Senility and Intestinal Flora
A Reexamination of Metchnikoff’s Hypothesis

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In order to investigate the differences which may exist between the flora of the feces of younger persons in their prime and those of old people and to determine whether such differences could be demonstrated between the feces of healthy and of senile old people, Drs. Orla-Jensen, Olsen, and Geill conducted experiments with the old people of De Gamles By and the young laboratory workers at the institution. They came to the conclusion that it is not the undesirable flora found in the aged which causes impaired digestion, but rather the impaired digestion which causes the undesirable intestinal flora.

Modern research in heredity has led to the conclusion that the attainment of old age is conditioned by heredity, and the factor is fortunately dominant. Thus if one parent reaches old age, the descendants may also reach it. But few persons live in circumstances so comfortable in all respects that they reach the maximum possible age. Life is in fact often shortened by disease, accident, worry of one kind or another, overwork, and even by irregular or immoderate living. The most intensely vital people are particularly prone to the latter, and thus a leveling of age takes place. Nevertheless, apparently weak people often survive to old age. The Danish author, Carl Ewald, relates a story of an old postmaster, who, on being asked how he managed to keep so young, answered simply that from his youth he had always had a weak stomach and had been obliged to be very careful about eating and drinking.

There is no doubt that the prolongation of human life which has actually taken place in modern times is due to the improvement of hygiene, personal not less than public. But this prolongation of life is not as great as the statistics show, because it depends mainly on the decrease in the death rate of babies, which has nothing to do with the age of adults, although both are influenced—in very different degree—by milk hygiene. For bottle-fed children this is, of course, of decisive importance, but it is also of importance for adults, because, as we shall see later, they also ought to consume milk.

In the seventies of the last century E. Baumann (1, 2, 3, 4, 5, 6) showed that putrefaction, very much like the putrefaction of the proteins outside the organism, can also take place in the human colon. By this process ptomaines and noxious aromatic substances (skatole, indole, cresols, phenols) are formed. The latter are excreted in the urine combined mainly with sulphuric acid, so that the extent of the putrefactive processes in the colon can be followed by analyses of the urine. Thus through this process a stream of pernicious substances flows constantly through the body and, therefore, a sensible mode of life is of importance. For instance, moderation in meat eating will limit the formation and excretion of these substances.

At the end of last century it was already known that putrefactive bacteria are susceptible to acid and thus that putrefactive processes can be suppressed by adding acid or sugar, which is turned into acid by fermentation. Use is made of the lactic acid fermentation to preserve vegetables (such as silage and sauerkraut) and to prevent the
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putrefaction and ensure the ripening of green cheese, which consists mainly of proteins. It was therefore quite natural that the Russian zoologist, Metchnikoff (11, 12), proposed at the beginning of this century to suppress putrefaction in the colon by inoculating it with powerful lactic acid bacteria.

Metchnikoff thought that arteriosclerosis, causing senility and shortening the life of man, was linked with putrefaction in the colon. This thesis has never been proved or disproved, but it is now known that arteriosclerosis can arise from many causes other than poisoning from the colon, e.g., acute infectious diseases or metabolic diseases such as diabetes. Metchnikoff regarded the colon as a noxious, sedimentary organ. Its only real function, like that of the urinary bladder, should be to ensure the excretion of residual products at convenient intervals. This arrangement, he thought, might be of great importance to animals when they had to run for hours to escape their pursuers, but for mankind it was normally unnecessary.

This opinion is, of course, quite wrong, because without a colon food could not be utilized as completely as it is; no significant bacterial activity normally proceeds in the stomach and the small intestine. As a rule it takes two to three hours for the food to pass through the winding small intestine, which is about 7 metres long, while it remains for twelve to twenty-four hours in the colon, which is only 1 metre in length. Thus many rather indigestible substances which enzymes are incapable of managing are brought into solution by bacteria, and for the most part absorbed, together with the large amount of water present in the colon.

When entering the colon, the food residues are highly diluted, and it is here that they assume the semi-solid form characteristic of normal feces. It is true that the power of absorption of the colon is very small in comparison with that of the small intestine, but on the other hand the delay in the colon is so long that the products of fermentation, both nitrogenous and non-nitrogenous, the latter mainly ether-soluble lactic acid, are in fact absorbed. Nevertheless, some of the calorific value of the nutrients is lost in the fermentation processes. In a pure lactic acid fermentation only one-third is lost; in fermentation by the coliform bacteria the loss is greater owing to the evolution of gas. Physiologically it is of great importance that the lactic acid formed is dextro-rotatory and not lavo-rotatory, since Parnas (20) has shown, as early as 1912, that the human organism is capable of utilizing only the former. Unfortunately the coliform bacteria of the colon mainly form lavo-lactic acid.

