Essentials of Applied Physiology for NURSING Students



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Semester-I

As per Revised INC Syllabus for BSc Nursing



K Sembulingam
Prema Sembulingam

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4 CHAPTER

Homeostasis

CHAPTER OUTLINE

- CONCEPT OF HOMEOSTASIS
- IMPORTANCE OF HOMEOSTASIS
- INTERNAL ENVIRONMENT
- ROLE OF BODY SYSTEMS IN HOMEOSTASIS
  - DIGESTIVE SYSTEM
  - RESPIRATORY SYSTEM
  - EXCRETORY SYSTEM
  - SKIN
  - BLOOD AND CIRCULATORY SYSTEM
  - LYMPHATIC SYSTEM
  - ENDOCRINE SYSTEM
  - SKELETAL MUSCLES
  - NERVOUS SYSTEM
- COMPONENTS OF HOMEOSTATIC SYSTEM
  - SENSORS OR DETECTORS OR RECEPTORS
  - CONTROL OR INTEGRATOR CENTER
  - EFFECTORS
- MECHANISM OF ACTION OF HOMEOSTATIC SYSTEM
  - NEGATIVE FEEDBACK CONTROL SYSTEM
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  - FEED-FORWARD CONTROL SYSTEM
- APPLIED PHYSIOLOGY: HOMEOSTATIC IMBALANCE
- IMPLICATIONS AND APPLICATIONS IN NURSING CARE FOR DISORDERS OF HEMOSTATIC IMBALANCE

CONCEPT HOMEOSTASIS

'Homeostasis' is defined as a process during which constant internal environment of the body is maintained (homeo = same; stasis = standing). The word 'homeostasis' was introduced by **Walter Bradford Cannon**, Professor of Physiology in Harvard Medical School in 1929.

IMPORTANCE OF HOMEOSTASIS

Importance of internal environment was notified by **Claude Bernard**, French Physiologist of 19th century. He enlightened the fact that multicellular organisms including man live in a perfectly organized and controlled internal environment which he called **milieu intérieur**.

INTERNAL ENVIRONMENT

Internal environment of the body is the **extracellular fluid (ECF)** in which all the cells live. It is the fluid outside the cell, and it constantly moves throughout the body. ECF includes blood, which circulates in the vascular system and **interstitial fluid** which is present in between the cells**.** ECF contains nutrients, ions and all other substances necessary for the survival of the cells.

Healthy living of large organisms including man depends upon constant maintenance of internal environment within the physiological limits. If it deviates beyond the **set limits**, body suffers from malfunction or dysfunction.

ROLE OF BODY SYSTEMS IN HOMEOSTASIS

Most of the body systems are involved in homeostatic mechanism. Role of each system in homeostatic mechanism is given below:

1. DIGESTIVE SYSTEM

Nutrients are essential for growth and activities of the cells. Nutritive substances such as amino acids,

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carbohydrates and fatty acids also form source of energy required for activities of the cells.

The digestive system is responsible for digestion and absorption of nutritive substances into the blood. Blood in turn transports supplies the substances to cells of the body.

2. RESPIRATORY SYSTEM

Respiratory system is responsible for exchange of gases (oxygen and carbon dioxide) throughout the body. It supplies adequate amount of oxygen to the cells for metabolism of the nutrients. At the same time, carbon dioxide is removed from the cells and expelled out of body via lungs. This system is also responsible for maintenance of water balance, acid balance and temperature of the body.

3. EXCRETORY SYSTEM

Kidneys and other excretory organs are involved in the excretion of waste products. Kidneys are also responsible for maintenance of water balance, electrolyte balance, acid- base balance and osmolality of body fluids.

4. SKIN

Skin covers and protects all organs of the body from mechanical blows, bacteria, toxic substances and ultra-violet rays. By secreting sweat skin plays an important role in regulation of body temperature and water balance. It also excretes small quantities of waste materials such as urea, salts and fatty substances. Skin also forms the largest sense organ. It has many receptors which convey sensations to the brain via afferent nerves.

5. BLOOD AND CIRCULATORY SYSTEM

Circulatory system includes heart and blood vessels. Heart is responsible for flow of blood via blood vessels throughout the body. Blood transports nutritive substances, oxygen and other important substances such as hormones to all cells of the body. It also removes carbon dioxide, metabolic and other waste products which are to be excreted.

