	11.3	41.0	1.96	4.48
2	1.16	58.2	11.0	42.3	1.97	4.72
17	1.14	53.3	10.5	40.1	2.06	4.35
9	1.13	56.6	11.3	42.3	2.15	4.64
10	1.11	50.7	11.2	37.7	2.01	4.23
16	1.11	53.8	10.9	39.7	1.93	4.39
8	1.08	52.0	10.6	39.0	2.00	4.33
19	1.08	55.8	10.2	42.4	1.74	4.66
5	1.07	56.2	11.1	41.5	1.97	4.55
7	1.06	53.9	11.2	41.7	1.78	4.48
15	1.06	52.0	10.1	39.0	2.09	4.36
3	.75	57.1	10.8	42.3	1.85	4.70
Average	....	53.8	10.9	40.0	1.95	4.43
Type C—Intermediate						
2	1.28	54.1	11.3	39.5	1.84	4.35
9	1.26	58.2	11.3	40.5	2.15	4.55
16	1.26	55.7	10.8	41.6	1.95	4.70
4	1.23	56.1	11.5	40.6	2.18	4.41
11	1.22	58.2	11.5	42.6	1.97	4.51
13	1.20	55.7	10.8	40.0	1.88	4.40
5	1.19	58.0	11.3	41.4	2.04	4.54
12	1.18	55.1	10.2	41.3	1.86	4.53
15	1.18	55.0	11.1	41.0	1.82	4.42
6	1.15	58.1	10.2	46.9	1.72	4.96
8	1.15	57.3	10.6	43.8	2.08	4.69
10	1.13	57.0	11.1	42.6	2.16	4.38
18	1.09	58.5	11.1	44.4	2.01	4.73
19	1.08	59.1	11.3	44.5	1.83	4.91
7	1.07	57.2	11.7	40.5	2.01	4.52
Average	....	56.9	11.1	42.1	1.96	4.57
Type D—Rangy						
16	1.20	56.9	11.6	42.7	1.96	4.76
20	1.20	55.4	11.5	40.5	2.11	4.57
5	1.09	54.6	11.1	38.1	2.17	4.43
2	1.04	56.7	11.6	41.9	2.42	4.64
1	1.02	58.4	10.3	45.3	2.14	4.89
4	1.01	54.1	11.4	39.2	2.43	4.37
12	1.01	59.7	11.4	44.6	2.06	4.88
14	.99	63.6	11.6	46.7	2.41	5.10
7	.97	56.0	11.6	39.7	2.33	4.36
3	.94	53.2	11.3	40.3	2.00	4.34
15	.91	52.1	11.8	36.9	2.19	4.13
19	.90	54.9	12.3	39.7	2.50	4.47
9	.88	56.8	11.9	39.8	2.59	4.51
6	.82	54.7	11.0	41.3	2.14	4.52
18	.76	54.6	10.5	42.0	1.83	4.48
Average	....	56.1	11.4	41.2	2.22	4.56
Average of all types	....	55.6	11.1	41.1	2.04	4.52

the more rapid gains and would contain, therefore, more protein and mineral matter and less fat, dry matter, and energy. A study of the table, however, shows that this was not the case. There appears to be no progressive change in the percentage of any of the analyzed constituents or in the gross energy of the gain per gram with progressively decreasing rates of growth. Also, a comparison of the rates of gain with the composition of the carcasses of the fat pigs reveals no appreciable correlation.

No considerable average differences exist among the three types of pigs in the composition of their gains. A distinct tho slight increase in the percentage of ash in the gains of the Rangy pigs as compared with the other types seems to exist, while the gains of the Chuffy pigs were somewhat more watery and lower in fat and energy than those of the Intermediate type in particular.

The differences, however, are so small that the average composition for the entire 45 pigs may be considered as applying to Poland China pigs in general. It may be said, therefore, that during growth and fattening from about 70 to 225 pounds, pigs of this breed put on gains containing, on the average, 56 percent of dry matter, 11 percent of crude protein (N x 6.0)[1], 41 percent of fat, and 2 percent of mineral matter, and possessing an energy value of 4.5 calories per gram, or 2.1 therms per pound.

Hence it may be computed that for pigs gaining 1 pound a day, the average daily increment in protein would approximate .11 pound, in mineral matter (ash) .021 pound, and in gross energy 2.1 therms. For daily gains of 1.5 pounds per day, representing more nearly the maximum rate of gain, the daily increments would be .17 pound of protein, .031 pound of mineral matter (ash), and 3.1 therms of gross energy.

These figures may be taken to measure the requirements of these nutrients for growth and fattening, tho obviously they cannot be covered by equal amounts of digestible food nutrients unless allowance is made for the losses of the latter in the course of their assimilation. On the assumption that the average biological value of the protein[2] of good farm rations may be taken to be 60, and that the metabolizable energy of feed is utilized to the extent of 75 percent, then it may be computed that for pigs gaining at rates of 1 pound and 1.5 pounds daily the requirements of digestible protein for growth and fattening would approximate .18 and .28 pounds respectively, and the requirements of metabolizable energy 2.8 and 4.1 therms respectively. These requirements are, of course, to be added to the mainte-

[1] If the factor 6.25 is used, the average percentage of crude protein increases from 11.1 to 11.6.

[2] The biological value of a protein is the maximum percentage of the digestible protein that is available for the maintenance and growth of animals.

nance requirements, which would vary with the weight of the animal. The question of the total food requirements of growing pigs will be considered in a later section of the bulletin.

The nutritive ratio of a gain containing .11 pound of protein and 2.1 therms of energy per pound is 1 to 9, and that of the estimated quantities of digestible protein and metabolizable energy required to produce a gain of this character would be 1 to 7.4. Apparently a fairly wide nutritive ratio is consistent with maximum growth.

Distribution of Added Nutrients in the Carcass. Another question of practical significance concerning the growth and fattening of farm animals relates to the distribution of the added nutrients among the different anatomical divisions of the body. From the weights of samples of the control and the fat pigs, and from the percentage composition of these samples, the distribution of nutrients among the more important divisions of the carcass may be computed. Similar computations may also be made relative to the gains in nutrients. The results of such computations for dry matter, crude protein, ash, and gross energy make up Table 30.

In the carcasses of both control and fat pigs the greater part of the dry substance was contained in the lean and fat tissues of the dressed carcass, and this is even more true of the gains of dry substance, of which the edible meat of the dressed carcass contained an average of 74 percent. The crude protein was more evenly distributed thru the carcass, tho of the gain in protein in the fat pigs an average of almost 60 percent (57.7) was added to the boneless meat of the dressed carcass. Seventy-five to 80 percent of the mineral matter in the carcasses was located in the bones, and 80 percent of the mineral matter added during growth was deposited in the skeleton. The lean of the carcass contained 12 to 13 percent of its mineral matter and received over 13 percent of the added minerals. As regards gross energy, even in the control pigs the fatty tissues contained more than any other sample, namely, 35 to 47 percent; in the fat pigs 50 to 53 percent of the total energy content of the carcass was located in the fat sample. Of the gains of energy, 54 percent went to the adipose tissue and over 24 percent to the lean meat on the carcass, a total of 78 percent for the boneless meat of the dressed carcass.

Thus during growth and fattening 74 percent of the increment in dry matter, 58 percent of the increment in protein, 14 percent of the increment in mineral matter, and 78 percent of the increment in gross energy were added to the boneless meat of the carcass, economically the most important part of the animal.

Relation of Feed Consumed Above Maintenance to Gross Energy of Gains. The provisions in the plan of this experiment for the individual feeding of the pigs, for the determination of the maintenance requirements of feed, and for the slaughter and analysis of

TABLE 30.—PERCENTAGE DISTRIBUTION OF DRY SUBSTANCE, CRUDE PROTEIN, ASH, AND GROSS ENERGY AMONG THE MOST IMPORTANT CHEMICAL SAMPLES, FOR THE CONTROL PIGS, THE FAT PIGS, AND THE GAINS PUT ON BY THE FAT PIGS: FIRST EXPERIMENT

Sample	Dry substance			Crude protein			Ash			Gross energy		
	Control pigs	Fat pigs	Gains	Control pigs	Fat pigs	Gains	Control pigs	Fat pigs	Gains	Control pigs	Fat pigs	Gains
Type B—Chuffy												
Fat	40.0	48.2	50.6	10.7	10.0	9.7	2.7	2.1	1.5	46.9	53.4	55.3
Lean	25.4	24.9	24.8	39.2	47.1	50.7	11.5	13.0	13.9	24.7	23.4	23.2
Bone	16.1	10.9	9.3	19.5	14.9	12.8	75.2	78.4	80.3	11.1	7.1	5.8
Skin	6.3	6.7	6.9	9.1	12.3	13.7	1.0	.5	.0	6.3	7.3	7.7
Offal[1]	8.4	7.8	7.7	14.5	9.9	7.9	4.9	3.7	3.6	7.7	7.6	7.4
Type C—Intermediate												
Fat	35.0	45.6	48.0	9.8	8.3	7.6	2.7	1.6	.7	42.0	52.1	54.3
Lean	28.5	27.6	27.4	42.5	47.3	49.1	13.0	13.3	13.1	28.3	25.4	24.8
Bone	17.7	11.0	9.5	19.3	15.5	13.9	75.6	78.7	80.0	12.1	7.6	6.8
Skin	6.2	7.0	7.3	7.8	14.1	16.6	.9	.5	.0	6.3	6.6	6.8
Offal[1]	8 4	7.3	7.0	13.4	9.2	7.5	4.8	3.6	3.4	7.5	7.4	7.4
Type D—Rangy												
Fat	29.0	43.0	46.0	9.4	8.3	7.7	2.3	1.5	.6	35.5	49.6	52.4
Lean	38.0	27.6	25.4	40.8	46.2	48.3	12.3	13.2	13.6	28.0	25.6	25.0
Bone	20.8	12.6	10.8	20.2	16.8	15.5	75.5	79.4	80.9	15.4	8.5	7.1
Skin	7.9	7.9	8.0	9.2	13.7	15.5	1.1	.5	.0	8.3	8.0	8.0
Offal[1]	9.0	7.4	7.1	13.7	9.6	8.2	4.9	3.8	3.7	8.1	7.3	7.1

[1]Including the caul and mesentery fats.

both control and fat pigs render possible a comparison of feed consumed above the estimated maintenance requirements with the composition of the gains put on. The ration fed can be considered liberal in its content of protein and mineral matter and adequate, in all probability, in its content of the necessary vitamins. Hence the amounts required for maintenance were determined by the net energy content of the ration, and the gross energy of the gains put on was determined by the amounts of net energy consumed above the maintenance requirements. On the other hand, the relation of protein and mineral matter consumed to the protein and mineral matter of the gains is not highly significant even if a maintenance requirement of protein and minerals be deducted from the intakes since it is probable that in all cases an excess of these nutrients was consumed.

The utilization of the feed consumed, or of the feed energy consumed, would be best expressed by relating it to the sum of (1) the energy expended in life and activity and (2) the energy stored during growth and fattening. Unfortunately the data secured in this experiment do not permit an expression of these two factors in terms of energy or in any common terms. Hence the two cannot be summated. An alternative method of procedure is to determine the energy expense of the pigs in terms of feed, as was done in the maintenance experiments, deduct the estimated feed used for this purpose from the total feed consumed, and relate the excess feed to the gross energy of the gains secured.

This method assumes, somewhat gratuitously, not only that the basal metabolism and the activity of the maintenance pigs per unit of weight was equal to that of the fattening pigs, but also that the utilization of feed energy for these purposes is not affected by the level of feeding, that is, by the feed consumption per unit of weight. Admittedly no evidence can be offered for the essential correctness of either assumption; in fact there are good reasons for believing that the latter assumption is not true, tho how greatly it diverges from the truth cannot at present be said. However, since this method is the only one that can be used under the prevailing circumstances, it has been applied to the data at hand in Tables 31, 32, and 33.

The logic of the method can probably be best explained by following the calculations for one pig. Pig 1 of the Chuffy type in 129 days of feeding increased in weight from 73 to 230 pounds, making a total gain of 157 pounds, this gain containing 284 therms of gross energy. The total feed consumption was 632 pounds. The estimate of the amount of feed used for maintenance is based on three values: (1) the average weight of the pig during the feeding period, 143 pounds, obtained by averaging all of the weekly weights; (2) the average daily feed requirement per 100 pounds live weight (weight ratio), 1.41 pounds, obtained by averaging the type averages for the two

TABLE 31.—NET ENERGY COMPUTATIONS FOR TYPE B, CHUFFY PIGS: FIRST EXPERIMENT

Pig No.	1	2	3	4	5	7	8	9	10	12	15	16	17	18	19
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Final weight	230	225	218	220	225	224	223	223	228	220	217	223	232	229	231
Initial weight	73	75	72	59	62	72	68	61	76	68	65	71	76	65	77
Gain	157	150	146	161	163	152	155	162	152	152	152	152	156	164	154
Average weight	143	141	113	124	128	139	129	126	135	131	129	130	138	130	139
Days on experiment	(129)	(129)	(194)	(137)	(151)	(143)	(143)	(143)	(137)	(129)	(143)	(137)	(137)	(137)	(143)
Maintenance feed per day															
Per 100 pounds	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41
Per head	2.02	1.99	1.59	1.75	1.80	1.96	1.82	1.78	1.90	1.85	1.82	1.83	1.95	1.83	1.96
Total feed	632	577	703	587	596	621	580	602	589	595	582	568	587	607	610
Total feed for maintenance	261	257	308	240	272	280	260	255	260	239	260	251	267	251	280
Total feed consumed above maintenance	371	320	395	347	324	341	320	347	329	356	322	317	320	356	330
	therms	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*
Gross energy of gains	284	321	310	294	337	309	303	339	292	309	301	303	309	340	326
Net energy of feed per 100 pounds	77	100	78	85	104	91	95	98	89	87	93	96	97	96	99

TABLE 32.—NET ENERGY COMPUTATIONS FOR TYPE C, INTERMEDIATE PIGS: FIRST EXPERIMENT

Pig No.	2	4	5	6	7	8	9	10	11	12	13	15	16	18	19
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Final weight	230	224	230	226	225	222	221	219	230	226	230	230	230	224	218
Initial weight	55	65	67	69	63	64	59	57	72	64	59	61	68	51	63
Gain	175	159	163	157	162	158	162	162	158	162	171	169	162	173	155
Average weight	125	132	133	135	132	130	127	119	138	126	130	132	133	122	128
Days on experiment	(137)	(120)	(137)	(137)	(151)	(137)	(120)	(143)	(120)	(137)	(132)	(135)	(120)	(158)	(143)
Maintenance feed per day															
Per 100 pounds	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Per head	1.51	1.60	1.61	1.63	1.60	1.57	1.54	1.44	1.67	1.52	1.57	1.60	1.61	1.43	1.55
Total feed	577	505	606	597	632	573	570	619	585	586	595	630	574	724	575
Total feed for maintenance	207	206	221	223	242	215	190	206	215	208	225	229	208	234	222
Total feed consumed above maintenance	370	359	385	374	390	358	371	413	370	358	370	410	366	490	354
	therms	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*
Gross energy of gain	344	322	330	357	330	338	332	320	320	335	339	336	343	374	344
Net energy of feed per 100 pounds	93	91	87	95	85	94	89	77	86	94	92	82	94	76	97

TABLE 33.—NET ENERGY COMPUTATIONS FOR TYPE D, RANDY PIGS: FIRST EXPERIMENT

Pig No.	1	2	3	4	5	6	7	9	12	14	15	16	18	19	20
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Final weight	210	225	226	232	220	230	230	222	223	224	228	225	224	210	221
Initial weight	58	59	58	57	64	59	60	70	70	74	52	60	56	63	66
Gain	101	104	108	175	105	171	107	152	153	150	176	165	108	156	155
Average weight	124	133	121	194	128	115	130	137	125	125	114	120	113	122	126
Days on experiment	(158)	(158)	(179)	(178)	(151)	(208)	(173)	(178)	(151)	(151)	(194)	(187)	(220)	(178)	(190)
Maintenance feed per day															
For 100 pounds	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31
For feed	1.69	1.74	1.59	1.69	1.61	1.51	1.82	1.79	1.64	1.64	1.49	1.57	1.48	1.60	1.65
Total feed	931	953	983	998	899	709	909	935	858	889	705	904	791	927	955
Total feed for maintenance	905	975	985	980	943	814	815	810	948	948	980	915	920	977	918
Total feed consumed above maintenance	378	378	398	388	426	395	375	325	410	334	476	380	465	350	342
	therms	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*
Gross energy of gain	357	343	334	345	332	348	331	311	337	317	320	357	315	313	320
Net energy of feed per 100 pounds	91	91	84	80	78	88	88	96	82	101	68	93	71	89	94

groups of maintenance pigs (see Tables 18 and 19) and (3) the number of days on experiment, 129. For this pig the average daily maintenance requirement is thus estimated at 2.02 pounds of feed and the total at 261 pounds. Hence the amount of feed consumed above maintenance was 632 — 261 = 371 pounds. Since this amount of excess feed produced a gain of 284 therms of energy in the form of body substance, the net energy of the feed per 100 pounds is equal to 284 ÷ 3.71 = 77 therms.

For the 15 Chuffy pigs the average net energy value of the feed was 92.3 therms per 100 pounds, for the Intermediate pigs it was 88.7 therms, and for the Rangy pigs, 87.4 therms. However, the average differences between types cannot be considered significant in view of the rather wide range of the individual estimates within each type. The average for the 45 pigs was 89.5 therms per 100 pounds of feed.

A net energy value of 89.5 therms per 100 pounds is much lower than would be expected from Armsby's[2] estimates of the net energy values of corn, tankage, and middlings for pigs. The average ration consumed by these pigs contained 76 percent of corn, 8 percent of tankage, and 16 percent of wheat middlings. Taking Armsby's values of 129 therms per 100 pounds for corn, 109 therms for tankage, and 104 therms for middlings, the net energy value of the ration should be 116.6 therms per 100 pounds instead of 89.5 therms, as computed from the results of this experiment. A discussion of this difference will be reserved until the results of the next year's experiment are considered.

SECOND EXPERIMENT

The chemical work in the second year's experiment (1923-24) was concerned with the Very Chuffy type of Poland China pig (Type A), the Intermediate type (Type C), and the Rangy type (Type D). All the pigs were farrowed in March except a very small minority which were farrowed in late February.

COMPOSITION OF THE CONTROL PIGS

Since the Very Chuffy pigs were to be started on experimental feeding as they individually reached a weight of approximately 55 pounds, and the Intermediate and Rangy pigs as they reached an approximate weight of 70 pounds, the control pigs of the three types were slaughtered for analysis at approximately these weights. Five pigs of the Rangy type were slaughtered on July 3, five of the Intermediate type on July 10, and five of the Very Chuffy type on July 17.

In order to reduce as far as practicable the amount of analytical work in this experiment, all pigs analyzed were divided into two samples. On the day of slaughter the dressed carcass was prepared

[2] Armsby, H. P. The nutrition of farm animals. Page 7. 1917.

TABLE 34.—LIVE WEIGHTS AND EMPTY WEIGHTS OF THE CONTROL PIGS, AND WEIGHTS AND PERCENTAGES OF "FILL" : SECOND EXPERIMENT

Pig No.[1]	Live weight	Weight of contents of alimentary tract	Empty weight		Contents of alimentary tract in percent of live weight
Type A—Very Chuffy					
	lbs.	*lbs.*	*lbs.*	*lbs.*	
21	77.4	26.1	4.7	72.8	24.0	6.1
22	77.6	26.1	7.3	72.3	25.7	9.1
23	70.7	23.0	4.6	66.1	20.9	6.1
24	53.4	24.2	4.1	49.3	22.3	7.7
25	49.0	22.2	2.6	46.4	21.1	5.2
Average	58.6	24.3	4.2	49.4	22.4	7.9
Type C—Intermediate						
3	67.0	30.2	4.3	62.0	28.1	6.8
21	70.9	32.2	3.7	67.3	30.5	5.1
22	71.1	32.2	6.3	64.8	29.4	8.9
23	68.9	30.2	5.2	63.7	28.9	7.6
24	75.6	34.3	8.6	66.9	30.4	11.4
Average	70.6	32.0	5.7	64.9	29.4	8.0
Type D—Rangy						
21	69.3	32.4	2.9	66.3	30.1	4.3
22	73.5	33.3	5.9	67.6	30.7	8.0
23	70.7	32.5	4.6	72.3	32.8	5.7
24	68.8	31.2	5.4	63.4	28.8	7.8
25	74.7	33.9	5.6	69.2	32.6	7.6
Average	72.6	32.9	4.8	67.8	30.7	6.7

[1]The sex of these pigs was not recorded.

NOTE.—The Type A pigs were slaughtered on July 17, the Type B pigs on July 10, and the Type D pigs on July 7.

in the usual way, divided into halves, weighed, and taken to the refrigerator. The remainder of the carcass, with the exception of the hair, scurf, and toenails, was weighed, ground, sampled, and analyzed together. This was called the "offal sample" and consisted mainly of the blood and viscera.

