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# UNIT 9 NUTRACEUTICALS AND MISCELLANEOUS PRODUCTS

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## Structure

- 9.0 Objectives
- 9.1 Introduction
- 9.2 Nutraceutical Compounds Available from Fish and Shell Fish
- 9.3 Nutraceuticals Derived from Fin Fish
  - 9.3.1 Marine Oils
  - 9.3.2 Squalamine
  - 9.3.3 Other Nutraceuticals
  - 9.3.4 Marine Enzymes
  - 9.3.5 Antioxidant
  - 9.3.6 Bio-active Compounds
- 9.4 Products from Shell Fishes
  - 9.4.1 Use of Chitin Derivatives
  - 9.4.2 Nanotechnological Application of Chitosan
  - 9.4.3 Biotechnological Applications of Chitosan
- 9.5 Let Us Sum Up
- 9.6 Glossary
- 9.7 Suggested Further Reading
- 9.8 References
- 9.9 Answers to Check Your Progress

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## 9.0 OBJECTIVES

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After reading this unit, you will be able to:

- define nutraceuticals and identify their source;
- summarise different nutraceutical compounds derived from fin fishes and shell fishes; and
- explain their preparation and uses.

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## 9.1 INTRODUCTION

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Nutraceuticals are foodstuffs which provide health benefits in addition to their basic nutritional value. These may include fortified foods as well as dietary supplements that can be sold in capsules, tablets or powders. The idea behind the use of nutraceuticals is that certain organic extracts can have positive benefits on both the mind and body. From cancer to vertigo, claims of nutraceutical's effectiveness in combating or altogether curing a long list of ailments are abundant.

The term “nutraceuticals” is a combination of the words nutrition and pharmaceuticals. The issues that comes to the minds of many who consider using

nutraceuticals to combat their illness are frequently safety related. The idea of using nature's best to cure the body's problems sounds promising. After all, why should one involve synthetic chemicals with long term effects that are uncertain in fixing that which is not synthetic? Then, again natural is not synonymous with safe. Plenty of naturally derived items have a negative impact on the mind and body, and experimenting with the unknown or little known, can be risky.

Unfortunately, the solution to this issue is not a simple one. Certain nutraceuticals have indeed been tested and deemed appropriate by the US, Food and Drug Administration for use in the prevention of select ailments. Others have been tested repeatedly and deemed effective but not or not yet, officially approved by the FDA. Yet, others have received mixed results during testing and their usage and effects are of a questionable nature. In India, the research is on to find out useful bioactive compounds especially available from marine animals.

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## **9.2 NUTRACEUTICAL COMPOUNDS AVAILABLE FROM FISH AND SHELL FISH**

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Nutraceuticals have been credited with curing a wide variety of ailments/diseases. From the minor to the serious, many have adamantly insisted that the nutraceuticals they tried were responsible for eliminating their health problems. While some popular nutraceuticals have been tested and approved for treatment, traditionally most of them are used in indigenous medicines. Many parts of the fish as well as discards such as fish body oils, fish liver, fish bone, milt, fish skin, fish lips, are considered as sources of nutraceuticals as they may contain many vitamins, minerals, hydrocarbons, amino acids etc. Some of the products derived from fish and shell fish are listed below:

- 1) ***Fish oils:*** Poly unsaturated fatty acids (PUFA) belonging to the omega-3 family namely EPA (eicosapentaenoic acid), DHA (docosahexaenoic acid) and; phospholipids, squalene, vitamins A & D, cholesterol, hydrolysates, peptides, amino acids and protamines.
- 2) ***Biochemical and Pharmaceuticals Products:*** Nucleic acids, protamines, streptogenin glutathione, cortisone, bile salts and proteolytic enzymes, insulin, calcium, collagen, enzymes such as pepsin, trypsin, chymotrypsin, alkaline phosphatase and hyaluronidase, hormones etc., Chitin, chitosan, Glucosamine, carotenoids/xanthophylls, chondroitin sulphate, protein hydrolysates etc.
- 3) ***Fish Proteins and their By-products:*** Proteins power up from lowering cholesterol and blood pressure to aiding in weight management and muscle recovery, proteins play an important role in today's functional foods and beverages. Whether, they are pure proteins, hydrolysate or peptides, proteins are packing a punch in today's products. Protein hydrolysates and bioactive peptides are the products resulting from protein hydrolysis achieved by enzymes, acid or alkali and fermentation process.
- 4) ***Protein hydrolysates:*** Enhance immune response. They also have anti-oxidant activity as well as angiotension convering enzyme (ACE) inhibiting activity.
- 5) ***Carotenoids and their oxygenated derivatives*** (xanthophylls) are another group of bioactive agents.

