

Theme 4: Life Processes - Nutrition in Human Beings



Prior Knowledge

It is recommended that you revise the following topics before you start working on these questions.

- Organs of the digestive system in humans
- Role of enzymes
- Relationship of the digestive system with the respiratory and circulatory system



Energy from Food

In 2015, one of the popular noodles brands was banned in India since it was concluded to be unhealthy to eat. Though the ban was removed after some time, it triggered debates which continue till date in some groups of people. Who decides if a packed food product can be sold in the market or not? In India, the Food Safety and Standards Authority of India (also known as FSSAI) is responsible for protecting people's health by supervising the quality of food. FSSAI regulates the quality of packed food products by issuing rules and guidelines which each manufacturer needs to comply with. For example, as per the FSSAI rules each packed food item must have a green dot or red dot to indicate whether it is a veg or non-veg product. Another regulation ensures that packed food items have labels showing the nutritional value of the food product including the information on how much energy can one derive from that food product. The food's energy value is measured in this unit called Calorie. If a food packet says that 100 g of that food would give us 400 Calories, does our body get the full 400 Calories or less than that? Note that some energy is spent in digesting the food as well. Digestion is essential for extracting the energy from the food. How much is this energy? What if it is equal to the energy we get from the food? What if it is more?

Case Study A - Negative Calorie Food

People often attempt to lose weight to be fit and healthy. One of the ways which is being talked about is to eat food with negative calories. If the energy spent in digesting a food item is more than the energy we get out of it, the final effect of eating the food item would be loss of energy. So, the claim made by people is that you will lose more energy if you eat these food items when compared with fasting! A research institute studied the energy used by our body to digest food and described it in terms of the percentage of energy obtained from different components of food (see table 4.1).

Component of food	Amount of energy used to digest the food (in terms of % of energy obtained from that food)
Carbohydrates	5 to 10%
Fats	Less than 5%
Proteins	20% to 30%

Table 4.1, Percentage of energy spent in digestion of different types of food components

For instance, if one obtains 100 Calories of energy by digesting the fats in a food item, the energy spent in the digestion itself would be less than 5 Calories.

Question 1

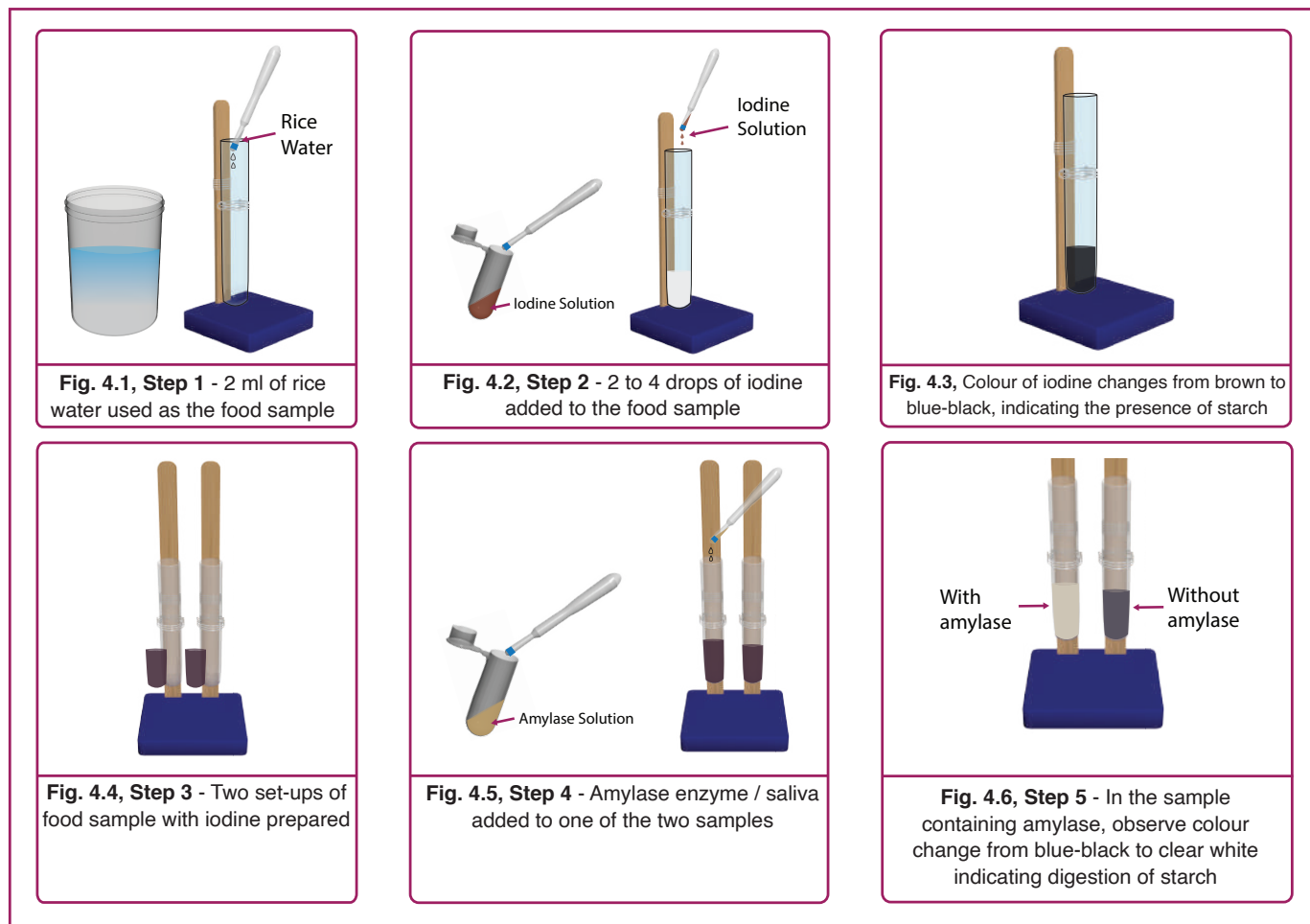
Assuming that the findings of the research institute are accurate, what can you infer about negative calorie food? Choose the most appropriate option.

