UNIT 4 THE MICRONUTRIENTS — I: VITAMINS

Structure

4.1 Introduction
4.2 Fat-soluble Vitamins
   4.2.1 Vitamin A
   4.2.2 Vitamin D
   4.2.3 Vitamin E
   4.2.4 Vitamin K
4.3 Water-soluble Vitamins
   4.3.1 Vitamins of the B-complex Group
   4.3.2 Vitamin C
4.4 Let Us Sum Up
4.5 Glossary
4.6 Answers to Check Your Progress Exercises

4.1 INTRODUCTION

You learnt about the sources, functions and utilization of macronutrients in Block 1. We will now begin our discussion on micronutrients with the study of vitamins in this unit.

The “vita” part of the word “vitamin” means “life”. Vitamins are, in fact, vital and essential for life and health. They regulate metabolism, help in the growth and maintenance of our body and protect against disease. You will learn a great deal about these functions in the unit.

Vitamins (like carbohydrates, fats and proteins) are organic compounds. Unlike these nutrients, however, vitamins are present in minute quantities in food. This does not mean we need vitamin pills to meet our needs! We can meet our requirements for vitamins quite easily by consuming the right types of foods.

Some of the vitamins are soluble in water while others are soluble in fat. They are hence classified into two categories: water-soluble vitamins and fat-soluble vitamins. This unit will introduce you to the different vitamins included in each of these categories. You will learn about the food sources, functions and absorption of these vitamins.

Objectives

After studying this unit, you will be able to:
- differentiate between fat-soluble and water-soluble vitamins
- identify the food sources of each vitamin
- describe the mechanism of absorption of each vitamin
- describe the storage of fat-soluble vitamins
- state the important functions of each vitamin in the body

4.2 FAT-SOLUBLE VITAMINS

Vitamins A, D, E and K are known as the fat-soluble vitamins. These vitamins are, therefore, present in food in close association with fats. An interesting fact about fat-soluble vitamins is that after being used for specific functions, the excess amount of these vitamins is stored in the body. Let us now learn more about each of these vitamins.

4.2.1 Vitamin A

Vitamin A or retinol is found only in the foods of animal origin. Animal foods like milk, butter, ghee, egg, fish and liver are rich sources of vitamin A. Liver oils of fish like halibut, cod, and shark are the richest sources.
Plant foods do not contain retinol. They contain certain orange or yellow coloured pigments called carotenoids which can be converted to retinol in the body. In other words, these carotenoid pigments are precursors of vitamin A. The word “precursor”, of course, refers here to a substance which can be converted to the vitamin in the body.

*Beta carotene* is the most widely distributed carotenoid in plant foods. Most of the yellow and orange colour of vegetables and fruits is due to these carotenoid pigments as we mentioned earlier. Ripe fruits such as mango, papaya and yellow/orange vegetables like carrot and pumpkin are rich in beta carotene. Green leafy vegetables also contain carotenoid pigments. Here the yellow and the orange colour of the carotenoid pigments is masked due to the presence of another pigment called chlorophyll which, as you may know, is green in colour. Green leafy vegetables such as spinach, mustard leaves and fenugreek leaves are very rich sources of beta carotene.

We earlier mentioned specific animal foods which are rich sources of vitamin A. However, you know that animal foods are expensive. Most Indians do not consume enough animal foods to meet the vitamin A needs of the body. Hence they depend on plant foods to meet their vitamin A needs. Plant foods, as you know, do not have retinol. They contain beta carotene instead. The conversion of beta carotene to vitamin A or retinol is not very efficient in the body. In fact only half of the beta carotene absorbed is converted to retinol. Thus people who consume less animal foods need to consume enough plant foods such as green leafy vegetables and orange-yellow fruits to meet vitamin A needs.

**Absorption and storage:** You have read that vitamin A is ingested either in the form of retinol or carotene. After absorption from the intestinal cells, retinol forms a complex with some fat-containing particles called chylomicrons and is taken to the bloodstream. Carotene is absorbed in much the same way as retinol. After absorption most of the carotene is converted to retinol in the cells of the small intestine itself.