When the carcass had been chilled for several days, both halves were reweighed to determine the shrink in storage, and the right half was divided by knife into skin, lean, fat, and bone. Each of these divisions was weighed and ground separately, after which identical convenient aliquots from each were composited into one sample for analysis.

The average dry weight of hair, scurf, and toenails from a number of animals in each slaughter weight was determined, and by applying

TABLE 35.—WEIGHTS OF PARTS OF CARCASSES OF THE CONTROL PIGS: SECOND EXPERIMENT

Pig No.	Live weight	Offal	Dressed carcass				
			Lean	Fat	Skin	Bone	Total
Type A—Very Chuffy							
	kgs	kgs	kgs	kgs	kgs	kgs	kgs
21	26.1	4.88	8.82	4.32	1.36	2.90	17.40
22	25.1	5.08	8.40	3.76	1.24	3.22	16.62
23	23.0	5.22	6.84	3.08	1.32	2.82	14.06
24	24.2	5.20	7.12	4.74	.96	2.78	15.60
25	22.2	4.55	7.78	3.18	1.24	2.94	15.14
Average	24.3	4.99	7.80	3.82	1.22	2.94	15.76
Average in percent	....	....	(49.5)	(24.2)	(7.7)	(18.7)	(100.0)
Type C—Intermediate							
3	30.2	6.18	9.16	6.22	1.58	3.78	20.74
21	32.2	5.75	10.36	6.98	1.46	3.84	22.64
22	32.2	6.52	10.08	6.46	1.70	3.76	22.00
23	31.3	6.30	9.72	5.70	1.62	3.66	20.70
24	34.3	6.38	9.98	6.40	1.66	4.06	22.10
Average	32.0	6.23	9.86	6.36	1.60	3.82	21.64
Average in percent	....	....	(45.6)	(29.4)	(7.4)	(17.7)	(100.0)
Type D—Rangy							
21	31.4	6.01	10.66	6.18	1.84	3.94	22.62
22	33.3	6.66	11.60	5.28	1.76	4.56	23.20
23	34.8	6.45	12.30	5.46	2.10	4.58	24.44
24	31.2	5.42	11.84	3.60	1.80	4.20	21.44
25	33.9	6.19	10.64	6.42	1.96	4.10	23.12
Average	32.9	6.15	11.40	5.40	1.90	4.28	22.96
Average in percent	....	....	(49.7)	(23.5)	(8.3)	(18.6)	(100.0)

average analyses to this material, obtained in the experiment of the preceding year, the weights of nutrients per pig were estimated.

The above general description of the preparation of samples in the second experiment apply to the handling of the control pigs except for a further simplification. Instead of analyzing the offal samples individually, they were composited for each type.

The slaughter weights of each of the control pigs and the weights and percentages of "fill" are collected in Table 34. The contents of

TABLE 36.—PERCENTAGE COMPOSITION OF DRESSED CARCASSES OF THE CONTROL PIGS: SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
			Type A—Very Chuffy		
	pct.	*pct.*	*pct.*	*pct.*	*cal.*
21	48.20	14.64	28.24	3.16	3 452
22	45.39	14.82	25.98	3.31	3 292
23	50.12	12.78	33.04	3.47	3 822
24	50.19	12.72	31.19	3.23	3 843
25	40.85	14.58	22.80	3.33	2 910
Average	46.95	13.91	28.25	3.30	3 464
			Type C—Intermediate		
3	49.84	12.66	33.07	2.94	3 805
21	51.40	12.66	33.58	2.77	3 983
22	50.56	12.36	33.15	2.85	3 615
23	41.94	12.54	23.00	3.15	2 989
24	48.79	13.56	32.02	3.40	3 734
Average	48.51	12.76	30.96	3.02	3 625
			Type D—Rangy		
21	49.77	12.78	33.84	3.15	3 916
22	55.58	13.08	33.00	3.24	3 930
23	47.08	12.60	30.49	2.91	3 550
24	43.72	14.58	24.04	3.42	3 177
25	52.30	12.00	35.98	3.27	4 187
Average	49.69	13.01	31.47	3.20	3 752
Average of all types	48.38	13.23	30.23	3.17	3 614

the alimentary tract represent a fast of approximately 18 hours. The average percentage "fill" for all the control pigs was 7.5.

From the percentages of separated fat in the dressed carcass (Table 35) it appears that the pigs of the Intermediate type were in the best condition at the beginning of the experiment. The percentages of lean, fat, skin, and bone were surprisingly similar for the Very Chuffy and Rangy pigs.

The results of the chemical analysis of the dressed carcasses for the pigs of the different types (Table 36) do not indicate any considerable differences in fat content. According to these values the Very Chuffy pigs were in general the least fat and the highest in protein and ash. With these samples, as with all others in the two type experiments, the gross energy was determined directly in the bomb calorimeter.

The chemical analyses of the composite offal samples for the three types of control pigs are given in Table 37.

TABLE 37.—PERCENTAGE COMPOSITION OF COMPOSITE OFFAL SAMPLES FROM THE CONTROL PIGS: SECOND EXPERIMENT

Type	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
Chuffy	24.36	12.84	6.63	1.00	1 440
Intermediate	28.26	13.02	8.23	.91	1 609
Rangy	23.82	13.14	7.41	.92	1 551

The total amounts of nutrients found in all samples from the control pigs have been expressed in Table 38 as percentages of the live weights of the pigs. The average percentages for the different types given in this table have been used in later computations of the initial composition of the pigs slaughtered at larger weights in arriving at estimates of the composition of the gains put on.

TABLE 38.—PERCENTAGE COMPOSITION AND ENERGY CONTENT OF THE LIVE CONTROL PIGS: SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
			Type A—Very Chuffy		
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
21	37.31	12.71	20.08	2.34	2 603
22	34.16	12.41	17.85	2.34	2 404
23	36.80	11.31	21.75	2.39	2 696
24	38.17	11.48	21.52	2.31	2 816
25	33.42	13.14	16.87	2.52	2 309
Average	35.97	12.21	19.61	2.38	2 566
			Type C—Intermediate		
3	40.62	11.84	24.44	2.25	2 973
21	41.73	11.69	25.09	2.15	3 117
22	40.71	11.51	24.29	2.17	2 818
23	33.99	11.40	16.90	2.30	2 331
24	37.18	11.58	22.21	2.39	2 732
Average	38.85	11.60	22.59	2.25	2 794
			Type D—Rangy		
21	40.94	12.19	25.79	2.48	3 145
22	43.94	12.18	24.45	2.46	3 071
23	38.00	11.73	22.79	2.24	2 807
24	34.73	12.80	17.80	2.53	2 482
25	40.51	11.01	25.91	2.45	3 166
Average	39.62	11.98	23.35	2.43	2 934
Average of all types	38.15	11.93	21.85	2.35	2 765

The average composition of the live control pigs was: dry substance, 38.15 percent; crude protein, 11.93 percent; fat, 21.85 percent; ash, 2.35 percent; and gross energy, 2.76 calories per gram. Allowing an average "fill" of 7.49 percent would place the average water content at 54.36 percent. The average composition, on the basis of the empty weight, would be: water, 58.76; crude protein, 12.90; fat, 23.62; ash, 2.54; and gross energy, 3.00 calories per gram.

The control pigs in this experiment contained somewhat more fat than those of the preceding year, 21.85 as compared with 18.69 percent. On the fat-free, live-weight basis the averages for the two years were as follows:

	Dry substance *percent*	Protein *percent*	Ash *percent*
Control pigs of first experiment	18.83	14.28	2.80
Control pigs of second experiment	20.86	15.27	3.01

THE MAINTENANCE EXPERIMENTS

Maintenance trials were run on a number of pigs in each of the three types at the initial weight of 55 to 70 pounds and at the market weight of 225 pounds. In addition to the feeding experiments to determine the amount of feed required for the maintenance of weight, digestion trials were run upon some of the pigs in each of the two maintenance groups. Besides the ordinary determinations on feed and feces, these digestion trials included gross energy determinations upon feed, feces, and urine, permitting the estimation of the metabolizable energy of the ration.

Since the maintenance experiments were planned only with reference to estimations of the feed utilization of the 225-pound fat pigs, the maintenance pigs were fed a ration approximating closely in composition the average ration that these fat pigs consumed during their fattening period. This average ration contained 78.5 percent of shelled corn, 6.6 percent of tankage, 13.2 percent of wheat middlings, and 1.7 percent of alfalfa meal. The corn was fed whole and the other constituents as a ground mixture. The average percentage composition of the feeds used thru the maintenance and fattening periods of the second experiment is summarized in Table 39.

The young maintenance pigs of the Very Chuffy type received daily 6.5 ounces of whole corn and 1.5 ounces of a mixture containing 8 parts of middlings, 4 of tankage, and 1 of alfalfa meal. The Intermediate and Rangy pigs averaging somewhat larger in weight, received daily 7 ounces of corn and 2 ounces of the mixture. The fat maintenance pigs received varying amounts of corn and the same mixture, averaging closely 4 parts of the former to 1 of the latter.

It was hoped that the maintenance feeding could continue until each pig was at constant weight on constant feed for eight weeks.

TABLE 39.—AVERAGE CHEMICAL COMPOSITION OF FEEDS USED THRUOUT THE SECOND EXPERIMENT

Feed	Dry substance	Crude protein	N-free extract	Crude fiber	Fat	Ash	Gross energy	
							Per 100 pounds	Per gram
	pct.	*pct.*	*pct.*	*pct.*	*pct.*	*pct.*	*therms*	*sm. cals.*
Corn	84.68	8.86	70.07	2.76	1.65	1.34	169.14	3 729
Tankage	89.87	56.13	5.69	2.86	4.51	20.68	178.31	3 931
Middlings	87.18	16.13	59.62	4.70	2.83	3.90	180.03	3 969
Alfalfa meal	85.72	15.58	31.67	28.18	1.29	9.00	175.36	3 866

With the larger pigs, whose maintenance feeding started in December and continued into March, this ideal was realized; but with the younger maintenance pigs, whose feeding started July 21 and in some

TABLE 40.—AVERAGE FEEDING RESULTS OF THE MAINTENANCE TRIALS ON THE YOUNG PIGS: SECOND EXPERIMENT

Pig No. and sex[1]	Initial body weight	Maintenance body weight	Average daily feed	Feed per 100 pounds body weight[2]
Type A—Very Chuffy				
	lbs.	*lbs.*	*lbs.*	*lbs.*
1b	54	47	.500	1.06
2s	52	44.5	.500	1.12
3s	54	43	.500	1.16
4—	56	44	.500	1.14
5—	55	44	.500	1.14
Average	54	44.5	.500	1.12
Type C—Intermediate				
6s	75	62	.562	.91
7b	79	62	.562	.91
8s	72	61	.562	.92
9s	73	60	.562	.94
10—	71	60	.562	.94
Average	74	61	.562	.92
Type D—Rangy				
11s	68	58	.562	.97
12b	69	57	.562	.99
13s	69	58	.562	.97
14b	73	59	.562	.95
15b	71	58	.562	.97
Average	70	58	.562	.97

[1]s = sow; b = barrow. [2]Computed by the simple weight ratio.

TABLE 41.—AVERAGE FEEDING RESULTS OF THE MAINTENANCE TRIAL ON THE FAT PIGS: SECOND EXPERIMENT

Pig No. and sex	Initial body weight	Maintenance body weight	Average daily feed	Feed per 100 pounds body weight[1]
	Type A—Very Chuffy			
	lbs.	*lbs.*	*lbs.*	*lbs.*
10s	217	211	2.20	1.04
12—	242	239	2.50	1.05
14b	221	218	2.26	1.04
Average	240	233	2.32	1.04
	Type C—Intermediate			
6—	223	228	2.23	.98
8b	260	263	2.64	1.00
11—	240	242	2.40	.99
14b	241	237	2.56	1.08
Average	241	242	2.46	1.01
	Type D—Rangy			
4b	269	268	2.76	1.03
7s	229	226	2.42	1.07
12—	243	241	2.43	1.01
18b	218	219	2.28	1.04
19b	256	250	2.63	1.05
Average	243	241	2.50	1.04

[1]Computed by the simple weight ratio.

cases as late as August 25, it was found that in October, when the weather became cold and an epidemic of respiratory infection involved practically all the pigs, their weights decreased on amounts of feed sufficient for maintenance during the warmer season. Hence for some of these pigs constant weight was maintained for only four or five weeks.

The average data for the two maintenance feeding trials are given in Tables 40 and 41.

The results of these feeding trials indicate, in agreement with the results obtained the preceding year, that the Intermediate-type pigs required less feed for the maintenance of body weight than did the pigs of the other types, probably because of a smaller degree of activity. The pigs of the Rangy type rank next in this respect, while the Very Chuffy pigs, like the Chuffy pigs of the preceding year, were the least economical.

Changes in Composition of Young Maintenance Pigs. Feeding trials alone, however, cannot give reliable information of maintenance energy requirements because, altho body weight is maintained, the

energy stored in the body may be considerably diminished. In the first experiment information on this point was obtained by slaughtering the maintenance pigs at the end of their period of experimental feeding and examining the carcasses by chemical methods. A comparison of the composition of these carcasses with that of the control pigs revealed surprisingly large losses of energy during the period of maintenance feeding. The maintenance trials of the second experiment were also planned to include such examinations of the carcasses of the maintenance pigs, but unfortunately it was not found to be expedient to carry out this work on the young maintenance pigs because of the prevalence of respiratory infection during October. Their feeding trials, therefore, altho remarkably uniform in the results obtained, cannot be used in the estimation of the true maintenance requirements. Attention may be called, however, to the remarkably good agreement between the results shown in Table 40 and those given in Table 7, relating to the young maintenance pigs of the preceding experiment.

Changes in Composition of Fat Maintenance Pigs. The 225-pound maintenance pigs were slaughtered and analyzed according to the routine explained above as applying to all pigs in the second ex-

TABLE 42.—LIVE WEIGHTS AND EMPTY WEIGHTS OF THE FAT MAINTENANCE PIGS AND WEIGHTS OF FILL: SECOND EXPERIMENT

Pig No.	Live weight		Weight of fill	Empty weight		Percent of fill
			Type A—Very Chuffy			
	lbs.	*kgs.*	*lbs.*	*lbs.*	*kgs.*	
10	209.4	95.0	4.0	205.4	93.2	1.9
14	214.2	97.2	5.7	208.5	94.6	2.7
Average	211.8	96.1	4.9	207.0	93.9	2.3
			Type C—Intermediate			
6	234.6	106.4	4.7	229.9	104.3	2.0
8	258.1	117.1	3.5	254.6	115.5	1.4
11	243.7	110.5	7.0	236.7	107.4	2.9
14	238.3	108.1	8.7	229.6	104.1	3.7
Average	243.7	110.5	6.0	237.7	107.8	2.5
			Type D—Rangy			
4	270.8	122.8	7.5	263.3	119.4	2.8
7	227.6	103.2	9.7	217.9	98.8	4.2
12	236.4	107.2	12.0	224.4	101.8	5.1
18	214.1	97.1	6.1	208.0	94.3	2.8
19	251.6	114.1	8.7	242.9	110.2	3.5
Average	240.1	108.9	8.8	231.3	104.9	3.7

TABLE 43.—WEIGHTS OF PARTS OF CARCASSES OF THE FAT MAINTENANCE PIGS: SECOND EXPERIMENT

Pig No.	Offal	Dressed carcass				
		Lean	Fat	Skin	Bone	Total
Type A—Very Chuffy						
	kgs.	*kgs.*	*kgs.*	*kgs.*	*kgs.*	*kgs.*
10	9.37	38.88	25.80	3.54	8.00	76.22
14	10.03	39.72	28.54	3.84	9.74	81.84
Average	9.70	39.30	27.18	3.70	8.88	79.04
Average in percent	.....	(49.7)	(34.4)	(4.7)	(11.2)	(100.00)
Type C—Intermediate						
6	11.59	40.36	31.92	4.02	8.82	85.12
8	11.48	47.60	34.68	4.14	11.56	97.98
11	12.16	44.26	32.78	3.84	10.64	91.52
14	11.91	41.12	28.14	6.18	12.58	88.02
Average	11.79	43.34	31.88	4.54	10.90	90.66
Average in percent	.....	(47.8)	(35.2)	(5.1)	(12.0)	(100.00)
Type D—Rangy						
4	11.76	49.28	24.76	5.14	12.66	91.84
7	11.12	45.60	19.34	5.98	12.94	83.86
12	13.09	41.92	28.46	4.22	11.08	85.68
18	10.86	36.40	28.96	4.18	10.44	79.98
19	13.06	48.24	28.96	5.74	12.72	95.66
Average	11.98	44.28	26.10	5.06	11.96	87.40
Average in percent	.....	(50.7)	(29.9)	(5.8)	(13.7)	(100.00)

periment. The essential weights and chemical data are given in Tables 42 to 46. Because of their relative insignificance, only the average analyses of the offal samples for the three types of pigs are reported.

The marked difference in "fill" between the fat pigs weighing about 225 pounds that were taken directly from full feed and those that were taken from a maintenance ration is of interest. The average fill of the full-fed pigs was 12.1 pounds and for the maintenance pigs, 7.1 pounds.

A comparison of the percentage composition of the 225-pound pigs killed at the end of their fattening period and those killed after a maintenance period of two or three months does not reveal the large differences noted in the preceding year. For convenience of study the average composition of the dressed carcass, offal, and entire body of the three types and the two groups of pigs are summarized in Table 47.

TABLE 44.—PERCENTAGE COMPOSITION AND ENERGY CONTENT OF DRESSED CARCASSES OF THE FAT MAINTENANCE PIGS:[1] SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type A—Very Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
10	61.13	13.02	41.09	3.15	4 469
14	59.40	11.88	44.48	2.83	4 810
Average	60.26	12.45	42.79	2.99	4 640
		Type C—Intermediate			
6	61.69	11.16	47.51	2.88	5 015
8	59.13	12.06	43.88	2.93	4 774
11	61.00	11.64	45.76	2.74	5 809
14	56.11	12.66	40.10	3.28	4 433
Average	59.48	11.88	44.31	2.96	4 758
		Type D—Rangy			
4	57.62	12.84	40.92	3.29	4 444
7	51.91	13.20	33.97	3.76	3 929
12	57.34	11.94	41.64	3.12	4 713
18	61.89	11.82	46.50	2.66	4 998
19	55.98	12.42	40.33	3.05	4 334
Average	56.95	12.44	40.67	3.18	4 484

[1]Corrected.

Except for a general increase in the ash content and a prevailing increase in protein, the composition of the fat maintenance pigs was quite similar to that of the fat pigs. In particular this similarity holds for the gross energy content, the differences indicated in the table being such as would be expected from the statistical "error of sampling" alone.

Possibly a partial explanation of the absence of marked differences in the fat and energy content of the fat maintenance pigs and of the fat pigs weighing 225 pounds may be found in the fact that in several cases the maintenance pigs were not put upon the maintenance ration

TABLE 45.—AVERAGE PERCENTAGE COMPOSITION OF OFFAL SAMPLES OF THE FAT MAINTENANCE PIGS: SECOND EXPERIMENT

	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
Type A	30.37	13.14	14.62	1.00	2 289
Type C	34.15	12.66	18.97	.83	2 573
Type D	33.37	12.47	18.45	.96	2 393

TABLE 46.—PERCENTAGE COMPOSITION OF THE FAT MAINTENANCE PIGS, ON LIVE-WEIGHT BASIS: SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type A—Very Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
10	51.87	11.88	34.09	2.63	3 782
14	53.61	11.48	39.29	2.51	4 331
Average	52.74	11.68	36.69	2.57	4 057
		Type C—Intermediate			
6	53.05	10.41	39.85	2.40	4 277
8	52.62	11.48	38.33	2.54	4 228
11	55.21	11.06	40.86	2.37	4 347
14	49.29	11.89	34.36	2.78	3 875
Average	52.54	11.21	38.35	2.52	4 182
		Type D—Rangy			
4	46.28	10.90	32.14	2.56	3 539
7	45.59	12.30	29.07	3.18	3 428
12	50.29	11.09	35.84	2.62	4 090
18	55.25	11.16	41.05	2.32	4 444
19	50.73	11.94	35.77	2.66	3 890
Average	49.63	11.48	34.77	2.67	3 878

at the end of their fattening period; with some pigs several weeks intervened. In this interim considerable weight was put on, particularly by Pig 8 of the Intermediate type and Pigs 4 and 19 of the Rangy type and to a less extent by Pigs 11 and 14 of the Intermediate type and Pig 12 of the Rangy type. In these cases, therefore, it is questionable whether comparison with the 225-pound fat pigs is significant.

