THIRD EDITION

The Pearson Guide to B.Sc. Nursing Entrance Examination

Includes 5 Model Test Papers 5,500+ MCQs

Dr Saroj Parwez

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The Pearson Guide to the

B.Sc. Nursing

Entrance Examination

Third Edition

Dr Saroj Parwez

PEARSON

Delhi • Chennai

Published by Pearson India Education Services Pvt. Ltd, CIN: U72200TN2005PTC057128, formerly known as TutorVista Global Pvt. Ltd, licensee of Pearson Education in South Asia.

ISBN 978-93-325-4550-2
eISBN 978-93-325-5892-2

Head Office: A-8 (A), 7th Floor, Knowledge Boulevard, Sector 62, Noida 201 309, Uttar Pradesh, India.
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For my beloved husband who plays

a vital role in making me what

I am

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FOREWORD TO THE FIRST EDITION

Dr (Mrs) INDERJIT WALIA, Ph. D.
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"Nursing is a special profession; in-built in it is the Golden Rule—Treat others the way you'd want them to treat you." I fully agree with this opening sentence aptly quoted by Dr Saroj Parwez. It sums up why nurses should be caring, sympathetic, responsible and detail-oriented. These qualities coupled with a formal university degree would make nurses efficient and confident, and enable them to direct or supervise others, correctly assess patients' condition and determine when consultation is required. Besides these traits, nurses also need to inculcate in themselves emotional stability to cope with human suffering, emergencies and other stresses.

It is heartening to see many youngsters aspiring to enter this profession. The demand for trained professionals in the industry has also increased manifold in India, and more and more institutes are now conducting entrance tests to select the best talent available to occupy their classrooms. Surely, this is good news for the nursing profession. Further, job opportunities for nurses within India and abroad, in all specialties, are expected to grow exponentially. In fact, the nursing profession is globally projected to create the second largest number of new jobs among all occupations. In addition, the number of older people who are much more likely to need nursing care in comparison to younger people is projected to grow rapidly.

The Pearson Guide to the B.Sc. Nursing Entrance Examination by Dr Saroj Parwez is a self-explanatory volume that helps aspirants prepare for the entrance examination for this course. Since the book adequately covers all the aspects of the test, I have no doubt that the book will be of immense help to students seeking admission in the best nursing institutes of India. With a national-level Common Entrance Test for B.Sc. Nursing becoming a near-future possibility, I am sure that a book of this nature will enhance the students' chances of clearing such tests in the first attempt.

To face the challenge of new trends in medical care services, aspirants must chart their course carefully and choose the best resource to equip themselves. Picking up this book is a good beginning.

All the best!

Dr Inderjit Walia
Ex-Principal
National Institute of Nursing Education

FOREWORD TO THE THIRD EDITION

Prof. Dr S.S. Gill
Vice Chancellor
Baba Farid University of Health Sciences
Faridkot (Punjab)

www.bfuhs.ac.in

Nursing is one of the most trusted and the fastest growing professions in the world. It is a career with a huge range of opportunities for anyone with a passion to make a difference. The range of nursing specialties is varied and a professional can work in government hospitals, nursing homes, urban corporate hospitals, defence services, nursing schools and colleges and many other avenues.

Therefore, a professional degree is a must for those who have chosen nursing as their career as it will help them advance towards their goals.

This new edition of *The Pearson Guide to the B.Sc. Nursing Examination* by Dr Saroj Parwez is a self-explanatory resource for all aspirants who are preparing to get admission in the elite nursing colleges in India. This book comprehensively covers most formats of written tests of different institutions and universities. I am sure that this book will help students get that coveted seat in the nursing institute of their choice.

I congratulate Dr Parwez for writing this book.