Intestinal putrefaction is, of course, more marked when evacuation is slow than when it is normal. The resulting harmful effect is, however, counteracted because absorption in the colon ceases almost entirely when the contents are dry. The organism has also an alternative method of defending itself
against poisoning. If putrefaction is active, much hydrogen sulphide is formed, and as the sulphides are highly purgative rapid evacuation is ensured. The constipating effect of iron and bismuth salts is dependent on the fact that they render the sulphide insoluble.

When Metchnikoff learned that centenarians were especially numerous in Bulgaria and that Yoghurt is the national food, he very naturally suggested the inoculation of the intestine with this sour milk product. Metchnikoff, who was blessed more with intuition than with the patience of the true scientist, felt so sure about this that without further research he wrote two semi-popular works on the subject. Both were translated into many languages. One may still read with interest his philosophic reflections about how everything in this world would improve if people could grow old without suffering the infirmities of age. Among the experienced and seasoned old men, full of wisdom, it should not be difficult to find ideal judges and politicians to guide and rule the peoples.

Fortified by these theories it was quite natural that Yoghurt should begin a triumphal march the world over. Not only was Yoghurt eaten as such, it was also sold in tablets said to contain Yoghurt bacteria. As a rule they contained only spores of putrefactive bacteria, since Yoghurt bacteria do not easily tolerate drying. Many physicians were firm believers in Metchnikoff’s theories, and some went so far as to remove larger or smaller parts of the colon from patients suffering from indigestion.

As an excuse for Metchnikoff it can be said that when he conceived his great theory the time was not yet ripe for proving it. Like the science of the taxonomy of plants, the taxonomy of bacteria rested at that time on an essentially morphologic basis which, with bacteria, did not permit as accurate a classification as that which has become possible by the use of physiologic methods. Many errors arose from the assumption that the bacteria excreted with the feces were identical with those taken in with the food, the only criterion being that they looked alike under the microscope.

With regard to the lactic acid bacteria it is now known that widely different species exist and develop in different places. Vegetable substances, milk, saliva, and feces all contain specific lactic acid bacteria. Feces from herbivorous animals contain lactic acid bacteria entirely different from those found in feces from carnivorous animals. Most of the lactic acid bacteria of milk cannot thrive at all in our intestinal canal. Hence in the feces of people who daily consume sour milk or Yoghurt one rarely finds lactic acid bacteria differing from those found in people who do not consume these products.

The predominant lactic acid bacteria in the feces of healthy persons are the so-called enterococci, two rod-shaped bacteria, Thermobacterium intestinale (formerly called Bacillus acidophilus), and the forked anaerobic Bacterium bifidum which are found in large numbers. The latter, which was originally thought to be found only in the feces of babies, is in fact present in large numbers in the feces of adults and may sometimes constitute half of the bacterial population. It is therefore not surprising that the vaginal secretion in women is infected with Bact. bifidum and that in turn the child is infected from the moment of birth.

If it is desired to establish lactic acid bacteria in the intestine it is useless to use Yoghurt bacteria. Only lactic acid bacteria natural to the intestine can be used. Orla-Jensen (15, 16) as early as 1912, suggested the use of Bact. bifidum, and Rettger (21) has introduced acidophilus milk in America with success and shown that it is effective in certain disturbances of the digestion.

A condition for the establishment of lactic acid bacteria in the colon is that sugar be available. The ordinary sugars, however, are completely absorbed in the small intestine unless they are fed in such amounts that diarrhea results. Diastase and Schiller
(9, 10) were the first to point out that dextrin and lactose are not absorbed in the small intestine. As they stated, this is because of the lack of the appropriate hydrolytic enzymes. Although infants possess lactase, this enzyme, as was found later, is not present in the adult.

In addition to dextrin and lactose, plants undoubtedly contain other carbohydrates which are not absorbed in the small intestine and which may produce acid in the colon. Inulin is an example, but since it occurs only in the roots of Scorzonera, in Jerusalem artichokes, and in a more or less roasted form in coffee substitutes, it is of no practical significance. But that dextrin (or the dextrins) behave as described is an observation the full importance of which has never been sufficiently emphasized.