Estimates of Feed Required for Maintenance. Correction of the feed records of the fat maintenance pigs for the indicated changes in the energy content of their bodies (Table 47) in a manner similar to that used for the maintenance pigs of the preceding experiment (Table 19) yields the estimates in Table 48. The average daily feed requirements per 100 pounds body weight for the three types were 1.11, .93, and .95 pounds respectively, as compared with 1.21, .98, and 1.23 pounds for the Chuffy, Intermediate, and Rangy pigs in the preceding experiment (Table 19). Considering the Very Chuffy and Chuffy types as comparable in their feed requirements per unit of weight, the agreement between the two experiments is good except for the Rangy type. The fact that the computations for the Rangy pigs from the data of the second experiment may be faulty, as explained

TABLE 47.—COMPARISON OF AVERAGE PERCENTAGE COMPOSITION OF THE 225-POUND FAT PIGS AND OF THE FAT MAINTENANCE PIGS: SECOND EXPERIMENT

	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
			Type A—Very Chuffy		
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
Dressed carcass					
Fat pigs	62.24	9.93	49.21	2.21	4 956
Maintenance pigs	60.26	12.45	42.79	2.99	4 640
Offal					
Fat pigs	31.50	12.45	15.41	.83	2 288
Maintenance pigs	30.37	13.14	14.62	1.00	2 289
Live pig					
Fat pigs	51.59	9.37	39.40	1.80	4 070
Maintenance pigs	52.74	11.68	36.69	2.57	4 057
			Type C—Intermediate		
Dressed carcass					
Fat pigs	60.64	11.60	45.10	2.72	4 830
Maintenance pigs	59.48	11.88	44.31	2.96	4 758
Offal					
Fat pigs	31.51	12.53	16.22	.89	2 253
Maintenance pigs	34.15	12.66	18.97	.83	2 573
Live pig					
Fat pigs	51.39	10.89	37.09	2.24	4 053
Maintenance pigs	52.54	11.21	38.35	2.52	4 182
			Type D—Rangy		
Dressed carcass					
Fat pigs	55.94	12.32	40.23	2.73	4 422
Maintenance pigs	56.95	12.44	40.67	3.18	4 484
Offal					
Fat pigs	29.10	12.98	14.42	.91	2 083
Maintenance pigs	33.37	12.47	18.85	.96	2 393
Live pig					
Fat pigs	47.45	11.57	33.00	2.24	3 710
Maintenance pigs	49.63	11.48	34.77	2.67	3 878

above, may account for this discrepancy. Also the fact that in this experiment only two of the fat maintenance pigs of the Very Chuffy type were slaughtered[1] detracts from the significance of the average estimate of this type.

It seems evident, therefore, that the maintenance experiments of the second type were much less successful than those of the first year.

[1] Pig 12 of the Very Chuffy type became sick, lost in weight, and was removed from the experiment.

TABLE 48.—CORRECTED FEED REQUIREMENTS OF THE FAT MAINTENANCE PIGS: SECOND EXPERIMENT

Pig No.	Initial weight	Average weight	Initial energy content	Final energy content	Loss of energy	Total feed eaten	Feed equivalent of energy loss[1]	Maintenance period	Maintenance feed per day	
									Total	Per 100 pounds body weight[2]
Type A—Very Chuffy										
	lbs.	*lbs.*	*therms*	*therms*	*therms*	*lbs.*	*lbs.*	*days*	*lbs.*	*lbs.*
10	217	212	400	359	41	145	31	66	2.67	1.26
14	221	218	408	421	−13	149	10	66	2.11	.97
Average	...	215	404	390	14	...	...	...	...	1.11
Type C—Intermediate										
6	223	228	410	455	−45	194	34	87	1.84	.81
8	260	262	478	495	−17	230	13	87	2.49	.95
11	240	242	439	480	−41	132	31	55	1.84	.76
14	241	237	443	419	24	187	18	73	2.81	1.19
Average	...	242	442	462	−20	...	...	...	...	.93
Type D—Rangy										
4	269	268	453	435	18	240	14	87	2.60	.97
7	229	226	385	354	31	177	23	73	2.74	1.21
12	243	241	409	438	−29	134	22	55	2.00	.83
18	218	219	367	431	−64	166	48	73	1.62	.74
19	256	250	427	444	−17	192	13	73	2.45	.98
Average	...	241	408	420	−12	...	...	...	...	.95

[1]Assuming that the metabolizable energy of the ration, 1,331 calories per pound, is completely utilizable. [2]Using the ratio of body weights.

Since the rations of the two series of experiments were quite similar, the estimates of the feed requirements for maintenance obtained in the first year's work, rather than the incomplete maintenance estimates of the second year, will be used in computations of the utilization of feed energy by the fat pigs weighing 225 pounds. It is not believed that the application of the estimated requirements of the Chuffy pigs to the Very Chuffy pigs of this experiment will result in serious error.

Digestibility and Metabolizable Energy of the Maintenance Ration. During the period of maintenance feeding 9 of the young pigs and 8 of the fat pigs were subjected to digestibility studies in which, besides the chemical examination of feed and feces, the gross energy content of feed, feces, and urine was also determined, thus permitting the computation of metabolizable energy. The nitrogen content of

TABLE 49.—COEFFICIENTS OF DIGESTIBILITY OBTAINED WITH THE YOUNG MAINTENANCE PIGS: SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein	N-free extract	Crude fiber	Fat
			Type A—Very Chuffy		
	pct.	*pct.*	*pct.*	*pct.*	*pct.*
2	67	60	84	13	67
1	75	69	91	28	71
3	75	59	87	14	63
			Type C—Intermediate		
6	74	68	87	−11	80
7	68	65	82	−11	57
8	70	64	91	−33	77
			Type D—Rangy		
13	80	71	90	33	80
15	52	68	84	−25	71
14	65	61	83	−11	67
Average	69.6	65.0	86.6	− .3	70.3

the urine was also determined, so that estimates of nitrogen balances and corrections of metabolizable energy to a condition of nitrogen equilibrium could be made. The collection periods in all cases were of ten days' duration. The periods of preliminary feeding were several weeks in length.

TABLE 50.—COEFFICIENTS OF DIGESTIBILITY OBTAINED WITH THE FAT MAINTENANCE PIGS: SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein	N-free extract	Crude fiber	Fat
			Type A—Very Chuffy		
	pct.	*pct.*	*pct.*	*pct.*	*pct.*
10	84	76	90	51	81
14	85	79	92	50	63
			Type C—Intermediate		
14	80	76	88	9	66
8	84	78	89	43	79
			Type D—Rangy		
7	79	73	85	5	67
19	83	79	89	12	74
18	84	80	90	40	76
4	85	79	91	39	66
Average	83.3	77.6	89.6	33.3	71.9

TABLE 51.—AVERAGE DAILY NITROGEN BALANCES OF THE YOUNG MAINTENANCE PIGS: SECOND EXPERIMENT

Pig No.	Nitrogen of feed consumed	Nitrogen of feces	Nitrogen of urine	Nitrogen balance
		Type A—Very Chuffy		
	grams	*grams*	*grams*	*grams*
2	4.80	1.92	3.53	.35
1	4.64	1.44	3.14	.06
3	4.64	1.92	2.56	.16
		Type C—Intermediate		
6	5.44	1.76	3.03	.65
7	5.44	1.92	2.93	.59
8	5.28	1.92	3.47	— .11
		Type D—Rangy		
13	5.44	1.60	3.14	.70
15	5.44	1.76	3.14	.54
14	5.28	2.08	3.70	— .50
Average	.....	.....	.....	.27

The heavier maintenance pigs utilized their feed better than the young pigs mainly because of a higher digestibility of protein, which in the former case averaged 77.6 percent and in the latter 65.0 (Tables 49 and 50). The heavier pigs also appeared to use the crude fiber more efficiently than the lighter pigs. The young maintenance pigs

TABLE 52.—AVERAGE DAILY NITROGEN BALANCES OF THE FAT MAINTENANCE PIGS: SECOND EXPERIMENT

Pig No.	Nitrogen of feed consumed	Nitrogen of feces	Nitrogen of urine	Nitrogen balance
		Type A—Very Chuffy		
	grams	*grams*	*grams*	*grams*
10	22.08	5.28	11.60	5.20
14	21.12	4.48	12.62	4.02
		Type C—Intermediate		
14	24.16	5.92	13.50	4.74
8	26.24	5.76	16.61	3.87
		Type D—Rangy		
7	22.88	6.08	8.69	8.11
19	24.64	5.12	16.61	2.91
18	22.88	4.64	17.38	.86
4	25.76	5.28	15.77	4.71
Average	.....	.....	.....	4.30

TABLE 58.—METABOLIZABLE ENERGY OF RATION OF THE YOUNG MAINTENANCE PIGS: SECOND EXPERIMENT

Pig No.	Live weight	Dry substance consumed	Digestible organic matter	Energy of feed consumed	Energy of feces	Energy of urine[1]	Metabolizable energy			
							Total per day	Per kg. dry substance	Per lb. digestible organic matter	Percent of gross energy
	Type A—Very Chuffy									
	lbs.	*kgs.*	*lbs.*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*per.*
2	41	.903	.333	.933	.205	.032	.67	3.28	2.00	71.4
4	40	.904	.370	.910	.150	.010	.74	3.65	2.00	80.0
6	40	.901	.340	.880	.218	.027	.63	3.18	1.87	72.2
	Type C—Intermediate									
1	50	.926	.380	1.035	.250	.030	.78	3.80	1.04	72.1
3	50	.927	.402	1.020	.280	.022	.71	3.12	1.06	69.5
5	60	.923	.386	.978	.254	.025	.70	3.13	1.81	71.5
	Type D—Rangy									
10	58	.926	.408	1.035	.193	.036	.81	3.57	1.98	77.0
12	58	.927	.373	1.020	.237	.021	.76	3.36	2.04	74.7
14	58	.923	.350	.978	.286	.024	.67	3.01	1.88	68.6
Average	53.5	.918	.380	.978	.230	.027	.72	3.20	1.94	73.2

[1] Corrected to N equilibrium by the use of Rubner's factor of 7.45 calories per gram of nitrogen.

TABLE 51.—METABOLIZABLE ENERGY OF RATION OF THE FAT MAINTENANCE PERIOD SECOND EXPERIMENT

Pig No.	Live weight	Dry substance consumed	Digestible organic matter	Energy of feed consumed	Energy of feces	Energy of urine	Metabolizable energy			
							Total per day	Per kg. dry substance	Per lb. digestible organic matter	Percent of gross energy
			Type A—Very Chuffy							
	lbs.	*kgs.*	*lbs.*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*per cent*
10	911	.874	1.598	3.78	.671	.126	2.98	3.38	1.85	78.8
11	918	.868	1.587	3.78	.530	.153	3.04	3.55	1.91	81.0
			Type C—Intermediate							
11	967	.883	1.766	4.26	.815	.102	3.33	3.80	1.90	78.0
8	904	1.044	1.911	4.48	.778	.127	3.57	3.42	1.87	79.8
			Type D—Hungry							
7	920	.841	1.690	4.02	.812	.134	3.07	3.30	1.91	76.5
10	950	1.007	1.830	4.36	.700	.142	3.52	3.40	1.92	80.7
12	910	.905	1.650	3.88	.640	.130	3.40	3.48	1.87	79.0
1	908	1.013	1.927	4.58	.684	.102	3.70	3.55	1.92	80.0
Average	946	.930	1.761	4.11	.707	.136	3.37	3.44	1.89	79.4

Corrected to N equilibrium by the use of Rubner's factor of 7.45 calories per gram of nitrogen.

were storing nitrogen at the average rate of .27 gram per day and the fat maintenance pigs, at the average rate of 4.30 grams per day (Tables 51 and 52).

For the young pigs the metabolizable energy per kilogram of dry matter eaten averaged 3.29 therms and per pound of digestible organic matter, 1.94 therms (Table 53). For the fat pigs these averages were, in order, 3.44 and 1.89 therms (Table 54). An average of 73.2 percent of the gross energy of the feed was metabolizable for the young pigs and 79.4 percent for the fat pigs.

Metabolizable Energy Required for Maintenance. If it is permissible to combine the feeding data relating to maintenance requirements of the first year's experiment with the determinations of the metabolizable energy of the feed obtained in the second year's work, an estimate of the amount of metabolizable energy required for the maintenance of the energy equilibrium of swine may be made.

The ration used in the first maintenance trial contained approximately 90 percent of dry matter. On the assumption that the metabolizable energy content was 3.36 therms per kilogram of dry matter, which is equal to 1.525 therms per pound, the young maintenance pigs appeared to need an average of 2,031 calories of metabolizable energy per day per 100 pounds live weight (weight ratio), while the fat pigs required an average of 1,551 calories (Table 55). Armsby[1] has com-

TABLE 55.—METABOLIZABLE ENERGY REQUIRED FOR MAINTENANCE OF SWINE PER 100 POUNDS LIVE WEIGHT PER DAY

50-pound pigs			225-pound pigs		
Type	Feed	Metabolizable energy	Type	Feed	Metabolizable energy
	lbs.	*cals.*		*lbs.*	*cals.*
B	1.62	2 223	B	1.21	1 661
C	1.44	1 976	C	.98	1 345
D	1.39	1 908	D	1.23	1 688
Average	1.48	2 031	Average	1.13	1 551

puted from the results of live-weight experiments that swine need some 1,534 calories of metabolizable energy per day per 100 pounds live weight for maintenance, altho a wide range of estimates were obtained from individual experiments. This estimate of Armsby's is in close agreement with the average obtained in this experiment for the older swine, which weighed approximately 225 pounds. The young pig appears to require, per unit of weight, a considerably larger amount of energy, approximately one third more.

[1] Armsby, H. P. The nutrition of farm animals, 287.

THE FATTENING EXPERIMENT

The fattening experiment involved 60 pigs, 20 from each of the Very Chuffy, Intermediate, and Rangy types. These pigs were put upon experimental feeding individually as they reached the desired initial weights, that is, 55 pounds for the Very Chuffy type and 70 pounds for the Intermediate and Rangy types. The pigs that were started first on June 30 included some pigs that were slightly heavier than these weights. The remaining pigs were put on experiment during July, with the exception of Pig 16 of the Very Chuffy group, which was started on August 4.

The ration used consisted of mixtures of shelled corn, tankage, middlings, and alfalfa meal varied according to the weights of the pigs. The corn was fed whole and the other feeds in a mixture consisting of 8 parts of middlings, 4 parts of tankage, and 1 part of alfalfa meal. The ratio of corn to mixture was changed according to a definite plan as the pigs increased in size.

TABLE 56.—LIVE AND EMPTY WEIGHTS AND "FILL" OF THE PIGS KILLED AT APPROXIMATELY 175 POUNDS: SECOND EXPERIMENT

Pig No. and sex[1]	Date of slaughter	Live weight		Weight of contents of alimentary tract	Empty weight		Contents of alimentary tract in percent of live weight
		lbs.	*kgs.*	*lbs.*	*lbs.*	*kgs.*	*pct.*
Type A—Very Chuffy							
6b	Nov. 26, 1923	168.88	76.60	8.63	160.25	72.69	5.11
9s	Nov. 26, 1923	183.81	83.37	9.94	173.88	78.87	5.40
16s	Dec. 20, 1923	190.69	86.50	6.88	183.81	83.37	3.61
18b	Nov. 20, 1923	178.94	81.17	10.19	168.75	76.54	5.69
19b	Nov. 26, 1923	178.88	81.14	.....	.....	.....	.....
20s	Nov. 26, 1923	167.00	75.75	8.69	158.31	71.81	5.20
Average		178.03	80.76	8.87	169.00	76.63	5.00
Type C—Intermediate							
3s	Nov. 1, 1923	183.63	83.29	10.25	173.38	78.64	5.58
5s	Oct. 11, 1923	170.88	77.51	14.31	156.56	71.01	8.37
13b	Oct. 1, 1923	182.56	82.81	14.38	168.19	76.29	7.88
Average		179.02	81.20	12.98	166.04	75.31	7.28
Type D—Rangy							
14b	Oct. 1, 1923	169.88	77.06	12.94	156.94	71.19	7.62
15b	Nov. 14, 1923	188.19	85.36	12.25	175.94	79.80	6.51
20b	Oct. 1, 1923	174.94	79.35	13.19	161.75	73.37	7.54
Average		177.67	80.59	12.79	164.88	74.79	7.22

[1] s = sow; b = barrow.

It was the original plan of the experiment to kill five pigs from each type at a weight of approximately 175 pounds, five at a weight of approximately 225 pounds, and five at a weight of approximately 275 pounds, the remaining five pigs to be used at a weight of about 225 pounds in a maintenance feeding trial. However, during the months of October and November, as with the first experiment, an epidemic of respiratory infection destroyed several of the pigs, and because of this and other unforseen contingencies the above plan was not adhered to.

Composition of Pigs Slaughtered at 175 Pounds. Twelve pigs were slaughtered at weights approximating 175 pounds, 6 from the Very Chuffy type and 3 each from the other two types. The dates of slaughter, live, and empty weights, and the weights and percentages of "fill" for these pigs are collected in Table 56. The average per-

TABLE 57.—WEIGHTS OF SAMPLES AND PHYSICAL COMPOSITION OF DRESSED CARCASSES OF THE 175-POUND PIGS: SECOND EXPERIMENT

Pig No.	Offal	Dressed carcass				
		Lean	Fat	Skin	Bone	Total
Type A—Very Chuffy						
	kgs.	*kgs.*	*kgs.*	*kgs.*	*kgs.*	*kgs.*
6	10.25	29.42	18.76	3.04	7.20	58.42
9	11.23	29.78	23.78	3.02	7.38	63.96
16	10.75	29.34	28.54	2.78	6.56	67.22
18	10.88	27.68	22.96	3.06	7.80	61.50
19	9.51	29.02	24.42	3.08	6.70	63.22
20	9.53	26.80	22.50	2.92	6.58	58.80
Average	10.36	28.68	23.50	2.98	7.04	62.18
Average in percent		(46.1)	(37.8)	(4.8)	(11.3)	(100.0)
Type C—Intermediate						
3	9.28	28.86	25.30	3.26	7.20	64.62
5	10.82	25.38	20.26	4.28	7.84	57.76
13	11.06	28.92	19.86	4.24	8.82	61.84
Average	10.39	27.72	21.80	3.92	7.96	61.40
Average in percent		(45.1)	(35.5)	(6.4)	(13.0)	(100.0)
Type D—Rangy						
14	10.73	24.98	21.78	3.74	7.42	57.92
15	11.24	32.44	18.80	4.14	9.12	64.50
20	11.54	25.52	20.66	4.06	7.78	58.02
Average		27.64	20.42	3.98	8.10	60.14
Average in percent		(46.0)	(34.0)	(6.6)	(13.5)	(100.0)

centage fill for the Very Chuffy pigs was 5.0, for the Intermediate pigs 7.3, and for the Rangy pigs 7.2.

On the average the dressed carcasses from the Very Chuffy pigs contained a larger percentage of separable fat (37.8) than those of the other types (35.5 and 34.0, in order) and a smaller percentage of skin (4.8, as compared with 6.4 and 6.6) and bone (11.3 as compared with 13.0 and 13.5) (Table 57). The percentage composition of the dressed carcasses, as determined by chemical analysis (Table 58), was not, however, significantly different for the different types except possibly with reference to ash. In fat and energy content the three types of carcasses are not to be certainly distinguished, tho in general the Very Chuffy pigs rank the highest in these respects. They appear to be significantly lower in ash than the dressed carcasses of either the Intermediate or the Rangy pigs.

The average percentage composition of the offal samples only is given in Table 59. The percentage composition of the entire carcasses on the live-weight basis (Table 60) shows the same general relations among the three types as that of the dressed carcasses.