Dr S.S. Gill
Vice-Chancellor
Baba Farid University of Health Sciences

PREFACE TO THE FIRST EDITION

As a student, you must be aware of the importance of using the appropriate tools to learn and draw knowledge from extensive research. *The Pearson Guide to the B.Sc. Nursing Entrance Examination* is a cauldron of inputs from both extensive research and intense learning. One of the crucial features for the success of any book—and of the readers reading it—is the way in which it is conceived and developed. This book owes its existence to comprehensive research and scientific planning. You will find the result reflected in the content as well the structure of the book. Each section is narrow-sliced into various sub-sections comprising quick-reference material and formats of the questions generally asked in the examination from that particular section.

At the end of each section, a comprehensive Question Bank with adequate number of questions has been provided to help the readers test their knowledge of the subject.

A number of detailed tables and clear illustrations are used to support the concepts explained. Important information pertaining to the topic of discussion is provided as boxed items. These are cutting-edge info-bytes that make learning interesting and also add value to it. Five practice test papers are given in the last section of the book in the same format as seen in the entrance tests. These will provide sufficient help to students to gauge their preparedness.

We have developed a focused Web companion for this book, at *www.thorpeseducation.com,* which is available free of cost to the privileged owner of this book. It is a perfect preparation tool which offers serious candidates a chance to test their level of preparation by solving downloadable subject-oriented practice tests. Students will find this material extremely useful.

Creating *The Pearson Guide to the B. Sc. Nursing Entrance Examination* has been a team effort. Despite our best efforts to offer a quality product, we are sure that there is scope for improvement. I hope the readers will find this book useful and send us their comments and suggestions towards improving the text.

Readers may also submit their comments online. Such suggestions will go a long way in making this book error free in the coming editions.

Finally, I am thankful to my colleague and friend, Dr Inderjeet Walia, Principal, The National Institute of Nursing Education, for writing a foreword for the first edition of this book.

All the best!

Dr Saroj Parwez

PREFACE TO THE THIRD EDITION

This edition of *The Pearson Guide to the B.Sc. Nursing Entrance Examination* presents an indispensable resource for aspirants who want to earn the degree from reputed nursing institutes. It is heart-warming to see how well the first edition of this title was received by students and teachers in the test preparation domain. However, with the passing of each year, I felt the need to include new topics and questions in this book. Thus, I have made an effort to improve on the presentation of this book, while retaining the key features of the first edition.

The objective is to present the subject in a structured manner to familiarise candidates with the current trends and types of questions. New topics have been added, some of the existing ones have been rearranged and a few sections completely overhauled to suit the latest requirements of the students. The demand for a resource like this was being increasingly felt with the entrance examination becoming more and more competitive every year. Aspirants needed a book with sound pedagogy to help them in self-evaluation. This third edition of the book not only helps students to revisit the topics they had studied in their science syllabus (Physics, Chemistry and Biology) but also provides useful chapters on General Knowledge and English.

Nursing has always been India's largest and most successful profession in the field of healthcare. The tremendous growth in the Indian healthcare sector has created an immense demand for professionals with a university degree in nursing. With the advent of the B.Sc. Nursing course, this noble and responsible profession has become highly rewarding and immensely remunerative as well. This has propelled the Indian B.Sc. Nursing degree course to evolve to international standards and open greater employment opportunities, galvanizing fresher talents to the nursing profession. The demand for nursing professionals and progressive development of the nursing field is sure to continue; as can be witnessed from the world statistics data that projects nursing as among the fastest growing professions. Today, nursing professionals are employed in a wide variety of commercial, government and professional settings, which include corporate hospitals, government organisations, service organisations, advanced clinical specialties and educational institutions.

Almost all elite nursing institutions carry out admission tests to fill up their seats. I wish all students good luck to face their upcoming challenges and believe that this book will serve them well in achieving success.

I have also modified the contents of the focused Web companion for this book at *www.thorpeseducation.com*, which is available free of cost to the owners of this book. It is a perfect preparation tool which offers a chance to candidates to test their preparation levels by solving downloadable subject-oriented practice tests. I am certain that the users of this book will find it extremely useful.

