Function of the Liver and Pancreas and the Parts which their Secretions perform in Digestion

When we consider the importance of the above subject, and comparatively how little is at present known of the functions of these organs; it ought to stimulate every one studying Physiology, to do anything if in his power to clear up the mystery, which envelopes their functions. The following is merely a compilation as lack of opportunity, and time have prevented me from even repeating many experiments, which some think require corroboration, before we can consider them as absolutely correct, and draw definite conclusions from them. As an instance of some discrepancies, which I shall have more particularly to consider afterwards, I might adduce the difference of opinion held by Beaumont and Bernard, as to the pancreatic juice the latter affirming it to be alkaline, the former acid - A difference which must certainly have a most important influence on the conclusions, we may draw from the experiments of each. if we are inclined to put faith in their experiments.

I propose to consider first the Liver and its secretion the Bile, and the part which the latter performs

in Digestion. There are three most important modes of enquiry, which may assist us in forming correct ideas on the functions of the liver and bile -

1st Observations on its normal and healthy action

2nd On its pathological conditions and the changes which it undergoes in some diseases, also the effects which these changes produce on the animal economy -

3rd Observations on the state and comparative size of the liver, through some well known tribes of animals, or in fact its functions as shown by Comparative anatomy.

In the first of these or "observations on its normal and healthy action", we must take into consideration the mode in which it is supplied with the blood, from which it eliminates its secretion. It is needless to adduce any argument to prove that the bile is secreted from the portal blood, and not from that furnished by the Hepatic Artery - The portal vein is formed by the union of the splenic and pancreatic veins with the veins which come from all the chylopoietic viscera, and this vein during digestion must contain a much larger amount of soluble constituents than the ordinary venous blood, from the fact that a very large proportion of the soluble matter taken

into the system is absorbed by the veins, from which the Portal is formed - Béclard has made an elaborate series of experiments to find out in what these differences consist, and in his first series of analyses he determined that the arterial constitution of the blood throughout the body is identical, as his analyses did not differ more than was fully accounted for by limit of error in analysis. His second series of experiments, of which I subjoin the results, were to determine the differences in the arterial and venous circulation generally. These are a loss in the amount of albumen, and in one experiment in which the fibrine was estimated a gain in that constituent. These results he says agree with those of other observers, who have written on the subject, and on calculation this gain in weight in albumen will be found in exact ratio to the loss of weight, which the albumen has sustained. Béclard made his experiments by bleeding the animal at the same moment in two places - Instances of these are the three following.

Analysis of Blood from Horse - Carotid Artery Jugular Vein

Water	792.87	783.84
albumen & Salts	90.62	88.72
Globules	132.31	122.94
Fibrine	4.20	4.50

The third series of experiments are more important to our present object as shewing the differences, between the constitution of the blood in the Jugular and Splenic veins. To determine the composition of the blood in the Splenic vein no less than sixteen experiments were made, some of which I quote, but as almost all are similar I only give the general result which is an average diminution of 16.08 per 1000 parts in blood globules and fibrine. In two experiments also in which the fibrine was determined a considerable increase was noted and the mean augmentation in the amount of Albumen is 13.02 per 1000 parts.

I Experiment made on a small and feeble dog

	Jugular Vein	Splenic Vein
Water	810.60 –	826.81
Globules & Fibrine	98.31 –	81.77
Albumen & Salts	91.10 –	91.41

II Experiment made on a dog of mean height and strong

	Jugular	Splenic
Water	751.703 –	764.12
Globules & Fib.	180.178 –	143.64
Albumen & Salts	68.119 –	92.24

III On a tall hound

	Jugular Vein	Splenic Vein
Water	764.33 –	765.45
Globules & Fibrine	164.25	144.82
Albumen & Salts	71.42	89.73

IV On a strong dog of mean height

	Jugular vein	Splenic vein	Arterial
Water	778.87	746.304	750.62
Albumen & Salts	79.41	124.792	89.53
Globules & Fibrine	141.72	128.901	159.85

His fourth series of experiments comprises some to determine nature of blood, which traverses the superior mesenteric vein, and he proves that the composition of this blood differs most materially, when the experiment is made at an early period of digestion, during full digestion, or when the animal has fasted for some time. His experiments also seem to confirm the observation, that albuminous matter is almost entirely absorbed by the venous system, and fatty matter by the chyliferous. In those cases in which the animal had been killed fasting and the blood examined we find that the albumen has diminished and the globules increased, while in those animals whose blood was taken and examined soon after a meal we find the albumen much increased, and the globules diminished.

An example of the differences is as follows.

Fasting	Jugular Vein	Sup. Mesenteric
Water	766.41	732.37
Globules & Fibrine	148.92	192.32
Albumen & Salts	84.67	75.29

In full digestion	Jugular Vein	Superior Mesenteric
Water	778·90	778·85
Globules & Fibrine	158·20	58·97
Albumen & Salts	62·90	162·18

It is evident also that much will depend on the quantity of fluid which the animal has taken during his meal as that will alter most certainly the quantity of solids in the blood. I think that the above experiments, or rather whole series of experiments prove most completely that the Portal Vein carries blood containing much more albumen (especially during digestion) and soluble salts than the general venous circulation. And it is chiefly during the period of digestion that the secretion of Bile takes place. It is to be regretted that we have no experiments from the same author to inform us exactly in what the composition of Hepatic Blood (blood from Hepatic vein) differs from Portal Blood. In reference to this I give the following copy from the Medical Times of a translated portion of Lehmann's Physiological Chemistry