Dextrin is formed by the digestion of starch, and human beings consume starch to a greater extent than any other carbohydrate. It would simply be impossible to eat corresponding quantities of sugar without causing diarrhoea. Since starch is hydrolyzed in stages, it becomes a slowly available source of sugar. The sugar first formed is absorbed before more appears and in this way we avoid too large a sugar concentration in the small intestine, while the dextrin which is formed ensures a certain degree of acidity in the colon. This must explain why many people who drink very little milk nevertheless are in good health. What has been said is especially true of consumers of large quantities of beer since they acquire large amounts of dextrin in that beverage.

To most people, however, milk is beneficial, not only because it is a general and easily digestible food, but because in adults the milk sugar is not absorbed in the small intestine but gets as far as the colon where it is more easily fermented by the lactic acid bacteria present than are dextrin and inulin. Milk may therefore be replaced not only by pure milk sugar but by whey or whey-cheese. The latter contains, besides the water soluble vitamins of the milk, some 60 per cent of milk sugar.

All investigators have found that milk sugar may change the intestinal flora in the right direction. Thus Orla-Jensen and Winther (19), using a daily dose of 70 gm. of milk sugar (without inoculation), succeeded in changing the intestinal flora in several persons to such a degree that the lactic acid bacteria—especially Bact. bifidum—predominated. The number of the coliform and putrefactive bacteria fell to a minimum (1 per cent of the total amount of bacteria). If it is desired to establish lactic acid bacteria, those organisms characteristic of the intestine must be used in the form of milk culture and not as tablets without milk.

In this way it is possible to cure certain intestinal diseases or disturbances of the digestion. Whether it is possible in the same way to prevent arteriosclerosis and senility and thus to prolong human life is an entirely different matter, and the idea now finds no general acceptance. One thing should be remembered in this connection, viz., that we have passed from the one-sided bacteriologic age in which Metchnikoff lived to an exaggerated vitamin and hormone age where, instead of sterilized food, uncooked food is preferred. Those who still believe in the possibility of prolonging life are of the opinion that the means must be the miracle of vitamins and hormones. It is true that the sex hormones, for a time at least, have proved rejuvenating.

Nevertheless nobody will deny the possibility of an association between the intestinal flora and senility according to Metchnikoff's idea. Shortly before the outbreak of the last war Orla-Jensen received a request from Dr. Korenchevsky, Hon. Secretary of the British Society for Research on Ageing, to explore the idea. There is a similar Society in Denmark and two of its members, Dr. Torben Geill, Physician-in-Chief of De Gamles By (a Social Settlement for the Aged in Copenhagen) and Dr. Erik Olsen, collaborated with Orla-Jensen in the present investigation. The present communication represents a summary of this work, Senility and Intestinal Flora, which has been
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published in detail with several tables in
Det. Kongelige Danske Videnskabernes
Selskab Biologiske Skrifter (17).

As surgical procedures were out of the
question in these investigations we had to
confine ourselves to the study of the intesti
nal bacteria found in freshly excreted feces.
This, to be sure, only represents the last part
of the intestine, but it is the most inter
esting for our purpose because it is here
that the putrefactive processes tend to take
place.

The bacteria of the feces can be divided
into three main groups: the lactic acid bacte
ria already mentioned, the coliform bacteria,
and the putrefactive bacteria. The coliform
bacteria occupy an intermediate place be
tween the two other groups, since in sugar-
containing media they form acid and thus,
like the lactic acid bacteria, prevent putre
faction, while in sugar-free media they form
indole and other putrefactive products.
Therefore, given the correct nutriments
the coliform bacteria are advantageous, al
though they deal less economically with the
carbohydrates than the lactic acid bacteria.
Very possibly they are quite indispensable
because they form K-vitamin (18).

The typical putrefactive bacteria are the
ones which ought especially to be suppres
ted. Under the anaerobic conditions of the colon
Clostridium welchii is the most numerous of
these. As no putrefaction takes place in
cheese as long as the pH is maintained under
5.6, it apparently should not be difficult to
avoid putrefaction. Nevertheless in the rec
tum and also in the last part of the colon
putrefaction can never be totally avoided.
The pH of the feces is normally higher than
6, often more than 7; and this is so even
though large amounts of milk-sugar are in
gested. But of course, it is not unimportant
if putrefaction sets in at the beginning of
the colon or only at the end of it. Samples
of feces from the middle of the colon are
only to be obtained in conditions of diar
rhea, and in such cases the pH can fall
even to 5.5.

