View Article Online / Journal Homepage / Table of Contents for this issue

Published on 01 January 1841. Downloaded on 5/9/2026 11:59:53 PM.

XXIX. *On the Formation of Fat in the Animal Body.* By JUSTUS LIEBIG, *Ph.D., M.D., F.R.S., &c.*

Read January 3, 1843.

[Translated from the German original by Mr. E. F. Teschemacher.]

IN my published work on 'Organic Chemistry, in its application to Physiology and Pathology,' I have endeavoured to explain the nutrition of the human and animal organism, according to the present state of organic chemistry. I have pointed out the relation between the nitrogenous food and the nitrogenous constituents of animal bodies, and have considered the non-nitrogenous constituents of the food as the means of the formation of the non-nitrogenous constituents of animals.

The circumstance, that the large class of carnivorous animals do not take any sugar, starch, or gum in their food, leads of itself to the opinion that these substances are not required for proper nourishment, namely, for the formation of blood; and as it appears from the analysis of plants containing nitrogen, that they possess a similar composition to the substances of the blood, it follows also that in the bodies of herbivorous and graminivorous animals, the carbon of the sugar, gum and starch cannot be applied to the formation of the blood. The nitrogen of the nitrogenous ingredients of the food is therefore in a state of combination, in which the elements necessary for the production of the albumen are already present both in number and relative proportions; in the food of the graminivorous animals, we know after all of no other compound, which can supply nitrogen to starch, sugar, or gum, for the production of albumen.

As sugar, gum and starch, in their normal state, disappear in the vital processes of graminivorous animals, and as they are given out of their bodies as carbonic acid and water, it

View Article Online

follows from such a conversion that they serve by means of the respiration for the production of animal heat.

The disappearance of fat in animals in consequence of disease, or of an increased absorption of oxygen, and its being given out in the form of carbonic acid and water, is a proof that that non-nitrogenous body is converted to the same use as sugar, gum, or starch in animal bodies, and for want of other non-nitrogenous food is applied to the respiration.

The further consideration, that the flesh of the carnivorous, which of all animals eat most fat, contains no fat, and is not eatable; that the fat in the bodies of graminivorous animals increases when the process of respiration, and with it the absorption of oxygen diminishes, through a want of exercise or an increase of temperature, leads to the conclusion that the fat has its origin in the non-nitrogenous food, the carbon remaining in the body in the form of fat when there is a deficiency of the necessary quantity of oxygen to convert it into carbonic acid.

Supported by the example of what certainly takes place in the processes of fermentation and putrefaction, in which sugar and starch, by giving out oxygen or carbonic acid, form new combinations, which, like æther and fusel oil, more resemble fat in their properties than any other known compounds, I have endeavoured to trace out the formation of fat, on the supposition that the carbon of non-azotized substances remains in the animal body in the form of fat.

According to my statement, the fat consequently originates from the non-nitrogenous constituents of the food: let us suppose from sugar, then this must have undergone a chemical change in conformity with my proposition.

The formation of wax from honey which contains none, in the body of the bee, of which, from the experiments of M. Grundlach of Cassel, there can be no doubt, appears to remove every objection to the possibility of such an action taking place.

I never had the least idea of defending in my book the opinion, or even of expressing it, that the fat which was taken in the food of animals did not contribute to increase the quantity of fat in their bodies; but I was not aware of any supply of butter in the grass which is daily consumed by cows, or of tallow, of lard, or goose-fat in potatoes, barley and oats; in the analyses of these substances as at present given, they contain only waxy substances, and that in such a small quantity that I consider the formation of fat could not be attributed to it.

Published on 01 January 1841. Downloaded on 5/9/2026 11:59:53 PM.

View Article Online

These ideas concerning the origin of fat in animal bodies took a new direction from a note which M. Dumas appended in the *Annales de Chimie* (new Series, vol. iv. p. 208) to my treatise on the nitrogenous food of the vegetable kingdom; in this note M. Dumas says,—“ M. Liebig is of opinion that graminivorous animals *produce* fat out of sugar and starch, while MM. Dumas and Boussingault consider it as a fixed rule, that animals, of whatever kind, produce neither fat nor any other alimentary substance; that they receive from the vegetable kingdom all their aliments, whether it be sugar, starch, or fat.

“ Were the proposition of M. Liebig founded upon fact, the general formula of chemical equivalents of both kingdoms, as defined by MM. Dumas and Boussingault, would be false. But the commission on gelatine has dispelled all doubt, that the animals which eat fat are the only ones in which fat is found to accumulate in the tissues.”

The origin of fatty compounds in animal bodies has, through this note, become a question of dispute.

