Essentials of

APPLIED MICROBIOLOGY

for BSc Nursing Students

As per the Revised INC Syllabus

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MICROBIOLOGY
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Third Edition

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Dedicated to the Sweet Memories of
our Loving Daughter

Dr Hina Arora

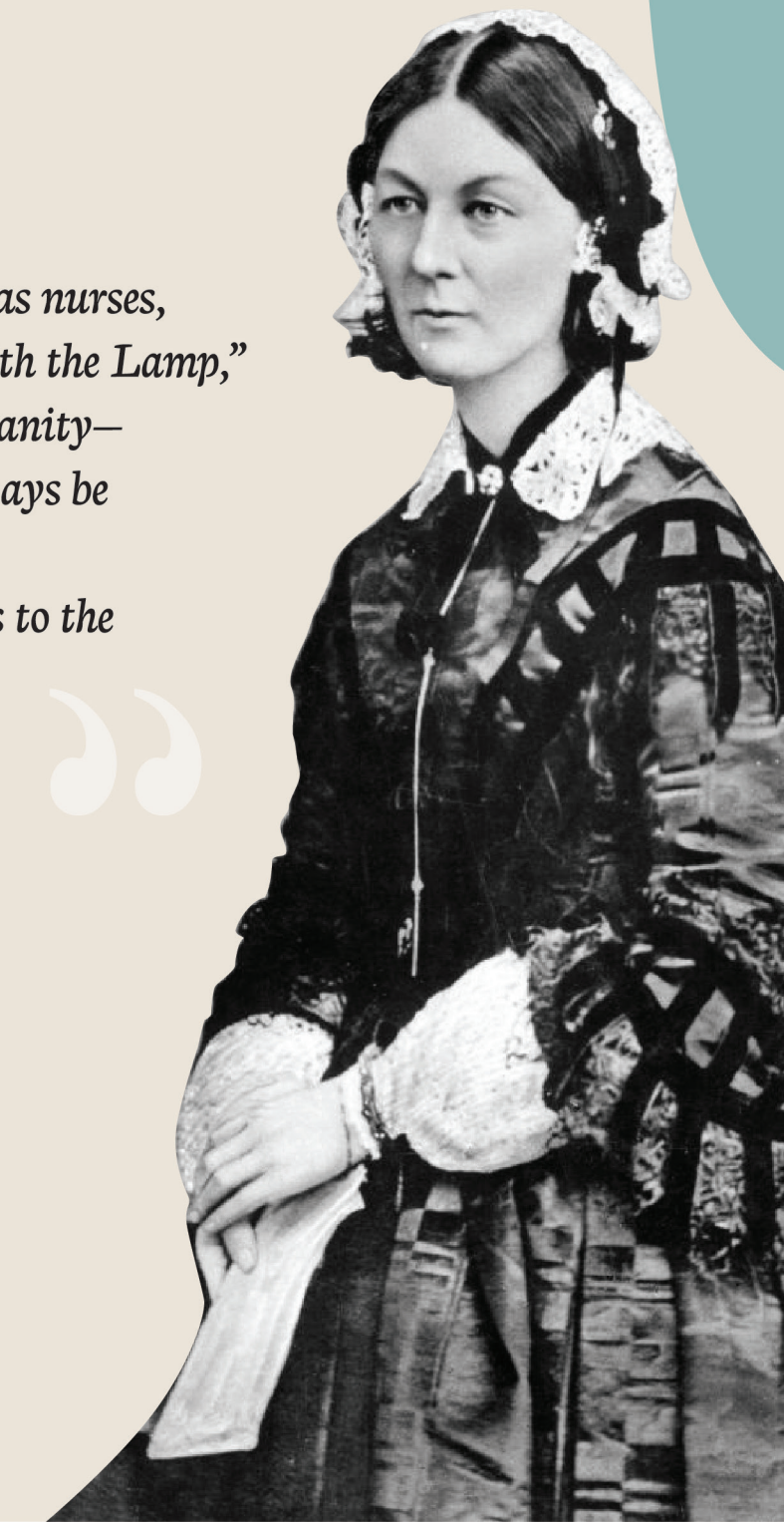
BDS, IDES 2001
09-04-1976 to 02-11-2009

CBS Nursing Knowledge Tree

Extends its Tribute to

Florence Nightingale

For glorifying the role of women as nurses,
For holding the title of " The Lady with the Lamp,"
For working tirelessly for humanity–
Florence Nightingale will always be
remembered for her
selfless and memorable services to the
human race.