White blood cells are responsible for protection of the body from invading organisms and development immunity against pathogenic agents.

6. LYMPHATIC SYSTEM

Lymphatic system is a closed system of lymphatic vessels and lymph nodes through which lymph flows. Major function of lymph is to return proteins from tissue space into blood. It is also responsible for redistribution of fluid in the body. Lymph nodes form defense barriers of the body by destructing bacteria and other toxic agents.

Lymph nodes also filter lymph and retain proteins and lipids which are essential for the body.

7. ENDOCRINE SYSTEM

Many hormones secreted by endocrine glands are essential for the metabolism of nutrients and other substances necessary for the cells. Hormones also are necessary for growth and functions of various tissues of the body.

8. SKELETAL MUSCLES

Skeletal muscles are involved in homeostasis by helping the organism to move around in search of food. It also helps to protect the organism from adverse surroundings, thus preventing damage or destruction.

9. NERVOUS SYSTEM

Central nervous system, which includes brain and spinal cord plays an important role in homeostasis. Sensory system detects state of body or surroundings. Brain integrates and interprets the pros and cons of this information and commands the body to act accordingly through motor system. So, the body can avoid the damage.

Autonomic nervous system regulates all vegetative functions essential for homeostasis.

COMPONENTS OF HOMEOSTATIC SYSTEM

Homeostatic system in the body includes **three components**:

1. SENSORS OR DETECTORS OR RECEPTORS

Sensors recognize the deviation in any activity in internal environment and transmit the message to control center **(Fig. 4.1)**.

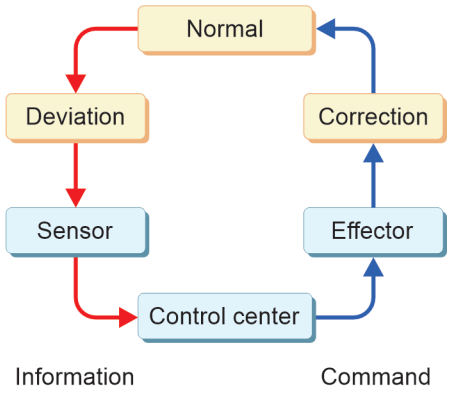


FIGURE 4.1: Components of homeostatic system.

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2. CONTROL OR INTEGRATOR CENTER

Control center receives the message from receptors and immediately sends commands to concerned effectors.

3. EFFECTORS

Effectors receive the commands from center and either accelerate or inhibit the activity so that normalcy is restored.

MECHANISM OF ACTION OF HOMEOSTATIC SYSTEM

Homeostatic mechanism in the body is responsible for maintaining normalcy of various body systems. Whenever there is any change in behavioral pattern of any system, the effectors bring back the normalcy. Normalcy is brought back either by inhibiting and reversing the change or by supporting and accelerating the change depending upon requirement of situation. This is achieved by means of feedback signals or control system.

Homeostatic mechanism functions by **three types** of feedback control systems:

1. Negative feedback control system
2. Positive feedback control system
3. Feed-forward control system.

1. NEGATIVE FEEDBACK CONTROL SYSTEM

Negative feedback control system reacts to arrest the change or reverse the direction of change in homeostasis. After receiving the message, effectors send negative feedback signals back to control center. Control center modifies the commands and attempts to maintain homeostasis.

Many homeostatic mechanisms in the body function through negative feedback.

Examples of Negative Feedback

i. *Regulation of secretion of hormone by negative feedback*

Thyroid-stimulating hormone (TSH) released from pituitary gland stimulates thyroid gland to secrete thyroxine. When thyroxine level increases in blood, it inhibits the secretion of TSH from pituitary so that, secretion of thyroxine from thyroid gland decreases **(Fig. 4.2)**. On the other hand, if thyroxine secretion is less, its low blood level induces pituitary gland to release TSH. Now, TSH stimulates thyroid gland to secrete thyroxine. Refer Chapter 51 for details.

ii. *Regulation of water balance by negative feedback*

Another example of negative feedback mechanism is regulation of water balance in the body **(Fig. 4.3)**. Refer Chapter 98 for details.

