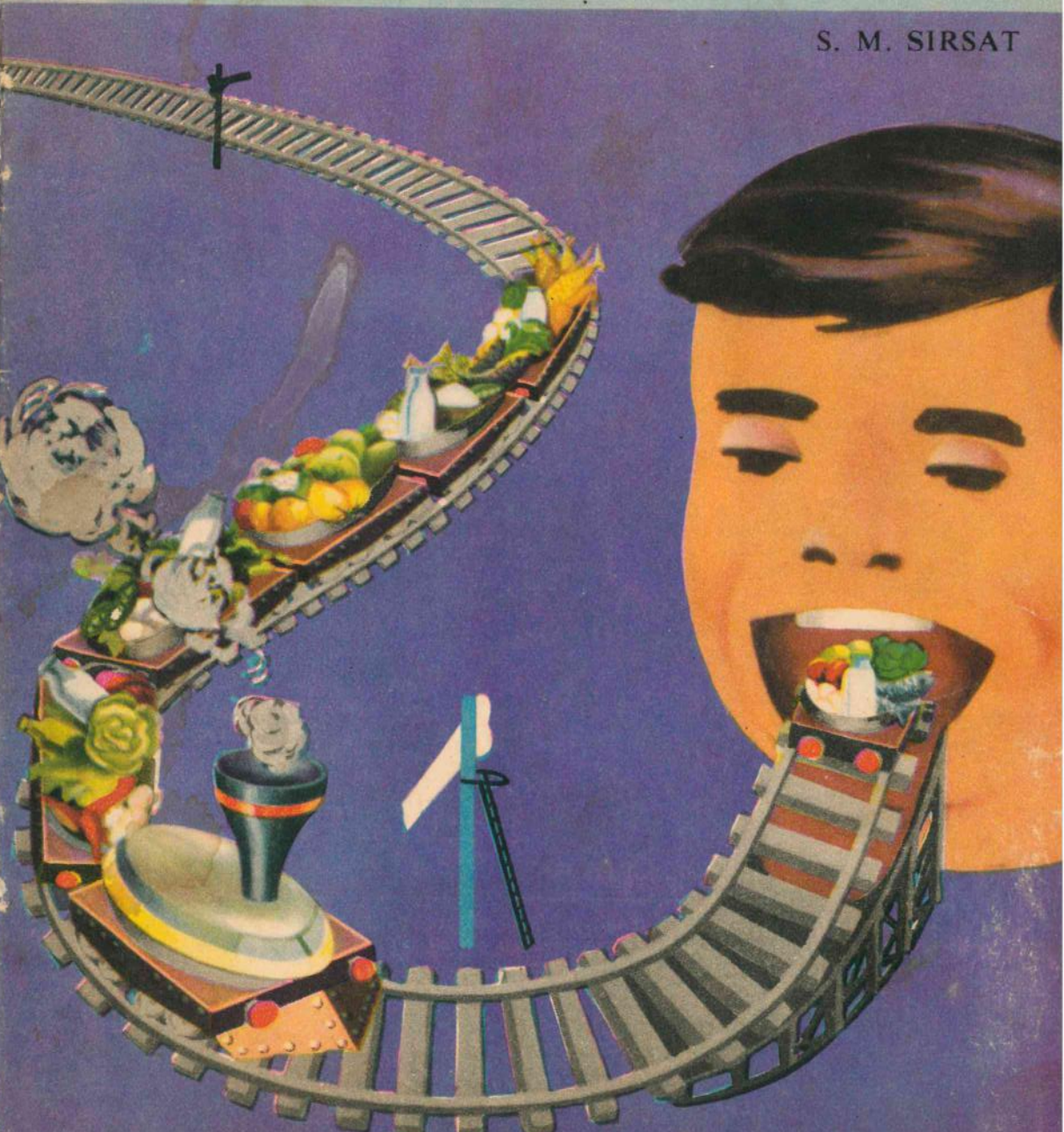
THE JOURNEY OF A MORSEL

S. M. SIRSAT



CITIZENS OF TOMORROW SERIES 13

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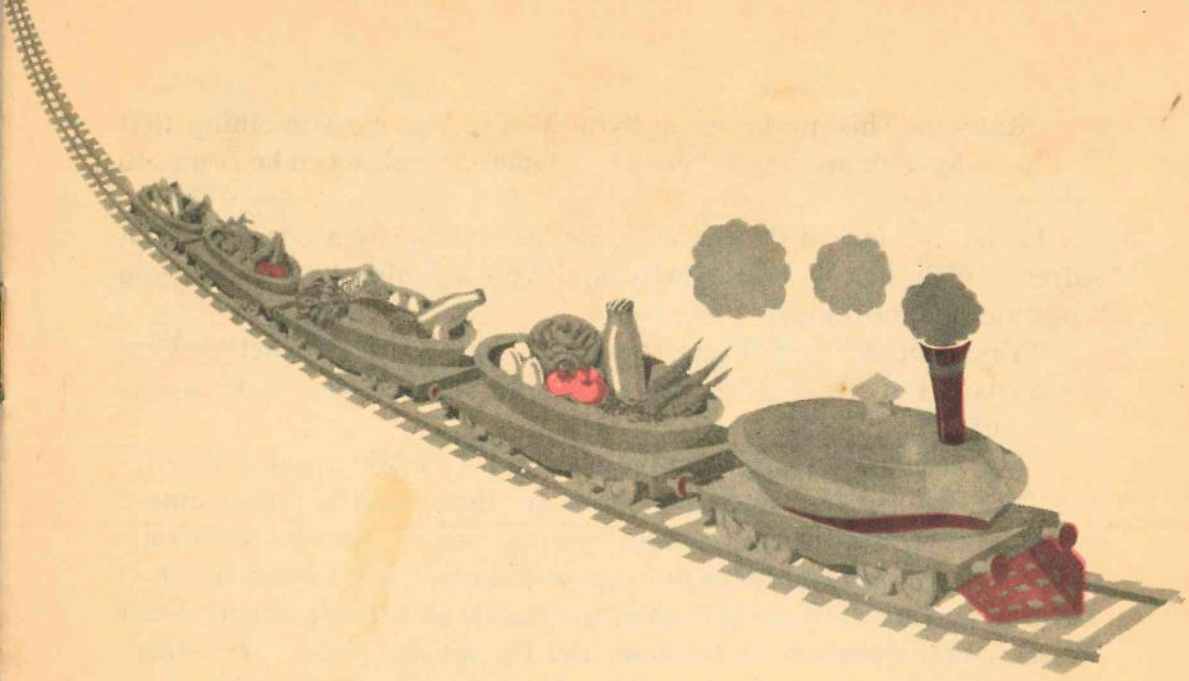


1. The Goods

ONE SATURDAY fourteen-year-old Ramesh and his younger sister Leela came home, washed their hands and sat down to lunch. Leela had got very tired playing hopscotch with her friends during the recess and was pecking at her food. Their mother, usually a patient woman, got annoyed and said, "Leela, hurry up and finish your lunch. Unless you eat properly, you won't grow up to be a big girl and wear all my nice sarees."

Ramesh was very amused at this and said, "Amma, whether Leela eats one or two chapatis, what difference does it make to her growing?"

"Ramesh," his mother said, "you have asked me something that needs a long answer. You better ask Doctor Uncle when he comes to dinner tonight."

In the evening, at the dinner table, her mother reminded the children, "Well, here is Uncle, why don't you ask him the question you put me this morning?"

"Yes, Uncle," said Leela, "does it really matter whether I eat one chapati or two? After all, what difference does it make to my growing up?"

"If you children really want the answer, I'll explain to you in detail."