Dr Saroj Parwez

About Nursing Education in India

PART 1

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UNIT 1

Introduction to Nursing Education in India

NURSING AS A PROFESSION

Nursing is a unique profession; the basic golden rule of nursing is *treat others the way you would want them to treat you* and this sums up why nurses should be caring sympathetic, responsible and detail oriented. Nursing is not only emotionally and possibly monetarily rewarding in the short term, but also carries the promise of long-term reciprocity. As a nurse, especially when you are well, you can and should do your best for those who are frail or unwell; because someday, if you become frail or unwell, you have to hope that others will do the same for you. Although a similar circle of 'instant karma' also holds between the doctors and the patients, the relationship is not as day-to-day or intimate. Of all the common relationships between the professionals and the people they serve, perhaps only teachers and students share the same kind of close and inevitable interchangeability that nurses and their patients have. Therefore, if you choose to be a good nurse, be a good student; if God or fortune smiles and when your time comes to be a teacher or a patient, you will not be disappointed by those who follow in your footsteps.

IS NURSING A CAREER FOR YOU?

Are you the kind of person who can be a good nursing student and then a good nurse? The following are some of the points you need to consider. Being able to help people with their health needs is a wonderful thing, and it is amazing, if you want to learn how to do that. However, there is more to education than mere diploma or degrees. Because nursing is a practical discipline, it is necessary that the nurses are prepared to be skilled and knowledgeable. Further, they should have a positive attitude for life learning and practice. However, the following points need to be taken into consideration:

- Spending long hours on your feet.
- Multitasking enough to care for six to ten patients at the same time.
- Prioritizing the care for the sickest patients first, rather than what you feel about the patients.
- Maintaining patients' privacy and confidentiality of their information.
- Treating the prisoner patients sometimes.

SCENARIO OF NURSING EDUCATION IN INDIA

Nursing education in India is regulated by the Indian Nursing Council that safeguards the quality of nursing education in the country through the prescription of syllabi, inspection, examination, certification and registration. Current courses in nursing are offered both at diploma and degree levels. It qualifies the following courses:

1. Female Health Worker Supervisor course of 6 months;
2. Multipurpose Health Worker Course of 1 year duration;
3. General Nursing Midwifery (GNM) Course of 3½ years and are all school-level courses;
   Qualification: 10+2 or equivalent with at least 45% marks. While science as a subject in 10+2 is not compulsory, some colleges do admit only science group students. The qualifying percentage of marks also varies from state to state; many colleges admit students having less than 45% as well.
4. B.Sc. nursing programmes for fresh candidates at the university level;
   Qualification: 10+2 or equivalent with at least 45% marks. The qualifying percentage required for admission at most colleges is minimum 45% of total marks and minimum 50% in Science. Science as a subject in 10+2 is compulsory at almost all colleges. Students who are joining B.Sc. Nursing after passing GNM are an exception.
5. Post-basic B.Sc. level, which is continuing education for practicing diploma nurses.

Apart from abovementioned points, next level of education in nursing is just like any other regular stream of education, such as M.Sc., M.Phil. and Ph.D. in nursing facilities. The qualification required is B.Sc. Nursing or equivalent.

This post-graduation course requires relevant graduation for qualifying. Most colleges have entrance tests to screen and short list eligible candidates for admission. Colleges issue application forms for the entrance well in advance.

