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 those who are 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 repeating many experiments, which some think can require confirmation, before we 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 former 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. These are the most important mode of inquiry, 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 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 chyluspoietic 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
n into the system is absorbed by the veins, from which the Portal is formed. Bécldt 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 analyses. His second series of experiments, of which I subjoin the results, were to determine the differences in the arterial and venous circulators generally. These are a loss in the amount of albumen, and in one experiment in which the fibres was estimated a gain in that constituent. These results he says agree with those of other observers, who have written on the subject, and in calculation this gain in weight in albumen will be found in exact ratio to the loss of weight, which the albumen has sustained. Bécldt made his experiments by bleeding the animal at the same moment in two places. Instances of these are the three following.


<table>
<thead>
<tr>
<th></th>
<th>Water</th>
<th>albumen Water</th>
<th>Globules</th>
<th>Globine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>772.84</td>
<td>783.84</td>
<td>132.31</td>
<td>4.20</td>
</tr>
<tr>
<td>2nd</td>
<td>90.62</td>
<td>88.72</td>
<td>122.94</td>
<td>4.50</td>
</tr>
</tbody>
</table>
No third series of experiments are more important to the present object as showing the difference between the constitution of the blood in the jugular and splenic veins. To determine the composition of the blood in the spleen 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 was 13.02 per 1000 parts.

I. Experiment made on a small and feeble dog.

<table>
<thead>
<tr>
<th>Jugular</th>
<th>Spleenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>810.60  - 826.81</td>
</tr>
<tr>
<td>Albume &amp; Glob.</td>
<td>98.31  - 81.74</td>
</tr>
<tr>
<td>Albume Salt</td>
<td>91.10  - 91.41</td>
</tr>
</tbody>
</table>

II. Experiment made on a dog of mean height and strong.

<table>
<thead>
<tr>
<th>Jugular</th>
<th>Spleenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>751.90  - 764.12</td>
</tr>
<tr>
<td>Albume &amp; Glob.</td>
<td>180.178 - 143.64</td>
</tr>
<tr>
<td>Albume Salt</td>
<td>68.112  - 92.24</td>
</tr>
</tbody>
</table>

III. On a tall hound.

<table>
<thead>
<tr>
<th>Jugular</th>
<th>Spleenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>764.33  - 765.45</td>
</tr>
<tr>
<td>Albume &amp; Glob.</td>
<td>164.25  - 144.82</td>
</tr>
<tr>
<td>Albume Salt</td>
<td>41.42  - 89.43</td>
</tr>
</tbody>
</table>
On a strong dog of mean height

<table>
<thead>
<tr>
<th>Vena Jugularis</th>
<th>Vena Splenica</th>
<th>Arteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>746.87</td>
<td>746.30y</td>
</tr>
<tr>
<td>Albumen Vacis</td>
<td>79.41</td>
<td>124.79y</td>
</tr>
<tr>
<td>Globules V. fibrine</td>
<td>141.72</td>
<td>128.90y</td>
</tr>
</tbody>
</table>

His fourth series of experiments comprises some to determine the 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 nervous 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:

<table>
<thead>
<tr>
<th>Vena Jugularis</th>
<th>Vena Splenica</th>
<th>Sup. Mesenteric.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>766.41</td>
<td>732.37</td>
</tr>
<tr>
<td>Globules V. fibrine</td>
<td>148.92</td>
<td>192.32</td>
</tr>
<tr>
<td>Albumen Vacis</td>
<td>84.67</td>
<td>155.29</td>
</tr>
</tbody>
</table>
In full digestion Insulae Rovi Superior Portion

<table>
<thead>
<tr>
<th>Water</th>
<th>778.90</th>
<th>778.85</th>
</tr>
</thead>
<tbody>
<tr>
<td>Globules Liberum</td>
<td>158.20</td>
<td>58.97</td>
</tr>
<tr>
<td>Albumen Water</td>
<td>62.90</td>
<td>162.18</td>
</tr>
</tbody>
</table>