"The blood of the Hepatic Vein compared with the blood of the Vena portae is much poorer in water, its water as compared with that of the Portal Vein is during digestion as 3 to 4, and after perfect digestion as 5 to 12. The clot of the blood of the Hepatic Vein is voluminous and while 100 parts of Portal Blood separate 34 parts

of serum, the same quantity of blood from the Hepatic vein separates only 15 parts. The Hepatic vein blood is much richer in cells both coloured and colourless than the Portal blood; the colourless corpuscles are of the most varied size and shape, the coloured in heaps have a distinct violet tint, and their walls imbibe water, and they are much more easily destroyed than the cells in the blood of other vessels. The blood cells in the Hepatic vein are poorer in fat and in salts and especially poorer in haematine, or at least in iron. The liquor sanguinis is much denser than that of the Portal vein and contains much more solid matter with the exception of the fibrine which is either wanting or in very small quantity. If in 100 parts of serum of Portal blood 8·4 (84 per 1000) of solids are contained in the serum of Hepatic blood there are 118 (118 per 1000) solids in 100. On comparing the individual solids of the serum the Hepatic vein blood contains less albumen and less fat and much fewer salts but the quantity of extractives and especially of sugar is remarkably increased".

As to the constituent of the blood, from which the chief part of bile is formed, or if it is formed from more than one we are quite ignorant, at least we have

little more than conjecture, founded on its analyses to guide us, but a knowledge of comparative Anatomy here assists us, as I shall consider more hereafter. The bile is a yellowish fluid tinged with green and exposure to the air renders it darker. It is always alkaline and has a peculiar viscid feel when rubbed between the fingers. It has been frequently analysed and I mention the chief products found by analysis. Many other compounds have been supposed to exist than those which I shall mention but by far the greater number of these, most probably are formed by decompositions during analysis as there are no compounds more easily changed on the application of reagents than those forming the principal constituents of bile. I shall only particularly consider the chief ingredient and that which seems quite essential to its production viz- Cholate of Soda, or a substance analogous to it as the substance found in bile does not precisely correspond to that salt. Cholic acid must be formed from some azotized constituent of the blood but whether from fibrine or albumen does not clearly appear- most probably albumen as that substance seems to be diminished in quantity so also is fibrine so that can scarcely add anything to our conjecture

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Liebig gives the formula for one atom of cholic acid $C_{76}\ N_2\ H_{66}\ O_{22}$ and supposes from the analysis of Urine of serpents that it is formed in the following manner – He says "Let us now add the half of the numbers which represent the formula of cholic acid to the elements of the urine of serpents that is to neutral urate of Ammonia as follows

½ Formula for Cholic Acid $C_{38}\ N\ H_{33}\ O_{11}$

Urate of Ammonia { equiv Uric acid $C_{10}\ N_4\ H_4\ O_6$
– Ammonia $N\ H_3$ $C_{10}\ N_5\ H_7\ O_6$

$C_{48}\ N_6\ H_{40}\ O_{17}$

But this formula expresses the composition of blood with the addition of one equivalent of Oxygen and one of water"

And he brings further formulae to bear which with additions seem to favour the same view Again he says "If then we consider cholic acid and urate of Ammonia the products of the transformation of Muscular fibre since no other tissue of the body contains proteine (for albumen passes into tissues without our being able to say that in the vital process it is directly resolved into Cholic acid and Urate of Ammonia) then exist in fibrine with the additions of elements of water, all the elements essential to this metamorphosis and

except the Sulphur and Phosphorus which are oxidised probably, no element is separated"

Liebig then goes on to say that the uric acid formed is converted by the addition of Oxygen into Urea and Alloxan, which latter by a further dose of oxygen also changes into Urea and oxalic & Carbonic acids chiefly- Again he gives a complicated account of the manner in which he supposes that proteine compounds are transformed in the herbivora, but it will be unnecessary for me to quote that passage. He denies that urea is formed from any portion of the albumen, until after that albumen has formed a part of the organised tissue, and he says that albumen undergoes no change in passing through the liver and kidneys - With regard to the former part of this assertion it appears to me to rest on very questionable ground as it has frequently been found that when a larger amount of nitrogenous food than ordinary has been taken, and muscular action not increased sufficiently to account for a occasion greater waste in the tissues, the quantity of urea and uric acid in the urine is greatly increased - As to the latter part that albumen is unchanged in passing thro the liver and Kidneys - Physiology leads us to believe the Kidney at least chiefly an eliminating organ, but is it the same with the liver? I think not: when

we examine the results of Lehmanns experiments we find the proportion of albumen in the blood diminished in passing through the liver, and we do not find albumen in the secretion, must we not necessarily infer that a portion of the albumen has been changed into other products? In examining the accounts of analyses of cholic acid in the carnivora there appeared a singular coincidence between the composition of cholic acid plus two atoms of uric acid on the one hand, with the composition of albumen on the other - It is not impossible that such a change may take place - for the percentage composition of such a compound very much resembles that of some analyses of albumen, and there is also a striking resemblance in the atomic composition of the two not more difference being apparent than for which the limit of error in analysis might easily account. Both Cholic acid and Uric acid are found in greater abundance in the secretions of the carnivora than in those animals which feed only on vegetable or even on a mixed diet. The cholic acid in the bile is combined with Soda and this originally derived from the common salt taken in as food.

Bile contains a nitrogenised sugar denominated

by some picromel, by others biline, and supposed by Berzelius to be the chief constituent of Bile- It appears analogous to Cholic acid in its constitution. Bile contains a considerable quantity of colouring matter, which imparts the characteristic colour to faeces and appears to be invariably excreted.