TABLE 58.—PERCENTAGE COMPOSITION OF DRESSED CARCASSES OF THE 175-POUND PIGS: SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type A—Very Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
6	56.86	10.26	42.94	2.22	4 583
9	54.96	11.94	39.34	3.13	4 475
16	60.43	11.22	47.07	2.10	5 025
18	57.73	12.18	42.64	2.72	4 660
19	56.59	12.06	42.64	2.76	4 810
20	59.27	11.64	43.58	3.11	4 665
Average	57.64	11.55	43.04	2.67	4 703
		Type C—Intermediate			
3	54.28	12.78	37.58	3.43	4 257
5	58.89	12.24	42.17	3.20	4 532
13	57.93	12.60	39.63	3.21	4 273
Average	57.03	12.54	39.79	3.28	4 354
		Type D—Rangy			
14	57.67	11.88	42.72	3.15	4 626
15	55.77	12.42	39.20	3.15	4 411
20	60.71	11.88	42.38	3.13	4 517
Average	58.05	12.06	41.43	3.14	4 518
Average of all types	57.59	11.92	41.82	2.94	4 569

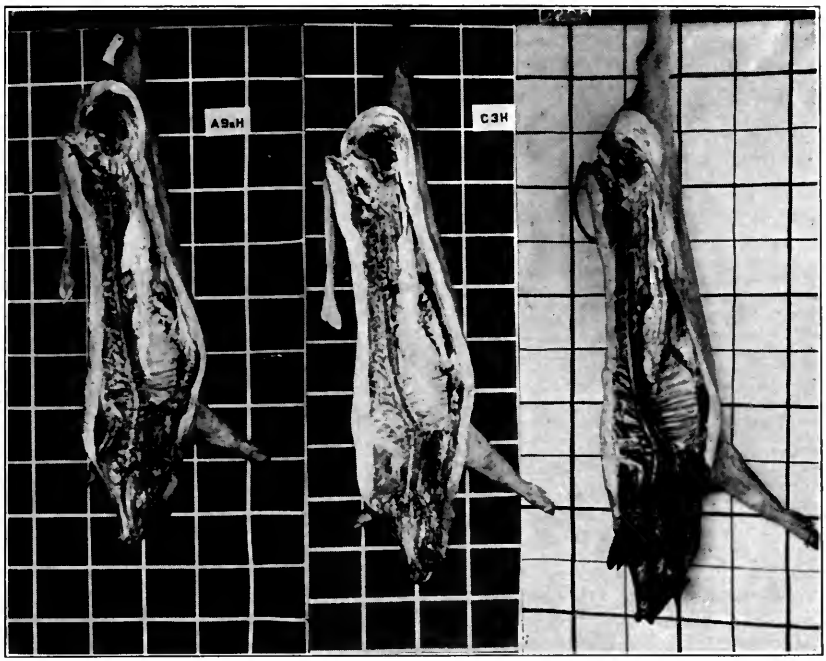

FIG. 3.—REPRESENTATIVE CARCASSES OF VERY CHUFFY, INTERMEDIATE, AND RANGY PIGS SLAUGHTERED AT APPROXIMATELY 175 POUNDS LIVE WEIGHT: SECOND EXPERIMENT

The Very Chuffy carcass contained a larger percentage of separable fat and a smaller percentage of skin and bone than the other carcasses. The results of chemical analysis of these carcasses were not significantly different for the three types except possibly with reference to ash.

On the empty-weight basis the average percentages of dry substance for the three type groups were 51.1, 50.8, and 51.3 respectively; the average percentages of crude protein were 11.4, 12.3, and 11.9, of fat 36.8, 34.2, and 35.4, and of ash 2.3, 2.8, and 2.7; the average amounts of gross energy per gram of empty carcass were 4.12, 3.84, and 3.95 calories.

Composition of Gains up to a Weight of 175 Pounds. Applying the average percentage composition of the control pigs (Table 38) of the three types to initial weights of 55 pounds for the Very Chuffy type and 70 pounds for the Intermediate and Rangy types, and the average percentage composition of the pigs killed at approximately 175 pounds to an exact weight of 175 pounds, will give the weights of nutrients in pigs of these weights. Subtracting the estimated

TABLE 59—AVERAGE PERCENTAGE COMPOSITION AND ENERGY CONTENT OF OFFAL SAMPLES FOR EACH TYPE FOR THE 175-POUND PIGS: SECOND EXPERIMENT

	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
	pct.	*pct.*	*pct*	*pct.*	*sm. cals.*
Type A	29.22	12.69	14.28	1.03	2 107
Type C	28.39	12.54	12.38	.88	1 964
Type D	28.57	12.26	14.20	1.00	2 012

weights of nutrients in the 55-pound and 70-pound pigs from the estimated weights in the 175-pound pigs of like type will give estimates of the gains in nutrients between these live weights. The percentage composition of these gains is obtained by dividing the weights of added nutrients by the corresponding gains in live weight, namely, 120 pounds for the pigs of the Very Chuffy type and 105 pounds for the pigs of the other types.

It seems unnecessary to report the intermediate calculations leading to the estimated percentage composition of gains. The Very

TABLE 60.—PERCENTAGE COMPOSITION AND GROSS ENERGY CONTENT OF THE 175-POUND PIGS ON BASIS OF LIVE WEIGHT: SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
			Type A—Very Chuffy		
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
6	47.58	10.10	34.48	1.85	3 780
9	46.29	11.16	32.09	2.55	3 725
16	51.06	10.53	38.38	1.80	4 194
18	48.26	11.16	34.56	2.21	3 854
19	47.94	11.25	35.04	2.27	4 023
20	49.93	10.94	35.37	2.60	3 892
Average	48.51	10.86	34.99	2.21	3 911
			Type C—Intermediate		
3	45.70	11.73	30.47	2.80	3 539
5	48.42	11.08	33.45	2.52	3 699
13	47.17	11.42	31.06	2.54	3 449
Average	47.10	11.41	31.66	2.62	3 562
			Type D—Rangy		
14	47.31	11.08	33.82	2.53	3 753
15	46.54	11.29	31.63	2.57	3 624
20	49.02	10.75	33.21	2.44	3 632
Average	47.62	11.04	32.89	2.51	3 670

Chuffy pigs in gaining from 55 to 175 pounds put on added weight containing 54.3 percent of dry matter, 10.2 percent of crude protein (N x 6.0), 42.0 of fat, and 2.1 of ash, and possessing a gross energy value of 2.05 therms per pound. The gain of the Intermediate pigs from 70 to 175 pounds live weight contained 52.6 percent of dry matter, 11.3 percent of crude protein, 37.7 percent of fat, 2.9 percent of ash, and 1.85 therms of gross energy per pound. The gain of the Rangy pigs thru the same weight interval contained 53.9 percent of

TABLE 61.—LIVE AND EMPTY WEIGHTS AND "FILL" OF THE PIGS KILLED AT APPROXIMATELY 225 POUNDS: SECOND EXPERIMENT

Pig No. and sex[1]	Date of slaughter	Live weight		Weights of contents of alimentary tract	Empty weight		Contents of alimentary tract in percent of live weight
Type A—Very Chuffy							
		lbs.	*kgs.*	*lbs.*	*lbs*	*kgs.*	*pct.*
11b	Dec. 20, 1923	226.1	102.5	13.2[2]	212.8	96.5	5.9
17s	Jan. 3, 1924	234.8	106.5	16.5	218.3	99.0	7.0
Average		230.4	104.5	14.9	215.6	97.8	6.4
Type C—Intermediate: Hand-fed							
1b	Jan. 3, 1924	218.6	99.2	6.7	211.9	96.1	3.1
2b	Dec. 10, 1923	228.2	103.5	7.4	220.8	100.2	3.3
9b	Nov. 8, 1923	224.0	101.6	13.4	210.6	95.5	6.0
15b	Nov. 20, 1923	224.4	101.8	12.3	212.1	96.2	5.5
18s	Nov. 8, 1923	239.2	108.5	12.2	226.9	102.9	5.1
19b	Nov. 26, 1923	223.8	101.5	12.1	211.7	96.0	5.4
Average		226.4	102.7	10.7	215.7	97.8	4.7
Type C—Intermediate: Self-fed							
60s	Oct. 16, 1923	210.4	95.4	.....	.....	.....	.....
90s	Oct. 11, 1923	217.0	98.4	.....	.....	.....	.....
91s	Nov. 20, 1923	217.0	98.4	.....	.....	.....	.....
99s	Nov. 20, 1923	219.1	99.4	.....	.....	.....	.....
99b	Oct. 16, 1923	230.9	104.7	.....	.....	.....	.....
Average		218.9	99.3	.....	.....	.....	.....
Type D—Rangy							
2b	Dec. 10, 1923	221.1	100.3	7.7	213.4	96.8	3.5
5b	Dec. 20, 1923	232.4	105.4	14.9	217.5	98.7	6.4
8b	Nov. 26, 1923	219.9	99.8	17.8	202.1	91.7	8.1
9s	Nov. 14, 1923	228.4	103.6	12.2	216.1	98.0	5.4
16b	Nov. 14, 1923	225.3	102.2	11.1	214.2	97.2	4.9
Average		225.4	102.2	12.7	212.7	96.5	5.6

[1]s = sow; b = barrow. [2]Not weighed. Average for A, C, and D types.

dry matter, 10.4 percent of protein, 40.3 percent of fat, 2.6 percent of ash, and 1.94 therms of gross energy per pound.

Composition of Pigs Slaughtered at 225 Pounds. Two pigs of the Very Chuffy type, 6 of the Intermediate, and 5 of the Rangy were slaughtered at a weight of 225 pounds. In addition 5 Intermediate pigs that had been self-fed in a group of 10 on the same ration as the hand-fed pigs were also slaughtered at this weight. These pigs, probably because of the competition accompanying lot feeding, had

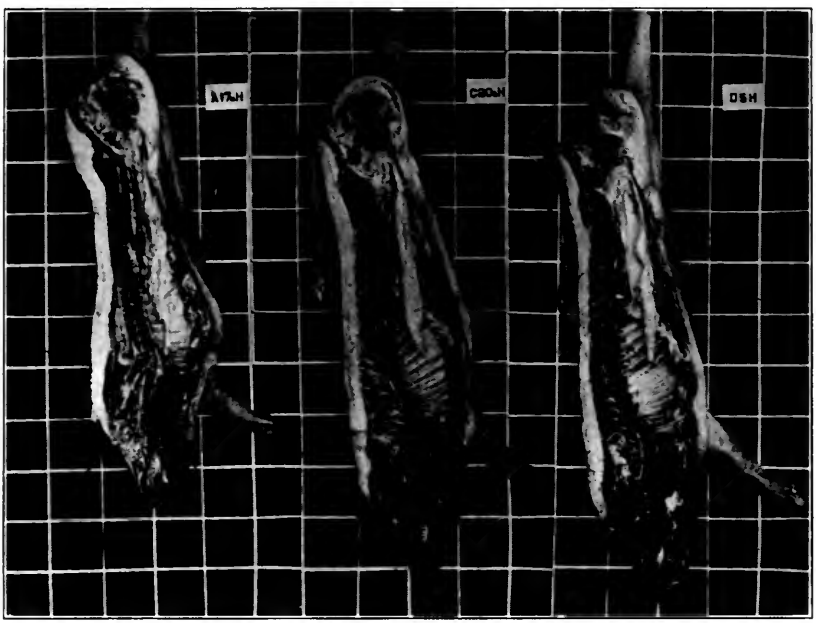

FIG. 4.—REPRESENTATIVE CARCASSES OF VERY CHUFFY, INTERMEDIATE, AND RANGY PIGS SLAUGHTERED AT APPROXIMATELY 225 POUNDS LIVE WEIGHT: SECOND EXPERIMENT

The dressed carcasses of the Very Chuffy pigs slaughtered at this weight were in general higher in fat than those of the Intermediate pigs, which in turn were noticeably fatter than those of the Rangy pigs.

consumed more feed and had gained considerably faster than the hand-fed pigs. The results of their analyses, when compared with those for the hand-fed pigs of the same type, are of interest in connection with the general question of the effect of the rate of gains upon the composition of the carcass and of the gains in weight.

The weights, "fills", slaughter data, and the percentage composition of the dressed carcasses of these 18 pigs are presented in Tables

TABLE 62.—WEIGHTS OF SAMPLES AND PHYSICAL COMPOSITION OF DRESSED CARCASSES OF THE 225-POUND PIGS: SECOND EXPERIMENT

Pig No.	Offal	Carcass composite				
		Lean	Fat	Skin	Bone	Total
Type A—Very Chuffy						
	kgs.	*kgs.*	*kgs.*	*kgs.*	*kgs.*	*kgs.*
11	12.01	33.26	35.06	3.76	6.92	79.00
17	12.62	34.28	34.52	3.86	7.98	80.64
Average	12.32	33.78	34.80	3.82	7.46	79.86
Average in percent	.....	(42.3)	(43.6)	(4.8)	(9.3)	(100.00)
Type C—Intermediate: Hand-fed						
1	11.34	40.34	28.64	3.60	8.34	80.92
2	14.03	31.56	37.40	4.22	9.80	82.98
9	13.05	36.88	27.60	3.80	8.06	76.34
15	13.03	35.64	28.72	3.30	9.08	76.74
18	12.77	37.62	31.98	4.38	8.40	82.38
19	12.72	36.86	29.64	3.78	8.74	79.02
Average	12.82	36.48	30.66	3.84	8.74	79.72
Average in percent	.....	(45.8)	(38.5)	(4.8)	(11.0)	(100.0)
Type C—Intermediate: Self-fed						
60	13.29	26.90	32.08	4.46	6.96	70.40
90	12.44	30.82	32.88	3.46	7.48	74.64
91	12.20	38.20	29.10	3.74	7.30	78.34
99[1]	13.13	28.50	36.32	4.00	7.90	76.72
99[2]	14.26	36.70	31.64	5.06	8.24	81.64
Average	13.06	32.22	32.40	4.14	7.58	76.34
Average in percent	.....	(42.2)	(42.4)	(5.4)	(9.9)	(100.0)
Type D—Rangy						
2	13.85	38.34	28.54	3.84	11.16	81.88
5	15.00	36.00	30.36	3.56	11.24	81.16
8	13.98	33.16	23.58	4.66	11.76	73.16
9	13.76	38.72	26.12	4.20	9.64	78.68
16	13.06	39.14	25.56	4.22	10.06	78.98
Average	13.93	37.08	26.84	4.10	10.78	78.80
Average in percent	.....	(47.1)	(34.1)	(5.2)	(13.7)	(100.0)

[1]Sow. [2]Barrow.

TABLE 63.—PERCENTAGE COMPOSITION OF DRESSED CARCASSES OF THE PIGS KILLED AT APPROXIMATELY 225 POUNDS: SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type A—Very Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
11	60.85	10.32	47.87	2.08	4 624
17	63.63	9.54	50.54	2.34	5 287
Average	62.24	9.93	49.21	2.21	4 956
		Type C—Intermediate: Hand-fed			
1	60.17	12.78	43.26	2.64	4 784
2	64.50	10.02	50.77	2.56	5 349
9	58.14	11.04	43.51	2.24	4 628
15	60.35	11.76	44.91	(3.71)[1]	4 811
18	62.73	12.54	44.62	2.57	4 716
19	57.95	11.46	43.55	2.59	4 694
Average	60.64	11.60	45.10	2.52	4 830
		Type C—Intermediate: Self-fed			
60	64.95	10.56	51.15	2.24	5 386
90	64.29	10.08	51.75	2.15	5 345
91	58.18	12.00	44.86	2.37	4 706
99[2]	65.56	9.72	53.63	1.75	5 547
99[3]	63.36	11.04	47.69	2.37	4 976
Average	63.27	10.68	49.82	2.18	5 192
		Type D—Rangy			
2	57.71	11.82	42.00	2.59	4 571
5	57.95	11.82	42.85	2.77	4 609
8	54.52	13.16	38.18	2.69	4 159
9	55.29	12.60	39.25	2.89	4 365
16	54.24	12.18	38.87	2.69	4 407
Average	55.94	12.32	40.23	2.73	4 422

[1]Omitted from the average. [2]Sow. [3]Barrow.

61, 62, and 63. The dressed carcasses of the 2 Very Chuffy pigs were in general higher in fat than those of the 6 hand-fed Intermediate pigs, which in turn were noticeably fatter than those of the 5 pigs of the Rangy type. The self-fed pigs of the Intermediate type produced dressed carcasses rather distinctly fatter than the hand-fed pigs of the same type. The higher ash content of the dressed carcasses of the Rangy pigs is also noticeable. The offal samples of the three types showed only inconsiderable differences in percentage composition.

TABLE 64.—AVERAGE PERCENTAGE COMPOSITION OF OFFAL SAMPLES OF THE 225-POUND PIGS: SECOND EXPERIMENT

Type	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
A	31.50	12.45	15.41	.83	2 288
C, hand-fed	31.51	12.53	16.22	.89	2 253
C, self-fed	31.26	12.25	16.04	.89	2 349
D	29.10	12.98	14.42	.91	2 083

TABLE 65.—PERCENTAGE COMPOSITION AND GROSS ENERGY CONTENT OF THE 225-POUND PIGS ON BASIS OF LIVE WEIGHT: SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
			Type A—Very Chuffy		
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
11	51.13	9.72	38.94	1.72	3 864
17	52.05	9.01	39.86	1.88	4 275
Average	51.59	9.37	39.40	1.80	4 070
			Type C—Intermediate: Hand-fed		
1	53.04	12.17	37.08	2.28	4 180
2	55.78	10.18	42.35	2.18	4 571
9	48.37	10.17	35.11	1.82	3 807
15	50.35	10.70	36.31	2.92	3 974
18	51.46	11.30	35.73	2.08	3 843
19	49.33	10.82	35.96	2.14	3 941
Average	51.39	10.89	37.09	2.24	4 053
			Type C—Intermediate: Self-fed		
60	52.43	9.80	39.94	1.77	4 291
90	52.14	9.34	40.45	1.73	4 279
91	50.47	11.43	37.57	2.00	4 039
99[1]	52.88	9.17	41.56	1.44	4 472
99[2]	54.34	10.49	39.97	2.03	4 238
Average	52.45	10.05	39.90	1.79	4 264
			Type D—Rangy		
2	51.59	11.72	36.30	2.25	4 027
5	49.24	11.08	35.23	2.28	3 882
8	44.23	12.23	29.81	2.11	3 344
9	46.28	11.47	31.84	2.35	3 611
16	45.91	11.33	31.84	2.22	3 688
Average	47.45	11.57	33.00	2.24	3 710

[1]Sow. [2]Barrow.

TABLE 66.—LIVE AND EMPTY WEIGHTS AND "FILL" OF THE PIGS KILLED AT APPROXIMATELY 275 POUNDS: SECOND EXPERIMENT

Pig No. and sex	Date of slaughter	Live weight		Weight of contents of alimentary tract	Empty weight		Contents of alimentary tract in per cent of live weight
Type A—Very Chuffy							
		lbs.	*kgs.*	*lbs.*	*lbs.*	*kgs.*	*pct.*
5s	Feb. 26, 1924	276.4	125.4	10.7	265.7	120.5	3.9
Type C—Intermediate							
10s	Feb. 1, 1924	283.9	128.8	6.3	277.6	125.9	2.2
12b	Dec. 10, 1923	279.1	126.6	10.7	268.4	121.8	3.8
16b	Dec. 20, 1923	276.5	125.4	12.7	263.7	119.6	4.6
17b	Jan. 3, 1924	285.8	129.6	13.4	272.4	123.6	4.7
Average		281.3	127.6	10.8	270.5	122.7	3.8
Type D—Rangy							
1s	Jan. 8, 1924	267.7	121.4	6.9	260.8	118.3	2.6
3b	Jan. 8, 1924	271.1	123.0	10.4	260.7	118.2	3.8
6b	Jan. 8, 1924	280.2	127.1	12.8	267.8	121.5	4.4
10b	Jan. 8, 1924	275.6	125.0	11.8	263.8	119.7	4.3
13b	Dec. 10, 1923	269.0	122.0	11.5	257.5	116.8	4.3
Average		272.7	123.7	10.6	262.1	118.9	3.9

The estimated percentage composition of the 225-pound pigs on the basis of the live weight will be found in Table 65. Since these values are mainly determined by the composition of the dressed carcasses, they do not require any special discussion.

On the empty-weight basis the average percentage composition of the 2 Very Chuffy pigs was 55.1 percent dry matter, 10.0 percent crude protein, 42.1 percent fat, and 1.92 percent ash. The corresponding figures for the Intermediate-type hand-fed pigs were 53.9, 11.4, 38.9, and 2.35 respectively; and for the Rangy pigs, 50.3, 12.3, 35.0, and 2.37. The average gross energy content per gram of empty weight for the three types was 4,350, 4,254, and 3,932 small calories.

Composition of Gains up to a Weight of 225 Pounds. Estimates of the average percentage composition of the gain from 55 to 225 pounds for the Very Chuffy pigs and from 70 to 225 pounds for the other two types follow:

Type	Dry matter	Crude protein (N x 6.0)	Fat	Ash	Gross energy per pound
	pct.	*pct.*	*pct.*	*pct.*	*therms*
A, Very Chuffy	56.6	8.4	45.8	1.61	2.066
C, Intermediate, hand-fed	57.1	10.6	43.7	2.23	2.095
C, Intermediate, self-fed	58.6	9.3	47.7	1.58	2.234
D, Rangy	51.7	11.4	38.0	2.19	1.875

TABLE 67.—WEIGHTS OF SAMPLES AND PHYSICAL COMPOSITION OF DRESSED CARCASSES OF THE 275-POUND PIGS: SECOND EXPERIMENT

Pig No.	Offal	Carcass composite				
		Lean	Fat	Skin	Bone	Total
Type A—Very Chuffy						
	kgs.	*kgs.*	*kgs.*	*kgs.*	*kgs.*	*kgs.*
5	14.97	45.26	39.16	4.54	9.40	98.36
Average in percent	(46.0)	(39.8)	(4.6)	(9.6)	(100.0)	
Type C—Intermediate						
10	15.69	44.52	42.06	4.76	9.16	100.50
12	15.62	40.76	41.54	5.56	11.96	99.82
16	14.96	37.26	48.32	3.92	9.26	98.76
17	14.85	38.36	47.40	5.04	11.36	102.16
Average	15.28	40.22	44.84	4.82	10.44	100.32
Average in percent	(40.1)	(44.7)	(4.8)	(10.4)	(100.0)	
Type D—Rangy						
1	12.03	42.84	38.44	4.86	11.46	97.60
3	14.55	40.20	44.16	4.48	10.10	98.94
6	15.61	46.48	36.24	5.22	11.78	99.72
10	14.70	45.50	38.34	5.20	11.28	100.32
13	15.23	43.56	39.78	5.20	11.88	100.42
Average	14.42	43.72	39.40	5.00	11.30	99.42
Average in percent	(44.0)	(39.6)	(5.0)	(11.4)	(100.0)	

The smaller fat content of the gains of the Rangy pigs and the greater fat content of the gains of the self-fed Intermediate pigs are worthy of special note.