## 9.3 NUTRACEUTICALS DERIVED FROM FIN FISH

Let us now look into the useful products from fin fish. Fin fish as you know are the group comprising only fishes (excluding shell fishes).

### 9.3.1 Marine Oils

Lipids constitute between 10 and 40% of total human diet. They are an important source of essential important fatty acids. Oil originates from the body of fatty fish, the liver as well as blubber of marine mammals such as seal. Fishes like salmon, tuna (Fig.9.1), mackerel, herring and sardine produce large amounts of fish oil. Oil can be extracted from flesh as well as from offal from the fish processing industry. Livers from many fishes are rich sources of oil. Sharks, cod, halibut are valuable for their liver oils (Fig.9.2 a and b.). The oils form nearly 2 to 3 %.



**Fig.9.1: Tuna oil**



**Fig. 9.2(a): Cod liver oil capsules**



**Fig.9.2(b): Shark liver oil capsules**

Hardened fish oil is used in margarine. Margarine is a mixture of at least 80% fat or oil in which 16% water or milk has been emulsified.

Fish oil refining process steps include extraction of the crude oil, degumming, neutralizing, bleaching and deodorizing. Fish lipids are known to be rich in PUFA especially n-3 PUFA family of linolenic acid (C 18:3) and its derivatives such as eicosapentaenoic acid (EPA/ C 20:5) docosapentaenoic acid (DPA/C22:5) and docosahexaenoic acid (DHA/C22.6). EPA has a beneficiary influence on the cardiovascular system and inhibits very low density lipoprotein (VLDL) formation, cell proliferation and the inflammatory and allergic response (Fig.9.3). DHA is major component of grey matter of brain and the eye retina and the important component of heart tissue – consequently plays an important role in brain development and retinal function of the foetus and infants.



**Fig.9.3: Omega-3 fish oils**

In view of the great concern regarding coronary thrombosis and its association with cholesterol, it is pointed out that fish oils with high levels of unsaturated fatty acids are known to reduce blood cholesterol level. Interest in the high content of this long chain polyunsaturated omega-3 fatty acids (Fig.9.3) grew during 1970's and 1980's with the observation that the mortality through coronary heart disease was low in Eskimos who consume a large amount of seafood. These fatty acids play a vital role in human nutrition, disease prevention and health promotion. You must realize that long chain n-3 PUFA cannot be synthesized by humans and must be obtained from the diet; hence the importance of fish in diet. A preventive and curative effect has also been linked to the PUFA in fish oils for arterial hypertension, human breast cancer, inflammatory diseases, asthma and disorders of the immune system. Fish liver has been a source of oils for the prevention of disorders associated with vision and growth. Adults are recommended a daily intake of 350 mg of EPA/DHA which corresponds to approximately 30g fish/day. Generally, marine fish like herring, mackerel are very rich in EPA and DHA. For those who prefer not to eat fish can get these as supplements in the form of pure oils or in the form of capsules. PUFA are used in the treatment of hypertension, arthritis, diabetes etc. The fatty acids found in seal oils include a high level of DHA – up to 10 times than that of fish oils. A study indicated that low dose of seal oil supplementation can reduce atherogenic risk indices in young healthy individuals.

Fish oils in the diet also help in the production of a very important group of lipids called prostaglandins. These are set to influence the prevention of excessive fat deposition in the arteries.

Extraction of PUFA is done by cooking of raw material, pressing, centrifuging and filtration. PUFA can be prepared by chromatographic method, distillation method, low temperature crystallization, superficial fluid extraction, urea complexation and enzymatic methods.