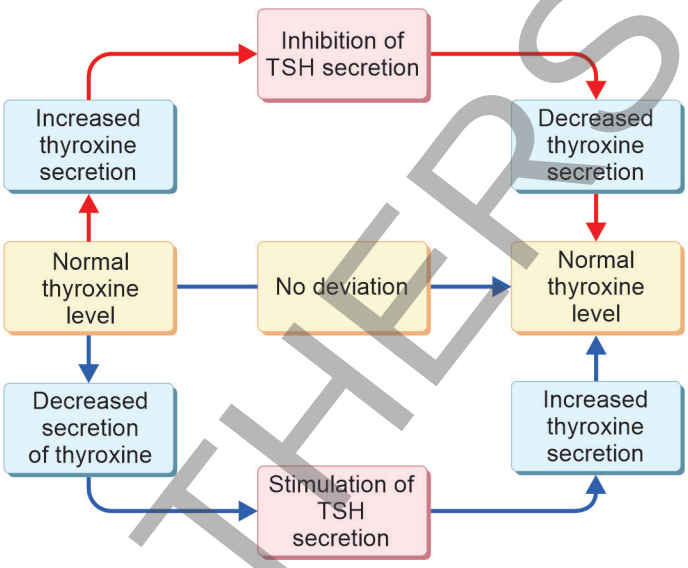


FIGURE 4.2: Negative feedback mechanism: Secretion of thyroxine. TSH = Thyroid-stimulating hormone.

2. POSITIVE FEEDBACK CONTROL SYSTEM

Positive feedback control system reacts to increase the intensity of the change in the same direction. Positive feedback is less common than negative feedback. However, it has its own significance particularly during emergency conditions.

Examples of Positive Feedback Control System

Well known positive feedback mechanism occurs during blood clotting. Blood clotting is necessary to arrest bleeding during injury.

Thrombin formed in second stage of blood clotting stimulates the formation of more prothrombin activator in addition to converting fibrinogen into fibrin **(Fig. 4.4)**. It causes formation of more and more amount of prothrombin activator so that the blood clotting process is accelerated and blood loss is prevented quickly (Chapter 17).

Other processes where positive feedback occurs are **milk ejection reflex** (Chapter 50) and **parturition (Fig. 4.5)** (Chapter 61), and both the processes involve oxytocin secretion.

3. FEED-FORWARD CONTROL SYSTEM

Feed-forward control system anticipates the change or deviation that may occur in a later stage and takes appropriate control action to avoid the disturbance. Whereas the feedback control systems detect the deviation only when it happens.

Examples of Feed-forward Control System

1. Preadaptation before onset of exercise such as changes in cardiovascular system in order to prepare the body for exercise.

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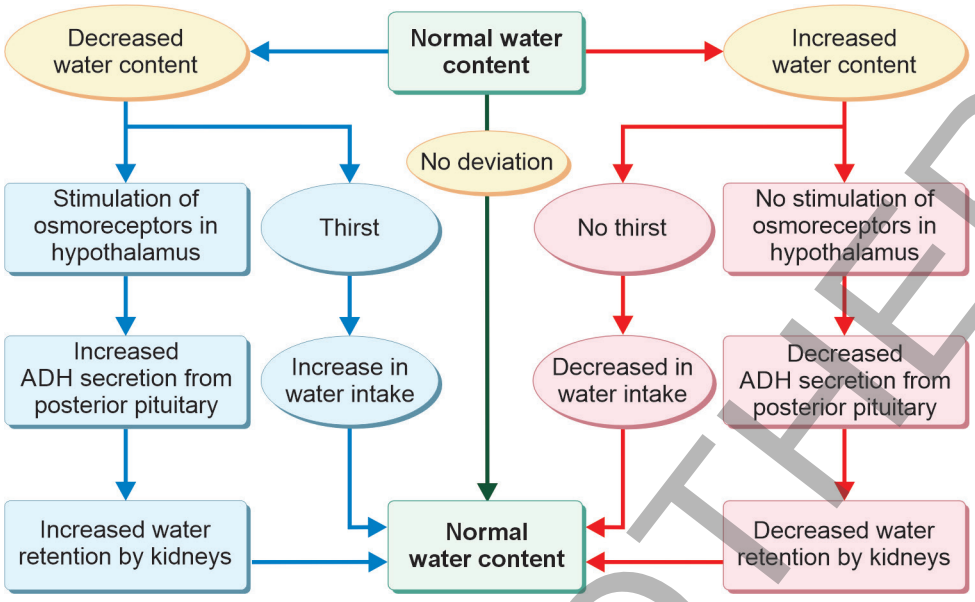


FIGURE 4.3: Negative feedback mechanism: Maintenance of water balance. ADH = Antidiuretic hormone.