"Yes, Uncle," they exclaimed and, for the next hour during dinner their uncle started them on what he aptly called, THE JOURNEY OF A MORSEL, or how food helps us to grow and live. In this book we shall also follow this story with Ramesh and Leela and their mother. Their uncle's first question to Ramesh and Leela was, "Have you learnt about the various constituents of food in your science classes?"

"O yes," said Ramesh, "I have, but I don't think Leela has."

"Well," said the doctor, "before going on to the changes food undergoes in our bodies, let us first see what the chemical substances in our food are and how our body uses them."

"I know one," said Ramesh, "Carbohydrates—because my science teacher keeps on saying I must eat plenty of carbohydrates since I play so much cricket."

"That's right," said his uncle. "Carbohydrates or starches are one group of substances needed by our bodies, and their main function is to provide heat and energy for living—for breathing and speaking and moving."

"Like petrol in a car," burst out Leela and they all laughed.

"Carbohydrates are found in sugar," continued the doctor, "in cereals like rice, jowar and wheat, and starchy vegetables like potatoes, turnips and beetroot."

Carbohydrates

Proteins

"Don't we need proteins too?" Ramesh showed off a little and added, "Our teacher says they are very important."

"Yes, indeed," replied the doctor. "They are the main substances which *build* the body as it were. They are necessary for maintaining many of the essential processes in our bodies. Can you name some?"

"Yes," replied Ramesh, "mutton and eggs contain proteins. So does dal, isn't that right?"

"You are right. The main protein-containing foods are meat, eggs, poultry, milk and some lentils like dal," said the doctor.

"What about the ghee and butter mother makes us eat? Are they not useful?" asked Leela.

"Of course," replied her uncle, "very useful indeed. These two items, as also oil, are fats, the main source of warmth for the body."

"Does that mean a very fat man is warmer than a thin one?" asked Leela,

"Not at all," said her uncle amidst Ramesh's giggles. "It is only that a fat man has more fat in his body than he uses to keep warm and has it stored up in his body in areas known as fatty tissue. As you know, ghee and butter are made from the fatty portions of milk. Besides milk, eggs, coconuts, peanuts, and seeds like *til* also contain much fat. These fats are extracted as oil and used in our diet."

Fats

"Except linseed oil," said Ramesh. "I use it to oil my bat and mother shouts at me if I leave the bottle in the kitchen, as the cook might use it in the food by mistake!"

"So," said Leela, "that is the end of your story—we need fats and proteins and carbo– carbo–"

"Carbohydrates, silly," said Ramesh in a lordly, grown-up manner.

"O no," said their uncle, "there is another very necessary group of substances we must have in our diet—the vitamins."

"What a funny name Uncle," said Leela.

"I don't think it's funny," said Ramesh.

The doctor cut the controversy short saying, "The word vitamin comes from the Latin *vita* which means life. So vitamin means something vital or needed for life."

"What are these substances?" asked Leela.

"They are naturally present in our food, and without them we cannot remain healthy. They are named after the alphabet—"

"You mean A,B,C,D,E,F?" said Leela.

"Just exactly that," said her uncle. "They are found in many of the foods we eat—eggs, milk, vegetables, meat, fish liver oil—"

"Is that why mother made me drink that nasty-smelling cod liver oil last year?" said Leela.

Lack of Vitamin A

Lack of Vitamin B

"That's right," said her uncle, "that's because you were getting so many colds. Vitamin A in the fish liver oil helps to prevent them."

"And B and C and D?" asked Ramesh.

"B keeps the nerves and red blood cells healthy; D, with the help of sunlight, builds strong bones; and C helps in the healing of wounds and also to fight infection."

"What happens if we don't eat enough vitamins?" asked Leela.

"Then we get what are called deficiency diseases," said his uncle. "Lack of vitamin A produces a rough skin and night blindness; without B one gets beriberi—"

"Another funny word!" said Leela.

"Without D, people, specially growing children, get a bone disease called rickets," continued the uncle.

"Why did you leave out Vitamin C?" asked Ramesh.

"Because I wanted to tell you something interesting about it. Vitamin C prevents a disease called scurvy. It is present in some fresh vegetables and, mainly, in all citrus fruits. You and I can easily buy them every day and get our vitamin C ration. In the old days, when there were only sailings ships, the sailors often never saw land for months on end and got no fresh vegetables. To prevent scurvy, they

Lack of Vitamin C

Lack of Vitamin D

were made to drink lime juice every day and even today the British seaman is nicknamed 'Limey'."

"Are there vitamins up to Z?" asked Leela.

"O dear, no," laughed her uncle. "Besides the ones I told you about, there is E which is particularly needed by women when they are pregnant. Then there is vitamin K which prevents bleeding. What is important is that you must have the correct proportions of all body-building and energy-giving substances in your diet. Only with such a well-balanced diet, will you grow properly, have enough energy and keep healthy. Milk is the one food that has all necessary substances in it and is thus, by itself, an ideal balanced food. This is why babies grow so well on it."

"Why can't I do the same?" pouted Leela.

"Because you are a great big girl of ten who has to grow up into a young lady one day. So you better eat all your food properly," said her uncle.

"But Uncle, what actually happens to the different kinds of food that we eat?" asked Ramesh.

"The food that we eat is absorbed by the body. The smallest blood vessels, known as capillaries, absorb what we eat. But, of course,

Ramesh, a slice of bread, a chunk of meat or a lump of butter, cannot enter these tiny blood vessels. They must first be broken into pieces and turned into paste or liquid form. This breakdown is accomplished by helpers, juicy substances called enzymes. These are produced in the body itself.

Dinner was over, and the doctor remarked, "You children seem really interested in knowing what's going to happen to the chapatis you have eaten tonight. Maybe, when I call next week, we may talk more about it."

"Yes, Uncle, please !" both of them pleaded, as the doctor left.

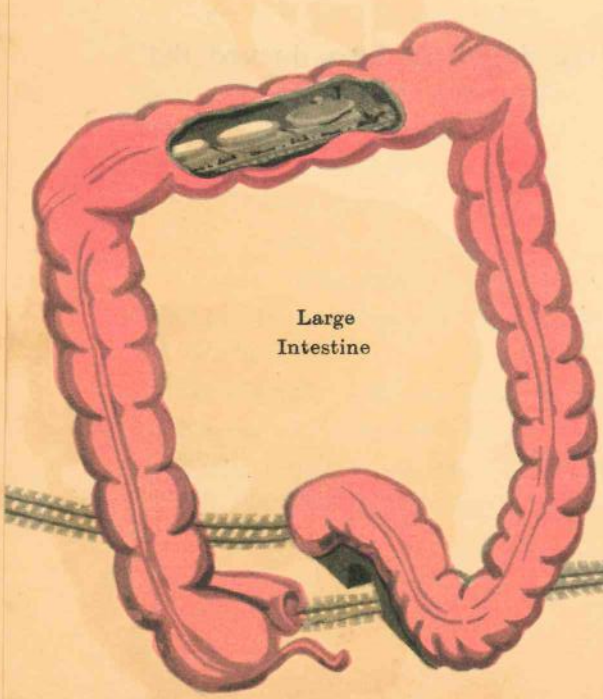
The doctor had hardly left when he reappeared saying, Perhaps I should also mention that when we eat cereals or vegetables we also take in some portions of the grain or vegetable, for example the bran of cereals or vegetables fibres, which we cannot digest and assimilate but which nevertheless play an important role as what is called roughage. This roughage, mixed with our food, stimulates the muscular movements of the stomach and intestines which are essential for good digestion.