Retinol (whether absorbed as such or formed in the body from carotene) is transported by the blood to the liver as part of the chylomicrons. Approximately 90 per cent of the total absorbed vitamin is stored in the liver and the remaining 10 per cent is distributed in other organs and glands like the kidneys, lungs and adrenal glands.

Being a fat-soluble vitamin, the presence of bile and fats greatly aids in vitamin A absorption. Further, proteins help in its transport from the liver to other body tissues. This is an example of how nutrients interact with each other.

**Functions:** What does vitamin A do in the body? This remarkable substance has, in fact, three important functions as listed below:

1) **Maintaining normal vision:** Vitamin A plays an important role in maintaining normal vision. To understand this better we must first be familiar with the structure of the eye. Look at Figure 4.1. Can you spot the retina?

The retina has two kinds of cells — rods and cones. Both rods and cones are sensitive to changes in light but they react differently and perform different functions. While rods are sensitive to dim light, the cones respond to bright light.

Let us take a closer look at the rods. The rods contain a pigment called rhodopsin. Rhodopsin is formed by the combination of a specific form of vitamin A with a protein. The amazing thing about rhodopsin is that it breaks down into its components when exposed to bright light. In the dark these components — vitamin A and protein — again combine to regenerate rhodopsin.

Now, what is the significance of rhodopsin in maintaining normal vision? Rhodopsin helps us to see in dim light. Consider the following situation. There must have been many occasions when you walked into the dark from a brightly lit room. You would definitely remember not being able to see for a short while. Why does this happen? It’s all because the rhodopsin has broken
Fig. 4.1 Structure of the eye

Adapted from illustration in Essentials of Nutrition and Diet Therapy by Sue R. Williams, Times Mirror/Mosby College Publishing, 1986 (4th edition)

down into its two components. It is, therefore, no longer able to perform its functions. How, then, did you begin to see in the dark? This happened because rhodopsin is regenerated once again in the dark. If you look at these events closely you would notice that we started with rhodopsin and now we have gone through a process by which it is broken down and then regenerated. This is an example of a “cycle” in metabolism and is called the visual cycle (Figure 4.2).

2) **Supporting growth**: Vitamin A is essential for the growth of the skeleton and soft tissues. The exact role of the vitamin in the growth of the body is still not understood. Research studies in this area have indicated that with the deficiency of vitamin A in the body, bones do not grow to their full length and the overall growth of the body is affected.

3) **Protecting against disease**: Vitamin A plays an important role in keeping epithelial tissues moist and healthy. Some examples of epithelial tissues are
the skin, the lining of our eyes and the lining of organs like the intestine and lungs. Without vitamin A the epithelial tissue will become dry and cracks will appear in the skin or inner walls of the digestive tract or lungs. This makes it easy for the germs to enter and cause diseases like diarrhoea, respiratory infections and eye infections. Various research studies have supported this and shown that vitamin A plays a beneficial role in preventing common illnesses in young children. When body levels of vitamin A are low the chances are more that the young child will develop infectious diseases. If these diseases are sufficiently severe they can even cause death. This is the reason why the deficiency of vitamin A is associated with child death.

4.2.2 Vitamin D

Vitamin D is also called the “sunshine vitamin”. This is because it is manufactured from a substance present in our skin on exposure to sunlight. As a result of this, we do not necessarily have to depend on dietary sources of vitamin D. The easiest way of obtaining the vitamin is, in fact, enough exposure to sunlight.

Which foods contain vitamin D? Foods of animal origin like eggs, liver and butter contain the vitamin in significant amounts. It is, however, the fish liver oils which are the richest sources. On the other hand, most of the commonly used foods of plant origin do not contain vitamin D.

Absorption and storage: What happens to vitamin D in the body? The vitamin D we take in is absorbed along with fats from the small intestine. Bile is essential for effective absorption of fats and therefore, of vitamin D. Once absorption is completed, vitamin D enters the bloodstream as a part of the chylomicrons. Vitamin D formed in the skin on exposure to sunlight also enters the bloodstream. Whatever the source, the vitamin is then taken to the liver. Some of it is stored there and the remaining is distributed by the blood to various body tissues.