Florence Nightingale
(May 1820 – August 1910)

Preface to the Third Edition

Infectious diseases account for nearly 26% of the total diseases in the world with an even higher prevalence in the developing countries. A sound knowledge of microbes responsible for these diseases is vital for understanding their epidemiology, pathogenesis, diagnosis, management and prevention. The emergence of new microbes and the diseases they cause, driven by changing environmental and ecological conditions, along with the threat of genetic engineering by terrorists, represents a significant challenge. The persistent problem of hospital-acquired infections (HAIs) among immunocompromised patients, coupled with the difficulty of their management and nonavailability of new antimicrobial agents, remains a major problem faced by the medical faculty. Microbiology lies at the core of these challenges, and nurses play a pivotal role in the prevention and control of HAIs.

It gives me immense pleasure to present the third edition of *Essentials of Applied Microbiology for BSc Nursing Students*, a comprehensive and student-friendly text designed to strengthen the foundation of nursing education in the field of microbiology. This third edition of the book is a thoroughly revised, fully colored edition, carefully structured into nine sections: Introduction, General Characteristics of Microbes, Infection Control and Safety, Pathogenic Organisms-I Bacteria, Pathogenic Organisms-II Viruses, Pathogenic Organisms-III Fungi, Pathogenic Organisms-IV Parasites and Medically Important Arthropods, Immunity, and Miscellaneous. All chapters have been written and arranged as per the latest Indian Nursing Council (INC) syllabus. Appendices on Immunization Schedule, Antibiotic Stewardship in Hospitals and Oncogenic Viruses have been added. The text is presented in a lucid manner to help students thoroughly imbibe the fundamentals of the subject. A picture speaks more than a thousand words. Keeping this fact in mind, all the diagrams have been redrawn and a number of colored photographs have been given wherever relevant, to enrich the learning experience of the students. The text has been interspersed with boxes that highlight the important information. Each chapter concludes with key points that enlist the highly important points of the chapter for quick revision. Assess Yourself section given at the end of every chapter contains Long and Short Answer Questions and MCQs to reinforce the subject and prepare students for examination.

I extend my special thanks to **Mr Satish Kumar Jain** (Chairman) and **Mr Varun Jain** (Managing Director), M/s CBS Publishers and Distributors Pvt Ltd for their wholehearted support in publication of this book.

Last but not least, I sincerely thank the entire CBS team for bringing out the book with utmost care and attractive presentation. I would like to thank Ms Nitasha Arora (Assistant General Manager – Publishing) and Dr Anju Dhir (Sr. Product Manager cum Commissioning Editor) for their publishing support. I would also like to extend my thanks to Ms Surbhi Gupta (Sr. Editor cum Team Lead), Mr Ashutosh Pathak (Assistant Production Manager cum TL) and all the production team members for devoting laborious hours in editing, designing and typesetting the book.

This book will be highly useful to BSc (N) and BSc (N) (Post Basic) students. It is also hoped that it will serve as a useful resource for the teachers of Microbiology. The readers are requested to send suggestions for improvement of the book which will be incorporated in the subsequent editions. Shortcomings, if any, may please be communicated at draroradr@rediffmail.com.

D R Arora

Preface to the First Edition

Microbiology is a valuable and useful discipline that offers an exhaustive view of an invisible world. One has only to pick up a newspaper to be struck by daily reminders of the impact microbiology has on the world around us, whether it be emerging diseases, the roles of viruses in cancer, the development of new vaccines, drugs, etc. As we look back over these past few years, one idea that sounds even truer than ever is an observation made by the renowned microbiologist Louis Pasteur, about 120 years ago:

Life would not long remain possible in the absence of microbes

With the revision of syllabus recently by the Indian Nursing Council, we felt a need to develop a textbook for nursing students that adheres to the syllabus thoroughly and can develop their interest in the subject as well. Every relevant development in the field of microbiology has been added in the chapters to keep the students abreast of the latest advancements. The text has been presented in a simple and lucid manner. Every chapter has been well illustrated with relevant fully colored diagrams, clinical photographs and photomicrographs to enhance the understanding of the students. All the important information in the chapters has been highlighted in separate boxes. Key points given at the end of each chapter summarize the most important points discussed in the chapter. *Assess Yourself* section that includes long and short answer questions as well as multiple choice questions has been given for quick review and recapitulation.

The primary goals of this textbook are to:

1. Involve you in the relevance and excitement of microbiology.
2. Help you understand the natural roles, structure, and functions of microorganisms.
3. Keep building your knowledge and facilitating your ability to apply the subject matter.

It is sincerely hoped that this textbook will be able to fulfill its goals and justify its name by bringing the essentials of the subject to the doorstep of every nursing student. The readers are requested to send suggestions for the improvement of the book at drararoadr@rediffmail.com. The suggestions and changes will be incorporated in subsequent editions.