As far as regards myself, I have neither time nor inclination to engage in it; the object of my observations was to leave no doubt of the physiological importance of the fat of animal bodies, as regards the process of respiration. In this view MM. Dumas and Boussingault agree with me.

I think it now right to explain the reasons which induced me to consider that little or no increase of fat in animal bodies was to be ascribed to the ingredients of the food containing fat, consumed by graminivorous animals.

The food which, according to the experience of physicians, has a decided influence on the formation of fat in animal bodies, is that which is richest in starch, sugar, and other substances of a similar constitution.

Rice, Indian corn, beans, peas, linseed, potatoes, beet are used in husbandry in large quantity with great effect for fattening, that is, for the increase of flesh and fat. In Bavaria beer is used as a stimulating food for the increase of fat.

Whether much or little importance may be ascribed to the universal experience of husbandry, it is certain that animals which are fed upon these different substances, under certain conditions (abundance of food, little exercise, high temperature, &c.), after some time become much fatter than before. This fat proceeds from the food. Rice, beans and peas have been carefully analysed by various chemists. Braconnot found in Carolina rice 0·13 per cent. of oil, in Piedmont rice 0·25 per cent.; Vogel found in rice 1·05 per cent.

Published on 01 January 1841. Downloaded on 5/9/2026 11:59:53 PM.

View Article Online

Published on 01 January 1841. Downloaded on 5/9/2026 11:59:53 PM.

According to these analyses, the organism received from 1000 lbs. of Carolina rice 1·3 lb. or 2·5 lbs., or according to Vogel $10\frac{1}{2}$ lbs. of fat.

Peas contain, according to Braconnot, 1·20 of a substance soluble in æther, which he calls leafgreen (chlorophyll). The bean of the *Phaseolus vulgaris*, according to the same chemist, contains 0·70 of fat soluble in æther. Fresenius obtained from peas 2·1 per cent. of a substance soluble in æther, from linseed 1·3 per cent.

For every 1000 lbs. of peas or beans the organism receives, according to Braconnot 12 lbs., according to Fresenius 21 lbs. of fat, and from as many beans only 7 lbs. of fat.

Beer, as far as I am aware of, contains no fat: Fresenius obtained from the pulp of the beet-root 0·67 per cent. of a substance soluble in æther.

According to further direct examinations made in our laboratory, 1000 parts of dried potatoes gave 3·05 parts of a substance soluble in æther. This substance possessed all the properties of resin or wax; we will, however, assume that potatoes contain $\frac{3}{1000}$ of their weight of fat. Three one-year-old pigs, fattened with 1000 lbs. peas and 6825 lbs. potatoes fresh boiled, which are equal to 1638 lbs. of dried potatoes, increased in weight in thirteen weeks from 80 lbs. to 90 lbs. each. A fully fattened pig averages in weight from 160 lbs. to 170 lbs., and after killing the fat weighs from 50 lbs. to 55 lbs. The three pigs have consumed 21 lbs. of fat, contained in the 1000 lbs. peas, and 6 lbs. in the 1638 lbs. of potatoes, together therefore 27 lbs. Their bodies, however, contained from 150 lbs. to 165 lbs. of fat. There is an increase of from 123 lbs. to 135 lbs. more fat than the food contained. A pig one year old weighs from 75 lbs. to 80 lbs.; suppose it to contain 18 lbs. of fat, there still remains, leaving entirely out of question the matters soluble in æther contained in the excrements, 69 lbs. to 74 lbs. of fat*; the production of which

* M. Vogt, a butcher at Giessen, in answer to some questions of mine, gave me the following as the result of his experience, which has been confirmed by other intelligent persons:—A restless pig is not adapted for fattening, and however great the supply of food it will not grow fat. Pigs which are fit for fattening must be of a quiet nature; after eating they must sleep, and after sleeping must be ready to eat again. When a pig is a year old it weighs from 75 lbs. to 80 lbs., and if the fat is intended to be used as lard, it must be fed daily for thirteen weeks with 20 lbs. to 25 lbs. of boiled potatoes, and about a measure of peas (2 litr.); towards the end of the time the food may be somewhat diminished. A pig so fattened weighs from 160 lbs. to 170 lbs., and contains of fat and lard, taken altogether, from 50 lbs. to 55 lbs. A pig of a year old has a lard membrane under which the lard is secreted, but at that age it does not contain lard.

View Article Online

Published on 01 January 1841. Downloaded on 5/9/2026 11:59:53 PM.

in the organization cannot be doubted, and whose formation remains to be accounted for.