Functions: You might have heard that vitamin D makes bones strong and healthy. This is absolutely correct. How does vitamin D help in this? Read on to find out. Minerals like calcium and phosphorus, when deposited in the bones, make them strong and hard. The process of deposition of minerals in the bones is termed as mineralization of bones. Vitamin D aids the process of mineralization in two ways:

i) by increasing the absorption of calcium and phosphorus and
ii) by helping in the deposition of calcium and phosphorus in bones.

Check Your Progress Exercise 1

1) What are carotenoids? List the rich sources of beta carotene.

2) Indicate whether the following statements are true or false. Correct the false statements.
   a) Bile is essential for effective absorption of vitamin A and D. (True/False)

   b) We meet most of our vitamin D needs from dietary sources. (True/False)

   c) Vitamin A keeps the epithelial tissue dry. (True/False)
4.2.3 Vitamin E

Vitamin E is present in almost all foodstuffs. Vegetable oils like groundnut, soya, cottonseed, and safflower are rich sources of vitamin E. Other good sources are whole grain cereals, dark green leafy vegetables, pulses, nuts, and oilseeds. Foods of animal origin are low in vitamin E. However, foods like egg yolk, butter, and liver contain some amount of the vitamin.

Absorption and storage: Like the other fat-soluble vitamins, absorption of vitamin E also requires the presence of fat and bile. After absorption from the upper part of the small intestine, vitamin E (as part of chylomicrons) is carried to the liver through the blood stream and is distributed to various body tissues. Almost all the body tissues have a small amount of the vitamin but it is mainly stored in muscles and adipose tissue.

Functions: The main role of vitamin E in our body is the protection it gives to other substances like unsaturated fatty acids, vitamins A and C. It prevents their destruction in the body as well as in foods.

4.2.4 Vitamin K

Among plant foods, green leafy vegetables like spinach, cabbage, and lettuce are rich sources of vitamin K. Other good sources include animal foods such as egg yolk, milk, and organ meats like liver. Vitamin K is also manufactured by certain helpful bacteria which are normally present in the small intestine. Approximately half of the vitamin K needed by us gets manufactured in the intestinal tract and the other half is obtained from animal and plant foods.

Absorption and storage: The absorption of vitamin K requires bile since vitamin K is fat-soluble. After absorption from the upper part of the small intestine, the vitamin is distributed to various body tissues. Vitamin K is stored in very small amounts in the body and its concentration is not high in any particular tissue.

Functions: Have you ever observed what happens when you cut your finger? Your finger, of course, starts bleeding. But after a while, blood stops oozing out. Why? This is because a clot is formed on the wound and seals it off. Vitamin K plays an important role in clotting of blood and is therefore also termed as the "antibleeding vitamin" (one which prevents uncontrolled bleeding). How does vitamin K help in clotting of blood? It helps in the formation of a protein called prothrombin which, in turn, is essential for blood clotting.

Check Your Progress Exercise 2

1) Match the following.
   a) Vitamin A       i) Prevention of destruction of unsaturated fatty acids
   b) Vitamin D       ii) Vision in dim light
   c) Vitamin E       iii) Coagulation or clotting of blood
   d) Vitamin K       iv) Absorption of calcium and phosphorus

2) Fill in the blanks.
   i) ............... are the richest sources of vitamins A and D.
   ii) Rods of the retina are sensitive to ...............
   iii) Presence of ........... and ........... aids in the absorption of fat-soluble vitamins.
   iv) Vitamin K is also known as the ............. vitamin.
4.3 WATER-SOLUBLE VITAMINS

We have so far studied the fat-soluble vitamins. Let us now move on to the water-soluble ones. Vitamin C and vitamins of the B-complex group are known as water-soluble vitamins owing to their solubility in water. Unlike the fat-soluble vitamins, these vitamins cannot be stored in our body in considerable amounts. The excess amount of these vitamins is instead excreted from the body in the urine.