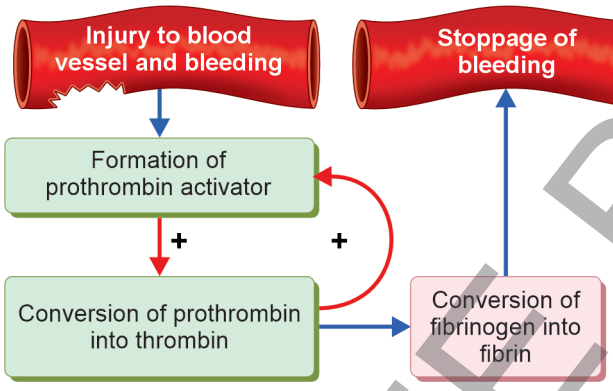


FIGURE 4.4: Positive feedback mechanism: Coagulation of blood. Once formed, thrombin induces the formation of more prothrombin activator.

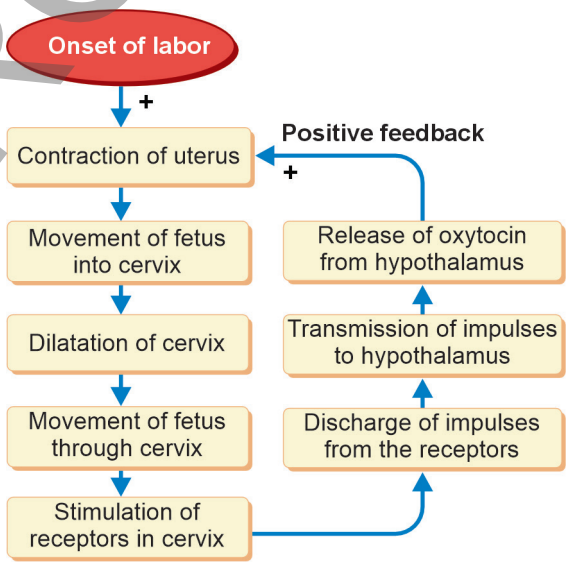


FIGURE 4.5: Positive feedback mechanism: Parturition.

2. Secretion of gastric juice (along with salivary secretion) even before entrance of food in mouth.
3. Increase in secretion of luteinizing hormone prior to ovulation.

APPLIED PHYSIOLOGY: HOMEOSTATIC IMBALANCE

Homeostatic imbalance is the failure of the body to maintain constant internal environment. It is the starting point of disorders and diseases in the body.

Causes and Consequences of Homeostatic Imbalance

Refer **Table 4.1**.

IMPLICATIONS AND APPLICATIONS IN NURSING CARE FOR DISORDERS OF HOMEOSTATIC IMBALANCE

IMPLICATIONS IN NURSING CARE FOR DISORDERS OF HOMEOSTATIC IMBALANCE

1. *Early Detection Trends in Homeostatic Imbalance*

Nursing implications focus on early detection of trends among issues. Nurses must focus on physical and mental conditions of patients, patient deterioration and unnoticed (subtle) changes in values of laboratory

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TABLE 4.1: Common causes and consequences of homeostatic imbalance.

Common causes	Common consequences
1. Stress	1. Acidosis
2. Altered eating habits	2. Diabetes mellitus
3. Alcohol consumption	3. Hypoglycemia
4. Sleeplessness	4. Hyperglycemia
5. Over-exercise	5. Dehydration
6. Lack of water intake	6. Hypertension
7. Hypoxia	7. Heart failure
8. Long-term illness	8. Gout
9. Genetic mutation	9. Infections
10. Aging	10. Disease caused by toxins

tests including blood glucose level and electrolyte levels.