M. Boussingault's examinations concerning the influence of food on the quantity and composition of the milk of the cow, furnish other more important grounds for the opinion that animals produce fat out of certain food, which is neither fat itself, nor contains fat (*Annales de Chim. et de Phys.* t. lxxi. p. 65).

M. Boussingault's experiments correspond with universal experience, and I believe are to be relied upon; it is, therefore, the more inconceivable to me that he has placed himself by the side of those who support the opposite opinion.

A cow was fed at Bechelbrunn during eleven days upon daily rations of 38 kilogrammes of potatoes, and therefore in eleven days upon 418 kil. Also 3·75 kil. chopped straw; in eleven days, 41·25 kil. In these eleven days she gave 54·61 litres of milk, which contained 2284 gram. butter. As 418 kil. of fresh potatoes are equal to 96·97 kil. of dry potatoes (potatoes contain, according to M. Boussingault, 76·8 water and 23·2 solid matter, *Annales de Chim. et de Phys.* 1838. p. 408); further, as 1000 gram. potatoes contain only 3·05 gram. of soluble matter, and the straw, according to experiments made here, contains only 0·832 per cent. of a substance soluble in æther (a crystalline wax), the cow had, therefore, in eleven days consumed 291 + 343 gram. = 634 gram. of substance, soluble in æther. There was contained in this milk however 2284 gram. of fat.

In another case, in a trial carried on in winter, the daily rations of the cow was for a long time 15 kil. of potatoes and $7\frac{1}{2}$ kil. of hay. The quantity of milk amounted in six days to 64·92 litres. These 64·92 litres of milk contained 3116 gram. of butter. In six days the cow consumed 90 kil. of fresh potatoes, equal to 19·88 of dried; in the same time 45 kil. of hay were consumed. Suppose that the 19·88 kil. of potatoes supplied to the cow contained 60 gram. of fat, the other 3056 gram. of butter must have originated from the 45 kil. of hay. According to this, hay must contain nearly 7 per cent. of fat. This is easily ascertained by experiment.

From hay of the best quality, in the state in which it is consumed by the cows, 1·56 per cent. of a substance soluble in æther was obtained in the Giessen laboratory. Taking the hay to contain 1·56 per cent. of butter, the 45 kil. of hay could supply the cow with only 691 gram., there remains, therefore, to discover whence the other 2365 gram. of butter originated which M. Boussingault found in the milk.

View Article Online

Published on 01 January 1841. Downloaded on 5/9/2026 11:59:53 PM.

In a note which M. Dumas has appended to a communication of M. Romanet's (*Comptes Rendus de l'Acad. des Sciences*, 24 Oct.), the following remarks are made:—

"Hay contains in the state in which it is consumed by the cow, nearly 2 per cent. of fatty matter. We will show (MM. Dumas and Payen) that the ox which is fattened and the milch cow furnish a *smaller* quantity of fatty material than the fodder contains. As regards the milch cow in particular, the butter in the milk corresponds very nearly with the quantity of fatty material contained in its food; at least as far as in that of the food we have yet studied, namely hay and Indian corn, which last the cow does not usually obtain as food."

After the foregoing facts, which I could considerably multiply, it will be very difficult for MM. Dumas and Payen to prove that the cow, for instance, furnishes from the fatty matter contained in the food only the corresponding quantity of butter. The proof of the supposition, besides, that animals receive the fat in their food in the same state as it is found in their bodies, is impossible. Nothing is easier to decide than the question whether or not the butter which the cow produces, is contained as butter in the hay.

Hay gives after exhaustion by æther a green solution, and on evaporation a green residue, with a strong agreeable smell of hay, which possesses no properties characteristic of fatty substances. This green residue consists of various substances, of which one is of a waxy or resinous nature, known under the name of chlorophyll; another ingredient of the same crystallises from a concentrated æthereal solution in minute laminæ, and is the crystalline wax which Proust obtained from plums and cherries, from the leaves of cabbages, from a species of *Iris*, and from grasses, and which is probably identical with the wax that Avequin collected in such large quantities from the leaves of the sugar-cane. M. Dumas has analysed this substance, and found it to differ both in composition and properties from any of the known fats; in consequence of which he felt justified in giving the name cerosine to this substance.

M. Fresenius obtained by means of æther from straw, and M. Jägle, of Strasburg, from the fresh plant, *Fumaria officinalis* (in the Giessen laboratory), by means of alcohol, a crystalline wax, very similar to cerosine. The occurrence of wax in the vegetable kingdom is very extensive, generally accompanied by chlorophyll.