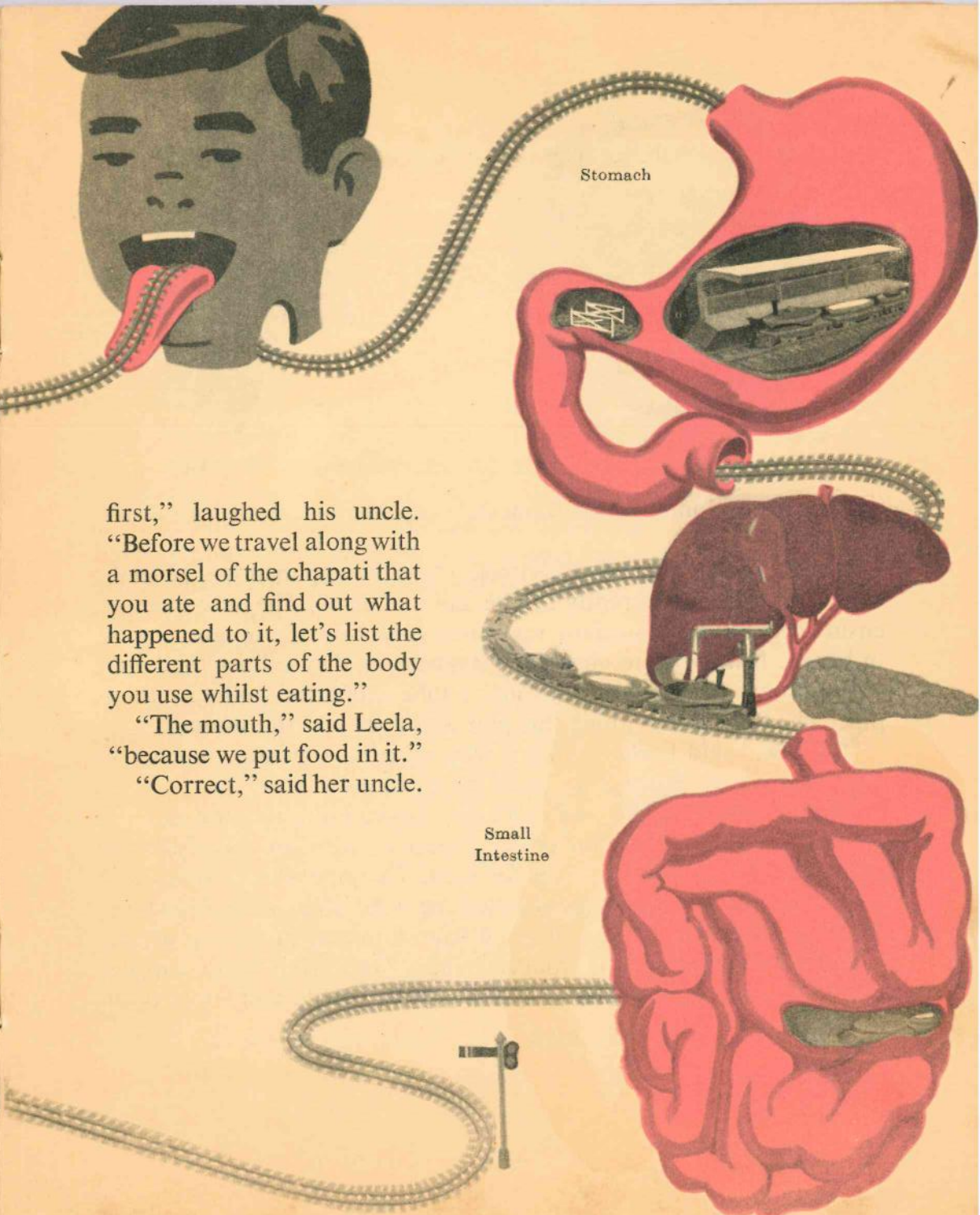
"Good Night, once again," said the doctor as he unlocked the door of his car.

2. The Route

THE CHILDREN finished their studies early and waited eagerly for their uncle. He finished his work, and came to their house. Before he could even sit down Ramesh jumped up, "Uncle, what happened to those chapatis that night?" . . .

"Wait, Ramesh, first things

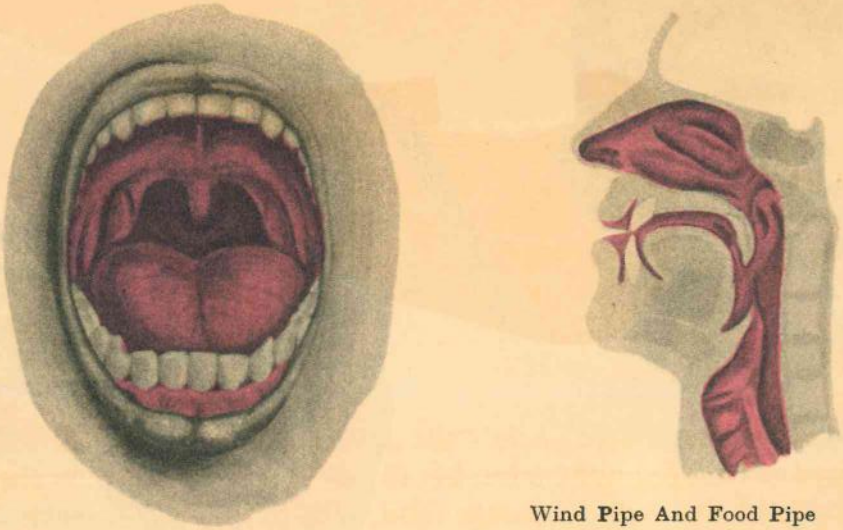




first," laughed his uncle. "Before we travel along with a morsel of the chapati that you ate and find out what happened to it, let's list the different parts of the body you use whilst eating."

"The mouth," said Leela, "because we put food in it."

"Correct," said her uncle.



Wind Pipe And Food Pipe

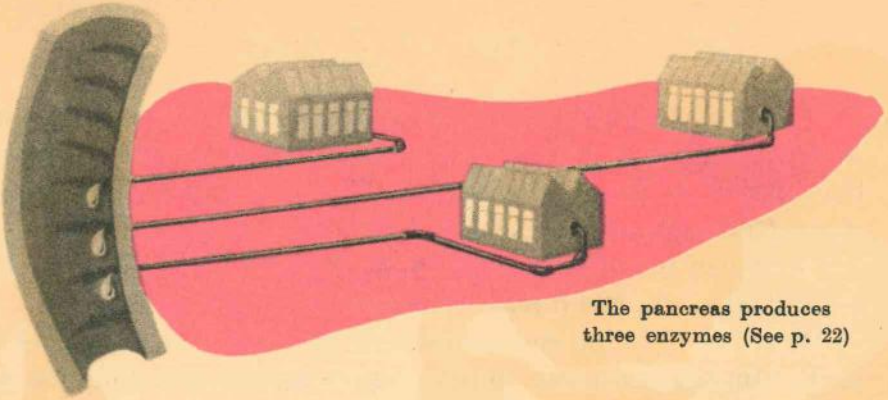
"And teeth," interrupted Ramesh, "because we have to bite what we eat."

"That's right," continued his uncle, "a grown-up man has 32 teeth which are shaped differently to bite, cut and grind. They are there to ensure that we don't swallow very large bits. Now the tongue comes in handy. It helps us to chew (or masticate, as they call it) food and to swallow it. The mouth leads into a tube called the gullet or food pipe. The food passes along this pipe and goes into the stomach."

"I know," said Leela. "That is why we cannot breathe when the food is going in. There is no place for air to go in also."

"Silly," said Ramesh, "we don't get choked every time we eat."

"No, you don't," said his uncle, "because there are two different pipes, one for air and the other for food. The pipe which carries the air we breathe into the lungs is called the wind pipe and is found behind the food pipe. There is a small flap of muscle at the top of the wind pipe which stops food from entering it. Only rarely does it happen that food enters it, and then we automatically cough, and try to push it out."