It has long been known that most of the
bacteria observed are dead. They originate
higher up in the digestive tract and perish
in the lower sections where, however, new
bacteria develop. Many of the dead micro
organisms are autolyzed and digested, where
by the nutrients they have consumed are
again utilized. As we know, these facts are
of the greatest importance in ruminants. In
this way it is made possible for them to
utilize a small amount of ammonium salts
because in the rumen these are transformed
to bacterial protein, which is later digested.

This phenomenon is also of importance
for the vitamin supply, since, in the diges
tive apparatus, vitamin-forming bacteria
develop which when digested may make the
supply of particular vitamins unnecessary.
For this reason cattle do not need to be sup
plied with vitamin B, and human adults may
do without vitamin K from extraneous
sources.

Feces are extraordinarily rich in bacteria,
which constitute 5 per cent of the volume.
By direct counting under the microscope
about 100,000,000,000 of bacteria per gram
are normally found, of which some 5,000,-
000,000 per gram are living. The numbers
as well as the species of the bacteria found
in feces vary greatly from day to day even
in the same person, the diet having a pro
found influence. After some preliminary
investigations we succeeded in finding two
lactic acid bacteria which are characteristic
for certain persons: Bacterium bifidum and
Streptococcus salivarius.

Bact. bifidum is always found in feces of
certain persons and in considerable numbers
whereas it seems lacking in the feces of
others. We designate these persons as
"bifidum-positive" and "bifidum-negative"
respectively.

If milk cultures of Bact. bifidum are
given to bifidum-negative persons for a pro
tracted period this organism will usually
thrive in their digestive canal, but it may
fail to establish itself and if established may
disappear completely if the administration
of the cultures is discontinued. The ordinary
salivary streptococcus, Str. salivarius, which
has not been demonstrated in feces before, is often found in the feces of old persons. In one case we found 20 millions per gram, a number which remained remarkably constant over a period of three to four years. It is therefore natural that in our bacteriologic investigations of feces we have been especially interested in these two indicator-bacteria. A detailed description of the method of investigation, including the technique employed for counting the bacteria in the stool, can be found in the original paper (17).

The direct approach to the solution of the present problem would be nutritional studies with feces examination conducted on a larger group of individuals throughout the greater part of their lives, but this is, of course, not possible. There was therefore no alternative but to evaluate on a statistical basis any differences which may exist between the flora of the feces of younger persons in their prime and of those of old people and to determine whether any differences could be demonstrated between the feces of healthy and senile old people. For the study of senile old people the inmates of De Gamles By who all live under very nearly the same conditions, constituted an unusually suitable group.

to the degree of general arteriosclerosis, but such a classification is impossible to make with living persons. Gradually as the persons under observation died the degree of arteriosclerosis was determined by autopsy. The postmortem findings have not so far invalidated the method of classification used. This is not surprising, since most of the subjects of investigation had done manual work. In people of that kind, arteriosclerosis nearly always starts in the brain, but experience has shown that in brain-workers it rarely begins in the brain, but in the region of the heart (angina pectoris) or elsewhere.

In the following table the results are summarized.

From this table it is perfectly clear that the intestinal flora of the aged and especially of old senile people is less advantageous than that of younger people. On the one hand there are far less bifidum-positive persons among the aged, and on the other there are many more with putrefactive bacteria in the intestinal canal than among the young ones.

It may be objected that the number of subjects under observation was too small or that our research methods were not accurate enough. But the differences are too great to be cancelled out by any likely errors of method, and, moreover, our results were confirmed by the following investigations which show that it is not the undesirable flora of the aged which causes their impaired digestion, but rather the impaired digestion which causes the undesirable intestinal flora.

Achlorhydria, or failing production of hydrochloric acid in the stomach, is a typical
sign of old age, and it seemed natural to associate the large number of Str. salivarius, which were frequently found in the feces of old people, with this phenomenon. An investigation actually showed that persons in whom Str. salivarius was a prominent inhabitant of the intestine suffered from achlorhydria. They were also bifidum-negative.