### 9.3.2 Squalamine

Squalamine cholestane sulfate (squalene) is an amino sterol found in the liver, gall bladder, intestines and testes and stomach of dogfish shark (Fig 9.4). It is effective against gram negative as well as gram positive bacteria, fungi, angiogenesis and tumor activities. It has been shown to be helpful in treatment of lung and ovarian cancer. It is used in regression of retinopathy. However, tissue concentration of this compound is very low. It is also an appetite suppressant indirectly helping in curbing obesity as well as diabetes.



Fig. 9.4: Squalene capsules

### 9.3.3 Other Nutraceuticals

#### a) *From fish milt*

Fish milt is often wasted; however milt from cod and herring is canned and used as a food product in England. Milt contains large amounts of protamine and nucleic acids and is often used for the industrial production of nucleic acids. Protamine is a naturally occurring cationic polypeptide found in mammals as well as fish. It is said to inhibit both gram negative and gram positive bacteria. By-products from cod species are potential sources of bio-active compounds. Protamine is a basic peptide containing more than 80% arginine. Protamine has been found in the testicles of more than 50 fish species. Protamine is used as an anti-bacterial agent in food processing and preservation. Protamine has the ability to prevent the growth of *Bacillus* spores.

#### b) *Products from Fish bones and cartilage*

Shark cartilage is good source of Chondroitin sulphate. Calcium is essential for numerous functions in our bodies including strengthening of teeth, bone, nerve function and many enzymatic reactions. It is also necessary for muscle contraction and regulation of the permeability of sodium ions across cell membranes. Calcium deficiency causes osteoporosis. Milk is a very good source of calcium. Fish bones are rich sources of calcium and phosphorus. The intake of small fish with bones can increase calcium bioavailability especially in populations with low intake of milk products.

Arthritis, the degenerative joint disease is characterized by the breakdown of the joint cartilage, causing pain, inflammation and loss of movement in the joint. Glucosamine, naturally produced in human body is a key building block of joint cartilage and joint fluid. Supplemental glucosamine (Fig.9.5) provides the building blocks our body needs for cartilage production. Specifically, glucosamine stimulates the synthesis of proteoglycons, resulting in tissue that holds water to give cartilage thickness and its cushioning effect. Human clinical studies on glucosamine have shown benefits on taking 1,500 mg daily in reducing cartilage degeneration as well as pain, inflammation and loss of joint movement. Chondroitin is another popular joint health supplement helping cartilage retain water. Shark cartilage and compounds of cartilage have been traditionally credited with a number of medical benefits including anti-cancer effects, fibrinolytic activities and beneficial effects on osteoarthritis, progressive systemic sclerosis and neuro-vascular glaucoma etc.



Fig. 9.5: Glucosamine

*c) From fish gall bladders or bile*

Insulin is also manufactured from fish gall bladders or bile especially from Cod, Tuna etc.

*d) From Fish skin*

Fish skin is a potential source of collagen. Proteins such as collagen and gelatin renew cartilage and ease joint mobility. Other novel proteins such as keratin and milk protein serve to reduce inflammation.

Collagen is the single most important protein of connective tissue. Shark skin collagen is one of the most abundant and important source of marine collagen. Shark skin collagen hydrolysates are sold as dietary supplements in Japan for the cure of Osteoporosis. One product named AE 941 is said to be effective as an anti-angiogenic properties [Fig.9.6(a)].

Another product Elastin from fish skin is used in skin care [Fig.9.6(b)], treatment of stretch marks and in hair care products to repair broken hair. Gelatin is used in the preparation of capsules, tablets and pastilles. In addition, gelatin is used in the production of microencapsulated oils for various pharmaceutical applications. Also used in surgery as a sterile and water insoluble sponge to control bleeding as well as to serve as an adhesive in protective dressings. Collagen and gelatin are obtained from outer skin of several species of fishes including freshwater fish.



Fig. 9.6(a): Collagen



Fig. 9.6(b): Skin care product

### 9.3.4 Marine Enzymes

Enzyme technology has been used extensively in the food processing industry. Enzymes which can be extracted from seafood and seafood by-products include digestive and cellular proteinases, extracellular gastric proteinases, chitinases, lipases, phospholipases, transglutaminases, polyphenoloxidase and others.