Composition of Pigs Slaughtered at 275 Pounds. Only 1 Very Chuffy pig was killed at a weight of 275 pounds, while 4 Intermediate and 5 Rangy pigs were slaughtered and analyzed at this weight. The data obtained are presented in Tables 66 to 70, in the same form as the data for the other groups of pigs.

Little comment on these results is needed, since essentially the same relations hold between the types at this weight as at the other weights.

The average percentage composition of the pigs on the empty-weight basis is given in Table 71.

Average Percentage Composition of Gains up to 275 Pounds. For the Intermediate and Rangy types it appears profitable to compute the percentage composition of the gains put on from an initial

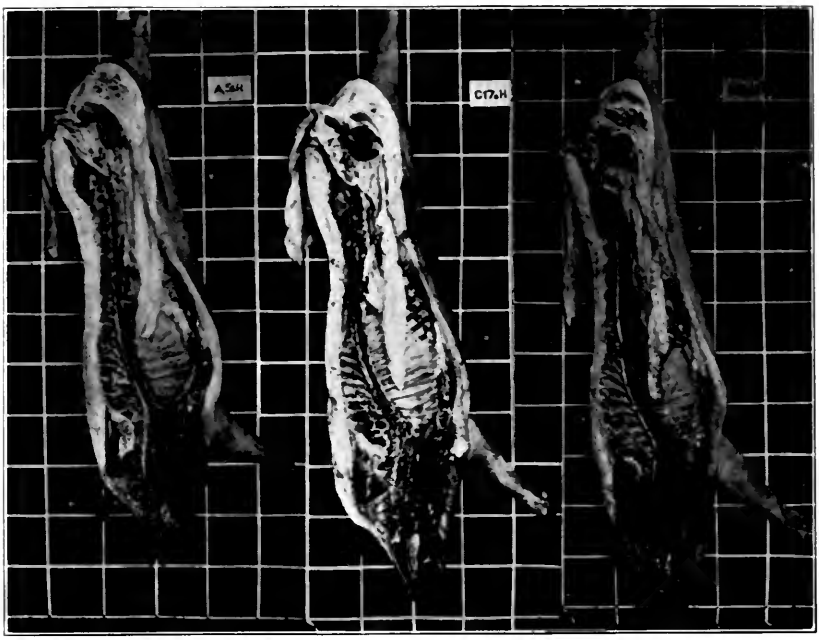

FIG. 5.—REPRESENTATIVE CARCASSES OF VERY CHUFFY, INTERMEDIATE, AND RANGY PIGS SLAUGHTERED AT APPROXIMATELY 275 POUNDS LIVE WEIGHT: SECOND EXPERIMENT

These carcasses showed essentially the same relations in physical and chemical composition between the types at this weight as at the other weights.

weight of 70 pounds to a weight of 275 pounds. Such computations, based upon the composition of the control pigs and of the pigs examined at weights approximating 275 pounds, follow: for the Intermediate pigs, dry matter 60.9, protein 9.5, fat 49.9, and ash 2.04 percent; for the Rangy pigs, dry matter 58.8, protein 10.7, fat 45.8, and ash 2.27 percent. The gross energy of the gain per pound for the Intermediate type is 2,310, and for the Rangy type 2,187 calories.

Comparison of Results Obtained for Pigs of Different Weights. The experiment of the second year affords the opportunity for determining the changes in the composition of the carcasses of growing and fattening pigs with advancing age. Tables 72, 73, and 74 have been constructed to facilitate a comparison of the groups of pigs examined at different weights. In all types increasing weight (and age) was associated with increasing percentages of fat and dry matter and decreasing percentages of protein and ash. This relation is particularly well shown in the pigs of the Intermediate type, in which the changes in composition with age proceed in a very regular fashion.

TABLE 68.—PERCENTAGE COMPOSITION OF DRESSED CARCASSES OF THE PIGS KILLED AT APPROXIMATELY 275 POUNDS: SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type A—Very Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
5	61.70	11.22	47.35	2.18	5 155
		Type C—Intermediate			
10	63.48	11.58	49.80	2.71	5 213
12	61.75	10.86	47.93	2.73	4 974
16	67.12	9.18	55.56	2.12	5 697
17	67.32	10.32	54.24	2.48	5 516
Average	64.92	10.49	51.88	2.51	5 350
		Type D—Rangy			
1	61.59	11.76	46.62	3.11	5 031
3	64.18	10.80	50.70	2.26	5 208
6	59.40	10.74	45.20	2.82	4 875
10	60.76	11.58	46.17	2.50	4 983
13	61.12	12.00	45.46	2.84	4 835
Average	61.41	11.38	46.83	2.71	4 986

TABLE 69.—AVERAGE PERCENTAGE COMPOSITION OF OFFAL SAMPLES FOR THE THREE TYPES OF 275-POUND PIGS: SECOND EXPERIMENT

Type	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
A[1]	29.93	12.00	15.46	.82	2 221
C	33.25	12.57	18.13	.85	2 397
D	32.94	13.31	17.52	.88	2 354

[1]The percentages were obtained on one pig only.

Since the greatest change with age is the change in fat content, it becomes a question of interest to determine whether the change in fat content accounts entirely for the changes noted in the other constituents. This may be determined by computing the percentages of dry matter, protein, and ash on the fat-free, or "protoplasmic" basis. This has been done for the entire empty carcass, with the results shown in Table 75. Apparently the fat-free substance of these pigs was very similar in composition regardless of age or type. The Very Chuffy pigs were somewhat more watery than the pigs of the other types, with correspondingly smaller contents of protein and ash. The control pigs also were slightly lower in protein than the older pigs. But it may be said that the fat-free material of all pigs closely ap-

TABLE 70.—PERCENTAGE COMPOSITION AND GROSS ENERGY CONTENT OF THE 275-POUND PIGS ON BASIS OF LIVE WEIGHT: SECOND EXPERIMENT

Pig No.	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
		Type A—Very Chuffy			
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
5	52.29	10.53	38.99	1.82	4 326
		Type C—Intermediate			
10	53.66	10.83	40.81	2.23	4 355
12	52.83	10.42	39.71	2.28	4 199
16	57.54	8.95	46.48	1.78	4 834
17	57.27	9.90	44.84	2.06	4 646
Average	55.32	10.02	42.96	2.09	4 508
		Type D—Rangy			
1	52.91	11.11	38.87	2.60	4 272
3	55.92	10.56	43.07	1.93	4 507
6	50.97	10.43	37.66	2.34	4 135
10	53.19	11.09	39.39	2.11	4 311
13	54.63	11.77	39.43	2.49	4 270
Average	53.52	10.99	39.68	2.29	4 299
Average of all types	54.12	10.56	40.92	2.16	4 385

proximated the following composition: 76.4 percent of water, 3.02 percent of nitrogen (18.9 percent of N x 6.25), and 3.7 percent of ash. These data indicate that the pig reaches a constant protoplasmic composition ("chemical maturity") at a much younger age than Moulton[1] has found from a composite study of data from a number of sources.

A comparison of the composition of gains between the different weight intervals is made in Table 76. It is apparent that with increasing age the fat content of the gains increases, while to a corresponding extent the protein and ash contents decrease. From the composition of the gains on the fat-free basis it is evident that they approxi-

TABLE 71.—AVERAGE PERCENTAGE COMPOSITION OF THE 275-POUND PIGS ON BASIS OF EMPTY WEIGHT: SECOND EXPERIMENT

Type	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
	pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
A[1]	54.4	11.0	40.6	1.89	4 501
C	57.5	10.4	44.7	2.17	4 688
D	55.7	11.4	41.3	2.38	4 473

[1]These percentages are for one pig only.

[1] Moulton, C. R. Jour. Biol. Chem. 57, 79. 1923.

TABLE [illegible].—AVERAGE? PERCENTAGE COMPOSITION OF DRESSED CARCASSES OF PIGS OF DIFFERENT TYPES AND WEIGHTS: SECOND EXPERIMENT

Live weight	Number of pigs averaged	Dry substance	Crude protein (N×6.25)	Fat	Ash	Gross energy per gram
Type A—Very Chuffy?						
lbs.		pct.	pct.	pct.	pct.	sm. cals.
[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]	3 [illegible]
[illegible]	6	[illegible]	[illegible]	[illegible]	[illegible]	4 [illegible]
[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]	4 [illegible]
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	5 [illegible]
Type C?—Intermediate?						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3 [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4 [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4 [illegible]
[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	5 [illegible]
Type D?—[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4 [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4 [illegible]
[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	4 [illegible]

TABLE [illegible] [illegible]

Live weight	Number of pigs averaged	Dry substance	Crude protein (N×6.25)	Fat	Ash	Gross energy per gram
Type A—Very Chuffy?						
lbs.		pct.	pct.	pct.	pct.	sm. cals.
[illegible]	5	[illegible]	[illegible]	[illegible]	1.[illegible]	1 [illegible]
[illegible]	6	[illegible]	[illegible]	[illegible]	1.[illegible]	2 [illegible]
[illegible]	2	[illegible]	[illegible]	[illegible]	.[illegible]	2 [illegible]
[illegible]	1	[illegible]	[illegible]	[illegible]	.[illegible]	2 [illegible]
Type C—Intermediate?						
[illegible]	5	[illegible]	[illegible]	[illegible]	.[illegible]	1 [illegible]
[illegible]	3	[illegible]	[illegible]	[illegible]	.[illegible]	1 [illegible]
[illegible]	6	[illegible]	[illegible]	[illegible]	.[illegible]	2 [illegible]
[illegible]	4	[illegible]	[illegible]	[illegible]	.[illegible]	2 [illegible]
Type D—Rangy						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.[illegible]	[illegible]
[illegible]	8?	[illegible]	[illegible]	[illegible]	1.[illegible]	2 [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.[illegible]	2 [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.[illegible]	[illegible]

TABLE 7A.—APPROXIMATE PERCENTAGE COMPOSITION OF PIGS OF DIFFERENT TYPES AND WEIGHTS: SECOND EXPERIMENT

Live weight	Number of pigs averaged	Dry matter	Crude protein (N×6.25)	Fat	Ash	Gross energy per gram
			LIVE-WEIGHT BASIS			
			Type A—Very Chubby			
lbs.		gm.	gm.	gm.	gm.	cal.
55	5	306.0	122.2	159.6	2.26	2,570
175	6	446.5	110.9	315.0	2.23	3,910
225	2	531.6	91.6	389.6	1.80	4,070
275	1	592.3	110.5	389.0	1.82	4,330
			Type C—Intermediate			
70	5	305.8	111.6	222.6	2.25	2,700
175	3	457.1	111.6	331.7	2.62	3,960
225	6	521.4	110.9	387.1	2.24	4,050
275	4	585.3	110.0	462.0	2.09	4,310
			Type D—Range			
70	5	306.6	122.0	220.3	2.46	2,980
175	3	457.6	111.0	332.9	2.53	3,970
225	5	457.4	111.6	333.0	2.24	3,710
275	5	508.5	111.0	388.7	2.29	4,200
			EMPTY-WEIGHT BASIS			
			Type A—Very Chubby			
lbs.		gm.	gm.	gm.	gm.	cal.
55	5	306.0	122.2	159.6	2.26	2,570
175	6	531.2	111.4	296.8	2.23	4,120
225	2	555.2	100.0	452.1	1.92	4,350
275	1	584.4	111.0	460.6	1.89	4,700
			Type C—Intermediate			
70	5	482.2	122.6	326.5	2.44	3,940
175	3	500.5	122.3	344.2	2.58	3,990
225	6	555.9	111.4	388.9	2.25	4,250
275	4	557.5	110.4	444.7	2.17	4,490
			Type D—Range			
70	5	482.4	122.5	325.0	2.60	3,140
175	3	531.3	111.9	385.4	2.72	3,960
225	5	532.3	122.3	385.1	2.37	3,900
275	5	555.7	111.4	441.3	2.28	4,470

made closely in composition the carcasses themselves. Some slight readjustment of the composition of gains is required to make them strictly comparable with the composition of the empty carcass since they do not allow for slight differences in "fill" at the different slaughter weights.

TABLE 75.—AVERAGE PERCENTAGE COMPOSITION OF PIGS OF DIFFERENT TYPES AND WEIGHTS ON FAT-FREE EMPTY BASIS: SECOND EXPERIMENT

Live weight	Approximate age	Number of pigs averaged	Dry substance	Crude protein (Nx6.0)	Ash
		Type A—Very Chuffy			
lbs.	*days*		*pct.*	*pct.*	*pct.*
55	122	5	22.5	16.9	3.28
175	281	6	22.6	18.0	3.69
225	281	2	22.5	17.3	3.32
275	348	1	23.2	18.5	3.18
Average	....	....	22.6	17.5	3.45
		Type C—Intermediate			
70	115	5	23.4	16.7	3.23
175	209	3	25.2	18.7	4.30
225	252	6	24.5	18.7	3.85
275	286	4	23.1	18.8	3.92
Average	...	...	24.0	18.2	3.77
		Type D—Rangy			
70	108	5	23.2	17.1	3.47
175	210	3	24.6	18.4	4.20
225	254	5	23.5	18.9	3.65
275	287	5	24.5	19.4	4.05
Average	...	...	23.9	18.5	3.80
Average of all types	...	...	23.6	18.1	3.69

A COMPARISON OF 225-POUND PIGS OF BOTH EXPERIMENTS

In order to determine how nearly the 225-pound pigs of the first year's experiment were duplicated in the second year's experiment the average percentage compositions of the dressed carcasses, entire carcasses (live-weight basis), and gains in weight have been collected in Table 77. Altho in general the pigs in the first year's work were slightly fatter than those in the second year's work, the agreement thruout was remarkably good.

MEASUREMENT OF TYPE

Altho the types of the pigs used in the first experiment can be illustrated by photographs and can be described in a general way, it is obviously desirable in defining the material with which an experimental investigation is concerned to measure it in as accurate a manner as possible. So far as experimental feeds and rations are concerned, this is possible by means of chemical analysis, so that a mere description of feeds and rations may well be considered as a poor substitute for a quantitative definition.

TABLE 76.—COMPUTED PERCENTAGE COMPOSITION OF GAINS IN LIVE WEIGHT TO DIFFERENT SLAUGHTER WEIGHTS: SECOND EXPERIMENT

Gain in weight from—	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per pound
		ORIGINAL BASIS			
		Type A—Very Chuffy			
lbs.	*pct.*	*pct.*	*pct.*	*pct.*	*cals.*
55 to 175	54.3	10.2	42.0	2.13	2 050
55 to 225	56.6	8.4	45.8	1.61	2 070
		Type C—Intermediate			
70 to 175	52.6	11.3	37.7	2.86	1 850
70 to 225	57.1	10.6	43.7	2.23	2 090
70 to 275	60.9	9.5	49.9	2.04	2 310
		Type D—Rangy			
70 to 175	53.9	10.4	40.3	2.64	1 940
70 to 225	51.7	11.4	38.0	2.19	1 870
70 to 275	58.8	10.7	45.8	2.27	2 190
		FAT-FREE BASIS			
		Type A—Very Chuffy			
55 to 175	21.2	17.6	....	3.67	....
55 to 225	19.9	15.5	....	2.97	....
		Type C—Intermediate			
70 to 175	23.9	18.1	....	4.59	....
70 to 225	23.8	18.8	....	3.96	....
70 to 275	22.0	19.0	....	4.07	....
		Type D—Rangy			
70 to 175	22.8	17.4	....	4.42	....
70 to 225	22.1	18.4	....	3.53	....
70 to 275	24.0	19.7	....	4.19	....
Average	22.5	18.1	....	3.93	....

No quantitative method of measuring experimental animals is in general use. It is true that in most of the experimental work involving farm animals the object is to test the feed rather than the animal, so that an accurate description of the animal is not so essential as that of the feed. But in experiments such as the one under discussion, in which the relative capacities of different types of animals are being studied, it obviously becomes a matter of importance to the significance of the results obtained to measure the type or conformation of the animals included in the different groups.

TABLE 77.—COMPARISON OF THE 225-POUND PIGS IN THE TWO EXPERIMENTS

Type	Experiment	Dry substance	Crude protein (Nx6.0)	Fat	Ash	Gross energy per gram
			Dressed carcass			
		pct.	*pct.*	*pct.*	*pct.*	*sm. cals.*
A.....	2	62.2	9.9	49.2	2.21	4 960
B.....	1	62.3	13.1	45.1	2.73	5 060
C.....	1	64.3	13.3	46.3	2.71	5 110
C.....	2	60.6	11.6	45.1	2.52	4 830
D.....	1	62.2	13.6	44.4	2.93	4 970
D.....	2	55.9	12.3	40.2	2.73	4 420
			Live pig			
A.....	2	51.6	9.4	39.4	1.80	4 070
B.....	1	48.4	10.9	34.2	2.05	3 900
C.....	1	50.5	11.2	35.6	2.06	4 000
C.....	2	51.4	10.9	37.1	2.24	4 050
D.....	1	49.2	11.5	34.1	2.24	3 900
D.....	2	47.4	11.6	33.0	2.24	3 710
			Gain			
A.....	2	56.6	8.4	45.8	1.61	2 070
B.....	1	53.8	10.9	40.0	1.95	2 297
C.....	1	56.9	11.1	42.1	1.96	2 319
C.....	2	57.1	10.6	43.7	2.23	2 090
D.....	1	56.1	11.4	41.2	2.22	2 252
D.....	2	51.7	11.4	38.0	2.19	1 870

With this conviction an attempt was made to apply to swine, in a modified form, a measurement of type that has been worked out by Yapp for dairy cattle at the Wisconsin Agricultural Experiment Station.[1] A type index is computed which measures the proportion the animal would fill of a rectangular solid determined by the animal's major dimensions. The dimensions chosen for dairy cattle were the height at withers (H) and the horizontal distance (L) from pinbone to point of shoulder. The type index is taken as the ratio of the volume of a rectangular solid equal to $H^2 \times L$, to the volume of the animal obtained from its weight and its specific gravity. It was found that a calf one week of age occupies only 12.6 percent of the volume of such a rectangular solid, while at 22 months of age it occupies 21.2 percent. Evidently the change in conformation of the calf in this interval of time is reflected in the change in type index.

[1] Wis. Agr. Exp. Sta. Bul. 352, 25. 1923.

TABLE 78.—TYPE INDEXES OF THE CONTROL PIGS: SECOND EXPERIMENT

Pig No.	Live weight	Specific gravity	Volume of pig	Volume of box	Type index
		Type A—Very Chuffy			
	lbs.		*cu. in.*	*cu. in.*	*pct.*
21	57.4	.997	1 594	3 536	45.1
22	57.6	.986	1 618	4 016	40.3
23	50.7	.977	1 435	3 646	39.4
24	53.4	.985	1 502	3 548	42.3
25	49.0	.996	1 363	3 693	36.9
Average	53.6	.988	1 502	3 688	40.8
		Type C—Intermediate			
3	66.5	.977	1 887	5 154	36.6
21	70.9	.981	2 003	5 640	35.5
22	71.1	.988	1 994	5 396	37.0
23	68.9	.979	1 951	5 499	35.5
24	75.6	.979	2 138	5 422	39.4
Average	70.6	.983	1 995	5 422	36.8
		Type D—Rangy			
21	69.2	.933	2 054	6 031	34.1
22	73.5	.879	2 317	6 716	34.5
23	76.7	.932	2 278	6 682	34.1
24	68.7	.965	1 974	6 151	32.1
25	74.7	.984	2 104	5 786	36.4
Average	72.6	.939	2 145	6 273	34.2

In applying this conception of a type index to swine it was thought advisable to relate the volume of the pig to the volume of a solid more closely restricted to the dimensions of the pig than the solid used for dairy cattle. The plan adopted was to refer the volume of the pig to the volume of a rectangular box into which the pig would just fit. The length of the box would be determined by the maximum length of the pig from snout to root of tail. Its height would be determined by the maximum height of the pig and its width by the maximum width of the pig.

These measurements of the pigs were taken with a tape and a caliper made for the purpose. The pig was thrown on its side[1] on a level floor and the maximum measurements were taken with the pig in this position. In the first measurements made the maximum height of the pig was taken as the height at the rear, but in the later measurements the maximum height of the back with the legs stretched straight was taken. The maximum length was the distance along the head and back from the end of the snout to the root of the tail.

[1] At the time of slaughter the pig was measured immediately after being stuck and before being scalded.

