LIV. FAT METABOLISM IN FISHES.

III. SELECTIVE FORMATION OF FAT DEPOSITS.

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IN a previous communication [Lovern, 1932, 2] data were given of the fatty acid compositions of the glycerides from three depôts in a single fish (*Acipenser sturio*), and some evidence was adduced that a reversible change from palmitic into palmitoleic acid was one factor controlling depôt fat composition. It was also suggested that for the sturgeon the fat in all depôts required a constant ratio of saturated to unsaturated acids. Three other species have now been studied, the conger eel (*Conger vulgaris*), a dolphin (species unfortunately not determined with certainty), and a porpoise (*Phocaena communis*). In the case of the conger eel, the main fat depôt consists of two strips of adipose tissue attached to the peritoneum, whilst the liver is a subsidiary depôt. In order to obtain sufficient liver fat for a full analysis, twelve large fish were used, the peritoneal fats and liver fats being combined. In the case of the dolphin (an immature specimen) and the porpoise (an adult female with a well-developed foetus) the main fat depôt is the blubber. This was divided into two classes in each case; (a) that from the body, and (b) that from the head, which is mainly found in a thick deposit in a hollow of the skull. These two fats had different compositions. In addition, the jaw-bones of these animals are filled with an oily pulp, which was extracted, giving a fat of different composition from the blubber fats.

In the hope of extending the range of depôts examined, a semi-micro-method of fatty acid analysis was elaborated. As pointed out previously [Lovern, 1932, 2], for an accurate analysis of a fish oil by macro-methods, roughly 200 g. of fat are required. It was desired to carry out such an analysis on quantities down to 10 g. of fat. A small distilling flask was used, with a bulb of 50 ml. capacity and a side-tube let into the bulb as in the Willstätter flask. A slight constriction in the neck supported a spiral of copper wire, to act as a fractionating column. Quantities as small as 1 g. could be fractionated from this, the residues usually being no more than 0.4 to 0.5 g. Fractions were collected in receivers made from shortened test-tubes, and quantities as low as 0.3 g. were frequently collected and the saponification equivalent and iodine value determined. Iodine values on one quarter of the usual quantity of material are easily performed by the use of proportionately smaller quantities of reagents and titration with more dilute thiosulphate. Equivalent determinations on as little as 0.1 g. of material were carried out. The fat was weighed into a shortened test-tube, 2 ml. of *N*/2 alcoholic potash were added and the mixture was boiled for one hour under reflux with exclusion of carbon dioxide. The contents were washed out with 80 ml. of neutral alcohol into a suitable flask and titrated with *N*/50 sulphuric acid. A good end-point at such dilution depends on the choice of a suitable indicator, *e.g.* dibromothymoltetrachlorophthalein [Cornwell and Esselstyn, 1927]. This has a

very small p_H range (8.8 to 8.4) from deep blue to colourless, and after a little practice, satisfactory duplicates could always be obtained. A blank determination was made as usual.

In every case, as large a quantity of fat as possible (up to 200 g.) was used. Wherever possible, fractional distillations were carried out in the usual Willstätter flasks, and where this was impossible, in the small flask. Equivalent and iodine value determinations were also performed on full quantities where available, and when determined on smaller amounts, the procedure was adapted to make use of as much material as was available. Unfortunately, in the micro-method, it was often impossible to refractionate the fractions from the primary distillation, and this is probably the greatest source of error. In certain cases mixtures have to be taken as containing only two components for the composition to be calculated, and it is almost impossible to obtain only such fractions in one distillation, especially perhaps in this simpler distilling flask. Each fraction however will contain mainly two components, and in many cases only two.

By the use of these micro-methods, analyses were also made of the fats from the blubber of the foetus, and the liver, lungs and heart of the porpoise. In each case only the glyceride fraction was used, the accompanying phosphatides being separated with acetone. The analytical procedure was the same as that adopted in previous cases, except as regards the *isovaleric* acid, which was recovered by steam-distillation. Small quantities of lauric acid also always came over at the same time. The steam-volatile acids were dealt with by ether extraction and fractional distillation, as in the method of Hilditch and Jones [1929], for butter-fats.

The blubber and jaw-fats of the dolphin and porpoise all contain small amounts of waxes, but glycerides preponderate to such an extent that the presence of the waxes can be ignored and the mixed fatty acid composition considered as being essentially that of the glyceride fatty acids. In one case only, that of the head blubber of the dolphin, was the higher alcohol mixture from these waxes examined in detail. It was found to consist mainly of cetyl and oleyl alcohols, with appreciable amounts of tetradecanol and octadecanol. The method used in this analysis was that described by Hilditch and Lovern [1929, 2].