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 salt 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 is 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 Hec-
aptic vein separates only 15 parts. The Hepatic vein
blood is much richer in cells both colored and color-
less than the Portal blood; the colorless corpuscles
are of the most varied size and shape, the colored,
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 haemo-
tine, or at least in iron. The liquor sanguinis is
much clearer than that of the Portal vein, and con-
tains much more solid matter with the excep-
tion of the fibrine which is either wanting or
in very small quantity. If in 100 parts of
serum of Portal blood 9.4 (94 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 extre-
tion 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 analysis
to guide us, but a knowledge of Comparative Anatomy
her 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 proba-
bly are formed by decompositions during analysis
as there are no compounds more easily changed
on the application of reagents than those forming
the principal constituent, of bile. I shall only parti-
cularly consider the chief ingredient and that which
seems quite essential to its production viz. Cholicate 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 agoti-
zed constituent of the blood but whether from fibrine
n albumen does not clearly appear. Most probably
albumen so that substance seems the diminished in
quantity so also is fibrine so that can scarce ally add
anything to mr conjecture
Liebig gives the formula for one atom of choleic acid $C_{18} H_{22} O_{11}$ and supposes from the analysis of urine of supenzo that it is formed in the following manner.

He says: "Let us now add the half of the numbers which represent the formula of choleic acid to the elements of the urine of supenzo that is to neutral urate of ammonia as follows:

\[
\begin{align*}
\text{Formula for Choleic Acid:} & \quad C_{18} H_{22} O_{11} \\
\text{Urate of Ammonia:} & \quad C_{10} H_{15} N_{6} O_{6}
\end{align*}
\]

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 which with additions seem to favour the same view again he says: "If then we consider choleic acid and urate of ammonia the products of the transformation of muscular fibre since no other tissue of the body contains protein (for albumen passes into tissues without any being able to say that in the vital process it is directly resolved into choleic acid and urate of ammonia) there exist in fibro with the additions of elements of water, all the elements essential to this metamorphoses and..."
except the Sulphur and Phosphorus which are oxidised probably, no element is separated.

Lafay then goes on to say that the urine acid formed is converted by the addition of Oxygen into Urea and Alumina, which latter by a further dose of Oxygen also changes into Urea and oxalic Carbamic acid chiefly. Again he gives a complicated account of the manner in which he supposes that protein compounds are transformed in the kidneys, 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 this former part of the assertion it appears to me to rest on very questionable ground as it has frequently been found that when a larger amount of nutritious food than ordinary has been taken, and muscular action not increased sufficiently to account for a decrease of waste in the tissues, the quantity of urea and urine acid in the urine is greatly increased. As to the latter part that albumen is unchanged in passing thru the liver and kidneys. Physiology leads us to believe the kidney at least chiefly in eliminating urine, but is it the same with the liver? I think not...
we examine the results of Lehmann's 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 carminum that appeared in 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 may much resemble 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 the limit of error in analyses might easily account. Both cholic acid and uric acid are found in greatest abundance in the secretions of the carminum 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 pinioned, by others belived, and supposed by
Bergelius to be the chief constituent of Bile. It
appears analogous to Phollic acid in its constitu-
tion. Bile contains a considerable quantity of
colouring matter, which imparts the characteristic
colour to faeces and appears the invariably excited
within the last two years Blainard has made a series of
experiments on the production of sugar in the
liver independently of the injection of saccharine
lucenous matter in the food. His experiments occu-
py a considerable portion of space in the second
volume of the Archives internationales de Medicine
and it would take up too much space to repeat them
here. I may 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, which in animals fed only on enteralised
food. I shall quote the general conclusions at which
he has arrived in his own words:

1° Que l'état physiologique il existe constam-
ment et normalement du sucre de diabete dans le
sang der coule 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 there 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, peu conséquent avant l'ingestion directe des aliments.