4.3.1 Vitamins of the B-Complex Group

As the name indicates, this is a group of vitamins with similar functions. Vitamins of the B-complex group include: thiamine (B₁), riboflavin (B₂), folic acid, niacin and vitamin B₁₂. They usually occur together in foods. The B vitamins act as coenzymes and help in the metabolism of carbohydrates, proteins and fats. You are already familiar with enzymes. What are coenzymes? Coenzymes are substances which are needed by enzymes to do their job effectively. Hence they can be considered as the helpers of specific enzymes. In fact these enzymes cannot function in the absence of their specific coenzymes (Figure 4.3).

Let us now learn more about the food sources, absorption, storage and functions of each of these vitamins.

**Thiamine or B₁:** Thiamine or B₁ is widely distributed in animal and plant foods. Almost all the foodstuffs except fats, oils and sugar contain small amounts of thiamine. Plant foods such as whole grain cereals (i.e. wheat and rice) and whole pulses are also rich sources of thiamine.

Among the foods of animal origin lean meats, poultry and egg yolk are good sources. One point that needs to be emphasized here is that the processing of cereals and pulses can significantly alter their thiamine content as well as the content of some of the other vitamins. You will find more information on this aspect in Highlight 1. The discussion is relevant not just to thiamine but to other vitamins as well.

**HIGHLIGHT 1**

**Influence of Processing on Nutritive Value**

We use various methods to process our foodstuffs. Processing, in fact, includes all those procedures which foods are subjected to from the time of harvest to
The Micronutrients—II: Vitamins

Vitamins

consumption. This means pre-preparation and preparation/cooking are also forms of processing. Here we will look at some specific examples of processing—processing of wheat, processing of rice and the pre-preparation procedures like sprouting and fermentation.

- **Processing of wheat**: Wheat is usually not consumed in the form of wheat grains as such but in the processed form e.g. whole wheat flour (atta), refined wheat flour (maida and suji/rawa). Most of the thiamine and other B vitamins are present in the outer covering or bran and the germ layer of the wheat grain (Refer to Figure 2.5, Block I). Atta or whole wheat flour has most of the bran and part of the germ layer in it and is a good source of thiamine. However, maida and suji have very little bran and germ and hence are poor sources of thiamine and other B-complex vitamins in general.

- **Processing of rice**: Polished rice is very poor in B-complex vitamins—thiamine in particular. What do we mean by polishing? Paddy (or rice with husk) is either ground in machines or pounded by hands to remove the outer husk. After this the grain is further cleaned to give it a white, polished appearance. Removal of husk and polishing both cause heavy losses of thiamine as well as some of the other B vitamins.

Rice is also available in another form called parboiled (sela) rice. Parboiled rice is prepared by soaking raw rice in water for 2 to 3 days, boiling or steaming and then drying. During this process most of the nutrients present in the outer layers of the grain move to its interior. Thus thiamine and the other vitamins are not lost when the outer layers of rice are removed during subsequent processing.

- **Sprouting and fermentation**: Sprouting and fermentation of whole grain cereals or pulses increases their content of B-complex vitamins and vitamin C. Sprouting, as you know, is the process of growing or germination of seeds or grains by first soaking them in water and then leaving the grains moist for about 24 hours by wrapping them in moist cloth (Figure 4.4). You can sprout whole pulses like green gram and use them for making raita (a curd preparation), stuffed paranthas or eat them as such in the form of salads.

Fermentation, on the other hand, refers to the chemical changes taking place in certain foods when mixed in a ground form with added fluid and kept overnight at a suitable temperature. During this time certain beneficial bacteria multiply and grow in the food mixture and bring about some desirable changes in it. You may already be familiar with these changes.

Fermentation makes the mixture light and fluffy in appearance and more digestible. Let us now talk about some fermented foods. Idlis are commonly consumed in the south and are made by steaming a fermented mixture of rice and urad dal. Similarly dhokla, a dish consumed in West India (Gujarat), is prepared by steaming a fermented mixture of curd and besan (bengal gram flour).
After ingestion, thiamine is absorbed and enters the bloodstream. It is utilized to perform several important functions. Excess thiamine (i.e., the amount in excess of the body needs) is excreted in the urine.