The blubber fats from the members of the porpoise and dolphin family are well-known to be peculiar in respect of the presence of *isovaleric* acid. Gill and Tucker [1930] found in the jaw-oil of a species of dolphin (*Tursiops truncatus*) 86.7 % *isovaleric* acid, 8.4 % palmitic acid and 4.9 % oleic acid. They also found 18.7 % of higher alcohols (mainly dodecanol with some tetradecanol). It must be pointed out that their deduction as to the palmitic and oleic acid percentages was based only on an equivalent and iodine value of the mixed non-steam-volatile acids. By analogy with the results of the present analyses, it seems most improbable that only these two acids were present; indeed, one would expect myristic and palmitoleic to be more important constituents than palmitic and oleic, since the percentage of *isovaleric* acid was exceptionally high, and, in the present results, the higher the percentage of *isovaleric* acid, the larger the proportions of myristic and palmitoleic acids.

The analyses are given in Tables I, II and III, Table I giving the particulars of the oils, and Tables II and III the quantitative compositions of the mixed fatty acids, as weight and molecular percentages respectively.

As in previous papers, the average degree of unsaturation of the C_{18} , C_{20} and C_{22} acids is expressed in terms of lack of hydrogen. The C_{14} and C_{16} unsaturated acids were in every case monoethylenic only. The palmitoleic and oleic acids in each fat were the ordinary $\Delta^9, 10$ acids, as shown by the production of azelaic acid on oxidation with permanganate in acetone solution.

Table I. *Particulars of fats.*

Species	Fat from	Iodine value	Sap. equiv.	Unsaponifiable %	Type of unsaponifiable
<i>Conger vulgaris</i>	Liver	109.4	—	2.5	Mainly cholesterol
"	Peritoneum	141.7	—	0.7	"
Dolphin	Body blubber	136.0	263.4	2.2	Mainly " higher alcohols
"	Head blubber	82.33	228.4	7.5	"
<i>Phocaena communis</i>	Body blubber	88.82	225.7	2.4	"
"	Head blubber	64.76	204.7	2.1	"
"	Jaw	44.93	196.3	3.6	"
"	Foetal body blubber	108.9	267.8	2.4	Largely " cholesterol
"	Heart	121.3	—	9.7	Mainly cholesterol
"	Lungs	119.5	—	15.0	"
"	Liver	175.0	—	32.1	"

Table II. *Composition of mixed fatty acids (Wt. %).*

Species	Depôt	Saturated					Unsaturated				
		C ₆	C ₁₂	C ₁₄	C ₁₆	C ₁₈	C ₁₄	C ₁₆	C ₁₈	C ₂₀	C ₂₂
<i>Conger vulgaris</i>	Liver	—	—	5.2	19.2	0.4	0.4	18.0	37.5 (-2.0H)	12.4 (-5.6H)	6.9 (-8.1H)
"	Peritoneum	—	—	1.8	18.8	0.9	—	6.2	40.6 (-2.1H)	18.3 (-5.4H)	13.4 (-8.4H)
Dolphin	Body	3.2	1.0	7.2	8.6	0.8	4.7	25.9	24.1 (-3.3H)	18.6 (-6.5H)	5.9 (-7.6H)
"	Head	13.9	2.4	12.5	11.6	0.4	2.7	25.4	15.8 (-2.8H)	12.7 (-5.5H)	2.6 (-7.2H)
<i>Phocaena communis</i>	Body	13.6	3.5*	12.1	4.7	—	4.7	27.2	16.7 (-2.8H)	10.5 (-4.8H)	7.0 (-4.9H)
"	Head	20.8	4.1	15.8	7.5	0.2	4.6	20.8	15.2 (-2.6H)	9.4 (-4.5H)	1.6 (-4.7H)
"	Jaw	25.3	4.6*	28.3	4.1	—	3.2	20.3	9.3 (-2.6H)	4.9 (-4.9H)	—
"	Foetus	1.2	—	14.9	0.6	—	12.3	48.1	15.4 (-4.0H)	7.5 (-7.4H)	—
"	Liver	—	—	—	7.6	5.5	—	6.1	42.5 (-2.8H)	27.3 (-5.4H)	11.0 (-6.5H)
"	Lungs	—	—	4.6	9.0	1.2	0.1	16.5	27.0 (-2.4H)	31.0 (-3.3H)	10.6 (-5.4H)
"	Heart	—	—	8.1	8.2	4.4	4.4	16.8	50.4 (-3.6H)	7.6 (-5.4H)	—

* Trace of lauroleic acid present.