### 9.3.5 Antioxidants

In living organisms, oxidation is associated with ageing, membrane damage, heart disease, stroke, emphysema and cancer through free radical mediated modification of DNA, proteins, lipids and small cellular molecules. Lipid oxidation involves the generation of reactive oxygen species such as superoxide anion and hydroxyl radicals, and is one of the major reasons for food quality deterioration during storage. Anti-oxidants in food can protect the body against oxidative stress and lead to disease risk reduction. Since synthetic antioxidants are thought to cause potential health hazards, a search is on to get antioxidants from natural sources. Some of the natural antioxidants derived from plants are tocopherols and polyphenols. Recently, marine organisms have attracted attention as a source of antioxidants to be used as a substitute for natural plant anti oxidants. Naturally occurring antioxidants have been found in marine algae, invertebrates, fish, shell fish and marine bacteria. Marine animals and their waste are rich in protein. Hydrolysis of protein leads to the production of protein hydrolysates which have an inhibitory influence on lipid oxidation. Pigments extracted from marine sources/ animals also function as antioxidants. For example, carotenoid pigments are synthesized in plants bacteria and microalgae. Crustacean processing waste is a rich source in carotenoid pigments. Carotenoid pigments are used as colorants for food, drugs and cosmetics as well as animal feed and nutritional supplements

### 9.3.6 Bio-active Compounds

The concept of using bio-active compounds of marine origin has a very ancient tradition. Since a long time, bio-active components from marine sources were used as drug carriers, demulcents and nutritional supplements. Another reason is the search for antibiotics that can overcome the problem of multidrug resistant bacterial strains. Utilization of fish and shell fish waste helps in reducing pollution and disposal of seafood waste from processing plants.



#### Check Your Progress 1

**Note:** a) Use the space given below for your answers.

b) Check your answers with those given at the end of the unit.

1) What are nutraceuticals?

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 .....

2) Name some of the sources of nutraceuticals in fish?

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 .....

3) Name two biochemical products produced from fish?

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 .....

4) What are the uses of squalamine?

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 .....

5) Give one use of glucosamine.  
.....  
.....

6) Give uses of collagen.  
.....  
.....

**9.4 PRODUCTS FROM SHELL FISHES**

Shell fish waste especially head and exoskeleton from shrimps, crabs; lobsters after processing are very useful for the production of valuable nutraceutical products such as chitin. The major sources of chitin are prawn shell, crab shell, Antarctic krill, squilla, clams, oyster, squid, fungi and insects. In recent times, due to the high export demand of prawns and other shell fishes, many processing factories have come up in coastal states. These factories produce huge amounts of shell wastes. These shell wastes can be profitably recycled to produce chitin and related products. At present, prawn shell/crab shell are used for the preparation of chitin and chitosan in industrial level (Fig.9.7).



**Fig. 9.7: Chitin and chitosan**

Chitin is present in its sources as chitin protein complex along with minerals mainly calcium carbonate. The process for chitin production comprises deproteinisation using dilute alkali or proteolytic enzymes and demineralization using dilute acids. The deacetylation of chitin to produce chitosan is effected by treatment with concentrated alkali.

Glucosamine – The monomer of chitin has been reported to possess health benefits such as wound healing, treatment of arthritis etc.

**9.4.1 Uses of Chitin Derivatives**

Glucosamine maintains the strength, flexibility and elasticity of cartilage, used for treating or preventing Osteo-arthritis and increases proteoglycan synthesis and prevent cartilage degradation (Fig.9.8). Chemical modifications including graft polymerization of vinyl monomers are considered to have the stability of chitin and enhancement of lysozyme susceptibility. Immuno adjuvant activity of chitosan was found to be similar level to that of lentinam. Carboxymethyl chitin (CM Chitin) is a biodegradable material having mitogenic activity for short period. 6 O-CM chitin is also found to be effective intermediate for a heparinoid for relief from hypertension. Biodegradability of CM chitin is a proved one.





**Fig. 9.8: Glucosamine**

Many of chitosan's biomedical application depend on its non-toxic and biodegradable properties.