- a. The findings are not related
- b. Data is not sufficient to conclude
- c. It is not possible to have negative calorie food
- d. Negative calorie food must be rich in protein

Answer

Case Study B - Experiment with Starch

Out of the different components of food, carbohydrates are the primary source of energy. Carbohydrates are produced by plants through photosynthesis and stored in the form of starch. When iodine is added to starch, the colour of iodine changes from brown to blue black (see Fig 4.1 to 4.3).



Question 2

Fig. 4.4 to 4.6 shows an experiment. What is the hypothesis this experiment is testing? What is the role of iodine in this experiment?

Answer

Case Study B (continued) - Types of variables

Variables: The quantities which can vary are called variables. E.g. the price of petrol in India may change based on the price of crude oil in the international market and hence can be considered a variable. However, the maximum volume of petrol which can be filled in the fuel tank of a given vehicle cannot change (unless you get the tank redesigned). Hence, this cannot be considered a variable and is called a constant.

In the context of experiments, there are three types of variables:

Independent variable - The variable whose value is changed during the experiment.

Dependent variable - This variable is measured/observed during the experiment as we vary the independent variable.

Controlled variable - This quantity is kept unchanged during the experiment. It can vary, and hence is not a constant, but it is kept unchanged during the experiment so that we can derive unambiguous inferences from the experiment.

Question 3

In our experiment (Fig. 4.4 to 4.6), there are multiple variables out of which, some are listed in Table 4.2. Each variable has been given a short name to make the reference easier.

#	Variable name	Short name
1	Colour of food sample and iodine before adding saliva	CB
2	Colour of food sample and iodine after adding saliva	CA
3	Quantity of food sample (in ml)	FS
4	Quantity of iodine (in number of drops)	IO
5	Quantity of saliva (in number of spits)	SA
6	Temperature of mixture of food sample and iodine (room temperature/warm/ice cold)	TE
7	Time taken for colour of mixture (of food and iodine) to change (in seconds)	TI
8	Presence/absence of saliva/amylase (present/absent)	SL

Table 4.2, Multiple variables with short name

We will now conduct another experiment where we will vary the “Quantity of saliva” (SA in Table 4.2) and observe the impact on digestion time, which can be inferred from the time taken for the colour of mixture to change (named as TI in Table 4.2). For this experiment, some variable(s) will be independent, some will be dependent and some controlled. The types of 4 out of 7 variables have been given below. Fill the type for remaining 3 in the

respective blank spaces inside the answer box.

CB	CA	FS	IO	SA	TE	TI
Dependent	_____	Controlled	Controlled	Independent	_____	_____

Question 4

We will now vary TE and observe the impact on TI. Fill the missing variable types for this experiment.