Within the last two years Bernard has made several series of experiments on the production of sugar in the liver independently of the ingestion of saccharine or sugary matter in the food - His experiments occupy a considerable portion of space in XVIII^th^ Vol. of the Archives Générales de Médecine and it would take up too much space to insert them here - I must say that he appears to have proved most distinctly that sugar identical, with that found in milk is discovered normally present in the blood which flows from the liver to join the Inferior Cava - and that in animals fed only on nitrogenised food. I shall quote the general conclusions at which he has arrived in his own words

1° Qu'à l'état physiologique il existe constamment et normalement du sucre de diabète dans le sang du coeur et dans le foie de l'homme et des animaux

2° Que la formation de ce sucre dans le foie et

The Author seems unacquainted with the fact that this
also was a discovery of Bernard -

qu'elle est indépendante d'une alimentation sucrée ou amylacée

3° Que cette formation du sucre dans le foie commence à s'opérer dans l'animal avant la naissance par conséquent avant l'ingestion directe des aliments-

4° Que cette formation de matière sucrée qui versit une des fonctions du foie paraît liée à l'intégrité des nerfs pneumogastriques."

I should have said that Bernard found on cutting the pneumogastric nerves that this change was prevented and that then no sugar could be found in the blood from the liver after that operation. Some observers have said that on wounding the cerebellum in animals diabetic sugar is found in the urine. Bernards views on the functions of the liver are thus summed up in the Medical Times of 23rd Nov 1850. "In some interesting lectures delivered at the College of France M. Bernard gave the following summary of his views on this subject. That several products viz Sugar, fat and fibrine are formed in the liver; whatever the aliment may be the liver transforms it into these three substances hence the great variety of aliments does not change the composition of the blood- One great use of the liver is then to maintain in the blood these conditions without which a tolerable degree of unifor-

" nity would be impossible. The liver then may then
" be preeminently regarded as an organ of sanguifica-
" tion being assisted herein by other organs such as the
" Spleen and chyliferous vessels and apparatus. In
" addition to these the liver is an eliminating organ
" and Bernard adopts the opinion that it is comple-
" mentary to the lungs in the separation of carbon".
With reference to these views we must remember that
Lehmann's experiments proved that the Hepatic Vein
blood contains much less fibrine than the Portal Blood
hence must discard the idea in toto that the liver is a
manufacturer of fibrine - with regard to manufacturing
sugar there can be no doubt that the liver does this and
as to fat our knowledge at present is not at all precise
I think we cannot on such slight grounds say that
the liver is specially engaged in keeping the blood at
an average standard, as we have no evidence that the
liver changes albumen in large quantity and if to this
we add fibrine, fat, sugar and a small portion of gela-
tine we have the only compounds which are contained
in the blood which reaches the liver as all alimentary
substances come under one of these forms before being
admitted into the circulation at all. It is to the
differing amount of the three first in food that we ascribe
its different appearance and quality and how then can

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we ascribe to the liver changing compounds into the substances of which they consist already whilst Bernard supposes that they may be mutually transformed.

Various observers have perhaps never disagreed more on any subject than concerning the function of the bile. Some have attributed to it a most important office in digestion while others have contended that it is solely excrementitious. There cannot be the slightest doubt that its true function is most intricate - it doubtless assists in rendering the chyme fitted for nutrition tho we do not know what change it induces in that substance. Portions of it are also true excretions and act as poisons if retained in the circulating fluid - Experiments the converse of each other prove this - If the bile is prevented from being separated in an animal it dies from poisoning. If the whole of the bile is conveyed out of the body by a tube from the gall duct the animal dies from inanition

The functions of the liver are thus described by Wilson, Esq. The liver performs two most important functions in the animal economy 1st It separates from the venous blood of the chylopoietic viscera certain elements which are needful to digestion, and secondly it depurates the venous blood the first of these constitutes the function of the bile, the second is evinced in a comparative

"examination of two of the great depurating organs, the
"lungs and the liver, in the various classes of animals where
"the latter will be found constantly in exact relation with
"the development of the respiratory organ and with the
"necessity for the removal of the larger quantity of Hydro-
"gen and Carbon from the blood. Thus in herbivorous
"animals the liver is small; It is small also in Mon-
"keys & in man. It is large and has reached its
"highest state of development amongst mammiferous
"animals in carnivora. In birds it is larger in propor-
"tion than in carnivora from the greater necessity of a
"highly oxygenated blood in that class of animals
"In reptiles with cold blood and a low degree of respira-
"tion it is large, it is large also and for the same
"reason in fishes and very large among the invertebrata"

May not the larger size of the liver in birds arise from the necessity of getting rid of a large quantity of nitrogenous tissue, which must result from the great amount of exercise which birds take?

Dr Beaumont of the United States Medical Service tried a considerable number of experiments on the Stomach of St Martin to determine the use of the bile, and the conclusion, at which he arrived, was that it was concerned in bringing the fatty matter into a state of solution, and this he describes in the following way - He added

oxbile to some of the chyme procured from St. Martins stomach - this immediately produced fine coagula of a slightly yellowish colour tinged with green - And to this mixture was added a drachm of dilute muriatic acid, which produced a white balsamic mixture, which after standing at rest some short time separated into three distinct parts, a clay coloured sediment at bottom, a whey coloured fluid above, and a thin oily pellicle on the top - All of his experiments were made much in the same way and we cannot place dependance upon the results as the admixture of Muriatic Acid completely invalidated them - Dr Beaumont erroneously imagined that the pancreatic secretion was acid instead of alkaline - This alkalinity recent experiments seem completely to determine. I shall here quote one of Dr Beaumonts experiments in his own words - as in the first part of the experiment we have the effect of the bile seen at once. he says "More minutely to observe the respective changes by the "addition of Bile and Muriatic acid in the several "parcels of chyme formed in experiment No. 31 (March 31, 1834) "and to note this difference I put equal quantities of each into glasses and added a portion of "hogs gall - In that taken from the stomach at 10 "o clock, one hour after having eaten, fine bright "orange coloured coagula were immediately formed

" equally diffused through a fluid of the same colour, exhib-
" iting no perceptible sediment on standing at rest, but
" yeild the coagula uniformly suspended throughout the
" fluid. The dilute acid added to this occasioned
" a copious sediment to fall to the bottom, and with
" it all the colour of the mixture leaving a transparent
" semigelatinous like fluid above in the proportion of
" three fifths of the whole upon the surface of which floated a thin
" white pellicle. The second portion that produced
" on the bath under the same treatment exhibited
" nearly the same appearance with the exception of the
" colour which was a shade or two lighter. The sediment
" was not quite so compact, the fluid less gelatinous
" and there was less of the white pellicle on the surface"
I shall defer making any remarks on these as also the
experiments of Bernard upon the function as it will be
more appropriate to place them in juxtaposition with
those on the Pancreatic secretion.