We hope you enjoy reading this book, as much as we enjoyed writing it!

D R Arora

Special Features of the Book

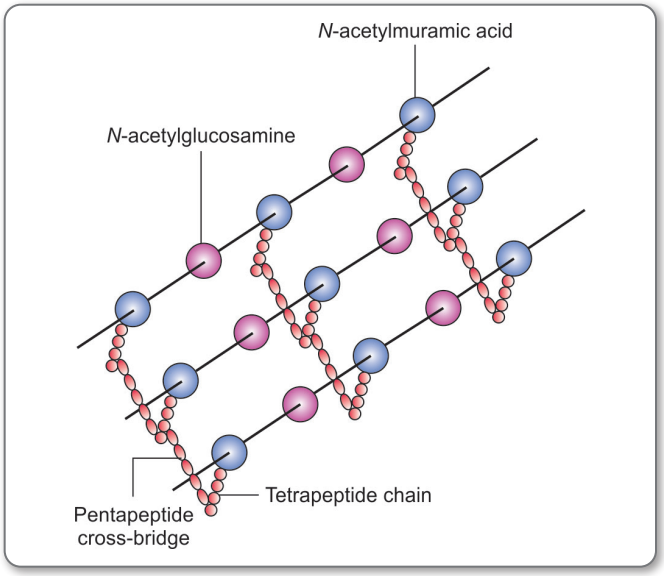


Fig. 2.4: Chemical structure of peptidoglycan.

Numerous tables are incorporated to supplement the text, and facilitate clear understanding of the concepts.

TABLE 8.2: Suggested infection control committee members

Hospital Director/Dean/Principal	Chairman
Microbiologist/Epidemiologist	Infection Control Officer
Chief of medical services	Member
Quality control/Assurance officer	Member
Heads of various clinical departments	Members
Head of pharmacy	Member
Head of support services	Member
Chief nurse	Member
Infection control nurses	Members

Supplemented with 200 + fully colored images and illustrations to enable easy and quick grasp of the relevant topic.

Additional information boxes have been incorporated throughout the text.

Nagler's reaction

A culture plate containing 6% agar, 5% peptic digest of sheep blood and 20% human serum or 5% egg yolk is prepared. The plate is dried. On one half of the plate, 2–3 drops of *C. perfringens* antitoxin are spread and allowed to dry. The plate is then inoculated with the test organisms or the exudate under study and incubated anaerobically at 37°C for 18 hours. On the section containing no antitoxin, *C. perfringens* colonies show surrounding zone of opalescence, i.e., Nagler's reaction whereas colonies of the remainder half of the plate show no change (Fig. 15.2).

Important terms and facts are presented to familiarize the readers with essential microbiological terminology.

Key Points

- *Hospital-acquired infection may be defined as an infection occurring in a patient in a hospital or other healthcare facility in whom the infection was not present or incubating at the time of admission. This includes infections acquired in the hospital but appearing after discharge, and also occupational infections among staff of the facility.*
- **Factors influencing nosocomial infection** include hospital environment, injudicious use of antibiotics, hospitalized patients with preexisting diseases such as diabetes, immunosuppression and patients with prosthetic implants, diagnostic or therapeutic intervention and blood and blood products used for transfusion.
- **Routes of transmission of infection** in hospital include contact spread, airborne spread, oral route, parenteral route and self-infection.
- *Every hospital should have* **antibiotic policy**, **disinfection policy** *and* **infection control committee**. *The functions of the latter include surveillance and control of infection and monitoring of hygiene practices.*

Assess Yourself section at the end of each chapter is designed to facilitate self-evaluation and analysis.

Assess Yourself

Long and Short Answer Questions

1. Discuss the pathogenesis of anthrax.
2. Discuss laboratory diagnosis of anthrax.
3. Write short notes on:
   (a) Malignant pustule
   (b) Prophylaxis of anthrax

Multiple Choice Questions

1. Koch's postulates were satisfied for the first time with:
   (a) *Bacillus anthracis*
   (b) *Clostridium tetani*
   (c) *Corynebacterium diphtheriae*
   (d) *Salmonella serotype* Typhi
2. 'Medusa head' appearance of the colonies is characteristic of:
   (a) *Proteus mirabilis*
   (b) *Clostridium tetani*
   (c) *Bacillus anthracis*
   (d) *Pseudomonas aeruginosa*
3. Malignant pustule is characteristic of:
   (a) cutaneous anthrax
   (b) pulmonary anthrax
   (c) intestinal anthrax
   (d) All of the above
4. An organism that can cause cutaneous infection and can be transmitted by spores is:
   (a) *Staphylococcus aureus*
   (b) *Streptococcus pyogenes*
   (c) *Yersinia pestis*
   (d) *Bacillus anthracis*