You would now be interested in finding out what exactly thiamine does in the body. Thiamine plays an important role in the metabolism of carbohydrates. We mentioned coenzymes before. Thiamine forms a part of a specific coenzyme involved mainly in carbohydrate metabolism. The main function of this coenzyme is its role in the burning or oxidation of glucose to produce energy.

Riboflavin or B2: Riboflavin or B2 is widely distributed in plant and animal foods. Milk, liver, kidney, eggs, and green leafy vegetables are good sources of riboflavin. Whole grain cereals and pulses contain fair amounts. On refining there is some loss of the vitamin. However, sprouting and fermentation of whole grain cereals and pulses can markedly increase their content of riboflavin and other B vitamins as mentioned in Highlight I. An average mixed diet including milk, green leafy vegetables, whole cereals, and pulses (especially when sprouted) can take care of the riboflavin needs of vegetarians. Non-vegetarians can also obtain riboflavin from animal foods.

The riboflavin which we ingest is absorbed from the upper part of the small intestine into the bloodstream and is taken to various body tissues to perform specific functions. Like other water-soluble vitamins, excess riboflavin is excreted in the urine.

How is riboflavin used by the body? Riboflavin plays an important role in the metabolism of carbohydrates, fats, and proteins. This is because of the fact that it forms part of two distinct coenzymes which help to release energy from the end products of digestion of carbohydrates, fats, and proteins.

Niacin: Niacin is another member of the B-complex family. The good sources of niacin include meat, fish, poultry, cereals, pulses, nuts, and oilseeds. One interesting point about niacin is that it can also be formed in the body from an amino acid called tryptophan. Milk is a good example of a food rich in tryptophan but not in niacin. The tryptophan present in milk protein can be converted to niacin in the body. Thus milk provides appreciable amounts of niacin.

Niacin (like riboflavin) is also part of coenzymes which help to release energy from the end products of the digestion of carbohydrates, fats, and proteins. It thus helps in their metabolism.

Folic acid: Folic acid is also widely distributed in foods. Green leafy vegetables and organ meats (like liver and kidney) are very rich sources of folic acid. Whole grain cereals, pulses, eggs, and dairy products are also good sources of folic acid.

After absorption, folic acid is taken to various body tissues through the bloodstream for specific functions. Normally some amount of folic acid is stored in the body. The principal storage organ is the liver. Under normal circumstances, the body stores of folic acid are sufficient to meet the requirements of the body for several months even if no folic acid is available through the diet.

Folic acid plays an important role in blood formation. You may be aware that blood has three kinds of cells — red blood cells, white blood cells, and platelets — suspended in a fluid called plasma. Folic acid is important for the proper development of red blood cells.

Vitamin B12 or Cobalamin: Vitamin B12 or cobalamin is present only in the foods of animal origin. Liver, kidney, milk, eggs, and sea foods (e.g., shrimps, crabs, lobsters) are rich sources of vitamin B12. Plant foods do not contain the vitamin. Vitamin B12 is also synthesized in our body in the intestinal tract by certain helpful bacteria.

Vitamin B12 can only be absorbed in the presence of a specific chemical substance called intrinsic factor. This substance is secreted by the cells of the stomach. Vitamin B12 ingested combines with intrinsic factor and is absorbed from the small intestine. Bacteria present in the intestine can also produce vitamin B12. But this cannot be absorbed without the intrinsic factor which is found only in the
stomach. The vitamin $B_{12}$ produced by the bacteria is hence excreted from the body through faeces.

Our body's requirement for vitamin $B_{12}$ is very small. Consumption of even small amounts of animal foods like milk can take care of the vitamin $B_{12}$ needs of the body.

Vitamin $B_{12}$ is necessary for the proper functioning of the digestive tract, nervous system and the bone marrow. In the bone marrow, vitamin $B_{12}$ (like folic acid) is also involved in the formation of normal red blood cells.

Check Your Progress Exercise 3

1) What are coenzymes?

2) Which B vitamins play a significant role in blood formation?