Liebig considers the Bile in the light of a secretion
only and he calculates that in a healthy state
only one fortieth to one fiftysixth part of the amount
secreted passes off with the faeces. (Berzelius)
This statement must be received with caution as our
data for determining the questions in which it rests
are so very limited. If we believe what is so frequently

stated, that to a certain extent the liver is vicarious with the lungs, we cannot hold the doctrine that the bile is a secretion only, for if it were so the liver would simply separate an amount of hydrocarbonaceous compounds to be again absorbed, and got rid of by the lungs, as water and Carbonic acid. It was from analyses by Berzelius that Liebig made this calculation, and as it is so difficult a matter to separate the bile from the faeces, more especially when we have reason to believe that it is changed, so much after entering the alimentary canal, we must be very cautious how we draw conclusions from such data and Liebig himself states that "Berzelius found in 1000 parts of fresh human faeces only nine parts of a substance similar to Bile" he does not even know whether it was actually Bile or that the whole of it was separated.

I shall now consider shortly some of the causes producing disease in the liver as an indirect means of arriving at its function.

1st of these is "Great Atmospheric heat" for this agent alone seems to have a great tendency in warm countries to induce Hepatic disease. It has been proved from calculations made from trustworthy data that in the East Indies the average annual percentage of Hepatitis is treble what it is in the Western Hemisphere, and that

it varies much, according to the heat of the climate even in India being much more prevalent in the Southern part than in the Northern. It is also much more prevalent among the European population than among the blacks in the West Indies. Though the cases of these hepatic affections are much more numerous in hot regions, they are not nearly so much varied in their nature being usually confined to Inflammation and its consequences.

2nd Cause producing disease in the liver - The Quantity and Quality of food used are by no means unimportant as regards the action of the liver - An over proportion of animal food seems to favor an excessive secretion of Bile as do highly seasoned dishes either from the special effect of the seasoning or from causing more animal food to be taken

3rd Persons leading a sedentary life are more liable to Hepatic disease, than those who take a full amount of exercise and this is generally believed to arise from the inactivity thereby induced in the circulation thro the liver -

4th The Influence of excess of alcoholic liquors in inducing diseases of the liver has been much insisted on, both in temperate and tropical climates, with this difference that in the former it is inflammation of a

more or less acute type which is produced, while in temperate climates fatal cases arising from this cause generally exhibit the granular degeneration - Dr Mills of Dublin opposes the Idea that Wine and Spirits operate at all, in the production of these diseases, as he says that Hepatic affections are as common among the temperate - It has also been remarked that the troops stationed in Nova Scotia and New Brunswick suffer less than those at home, though from the low price of spirits there are few Stations where the Intemperance is greater. It may be observed too, that Sir George Ballingall while he conceives that in India, affections of the liver are obviously in a great majority of instances the joint effects of climate and intemperance, acknowledges that in others we find them the result of climate only - When originating solely from the latter cause, he adds they are often very obscurely marked.

I think these are the chief causes of disease of liver which must be taken into account and for them I am chiefly indebted to Dr Thompsons articles on this subject in the "Library of Medicine"

Now with regard to the first of these causes or the effect of climate on the liver. It is not at all surprising that disease should be more common in Europeans

and thus throw more work on the liver in its excrementitious capacity

whose habits and mode of eating adapt them specially for living in a country where they must take sufficient food to supply the animal heat - They go out to India and for some time perceive their appetite failing, without any apparent cause and in order to correct this take stimulants in various forms, some of which directly and others indirectly increase greatly the quantity of carbon in the system and do not allow the ordinary effete matter to be properly consumed or thrown off. The same argument applies to those cases in which sufficient exercise is not taken and precisely the same with those who take more than the proper proportion of animal food. Now precisely the same argument guides us in considering what will be the effect of taking alcoholic stimulants. We must remember that of all substances taken as food there are none so easily converted into the ultimate products of the system viz water and Carbonic acid as an alcoholic liquors. Alcohol acts in two ways, immediately, stimulating and exciting the alimentary canal, and disturbing the changes, which are taking place in the blood by requiring first, to be supplied with oxygen to convert all its Carbon and Hydrogen into Carbonic acid and water before any other substance can be so - And the fact that Sir G. Ballingall mentions that liver disease is most uncommon when the intemperance

is greatest, viz in Nova Scotia and New Brunswick is I think easily explained on this ground, that in these countries, the system requires an additional amount of heat which these stimulants much assist in supplying or in other words that the Carbon and Hydrogen which these Stimulants contain are merely part of the fuel necessary to keep up animal heat.