Answers to MCQs

1. a **2.** c **3.** a **4.** d

Syllabus

Applied Microbiology

Unit	Time (Hrs)		Learning Objectives	Content	Teaching Learning Activities	Assessment Methods
	Th.	Pr.				
I	3		Explain concepts and principles of microbiology and their importance in nursing.	**Introduction:** • Importance and relevance to nursing • Historical perspective • Concepts and terminology • Principles of microbiology	Lecture cum discussion	• Short answer questions • Objective type
II	10	10 (L/E)	Describe structure, classification, morphology, and growth of bacteria. Identify microorganisms	**General characteristics of microbes:** • Structure and classification of microbes • Morphological types • Size and form of bacteria • Motility • Colonization • Growth and nutrition of microbes • Temperature • Moisture • Blood and body fluids • Laboratory methods for Identification of microorganisms • Types of staining—simple, differential (Gram's, AFB), special—capsular staining (negative), spore, LPCB, KOH mount. • Culture and media preparation—solid and liquid. Types of media—semi synthetic, synthetic, enriched, enrichment, selective and differential media. Pure culture techniques—tube dilution, pour, spread, streak plate. Anaerobic cultivation of bacteria.	• Lecture cum discussion • Demonstration • Experiential learning through visual	• Short answer questions • Objective type
III	4	6 (L/E)	Describe the different disease producing organisms.	**Pathogenic organisms** • Microorganisms—Cocci—Gram-positive and Gram-negative; Bacilli—Gram-positive and Gram-negative • Viruses • Fungi—superficial and deep mycoses • Parasites • Rodents and vectors • Characteristics, source, portal of entry, transmission of infection, Identification of disease producing microorganisms.	• Lecture cum discussion • Demonstration • Experiential learning through visual	• Short answer • Objective type

Contd...

Unit	Time (Hrs)		Learning Objectives	Content	Teaching Learning Activities	Assessment Methods
	Th.	Pr.				
IV	3	4 (L/E)	Explain the concepts of immunity, hypersensitivity and immunization.	**Immunity** • Immunity—types, classification • Antigen and antibody reaction • Hypersensitivity reactions • Serological tests • Immunoglobulins—structure, types and properties • Vaccines—types and classification, storage and handling, cold chain, Immunization for various diseases. • Immunization schedule.	• Lecture • Discussion • Demonstration • Visit to observe vaccine storage • Clinical practice	• Short answers • Objective type • Visit report

Infection Control and Safety

Unit	Time (Hrs)		Learning Objectives	Content	Teaching Learning Activities	Assessment Methods
	Th.	Pr.				
I	2	2(E)	Summarize the evidence-based and effective patient care practices for the prevention of common healthcare associated infections in the healthcare setting.	**Hospital acquired infection (HAI)** • Hospital acquired infection • Bundle approach ▪ Prevention of urinary tract infection (UTI) ▪ Prevention of surgical site infection (SSI) ▪ Prevention of ventilator associated events (VAE) ▪ Prevention of central line associated blood stream infection (CLABSI) • Surveillance of HAI—infection control team and Infection control committee	• Lecture and discussion • Experiential learning	• Knowledge assessment-MCQ, Short answer type
II	3	4 (L/E)	Demonstrate appropriate use of different types of PPEs and the critical use of risk assessment.	**Isolation precautions and use of personal protective equipment (PPE)** • Types of isolation system, standard precaution and transmission-based precautions (Direct Contact, Droplet, Indirect) • Epidemiology and Infection prevention – CDC guidelines • Effective use of PPE	• Lecture • Demonstration and Redemonstration	• Performance assessment
III	1	2 (L)	Demonstrate the hand hygiene practice and its effectiveness on infection control.	**Hand Hygiene** • Types of hand hygiene. • Hand washing and use of alcohol hand rub • Moments of hand hygiene • WHO hand hygiene promotion	• Lecture • Demonstration and Redemonstration	• Performance assessment
IV	1	2 (E)	Illustrates disinfection and sterilization in the healthcare setting.	**Disinfection and sterilization** • Definitions • Types of disinfection and sterilization • Environment cleaning • Equipment cleaning • Guides on use of disinfectants • Spaulding's principle	• Lecture discussion • Experiential learning through visit	• Short answers • Objective type

Contd...