4° Que cette formation, de matière sucrée qui serait une des fonctions du foie pourrait être 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 there was 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.

Bernard's views on the functions of the liver one thus summed up in the Medical Times of 23rd Nov 1850. "In some interesting lectures delivered at the College of France Dr. Bernard gave the following summary of his views on this subject. Since 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 uninfor-
mit, would be impossible. The liver then may then be preeminently regarded as an organ of excreta
tion, being assisted herein by other organs such as the
bladder 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
Schonlein's experiments proved that the Hepatic
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 this
be add fibrine, fat, sugar and a small portion of prote-
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 assign
its different appearance and quality and how they can
Cyclopaedia Anatomy & Physiology
we ascribe to the liver changing compounds into the
substances of which they consist already in the
forms suppose that they may be mutually transformed.

Various observers have perhaps more 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,
the 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 Nitsche.
The liver performs two most important functions in the
animal economy. 1st It separates the venous blood of
the chylodrophic viscera certain elements which are
needful to digestion, and secondly it separates the
venous blood the first of these constitutes the function
of the bile, the second is evidenced in a comparative
examination of two of the great excreting 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 Oxygen and Carbon from the blood. Thus in herbivorous animals the liver is small; it is small also in Monkeys and in man. It is large and has reached its highest state of development amongst mammiferous animals in Carnivora. In birds it is larger in proportion 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 respiration 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 nitro- genous excreta, 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 because of bringing the fatty matter into a state of solution, and this he describes in the following way - He added
exible to some of the chyme produced from St. Martin's stomach - this immediately produced fine coagula of a slightly yellowish color tinged with green - and this mixture was added a drop 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 colored sediment at bottom, a clay colored fluid above, and a thin oily film over the top - all of his experiments were made much in the same way and he cannot place dependance upon the results as the admixture of Muriatic Acid completely invalidates them. St. 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 St. Beaumont's experiments in his own words - as in the first part of the experiment we have the effect of the bile seen at once being minutely to observe the respective changes by the addition of Bile and Muriatic Acid in the several parcels of chyme formed in experiments.

31st March, 1818,

and to note their difference I put equal quantities of each into glasses and added a portion of hops gall. In that taken from the stomach at 10 o'clock, one hour after having eaten, fine bright orange colored coagula were immediately formed.
equally diffused through a fluid of the same colour,without
ity no perceptible sediment on standing at rest, but
held the coagula uniformly suspended throughout the
fluid. The dilute acid added to this occasioned
acquisous sediment to fall to the bottom, and with
it all the colour of the mixture leaving a transparent
semigelatious liquid above in the proportion of
threefifths of the whole upon which floated a thin
white pellicle. The second portion that produced
on the baths 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.

Litig considers the Bile as the light of a secretion,
only and he calculates that in a healthy state
only the forty-ninth of the fiftieth part of the amount
secreted passes off with the faces. (Bengelius)
This statement must be received with caution as our
data for determining the quantity in which it rests
are so very limited. If we believe what is so frequently
stated, that to a certain extent the bile is associated 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 hydrosoluble component to be again absorbed, and get rid of by the lungs, as water and carbonic acid. It was from analyses by Benkelman that Liebig made this calculation, and as it is 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 "Benzelius found in 100 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 intricate means of arriving at its function.

1st. If there 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 twice what it is in the Western Hemisphere, and that
it varies much, according to the heat of the climate, 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 con-
sequences.

2. Cause producing disease in the liver. The Quan-
tity and Quality of food used are by no means unim-
portant as regards the nature of the liver. An improp-
tion of animal food seems to favor an excessive secre-
tion of bile as its highly seasoned dishes either from
the special effect of the seasoning or from causing
more animal food to be taken.

3. 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
this the liver.

4. 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 the
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. Hill 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 Java, Sattic 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 to, that Sir George Ballingale, while he concurs that in India, affection 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 strongly marked.