3rd Means of determining function of liver by Comparative anatomy. I think that in many instances this is a means of arriving at conclusions much neglected and one which could with great advantage be further pursued. In the present instance what has been written on the subject confirms greatly the view which I am disposed to take that the bile is secreted from the nitrogenised part of the food only. and also that it may be separated in the manner I formerly mentioned by the change directly into Cholic acid and Uric acid as we find that in carnivorous birds & those eating fish only the faeces consist chiefly of Uric Acid. If we trace the development of the bile upwards we shall find that it is greatest in carnivora and smallest in herbivora and that animals living on a mixed diet hold an intermediate space with reference to the size of the liver. The carnivora among birds are said to have larger livers than those eating grain &c -

[I had anticipated being able to procure several species of birds feeding on all kinds of food but was unable

to do so, is that I cannot compare the relative size of the liver in these different circumstances of food as I had hoped)

I now come to speak of the functions of the Pancreas and the part which its secretion performs in digestion and I should have pursued the same plan as I have done with the liver but little or nothing is known of the true pathology of the pancreas and I believe absolutely nothing definite of the effects which disease produces on the secretion. It has however been noticed in several cases that when the pancreas was much diseased fatty and oily matters have been passed mixed with faeces.

Several authors and among them Dr Gregory Mr Duncan and Dr Beaumont have described the pancreatic as an acid secretion, but I think if we consider for only a short time the circumstances under which the pancreatic juice is poured into the duodenum we must at once negative this opinion. The pancreatic secretion is poured into the duodenum along with the bile, which latter is always alkaline, so that if the pancreatic juice was acid it is

necessary that these juices being mixed together should neutralize each other, again we find that the chyme acid when it leaves the stomach, becomes alkaline after it has been mixed with the biliary and pancreatic secretions, and continues so until it reaches the coecum if the pancreatic secretion was acid, we should not anticipate that such would be the case.

little was known of the function of the pancreatic secretion until within the last two or three years, since Bernard published an elaborate series of experiments which seemed to prove that the function of that juice was chiefly to act upon the fatty matter of the food. These results and detailed accounts of the experiments were published in the "Archives générales de Médecine" Tome XIX for 1848 some portion of which I give below. Dr Bernard commenced his "Mémoire" which was read to the Biological Society of Paris by observing that anatomists had long considered the pancreas as an abdominal salivary gland, and had unjustly ascribed to its secretion the attributes of saliva He proposed to demonstrate experimentally, that the pancreatic juice is alone destined and without assistance from any abdominal organ to digest the neutral fatty matters contained in the aliment and to cause in this way their absorption by the chyliferous vessels.

1st Series of Experiments - Of the extraction of the pancreatic juice and on the conditions of its secretion.

1st Experiment at the beginning of digestion - A very large Spaniel, fasting for twelve hours in good health, made at 7 in the morning a copious meal after which it drank some water. As soon almost as the ingestion was completed it was placed upon the operating table so that the pancreatic juice might be extracted from him - I made (says Dr B) an incision in the right hypochondrium, which allowed me to bring the duodenum and a part of the pancreas outside. The texture of the pancreas was of a light red colour, and its vessels were moderately filled with blood. The duodenum was empty and no chyle tubes were visible at that time - I isolated as rapidly as I could the largest of the two pancreatic ducts, which opens separately into the duodenum about two centimetres below the bile duct. This duct was white and about the size of a strong crow quill. It was filled with some liquid. At each effort which the animal made in crying out the quantity of liquid became greater and the canal more distended - I opened the duct with the point of scissors and immediately there flowed out large round drops of the pancreatic juice, which appeared colourless, limpid and of a viscid and

streaky consistence - A little blood from neighbouring vessels and vessels flowed out, but the pancreatic juice did not at all incline to mix with the blood. I introduced into the open end of the duct a small silver tube and fixed it by a thread passed under the duct. Having replaced the duodenum and pancreas in the abdomen I closed the wound by a suture and left out the end of the silver tube so that I might collect the pancreatic juice. Almost immediately the pancreatic fluid drained out by the tube in large streaky drops, limpid succeeding each other with greater rapidity whenever the animal made an effort and shewing with turnsole paper a strong alkaline reaction. After having confirmed the alkaline reaction of the first drops of the pancreatic juice I fixed a little caoutchouc vessel on the tube for the purpose of receiving it this little vessel had been previously compressed so as to force the air out of it and to make reaction by the tendency of the walls to resume their former rounded form. The animal was then untied and set at liberty and went & lay down without manifesting uneasiness. Five and a half hours afterwards I returned & found the animal quietly lying down. I detached the reservoir & found it contained 8.7 grammes of Pancreatic juice presenting the same characters as before.

Next morning after operation the fluid distilled in abundance

I obtained in the same way in an hour & a quarter 16 grammes of the juice which was evidently modified. The liquid was strongly alkaline, fluid as water and had altogether lost its viscid character moreover it was slightly opalescent and let fall a little feathery cloud to the bottom of the vessel. In the evening the silver tube fell with the ligature the animal was feverish sat nothing but drank abundantly the wound commenced suppurating & in the space of 8 or 9 days the dog was quite well.

I have been thus minute in translating the description of the first experiment as I wished to carry you with me through all its stages

2nd Experiment. In full digestion. The pancreas in this experiment was gorged with blood its vessels turgid and its tissue presented an intense red colour. This experiment with the exception I have named above presented the same features as the last. The pancreatic fluid obtained presented the same characters was strongly alkaline became modified when inflammation came on Bernard gives as another character that the amount of pancreatic juice was less. I think this might arise from accidental circumstances

3rd Experiment. Fasting. The pancreas appeared exsanguine extremely pale its vessels little developed & its tissue in colour approached the whiteness of milk. The pancreatic duct was quite empty and even its sides were scarcely moist with pancreatic secretion At last a drop of the secretion appeared at the end

of the tube and during the day a few more appeared from which Bernard determined that it was alkaline as strongly as those preceding Thirty hours after the operation inflammation had come on and the pancreatic juice became abundant as in the former cases though modified. The next experiments 4th & 5th were not made so successfully as the former therefore I shall only say a few words about them. In these from the efforts of the animals the pancreas was exposed for a long time to the air which seemed to modify its appearances &c completely It was still however completely alkaline