Unit	Time (Hrs)		Learning Objectives	Content	Teaching Learning Activities	Assessment Methods
	Th.	Pr.				
V	1		Illustrate on what, when, how, why specimens are collected to optimize the diagnosis for treatment and management.	**Specimen collection (review)** • Principle of specimen collection • Types of specimens • Collection techniques and special considerations • Appropriate containers • Transportation of the sample • Staff precautions in handling specimens	• Discussion	• Knowledge evaluation—quiz and performance assessment • Checklist
VI	2	2 (E)	Explain biomedical waste management and laundry management.	**Biomedical Waste (BMW) Management** *Laundry management process and infection control and prevention.* • Waste management process and infection prevention • Staff precautions • Laundry management • Country ordinance and BMW National guidelines 2017: Segregation of wastes, Color coded waste containers, waste collection and storage, packaging and labeling, transportation	• Discussion Demonstration • Experiential learning through visit.	• Knowledge assessment by short answers, objective type • Performance assessment
VII	2		Explain in detail about Antibiotic stewardship, AMR Describe. MRSA/MDRO and its prevention.	**Antibiotic stewardship** • Importance of antibiotic stewardship • Antimicrobial resistance • Prevention of MRSA, MDRO in healthcare setting	Lecture and discussion • Written assignment-Recent AMR guidelines	Short answers, Objective type • Assessment of assignment
VIII	2	4 (L/E)	Enlist the patient safety indicators followed in a healthcare organization and the role of nurse in the patient safety audit process.	**Patient safety indicators** • Care of vulnerable patients • Prevention of Iatrogenic injury • Care of lines, drains and tubings • Restrain policy and care—physical and chemical • Blood and blood transfusion policy • Prevention of IV complication • Prevention of fall • Prevention of DVT • Shifting and transporting of patients • Surgical safety • Care coordination event related to medication reconciliation and administration • Prevention of communication errors • Prevention of HAI • Documentation	• Lecture • Demonstration • Experiential learning	• Knowledge assessment • Checklist
IX	1	1 (E)	Captures and analyzes incidents and events for quality improvement.	**Incidents and adverse events** • Capturing of incidents • RCA • CAPA • Report writing	• Lecture • Role-play • Inquiry-based learning	• Knowledge assessment—short answers, objective type

Contd...

Unit	Time (Hrs)		Learning Objectives	Content	Teaching Learning Activities	Assessment Methods
	Th.	Pr.				
X	1		Enumerate IPSG and application of the goals in the patient care settings.	**International patient safety goals (IPSG)** • Identify patient correctly • Improve effective communication • Improve safety of high alert medication • Ensure safe surgery • Reduce the risk of healthcare associated infection • Reduce the risk of patient harm resulting from falls • Reduce the harm associated with clinical alarm system	• Lecture • Role play	• Objective type
XI	2	3 (L/E)	Enumerate the various safety protocols and its applications.	**Safety protocol** • 5S's • Radiation safety • Laser safety • Fire safety ▪ Types and classification of fire ▪ Fire alarms ▪ Firefighting equipment • HAZMAT safety ▪ Types of spill ▪ Spillage management ▪ MSDS • Environmental safety ▪ Risk assessment ▪ Aspect impact analysis ▪ Maintenance of temperature and Humidity (department-wise) ▪ Audits • Emergency codes • Role of nurse in times of disaster	• Lecture • Demonstration/ experiential learning	• Mock drills • Post-tests • Checklist
XII	1		Explain importance of employee safety indicators.	**Employee safety indicators** • Vaccination • NSI prevention • Fall prevention • Radiation safety • Annual health check	• Lecture • Discussion	• Knowledge assessment by short answers, objective type
XIII	1		Identify risk of occupational hazards, prevention and post exposure prophylaxis.	**Healthcare worker immunization program and management of occupational exposure** • Occupational health ordinance • Vaccination program for healthcare staff • Needle stick injuries and prevention • Post-exposure prophylaxis	• Lecture method • Journal review	• Short answer