2. *High Risk Patient Monitoring*

Nurses must take special care for patients with high risk such as children who often have high metabolic rate and elders who have diminished organ function.

3. *Monitoring Compensatory Mechanisms*

Nurses must continuously monitor compensatory mechanisms developing in the body such as:

i. Shivering or increased sweating to regulate body temperature.
ii. Tachycardia (increased heart rate) to compensate low blood pressure.

4. *Interdisciplinary Collaboration*

Nurses must coordinate with dietitians for electrolyte-restricted diet.

CLINICAL APPLICATIONS IN NURSING CARE FOR DISORDERS OF HOMEOSTATIC IMBALANCE

Core clinical applications in nursing care are:

1. *Patient Education*

Nurses must educate the patient about dietary changes such as low-sodium or high potassium diet and to identify recurrence of symptoms.

2. *Management Electrolyte and Fluid Balance*

i. **For excess fluid volume:** Restrictions for fluid intake and administration of diuretics to prevent edema.
ii. **For less fluid volume:** Administration of oral IV fluids and monitoring signs of shock.
iii. **For excess electrolyte level:** Restriction of sodium or use of **phosphorous binding agents** (excess phosphorous level.
iv. **For low electrolyte level:** Careful and slow administration of potassium supplements by monitoring cardiac rhythms.

3. *Regulation of Acid-Base Balance*

Modification of oxygen therapy or alteration in ventilator settings to manage corban dioxide content and to encourage the patient for breathing exercise.

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MODEL QUESTIONS IN GENERAL PHYSIOLOGY

LONG QUESTIONS

1. Explain different types of cell junctions. Add a note on CAMs.
2. Describe the mechanism of active transport of substances through cell membrane.
3. Describe the mechanism of passive transport of substances through cell membrane.
4. Explain homeostasis in the body with suitable examples.

SHORT QUESTIONS

1. Cell membrane.
2. Functions of cell membrane.
3. Proteins of cell membrane.
4. Endoplasmic reticulum.
5. Ribosomes.
6. Mitochondria.
7. Golgi apparatus.
8. Functions of nucleus.
9. Stem cells.
10. Cytoskeleton.
11. Implications and applications in nursing care for disorders caused by abnormal cells.
12. Tight junctions.
13. Gap junctions.
14. Cell adhesion molecules.
15. Sodium-potassium pump.
16. Factors affecting rate of diffusion.
17. Endocytosis.
18. Implications and applications in nursing care for disorders associated with transport across cell membrane.
19. Negative feedback.
20. Positive feedback.
21. Implications and applications in nursing care for disorders of homeostasis.

VERY SHORT ANSWER QUESTIONS

1. Integral proteins.
2. List the organelles present in cytoplasm.
3. Functions of lysosomes.
4. Functions of peroxisomes.
5. Apoptosis.
6. Necrosis.
7. Cellular necrosis.
8. Proteins of tight junctions.
9. Adherence junction.
10. Focal adhesion.
11. Desmosome.
12. Hemidesmosome.
13. Protein channels.
14. Facilitated diffusion.
15. Active transport vs facilitated diffusion.
16. Phagocytosis.
17. Exocytosis.
18. Transcytosis.
19. Components of homeostatic system.
20. Homeostatic imbalance.

MODEL MULTIPLE CHOICE QUESTIONS

1. **Multifactorial genetic disorder is:**
   A. Sickle cell anemia
   B. Turner's syndrome
   C. Down syndrome
   D. Diabetes

2. **Lysosome are:**
   A. Membrane-bound organelles in cytoplasm
   B. Formed by smooth endoplasmic reticulum
   C. Covered by single-layered lipid
   D. Contain lipolytic enzymes

3. **Serotonin is secreted in mast cells by:**
   A. Golgi apparatus
   B. Mitochondria
   C. Lysosomes
   D. Peroxisomes

4. **Mitochondria:**
   A. Have their own RNA
   B. Store lots of sodium ion in their matrix
   C. Have hydrolytic enzyme in their cristae
   D. Move within cytoplasm

5. **Chromosomes are:**
   A. Formed by two molecules of DNA as a double helix
   B. Always visible under microscope
   C. Visible only with electron microscope
   D. Derived from chromatin