CB	CA	FS	IO	SA	TE	TI
_____	Dependent	_____	Controlled	_____	Independent	Dependent

Case Study B (continued) - Relate the Variables

Table 4.3 and 4.4 captures the results of an experiment where we vary the amount of saliva and temperature of mixture. The observations filled under the “Colour” columns are coded to improve the readability: **A** – deep blue/blackish / **C** – transparent / **E** – any other colour

OBSERVATIONS - EFFECT OF AMOUNT OF SALIVA

#	Amount of saliva	Colour (before)	Colour (After)	Time (min)
1	No Saliva	A	A	9 9 9
2	Spit once	A	C	0 0 2
3	Spit thrice	A	C	0 0 1

Table 4.3, Observations - Effect of amount of saliva on digestion

OBSERVATIONS - EFFECT OF TEMPERATURE

#	Temperature	Colour (before)	Colour (After)	Time (min)
1	Room temperature	A	C	0 0 2
2	Warm water	A	C	0 0 1
3	Ice cold water	A	C	0 0 4

Table 4.4, Observations - Effect of temperature on digestion time

It is common to find more than one variable in a system that are related to each other. Think of an example having the following variables: the price of petrol, total money paid for a fixed volume of petrol, the price of crude oil, oil production, etc., are all variables that are related to each other. However, the maximum capacity of the fuel tank, or average number

of kilometres the vehicle can run by using one litre of petrol (also known as its mileage), are not related.

Directly related: A situation where an increase in one quantity causes an increase in the other quantity, or a decrease in one quantity results in a decrease in the other quantity. Continuing the above example, as the price of petrol increases, the total money paid for a fixed volume of petrol also increases.

Inversely related: In other cases, as we increase one quantity, the other decreases. If we decrease one, the other increases. In this example, as the petrol price increases, the amount of petrol purchased in one visit may decrease and vice versa, assuming most people fill petrol by a rupee amount, say ₹ 500.

Question 5

Based on the observations in table 4.3 and 4.4, fill the following two blanks by one of these three options - Directly related /Inversely related /Not related.

- Time taken by food to digest is _____ to the amount of saliva added to the food
- Time taken by food to digest is _____ to the temperature

Question 6

Instead of using a qualitative indicator for temperature (warm, ice cold, etc), the last experiment was repeated with actual temperature values. Fig. 4.7 shows a graph, which plots the change in digestion time as the temperature is varied.

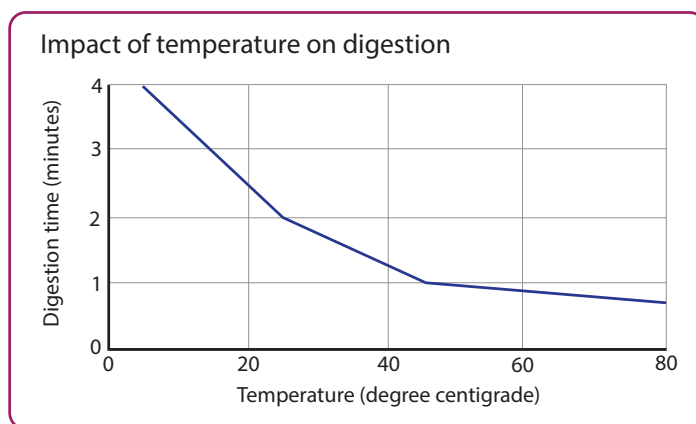


Fig. 4.7, Impact of Temperature on digestion time

Which of the following hypotheses provide the most appropriate explanation for what we observe in the graph?

- a. **Hypothesis 1:** As the temperature decreases, the time taken for the reaction decreases because when the temperature is low, molecules are closer to each other and that increases the probability of a chemical reaction between the molecules.
- b. **Hypothesis 2:** As the temperature increases, the time taken for the reaction decreases because when the molecules have higher energy they collide more often and that increases the probability of a chemical reaction between the molecules.
- c. **Hypothesis 3:** The digestion time changes with temperature because the pH changes as the temperature increases.
- d. **Hypothesis 4:** The digestion time changes with temperature because food melts as the temperature increases.

Answer

Question 7

Based on the observations in table 4.3 and 4.4, what rules would you practice in your life to improve the digestion of starch in your mouth? To answer this question, select the appropriate Rule and Reason from Table 4.5.