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

Now with regard to the first of these causes, viz. the effect of climate on the liver. It is not at all surprising that disease should be more common in Europeans.
and thus these more wrote in the line in its incremental 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 preserve their appetite failing, without any apparent cause and in order to cure 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 effect of matter to be properly consumed or thrown off. The same argument applies to those cases in which insufficient 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 if all substances taken as food then are more so easily converted into the ultimate products of the system, viz. water and carbonic acid as an alcoholic liquor. 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 used. And the fact that Dr. G. Ballingall mentions that this disease is most uncommon when the intemperance
in greatest, say in Nova Scotia and New Brunswick as 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.

3d 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 denatured part of the food only, and also that it may be separated in the manner I formerly mentioned. If only directly into Cholic Acid and Bic Acids as we find that in Carnivores liver but bile eating fish only the juices consist chiefly of Bic Acid. If we trace the development of the bile of animals we shall find that it is greatest in Carnivores 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 Herbivora among birds are said to have large livers than those eating grain &c.

I had anticipated being able to secure several species of birds feeding on all kinds of food but was unable
to do so, so that I cannot compare the relative size of the
bowel in these different circumstances, if good as it had
finished.

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 in
the secretion. It has been however been noticed in
numeral cases that when the pancreas was much increase
fatty and oily matter have been passed mixed with
feces.

Several authors and among them Dr. Gregory M. Beaus 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
passed into the duodenum we must at once negative
this opinion. The pancreatic secretion is passed 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 bilious and pancreatic secretions, and continues so until it reaches the duodenum. 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 details of the experiments were published in the "Archives générales de Médecine" Tome XIX for 1848 under the title 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 it 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 chyleous vessels.
1st Series of experiments. By the extraction of the pancreatic juice and on the constitution of its secretion.

2nd Experiment at the beginning of digestion. A very large spaniel, fasting for twelve hours in good health, made at 9 in the morning a copious meal after which it drank some water. As soon almost as the injection was completed it was placed upon the operating table so that the pancreatic juice might be extracted from him. I made (say at E) 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 cross quill. It was filled with some liquid. At each effort which the animal made in trying 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 viscous and
Thick, consistence. A little blood from neighbouring
parts and vessels flowed out, but the pancreatic juice
did not at all coalesce 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 pan-
cratic juice. Almost immediately the pancreatic fluid
drained out by the tube in large turbid drops, leaped
successively each other with greater rapidity whenever
the animal made an effort and throwing path through paper
a strong alkaline reaction. After having confirmed the
alkaline reaction of the first drops of the pancreatic juice
I fixed a little casserole 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 create
reception by the tendency of the bowl to receive the former
placed from. The animal was then cut off and sat at
liberty and went away down without manifesting lubricous
life and a half hour afterward as I let off a little the
animal quietly lying down. I detached the reservoir and
found it contained a 8/12 granulums of pancreatic juice having
the same characters as before.

Next morning after the operation the fluid distilled in abundance
I obtained in the same way in an hour a quarter 10 grammes of the juice which was evidently modified. The liquid was strongly alkaline, fluid as water and had altogether lost its acid character, moreover it was slightly opalescent and at first a little feathery close to the bottom of the vessel. In the evening the silver tube filled with the ligation, the animal was given the moisture, but drank abundantly the borsic commenced disappearing in the space of 3 or 4 days the dog was quite well.

I have been thus preoccupied in translating the description of the first experiments as I wish 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 explanation I have annexed above presents the same features as the last. The pancreatic fluid obtained presented the same character was strongly alkalinebecame modified. When inflammation came on Bernard gave it another character that the amount of pancreatic juices was less. I think this might arise from accidental circumstances.

3rd Experiment. Fasting. The pancreas appeared extremely dry its vessels little developed. Its tissues in color 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
continued and the pancreatic juice became abundant as in the
former cases though modified. The next experiments 34th 35th
were not made to successfully as the pancrees therefore. I shall
only say a few words about them. In those from the effects of the
animals the pancreas was exposed for a long time to the air
which served to modify its appearances. It completely. It
was still known completely alkaline.