TABLE 79.—TYPE INDEXES OF THE 175-POUND PIGS: SECOND EXPERIMENT

Pig No.	Live weight	Specific gravity	Volume of pig	Volume of box	Type index	Estimated initial type index
			Type A—Very Chuffy			
	lbs.		*cu. in.*	*cu. in.*	*pct.*	*pct.*
6	167.0	.953	4 855	11 442	42.4	34.8
9	183.8	.971	5 242	11 747	44.6	41.3
16	190.7	.953	5 542	12 992	42.7	38.7
18	177.9	.954	5 168	13 107	39.4	41.9
19	178.9	.963	5 146	11 568	44.5	42.4
20	167.0	.963	4 805	10 724	44.8	43.8
Average	177.6	.960	5 126	11 930	43.1	40.5
			Type C—Intermediate			
3	183.6	.972	5 232	14 910	35.1	29.2
5	170.9	.968	4 889	12 588	38.8	35.5
13	182.6	.957	5 286	13 057	40.5	35.0
Average	179.0	.966	5 136	13 518	38.1	33.2
			Type D—Rangy			
14	169.9	.960[1]	4 903	14 857	33.0	37.5
15	188.2	.960[1]	5 429	15 800	34.4	35.6
20	174.9	.960	5 045	13 941	36.2	31.4
Average	177.7	.960	5 126	14 866	34.5	34.8

[1]An assumed specific gravity, because of an error in the determination.

The specific gravity of the pigs was determined after slaughter. After being bled, scalded, and scraped, the carcass of each pig was lowered into a cylindrical tank made with as small a diameter as practicable, and the rise in water level was measured on a glass gauge running the length of the tank on the outside. From a previous calibration of the tank the volume of the carcass could be readily calculated from the rise in the water level. The volume of the live pig was estimated from that of the carcass by adding the volume of the blood, assuming the specific gravity of the blood to be 1.06. No allowance was made for the volume of the hair and scurf.

The results obtained on the four groups of slaughtered pigs are summarized in Tables 78, 79, 80, and 81. In addition to the type indexes of the slaughtered pigs indexes were computed for all animals at the start of the experiment from measurements upon each animal and volume estimates based on the live weight of the pig and the average specific gravity of the control pigs for that type as actually determined after slaughter. These estimates of the initial type indexes are included in the last column of Tables 79, 80, and 81.

TABLE 80.—TYPE INDEXES OF THE 225-POUND PIGS: SECOND EXPERIMENT

Pig No.	Live weight	Specific gravity	Volume of pig	Volume of box	Type index	Estimated initial type index
	lbs.		*cu. in.*	*cu. in.*	*pct.*	*pct.*
Type A—Very Chuffy						
11	226.1	.946	6 622	15 100	43.9	37.0
15	208.2	.971	5 941	13 513	44.0	41.9
17	234.8	.955	6 812	14 623	46.6	35.9
Average	223.0	.957	6 458	14 412	44.8	38.3
Type C—Intermediate						
1	218.6	.990	6 119	15 802	38.7	34.0
2	228.2	.940	6 724	16 446	40.9	34.5
9	224.0	.970	6 398	15 542	41.2	34.4
15	224.4	.968[1]	6 421	17 541	36.6	37.6
18	239.2	.964	6 874	17 425	39.4	26.5
19	223.8	.963	6 442	15 944	40.4	32.2
20	235.0	.981	6 634	16 940	39.2	33.2
Average	227.6	.968	6 516	16 520	39.5	33.2
Type D—Rangy						
2	221.1	.964[1]	6 354	16 689	38.1	32.8
5	232.4	.938	6 863	17 433	39.4	32.7
8	219.9	.978	6 227	16 625	37.5	33.3
9	228.4	.987	6 409	17 325	37.0	30.2
11	240.4	.965	6 901	18 048	38.2	31.8
16	225.3	.968	6 447	17 181	37.5	33.1
Average	227.9	.967	6 534	17 217	38.0	32.3

[1]An average specific gravity is assumed.

Apparently the type index chosen is larger the chuffier the type of pig, as would be expected from the method of its computation. It is also evident that for the same type the index increases as the animal fattens. This also is to be expected. However, the variations noted are not large in comparison with the index itself or in comparison with the variations obtained within any one type at any one weight. These latter variations are difficult to explain except on the basis of errors in the measurements of the pigs, and to anyone acquainted with the difficulties of measuring a live pig the possibility of considerable error, particularly in determining the maximum width and maximum height, will be readily appreciated.

Therefore, until a better method of obtaining the required measurements on pigs is perfected, or until the selection of other suitable measurements more accurately obtainable is made, the type indexes of individual animals cannot be considered very accurate measurements upon which, for example, selections for small differences in

TABLE XI.—TYPE INDEXES OF THE 275-POUND PIGS. SECOND EXPERIMENT

Pig No.	Live weight	Specific gravity	Volume of pig	Volume of box	Type index	Estimated initial type index
Type A—Very Chuffy						
2	Lbs. 276.8	.957[a]	Cu. in. 8.660	Cu. in. 18.188	per. 46.0	per. 42.8
Type C—Intermediate						
10	285.9	.945	8.318	19.024	42.8	32.6
12	279.1	.934	8.278	20.029	41.3	36.2
16	276.3	.951	8.050	19.928	43.0	35.3
17	285.8	.963	8.224	21.018	39.1	35.0
Average	281.3	.948	8.218	20.075	41.0	34.8
Type D—Rangy						
1	267.7	.970	7.844	20.788	36.8	29.3
3	271.1	.952	7.880	20.204	38.1	33.1
6	280.2	.958	8.119	23.876	34.0	29.4
10	275.8	.961	7.946	21.127	37.6	33.9
13	269.0	.942	7.910	20.971	37.7	36.8
Average	272.7	.955	7.902	21.393	37.0	32.9

[a] An average specific gravity is assumed.

type may safely be made. Possibly they are even less accurate for this purpose than naked-eye ratings. However, the average index for a group of animals must be conceded a much greater degree of accuracy, and as a quantitative description of the type or conformation of the pigs as a group it is in all probability of more value than a worded description, a group photograph, or a group of individual photographs.

We may say, therefore, that the Very Chuffy pigs at the start of the experiment possessed an index of 40.8. At a weight of 175 pounds the type index had increased to 42.1, and at 225 pounds, to 44.8.

The Intermediate type pigs started with an index of 36.8. At 175 pounds it was 38.1; at 225 pounds, 39.5; and at 275 pounds, 41.0. Eight self-fed pigs of this type slaughtered at 225 pounds gave an average type index of 39.9, agreeing closely with the average at this weight for the hand-fed pigs.

The Rangy pigs possessed an initial type index of 34.2, one of 32.3 at 175 pounds, 33.1 at 225 pounds, and 37.0 at 275 pounds. Ten self-fed pigs of this type slaughtered at the 225-pound weight gave an average type index of 38.1.

A group of 9 self-fed pigs of the Chuffy type slaughtered and examined at 225 pounds possessed an average type index of 42.7, compared with indexes at the same weight of 44.8 for the Very Chuffy hand-fed pigs and 39.5 for the Intermediate hand-fed pigs. A group

of 5 self-fed. Very Rangy pigs (Type E) examined at this weight gave an average index of 92.3, practically the same as that for the Rangy hand-fed pigs. It would appear that at this weight the better condition of the self-fed Very Rangy pigs offset the difference between the Very Rangy and Rangy types.

DIGESTIBILITY AND METABOLIZABLE ENERGY OF THE FATTENING RATION

Three pigs of the Intermediate type and three of the Rangy were used in the determination of the digestibility of the fattening ration and its content of metabolizable energy. The metabolism experiments were performed on these pigs shortly after they had reached a weight of 225 pounds; at the conclusion of the metabolism experiments they were put upon a maintenance experiment, the results of which have already been considered.

The ration used in four of these metabolism experiments was practically the same as the average ration fed thruout the fattening period and as the rations used in the maintenance trials, that is, approximately 4 parts of yellow corn to 1 part of a ground mixture containing 3 parts of wheat middlings, 4 parts of tankage, and 1 part of alfalfa meal. In two of the experiments, however, upon the heaviest pigs (Pig 4 of the Rangy type and Pig 8 of the Intermediate type) the ratio of corn to mixture was approximately 6 to 1.

The coefficients of digestibility obtained, computed in the ordinary way, are summarized in Table 32, while a comparison of the average coefficients obtained for the young maintenance pigs, the fat maintenance pigs, and the fattening pigs is given in Table 33.

The average digestion coefficients for the pigs on full feed are in good agreement with those obtained with the fat maintenance pigs except for the coefficients for fat. The young maintenance pigs gave low coefficients for dry matter, crude protein, and crude fiber. A probable explanation of these abnormally low results is suggested from the average composition of the feces for these three groups of pigs given in Table 34.

The high ash content of the feces of the young maintenance pigs is notable and is probably due to a retention in the alimentary tract of large amounts of cinders obtained from the dry lot in which they were fed previous to being placed in the metabolism crates. Definite indications of a disturbance in the digestion of protein and of crude fiber brought about by the presence of these cinders may be seen. The low coefficient of digestibility of dry matter is also explained.

In Table 35 the metabolizable energy of the ration, expressed in different ways, is given, together with the experimental data from which it was calculated. Per kilogram of dry matter the metabolizable energy averaged 4.36 therms for the fat pigs on full feed, 4.35

TABLE 82.—COEFFICIENTS OF DIGESTIBILITY OF THE FATTENING RATION: SECOND EXPERIMENT

Pig No.	Daily ration: Corn	Daily ration: Mixture[1]	Dry substance	Crude protein	N-free extract	Crude fiber	Fat
			Type C—Intermediate				
	grams	*grams*	*pct.*	*pct.*	*pct.*	*pct.*	*pct.*
6	2 100	510	82	69	90	35	59
8	3 140	530	80	68	88	23	51
11	2 000	500	83	73	89	39	61
			Type D—Rangy				
4	2 690	455	86	79	91	48	81
12	3 065	735	82	71	89	36	53
19	2 925	730	82	74	90	25	52
Average	.....	....	82.5	72.4	89.5	34.3	59.5

[1]Consisting of 8 parts of wheat middlings, 4 parts of tankage, and 1 part of alfalfa meal.

TABLE 83.—AVERAGE DIGESTION COEFFICIENTS OF THE RATION FOR THE THREE GROUPS OF PIGS STUDIED

Group	Dry substance	Crude protein	N-free extract	Crude fiber	Fat
	pct.	*pct.*	*pct.*	*pct.*	*pct.*
Young maintenance pigs	69.6	65.0	86.6	−.3	70.3
Fat maintenance pigs	83.3	77.6	89.6	33.3	71.9
Fat pigs on full feed	82.5	72.4	89.5	34.3	59.5

TABLE 84.—AVERAGE COMPOSITION OF FECES FOR THE THREE GROUPS OF PIGS: SECOND EXPERIMENT

Group	Dry substance	Crude protein	N-free extract	Crude fiber	Fat	Ash	Gross energy per gram
	pct.	*pct.*	*pct.*	*pct.*	*pct.*	*pct.*	*sm. cals.*
Young maintenance pigs	49.6	8.56	16.08	6.35	1.77	16.71	1 797
Fat maintenance pigs	34.8	7.24	16.16	4.30	1.47	5.98	1 527
Fat pigs on full feed	30.4	6.56	13.91	3.95	2.51	3.49	1 399

therms for the fat pigs on a maintenance ration, and 3.29 therms for the young pigs on a maintenance ration. Per pound of digestible organic matter, the metabolizable energy for the three groups of pigs was 1.86, 1.89, and 1.94 therms respectively. The metabolizable energy of the ration expressed as a percentage of the gross energy was 78.0, 79.4, and 73.2 for these three groups of pigs in the order given.

The nitrogen balance sheets of the six fat pigs on full feed during the ten-day collection periods will be found in Table 86.

TABLE 85.—METABOLIZABLE ENERGY OF THE FATTENING RATION: SECOND EXPERIMENT

Pig No.	Body weight	Dry substance consumed	Digestible organic matter	Energy of feed consumed	Energy of feces	Energy of urine[1]	Metabolizable energy			
							Total per day	Per kg. dry substance	Per lb. of digestible organic matter	Percent of gross energy
Type C—Intermediate										
	lbs.	*kgs.*	*lbs.*	*therms*	*therms*	*therms*	*therms*	*therms*	*therms*	*pct.*
6	220	2.186	3.92	9.517	1.771	.345	7.40	3.39	1.89	77.8
8	262	2.756	4.82	11.589	2.590	.264	8.73	3.17	1.81	75.4
11	233	2.163	3.91	9.421	1.758	.284	7.38	3.41	1.89	78.3
Type D—Rangy										
4	273	2.787	5.24	11.760	1.723	.553	9.48	3.40	1.81	80.6
12	233	3.107	5.55	13.523	2.591	.450	10.48	3.37	1.89	77.5
19	260	3.245	5.80	13.760	2.534	.401	10.82	3.34	1.87	78.7
Average	.....	.....		.....	.....	.....	.....	3.35	1.86	78.0

[1]Corrected to N equilibrium by the use of Rubner's factor of 7.45 calories per gram of nitrogen.

TABLE 86.—NITROGEN BALANCES OF THE FAT PIGS ON FULL FEED: SECOND EXPERIMENT

Pig No.	Nitrogen of feed consumed	Nitrogen of feces	Nitrogen of urine	Nitrogen balance
		Type C—Intermediate		
	grams	*grams*	*grams*	*grams*
6	46.24	14.08	21.85	10.31
8	60.48	19.36	27.93	13.19
11	45.92	12.16	14.56	19.20
		Type D—Rangy		
4	58.88	12.64	29.04	17.20
12	66.56	19.68	33.35	13.53
19	75.52	19.52	37.62	18.38

RELATION OF FEED CONSUMED ABOVE MAINTENANCE TO GROSS ENERGY OF GAINS

For the 13 pigs slaughtered at weights approximating 225 pounds the relation between the amount of feed consumed above the estimated maintenance requirements and the estimated gross energy content of the gains has been computed, with the same reservations concerning its significance that have already been explained in connection with similar computations of the preceding experiment. The results will be found in Table 87. The maintenance requirements have been taken from the results of the maintenance trials of the experiment of the first year, for reasons explained elsewhere (page 544). The requirement for Chuffy pigs of that experiment has been applied to the Very Chuffy pigs of this experiment.

As an average for the 13 pigs it appears that each 100 pounds of ration consumed above the estimated maintenance requirement produced a storage of 74.8 therms of gross energy in the carcasses of the growing and fattening pigs. This is lower than the average value for the 45 pigs of the preceding experiment, 89.5 therms, and is much lower than would be expected from Armsby's estimates of the net energy value of the ration for swine.

The average metabolizable energy content of the ration, as determined from the three groups of pigs upon which digestion trials were run, involving 23 individual pigs, is 3.35 therms per kilogram of dry matter. The average dry matter content of the ration is 85.32 percent, so that metabolizable energy per kilogram of ration is 2.86 therms, or 129.9 therms per 100 pounds. If 100 pounds of the ration possessed a net energy value of 74.8 therms for these fattening pigs, the percentage availability of the metabolizable energy would be 57.6. This is considerably less than the percentage estimated by Armsby, 78.14, but approximates the expected performance of the steer.

TABLE 87.—NET ENERGY COMPUTATIONS FOR THE 225-POUND HAND-FED PIGS: SECOND EXPERIMENT

	Type A—V. C.		Type C—Intermediate						Type D—Rangy				
	11	17	1	2	9	15	18	19	2	5	8	9	16
	lbs.												
Final weight	226	235	219	228	224	224	230	224	221	232	220	228	225
Initial weight	57	59	69	69	73	69	78	72	67	68	70	72	76
Gain	169	176	150	159	151	155	161	152	154	164	150	156	149
Average weight	125.3	129.1	136.2	138.9	139.5	138.3	153.9	133.1	129.4	136.0	131.5	142.9	144.9
Days on experiment	(173)	(186)	(172)	(149)	(131)	(143)	(131)	(138)	(128)	(152)	(135)	(137)	(137)
Maintenance feed per day													
Per 100 pounds	1.41	1.41	1.21	1.21	1.21	1.21	1.21	1.21	1.31	1.31	1.31	1.31	1.31
Per head	1.77	1.82	1.65	1.68	1.69	1.67	1.86	1.61	1.70	1.78	1.72	1.87	1.90
Total feed	726	797	758	727	613	662	703	625	623	696	608	642	631
Total feed for maintenance	306	339	284	250	221	239	244	222	218	271	232	256	260
Total feed consumed above maintenance	420	458	474	477	392	423	459	403	405	425	376	386	371
	therms												
Gross energy of gain	330	387	327	386	294	317	318	309	315	319	240	278	276
Net energy: Gross energy of gain per 100 pounds feed consumed above maintenance	79	84	69	81	75	75	69	77	78	75	64	72	74

Admittedly the calculations discussed in this section are indirect and are based upon questionable assumptions. The average direct experimental data for the group of 13 pigs are as follows: in a feeding period of 147 days a pig averaging 137 pounds in weight consumed 678 pounds of the experimental ration containing 807 therms of metabolizable energy. This amount of metabolizable energy sufficed to cover the pig's maintenance requirements and to produce a gain in body tissue containing 315 therms of gross energy. The conclusion that the energy gained represented only 57.6 percent of the metabolizable energy used for that purpose depends upon the validity of the assumption that the metabolizable energy required per unit of weight for maintenance is the same in the period of full feed as in the period of maintenance feeding.

In the present state of knowledge of energy metabolism it seems profitless to discuss the probable accuracy of this assumption and of the conclusion based upon it. However, other evidence may be cited to the effect that the percentage utilization of feed energy by swine is greatly exaggerated in Armsby's estimate of the net energy value of feed for this species.

In Research Bulletin 73 of the Missouri Agricultural Experiment Station Hogan, Weaver, Edinger, and Trowbridge report the results of an experiment designed to determine the relation of feed consumed to energy retention in swine. Sixteen pigs were slaughtered at weights ranging from 100 to 300 pounds, and the carcasses were submitted to complete chemical analysis. By comparing the energy content of pigs of different weights, estimates were made of the corresponding gains in energy, and from the amounts of feed consumed in the time required for these gains, the net energy consumed was estimated by employing Armsby's values.[1] Upon deducting from the estimated net energy intakes the estimated gross energy contents of the gains, estimates were secured of the net energy required for maintenance. These estimates, expressed per square meter of body surface per day, averaged approximately 3,000 calories. Now the basal metabolism of the pig may be taken roughly as 1,000 calories per square meter per day.[2] It seems extremely improbable that the requirement of energy of the active pig for maintenance should be three times its basal heat production. For example, a pig weighing 100 pounds (surface area 1.097 square meters, according to Hogan *et al*) standing 12 hours out of the 24, with an assumed increased energy expenditure of 20 percent, would have to travel 36 miles a day at a lively canter for a pig in

[1] Armsby, H. P. The nutrition of farm animals, 722.

[2] Deighton, T. Roy. Soc. (London) Ser. B. Proc. **95**, 340. 1923.
Rapport, D., Weiss, R., and Csonka, F. A. Jour. Biol. Chem. **60**, 583. 1924.
Wierzuchowski, M., and Ling, S. M. Jour. Biol. Chem. **64**, 697. 1925.
Wood, T. B. Jour. Agr. Sci. **16**, 425. 1926.
Armsby, H. P. The nutrition of farm animals, 285.

order to expend the equivalent of 3,000 calories per square meter of body surface daily.[1] It may be doubted whether a fattening pig would exhibit this much activity or anything approximating it.

Hence the estimate that the maintenance requirement of these pigs averaged 3,000 calories daily per square meter of surface may be considered much too high. In inquiring concerning the source of error it appears reasonable to suppose that it is directly traceable to an excessive estimate of the net energy intake of the pigs based upon Armsby's net energy values and, therefore, that these estimates are themselves much too high. This is the conclusion to which the data of these type experiments also point rather definitely.

In examining critically the experimental evidence upon which Armsby based his estimates of the heating effect of food on swine (*loc. cit.*, 653-656), the necessity of assuming thruout an average value for the fasting catabolism with which to compare the heat production on feed must detract considerably from the accuracy of the estimates made. Furthermore, this method is not analogous to the method used for cattle, in which the heat production of periods on different levels of feed is compared, since it involves the heating effect of the food consumed rather than the heating effect of increments of food imposed upon a basal amount. When the method applied to swine by Armsby is applied to steers, much smaller heat increments per unit of feed than those reported by Armsby are obtained.[2]

The heat increments thus computed for swine are not particularly concordant among themselves, and the differences obtained between different feeds are frequently so unexpected as to constitute circumstantial evidence of the unreliability of the method of computation or of the data to which it has been applied. The extremely high heating effect of palm oil and the greater heating effect of straw pulp than of wheat gluten may be cited in this connection. The fact that no experimental data are available on the heating effect of most of the feeds whose net energy values have been estimated may also be mentioned. For these reasons it must be concluded that no satisfactory estimates of the net energy value of feeds for swine are at present available.

NUTRIENT REQUIREMENTS OF PIGS

The most satisfactory estimate of the nutrient requirements of growing and fattening pigs, in terms of the expenditure and storage of nutrients in the body of the pig rather than in terms of digestible

[1] Assuming a very liberal expenditure in horizontal locomotion of .8 small calories per kilogram of weight per meter traveled.