**Fig. 9.9: Chitosan**

Chitosan (Fig 9.9) has been shown to facilitate wound healing and reduce serum cholesterol levels and stimulate the immune system. It helps in the following:

- Wound healing accelerator
- Reduce blood cholesterol levels
- Immune system stimulant
- Preparation of steroid hormones
- Oral therapy-treatment of wounds
- Ulcer inhibitor
- Anti-cancer and anti-tumour agents
- Bactericide
- Anti-ageing agents

#### **Antibacterial Property**

Following groups of bacteria were inhibited by chitosan of 1 to 5-log cycle at 1% concentration.

- *Escherichia coli*
- *Salmonella typhi*

- *Listeria monocytogenes*
- *Staphylococcus aureus*
- *Lactobacillus plantarum*
- *Lactobacillus brevis*
- *Bacillus cereus*

### **9.4.2 Nanotechnological Application of Chitosan**

Nanoparticles are generated by *in situ* gelation of the thiomers chitosan-4-thiobutylamidine (chitosan-TBA) with tripolyphosphate (TPP) followed by stabilization and are used for Microencapsulation, Controlled Release and Sustained Release of drugs. Chitosan-pEGFP nanoparticles can provide transfection of primary chondrocytes. Chitosan nanoparticles encapsulated in vesicular systems are used for oral immunization, Bioengineering, Immunology, Immunotherapy, Liposomal Delivery etc. Nano structured chitosan self-aggregate is a drug delivery carrier. A number of novel delivery systems have been developed including the entrapment of drugs, protein, antigens, or genes in small vesicles with polymeric material. It is demonstrated that stabilization of self-aggregate with diameter of about 150nm can be prepared and their characteristics are dependent on the molecular weight of chitosan, degree of substitution of deoxycholic acid, pH and ionic strength of the media. These self-aggregates find useful application in the area of drug delivery for therapeutic purposes.

#### **Properties of Chitosan Based Core Shell Nano Particles**

- Bio compatible
- High surface area
- Good dispersion to the surface area
- Good antibacterial property and laundering durability
- Multifunctional finishing treatment

Various functions can be built in a single treatment using nano technology, making the treatment much simpler and lower cost and with the synergistic effect; three-in-one and five-in-one have been developed. A transparent and slight yellow chitosan (CS)/Hydroxyapatite (HA) nanocomposite with high performance can be prepared by *in situ* hybridization and is used for internal fixation of bone fracture.

#### **Medical and Pharmaceutical Uses**

- Bacteriostatic agent
- Haemostatic agent
- Hydrogel ointment base formulation
- Wound dressing
- Hypocholesterolemic agent
- Antigastritis

- Antisore composition
- Non-woven fabrics (Fig.9.10)
- Preparation of surgical sutures
- Temporary artificial ligaments
- Temporary bioengineering material
- Films for drug release
- Biopolymer membranes
- Chitosan collagen biopolymer membrane
- Albumin chitosan membrane
- Haemodialysis and artificial skin



Fig. 9.10: Chitosan fibre yarn

### 9.4.3 Biotechnological Applications of Chitosan

It is used in tissue engineering – cyto - compatible and promoting adhesion and cellular protection. It behaves like a decoy of a biological material.

Many enzymes are immobilized using chitosan. Most common method of fixing enzymes to chitosan is by cross linking with di-aldehydes, glycerol and glutraldehyde.

#### Enzyme Immobilization

Enzyme	Proposed Use
AMP deaminase	AMP to IMP
Amylase diastase and glucoanalase	Starch and glycogen to D-Glucose
$\beta$ -D.galactosidase	Hydrolysis of lactose
D-Glucose isomerase	D-glucose to D-fructose and preparation of D-gluconic acid
$\beta$ -D.glucosidase	Hydrolysis of cellobiose
Lysozyme	Preparation of pharmaceuticals
Urease	Urea to ammonia and carbondioxide
<i>E.coli</i> cells	Synthesis of L tryptophan



### Check Your Progress 2

- Note:** a) Use the space given below for your answers.  
b) Check your answers with those given at the end of the unit.

1) What are the sources of chitin?

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.....

2) Spell the health benefits of Glucosamine.