Contents

Appendices

Appendix 1

Immunization Schedule

NATIONAL IMMUNIZATION SCHEDULE

National immunization schedule (NIS) for infants, children and pregnant women

Vaccine	When to give	Dose	Route	Site
For pregnant women				
TT-1	Early in pregnancy	0.5 mL	Intramuscular	Upper arm
TT-2	4 weeks after TT-1*	0.5 mL	Intramuscular	Upper arm
TT-booster	If received 2TT doses in a pregnancy within the last 3 years*	0.5 mL	Intramuscular	Upper arm
For infants				
BCG	At birth or as early as possible till one year of age	0.1 mL (0.05 mL until 1 month age)	Intradermal	Left upper arm
Hepatitis B-birth dose	At birth or as early as possible within 24 hours of birth	0.5 mL	Intramuscular	Anterolateral side of midthigh
OPV-0	At birth or as early as possible within the first 15 days	2 drops	Oral	Oral
OPV 1, 2 and 3	At 6 weeks, 10 weeks and 14 weeks (OPV can be given till 5 years of age)	2 drops	Oral	Oral
Pentavalent 1, 2 and 3	At 6 weeks, 10 weeks and 14 weeks (can be given till one year of age)	0.5 mL	Intramuscular	Anterolateral side of midthigh
Rotavirus#	At 6 weeks, 10 weeks and 14 weeks (can be given till one year of age)	5 drops	Oral	Oral
IPV	Two fractional doses at 6 and 14 weeks of age	0.1 mL	Intradermal two fractional dose	Right upper arm
Measles, Rubella (MR) 1st dose$	9 completed months – 12 months (can be given till 5 years of age)	0.5 mL	Subcutaneous	Right upper arm
JE-1**	9 completed months – 12 months	0.5 mL	Subcutaneous	Left upper arm

Contd...

Vaccine	When to give	Dose	Route	Site
Vitamin A (1st dose)	At 9 completed months with measles-rubella	1 mL (1 lakh IU)	Oral	Oral
For children				
DPT booster-1	16–24 months	0.5 mL	Intramuscular	Anterolateral side of midthigh
Measles/MR 2nd dose[$]	16–24 months	0.5 mL	Subcutaneous	Right upper arm
OPV booster	16–24 months	2 drops	Oral	Oral
JE-2	16–24 months	0.5 mL	Subcutaneous	Left upper arm
Vitamin A[***] (2nd to 9th dose)	16–18 months. Then one dose every 6 months up to the age of 5 years	2 mL (2 lakh IU)	Oral	Oral
DPT booster-2	5–6 years	0.5 mL	Intramuscular	Upper arm
TT	10 years and 16 years	0.5 mL	Intramuscular	Upper arm

[*] Give TT-2 or booster doses before 36 weeks of pregnancy. However, give these even if >36 weeks have passed. Give TT to a woman in labor, if she has not previously received TT.

[**] JE vaccine is introduced in select endemic districts after the campaign.

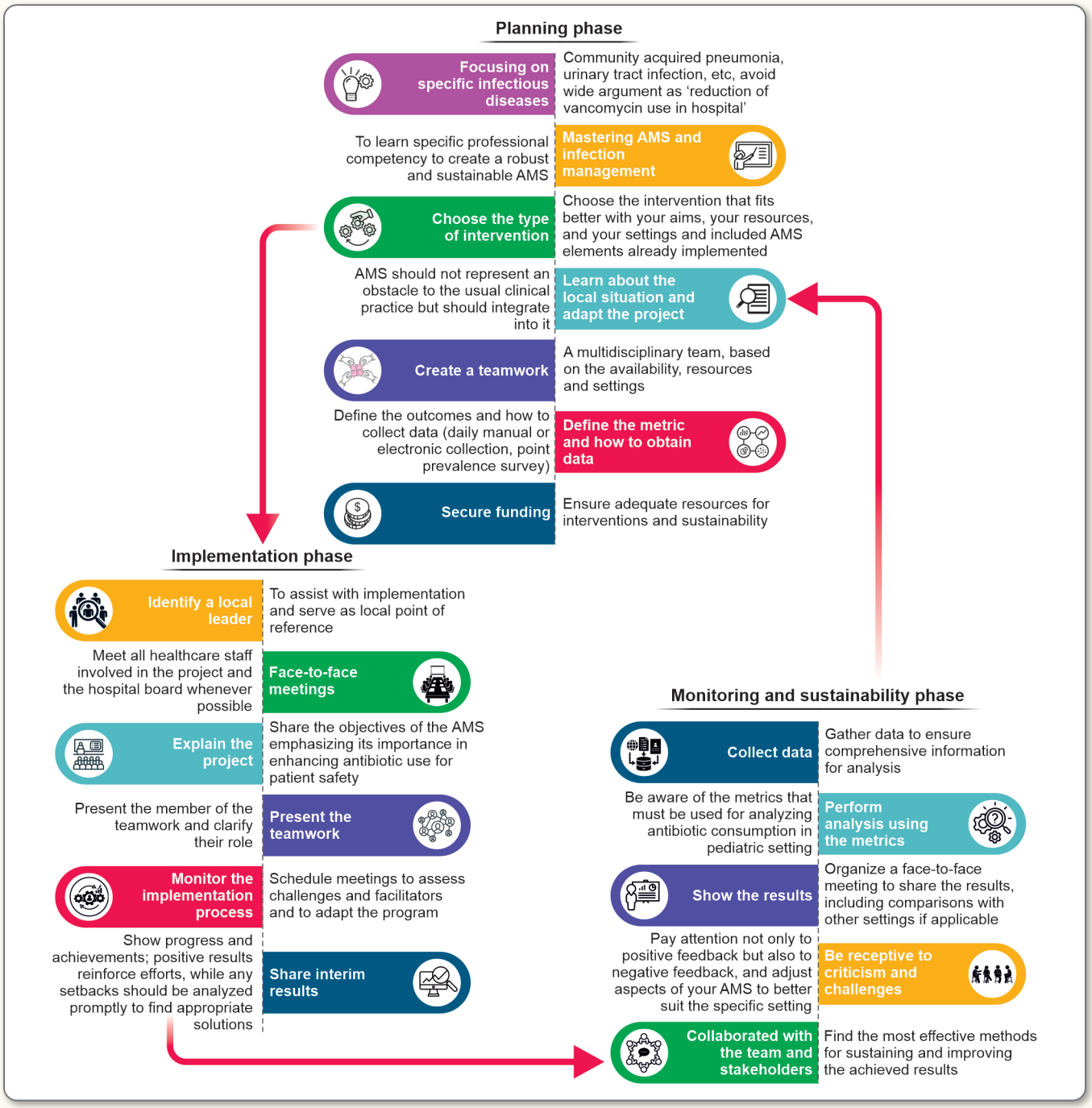
[***] The 2nd–9th doses of vitamin A can be administered to children 1–5-year-old during biannual rounds, in collaboration with ICDS.