4.3.2 Vitamin C

Vitamin C or ascorbic acid is also termed as the “fresh food vitamin” because fresh fruits and vegetables are its major sources (Figure 4.5). Fresh citrus fruits (like orange, lime and lemon) and other fruits and vegetables like guava, amla, papaya, green leafy vegetables, tomatoes, green chillies and capsicum are some of the excellent sources of vitamin C. Root vegetables like potato and sweet potato contain small amounts of the vitamin and they contribute significant amounts only when consumed in large quantities. Cereals and pulses as such are poor in vitamin C but when sprouted and fermented become good sources. Animal foods like fish, meat, milk, poultry and eggs contain little or no ascorbic acid.

![Fruits and vegetables](image)

When we are fresh, we have maximum vitamin C

Fruits like amla, guava, green leafy vegetables and green chillies are examples of some of the cheap sources of vitamin C. In fact, amla is the cheapest source and provides 20 times or more ascorbic acid as compared to the expensive citrus fruits.

Ascorbic acid is readily absorbed from the digestive tract and is then distributed to various body tissues. Organs and glands like the spleen, bone marrow, liver, pancreas, kidney and the retina of the eye have a high concentration of ascorbic acid.
Functions: Do you know that vitamin C
- plays a role in healing of wounds
- aids in the absorption of iron (a mineral which plays a role in blood formation)
- helps to overcome conditions of injury, infection and other stresses and
- prevents destruction of certain substances present in the body as well as in some foodstuffs.

These are some of the interesting facts about the functions of vitamin C. Wouldn’t you like to know more about them? Let us now take each of the above mentioned functions and study them in some detail. Vitamin C plays a role in:

1) **Wound healing:** Vitamin C plays an important role in the formation of a special kind of protein called collagen. The formation of collagen at the site of wound or injury aids in its healing. This protein is found in the connective tissue which holds together different other tissues much like cement holds bricks together. For example, collagen present in blood vessels makes them firm. Deficiency of vitamin C in the diet may result in fragile blood vessels which can easily rupture.

2) **Dealing with stress:** Ascorbic acid plays an important role in the release of two hormones—epinephrine and norepinephrine—from the adrenal glands of the body. These hormones help the body to deal with stressful situations like day-to-day tensions, stresses of infections and injury.

3) **Absorption of iron:** Iron is an essential component of red blood cells. Vitamin C aids absorption of iron by converting it into a more suitable form for absorption.

4) **Protecting certain substances from destruction:** Like vitamin E, vitamin C protects certain substances e.g., vitamin A and unsaturated fatty acids from being destroyed.

Check Your Progress Exercise 4

1. Give reasons for the following:
   i) Refined flours like maida and suji have less thiamine as compared to atta or whole wheat flour.
   ii) Milk can help to meet niacin needs.
   iii) Ascorbic acid is termed the “fresh food vitamin”.
   iv) Deficiency of thiamine in the diet can interfere with carbohydrate metabolism.

4.4 **LET US SUM UP**

Vitamins are organic compounds (other than carbohydrates, fats and proteins) which are needed only in small amounts by the body. They are divided into two
categories—fat-soluble vitamins and water-soluble vitamins. Important functions and food sources of fat-soluble and water-soluble vitamins are summarized in Tables 4.1 and 4.2 respectively.

### Table 4.1 : Summary of Fat-soluble Vitamins

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Sources</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vitamin A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retinol</td>
<td>Liver, egg yolk, cream, butter, ghee, milk</td>
<td>• Maintenance of health of epithelial tissues.</td>
</tr>
<tr>
<td>Beta Carotene</td>
<td>Yellow and orange vegetables, green leafy vegetables</td>
<td>• Vision in dim light.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Growth of skeletal and soft tissues.</td>
</tr>
<tr>
<td><strong>Vitamin D</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Action of sunlight on skin</td>
<td>• Calcium and phosphorus absorption</td>
</tr>
<tr>
<td></td>
<td>Animal foods like eggs, butter, fish liver oil</td>
<td>• Deposition of calcium and phosphorus in bones</td>
</tr>
<tr>
<td><strong>Vitamin E</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vegetable oils, whole grains, deep green leafy vegetables, pulses, nuts and oilseeds</td>
<td>• Protection of unsaturated fatty acids, vitamins A and C from destruction in the body/food</td>
</tr>
<tr>
<td><strong>Vitamin K</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dark green leafy vegetables, egg yolk, liver</td>
<td>• Clotting of blood</td>
</tr>
<tr>
<td></td>
<td>Bacterial synthesis</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4.2 : Summary of Water-soluble Vitamins