Bernard says in the last two years I have in repeating my experiments during my course or to shew them to the learned who wished to see them I have extracted the pancreatic juice from thirty four dogs His remarks on these cases are of no further interest or contain nothing more than could be easily deduced from the experiments I have related

He says that if the pancreatic juice is quite withdrawn from the system the animal speedily dies in a very emaciated state

II Series Physical & Chemical Characters of the Pancreatic juice

1 of the normal secretion obtained before inflammation has supervened. This is a colourless viscid liquid becomes frothy on agitation Has no characteristic odour placed upon the tongue it gives the tactile sensation of a viscid liquid. its taste somewhat saline very like that of the serum of the blood I have always says Bernard found the reaction of the

pancreatic juice very manifestly alkaline and I have never in any case found it neutral or acid Exposed to heat it coagulates en masse & is converted into a concrete matter of a white colour This white matter is equally precipitated by thing nitric sulphuric & muriatic acids, the metallic salts, pyroligneous Spirits & Alcohol The diluted acids acetic lactic & muriatic do not produce coagulation The alkalies not only do not precipitate it but cause the precipitate formed to redissolve — In looking over the accounts of pancreatic juice, it appears as has been remarked by Mr Majendie Tiedemann et Gmelin &c that it comports itself in the same way as liquid albumen. But Bernard says he can prove that it is not the same principle as that substance and also he will prove that it is not to albumen at all that it owes its peculiar properties The chemical proof which he adduces is, that when the pancreatic secretion has been coagulated by heat, by alcohol, or simply dried, it redissolves easily and completely in water, whereas albumen does not dissolve in appreciable quantity. It also imparts to the water its characteristic viscosity and its physiological properties.

The morbid pancreatic juice has no viscidity and does not coagulate by heating. It is still alkaline in its reaction with test paper though not so strongly as the normal pancreatic juice

The pancreatic is doubtless the most alterable of all the fluids of the body - When it is exposed to a low temperature it may be preserved several days without change, or the viscidity may even increase and the fluid may become converted into a substance analogous to a light jelly in appearance. If on the contrary it is maintained at a higher temperature it is modified rapidly, that is to say it gives out a nauseous odour and presents a cloudy deposit and loses the property of coagulating by heat. The alkaline reaction of the juice remains however under all these circumstances. In summer it may undergo the change while it remains in the little caoutchouc vessel And when this altered fluid is examined under the microscope - I have always found (says Bernard) a great quantity of needleshaped crystals having the characters of crystals of Margarine or Margaric Acid.

The pancreatic juice of rabbits of horses and birds present the same characters as I have described.

3rd Series of experiments - Physiological properties of pancreatic juice upon neutral fatty matter.

1st Experiment - Two Grammes of normal pancreatic juice freshly extracted were mixed with one gramme of oil of olives, which from its less specific gravity floated on the top and on agitating with the other

became converted into an emulsion which resembled chyle perfectly.

2nd 3rd & 4th Experiments with fresh butter, mutton fat and pork fat in place of oil of olives gave precisely the same results respectively. In leaving the products of the 4th Experiment on the sandbath at a heat of 98° for 15 @ 18 hours this appearance was unchanged thus proving that a chemical change had taken place. In five or six hours afterwards the mixture had acquired an acid reaction. In examining the products it was easy to determine that the fatty matter had been decomposed into glycerine and a fatty acid.

From the preceding facts it is easy to determine that the pancreatic juice possesses the power to emulsionize fatty matter.

Supplementary to these experiments Dr Bernard tried Bile, Saliva, Gastric juice, Serum of blood, and what he calls liquid "ciphalo rachidien" in the same way with olive oil, and at first they appeared to emulsionize but after standing in the bath at 98° for half an hour the oil was floating unchanged on the top thus proving that no combination had taken place. The Morbid pancreatic juice or that attended by standing does not possess this property. Bernard has tried these experiments many times and always with same results.

4th Series - Action of the pancreatic juice studied in the living body. Its action indispensable for the absorption of fatty matter -

After discussing slightly the nature of chyle and saying that it consists chiefly of changed oily matter He says that after tying the two pancreatic canals and giving animals oil, he found that the chyle contained no fatty matter but was a limpid fluid.

Experiment a large adult rabbit was taken and kept without food for twenty four or thirty six hours and then a quantity of oil was injected by means of a tube into the stomach and some carrots were given to the animal to eat. The rabbit was killed three or four hours afterwards and it was found that the oil was converted into an emulsion only after it had passed that part of the intestine where the pancreatic duct opened into it and that it is only after passing that point that the chyle assumes its proper milky appearance. Bernard says from his experiments it is impossible that Brodie's can be correct who thought that it was the bile which effected this change. He explained how it is that Magendie failed in verifying Brodie's experiments as the latter tied the bile duct in cats and found that the fat was not assimilated

the former on dogs and found that it was assimilated This is easily explained as in cats the bile duct conveys also the pancreatic duct into the duodenum hence Brodie concluded from tying the bile duct and finding fat not assimilated that it was the bile which united with the fat and rendered it amenable to absorption - Again in dogs the pancreas gives off two ducts one of which the least unites with the bile duct but the other enters alone into the duodenum - So that both of these experiments confirmed Bernards views.