Margaric or stearic acid, the principal ingredient of the fat of animals, is neither found in the seeds of corn, nor in herbs nor in roots which serve as food. It is evident that if the

View Article Online

ingredients of the food soluble in æther are convertible into fat, margarine and stearine must be formed out of wax or chlorophyll.

As far as our experience goes, the chlorophyll of the food taken in a green state is given out from the body unchanged; even in man the excrements retain the colour of the green vegetables consumed. It is also considered that the wax does not experience any change in the organism. All doubt may be removed by the simplest experiments; it may be shown that the excrements of the cow contain as much of the substances soluble in æther as has been consumed in the food. The excrements of a cow which was fed upon potatoes and grass were dried and exhausted by æther; a green solution was obtained, somewhat darker in colour than that given by hay, which upon concentration owed its consistency to a white crystalline waxy substance, which was surrounded by a dark green mother liquor. Upon further evaporation it gave out an unpleasant smell, and left when dried at 100° C., 3·119 per cent. of the weight of the excrements of fat and similar substances.

As M. Boussingault has found that the dried solid excrements (*Annal. de Chim. et de Phys.* t. lxxi. p. 322) amount to four-tenths of the weight of the dried fodder, it is evident that these excrements contain very nearly the same quantity of fatty substances as the food consumed.

7½ kilogr. of hay contain (at 1·56 per cent.) 116 gram. of fat. The 15 kilogr. of potatoes contain further 10 gram. of fat. In the whole, therefore, 126 gram. of fat.

The solid daily excrements weigh 4000 gram.; they contain (at 3·119 per cent.) 124·76 gram. of fat. A cow which produces in six days 3116 gram. of butter, consumes in its food during the same period 756 gram. of substances soluble in æther, and gives off in her excrements 747·56 gram. of substances of the same nature and properties; it must therefore follow, that in the production of 6¼ lbs. of butter in the milk, these ingredients of the food can have no share.

I consider I have now demonstrated that the fat which accumulates in the bodies of animals during the fattening process, and that the butter daily produced in the milk, do not originate from the wax or chlorophyll of the food, but from the other ingredients of it. I think I should be giving myself unnecessary trouble to look after facts to correct M. Dumas's peculiar opinion, because upon further consideration it is of a nature to correct itself.

It is similar to the idea of M. Payen, that the oil of potato spirit (fusel oil) is ready formed and contained in potatoes. But since it has been found that the last syrup

Published on 01 January 1841. Downloaded on 5/9/2026 11:59:53 PM.

View Article Online

arising from the preparation of beet-root sugar produces in the distillation of brandy a considerable quantity of fusel oil, no one will doubt its formation during the process of fermentation.

The opinion of M. Dumas is a necessary consequence of the exclusive hypothesis, that animals produce in their organism no substances serving as food (note quoted above), but that they receive all sustenance, whether sugar, starch, or fat, from the vegetable kingdom.

I agree perfectly in opinion with M. Dumas in relation to the substances which serve for the formation of blood; but differ from him in considering it as fully proved, as far as observation extends, that wax is formed in the body of the bee, and fat in the stall-fed cow.

In regard to the principle of M. Dumas, that the organism of an animal is not able to produce any substance serving as food, it is equivalent to saying that the organism produces nothing, but only transforms it; that no combination takes place in its body, when the materials are not present by means of which the metamorphosis originates. Thus the formation of sugar of milk in the bodies of carnivorous animals cannot take place, for dog's milk, according to Simon, contains no sugar of milk. Thus also fat cannot be produced in their organism; because, besides fat, they do not consume any non-nitrogenous food. But starch, gum and sugar contain, even with their large quantity of oxygen, all the ingredients of fatty bodies; and the formation of butter in the body of the cow, and of wax in that of the bee, leave hardly any doubt that sugar, starch, gum, or pectine, furnish the carbon for the *formation* of the butter or of the wax.

It is further certain that the brain (Fremy), the nerves, the blood (Lecanu), the fæces, and the yellow of the egg (Chevreul), contain a substance in considerable quantity with a far smaller proportion of oxygen than the known fatty acids, a substance which hitherto has not been found in the food of graminivorous animals. The formation of cholesterine from fat cannot be supposed without a separation of oxygen or of carbonic acid and water; it must be derived from a substance far richer in oxygen in consequence of a process of decomposition or metamorphosis, which, applied to the case of starch or sugar, explains their conversion into fat in the simplest manner.

In the before-mentioned note to the observations of M. Romanet, M. Dumas attempts, from the facts quoted in the preface to my Pathology, to weaken the conclusion to which I had arrived concerning the formation of fat in the animal

Published on 01 January 1841. Downloaded on 5/9/2026 11:59:53 PM.