In the hydrochloric acid of the stomach nature has provided man and animals with a wonderful means of protection against the large numbers of bacteria in the food—bacteria which may be more or less harmful if not actually pathogenic. In the dysentery epidemic in Aarhus (Denmark) in 1943, it was mainly the aged who suffered, and in the repeated paradyssentery epidemics in De Gamles By only the old people became ill, the staff, on the same diet, not being affected.

It is undoubtedly a fact that the bacteria of the saliva, which normally live in a neutral medium, are rather sensitive to acid, for which reason they do not survive the passage through the stomach when acid production is normal. We have pursued this question further by studying the bacteria in the contents of the stomach after Ewald's test meal, both in subjects with normal production of hydrochloric acid and in patients with achlorhydria. Since in the latter the contents of the stomach are emptied quite rapidly, samples were obtained after twenty minutes.

Under these conditions the pH of the contents of the stomach was, in normal persons, usually less than 2, and only a few thousands of bacteria were found per 1 cc. (which is less than in cow's milk obtained under hygienic conditions). If the samples of gastric contents were left standing for three hours at blood temperature, the number of bacteria fell to a few hundreds per 1 cc. owing to the lethal action of the hydrochloric acid.

The situation is different regarding the contents of the stomach of persons with achlorhydria, where the pH value is 5 or higher. In these samples millions of bacteria per 1 cc., mostly streptococci, e.g., Str. salivarius, were found, and if the samples were left standing for three hours at blood temperature they multiplied rapidly.

It follows, therefore, that the contents of the small intestine in normal persons are almost free from bacteria, while in persons with achlorhydria the contents are heavily infected \textit{inter alia} with lactic acid bacteria, which convert most of the nonabsorbable sugars already in the small intestine into absorbable lactic acid. Thus no sugar reaches the colon. Without sugar Bact. bifidum is unable to multiply and form acid in the colon; hence people with achlorhydria are, as a rule, bifidum-negative.

Another still more serious aspect is the inadequate digestion of the proteins in the absence of hydrochloric acid, not only in the stomach, but in the duodenum, since it is the acid in the contents which, with the aid of the hormone secretion, causes the flow of the pancreatic juice.

Further, since old people do not chew their food properly, all conditions are present for active putrefactive processes in the colon, viz., insufficient formation of acid together with considerable undigested protein. Such patients often suffer from evil-smelling diarrhoea. Now we understand fully why, as a rule, in the feces of the aged fewer Bact. bifidum and more putrefactive bacteria are found than in younger, healthier people.

Nevertheless it seems strange that many people with achlorhydria apparently suffer no ill effect from the absence of hydrochloric acid; others, however, are subject to pernicious anæmia. As Castle (8) demonstrated in 1929, the anti-pernicious anæmia factor is formed in the stomach from a thermolabile component (probably a hormone) and a thermostable component which originates in the digestion of proteins and is deposited in the liver. Therefore, the incomplete digestion of the proteins by persons with achlorhydria may account for the lack of the anti-pernicious anæmia factor, but in many cases the production of the hormone may also be impaired. According
to Munk-Plum (14) the thermostable constituent may be tyrosine, and according to Meulengracht (13) the thermostable substance is formed in the pyloric section of the gastric mucous membrane. If this should be the site of inflammation the formation of the anti-pernicious anæmia factor may be prevented. In pernicious anæmia we have found, in two cases, an inflammation of the mucous membrane of the stomach so severe that the test meal returned as a thick slime and contained in both instances large numbers of Staphylococcus aureus. In one case a pure culture of this organism (45 millions per cc. of slime) was found.

In contrast to the enterococci, Bact. bifidum does not grow without sugar and acid formation, and it is therefore to be assumed that in persons whose feces contain large numbers of Bact. bifidum in the living state (as is usually the case when acid production of the stomach is normal) the contents of the colon will always be acid enough to check putrefaction. With a reasonable diet, one containing not too much meat, but with a sufficiency of dextrin-forming foods, and milk-sugar, e.g., bread and potatoes, and milk foods supplemented by the necessary vitamins, such persons will rarely suffer from excessive putrefactive processes in the colon. But the danger is increased as soon as hydrochloric acid production fails, and Metchnikoff’s theory of the prolongation of life by means of the diet rests thus on the avoidance of achlorhydria or its harmful consequences.