Table III. *Composition of mixed fatty acids (Mols. %).*

Species	Depôt	Saturated					Unsaturated				
		C ₅	C ₁₂	C ₁₄	C ₁₆	C ₁₈	C ₁₄	C ₁₆	C ₁₈	C ₂₀	C ₂₂
<i>Conger vulgaris</i>	Liver	—	—	6.2	20.5	0.4	0.5	19.4	36.3	11.0	5.7
"	Peritoneum	—	—	2.3	20.8	0.9	—	6.9	40.8	16.9	11.4
Dolphin	Body	8.0	1.3	8.1	8.6	0.7	5.3	26.1	21.9	15.5	4.5
"	Head	29.2	2.6	11.7	9.7	0.3	2.5	21.4	12.0	8.9	1.7
<i>Phocaena communis</i>	Body	28.7	3.8	11.4	3.9	—	4.5	23.0	12.8	7.4	4.5
"	Head	39.6	4.0	13.4	5.7	0.1	3.9	16.0	10.5	5.9	0.9
"	Jaw	44.7	4.1	22.4	2.9	—	2.6	14.4	6.0	2.9	—
"	Foetus	2.9	—	16.2	0.6	—	13.5	47.0	13.7	6.1	—
"	Liver	—	—	—	8.6	5.6	—	6.9	43.7	25.7	9.5
"	Lungs	—	—	5.7	10.0	1.2	0.1	18.4	27.2	28.4	9.0
"	Heart	—	—	9.5	8.6	4.2	5.2	17.7	48.2	6.6	—

Consideration of these figures reveals several points of interest. In the conger eel we have another instance, as in the sturgeon, of an animal with a liver fat no more unsaturated than the depôt fat. But whereas in the sturgeon both fats have almost equal average unsaturations (iodine value), in the conger eel the liver fat has a much lower iodine value and is much harder. This is wholly due to the different proportions of the various acids present in each case. Unlike the sturgeon, the conger eel has no constant proportion of saturated acids. The oils resemble that from the liver of the halibut in the absence of linoleic acid [Lovern, 1932, 1].

The acids from the dolphin and porpoise blubber and jaw depôts resemble those of the oils from the sperm whale [Hilditch and Lovern, 1928], particularly the head oil of this whale, in that in each case a considerable proportion of the acids have molecular weights below those of the acids taken in the food and are hence products of metabolism. Also the proportions of certain acids which are present in the food are much altered in these depôts, *e.g.* the high proportions of myristic and palmitoleic acids. The oils further resemble the sperm oils in being a mixture of waxes and glycerides, although the proportion of waxes is much lower in the present cases. The occurrence of *isovaleric* acid as a fat constituent is apparently peculiar to the Delphinidae, but lauric acid has been found elsewhere in marine animals [Rees, 1933; Hilditch and Lovern, 1928].

The foetal fat of the porpoise had only a trace of *isovaleric* acid, but large quantities of C_{14} and C_{16} acids, whilst the degree of unsaturation of the C_{18} and C_{20} acids was the highest in the whole series, considerably higher even than that of the maternal liver. The liver fat had the highest average unsaturation, as shown by the iodine value, but this is due largely to the proportions of the different groups of acids (contrasted with the heart fat for instance). It is noteworthy that the organ fats have no *isovaleric* and lauric acids and do not contain unusually large proportions of C_{14} and C_{16} acids. In this respect also the porpoise and dolphin resemble the sperm whale, for Tsujimoto and Kimura [1928] reported the liver fat of the latter to be only glycerides, and with no preponderance of lower acids. This difference from the blubber and jaw fats is particularly emphasised when the results are expressed in molecular percentages.

If the *isovaleric*, lauric and much of the myristic acids, which are presumably metabolic products, had been separately built up into glycerides and then admixed with food fat entering the depôts, we should expect most of these acids to be present as fully-saturated glycerides, which would survive oxidation with powdered permanganate in acetone solution. The body fat of the porpoise which was used contained 10.5 % by weight of fully-saturated material. This was for the most part glycerides, although a small amount of higher alcohols was recovered from it. The composition of the mixed acids is given (wt. %) in Table IV. The significance of these results is best seen by comparing the proportions of each acid present as fully-saturated material.