Rule 1 (A1)	Have a fixed schedule for eating.
Rule 2 (A2)	Chew food for as long as we can.
Rule 3 (A3)	Each adult must drink at least 3 litres of water everyday.
Rule 4 (A4)	Eat warm food.
Reason 1 (R1)	The amylase enzyme is more active at high temperatures and hence the digestion process is faster.
Reason 2 (R2)	Enzymes, like amylase, get secreted at specific times of the day. For effective digestion, we should use them as they get secreted.
Reason 3 (R3)	When this rule is followed, more saliva gets secreted and mixed with food, which ultimately leads to faster digestion of starch.

Table 4.5, Rules and reasons related to food habits and practices

Select the rules which can be inferred from the observations of the experiment only. Do not pick those which are based on other data points or perspectives that you may already have.

a. A1-R2, A2-R3, A4-R1

b. A1-R2, A3-R3, A4-R1

c. A2-R3, A4-R1

d. A1-R2, A2-R3

Answer

Note that as the food stays in the mouth for more time, we secrete more saliva.

Question 8

Given below are the inferences drawn from the experiment observations captured in Table 4.3 and Table 4.4. Categorise these inferences into three categories - Correct inference, Incorrect inference, Insufficient data to draw this inference. Note that you may have prior knowledge on a subject but if that cannot be inferred from the experiment observations, then it needs to be categorised under insufficient data to draw this inference.

- a. Colour of food sample and iodine changes from blue black to colourless if and only if saliva is added.
- b. Rice water digests faster than potato.
- c. Colour of food samples changes faster when the amount of saliva is less
- d. Saliva is acidic.
- e. The amount of saliva secreted in the mouth is more when the temperature of food is higher.
- f. As we add more saliva, digestion time continues to decrease till it reaches zero

Answer

- a. _____
- b. _____
- c. _____
- d. _____
- e. _____
- f. _____

Case Study C - Secretion of Saliva

Saliva plays an important role in the digestion of food, not only by digesting starch but also by making the chewed food consistent before it is pushed to other parts of the digestive system. What decides the amount of saliva secreted and how do we hold it within the mouth?

Many humans suffer from this disease called Parkinson's disease (PD) which is a nervous system disorder that affects movements. Shaking head/legs/hands are one of the distinct symptoms of PD. Another symptom of PD is drooling where saliva flows out of the mouth

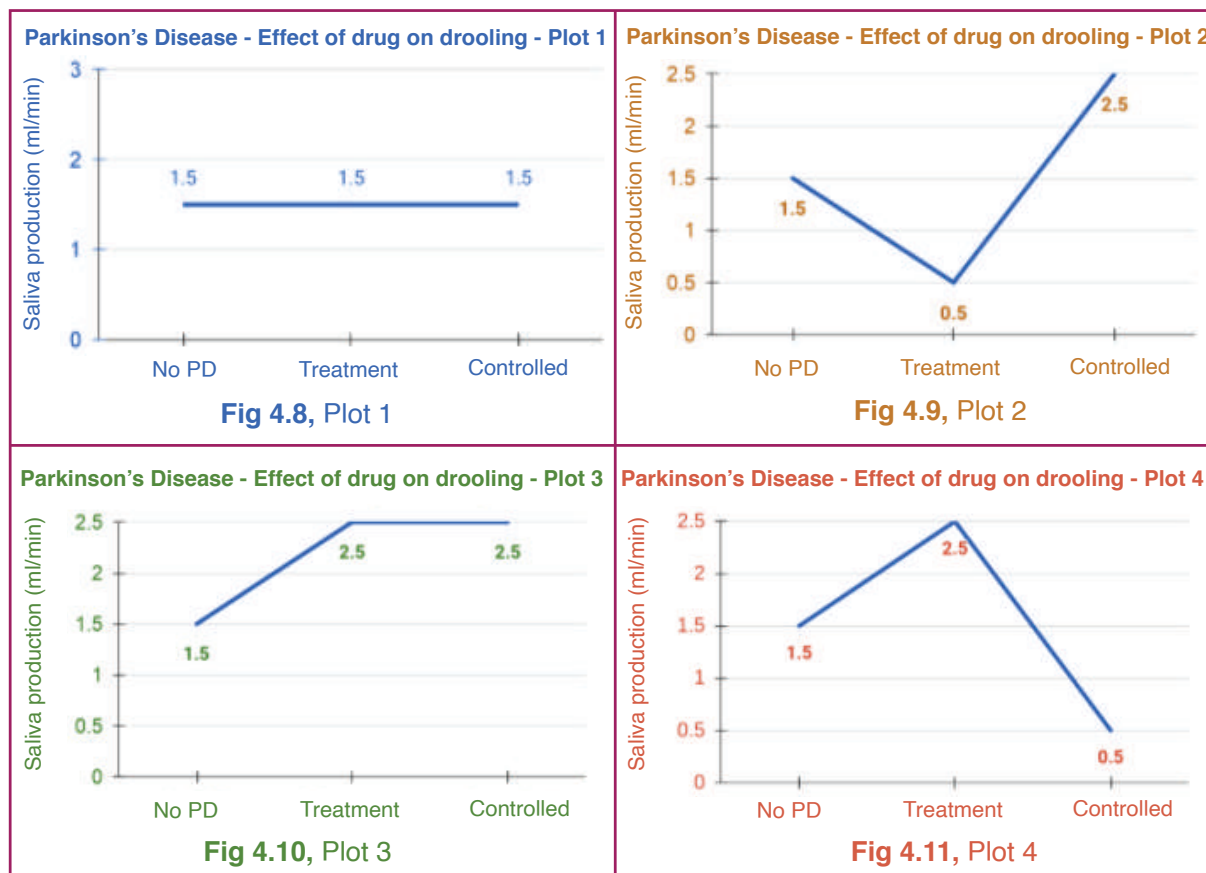
unintentionally. A group of researchers working on this problem proposed a reduction in the amount of saliva secreted as a solution to drooling. A medicine was designed for this and a study was conducted which showed that the medicine did not impact the saliva secretion rate in the people who were not suffering from PD. This study was conducted on 150 people belonging to three different subgroups (see Table 4.6).

