[From the LONDON, EDINBURGH, AND DUBLIN PHILOSOPHICAL MAGAZINE AND JOURNAL OF SCIENCE for June 1848.]

LXII. *The Law of the Nutrition of Animals pointed out by* Dr. R. D. Thomson, *illustrated by* F. Knapp, *Ph.D., Professor of Technology and Chemistry in the University of Giessen.*

ON the farm of Boussingault at Bechelbronn, in order to ascertain the quantity of milk produced, seven cows were subjected to an accurate series of experiments extending over a whole year. They received daily 30 pounds of hay, or of those roots similar in composition, and yielded together

Translated by Mr John Brown

8788 maass (3837 quarts). The time during which they supplied milk was 302½ days. This gives as a mean 4·1 maass (1·8 qt.) daily for each cow. But the quantity of milk varies very much; for in the months of July and August they yielded above 6 maass (2·64 qts.), while in February and March they gave only about 2½ maass (1·1 qt.). From observations of a similar nature, made however upon only one cow, the average daily quantity of milk yielded was 3·7 maass (1·63 qt.). If we take 2½ maass (1·097 qt.) as the lowest quantity, and 7 maass (3·073 qts.) as the highest, we get daily, for one cow, from 10·3 lbs. to 29 lbs. of milk, which contain—

	4·69 oz. troy	to	13·04 oz. butter.
	7·08	... ...	20·02 oz. sugar of milk and sol. salts.
	7·88	... ...	22·18 oz. caseine and insol. salts.
Total	19·65	... ...	55·24 oz. solid matter.

In reference to the influence which the food has upon the quantity of milk, all farmers know that cows give most milk with green food and less with hay, &c. In other respects the influence of the food is not so great as might be expected.

Boussingault and Le Bel agree upon this point, at least so far as concerns the quantity of milk*. Dr. R. D. Thomson, on the contrary, draws from similar and equally extensive experiments the conclusion, that the quantity of milk and butter increases in proportion to the quantity of nitrogen (contained in the plastic matter) of the food. He has drawn this conclusion from experiments upon two cows during periods of five days. His results are shown in the following table, in which grass is the only exception†.

Kind of food.	Pounds of milk.	Pounds of butter.	Nitrogen in the food in 5 days, in lbs.
Grass	114	3·50	2·32
Barley and hay	107	3·43	3·89
Malt and hay	102	3·20	3·34
Barley, molasses and hay	107‡	3·44	3·82
Barley, linseed and hay	108	3·48	4·14
Beans and hay	108	3·72	5·27

* Boussingault has recently found that hay is equally efficacious with grass in producing milk and muscle; a result which is certainly not applicable to hay made in usual seasons in this country.—Tr.

† Dr. Thomson attributes the superiority of grass to the proper balance of the proximate principles, which in hay and grain is much altered by the drying process.—Tr.

‡ In Dr. Knapp's work the number taken from the original is 106. The present number has been recalculated from the original data.—Tr.

Another table gives the average quantity of solid constituents of the milk for periods of five days.

Kind of food.	Grass.	Barley entire.	Malt entire.	Barley crushed.	Malt crushed.	Barley and Molasses.	Barley and Linseed.	Beans.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Milk................	29·64	25·57	24·82	28·12	26·61	26·96*	27·48	27·0
Butter	5·96	5·56	6·56	6·87	6·43	7·00	7·00	7·5

The milk consists of—water, 87·19; butter, 3·70; sugar, 4·35; caseine, 4·16; sol. salts, 0·15; insol. salts, 0·44. The constituents of the butter are oil, 86·3; caseine, 0·9; water, 12·8.

The fact that not merely the quantity of milk but also that of the butter increases with the amount of nitrogenous matter in the food (that is, with the proportion of plastic nourishment), is worthy of notice; for from the absence of nitrogen in the butter, we should be apt to expect the contrary. Playfair, in his experiments, has certainly inferred this; for according to him, those substances which do not contain nitrogen (potatoes, &c.), yield milk rich in butter, and rest (stall-feeding) acts in the same way; while if the animal be allowed to feed on poor pasture, where it must move about a good deal, it yields milk rich in caseine. But his experiments are continued for such short periods, that important conclusions cannot be deduced from them. From Dr. Thomson's observations, we find that if a cow always receives the same kind of food, the quantity of milk gradually decreases; but if its diet be changed, it rapidly increases. A frequent change of diet is therefore advantageous. He has also established the rule, that the quantity of milk obtained from a cow is greater in the morning than in the evening.

When fed on barley and hay, they yielded—

	Aug. 1.	Aug. 2.	Aug. 3.	Aug. 4.
Morning .	$11\frac{1}{2}$ lbs.	$11\frac{1}{2}$ lbs.	$10\frac{10}{16}$ lbs.	$10\frac{14}{16}$ lbs.
Evening .	$10\frac{1}{5}$	$9\frac{11}{16}$	$9\frac{11}{16}$	$9\frac{11}{16}$

[The following observations of Dr. Knapp are founded on a table given by Dr. Thomson, deduced from his own experiments, in which the relation between the nutritive and calorifiant matter is stated for different kinds of food.

* This number is 25·69 in the original German, but has been recalculated from the English data.—Tr.