[2] Forbes, E. B., Fries, A. J., Braman, W. W., and Kriss, Max. Jour. Agr. Res. 33, 489, Table 4. 1926.

food nutrients,[1] should be based upon established relations between (1) age and body weight, (2) body weight and chemical composition, and (3) age (or weight) and the minimum expenditures of nutrients compatible with the maintenance of life. The data secured in the swine-type studies described in the preceding pages afford information with respect to relations 1 and 2. Other published investigations also throw light upon these points and also, to some extent, upon relation 3. It appears possible, therefore, by the use of all available information to reach some definite, tho evidently only tentative, conclusions concerning the nutrient requirements of fattening pigs.

RELATION OF WEIGHT TO AGE

For growth alone it should be possible to establish a significant relationship for each species or breed of animals between age and weight were it not for the fact that for many of the different "improved" breeds of farm animals growth is usually accompanied by what must be considered physiologically as an excessive deposition of fat. A certain rate of fat deposition is undoubtedly associated with normal growth. Hence with animals such as swine, that readily fatten during growth, it is difficult to decide just how great a rate of fat deposition is essential for normal growth; and since excess fat may be deposited at greatly varying rates, observed relationships between age and weight in the case of swine are lacking in definite significance. No "normal growth curve" for swine can be justified as such without a demonstration that excessive fat deposition did not occur in animals from which the data were secured, while no age-weight curve for growing and fattening swine can possess a definite meaning unless it represents the maximum performance.

For these reasons nothing definite is known concerning the normal growth rate for swine and no normal rate of fattening can be said to exist. The time relations of these processes have thus defied standardization. A comparison of the age-weight relation of the individually fed pigs of the swine-type studies with that published by the Missouri Agricultural Experiment Station is of importance to the later discussion. Such a comparison will be found in Table 88.

In the experiment of the second year the withdrawal of pigs for slaughter was started when the pigs were about 28 weeks of age. Since the animals thus removed were generally among the heaviest of their respective groups, an attempt has been made, by removing from consideration also correspondingly lighter pigs, to obtain average weights fairly representative of the ages given.

Considerable differences in the rate of weight increase occurred

[1] Mitchell, H. H. The determination of the protein requirement of animals and of the protein values of farm feeds and rations. Bul. Natl. Research Council. 11, Part I, No. 55. 1926.

TABLE 88.—AGE-WEIGHT RELATION FOR GROWING AND FATTENING SWINE
(All weights in pounds)

Age in weeks	Illinois swine-type study												Selected average from two experiments[1]		Missouri data[2]	
	First experiment						Second experiment									
	Type B		Type C		Type D		Type A		Type C		Type D					
	No. of pigs	Average weight	No. of pigs	Average weight	No. of pigs	Average weight	No. of pigs	Average weight	No. of pigs	Average weight	No. of pigs	Average weight	No. of pigs	Average weight	No. of pigs	Average weight
		lbs.		*lbs.*		*lbs.*		*lbs.*		*lbs.*		*lbs.*		*lbs.*		*lbs.*
14	....	....	....	....	....	....	19	54	18	70	20	67	....	....	44	59.1
15	20	70	20	62	20	62	19	58	18	75	20	70	78	69	44	67.6
16	....	....	....	....	....	....	20	61	18	80	20	76	78	73	44	71.8
17	20	77	20	67	20	66	....	....	....	....	....	....	78	77	44	77.3
18	....	....	....	....	....	....	19	69	19	91	20	85	70	82	44	85.1
19	20	86	20	78	20	73	....	....	....	....	....	....	79	88	44	92.7
20	....	....	....	....	....	....	20	78	19	105	20	99	79	95	44	104
21	20	99	20	91	20	82	....	....	....	....	....	....	79	102	44	109
22	....	....	....	....	....	....	20	90	19	120	20	113	79	109	44	117
23	20	111	20	105	20	93	....	....	....	....	....	....	79	116	44	125
24	....	....	....	....	....	....	20	102	19	134	20	127	79	122	44	135
25	20	124	20	120	20	103	....	....	....	....	....	....	79	130	44	145
26	....	....	....	....	....	....	20	115	19	149	20	145	79	139	44	154
27	20	144	20	139	20	118	....	....	....	....	....	....	....	146	44	163
28	....	....	....	....	....	....	....	....	....	....	....	....	....	152	44	172
29	20	158	20	156	20	131	....	....	....	....	....	....	....	159	44	184
30	....	....	....	....	....	....	20	131	16	173	17	158	73	166	44	192
31	20	178	20	175	20	150	....	....	....	....	....	....	....	176	....	....
32	....	....	....	....	....	....	20	150	15	194	17	176	72	187	....	....
33	20	202	20	200	20	172	....	....	....	....	....	....	....	197	....	....
34	....	....	....	....	....	....	18	168	11	208	13	197	44	205	....	....
35	....	....	20	218	20	189	16	180	10	210	13	211	43	216	....	....
36	....	....	....	....	....	....	11	193	....	....	....	....	....	....	....	....
37	....	....	....	....	....	....	10	199	....	....	....	....	....	....	....	....
38	....	....	....	....	....	....	10	211	....	....	....	....	....	....	....	....
39	....	....	....	....	....	....	9	221	....	....	....	....	....	....	....	....

[1]Averages of all pigs except the Type D pigs of the first experiment and the Type A pigs of the second experiment. The remaining four groups were averaged as groups, larger groups receiving no greater weight than smaller. For weeks in which all pigs were not weighed, interpolated values were used. [2]Mo. Agr. Exp. Sta. Res. Bul. 62, 39.

TABLE 89.—COMPILATION OF DATA ON PERCENTAGE COMPOSITION OF PIGS AT DIFFERENT BODY WEIGHTS, ON LIVE-WEIGHT BASIS

Approximate weight	Illinois data						U. S. D. A. data[1]					Missouri data[2]				
	No. of pigs	Dry matter	Crude protein (Nx6.25)	Fat	Ash	Gross energy per gram	No. of pigs	Dry matter	Crude protein (Nx6.25)	Fat	Ash	No. of pigs	Dry matter	Crude protein (Nx6.25)	Fat	Ash
lbs.		*pct.*	*pct.*	*pct.*	*pct.*	*cals.*		*pct.*	*pct.*	*pct.*	*pct.*		*pct.*	*pct.*	*pct.*	*pct.*
1.8 (birth)	....	....	....	....	....	....	....	....	....	....	....	4[3]	20.3	14.2	2.0	4.1
15	....	....	....	....	....	....	7	34.1	13.9	17.3	3.1	....	....	....	....	....
35 (weaned)	....	....	....	....	....	....	7	30.3	14.2	13.0	3.4	....	....	....	....	....
55 to 70	30	36.1	12.3	20.3	2.3	2.63	7	32.9	14.9	15.5	3.1	....	....	....	....	....
100	....	....	....	....	....	....	7	41.0	14.4	24.1	3.0	2	40.2	13.9	15.6	2.8
150	....	....	....	....	....	....	....	....	....	....	....	2	47.5	12.9	25.5	2.6
160	....	....	....	....	....	....	9	48.5	13.5	32.6	2.8	....	....	....	....	....
175	12	47.9	11.5	33.6	2.4	3.76	....	....	....	....	....	....	....	....	....	....
200	....	....	....	....	....	....	....	....	....	....	....	2	49.4	13.8	28.2	2.5
215	....	....	....	....	....	....	9	54.1	12.1	39.8	2.4	....	....	....	....	....
225	58	49.5	11.6	34.9	2.1	3.93	....	....	....	....	....	....	....	....	....	....
250	....	....	....	....	....	....	....	....	....	....	....	2	52.5	12.4	33.1	2.6
275	10	54.1	11.0	40.9	2.2	4.38	....	....	....	....	....	....	....	....	....	....
300	....	....	....	....	....	....	....	....	....	....	....	2	58.9	11.4	41.5	2.0

[1]Ellis, N. R., and Hankins, O. G. Jour. Biol. Chem. **66**, 101, 1925. [2]Hogan, A. G., Weaver, L. A., Edinger, A. T., and Trowbridge, E. A. Mo. Agr. Exp. Sta. Res. Bul. 73. 1925. [3]Cited in Armsby, H. P., and Moulton, C. R. The animal as a converter of matter and energy, Table 18, 51. New York. 1925. Includes some analyses by other than Missouri workers.

TABLE 90.—COMPILATION OF DATA ON PERCENTAGE COMPOSITION OF PIGS AT DIFFERENT BODY WEIGHTS, ON EMPTY FAT-FREE BASIS

Approximate weight	Illinois data				U. S. D. A. data[1]				Missouri data			
	No. of pigs	Dry matter	Crude protein (Nx6.25)	Ash	No. of pigs	Dry matter	Crude protein (Nx6.25)	Ash	No. of pigs	Dry matter	Crude protein (Nx6.25)	Ash
lbs.		*pct.*	*pct.*	*pct.*		*pct.*	*pct.*	*pct.*		*pct.*	*pct.*	*pct.*
1.8 (birth)	....	....	....	....	....	....	....	....	4	18.7	12.7	4.2
15	....	....	....	....	7	21.6	17.9	3.9	....	....	....	....
35 (weaned)	....	....	....	....	7	22.6	18.5	4.3	....	....	....	....
55	5	22.5	17.6	3.3	....	....	....	....	....	....	....	....
65	15	20.9	16.3	3.0	7	22.7	18.9	3.9	....	....	....	....
70	10	23.3	17.6	3.3	....	....	....	....	....	....	....	....
100	....	....	....	....	7	24.3	20.0	4.1	2	21.6	18.3	3.7
150	....	....	....	....	....	....	....	....	2	21.8	19.2	3.9
160	....	....	....	....	9	25.3	20.8	4.4	....	....	....	....
175	12	23.8	19.0	4.0	....	....	....	....	....	....	....	....
200	....	....	....	....	....	....	....	....	2	24.5	20.6	3.8
215	....	....	....	....	9	25.3	21.2	4.2	....	....	....	....
225	58	24.5	19.5	3.6	....	....	....	....	....	....	....	....
250	....	....	....	....	....	....	....	....	2	24.3	19.8	4.1
275	10	23.8	19.9	3.9	....	....	....	....	....	....	....	....
300	....	....	....	....	....	....	....	....	2	25.9	20.5	3.7

[1]The U. S. Department of Agriculture results represent average analyses of the "analytical animal," that is, the sum of the chemical samples, rather than the empty animal. Since the difference in weight between the empty animal and the analytical animal may be considered as consisting largely of water, the percentages of dry matter, crude protein, and ash on the fat-free basis are slightly larger than the percentages that would have been obtained if the computation could have been made on the empty weight. The empty weights of the pigs are not reported.

TABLE 91.—COMPOSITION OF PIGS OF DIFFERENT WEIGHTS ON EMPTY FAT-FREE BASIS, FROM DATA OF WOOD

Animal No.	Age	Live weight	Fat content	Composition of fat-free empty animal		
				Dry matter[1]	Crude protein	Ash
	days	*lbs.*	*pct.*	*pct.*	*pct.*	*pct.*
7	26	14.8	15.7	23.3	19.0	4.3
20	24	14.1	18.5	19.4	16.4	3.0
29	26	16.0	14.5	19.0	15.6	3.4
3	57	28.0	12.7	21.0	17.3	3.7
4	100	61.0	8.7	21.6	18.0	3.6
8	141	105	14.2	23.4	19.4	4.0
31	186	164	15.5	25.1	21.2	3.9
11	206	208	26.6	29.1	25.1	4.1
9	78	34.5	10.5	22.9	17.4	5.4
2	119	97.0	14.9	21.9	17.8	4.1
32	164	140	16.0	22.6	18.2	4.5

[1]Determined indirectly by summation.

TABLE 92.—COMPARISON OF COMPOSITION OF SOWS AND BARROWS AT A WEIGHT OF APPROXIMATELY 225 POUNDS, ON LIVE-WEIGHT BASIS

Type	Sex	No. of pigs averaged	Percentage composition				Gross energy per gram
			Dry matter	Crude protein (Nx6.0)	Fat	Ash	
							sm. cals.
B	Sows	4	49.13	11.14	34.96	2.07	3 935
	Barrows	11	48.18	10.85	33.99	2.04	3 891
C	Sows	6	49.72	11.12	34.66	2.02	3 935
	Barrows	9	51.11	11.33	36.22	2.09	4 037
D	Sows	2	47.37	11.95	32.16	2.36	3 727
	Barrows	13	49.46	11.47	34.45	2.22	3 929

The recomputation of Wood's results on the empty fat-free basis brings them into essential agreement with the American data, as is evident from Table 91.

Thus the difference in the composition of pigs of different weights depends upon two factors. The most important factor is the fat content, which seems to be dependent primarily upon the system of feeding, particularly upon the amount of carbonaceous feed consumed above the requirements. The second factor is the varying composition of the protoplasmic tissues, which is unrelated to the method of feeding and probably dependent either upon the chronological age of the

animal or upon its physiological age as represented by the growth attained. Under the conditions of feeding represented in the American investigations reviewed, the protoplasmic composition of developing swine appears to reach approximate constancy ("chemical maturity") when a weight of 150 to 175 pounds is reached, so that pigs of greater weight will differ in composition in accordance with their fat content only.

The swine-type experiment of the second year affords the opportunity to determine whether the composition of sows differs materially from that of barrows. Among the 225-pound pigs examined in this experiment enough sows were included to make a comparison possible. The average results of sow and barrow analyses in the different types are summarized in Table 92.

Evidently no considerable sex difference existed. In this respect swine differ from poultry, i.e., pullets fatten more rapidly and grow more slowly than capons,[1] and also from cattle, i.e., heifers fatten more rapidly than steers.[2]

RELATION BETWEEN AGE AND MAINTENANCE REQUIREMENTS

The maintenance requirements of swine for any nutrient may be factored into the amount required to supply the basal (or minimal) expenditure and the amount required to supply the expenditure in the muscular activity more or less characteristic of the animal under usual farm conditions.

Considering energy requirements first, the basal energy expenditure of swine has been determined by Tangl,[3] who obtained an average value of 1,100 calories per day per square meter of body surface for two young growing animals about 7 months of age and weighing 40 to 50 kilograms, and an average value of 1,060 calories on the same basis for two animals about 15 months old and weighing 110 to 120 kilograms. These figures represent the heat production of pigs lying down, from 72 to 96 hours after the last meal. E. Voit[4] has recalculated the results of some earlier and less carefully controlled experiments of Meissl[5] on two adult fat hogs and has obtained values of 1,064 and 1,086 calories per square meter of surface per day.

Recently Deighton (*loc. cit.*) has studied the basal heat production of a pig at different ages and has found it to vary greatly and in much the same fashion as that of man. At birth and shortly after, it is low; it rises to a maximum, 70 percent above the adult level, at 4 months of age; and then decreases until 12 months of age, at which time only

[1] Mitchell, H. H., Card, L. E., and Hamilton, T. S. Ill. Agr. Exp. Sta. Bul. 278. 1926.

[2] Ill. Agr. Exp. Sta. Ann. Rpt. 1927-28, 99.

[3] Tangl, F. Biochem. Ztschr. 44, 252. 1912.

[4] Voit, E. Ztschr. Biol. 41, 113. 1901.

[5] Meissl, E. Ztschr. Biol. 22, 63. 1886.

TABLE 93.—METABOLIZABLE ENERGY REQUIRED FOR MAINTENANCE OF SWINE OF DIFFERENT AGES COMPARED WITH THEIR BASAL METABOLISM

Weight	Assumed age	Surface area[1]	Metabolizable energy required for maintenance	Basal metabolism per day	
				According to Deighton[2]	Assumed at 1,000 cals. per sq. m
lbs.	*mos.*	*sq. m.*	*cals.*		*cals.*
30	2	.433	620	571	433
50	3	.609	1 000	993	609
100	5	.966	1 860	1 623	966
150	6.5	1.266	2 570	1 914	1 266
200	8	1.534	3 140	1 988	1 534
250	9.5	1.780	3 570	2 051	1 780

[1]Computed by the Meeh formula, using Hogan and Skouby's constant of 777 (Jour. Agr Res. 25, 419, 1923.) [2]Taken from Deighton's curve (*loc. cit.*)

is the constant adult value of approximately 1,000 calories per square meter of surface attained. Later observations by Deighton, cited by Wood (*loc. cit.*), indicate considerable variability among different pigs, but the existence of a high level of basal metabolism at 4 months of age is confirmed.

The results of the two swine-type experiments reported herein permit a statement of the maintenance requirements of pigs of different age in terms of metabolizable energy on the assumption that the requirement per unit of weight from the 50-pound to the 225-pound pig varies in a linear fashion. A comparison of these values for pigs at different age and weight with estimates of the basal heat production is given in Table 93.

The amount of metabolizable energy required for maintenance is evidently a maximum figure for the net energy requirement that would be attained only if and when the metabolizable energy is 100 percent net available. It should be higher than the basal heat production for another reason, since it probably includes a considerable expenditure of energy for muscular activity, particularly horizontal locomotion. Hence the close agreement of the values in columns 4 and 5 of Table 93 for the 30- and 50-pound pigs is difficult to explain except on the basis of errors either in the estimation of the metabolizable energy requirement or in the basal metabolism. Since the former is based upon 15 determinations (Table 18), even tho indirect, while the latter is based upon direct observations on one pig only, it may perhaps be justifiable to accord the greater significance to the metabolizable energy value and to conclude that the basal metabolism of the young pig is not so intense per square meter of surface as Deighton's limited data would indicate. The adult level of basal metabolism is computed in the last column of the table.

TABLE 94.—DAILY EXCRETION OF URINARY NITROGEN BY SWINE SUBSISTING ON LOW-NITROGEN OR NITROGEN-FREE RATIONS

Body weight	Daily urinary nitrogen	Urinary N per kilogram body weight	Authority
kgs.	*grams*	*grams*	
10.9	.54	.050	McCollum and Steenbock[1]
14.3	.96	.067	McCollum and Hoagland[2]
16.8	.90	.054	McCollum and Steenbock
17.7	1.09	.062	McCollum and Hoagland
19.5	1.09	.056	McCollum and Steenbock
22.2	1.60	.072	McCollum and Hoagland
25.0	1.32	.053	Pfeiffer[3]
26.3	1.19	.045	Pfeiffer
37.2	1.61	.043	McCollum and Steenbock
38.1	2.00	.052	Mitchell and Kick[4]
38.1	1.88	.049	Mitchell and Kick
38.5	1.83	.047	McCollum and Steenbock
40.0	1.95	.049	Mitchell and Kick
41.0	1.54	.038	Morgan *et al*[5]
46.3	2.23	.048	McCollum and Hoagland
68.1	2.65	.039	McCollum and Steenbock
74.9	2.61	.035	McCollum and Steenbock

[1]Wis. Agr. Exp. Sta. Res. Bul. 21. 1912. [2]Jour. Biol. Chem. **16**, 305. 1913. [3]Jour. Landw. **33**, 149. 1885. [4]Unpublished data from Illinois Agricultural Experiment Station. [5]Landw. Vers. Sta. **75**, 1. 1914

For the older pigs the estimated metabolizable energy requirement exceeds the estimated basal metabolism to an increasing extent, until for the 200- and 250-pound pigs it is questionable whether the difference represents muscular work only. The former values are probably in excess of the net energy requirements for maintenance while the latter are undoubtedly below them.

The minimum expenditure of protein in maintenance is measured by the minimum output of urinary nitrogen on a nitrogen-free diet. Since muscular activity does not appreciably increase this expenditure if sufficient non-protein nutrients are being consumed, the uncertainty in deciding upon a representative amount of muscular activity in pigs of different size does not complicate the matter of protein requirements.

The results of a number of published and unpublished experiments on the urinary nitrogen output of pigs on low-nitrogen or nitrogen-free rations may be cited in this connection (Table 94). The arrangement is in the order of increasing body weight. In spite of the irregularity of the results per kilogram of body weight it is evident that as the weight of the pig increases, the minimum (endogenous) expenditure of nitrogen per unit of weight decreases. Thus for the pigs weighing from 10 to 20 kilograms the average loss of nitrogen in the urine is 58 milligrams per kilogram of body weight; for the pigs weighing 20 to 30 kilograms, it is 57 milligrams; for those weighing

30 to 40 kilograms, 48 milligrams; for those weighing 40 to 50 kilograms, 45 milligrams; and for those weighing over 50 kilograms, 37 milligrams. This is very nearly a linear decrease.

No data have been found that bear at all directly upon the minimum losses of minerals from the bodies of swine during maintenance.

NUTRIENT REQUIREMENTS OF PIGS OF DIFFERENT WEIGHT

On the basis of the more or less definite information above discussed an attempt has been made to formulate a statement of the daily requirements of protein, mineral matter, and energy by the growing and fattening pig. It has been necessary to make somewhat arbitrary estimates in certain cases and to smooth out in a somewhat arbitrary fashion what appear to be irregularities due to experimental error or to a lack of homogeneity in the experimental data. The final results are presented, therefore, as a purely tentative scheme subject to revision as more numerous, more representative, and more significant data accumulate.