Sample size (group of people tested)	150
Not suffering from PD	50
Treatment Group - Suffering from PD, underwent treatment	50
Controlled Group - Suffering from PD, no treatment	50

Table 4.6, Sample size and distribution of people in different categories

Question 9

Which out of the four graphs shown in Fig. 4.8 to 4.11 correctly represents the findings of the researchers?



a. A, C, D, B	b. C, A, B, D	Answer
c. D, A, B, C	d. C, D, A, B	

Question 10

Fig. 4.12 captures the four stages of the famous experiment conducted by Ivan Pavlov. A dog was placed in 4 different situations in the order shown in the picture. In each situation, the saliva secreted by the dog was collected.

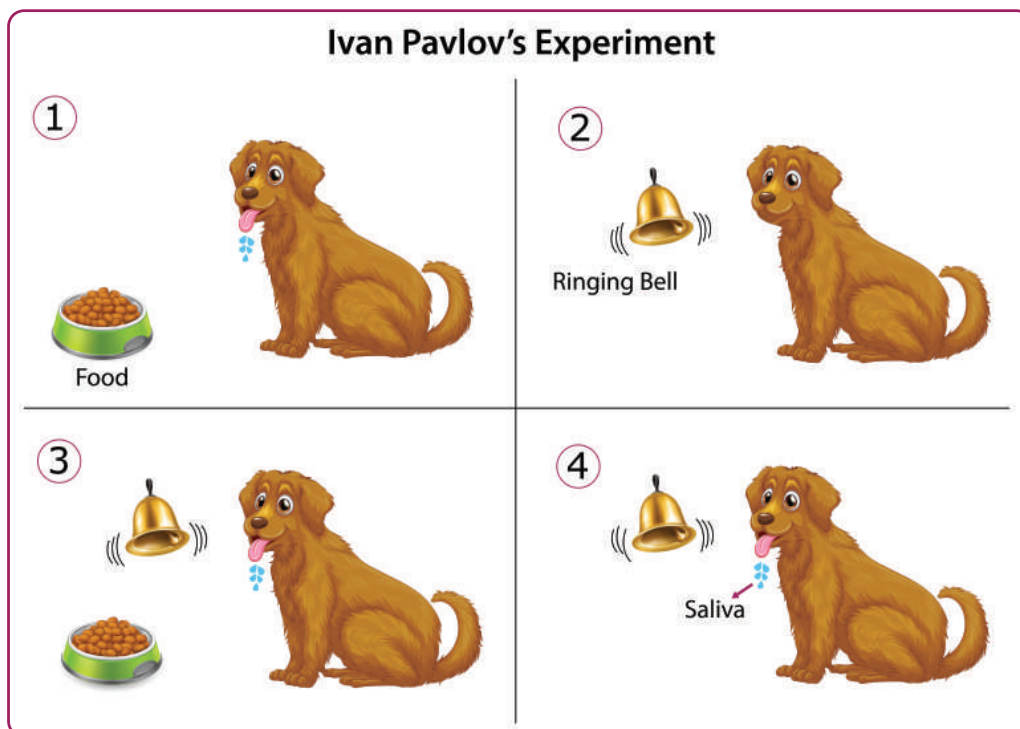


Fig. 4.12, The 4 stages of Pavlov's experiment

Given that the mouth secretes saliva for a purpose, in which of the four situations does the saliva not meet its intended purpose? Explain the reason as well.

Answer

Case Study D - Other parts of the digestive system

While saliva helps in speeding up the chemical reaction of starch digestion in our mouth, the teeth contribute through a physical change. Aakash met with an accident where he lost his canine and incisor teeth. He had only molar teeth left.

Question 11

Which of the following food items will he find difficult/not possible to eat?