Bernard says in the last two years he has repeated my
experiments during my course or to three times to the examiner
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 specie dies in a very emaciated state.

II Series Physical & Chemical Characters of the Pancreatic Juice

of the normal secretion obtained before inflammation has
supervened. This is a colorless viscous liquid become frothy
by agitation. Has no characteristic odour. Place upon the
tongue it gives the tactile sensation of a viscous liquid. Its taste
somewhat saline very like that of the serum of the blood.

I have always says Bernard, for the reaction of the
pancreatic juice very manifestly alkaline, and I have never in any case found it neutral or acid. Expose it to heat it coagulates on mass, it is converted into a concrete matter of a white colour. This white matter is equally precipitated by the nitric, sulphuric, hydrochloric, hydrobromic, and acetic acids, but not by alcohol. The dilute acid, acetic, lactic, hydrochloric acid, and acid alcohol, 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 Dr. Majendie, in Magdeburg, that it coagulates itself in a manner so liquid, albumen. But Bernard gives him the power that it is not the same principle as that substance, and that he will prove that it is not to albumen at all, but that it owes its peculiar properties to an acid, or more likely, to an inorganic agent, the chemical proof of 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 mixed pancreatic juice has no viscosity, 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 utilizable 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 viscosity 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 off a nauseous odour and presents a cloudy deposit and loses the property of coagulatiy 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 cautchoo vessel and when this altered fluid is examined under the microscope I have always found (says Bernard) a great quantity of needle-shaped 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 chafe perfectly.

2 and 3rd of 4th experiment, with fresh butter, mutton fat and pork fat in place of oil of olives gave precisely the same results respectively. On leaving the products of the 4th experiment on the sand-bath at a heat of 90° for 15 or 18 hours the appearance was unchanged thus proving that a chemical change had taken place.

If we n six hours afterwards the mixture had acquired an acid reaction. On examining the products it was easy to determine that the fatty matter had been decomposed into glycerine and a fatty acid.

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

Supplementary to these experiments Dr. Bernard tried bile, saliva, gastric juice, serum of blood, and what he calls liquid "aphabols" or vachidien in the same way with olive oil, and at first they appeared to mix but after standing in the bath at 90° for half an hour the oil was floating unchanged on the top thus proving that no combination had taken place. The protile pancreatic juice or that altered 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 proving 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 had 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 Majendie failed in verifying Brodie's experiments as the latter tied the bile duct in cats and found that the fat was not assimilated
the form in dogs and found that it was assimilated. This is easily explained as in cats the bile duct
comprises 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
sends off two ducts one of which the least unites
with the bile duct but the other enter alone into
the duodenum. So that both of these experiments
confirmed Bernard's views.

Bernard's conclusion from the whole of his experiment
is that the Pancreatic juice and it only, modifies the
fatty matter contained in food. In another work he
published he proposes to show 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 not gone over as punctually as I could Bernard's
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 quota-
tion from the Medical Times, of 23rd Nov, 1837 would
seem to throw discredit almost completely upon them
coming as the following does from Physiologist who
opinions have stood high both in Germany and this country. The experiments of Bernard on the function of the Pancreas juice accepted as they were by the French Academy without a dissentient voice, applauded as they were by Magendie and welcomed by the Physiologists of this country have been lately repeated in Germany, and the result has been that Bernard's opinion respecting the influence of the Pancreas juice in causing the digestion and absorption of fatty substances, have been widely 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 intestines.

2nd. He injected fat into the stomach of a rabbit in which animal the Pancreatic duct opened separately, and at some distance below from the bile duct, he killed the animal after three or four hours afterwards and found milky chyle in the lacteals only below the point where the pancreatic duct opened.