The pancreas produces three enzymes (See p. 22)

"Now," continued the uncle, "the gullet leads to the stomach where the food is changed quite a lot. Let us now learn the names of the various organs that help to change food. The first is the stomach. It is a bag like—"

"—like mother's shopping bag!" finished Leela.

"Not at all like your mother's shopping bag," said her uncle. "Her bag is made up of only one layer of plastic and, if it is filled with too many vegetables—"

"It will burst like a balloon," said Ramesh. "Yes," his uncle said, "we cannot afford to have that happen to our stomachs, can we? The stomach bag has four layers: an outside tough one to protect it; a second and a third of muscle—" and, before he could mention the fourth, Ramesh asked, "Why of muscle?"

"To make it smaller or larger according to need," replied his uncle. "All these layers contain nerves and blood vessels."

"I suppose blood vessels supply blood to the stomach," said Ramesh.

"Yes," his uncle replied, "you are getting quite clever. They do bring blood to the stomach. The nerves are there to carry messages from the brain to the stomach, telling the stomach when to start digesting."

"How cleverly we are made!" said Ramesh.

"Yes," said his uncle, "that is what I want you to understand. The innermost coat or, rather, lining of the stomach, the fourth layer, is, like the one in the mouth, made up of cells which produce the substances necessary for digestion." (See illustration on p. 22)

"How can the stomach alone do so much work?" asked Ramesh who liked work, but not too much of it, for himself.

"It is not only the stomach which carries out digestion," his uncle said. "In this area are present the liver, the gall bladder and the pancreas, all of which help to digest food in the stomach *and* in the intestines."

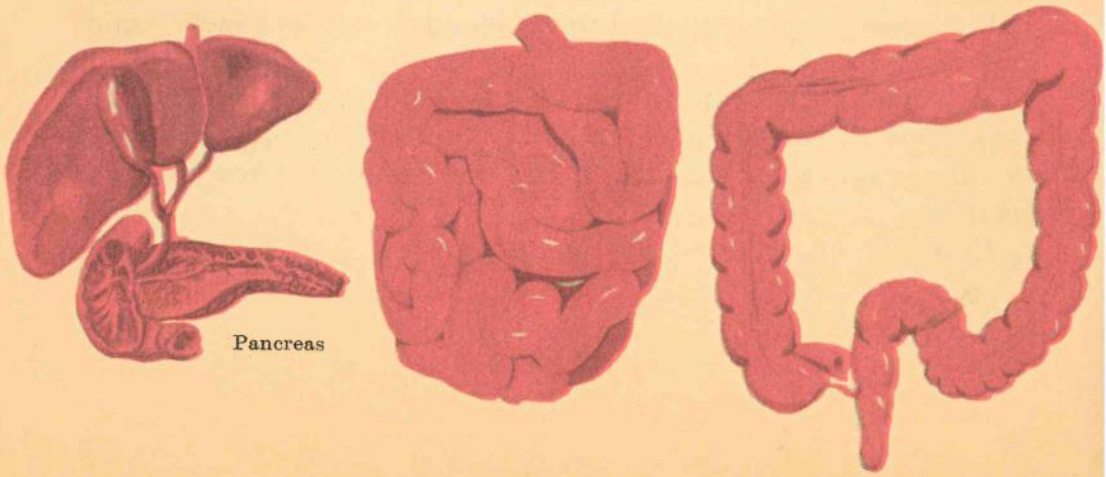
"Where?" asked Leela and Ramesh together.

"In the intestines also," their uncle replied. "From the stomach,the food goes to the small intestine which is a tube 6–7 metres in length."

"That long?" said Leela. "How can I have something that long in me when the whole of me is not that high?"

"Also, fancy calling something so long the *small* intestine—I think doctors are funny people," said Ramesh.

"Wait, children," said their uncle, "let me continue. The small intestine is so called in contrast to the next part of the digestive system which is the large intestine. The small intestine is only 2.5 cm in width, and is all coiled up to fit inside our bodies, while the large intestine, though less than two metres in length, is 6 cm in width."



"Why are the two parts of the intestines different if they are a continuous tube?" Ramesh asked.

"Because they have different functions to perform," his uncle replied. "Like the stomach, the small intestine is made up of a number of layers of cells, muscles, blood vessels, and nerves. Here, as the partly digested food goes along the whole length of the tube, it is fully broken down into simpler products which are absorbed by the blood vessels for the body's use. What is now left is the residual waste—to be thrown out."

"Now I understand," said Ramesh, "this waste matter goes down the large intestine, which acts as a drain pipe, and comes out as a stool."

"If you want to put it that way, it is so," said his uncle. "Anyway, as I told you before, it is the brain that orders digestion. It is like the king, and the various organs such as the teeth, mouth, stomach, intestines, liver, gall bladder, pancreas, these are the king's men."

"What happens if the king's men disobey their king, or mutiny?" asked Ramesh. "Who suffers?"

"We," said his uncle. "We get indigestion, stomachaches, loose stools and, sometimes, even fever."

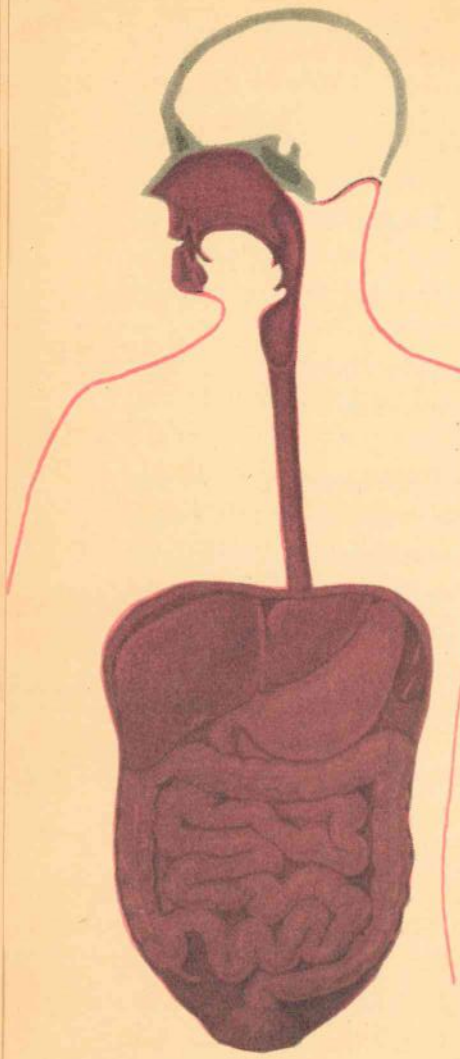
"Enough for today, children," their mother said. "You have school tomorrow, so off to bed."

"Yes, but we don't even known what each organ does to the food," grumbled Leela.

"We will talk about that next Saturday when you can keep up late," their uncle pacified her.

"—and wake up late on Sunday morning," said Leela triumphantly.

"Sure!" said her uncle.



The Digestive System

3. The Journey Begins

THE CHILDREN were pleasantly surprised to see their uncle with a raw mango in his hand when he arrived the next Saturday as promised. "Ramesh," he called, "get me a knife."

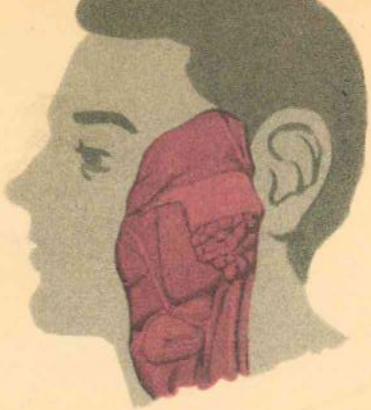
As he cut the juicy mango, Ramesh cried out, "I must have the largest piece! My mouth waters seeing you cut the mango—I love mangoes!"

"Ah, there starts our story again. That's exactly what happens when you put a morsel of food in your mouth," said his uncle.