The maintenance requirements of protein have been estimated at different body weights from the data of Table 94, assuming a linear decrease in nitrogen loss per kilogram of body weight from the lightest to the heaviest pigs. The maintenance requirement of energy has been taken from the metabolizable energy values of the swine-type experiment given in Table 93, column 4, scaling down the estimates for the two heaviest weights to an even 3,000 calories and decreasing to a smaller extent the estimates for the 100- and 150-pound pigs. This is an arbitrary change but appears to be in the right direction since the difference between the basal heat production and the net energy requirement for maintenance would appear to be smaller at these higher weights than the unchanged figures indicate. The general proposition that the requirement of metabolizable energy for the maintenance of swine is only slightly greater than that of net energy receives support from the recent work of Forbes and his associates[1] indicating that with steers approximately 80 percent of the metabolizable energy of light rations is net available, a percentage utilization much higher than that previously observed in the comparison of light and heavy rations.

No satisfactory estimate of the mineral requirements of maintenance can be made at present. Figures for the calcium requirement have been given, based upon Sherman's[2] studies in human nutrition, indicating a need for 1 gram of calcium for each 100 grams of protein.

The estimates of the requirements for growth have been largely based upon the average analyses of pigs weighing 55 to 70 pounds, 175 pounds, 225 pounds, and 275 pounds obtained in the Illinois

[1] Forbes, E. B., Fries, J. A., Braman, W. W., and Kriss, M. Jour. Agr. Res. 33, 483. 1926.

[2] Sherman, H. C. Jour. Biol. Chem. 44, 21. 1920.

swine-type studies (Table 89). The composition of weanling pigs has been taken from the U. S. Department of Agriculture work. It has been estimated from the data of Table 88 that pigs at weaning would weigh 30 pounds and would be 8 weeks of age; that at 65 pounds they would be 14 weeks old; at 175 pounds, 30 weeks; at 225 pounds, 35 weeks; and at 275 pounds, 41 weeks. The daily increments in

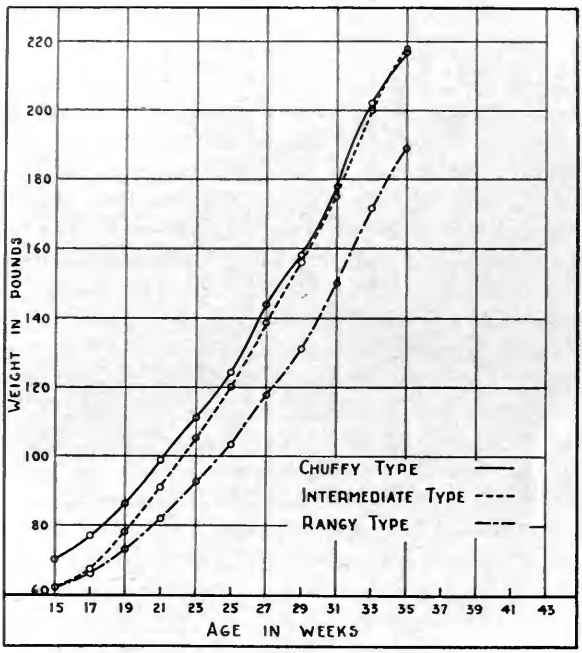

FIG. 6.—AVERAGE GROWTH CURVES OF THE CHUFFY-, INTERMEDIATE-, AND RANGY-TYPE PIGS IN THE FIRST EXPERIMENT

The growth curves are not carried beyond the twentieth week of the experiment because after this time pigs from each lot were being withdrawn for slaughter as they reached the desired weight of 225 pounds.

protein, mineral matter (ash) and energy have been computed from these data. The daily increment in calcium has been assumed to equal 30 percent of the daily increment in ash on the basis of unpublished data on the calcium and ash content of chickens, sheep, and horses.

The estimates thus made of the nutrient requirements of growing and fattening pigs will be found in Table 95. In evaluating and applying these estimates it should be kept in mind that they are based upon a moderate rate of growth and fattening, averaging about one

TABLE 95.—ESTIMATED DAILY NUTRIENT REQUIREMENTS OF GROWING AND FATTENING PIGS

Weight	Approximate age	Calcium			Total ash			Crude protein (Nx6.25)			Net energy		
		Maintenance	Growth and fattening	Total	Maintenance	Growth and fattening	Total	Maintenance	Growth and fattening	Total	Maintenance	Growth and fattening	Total
lbs.	*weeks*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*cals.*	*cals.*	*cals.*
30	8	.05	1.95	2.0	....	6.5	....	5	37	42	620	830	1 450
50	12	.08	2.10	2.2	....	7.0	....	8	41	49	1 000	1 180	2 180
100	20	.13	2.25	2.4	....	7.5	....	13	47	60	1 800	1 730	3 530
150	26	.16	2.40	2.6	....	8.0	....	16	54	70	2 500	2 390	4 890
200	32	.17	2.55	2.7	....	8.5	....	17	52	69	3 000	3 080	6 080
250	38	.14	2.70	2.8	....	9.0	....	14	50	64	3 000	3 330	6 330

pound daily. For more rapid rates the estimates should be increased accordingly and since, within limits, the rate of gain does not appear to affect the composition of the gain (see page 525), such a correction may be made justifiably.

It should also be kept in mind that these estimates refer to the animal, not to the feed. They are, therefore, coverable by feed nutrients only when allowance is made for all losses in the course of their utilization in digestion and in metabolism. This conception of "net" nutrient requirements is thus simply an extension of Armsby's conception of net energy.

In illustrating the application of these estimates to food nutrients, the case of energy and protein may be taken. Since the net energy content of feeds for swine is yet to be determined, an approximate statement of the net energy requirements in terms of metabolizable energy may be made on the following basis. In the experiment of the first year, which involved a much more extensive study of the relation between feed consumed and gains secured than the second year's work, the 45 fattening pigs averaging 128 pounds in weight consumed daily an average of 4.14 pounds of feed containing 5.68 therms of metabolizable energy. The daily energy storage amounted on the average to 2.19 therms, and the maintenance requirement may be estimated at 2.15 therms daily (Table 95). Hence the average net energy intake was 4.34 therms, or 76 percent of the metabolizable energy intake. Therefore, under the conditions of feeding represented by the values in Table 95 it may be assumed that approximately 76 percent of the metabolizable energy of a ration of corn, tankage, and middlings would be net available.

From unpublished data on the utilization of the protein of corn and tankage by swine it may be estimated conservatively that the biological value of the protein in a ration of corn, middlings, and tankage is at least as high as 50.

Hence the net protein and net energy requirements presented in Table 95 may be expressed approximately in terms of digestible protein

TABLE 96.—ESTIMATED DAILY REQUIREMENTS OF GROWING AND FATTENING PIGS FOR DIGESTIBLE PROTEIN AND METABOLIZABLE ENERGY

Weight of pig	Digestible protein	Metabolizable energy	Nutritive ratio 1 to:
lbs.	*lbs.*	*therms*	
30	.185	1.91	4.6
50	.216	2.88	6.2
100	.264	4.64	8.4
150	.308	6.43	10.2
200	.304	8.00	13.1
250	.282	8.33	14.9

and metabolizable energy by division by .50 and .76 respectively. This transformation yields the estimates of Table 96.

The nutritive ratio of the rations supplying protein and metabolizable energy in the proportions indicated has been estimated in the last column of the table on the assumption that the metabolizable energy content of protein is 4.1 calories per gram.

SUMMARY AND CONCLUSIONS

General Description of Experiments. The experimental data described and discussed in this bulletin were obtained as a part of certain swine-type studies undertaken by the Animal Husbandry Department of the University of Illinois. The purpose in securing these data was to obtain reliable information on: (1) the composition of growing and fattening pigs at different weights; (2) their maintenance requirements; (3) the rates at which the different nutrients are deposited in the carcasses of pigs during growth and fattening; and (4) the relation between feed (and food nutrients) consumed above the maintenance requirements and the nutrients recovered in the gains of pigs.

A number of different types of Poland China pigs were fed, submitted to digestion and metabolism studies, and slaughtered and analyzed in the course of these experiments in order to determine whether type affects any of the five factors above enumerated. The results obtained, however, have a far more general significance than as mere type comparisons.

The extent of the experimental inquiry is indicated by the numbers of pigs analyzed. Thirty pigs were analyzed individually at the initial weights of 55 to 70 pounds, 12 pigs at 175 pounds, 63 pigs at 225 pounds, and 10 at 275 pounds. Individual maintenance feeding trials were undertaken on 30 pigs at the initial weights and on 27 pigs at 225 pounds or over. Forty-two of these pigs were slaughtered and analyzed at the end of maintenance feeding in order to determine to what extent they had withdrawn nutrients from their bodies during this period. A total of 157 pigs were thus slaughtered and analyzed individually; from two to four separate analytical samples were obtained from each pig, and a number of composite samples involving all the pigs of one type in any one killing were also analyzed. Each sample was analyzed for dry matter, total nitrogen, fat (ether extract), ash, and gross energy. In addition to this analytical work all of the feed used in the maintenance and fattening experiments was submitted to routine analysis, including the gross energy determination; in the second year's work digestion and metabolism experiments were run on 23 pigs, some of which were on maintenance feed and some on full feed. The content of digestible nutrients and metabolizable energy in the rations used could thus be estimated.

Type Comparisons. The carcass analyses revealed only inappreciable differences between types in spite of large differences in their market finish. The dressed carcasses of pigs of distinctly different type slaughtered at the same weight, altho differing distinctly in market finish, analyzed very nearly the same. Apparently these carcasses differed in the distribution of fat but not in the content of fat. These results are in agreement with those of Hogan, Weaver, Edinger, and Trowbridge, obtained at the Missouri Agricultural Experiment Station (Research Bulletin 73).

More or less distinct type differences were noted with reference to the amounts of feed required to maintain energy equilibrium. In general, especially at the heavier weight, the Intermediate-type pigs were more economical of food energy in maintenance, particularly in comparison with the Chuffy and Very Chuffy pigs. This may have been due to less muscular activity or to a less persistent growth impulse under adverse conditions of feeding.

With reference to the utilization of feed no type differences were detected.

Maintenance Requirements for Body-Weight Equilibrium. Of a ration consisting of yellow corn, middlings, and tankage, approximately 1 pound per day per 100 pounds live weight (weight ratio) was required for the maintenance of body weight, both in the case of the young pigs weighing 50 to 70 pounds and also in the case of the fat pigs weighing 225 pounds and more.

Changes in Composition of Pigs on Maintenance Ration. A comparison of the composition of the maintenance pigs at the end of their period of feeding with their probable composition at the beginning indicated clearly that profound changes had occurred, particularly in the young pigs. These changes consisted of a more or less extensive withdrawal of fat and corresponding storage of water, protein, and ash. The period of inadequate feeding on a well-balanced ration had effectively suppressed body-weight changes but had not suppressed growth.

Among the young maintenance pigs of the first experiment, as a result of these changes in composition during a feeding period of 110 days, the energy content of the body decreased on the average 31 percent for the Chuffy pigs, 28 percent for the Intermediate pigs, and 16 percent for the Rangy pigs. Among the 225-pound maintenance pigs the average losses of body energy were 21, .5, and 15 percent respectively.

In the second year's work the young maintenance pigs were not slaughtered, and the fat maintenance pigs, heavier and older than the corresponding pigs of the preceding year, showed only inconsiderable changes in energy content.

Maintenance Requirements for Energy Equilibrium. On the basis of changes in composition of the pigs during the period of maintenance feeding, and also the basis of total amounts of feed consumed, it is possible to estimate the amounts of feed required to maintain energy equilibrium; in other words, to prevent a loss of energy from the body rather than merely a loss in weight. This estimate involves the use of certain simplifying assumptions, the accuracy of which is fully discussed in the text. For the maintenance of energy equilibrium it seems necessary to provide about 1.50 pounds of the ration used per 100 pounds live weight (using the weight ratio) for young pigs weighing 50 to 70 pounds. For older pigs, weighing 225 pounds or more, the first experiment indicated an average requirement of 1.13 pounds of feed, and the second, .95 pound, values not greatly different from those previously given for the maintenance of body weight. Certain average type differences were obtained, but their significance is difficult to assess because of the small number of pigs in each maintenance type group, and the variation among the individual estimates secured.

Digestibility and Metabolizable Energy of Experimental Ration. The digestibility and metabolizable energy value of the rations used in the two years' work were not appreciably affected by the level of feeding (maintenance as compared with full feed) or by considerable changes in the proportions of the individual feeds. Per kilogram of dry matter, the metabolizable energy averaged 3.347 therms for the fat pigs on full feed, 3.440 therms for the fat pigs on maintenance feed, and 3.287 therms for the young maintenance pigs. Expressed as a percentage of the gross energy of the ration, the metabolizable energy averaged 78.0, 79.4, and 73.2 for these three groups of pigs in the order given.

Changes in Composition of Pigs With Age. The percentage composition of the pigs killed at increasing weights exhibited the expected changes, that is, increasing contents of dry matter and fat and decreasing contents of protein and ash. The results were quite comparable with those obtained in recently reported experiments from the Missouri Agricultural Experiment Station and from the U. S. Department of Agriculture Experimental Farm at Beltsville, Maryland.

On the basis of the fat-free empty weight, the so-called "protoplasmic" basis, much of this variation in composition disappears, indicating that it is largely due to varying percentages of fat. In fact, after a weight of 150 to 175 pounds is reached under ordinary conditions of feeding, corresponding to an age of 25 to 30 weeks, the composition of pigs on the protoplasmic basis appears to be remarkably constant and to be unaffected by the system of feeding. This protoplasmic composition characteristic of maturity consists of 75 to 76 percent of water, 20 to 21 percent of crude protein, and approximately 4 percent of ash.

Effect of Sex and Rate of Gain on Composition of Swine. The composition of sow carcasses at a weight of 225 pounds is not appreciably different from that of barrow carcasses, the system of feeding being the same. Swine are thus clearly distinguished in this respect from cattle and poultry in which the female at any given weight (except for extreme immaturity) is distinctly fatter than the castrated male.

The composition of swine carcasses at the 225-pound weight and of the gains put on to that weight are not affected, or are affected only to an inconsiderable extent, by variations in the rate of gain ranging from .75 to 1.25 pounds per day, the system of feeding remaining the same.

Distribution of Added Nutrients in Carcass. In gaining weight from 65 to 225 pounds the pigs in this experiment deposited 74 percent of the added dry matter, 58 percent of the added protein, 15 percent of the added ash, and 78 percent of the added energy in the boneless meat of the dressed carcass. Eighty percent of the added ash was stored in the skeleton. Approximately 50 percent of the added protein and 24 percent of the added energy were stored in lean meat.

Net Energy Value of Rations. On the basis of certain simplifying assumptions it has been computed that the net energy value of the rations for growth and fattening averaged 89.5 therms per 100 pounds in the first experiment and 74.8 therms per 100 pounds in the second experiment. These values are much lower than would be expected from Armsby's computations of the net energy values of feeds for swine. Other evidence is cited and discussed in the text in support of the conclusion that swine are considerably less efficient in the utilization of feed energy than Armsby has estimated.

Measurement of Type. An attempt to measure the conformation, or type, of the pigs was made in the second year's experiment, based upon the reference of the volume of the pig to the volume of a box the three dimensions of which are determined by the maximum length, height, and width of the pig. The type index chosen was the percentage of the volume of this box that would be occupied by the pig. The index is larger the chuffier the type of pig; and for pigs of a given type it is larger the fatter the pig.

From a study of the numerous type indexes obtained in this experiment it appears that the one chosen is subject to wide individual differences, due probably to the difficulty in securing accurate dimensional measurements of pigs and to the fact that the differences between the types of pigs used in this experiment are not large. However, it is believed that the average index for a large group of animals of similar type and weight must be conceded a greater value as a quantitative description of type, or conformation, than a worded description, or a group photograph or a group of individual photographs.

Maintenance Requirements for Energy Equilibrium. On the basis of changes in composition of the pigs during the period of maintenance feeding, and also the basis of total amounts of feed consumed, it is possible to estimate the amounts of feed required to maintain energy equilibrium; in other words, to prevent a loss of energy from the body rather than merely a loss in weight. This estimate involves the use of certain simplifying assumptions, the accuracy of which is fully discussed in the text. For the maintenance of energy equilibrium it seems necessary to provide about 1.50 pounds of the ration used per 100 pounds live weight (using the weight ratio) for young pigs weighing 50 to 70 pounds. For older pigs, weighing 225 pounds or more, the first experiment indicated an average requirement of 1.13 pounds of feed, and the second, .95 pound, values not greatly different from those previously given for the maintenance of body weight. Certain average type differences were obtained, but their significance is difficult to assess because of the small number of pigs in each maintenance type group, and the variation among the individual estimates secured.

Digestibility and Metabolizable Energy of Experimental Ration. The digestibility and metabolizable energy value of the rations used in the two years' work were not appreciably affected by the level of feeding (maintenance as compared with full feed) or by considerable changes in the proportions of the individual feeds. Per kilogram of dry matter, the metabolizable energy averaged 3.347 therms for the fat pigs on full feed, 3.440 therms for the fat pigs on maintenance feed, and 3.287 therms for the young maintenance pigs. Expressed as a percentage of the gross energy of the ration, the metabolizable energy averaged 78.0, 79.4, and 73.2 for these three groups of pigs in the order given.

Changes in Composition of Pigs With Age. The percentage composition of the pigs killed at increasing weights exhibited the expected changes, that is, increasing contents of dry matter and fat and decreasing contents of protein and ash. The results were quite comparable with those obtained in recently reported experiments from the Missouri Agricultural Experiment Station and from the U. S. Department of Agriculture Experimental Farm at Beltsville, Maryland.

On the basis of the fat-free empty weight, the so-called "protoplasmic" basis, much of this variation in composition disappears, indicating that it is largely due to varying percentages of fat. In fact, after a weight of 150 to 175 pounds is reached under ordinary conditions of feeding, corresponding to an age of 25 to 30 weeks, the composition of pigs on the protoplasmic basis appears to be remarkably constant and to be unaffected by the system of feeding. This protoplasmic composition characteristic of maturity consists of 75 to 76 percent of water, 20 to 21 percent of crude protein, and approximately 4 percent of ash.

Effect of Sex and Rate of Gain on Composition of Swine. The composition of sow carcasses at a weight of 225 pounds is not appreciably different from that of barrow carcasses, the system of feeding being the same. Swine are thus clearly distinguished in this respect from cattle and poultry in which the female at any given weight (except for extreme immaturity) is distinctly fatter than the castrated male.

The composition of swine carcasses at the 225-pound weight and of the gains put on to that weight are not affected, or are affected only to an inconsiderable extent, by variations in the rate of gain ranging from .75 to 1.25 pounds per day, the system of feeding remaining the same.

Distribution of Added Nutrients in Carcass. In gaining weight from 65 to 225 pounds the pigs in this experiment deposited 74 percent of the added dry matter, 58 percent of the added protein, 15 percent of the added ash, and 78 percent of the added energy in the boneless meat of the dressed carcass. Eighty percent of the added ash was stored in the skeleton. Approximately 50 percent of the added protein and 24 percent of the added energy were stored in lean meat.

Net Energy Value of Rations. On the basis of certain simplifying assumptions it has been computed that the net energy value of the rations for growth and fattening averaged 89.5 therms per 100 pounds in the first experiment and 74.8 therms per 100 pounds in the second experiment. These values are much lower than would be expected from Armsby's computations of the net energy values of feeds for swine. Other evidence is cited and discussed in the text in support of the conclusion that swine are considerably less efficient in the utilization of feed energy than Armsby has estimated.

Measurement of Type. An attempt to measure the conformation, or type, of the pigs was made in the second year's experiment, based upon the reference of the volume of the pig to the volume of a box the three dimensions of which are determined by the maximum length, height, and width of the pig. The type index chosen was the percentage of the volume of this box that would be occupied by the pig. The index is larger the chuffier the type of pig; and for pigs of a given type it is larger the fatter the pig.

From a study of the numerous type indexes obtained in this experiment it appears that the one chosen is subject to wide individual differences, due probably to the difficulty in securing accurate dimensional measurements of pigs and to the fact that the differences between the types of pigs used in this experiment are not large. However, it is believed that the average index for a large group of animals of similar type and weight must be conceded a greater value as a quantitative description of type, or conformation, than a worded description, or a group photograph or a group of individual photographs.

The Nutrient Requirements of Swine. Finally, the data of this and of other recent similar experiments have been discussed with reference to the problem of the expression of the food requirements of pigs in terms of nutrient expenditures and the nutrient content of the tissues produced. The discussion has led to the formulation of tentative estimates of the food requirements of pigs differing in age and weight.

These estimates can be put to accurate use only in connection with information, largely unavailable at the present writing, concerning the net value of farm feeds as sources of energy, protein, and mineral matter for swine. However, an approximate method of using the estimates is described which is believed to be sufficiently accurate for most practical purposes.