Bernards conclusions from the whole of his experiments is that the Pancreatic juice and it only, modifies the fatty matter contained in food. In another work she published he proposes to shew if possible that the bile and pancreatic juice united have another function to perform but I am not aware that such a work has appeared

I have now gone over as succinctly as I could Bernards experiments and I must say that I think they are worthy of entire confidence and that he draws the proper conclusions from them - The following quotation from the Medical Times of 23rd Nov 1850 - would seem to shew discredit almost completely upon them coming as the following does from Physiologists whose

opinions have stood high both in Germany and this country. "The experiments of Bernard on the functions
" of the Pancreatic juice accepted as they were by
" the French Academy without a dissentient voice, ap-
" plauded as they were by Majendie and welcomed
" by the Physiologists of this country have been lately
" repeated in Germany, and the result has been that
" Bernards opinion respecting the influence of the Pan-
" creatic juice in causing the digestion and absorp-
" tion of fatty substances, have been in deby shaken
" if not altogether overthrown. Bernard's series of
" experiments may be reduced to three orders
" 1st He tied the pancreatic duct in dogs and then
" fed the animal with fatty substances, he could
" perceive no milky chyle in the lacteals, but the
" unchanged fat was found in the large intes-
" tines 2nd He injected fat into the stomach of a
" rabbit in which animal the pancreatic duct opens
" separately and at some distance below from the
" gall duct, he killed the animals three or four hours
" afterwards and found milky chyle in the lac-
" teals only below the point where the pancreatic
" duct opened 3rd He laid open the pancrea-
" tic duct and having obtained some of the fluid
" found that it formed at once a milky emulsion

with oily substances. None of these experiments have been confirmed & if they are correct they are susceptible of a different interpretation - Frerichs and Schmidt and Bidder have repeated the first frequently - They tied the pancreatic duct in cats and after the animal had fasted twelve hours so that no pancreatic juice could be supposed to remain in the stomach, they fed them with fatty meat, milk or butter and killed them in from 4 to 8 hours afterwards - They always found the most beautiful milky injection of the lacteals proving the absorption of fat without the aid of pancreatic juice. The second experiment of Bernard tho correctly reported appears to have been incorrectly interpreted by that observer - Schmidt and Bidder forced butter into the gullet of a guinea pig - two hours afterwards, they found the lacteals immediately below the pylorus very milky; two hours subsequently these vessels were more or less empty, but the vessels lower down were filled with fatty chyle; six hours after the ingestion of the fat the vessels below the pancreatic duct were milky and three to four hours after this the milky lacteals were only found at some considerable distance below the pancreatic duct - The fact is then that Bernard killed his animals always from 6 to 8 hours

"after the fat had been given and when it had descended
"so low in the intestines as to fill those lacteals only
"which were below the pancreatic duct - With regard to
"the third observation - Frerichs finds that the saliva
"and bile form an equally complete emulsion with
"fat as the pancreatic juice does. Another experiment
"of Frerichs seems by itself conclusive against Ber-
"nards hypothesis - In young dogs and cats, which
"had fasted for a long time he tied the intestine
"below the opening of the bile and pancreatic ducts,
"and injected below the ligature milk with olive oil
"or albumen and oil emulsion or olive oil by itself
"and found after two or three hours the lacteals
"filled with fatty chyle. This opinion seems conclu-
"sive against Brodies original opinion but Frerichs
"does believe the mixture of Bile and saliva to have
"an influence in insuring the fine division of the
"fatty matter - Schmidt and Bidder have also repeated
"with great care Bernards experiments upon the de com-
"position of fat during absorption and have demon-
"strated their incorrectness"

These statements certainly appear most extraordinary as Bernards experiments on the one hand and those of Frerichs & Schmidt and Bidder on the other are more at variance in matter of fact than in mere opinions and

and certainly nothing can now settle these points but a system of accurate experiments by some competent observer

M. Mialhé incidentally mentions in the course of an article on the function of the saliva that it is to the bile we must consider the absorption of fatty matters to belong his words are "Les matières passes "deviennent assimilables par l'intervention de la bile" he apparently considers it a matter quite settled- he proves however that in a great measure we are indebted to the saliva for changing the starch and amylaceous compounds into Glucose.

MM Bouchardat et Sanoras find that the pancreatic juice also enjoys the same power of converting amylaceous substances into Glucose

Bernard makes the same observation but says that the pancreatic fluid possesses this power in common with serum of blood, saliva, changed pancreatic secretion and a number of other alkaline fluids found in the animal system so that it cannot be considered as the chief function of the pancreatic juice.

In order to confirm or confute some of the opinions expressed in my last quotation from the Medical Times I made the following experiments, to see if possible

what effect the bile, pancreatic secretion, liquid albumen, Saliva, and water might have when agitated with Cod Liver oil. I selected Cod Liver oil as an example of an oily substance as it has been proved by experience to be one which is easily assimilated.

A. Mixed six drachms white of egg with two drachms of cod liver oil and strongly agitated the mixture for about the space of a minute. This produced a creamy like emulsion. The vessel containing it was placed in a warm water bath at a temperature of 98° for the space of a quarter of an hour and then a drop was taken from the bottom of the bottle and examined under the microscope. It presented a considerable number of oil globules about the size of those seen in milk many very much larger and some very large indeed. It scarcely however seemed perfectly homogeneous before being placed under the microscope.

B. In this experiment I mixed six drachms of human Saliva with two drachms of Cod Liver oil and treated it precisely as in the former instance. The liquid presented three strata the top one of which seemed oil in its ordinary state, the second of about equal or perhaps rather greater depth than the first consisted of white creamy looking matter and the third stratum was the chief and appeared to the naked

eye like milk It was examined microscopically with the same result as in A then being about the same proportion of large and small globules

C I mixed six drachms of bile taken about half an hour before from the gall bladder of a sheep with the same quantity of oil and treated it in precisely the same way as in the former cases. The oil in this case was completely or nearly separated from the liquid below and appeared on the top in its natural state. There was a more strip of a second stratum between the oil and the bile. Very few oil globules could be traced in this experiment when a portion was examined microscopically and those about the same size as the milk globules.