"Wait!" cried the mother. "I am also interested in the story. I'll bring a notebook and jot down a few points. I'm sure they'll be useful at the Ladies Club."

"I wonder from where the water comes into my mouth," said Ramesh.

"Under the ear, on both sides of our face, are a set of glands. When anything



The Salivary Glands

is put into our mouth, or even when we see food that we want to eat, these glands produce a sticky fluid."

"Like mine are doing now, eating this raw mango," said Ramesh.

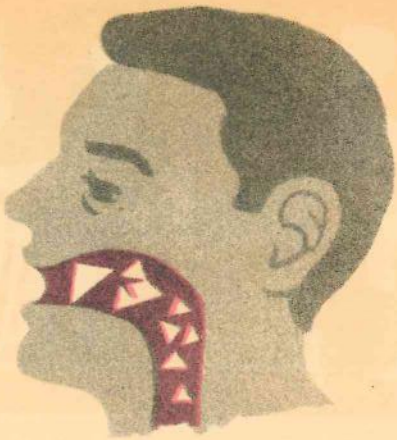
"Yes," his uncle agreed, "this fluid is called saliva. Do you know what it does?"

"I know. We have learnt in school that the water of the saliva moistens the food," replied Ramesh.

"Good!" said his uncle, "that is one of its uses—it makes the chewed food easier to swallow. It has many other uses too, all of which are important. It keeps your mouth, including the tongue and the lips, wet and clean. It has salts of sodium and potassium dissolved in it which mix with the food. It also contains a slimy mucus which lubricates the morsel so that it can pass through the food pipe or gullet easily and without damaging its delicate lining."

"However," the doctor continued, "its most important use is to start the breaking-down of carbohydrates or starches into a simpler substance called maltose, a form of sugar. This it does with the help of an enzyme called ptyalin (pronounced *ti-a-lin*). I shall tell you about enzymes—"

"—Just a minute," said the mother. "This is what I have noted about saliva:



Breaking-down of carbohydrates in the mouth

"Wets the food—helps in swallowing it—moistens the lips. The most important use: ptyalin in saliva changes carbohydrates or starches into maltose.

"Am I right?"

"Yes, quite right," said the doctor.

"How are the carbohydrates changed?" asked Ramesh.

"I suppose they are dissolved," replied the mother.

"No, it's not as simple as that," the doctor corrected. "This is the proper time to tell you about an important group of substances concerned in digestion."

"Are these substances present in food?" Leela asked.

"No, they are produced by the cells of various glands and organs and help in the process of digestion. Take the example of a big dinner party. There is always one chief cook isn't there?"

"Yes," said Leela, "when Auntie Saroj got married, the chief cook was a big fat fellow."

"Well," her uncle said,"to help this chief cook, there were a number of helpers to wash the vessels, clean the rice, chop the vegetables, etc., remember?"

"Quite so," Ramesh agreed. "Without them the dinner would never have been ready on time!"

"So also, in the process of digestion, there are a number of helpers who take part in breaking down the proteins, fats and carbohydrates into smaller, digestible units," his uncle said. "We have already called these helpers enzymes, haven't we?"

"But where are these helpers or enzymes found?" asked Ramesh.

"Enzymes are found in the mouth, the stomach and the small intestine. Some are produced in these organs while others are produced elsewhere in the body and are carried to these places all ready to change the complicated substances into simpler ones which the body can utilise."

"Do you mean to say that the helpers attack the food that we eat like bandits? My poor stomach!" Ramesh said.

"Ramesh, listen to your uncle carefully," said his mother. "I am sure he said these are helpers, not bandits or anything like that, because they are fulfilling a useful purpose."

"The most interesting part," the doctor continued, "is that each helper helps to break down only one particular type of substance. While some will break down only proteins, others will affect only fats, and yet others will touch only the carbohydrates."

"My word, there must be a regular army of them!" Ramesh said.

"O yes," his uncle agreed, "you will see how, at every stage, there is an enzyme to see that the food is changed gradually into the simplest forms so that our bodies can absorb them."

"Uncle, the food is still in the mouth. What happens next?" Leela reminded him.

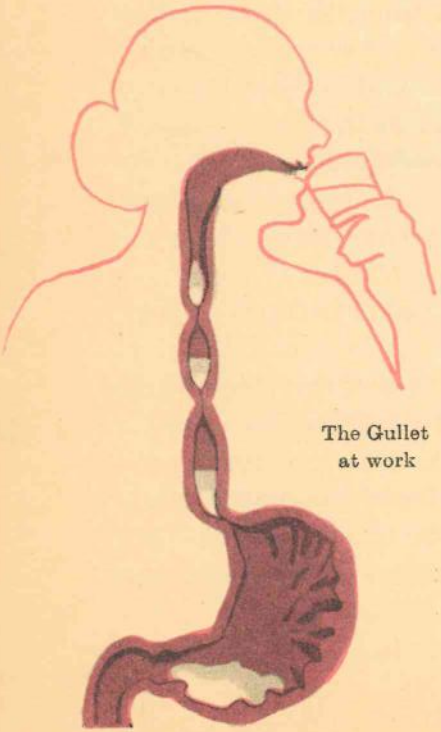
"Saliva gets completely mixed with food, while chewing it," her uncle explained "the ptyalin continues its action for a while and then, from the mouth the morsel goes down the gullet to the stomach."

"Does anything happen to the food while it passes through the gullet?" asked Ramesh.

"No," said his uncle, "the food pipe acts only as a channel between the mouth and stomach where things start happening in right earnest. The gullet has an outer layer of muscle which contracts and expands as it pushes the food down to the stomach in six to seven seconds."

"If the food is properly chewed, it will be in a semi-solid state, mixed with saliva, and the starchy carbohydrates will already be partly digested. At this moment, the stomach is ready to start attacking the food mass in order to break it down further."

"How can a stomach bag do that?" Leela asked.



The Gullet at work

"This process is not carried out *by* the bag, but *inside* it, Leela," her uncle explained patiently, "by the chemicals or enzymes produced by the cells of the innermost layer. Some cells of the stomach produce an acid which kills the germs in the food, i. e. it sterilises the food. Others produce a sticky glue-like substance to prevent the acid from corroding the stomach lining. Yet other cells produce different types of enzymes. Also present in the stomach are salts of sodium and potassium which are brought in by saliva, and all this mixture is called *gastric juice*."

"Does the food dissolve in this juice and get digested?" Leela asked.

"No, Leela," her uncle replied. "Here again, there is a division of labour. The acid makes the enzymes ready to start their job of demolition. An enzyme known as pepsin breaks up proteins into smaller units called peptones. These have to be broken into still smaller units known as peptides. There is another enzyme called renin, whose job is to solidify milk proteins."

"Solidify? Aren't liquids more easily digested than solids?" asked the astonished mother.

"Yes, as a rule, but in this case milk proteins can be digested more easily in a solid state," said the doctor.

"Oh, is that why we give curds in cases of diarrhoea?"

"Yes," said his uncle. "Of course grown-ups don't need this helper as much as babies do—"

"—Because they drink only milk and need to absorb proteins and grow up," Leela said. "How much I have learnt alredy!"

"In about two hours, this pasty mixture known as CHYME (pronounced *kyme*), consisting mainly of partly broken-down proteins, fats and carbohydrates, is ready to travel to the small intestine."

"Uncle, does food always travel in one direction only through the digestive system?" asked Ramesh.

"Before I answer, let's find out how your mother's diary reads."

THE JUICES IN THE STOMACH

1. The cells of the innermost layer of the stomach produce enzymes.
2. Some cells produce an acid.
3. Other cells produce a sticky glue-like substance which prevents the acid from corroding the stomach wall.
4. Saliva brings certain sodium and potassium salts to the stomach.
5. A mixture of all these gives us the GASTRIC JUICE.