	Relation of nutritive to calorifiant matter.
Cow's milk—food for a growing animal	1 to 2
Human milk	1 ... 6
Beans	1 ... $2\frac{1}{2}$
Oatmeal	1 ... 5
Semolina, Barley	1 ... 7
English wheat flour—food for an animal at rest.	1 ... 8
Potatoes	1 ... 9
Rice	1 ... 10
Turnips	1 ... 11
Arrow-root, Tapioca, Sago	1 ... 26
Starch	1 ... 40

(Thomson on the Food of Animals, p. 167.)

From this table it appears, that an animal taking exercise should be supplied with food formed upon the same principles as the first-mentioned six; and that in proportion to the exertion, the closer should be the relation between the ingredients.—Tr.]

In order to judge of the values of different kinds of food for practical purposes, it must first be ascertained in what relation the blood-forming or nutritive constituents stand to the calorifiant. The kind of food must also vary with age, kind of employment, way of living, climate, &c. With the highest probability we may predicate, that a man in an employment demanding great mental activity will require, in addition to a greater proportional amount of bodily rest, that the calorifiant and blood-forming constituents should be in a different proportion in the food, to that of the man whose employment requires great bodily activity.

Thomson has traced out a very simple and ingenious method of supplying this defect in our knowledge. He ascertains the weight and composition of the food given in a certain time, as also that of the excrement thrown out. From both factors he is enabled to calculate the quantity of food assimilated, as also the relation of the calorifiant to the blood-forming constituents. He found that a cow, stall-fed, assimilated daily 15·28 lbs. of rye-grass, which contained 1·56 lbs. of blood-forming and 13·00 lbs. of calorifiant matter. They thus stand in the relation of 1 to $8\frac{1}{3}$, a proportion which, it is highly probable, is much more nearly related in man, as the relation in the various kinds of farinaceous food is about 1 to 5 or 1 to 6. We know with certainty that in the infant the relation, as in milk, must be 1 to $2\frac{1}{2}$.

A company of soldiers were fed on flesh, bread, vegetables, legumes, beer, brandy, fat, &c.; and from the experiments made on these by Liebig, the relation of the blood-forming to the calorifiant matter in the food may be accurately determined. By ascertaining the amount of food taken and the excrement thrown out, the quantity of food assimilated may be determined, as also the above-mentioned relation. In this manner the following results were obtained:—

		Water.	Solid matter.	Relation of the blood-forming to the calorifiant matter ~~with~~ in the solids.
Pounds of food consumed	4001	1655	2346	298 : 1357
Pounds of excrement . .	294	$220\frac{1}{2}$	$73\frac{1}{2}$	13 : 51

Relation of the blood-forming to the calorifiant matter in the food assimilated } 285 : 1306 = 1 : 4·7.

As this number 4·7 is calculated from experiments made on persons who undergo considerable bodily exercise, it will increase* in those whose employment is sedentary. Although these numbers are not absolutely correct, some important conclusions may be drawn from them.

It is evident that the relation 1 to 4·7 is almost exactly that which exists naturally in the various kinds of grain. Those barbarous nations which live entirely on flesh, receive a large excess of blood-forming matter, which may be counterbalanced either by the addition of calorifiant matter, or by increased bodily exercise. On the contrary, the poorer classes amongst us are obliged to live on the cheapest food they can obtain, such as potatoes, &c.†, which are one half poorer in blood-forming or nutritive matter than the different kinds of grain. In the first case nature has only to get rid of an excess; but in the latter she has to supply a deficiency, which must be done by bread, milk, &c. It must be evident to every one that this way of living is unnatural in the extreme. A person living

* The word in the original is "vermindern;" but in the present case it is obvious that the author means the reverse of diminution.

† "The previous views," says Dr. Thomson (on Food, p. 173), "sufficiently explain the experiments which have been made upon cows, in which the result was unfavourable when they were fed on potatoes and beetroot in considerable quantities, as both of these substances contain an excess of calorifiant matter. It is well-known to feeders of cattle, that an animal fed on large quantities of potatoes is liable to such complaints as affections of the skin, and also to loss of weight. These consequently, it may be readily inferred, arise from the want of the proper balance between the elements of the food."—Tr.

entirely on potatoes may be said to be on the brink of a precipice without a single inch of ground before him, where the only safety lies in retreat. Its disadvantages may be shown in three different ways:—1st. It leads to imperfect bodily strength and unsoundness of health. 2nd. To increased mortality and shortness of life. 3rd. To loss of energy and to a kind of stupidity, and want of interest in everything but what concerns the merest animal interests. A country in this state is always ripe for rebellion, and ready to join in every insurrection.

From the above remarks, it would appear that the manufacture of brandy from potatoes is a separation of the excess of calorifiant matter, whilst the residue contains all the blood-forming constituents. It is mixed with the gluten of the malt, and thus forms a half-soluble food. In order however that it may suit the nature of ruminating animals, straw or some such food should be added to it. As potatoes contain about one part of albumen for ten of starch, the half of the starch may be converted into spirit, while the remainder will consist of a mixture having the nutritive and calorifiant constituents in the same proportion as in grain (1 : 5).