[#] Phased introduction, at present in Andhra Pradesh, Haryana, Himachal Pradesh and Odisha from 2016 and expanded in Madhya Pradesh, Assam, Rajasthan, and Tripura in February 2017 and planned in Tamil Nadu and Uttar Pradesh in 2017.

[$] Phased introduction, at present in five states namely Karnataka, Tamil Nadu, Goa, Lakshadweep and Puducherry. (As of Feb' 2017).

Appendix 2

Antibiotic Stewardship in Hospitals



Appendix 3

Oncogenic Viruses

Viruses that produce tumors in their natural hosts or in experimental animals, or induce malignant transformation of cells on culture are known as oncogenic viruses. A limited amount of genetic information (one or a few viral genes) can profoundly alter the growth behavior of cells, ultimately converting a normal cell into a neoplastic one. Many studies have been done using cultured animal cells rather than intact animals, because it is possible to analyze events at cellular and subcellular levels. In such cultured cells, oncogenic viruses can cause '**transformation**'.

Cellular transformation may be defined as a stable, heritable change in the growth control of cells in culture. Changes associated with transformed cells include:

- **Alterations in cell growth patterns:** Increased rate of growth, decreased requirement for serum growth factors, decreased cell adhesion to a substrate, enhanced ability to grow in semisolid medium, and loss of 'contact inhibition'. Because of loss of contact inhibition, the transformed cells are no longer inhibited by contact with other cells, as normal cells are, but tend to pile up to form a 'focus'. Induction of foci provides the basis for a quantitative assay for certain tumor viruses.
- **Alterations in cell surface:** Increased rate of transport of cell nutrients, increased secretion of proteases and protease activators, increased agglutinability by plant lactins, and changes in composition of glycoproteins and glycolipids, sometimes including the presence of virus-encoded proteins.
- **Alterations in intracellular components and biochemical processes:** Increased metabolic rate, increased glycolysis, altered levels of cyclic nucleotides, activation or repression of certain cellular genes, presence of viral DNA, mRNA and viral coded proteins; and changes in cell cytoskeleton, often resulting in a more rounded cell shape.
- **Tumorigenicity:** Production of tumors when transformed cells are injected into appropriate test animals, especially immunologically deficient animals.

The development of a tumor is usually a rare outcome of virus infection but it has nevertheless been estimated that up to 20% of human tumors have a viral risk factor.

TYPES OF ONCOGENIC VIRUSES

All known oncogenic viruses either have a DNA genome (DNA viruses) or generate a DNA provirus (RNA viruses) after infection of cells. DNA tumor viruses belong to the families Papovaviridae, Herpesviridae, Hepadnaviridae and Poxviridae. With the exception of hepatitis C virus which belongs to the family Flaviviridae, all other RNA oncogenic viruses belong to the family Retroviridae.

ONCOGENIC VIRUSES ASSOCIATED WITH HUMAN NEOPLASIA

Virus family	Virus	Associated tumors
DNA viruses		
Papovaviridae	Human papillomaviruses	Genital tumors (cervical, vulvar and penile cancers), squamous cell carcinoma
Herpesviridae	Epstein-Barr virus	Nasopharyngeal carcinoma, Burkitt's lymphoma, B cell lymphoma, Hodgkin's disease, immunoblastic lymphoma
	Herpes simplex virus (types 2 and 1)	Cervical neoplasia
	Cytomegalovirus	Cervical neoplasia
	Human herpesvirus 8	Kaposi's sarcoma
Hepadnaviridae	Hepatitis B virus	Hepatocellular carcinoma
Poxviridae	*Molluscipoxvirus*	Molluscum contagiosum

Contd...