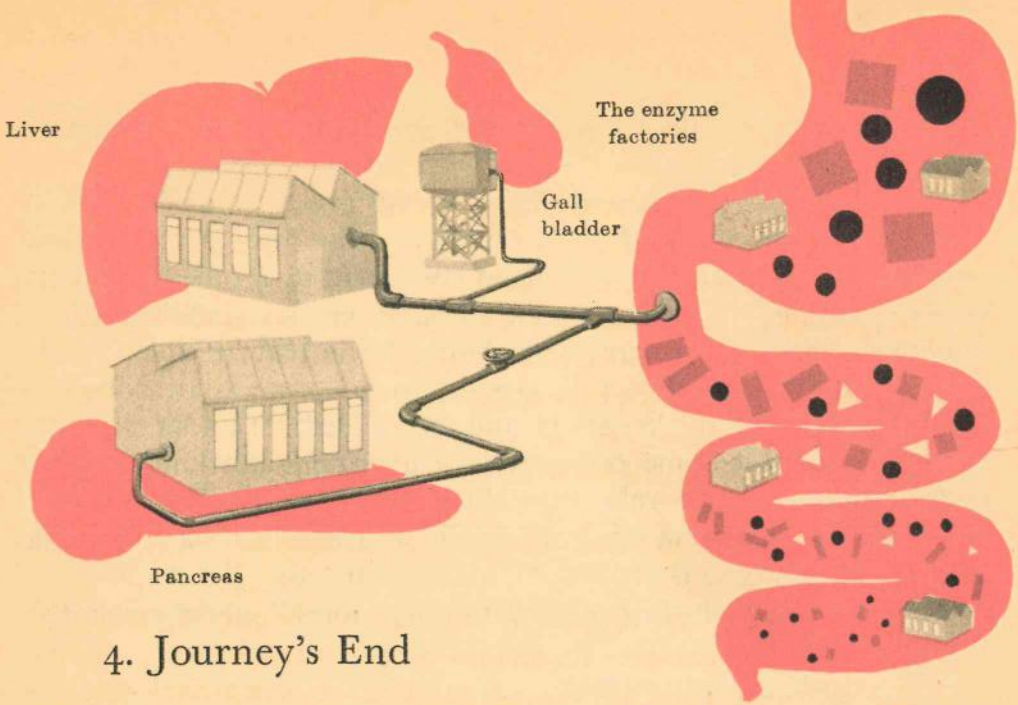
DIVISION OF LABOUR IN THE STOMACH

1. Acid starts the helpers or enzymes on the job of breaking down complex foods into simpler substances.
2. Helper pepsin, breaks up proteins into peptones and peptones into peptides.
3. Helper renin solidifies milk proteins.

END OF STOMACH ACTION

Within about two hours the mixture of partly broken down proteins, carbohydrates and fats is now ready to enter the small intestine.

"And now, to your question, Ramesh. Food normally travels only in one direction. But when we are ill, we sometimes vomit, don't we? When that happens, we have food travelling in the wrong direction—back from the stomach, through the gullet and into and out of the mouth."



4. Journey's End

"HOW BAD we are! We have left the poor food in the stomach for so long," said Ramesh when his uncle arrived the following week.

"We can do that in our story, Ramesh, but in reality the whole process of digestion is completed in 18 to 24 hours."

The mother opened her diary to continue her jottings. "Now let's see; where were we?" said the uncle. "The food has now come to the small intestine in a partly digested form called CHYME and it is here that the digestion is completed, so you can imagine how many helper substances have to be present."

"Are they all made in the small intestine?" asked Ramesh.

"No, digestion in the small intestine is the combined job of a number of organs. Let us see what substances are waiting here to attack the chyme that comes from the stomach. As I told you when we were talking of the organs of digestion, there are enzymes produced by the liver, the pancreas, and the gall bladder."

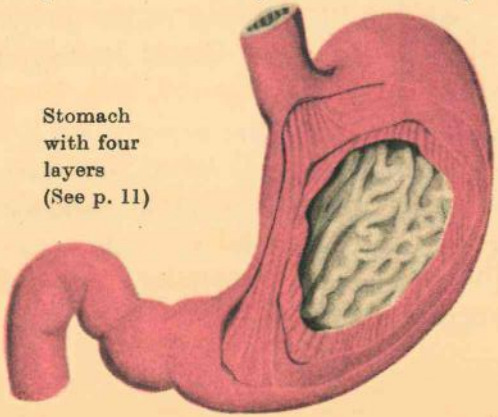
"Yes, Uncle, but the food does not seem to go to these organs," Ramesh said.

"No, Ramesh, it does not. The enzymes produced in the cells of these organs are conveyed to the small intestine and there take part in digestion. The pancreas is a gland connected by a tube to the part of the small intestine just after the stomach which is called the duodenum. Without the pancreas, we should be in real trouble as the gland produces enzymes for all types of food—proteins, carbohydrates, and fats." The uncle paused, and then added, "This small gland is wonderful. In it, some cells produce a protein-attacking enzyme called trypsin; in other cells it produces an enzyme called amylase for breaking down starch; and in still other cells, a fat-attacking enzyme called lipase is produced." (See illustration on p. 11)

"You are going too fast for me to take notes," complained the mother.

"This is what I have written :

1. A gland known as the pancreas produces enzymes for all types of food.
2. Some cells produce an enzyme called trypsin, which attacks proteins.
3. Other cells produce an enzyme called amy . . .



Stomach with four layers (See p. 11)

I didn't get it correctly. Please, would you repeat it ?"

"It is amylase," said the doctor. "It attacks starch. As I was saying, there are other cells that produce an enzyme called lipase which attacks fats. They are all present in the pancreatic juice which flows into the duodenal part of the small intestine, and mixes completely with the food."

"What does the liver do in the process of digestion?" asked the mother.

"The liver produces a yellow fluid called bile," the uncle said. "The bile contains salts which help to convert fat into finer particles. It is made by cells in the liver and then stored in the gall bladder which does not manufacture anything itself. The gall bladder is merely a storage tank for bile, and when intestinal digestion is to take place, it supplies bile to the small intestine. Bile is most important. To maintain sound health, fat must be properly absorbed in the body."

"Does not the small intestine, like the stomach, itself produce any enzyme?" Ramesh asked.

"O yes," his uncle replied, "the cells of the small intestine also produce enzymes for all three food types but, compared with the pancreas, in very small quantities. As the food, now mixed with powerful enzymes, goes on its long journey along the small intestine, two main events take place."

"What are they?" cried both the children together.

"Digestion and absorption," their uncle answered. "In the first place, the components of food get digested, and, secondly, they are absorbed by the body."

"In what form are they absorbed?" asked Ramesh.

"I told you earlier, Ramesh, that, in the stomach, proteins are broken down into peptones and peptides."

"But you also said there were still smaller units," Ramesh reminded him.

Breaking down of proteins

Breaking down of fats

"That's right," his uncle said. "In the small intestine, the peptides get broken down into the basic substances that make up proteins—the amino acids. There are about twenty of these substances."

"Don't tell me that you are going to name these twenty acids!" the mother exclaimed.

"O no, don't you worry! I don't think I know the names by heart. Anyway, these amino acids are even further simplified before absorption by the blood," said the uncle, "and, as for the fats, they are turned into a fine milky fluid known as an emulsion. This is done with the help of the—"

"—Lipase, so say my notes," the mother butted in.

"Correct," said the uncle. "Lipase breaks down fats to fatty acids and glycerol. This is necessary because the fat molecules are too large to be absorbed or taken up by the cells of the body. It must be remembered here that most of the fatty acids absorbed pass into lymph spaces in the walls of the small intestine.