6. **Junctional adhesion molecules are proteins present in:**
   A. Gap junction
   B. Tight junction
   C. Adherence junction
   D. Desmosome

7. **Connexins are involved in formation of:**
   A. Gap junction
   B. Tight junction
   C. Adherence junction
   D. Desmosome

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8. **Fencing function is possessed by:**
   A. Gap junction
   B. Tight junction
   C. Adherence junction
   D. Desmosome

9. **Integrins are involved in formation of:**
   A. Gap junction
   B. Tight junction
   C. Focal adhesions
   D. Desmosome

10. **Mechanically gated channels are present in:**
    A. Neuromuscular junction
    B. Synapse
    C. Pacinian corpuscle
    D. Ganglionic cells of retina

11. **Pinocytosis is:**
    A. A process of exocytosis
    B. Otherwise called cell drinking
    C. Otherwise called cell eating
    D. Tropomyosin

12. **Homeostatic imbalance is due to:**
    A. Stress
    B. Sleeplessness.
    C. Excess alcohol consumption
    D. All of the above

Answers

1. D	2. A	3. C	4. D	5. D
6. B	7. A	8. B	9. C	10. C
11. B	12. D			

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Essentials of Applied Physiology for NURSING Students

Salient Features

- Fulfils the requirements of nursing students and enables them to understand the essentials of physiology
- Fully updated with pathophysiological facts in accordance with the modern curriculum of nursing course
- Tables and figures formatted in a new attractive style to help students understand the contents easily
- Enriched with many boxes containing important facts on applied physiology
- Model Questions given at the end of each section will benefit the students to assess themselves and approach the subject with a clear idea
- The speciality of this book is inclusion of implications and applications in nursing care for almost all disorders.

K Sembulingam PhD is a renowned person in the field of Physiology. He has a long and vast experience of teaching Physiology to undergraduate and postgraduate medical students in various institutions in India and abroad. He had served MR Medical College, Kalaburagi, Karnataka, India; Sri Ramachandra Medical College and Research Institute, Chennai, Tamil Nadu, India; School of Health Sciences, Universiti Sains Malaysia, Kelantan, Malaysia; Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry, India; Sri Manakula Vinayagar Medical College and Hospital, Puducherry; Shri Sathya Sai Medical College and Research Institute, Nellikuppam, Tamil Nadu; and Madha Medical College and Research Institute, Chennai, Tamil Nadu. Currently, he is working as Visiting Professor at Datta Meghe Medical College, Nagpur, and Datta Meghe Institute of Higher Education & Research (Deemed to be University, Wardha, Maharashtra, India.

In addition to this textbook, he has published *Essentials of Medical Physiology*, *Essentials of Physiology for Dental Students*, and *Review in Medical Physiology*, which is like a pocketbook for quick revision before the examination. His interest and knowledge in research are commendable. He has published many papers in indexed scientific journals. He was the guide and supervisor for many PhD and postgraduate students in India and Malaysia. His fields of interest in research are Neuroscience, Stress Physiology, Antistressor Effects of Indigenous Plants, Fertility Control, and Evaluation of Autonomic Functional Status.

Prema Sembulingam PhD started her career as Lecturer in MR Medical College, Kalaburagi, Karnataka, India, and step-by-step gained a long and vast experience of teaching Physiology to undergraduate and postgraduate medical students by serving in various institutions in India and abroad. She worked as Professor of Physiology in Sri Ramachandra Medical College and Research Institute, Chennai, Tamil Nadu, India; School of Health Sciences, Universiti Sains Malaysia, Kelantan, Malaysia; Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry, India; Sathyabama University Dental College and Hospital, Chennai, Tamil Nadu; Sri Manakula Vinayagar Medical College and Hospital, Puducherry; Shri Sathya Sai Medical College and Research Institute, Nellikuppam, Tamil Nadu; and Madha Medical College and Research Institute, Chennai, Tamil Nadu.

She has co-authored all the books with Dr K Sembulingam. Her research experience is also commendable with many publications to her credit in indexed scientific journals. Her major field of interest in research is Evaluation of Autonomic Functional Status. Her other fields of interest are Neuroscience, Stress Physiology, and Antistressor Effects of Indigenous Plants.

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