Virus family	Virus	Associated tumors
RNA viruses		
Retroviridae	Human T lymphotropic viruses HTLV-1, HTLV-2, and HTLV-5	Several leukemias, sarcomas, and lymphomas
Flaviviridae	Hepatitis C virus	Hepatocellular carcinoma

ONCOGENIC VIRUSES ASSOCIATED WITH ANIMAL NEOPLASIA

Virus family	Virus	Associated tumors
DNA viruses		
Papovaviridae	Bovine papillomavirus	Dermal and esophageal papillomas, and squamous cell carcinoma
	Polyomavirus of rodents	Mouse adenocarcinomas, fibrosarcomas
	Simian virus 40	Sarcoma (rodents)
Herpesviridae	Frog herpesvirus	Renal adenocarcinoma
	Marek's disease virus	Neurolymphomatosis (fowl)
Hepadnaviridae	Woodchuck hepatitis virus	Hepatocellular carcinoma (woodchuck)
Poxviridae	Shope fibroma virus	Fibroma (rabbit)
	Yaba virus	Nodular fibromatous hyperplasia (monkey)
Adenoviridae	Adenovirus types 2, 5, 12	Fibrosarcomas (hamster)
RNA viruses		
Retroviridae	Mouse mammary tumor virus	Mammary adenocarcinomas, T cell lymphoma
	Avian leukosis viruses Rous sarcoma virus	Various sarcomas, some carcinomas, lymphomas and leukemias
	Avian reticuloendotheliosis virus	Lymphomas and leukemias
	Murine leukemia and sarcoma viruses	Lymphomas, leukemias and sarcomas
	Feline leukemia and sarcoma viruses	Lymphosarcomas (mainly T cell), myeloid leukemias, fibrosarcomas
	Bovine leukemia virus	B cell leukemias

MECHANISM OF CARCINOGENESIS

- **Viral oncogenes:** Retroviruses carry RNA-directed polymerase (reverse transcriptase) that forms a DNA copy of the RNA genome of the virus. The DNA copy (provirus) becomes integrated into the DNA of the infected host cell and replicates.
- **Cellular oncogenes:** Proto-oncogenes are genetic sequences in the cell nuclei controlling normal cell growth. When a viral DNA is posed to a proto-oncogene, the latter can be activated. becomes a cellular oncogene (*C-onc*), a process termed insertional mutagenesis. Transduction and insertional mutagenesis require oncogenic viruses.
- **Oncogenes of DNA tumor viruses:** The transforming genes of the oncogenic DNA viruses bear dose relationship to cellular gene products. They are integral components of the viral genome and provide important functions early in replicative cycle.
- **Antioncogenes:** In addition to oncogenes, there are certain genes which have been found to reduce the frequency of genetic mutations. These are the suppressor genes or antioncogenes. Deletion of their suppression effect can lead to oncogenesis.

ONCOGENIC DNA VIRUSES

- **Papillomaviruses:**
  - **Papillomaviruses** cause cervical, vulvar and penile cancers and squamous cell carcinoma. Cancer of cervix uteri is one of the important cancers associated with human papillomavirus types 16 and 18.
  - **Polyoma virus** may cause tumors in immunodeficient individuals.
  - **Simian virus 40** causes subclinical infection in monkeys, but when inoculated into baby rodents it leads to tumor formation.

- **Herpes viruses:**
  - **Herpes simplex virus** (types 1 and 2) and *Cytomegalovirus* may be associated with cancer cervix. *Cytomegalovirus* infection has also been suggested to be associated with Kaposi sarcoma and carcinoma of prostate. Human herpesvirus 8 causes Kaposi sarcoma.
  - **Epstein-Barr virus** is associated with Burkitt's lymphoma, B cell lymphoma, immunoblastic lymphoma, nasopharyngeal carcinoma and Hodgkin's disease.
- **Hepatitis B virus:** It is associated with hepatocellular carcinoma.
- **Poxviruses:** *Molluscipoxvirus* causes molluscum contagiosum in humans.

ONCOGENIC RNA VIRUSES

Retroviruses

- **Human T lymphotropic viruses HTLV-1, HTLV-2, and HTLV-5** cause several leukemias, sarcomas, and lymphomas.
- **Hepatitis C virus** has been associated with hepatocellular carcinoma.