Table IV. *Proportions of saturated acids combined as fully-saturated glycerides.*

	C_6	C_{12}	C_{14}	C_{16}
Composition of acids in fully-saturated portion	26.1	19.7	42.1	12.1
Reduced to 10.5 total	2.7	2.1	4.4	1.3
Present in 100 parts of original fat	13.6	3.5	12.1	4.7
% of original acid appearing as fully-saturated glycerides	19.9	60.0	36.4	27.7

The results for the lauric, myristic and palmitic acids are in full agreement with those for sperm head oil [Hilditch and Lovern, 1929, 1] in that larger proportions of the lower molecular weight acids are combined as fully-saturated material, but the *isovaleric* acid is an outstanding exception. Only 20 % of it is so combined, the remainder being combined in glycerides which have at least one unsaturated acid in the molecule. That 80 % of the *isovaleric* acid is combined as mixed saturated-unsaturated glycerides was proved by eliminating the two alternative explanations of the oxidation results. One of these is that *isovaleric* acid is itself unstable to oxidation. This was disproved by a second oxidation, which gave the same quantity of fully-saturated material, of the same mean equivalent. The second alternative is that the bulk of the *isovaleric* acid is present as mono- or di-glycerides, which would yield acidic products on oxidation. Gill and Tucker [1930] suggested that in the jaw fat of *Tursiops truncatus* some of it was so combined. A sample of the porpoise body fat was acetylated, and the mean equivalent of the product was 220.0 as against 225.7 before acetylation. This fall is easily accounted for by slight rancidity and the presence of traces of free alcohols, cholesterol, etc., and it is evident that no great quantity of mono- or di-glycerides can be present.

Whatever the origin of the *isovaleric* acid (and this may well be the same as that by which small quantities of this acid are normally produced as waste products in many animals), it can hardly be the same as that of the other fatty acids, all of which have a straight chain structure. The members of the Delphinidae differ from all other animals yet investigated in using this *isovaleric* acid as a constituent of their depôt fats, and it is perhaps also the only case of an acid of an odd number of carbon atoms being so used. In this utilisation of the *isovaleric* acid, it is largely combined as mixed glycerides with ordinary *n*-fatty acids, and the mode of combination is quantitatively quite different from that of the other saturated acids. In the case of the foetus it appears that *isovaleric* acid was not passed through the placenta, and that the portion found in the foetal blubber was produced by metabolic processes in the foetus itself. A small amount of fat was isolated from the placenta and the glyceride and phosphatide fractions separated. No *isovaleric* acid was present, and the glyceride acids had an iodine value of 117.7 and a mean equivalent of 275.5. Hence no large proportions of C_{14} and C_{16} acids could have been present. The acids from the phosphatide fraction had an iodine value of 96.7, too little being available for the determination of the mean equivalent.

A comparison of the fats from the depôts of each animal (excluding for the moment the organ fats, which are not really depôt fats, and the foetal blubber, which really belongs to a separate metabolic system) shows that the differences are progressive with the molecular weight of the component acids. For instance, in *Phocaena communis* (Table III), on passing from body to head and head to jaw, the *isovaleric*, lauric and myristic acids steadily rise, and the C_{18} , C_{20} and C_{22} acids fall. If the compositions are expressed as total groups (*i.e.* all C_{16} acids being grouped together for instance) in molar percentages, this progressive effect is striking (Table V).

In the conger eel, C_{14} and C_{16} acids are less in the peritoneum than in the liver, and C_{18} , C_{20} and C_{22} are higher. For the dolphin and porpoise the C_5 , C_{12} and C_{14} acids increase from body to head and head to jaw, whilst the C_{16} , C_{18} , C_{20} and C_{22} acids decrease. That the extent of these increases and decreases is in general progressive with molecular weight is apparent. The figures for the acids from the head and body blubbers of the sperm whale [Hilditch and Lovern, 1928] show precisely the same relationship.