A. Cooked vegetables	B. Big chapati/roti/bread
C. Cooked rice	D. Whole apple

Choose the correct answer option.

a. A and B	b. C and D	Answer
c. A and C	d. B and D	

Case Study D (continued)

With multiple painkillers and limited food intake, Aakash's digestive system got affected badly. On one of the days, he vomited twice in a span of four hours. He felt a pain in the throat after the vomit and he wondered what caused it. The sour taste also made him wonder if acid came out along with the vomit. When he spoke to one of his friends who was a Biochemist, his friend shared a theory about the functioning of the stomach. Aakash found his friend's theory hard to accept and decided to conduct an experiment which is shown through a series of pictures in Fig. 4.13-4.20.

Test the presence of protein in milk before digestion

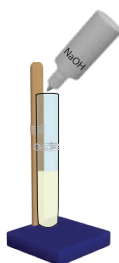


Fig. 4.13, Step 1 - add NaOH to milk

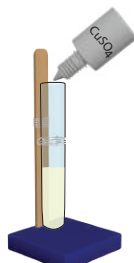
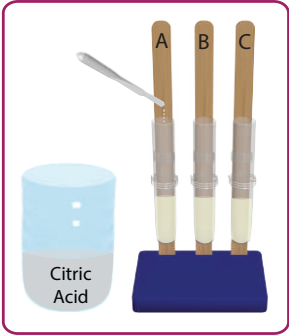
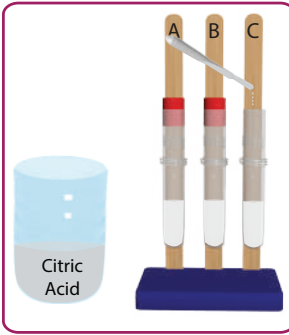
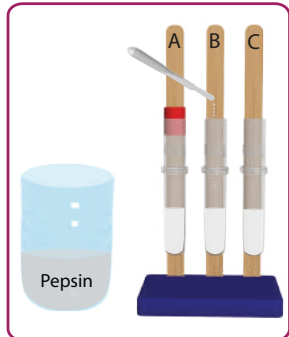
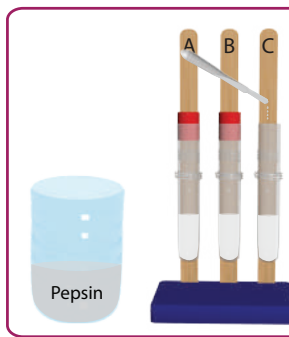



Fig. 4.14, Step 2 - add CuSO_4



Fig. 4.15, Step 3 - Colour changes to purple

Change of colour of copper sulphate (CuSO_4) from blue to purple indicates the presence of protein. If it remains blue, one can infer that protein is not present.