It is known that the hydrochloric acid of the stomach is formed by certain cells in the upper part of the fundus. The acid is formed from sodium chloride by a biochemical process of which at present we know nothing at all. In healthy persons the acid is formed in large amounts, about 1.5 L. of 0.1n hydrochloric acid daily. That is equal to 5.5 gm. of HCl. The liberated sodium residues are converted into carbonate or salts of organic acid which pass into the bile or the pancreatic juice and partly neutralize the contents of the stomach as they reach the duodenum. In this way the acid base equilibrium of the organism remains undisturbed.

But such a disturbance is inevitable if one supplies persons suffering from achlorhydria with as much hydrochloric acid as is required to give pepsin (which as a rule they do not lack) its full activity. It is therefore entirely out of the question to supply these patients with hydrochloric acid in such quantities. The problem is whether anything can be gained by the ingestion of smaller quantities of hydrochloric acid, and on this point opinions are divided. Many stomach specialists claim to have observed an improvement in their patients by giving them only 1/20 to 1/40 of the amount of hydrochloric acid produced in normal individuals, and some of them even think that small quantities of hydrochloric acid activate normal hydrochloric acid production in the stomach. This can hardly be the case in old patients suffering from achlorhydria in whom the glands of the fundus are totally atrophied.

It was natural for us to try to contribute to the solution of this question by bacteriologic means. We did this by investigating the feces of individuals with achlorhydria within our personal acquaintance who had for some time been taking hydrochloric acid in small quantities at their chief meals and by investigating their feces before and after they had taken varying quantities of hydrochloric acid. The hydrochloric acid was supplied in the form of betain-hydrochloride tablets. Each tablet releases 0.06 gm. of HCl. Thus with two tablets daily 0.12 gm. of HCl is released or 0.24 gm. with four tablets.

The latter quantity may easily disturb the acid-base equilibrium of the organism, causing a calcium deficiency in the blood. This was in fact the case with one woman, but the deficiency passed quickly when she received tablets of calcium lactate in the mornings. The patient has now followed this cure for a couple of years and while it is true that it has not improved her achlor-
hydria (the pH of the test meal was 7), her
genesis condition is essentially better, her
colon functions normally, and noxious diar-
rhoea has ceased. Even though her feces
still contain a large number of clostridia, 20
per cent of the flora consists of Bact. bifi-
dum and Str. salivarius is absent.

This case has taught us not to give our
patients betain-hydrochloride at main meals
without prescribing calcium lactate tablets
in the morning. At first we planned to give
two tablets of betain-hydrochloride daily for
three weeks followed by double the quantity
for another three weeks. Our investigations
are by no means complete, but we
already have had encouraging results, of
which the following are examples.

The test meal withdrawn from two old
men from De Gamle By showed pH values
of 6.4 and 6.7 respectively. They both had
numerous streptococci in the contents of the
stomach and in the feces and both were bifi-
dum-negative. The cure did not alter the
numbers of streptococci, but after taking
two betain-hydrochloride tablets daily for
some time, they became bifidum-positive.
One of these patients was also suffering
from pernicious anaemia. When the treat-
ment was discontinued both became bifidum-
negative again.

No good result, however, can be expected
without a reasonable diet containing soured
milk and some extra milk sugar. Even with
such a diet it is not always possible to es-
ablish Bact. bifidum in the intestinal canal.
We have not yet had the opportunity of
observing whether under such conditions it
can be established by adding milk cultures
of the organism to the diet.

Organic acids are often used instead of
hydrochloric acid in the treatment of achlor-
ydria. This medication has the advantage
of not disturbing the acid-base equilibrium.
In this connection it may be mentioned that
in the feces of a man 66 years old who had
for thirteen years taken 3.5 gm. of citric acid
daily for his so-called achlorhydria, we found
no less than 4,000,000,000 Bact. bifidum
per gram of feces. We also found Str. sali-
varius, but further examination proved that
he was suffering only from hypochlorhydria,
the pH in the test meal being 3.3. It is
characteristic of the feces from patients
with hypochlorhydria (and usually also for
patients with achlorhydria, who receive
hydrochloric acid) that both Bact. bifidum
and Str. salivarius are present.