"And, finally, we come to the carbohydrates, the digestion process of which starts in the mouth. The carbohydrates are further

Breaking down
of carbohydrates

broken down in the small intestine into basic sugars.

"The intestinal juice contains three enzymes, namely maltase, lactase and sucrase. Have you taken them down, Mother?"

"Yes indeed! Here they are," said the mother as she read out, "Intestinal juice—3 enzymes—maltase—lactase—sucrase."

"What on earth is the use of knowing these 'ases'!" Leela, who was completely bored by these names, interrupted.

"Ah, my dear Leela, these enzymes are important. The bread that you eat is carbohydrate or starch which is not soluble in water. That is why our cells cannot absorb it. The sugar that you eat, though soluble in water, also cannot be absorbed by the body. This is where these enzymes come in. As we learnt before, these carbohydrates are turned into sugars which are required to be further broken down into simpler forms of sugar, viz. glucose, fructose and galactose."

"So, from the 'asses' we go to 'osses'," remarked Ramesh jocularly.

"Now, now Ramesh, don't make too much of these words. They represent ordinary sugars which are widely distributed in nature,

some in plants, others in animals and yet others in both, and are commonly known as milk-sugar, cane-sugar, etc. Thus sugar digestion is completed and, as the digested food products travel along the intestinal tract, they get absorbed for the use of the body," concluded the doctor.

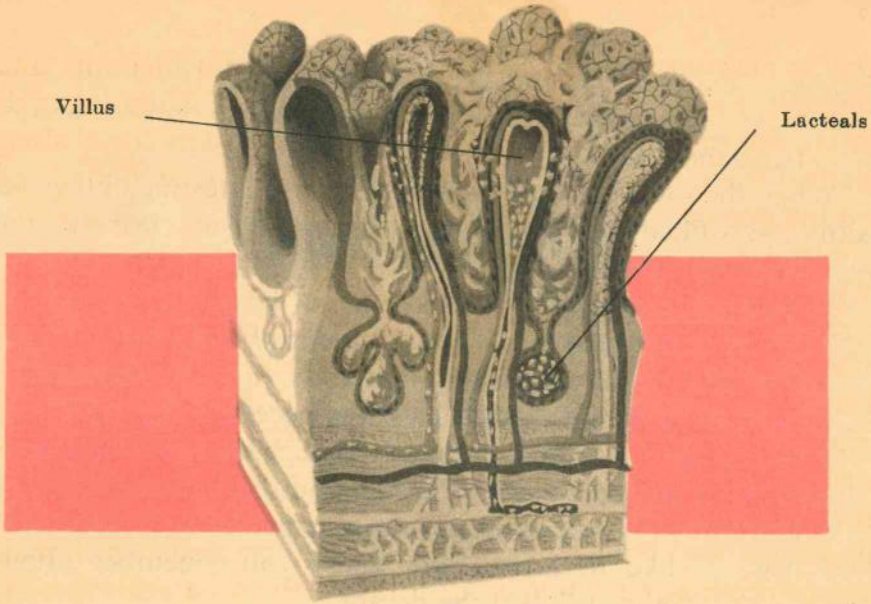
"Who takes them in?" asked Leela.

"Thats a good question, Leela." Her uncle was pleased at her interest. "Now let's try and understand the nature of the inside surface of the small intestine. It is not a flat, plain surface. It has folds, and any surface with folds, as you know, has a greater surface area than a corresponding flat surface. Thus the digested nutrients from food can be absorbed over a wide area. But that is not all. These folds are covered with numerous finger-like projections known as villi (singular, villus.) Even the cells which make up these projections have numerous folds on them—all this for increased absorption of nourishing food products. The blood vessels in these finger-like projections absorb sugars and amino acids. These projections also contain special fat-collecting vessels which are known as lacteals. Do you remember the lymph spaces in the walls of the small intestine which we talked about earlier? These are the lacteals and their job is to carry fat to a main blood vessel in the body."

"Uncle, what puzzles me is that, the small intestine being coiled, food travels up and down the coils," Ramesh said.

"Oh, I should have told you about that. I am glad you reminded me," his uncle replied. "Like the gullet and the stomach, the outermost layer of the small intestine consists of muscle. These muscles alternately contract and relax, thus narrowing and expanding the space inside the intestine. When this happens, the food gets pushed along under the control of the muscles.

"Now let us see what finally happens to the food, and what is left of it."



"I know!" asserted Ramesh. "What remains is only waste matter because most of the proteins, carbohydrates and fats are digested in the small intestine."

"Yes," said his uncle. "Besides waste matter, there is also water, and, as the residual waste—including undigested fats, proteins and carbohydrates—goes through the large intestine, the water is absorbed by the inner layer of this organ. So what is now left is the excreta or what are called fæces, mainly residual matter—some undigested material and bacteria."

"Bacteria ! Where do these come from?" asked Ramesh.

"Many types of bacteria live in the large intestine," said his uncle.

"Isn't that bad for us?" asked Leela.

"No, Leela, all bacteria are not harmful. There are some which are even useful to us in many ways. The type of bacteria which live within the large intestine help to make vitamins in the body. Some

of these come out with the fæces in the stool. To keep ourselves healthy, we must pass at least one stool a day to remove waste materials from the body.

"When the lowermost portion of the large intestine, known as the rectum, gets filled with fæces, there is a desire to clear it, and the person gets the urge to do so.

"So you see, Leela, why you have to eat food to grow big."

"Yes, Uncle, but may I ask you something?" said Leela. "When we have absorbed all the nourishing materials, how do they help us to keep warm, to grow up, and to have the necessary energy?"

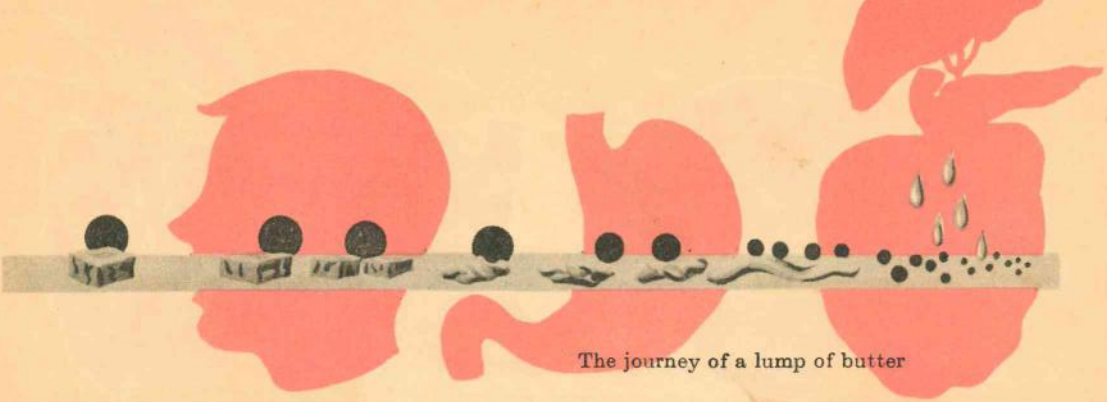
"That question is related indirectly to digestion. Perhaps my story will remain incomplete without telling you something about it, but I will leave this for next week. In the meanwhile, you must do something. I would like to know how much you remember about the journey of the morsel," said the doctor.

"You have told us so much Uncle," said Leela.

Her mother came to the rescue. "Why don't you prepare charts tracing the journey of the food. I am sure my notes will be of some help."

"That's a jolly good idea! Now I must be leaving. Bye bye children!"

"Bye bye Uncle! and thank you for everything."



The journey of a lump of butter

5. Food, Energy and Growth

"LOOK UNCLE, here are our charts," said Leela, a week later.

"Which one did you prepare, Leela?" the doctor asked.