Each test tube contains milk	
	
Fig. 4.16 , Step 4 - Acid added to test tube A	Fig. 4.17 , Step 5 - Acid added to test tube C
	
Fig. 4.18 , Step 6 - Pepsin added to test tube B	Fig. 4.19 , Step 7 - Pepsin added to test tube C
Pepsin enzyme helps speed up the digestion of protein	
	<p>Protein test after digestion - purple colour in A and B, blue in C</p>
Fig. 4.20 , Step 8 - Pepsin test after digestion	

Question 12

What do you think was the theory about the functioning of the stomach which Aakash was trying to test through the experiment shown in Fig. 4.13 to 4.20? Our stomach needs

- a. An acid to digest protein.
- b. An alkali to digest protein.
- c. An alkaline environment for the pepsin enzyme to get activated which is required for digesting protein.
- d. An acidic environment for the pepsin enzyme to get activated which is required for digesting protein.
- e. A neutral environment for the pepsin enzyme to get activated which is required for digesting protein.

Answer

Question 13

Table 4.7 shows the average pH levels of different organs of the digestive system.

Average pH level of organs of the digestive system	
Mouth	6.5 to 7.5
Oesophagus	7
Stomach	1 to 2
Liver	7 to 7.5
Pancreas	8 to 8.3
Small intestine	6.5 to 7
Large intestine	5.5 to 7

Table 4.7, pH levels of digestive system organs

Based on the data in the table which of the following statements is true?

- a. Stomach secretes acidic juices
- b. Stomach secretes alkaline juices but its effect is visible only when food reaches small intestine
- c. Pancreas secretes acidic juices
- d. Pancreas secretes alkaline juices
- e. Saliva is acidic and its effect is visible when it reaches the stomach along with food

Note that the food travels from the mouth through the oesophagus to the stomach and then to the small intestine where the juices secreted by the pancreas and liver, meet the food.

- a. _____
- b. _____
- c. _____
- d. _____
- e. _____

Question 14

Fig. 4.21 shows the different organs of the human body, which take part in the digestion of food.

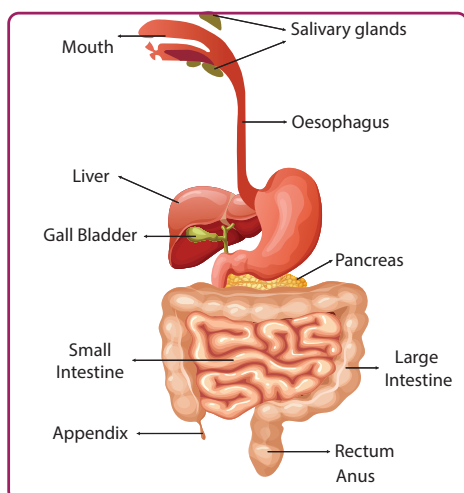


Fig. 4.21, Organs of human digestive system

In which organ (if any) of the digestive system does the food get converted to usable energy? How is the energy transferred from that part to the rest of the body?

Question 15

Which of the following is incorrect about the digestive system? You may choose more than one option here.

- a. All changes happening inside the digestive system are chemical changes
- b. Digestion is a combination of physical and chemical change
- c. It produces energy from food
- d. It uses energy to digest food
- e. It breaks food into smaller parts

Answer

Exploration Pathway



Digestion - Starch
(Amylase)

The process of digestion begins in our mouth when we chew our food to reduce them to smaller food particles. The amylase enzyme present in our saliva helps in breaking down complex carbohydrates such as starch present in wheat, potatoes, corn, rice and other grains - into simple sugars. Our body utilises these simple sugars to obtain the energy needed to do our daily activities.

In this TACTivity, we will perform a test to demonstrate the breakdown of starch by the amylase enzyme.



Digestion - Protein

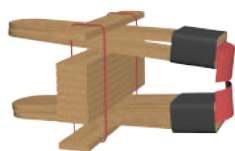
pH plays a significant role in digestion. While the mouth is alkaline to digest carbohydrates, the stomach is highly acidic to activate Pepsin, the enzyme that digests protein. In this TACTivity, we create an artificial stomach where we use citric acid and pepsin to help digest milk.



Explore - Osmosis

Osmosis is the process by which solvent molecules move from a less concentrated to a more concentrated solution through a semipermeable membrane.

This process is vital in all kinds of biological scenarios (in our kidneys, in plants, etc.), as well as human applications (e.g. water filters). Here, we use a potato to demonstrate two different kinds of osmosis - endosmosis and exosmosis.



Teeth Models

Animals have different types of teeth - Incisors, Canines, Premolars and Molars are the main ones. One can figure out a lot of information about the animal just by looking at the teeth. In this TACTivity, we create models of the four main types of teeth and understand their function.