View Article Online

body. These facts concern the quantity of fat in a goose fed upon Indian corn (maize), which corn I have alleged not to contain a thousandth part of fat or fatty substance. The experiments of M. Liebig, says M. Donné in the *Journal des Débats*, are throughout inexact and false, as MM. Dumas and Boussingault have obtained 9 per cent. of a yellow oil from Indian corn, which M. Dumas had the honour to exhibit to the Academy.

It must be evident to every unprejudiced person, that the fact mentioned in the preface has no necessary connexion with the discussion, concerning the production of fat, in the work itself, or in the appendix; it is not employed in the argument. While writing the preface, a friend of mine communicated to me the result of fattening geese with Indian corn. I found in the *Jour. de Chim. Médicale*, i. p. 353, an analysis of maize by Lespes, in which no trace of a fatty substance is mentioned. I further found by an examination by Gorham, in the 'Quarterly Journ. of Science,' xi. p. 205, that maize contained a particular substance, which he called zein, which was extracted by alcohol and could not be fat, as, on the authority of Gorham, this zein was not miscible with fat oils. Gorham does not mention any fat oil.

Therefore, according to every fact of which I was aware, maize contained neither fat nor any substance similar to fat. I had not myself at that time entered into any examination of it. The results obtained by MM. Dumas and Payen induced me, however, to undertake an examination of Indian corn, which was grown in my garden.

67 gram. of maize were exhausted by æther. The æther left behind, on evaporation on the waterbath, 2·849 gr. of a thick yellow oil.

The weight of this oil amounted to 4·25 per cent. of the seed. The difference in this experiment from that of MM. Dumas and Payen is very great; 9 per cent. is so much that this seed might be used with advantage in the manufacture of oil. I consequently altered the mode of examination by a proceeding which insured a perfect extraction. The seeds were treated with dilute sulphuric acid kept at nearly a boiling heat until they had almost disappeared. The residue was washed, dried and exhausted by æther. 77 grm. produced in this manner 3·594 grm. of a substance soluble in æther. Maize grown in the fruitful fields of Giessen, therefore, does not contain more than 4·67 per cent. I found since also an analysis by Bizio (*Brugnatelli Giornale*, t. xv. pp. 127, 180) which gives for Italian maize 1·475 per cent of fat oil.

Maize belongs to those seeds which produce a decidedly

Published on 01 January 1841. Downloaded on 5/9/2026 11:59:53 PM.

View Article Online

favourable influence on the formation of fat; some maize contains no fat (Lespes, Gorham), some contains above 4 per cent. of oil, and other maize contains 9 per cent. of fatty oil. According to each individual's view, arguments may be drawn from these observations favourable or unfavourable to the formation of fat in the animal body; but as the analysis of the excrements of the geese was not made, they cannot be taken into account.

The fatty oil obtained in the Giessen laboratory from the seeds of the maize, completely dissolved in an alkaline carbonate and formed a perfect soap; it consisted of a fatty acid, which probably is formed by the influence of the air on the fat contained in the seed on its becoming rancid.

According to the analysis of Dr. Fresenius, this oil consists in 100 parts of—

Carbon	79·68
Hydrogen	11·53
Oxygen	8·79

and possesses, therefore, a composition similar to known fats.

I consider it certain, that the fat which animals take in their food contributes to increase the quantity of fat in their bodies. We have of this certain and decided proof, in the pathological treatment of persons who daily take a considerable quantity of cod-liver oil.

I further consider it probable that oily fat may pass into crystallized fatty acids; and Wöhler's observation, that fusel oil from corn contains a considerable quantity of margaric acid, finds a satisfactory solution by the experiments of M. Mulder, which make the conversion of œnanthic acid into margaric acid probable.

In the Giessen laboratory the observation was made some years ago, that the oleic acid, in the state in which it is obtained from stearic acid manufactories, produces upon rapid distillation more than the half of a fluid product which on cooling becomes as hard as tallow, and upon expression produces 35 per cent. of margaric acid.

These experiments, which are well worth a closer investigation, render it not improbable that hard tallow might be formed out of liquid crystallizable oil.

Whether similar processes take place in animals, in relation to the formation of many of their compounds, to those that take place in plants, is hardly to be doubted.

The observation by Wöhler of the giving out of oxygen by the infusoria, which led him to put the question, whether the nourishment of these creatures was not dependent upon

Published on 01 January 1841. Downloaded on 5/9/2026 11:59:53 PM.

View Article Online

a similar decomposing process to that of plants, might by accurate examination be soon brought to a decision.

Published on 01 January 1841. Downloaded on 5/9/2026 11:59:53 PM.