.....  
.....

3) Give three uses of chitosan?

.....  
.....

4) Name three properties of chitosan based core shell Nano particles?

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.....



### Activity 1

Visit a local drug store. Ask the drug store manager to give you pharmaceutical products wherein fish derivatives are used. Make a small chart of the various drugs and their uses.

.....  
.....  
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## 9.5 LET US SUM UP

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Fish has been known as a health food since ages. Researches in recent time have opened wide possibilities of extracting rare and useful nutraceuticals from fish and shell fish. The large amount of shell fish waste which otherwise cause pollution can now be profitably used for the production of valuable life saving nutrients and pharmaceutical products. This unit compiles available information on nutraceuticals available from fish and shellfish.

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## 9.6 GLOSSARY

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- Ailments** : Minor illness.
- Angiogenesis** : The developments of new blood vessels.
- Angiotensin** : Name of two related proteins molecules regulating blood pressure.

<b>Bio-active</b>	: Biologically active.
<b>Biodegradability</b>	: Able to decompose naturally.
<b>Blubber</b>	: The thick subdermal layers of insulating fats in whales and large marine animals.
<b>Combat</b>	: Prevent.
<b>Derivatives</b>	: Related to chemical product.
<b>Fermentation</b>	: Breakdown of a material by microorganism.
<b>Gastric</b>	: Of the stomach.
<b>Hypertension</b>	: High blood pressure.
<b>Inhibiting</b>	: Hinder, restrain.
<b>Margarine</b>	: Butter substitute made from vegetable oil or animal fats.
<b>Nanocomposite</b>	: Nanotechnologically.
<b>Neuro Vascular Glaucoma</b>	: A group of eye disease characterised by increased intraocular pressure and degeneration of optic nerve.
<b>Obesity</b>	: Over weight.
<b>Osteoporosis</b>	: Weakening of bones due to calcium deficiency.
<b>Polyunsaturated Fatty Acid</b>	: Fatty acids having more than one double bond.
<b>Proliferation</b>	: Increase rapidly in number.
<b>Retinopathy</b>	: An inflammation of retina.
<b>Scelerosis</b>	: Hardening or induration of body part.
<b>Suppressant</b>	: An agent that halts some process such as secretion excretion and discharge.




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## 9.7 SUGGESTED FURTHER READING

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Shahidi, F. 2007. *Maximising the Value of Marine By-products*, Woodhead Publishing Limited, Cambridge, England.




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## 9.8 REFERENCES

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Muzarelli, R.1977. *Chitin*, Pergamon Press

Venugopal, V. 2006. *Seafood Processing*. Published in by CRC Taylors & Francis Group

Zbigniew, S., Karnicki, Anna Wojtasz- Pajak, Maciej M. Brzeski and Piotrj. Bykowski. 1994. (Eds.) *Chitin World*, Sea Fisheries Institute Gdynia, Poland.

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## 9.9 ANSWERS TO CHECK YOUR PROGRESS

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### Check Your Progress 1

- 1) Nutraceuticals are food stuffs which provide health benefits in addition to their basic nutritional value.
- 2) Fish body oils, fish liver, fish bones, milt, fish skin, lips, contain valuable nutraceuticals products.
- 3) Nucleic acids and protamines.
- 4) It is effective against both gram negative as well as gram positive bacteria, fungi, angiogenesis and tumor activities. It has been shown to be helpful in treatment of lung and ovarian cancer. It is used in regression of retinopathy.
- 5) Human clinical studies on glucosamine have shown benefits for taking 1,500 mg daily including reducing cartilage degeneration as well as pain, inflammation and loss of joint movement.
- 6) Shark skin collagen hydrolysates are sold as dietary supplements in Japan for the cure of Osteoporosis.

### Check Your Progress 2

- 1) The major sources of chitin are prawn shell, crab shell, Antarctic krill, squilla, clams, oyster, squid, fungi and insects.
- 2) It has been reported to possess health benefits such as wound healing, health build up etc.
- 3) Wound healing accelerator, Reduce blood cholesterol levels, Immune system stimulant.
- 4) Bio-compatible, high surface area, good dispersion to the surface area.