D I mixed six drachms of water with the same quantity of oil as used in former cases and treated it just in the same way. The same appearances were seen as in Exp. C - the water appearing somewhat milky - Examined under the microscope quite as many globules appeared as in that experiment when bile was used but very few in comparison to those seen in A & B

E I tried in vain to obtain some pure pancreatic fluid so I tried the experiment in the following manner. I obtained the pancreatic organs as entire as I could from two sheep just killed and being unable to obtain even a drop

by squeezing these, I cut them into small pieces while still warm and digested them with water in very small quantity for about half an hour at a temperature of 98°. occasionally stirring and shaking the mixture. I then squeezed out about six drachms and added two drachms of cod liver oil to it and shook it in the usual way. A complete emulsion was immediately formed much more quickly and perfectly than in any preceding case. It was kept in warm water as before and was comparatively little changed all that could be perceived was that there appeared a creamy layer on the top the liquid below much resembled milk. a tinge of blood was also perceptible as a small portion of that fluid was unavoidably mixed with the extract - Examined under the microscope it presented far more of the small sized fat cells than in any preceding experiment there were some large ones though not so many as in A. Altogether it far more resembled milk.

In making a review of these experiments

I think we may conclude that saliva has comparatively little to do with the absorption of fatty matter. As much from experiment B as from what Dr Beaumont continually observed in the stomach of St Martin that the oily portion of the food always

appeared floating on the mass of chyme before it passed out of the stomach. May not the mucus which saliva always contains have had some effect in holding the milk mechanically in suspension. To my mind C proves distinctly that sheeps bile at least has nothing whatever to do with the absorption of fatty matter, as no more oil was emulsionized than took place when water only was used - thus proving (as far as the sheep is concerned) that bile has no action on fatty matter, refuting what Frerichs so confidently asserted and confirmed the views of Bernard. E or the experiment with pancreatic extract is liable to some objections on account of the manner in which the pancreatic extract was obtained but unfavourable as such a mode of preparation was the effect was many times greater than in any other experiment. From what I have seen of the action of saliva I must say that I cannot think that Frerichs observation is correct when he says that the saliva forms an emulsion with oil. It appears to do so when shaken but if placed in a temperature of 98° for some time the oil appeared more completely to separate. I should have said that the bottles were allowed to stand some days at a temperature of about 60° and at the end of three days the considerable portion of oil appeared increased in each of A B C & D but in E it was totally unchanged

I am induced to believe from the experiment D that it is not at all impossible, that small portions of oil may be absorbed, without the intervention of any agent, but the peristaltic action of the intestines on the fluid & oil as the milky appearance produced in water by shaking oil briskly with it does not altogether disappear for at least three days without any additional shaking.

It is not at all my intention to consider the process of cell development by which these minute globules may be received into the lacteals but I think it is not impossible that they may be received in precisely the same manner as finely powdered charcoal which Carpenter states can be always detected in the lacteals when it has been administered to the animal in quantity before death -

Experiment F. I tied the intestinal tube of a cat (which had been kept fasting 24 hours previously) immediately below the point where the pancreatic and biliary ducts enter the tube and injected cod liver oil immediately above and below the ligature. I then left the animal at rest for three hours and at the end of that time killed it and examined the lacteal system. Above the ligature the lacteals were completely injected with white milky fluid, and two or three at most were filled below the ligature - and these two or three were immediately

below the ligature and there were none at all lower down injected.

Certainly this last experiment proves that it is either to the bile or pancreatic secretion that the assimilation of fat is owing and Magendie moved that after tying the "ductus communis choledochus" in dogs the fat was still assimilated so that it could not be owing to the mixture of bile with the fatty matter. must we not then conclude with Bernard that it is owing to the pancreatic fluid that an emulsion is produced and the fat assimilated.

I have twice once on dogs and once on rabbits determined the pancreatic fluid to be alkaline.

In drawing up a summary of the deductions which can easily be moved from what I have before stated. it will not be necessary to do more than touch upon several points.

In the first place we may safely say that the principal part of the bile is secreted from the albumen or fibrine contained in the Blood of the Portal vein. and that the liver is also a producer of fat and sugar from the azotised elements of food in several tribes of animals in fact I think in all tribes that feed upon animal food. I believe also that only the nitrogenised elements of blood are

concerned in producing bile. The liver is also an agent which gets rid of much effete matter which does not again returns into the circulation. We must have more decisive evidence than that which Bernard supplies before we can believe the liver to be directly an organ of sanguification. The experiments of Lehmann seem to favor this view, but I should be disposed to imagine that some mistake must have occurred either in printing or translating his account of the blood in the Hepatic vein is so extraordinary. I think we may fairly conclude that the bile has nothing whatever to do with the assimilation of fatty matter. The Bile precipitates matter unfitted for digestion (Beaumont) and I think that the first action of Bile is to neutralize the free acid which the chyme contains as the Muriatic acid has a much more powerful affinity for soda than Cholic acid (which can scarcely be considered otherwise than one of the weakest fatty acids) The Cholic acid or a portion of it is probably decomposed before reaching colcum and thus yields some of the sulphuret which is most commonly found in human faeces. Supposing then that the bile has thus neutralized the free acid which the chyme contains it becomes the part of the pancreatic fluid to exert what is I believe its peculiar viz in rendering the fatty matter

assimilable or amenable to the action of the absorbents but whether the fat is merely emulsionized or converted into a fatty acid and Glycerine before being absorbed we have not I think sufficient evidence to determine. The opinion has been expressed that it is the pancreatic secretion which neutralizes the acid of the chyme but this is not I think so probable as that the bile performs this office.

The special function which I should be disposed to attribute to the bile would be to neutralize the free acid of the chyme and exert some as yet unknown effect upon it. That of the pancreatic secretion to render assimilable fatty matter and both seem to assist in converting amylaceous substances into Glucose.

Thomas Mackford Lawrence