<table>
<thead>
<tr>
<th>Vitamin of the B-complex Group</th>
<th>Food Sources</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamine or B₁</td>
<td>Whole grain cereals, pulses, nuts, egg yolk, meat</td>
<td>• Role in carbohydrate metabolism in particular</td>
</tr>
<tr>
<td>Riboflavin or B₂</td>
<td>Green leafy vegetables, milk, eggs, organ meats like liver, kidney</td>
<td>• Role in the metabolism of carbohydrates, fats and proteins</td>
</tr>
<tr>
<td>Niacin</td>
<td>Cereals, pulses, milk, nuts and oilseeds, organ meats, fish</td>
<td>• Role in the metabolism of carbohydrates, fats and proteins</td>
</tr>
<tr>
<td>Folic acid</td>
<td>Whole grain cereals, leafy vegetables, milk and eggs, organ meats like liver and kidney</td>
<td>• Role in the formation of normal red blood cells in the bone marrow</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>Animal foods like milk, eggs, organ meats</td>
<td>• Role in the formation of normal red blood cells in the bone marrow and proper functioning of the digestive tract and nervous system</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>Citrus fruits, amla, guava, capsicum, green leafy vegetables, green chillies</td>
<td>• Role in collagen formation and hence in wound healing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Role in absorption of iron and prevention of destruction of other substances</td>
</tr>
</tbody>
</table>

### 4.5 GLOSSARY

**Beta carotene**: A fat-soluble carotenoid pigment present in plants which is a precursor of vitamin A.
Coenzymes: Specific substances which are essential for proper functioning of certain enzymes.

Processing: Refers to the treatment/preparation of foods/foodstuffs using specific techniques.

Refining: A processing procedure involving the removal of the outer covering of whole cereal or pulse grains.

Susceptible: Easily affected.

4.6 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1
1) Carotenoids are yellow and orange coloured pigments present in plant foods. These carotenoids can be converted to vitamin A in the body and hence are termed precursors of vitamin A. Green leafy vegetables, yellow and orange vegetables like carrot and pumpkin and fruits like mango, papaya are rich sources of beta carotene.

2) a) True b) False; we meet most of our vitamin D needs from exposure to sunlight. c) False; vitamin A keeps the epithelial tissues moist. d) True e) True

Check Your Progress Exercise 2
1) a) -ii); b) -iv); c) -i); d) -iii)
2) i) Fish liver oils ii) dim light iii) fat, bile iv) antibleeding

Check Your Progress Exercise 3
1) Coenzymes are the substances which are essential for the activity of some of the enzymes. They are also termed as helpers of enzymes. Specific coenzymes are needed for specific enzymes. Most of the B vitamins act as coenzymes and help in metabolism of carbohydrates, fats and proteins.

2) Folic acid and vitamin B₁₂

Check Your Progress Exercise 4
i) Whole wheat flour has most of the bran and part of the germ layer in it and is a good source of thiamine. However, maida or refined flour has very little bran and germ. Since bran and germ are rich in thiamine and other B-complex vitamins, whole wheat flour is rich in thiamine while refined flour is poor in thiamine.

ii) Milk is a rich source of tryptophan. Tryptophan can be converted to niacin. This is why milk can help to meet niacin needs.

iii) Ascorbic acid is called the ‘fresh food vitamin’ because it is present in substantial quantities in fresh fruits and vegetables.

iv) Thiamine is a part of coenzymes which play a role in metabolism of carbohydrates. Deficiency of thiamine in the diet can therefore interfere with carbohydrate metabolism.