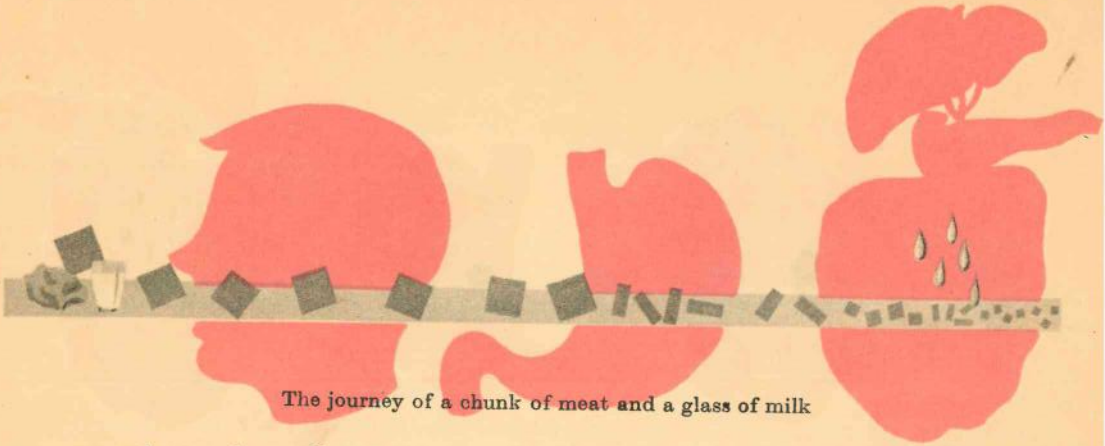
"I took the easiest. The journey of a lump of butter!"

"Good! Let me hear you explain your chart."

"There are three main stations along the journey, namely the mouth, the stomach and the small intestine. At the first two stations practically nothing happens. The butter melts in the mouth and is pushed down to the stomach. In the stomach it is churned as it were and it becomes a part of a paste called chyme. Then it is ready to enter the small intestine. It is at this station that action starts. Now the helper substance, lipase, pours in from the pancreas and changes the fat in the butter to fatty acids. Then comes the bile prepared by the liver and stored up in the gall bladder. It splits up fatty acids into very, very small droplets. These are absorbed by lacteals in the villi of the small intestine. From there they are collected by blood vessels."

"That's very good!" the doctor observed. "What about your chart, Ramesh? Isn't it supposed to show the journey of....."

"A chunk of meat or a glass of milk," interrupted Ramesh. "I won't repeat the stations. In the mouth the chunk is broken into bits by the teeth and the saliva and the tongue help us to chew it. Then it

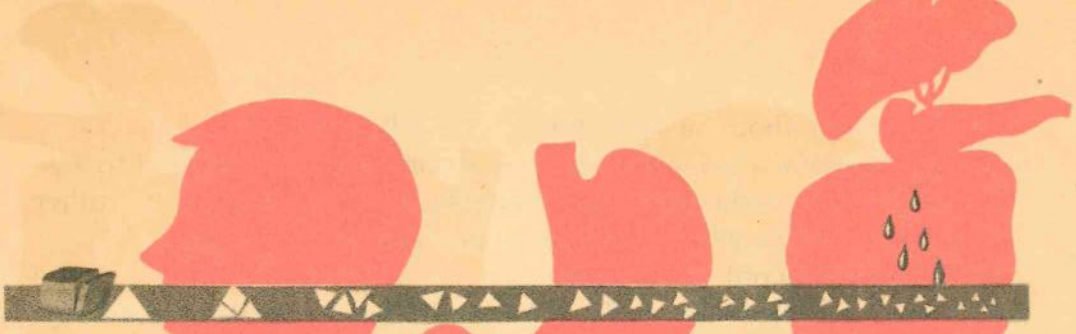


The journey of a chunk of meat and a glass of milk

goes down the gullet and enters the stomach. Now begins the action of the enzymes, pepsin and renin. Pepsin converts the proteins into peptones and peptides; renin turns the milk into curds. Now it goes into the small intestine where a pancreatic juice known as trypsin breaks up the proteins into still smaller units. Yet another enzyme, crepsin, from the small intestine itself, converts the proteins into amino acids. These are finally absorbed by the blood vessels in the villi."

"Now, Mummy, it's your turn," the children said together.

"Come, hear my story," said the mother pointing to her chart. "A crisp slice of bread gets broken in the mouth into tiny bits and, with the help of the enzyme ptyalin in the saliva, a part of the starch is converted into a form of sugar known as maltose. Going down the food pipe, it enters the stomach. As soon as the acid from the stomach mixes with the starch, the action of the ptyalin stops and the starch becomes a part of the chyme. It now enters the small intestine and several enzymes begin to attack. The AMYLASE from the pancreatic juice breaks down the remaining starch into maltose, thus completing the work ptyalin starts in the mouth. Now we come to those 'ases' which change the complicated sugars into 'oses'. Here are the three intestinal juices—maltase, lactase and sucrase, giving us glucose, fructose and galactose, respectively, the simplest forms of sugar, ready for absorption by the villi of the small intestine."



The journey of a slice of bread

"You have learnt a lot, haven't you?" said the doctor.

"Yes, Uncle, but I still do not know how heat or energy is produced by food," Ramesh said.

"I'll tell you briefly how the food absorbed by our bodies helps us to build our tissues and warm us or keep us energetic."

"We saw that proteins are finally broken down into amino acids which are absorbed through the small intestine and go mainly to liver."

"The same liver that makes the bile?" asked Ramesh.

"Yes Ramesh, the same," his uncle said. "You will notice that, for all the three types of food, the liver is most important."

"What does it do?" asked Ramesh.

"It is a storehouse for certain substances, a factory for others, and a distribution centre for still others," the doctor explained. In the case of the amino acids, they are sent out from the liver to the various tissues to be used in building them, or to get converted into enzymes, which are also proteins. At the end of the body-building and enzyme-producing processes we are left with a residual waste consisting of even simpler products than the amino acids."

"Then, where do they go?" Leela asked.

"Again to the liver where they are converted into urea, a simple chemical substance which is soluble in water. This urea goes through the kidneys and, along with the water, is removed from the body as urine. This is how proteins are used in the body."

"And what about carbohydrates?" asked the mother.

"As I told you these substances get absorbed in their simplest forms, as sugars. From the intestine, some sugar goes straight to other parts of the body. Most of it goes to the liver which stores it."

"The liver again!" said Leela.

"Yes," asserted her uncle. "As and when needed by the body, this stored sugar is sent out. In the tissues, say in the muscles which have to do a lot of work for us, this sugar is broken down by enzymes into water and a gas called carbon dioxide."

"I know," said Ramesh. "Isn't that the gas we breathe out?"

"Yes," his uncle said. "That's how we get rid of this waste product formed during our use of carbohydrates. During the breaking-up of the sugar, much energy and heat are released which are used by the tissues for their activity."

"What about my fat?" asked Leela.

"Fat has already formed a fine emulsion with the help of the bile. When it is absorbed by the blood vessels from the intestine, it goes straight on to the various tissues and is slowly used by the cells. As it is used, it breakes down finally into water and carbon dioxide."

"How does that happen, Uncle?" asked Ramesh.

"Again with the help of enzymes," his uncle replied. "The carbon dioxide gas is breathed out and the water is eliminated through the kidneys. During the breaking-down of fats, a lot of heat is generated, which keep us warm."

"Just think of it!" said Leela. "I have a nice dinner, play a little and go to sleep—and so much is happening inside me!"

"Quite true, Leela," her uncle said. "That is why you must follow the rules of good diet."

"Thank you, Uncle, we really enjoyed listening to the story of the Journey of a Morsel. Didn't we Leela?" said Ramesh.

"Yes, Uncle, thank you ever so much," said Leela.

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