Table V. *Acids arranged in molecular groups.*

Species	Depôt	C ₅	C ₁₂	C ₁₄	C ₁₆	C ₁₈	C ₂₀	C ₂₂
<i>Conger vulgaris</i>	Liver	—	—	6.7	39.9	36.7	11.0	5.7
"	Peritoneum	—	—	2.3	27.7	41.7	16.9	11.4
Dolphin	Body	8.0	1.3	13.4	34.7	22.6	15.5	4.5
"	Head	29.2	2.6	14.2	31.1	12.3	8.9	1.7
<i>Phocaena communis</i>	Body	28.7	3.8	15.9	26.9	12.8	7.4	4.5
"	Head	39.6	4.0	17.3	21.7	10.6	5.9	0.9
"	Jaw	44.7	4.1	25.0	17.3	6.0	2.9	—

This suggests that one of the mechanisms operating in the case of these animals to control the type of fat laid down in the different depôts rests on a basis of molecular size and might almost be some form of molecular filtration. Presumably the acids enter the depôts as glycerides and not as free fatty acids, but in either case similar reasoning could be applied. We will suppose for example, that in *Phocaena communis* the size of molecule which can readily pass through the membranes of the jaw depôt is less than that for the head, which in turn is less than that for the body. Under such circumstances a selective deposition of certain of the available glycerides would take place exactly in accordance with Table V. In the less permeable jaw depôt for instance, C₂₀ acids could only enter if combined as a triglyceride with two molecules of isovaleric acid, and C₂₂ acids could not enter at all. More combinations of C₁₈ acids would find an entry, *e.g.* one C₁₈ radical with two C₅ or two C₁₂ radicals, or with one C₅ and a C₁₂ or C₁₄ radical, and so on progressively for the other acids. What becomes of much of the higher molecular weight acids which the porpoise and dolphin take in their food (this applies also to the sperm whale) is not clear. A small amount will find its way into the organ fats in which lower acids do not preponderate, but it seems not unlikely that much of it is broken down into these same lower acids which are present in such large amounts. The somewhat low degree of unsaturation of the porpoise, dolphin and sperm whale C₂₀ and C₂₂ acids may be of significance in this respect. This progressive difference in the fat from the different depôts is also shown qualitatively by the characteristics of the fats from the same three depôts of another dolphin (*Lagenorhynchus albirostris*).

Table VI. *Fat from Lagenorhynchus albirostris.*

Depôt	Saponification equivalent	Iodine value
Body	253.9	112.2
Head	246.9	99.81
Jaw	226.1	65.15

Sunderland [1932] examined fats from *Phocaena communis*, making a different separation of the depôts. His samples were from the upper and lower jaws respectively, from the skull and from the blubber. The blubber included both the head and body sections. The fats had different saponification and iodine values, again showing a selective deposition.

If we visualise fat deposition taking place selectively on any basis of permeability differences, we should expect to find, *mutatis mutandis*, that the less permeable depôts (as found by analysis of the fatty acids) would be the smaller in size. Low molecular weight components will find equally easy entry into all depôts, but the larger molecules will only readily enter the more permeable depôts. In actual fact, such is the case. In the conger eel, the less permeable liver depôt contains roughly one-eighth as much fat as the peritoneal depôt. In the dolphin and porpoise, the body fat is much greater in quantity than the head

fat, which in turn is much greater than the jaw fat. The writer has no data for the relative quantities of head and body fat in the sperm whale, but it seems most probable that the body fat is the greater in quantity.

The position in the sperm whale is complicated, however, by the presence of so much wax, which is mainly of low molecular weight compared with triglycerides. Whilst this evidence as to relative size of depôts is in harmony with the molecular filtration theory, it must be borne in mind that some depôts may be restricted by anatomical structure, *e.g.* the jaw depôt of the porpoise. There is also the evidence of Channon and El Saby [1932] that in the herring fat does not necessarily enter all the depôts at the same time and may even be transferred from one depôt to another. It may well be that similar conditions obtain in the animals under discussion.

On this theory of molecular filtration, the saturated and unsaturated acids of the same number of carbon atoms would stand equal chances of entering any particular depôt, unless, of course, there is something peculiar in the mode of combination as glycerides. The only glyceride peculiarity so far evident which bears on this point is the tendency for lower saturated acids to concentrate in the fully-saturated fraction of the fat. Since all the saturated acids present are of relatively low molecular weight, this might conceivably result in a greater chance of saturated acids being found in small glyceride molecules than the corresponding unsaturated acids, and this would be more marked for myristic than for palmitic acid (Table IV). Had the glyceride composition been quite heterogeneous, one would have expected to find the same ratios of palmitic to palmitoleic acid and of myristic to myristoleic acid entering a depôt as were present in the supplies reaching that depôt, and hence the same *ratio* in each depôt, irrespective of the total quantities of these acids. The ratios are given in Table VII. In the case of the conger eel only the C_{16} ratio can be included.