3rd. He laid open the Pancreatic 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 or if they are correct they are susceptible of a different interpretation. Storch and Schmidt and Pridie have repeated the first frequently. They tied the pancreatic duct in cats and after the animal had fasted twelve hours so that its 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's correctly reported appears to have been incorrectly interpreted by that observer. Schmidt and Reide 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 injection 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 to low in the intestines as to fill these lacteals only which were below the pancreatic duct. With regard to the third observation, Treichs found that the saliva and bile form an equally complete emulsion with fat as the pancreatic juice does. Another experiment of Treichs seems by itself conclusive against Bernard's 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 conclusive against Bernard's original opinion, but Treich does believe the mixture of bile and saliva has an influence in ensuring the finer division of the fatty matter. Schmidt and Bidder have also repeated with great care Bernard's experiments upon the decomposition of fat during absorption and have shown that their incorrectness."

These statements certainly appear most extraordinary as Bernard's experiments on the one hand and those of Treichs, Schmidt, and Bidder on the other are more at variance in matter of fact than in mere opinions.
and certainly nothing can now settle these points but a system of accurate experiments by some competent observ

M. Mitchel accidentally mentions in the course of an article on the function of the salivary that it is to the

be apparently, considers it a matter quite settled

be proves however that in a great measure by an addition to the salivary for changing the starch and amylaceous compounds into glucose.

Il Il Buchardat et Lesnonor find that the pana\ncrease juice also enjoys the same power of converting amylaceous substances into glucose

Bernard makes the same observation but says that the pancreatic fluid possesses the same 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 albumin, saliva, and water might have when agitated with Cod Liver oil. I selected Cod Liver oil as an example of an oil, substance as it has been proved by experience the 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 90° 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. If scarcely known 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 be water.
eye like milk. It was examined microscopically and the same result as in A then being about the same properties 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 mere 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 B, 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 to rain to obtain some pure pancreatic fluid as I tried the experiment in the following manner. I obtained the pancreatic juice as entire as I could from two sheep just killed and being unable to obtain bile a drop
by squeezing these, I put them into small pieces while still warm and depisted them with water in very small quantity for about half an hour at a temperature of 70° occasionally stirring and shaking the mixture.
I then squeezed out about six drachmes and added two drachmes 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 worms which saliva always contains have had some effect in holding the milk mechanically in suspension. If my result proves distinctly that sheep bile at least has nothing whatever to do with the absorption of fatty matter, no once oil was emulsified than took place when water only was used - this proving (as far as the sheep is concerned) that bile has no action in fatty matter, refuting what Freuehs so confidently asserted and confirmed theories of Bernard. If the experiment with pancreatic extract is liable to one objection 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 Freuehs observation is correct when he says that the saliva forms an emulsion with oil. It appears true so when shaken but if placed in a temperature of 98° for some time the oil appeared more completely separated. I should have said that the bottle was 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 liquid of A B C D but in E it was totally unchanged.
I am induced to infer 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 puerile action of the intestines or the fluid Toll 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 produced 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 liver and that these were never at all even down injected.

Certainly this last experiment proves that it is either to the bile a pancreatic secretion that the assimilation of fat is owing and Magendie proved that after tying the ductus communis cholecdochus in dogs the fat was still assimilated so that it could not be owing to the mixture of bile with the fat on that 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 source of fat and sugar from the digested 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 nitrogenized 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 return into the circulation. We must have more decisive evidence than that which Bernard supplies before we can believe the liver to be directly a organ of purgation. The experiments of Lehnmann 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 so extraordinary. I think we may fairly conclude that the bile has nothing whatever to do with the excretion of fatty matter. The bile precipitate, matter, unfit 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 is a portion of it is probably decomposed before reaching the colon and thus yields some of the sulphur which is most commonly found in human feces. 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 properties rendering the fatty matter
assimilable or amenable to the action of the absorber, but whether the fat is merely emulsified or converted into a fatty acid and glycine 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 as 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. Such of the pancreatic secretion to render assimilable fatty matter and both assist in converting amylaceous substances into glucose.

Thomas Macfard Loudas