It seems from these investigations that
relatively small amounts of acid taken at
the chief meals have a beneficial effect on
the flora of the colon in achlorhydria. These
small amounts of acid are obviously capable
of checking propagation of bacteria in the
stomach and in the small intestine so that
sufficient sugar reaches the colon to permit
Bact. bifidum to grow.

It is possible that similar results can be
achieved by eating plenty of acid fruits
(including pickled cucumber) with meals
and drinking acid drinks like wine or sour
milk products. Milk in any form is ben-
eficial owing to its content of milk sugar, but
sour milk is more easily digested than sweet
milk, and this is especially true of people
with achlorhydria. Since Yoghourt is one
of the most acid of sour milk products,
Metchnikoff may have been justified to
some extent in recommending it, but for
reasons other than those he gave, because
the bacteria contained in milk products do
not thrive well in the human colon. Because
of the great buffer action of the milk, how-
ever, one can hardly recommend sour milk
products as a source of acid for patients
with achlorhydria; hydrochloric and citric
acid are more suited for the purpose. But
milk products are of much benefit as a
source of milk sugar and as a vehicle for
bacteria. For the last purpose cultures of
Bact. bifidum or of Tbm. intestinale are
most suitable. They are not to be taken at
the chief meals of the day but on an empty
stomach together with calcium lactate tab-
lets, if the latter are used.

That sour milk products also possess good
properties other than those mentioned in the
foregoing is apparent from the fact that,
according to Brun and Nielsen (7), they
favorably influence hyperchromic anæmia which, in contrast to pernicious anæmia, is not accompanied nor caused by achlorhydria and is not cured by liver preparations.

**Summary**

1. Since Yoghourt bacteria grow but poorly in the animal and human colon, they are not suited for the purpose of suppressing the putrefactive processes arising in the colon.

2. Yoghourt can, however, like other sour milk products, be of benefit, owing to its contents of milk sugar and lactic acid.

3. If the colon in certain diseases is in need of a change of its bacterial flora, this change should be produced by means of milk cultures of the lactic acid bacteria characteristic of the normal colon, viz., Bact. bifidum and Tbm. intestinale.

4. Normally these bacteria (especially the former) are present in ample amounts in the human colon. If they do not develop and form acid it is because insufficient sugar is provided with the food.

5. The only sugars ordinarily occurring in the food which are not absorbed in the small intestine and thus reach the colon are dextrin and milk sugar. Hence it is important that the food contain ample amounts of dextrin or dextrin-forming substances, like starch and milk-sugar-containing substances like milk.

6. Moreover, in order to avoid putrefaction in the colon, the food must not be too rich in protein. However, the proteins in milk do not putrefy as easily as those in meat (including meat or fish).

7. Some putrefaction in the last part of the colon and in the rectum cannot be avoided, but with a sensible diet there is extremely slight danger of the putrefactive processes in the colon gaining the upper hand, so long as the hydrochloric acid production of the stomach is at its full height.

8. This arrangement by which most of the harmful bacteria in the food are destroyed is frequently apt to fail with advancing age. For this reason, feces from old people shows on the average more putrefactive bacteria and less Bact. bifidum than feces from young and healthy people. When the acid production fails, there is also a greater chance for the salivary streptococi, Str. salivarius, to pass unscathed through the stomach. If individuals are classified according to the strength of their hydrochloric acid production, the flora of their colon (or feces) may be characterized as follows:

Persons with pH in a test meal lying between 1.6 and 2 have normochlorhydria and numerous Bact. bifidum in feces.

Persons with pH in a test meal lying between 2 and 5 have hypochlorhydria and a large number of both Bact. bifidum and Str. salivarius in feces.

Persons with pH in a test meal lying between 5 and 7 have achlorhydria and a large number of Str. salivarius in feces.

9. The reason that the putrefactive processes in the colon increase when the hydrochloric acid production in the stomach diminishes is not only to be found in the poorer digestion of the proteins, but also in the circumstances that the food, instead of being almost sterile when it leaves the stomach, is so filled with bacteria that the sugar from which acid is normally produced in the colon already is fermented in the small intestine.

10. The last mentioned condition seems to be improved if only a little hydrochloric acid or citric acid is consumed at the chief meals. At the same time, in the morning, one should take about ½ liter of some sour milk product (buttermilk, sour milk, or Yoghourt), preferably with the addition of a little extra milk sugar. In certain cases, milk cultures of Tbm. intestinale or Bact. bifidum are to be preferred.

**References**


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