Table VII. *Ratio of saturated to unsaturated acid.*

Species	Depôt	C_{14} acids	C_{16} acids
<i>Conger vulgaris</i>	Liver	—	1.1
"	Peritoneum	—	3.0
Dolphin	Body	1.5	0.33
"	Head	4.6	0.46
<i>Phocaena communis</i>	Body	2.6	0.17
"	Head	3.4	0.36
"	Jaw	8.8	0.20

The differences in the ratios are very large in certain cases, especially for the conger eel and for C_{14} acids in the dolphin and porpoise. With one exception the differences for the dolphin and porpoise are all in the same direction, an increasing ratio of saturated to unsaturated acid on passing from body to head and head to jaw. This is in agreement with the glyceride peculiarity. The jaw of the porpoise is an exception for the C_{16} acids, and in the conger eel there is a big difference in the opposite direction, *i.e.* a higher ratio in the more permeable depôt, which cannot be explained by glyceride structure.

The interpretation which seems most in accordance with all the facts is that the saturated and unsaturated acids of the same number of carbon atoms are interconvertible, as suggested in the previous paper for the sturgeon [Lovern, 1932, 2]. It would follow that the conversion takes place in the depôt itself. Support of the idea of interconvertibility is found in the work of Mazza and Stolfi [1933] and of Berend [1933] who have described dehydrogenases which act on higher fatty acids.

The peculiar composition of the porpoise and dolphin depôt fats raises some interesting questions. Where, for instance, is the site of the production of the lower fatty acids, due perhaps to breakdown of the C_{20} and C_{22} acids? Also of the *isovaleric* acid, which is apparently produced quite separately, and combined into mixed glycerides in a different manner from the other lower acids? That this site is the liver seems most unlikely, in view of the apparent entire absence of these acids from it—indeed, the liver fat closely resembles the other organ fats examined. In fact, the organ and the depôt fats are so thoroughly different in their whole composition that it is difficult to imagine the liver playing any large part in the metabolism of these depôt fats. An organ that is worthy of attention in this respect is the spleen, in view of its function of removing fat from the blood during alimentary lipaemia [Marino, 1933], and hence its rôle as an intermediary in the formation of depôt fats from food fat [*cf.* also Leites *et al.*, 1933].

In the case of the foetus it seems probable that the fat received from the maternal system is mainly of the ordinary marine type. This is modified by the foetus in two ways—by production of much C_{14} and C_{16} acids in place of C_{20} and C_{22} , and by admixture of *isovaleric* acid. The metabolic process from which the *isovaleric* acid arises evidently does not function to any great extent up to this stage. The characteristic composition of the foetal fat is further evidence that the *isovaleric* acid and the lower *n*-acids are produced by separate processes.

The molecular selectivity displayed in the formation of these depôt fats does not appear to hold for all species, *e.g.* the pike and the sturgeon [Lovern, 1932, 1, 2]. In these animals the different depôts appear equally permeable, resulting in the constant proportion of total C_{16} acids found for the sturgeon and the pike.

SUMMARY.

The liver and peritoneal fats of the conger eel, and the fats from a number of depôts and organs of a dolphin and a porpoise have been examined. Considerable differences in fatty acid composition are found in the different fats from one animal, indicating a highly selective formation of the fat deposits.

The porpoise and dolphin fats show great similarity of type to those from the sperm whale, thus affording further evidence that zoologically related species exhibit definite similarities in fat composition.

The porpoise and dolphin depôt fats are unique in containing large amounts of *isovaleric* acid and the mode of combination of this is peculiar.

The depôt fats of the porpoise and dolphin are quite different in type from the organ fats of the same animals. Whilst no explanation of this can be offered, it is not in harmony with the idea of fat transfer to the liver before utilisation. The theory of desaturation in the liver is also unsupported by the conger eel and porpoise figures. In the case of the porpoise, the heart fat contains an even more unsaturated group than the liver fat.

The blubber of a porpoise foetus showed a peculiar composition and a very high degree of unsaturation.

The depôt fats of all the animals show a molecular size gradation which suggests that one cause of specificity may be a molecular filtration.

Some further evidence is adduced in support of the idea of interconvertibility of saturated and unsaturated acids of the same number of carbon atoms.

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