1. To know more about the recognized B.Sc. Nursing Institutions in India, please visit http://www.indiannursingcouncil.org/pdf/bsc-recognized-Nursing-Institution.pdf on the website of the Indian Nursing Council (INC).
2. To know about the State-wise Distribution of Nursing Institutions and the Admission Capacity, please visit http://www.indiannursingcouncil.org/pdf/31-Oct-2012.pdf, on the website of the Indian Nursing Council (INC).
3. Admission Terms and Condition for admission to College of Nursing (revised from 2012 to 2013 Academic Year)
   For B.Sc. (Nursing):
   Eligibility criteria: 10+2 Class pass with 45% aggregate in PCBE
   Training duration: 4 Years
   Examination: University

   For B.Sc. (Post-basic Nursing)
   Eligibility criteria: 10+2 Class pass + GNM 2 years (for regular students); 10+2 Class pass + GNM 2 years + 3 years' experience (for distance-learning course students)
   Training duration: 2 Years
   Examination: University
4. Nurses' pledge are as follows:
   - I solemnly pledge myself before God and in presence of this assembly to practice my profession with dedication.
   - I will serve mankind with love and compassion, recognizing their dignity and rights irrespective of colour, caste, creed, religion and nationality.
   - I will endeavour to maintain up-to-date knowledge and skill to uphold standard of nursing care to individual, family and community in all settings and in all aspects of holistic care as a member of the health care team.
   - I will hold in confidence personal matters of my clients who are committed to my care and help them to develop confidence in the care rendered by me.
   - I will refrain from any activity that will harm my personal and professional dignity as a nurse.
   - I will actively support my profession and strive towards its advancement.
   - I will fulfil my responsibilities as a citizen and encourage change towards better health.

Introduction to the Written Examination

PART 2

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UNIT 1

About the Written Examination

ANATOMY OF THE WRITTEN EXAMINATION

The written test of B.Sc. Nursing entrance examination comprises three sections:

(i) Test of Life Sciences (Botany and Zoology)
(ii) Test of Physical Sciences (Physics and Chemistry)
(iii) Test of General Ability (English and General Knowledge)

The subjects of the papers, the time allowed and the maximum marks allotted to each paper are mentioned in the admission brochure/application form of each institute/university. However, the following table gives the five most frequently used formats of B.Sc. Nursing Entrance Examinations at various institutions/universities in India.

Formats	Subject Area	No. of Questions	Duration (in hrs)	Max. Marks
Format – I	Section – 1 (Biology)	25	2	100
	Section – 2 (Physics)	25		
	Section – 3 (Chemistry)	25		
	Section – 4 (General Ability)	25		
	TOTAL	**100**		
Format – II	Section – 1 (Life Sciences)	45	2	100
	Section – 2 (Physical Sciences)	50		
	Section – 3 (General Ability)	25		
	TOTAL	**120**		
Format – III	Section – 1 (Biology)	40	2	100
	Section – 2 (Physics)	30		
	Section – 4 (Chemistry)	20		
	Section – 5 (General Ability)	30		
	TOTAL	**120**		

Formats	Subject Area	No. of Questions	Duration (in hrs)	Max. Marks
Format – IV	Section – 1 (Biology)	50	2	250
	Section – 2 (Physics)	30		
	Section – 4 (Chemistry)	30		
	Section – 5 (General Ability)	10		
	TOTAL	**120**		
Format – V	Section – 1 (Biology)	55	2	200
	Section – 2 (Physics)	30		
	Section – 4 (Chemistry)	25		
	Section – 5 (General Ability)	10		
	TOTAL	**120**		

ANSWERS AND ANSWER SHEET EVALUATION

Methods of Showing Answers in Objective Type Multiple Choice Questions

Specimen Answer Sheet

Answer booklets are provided for all examinations. Particulars such as candidates' roll number and centre code are to be filled in the first using a ballpoint pen. This will be done on Side-1 of the answer booklet; further, the instructions for filling the biodata of the candidates in respective columns are also given.

On Side-2 of the answer booklet, 200 serial numbers (or more, depending on the number of questions set in the test) are provided. In front of each serial number, there will be five ovals or circles (◯) as shown in the following portion of specimen answer sheet:

How to Mark Answers

Each question is followed by answers that are serially numbered such as (1), (2), (3), (4) and (5) or (a), (b), (c), (d) and (e), which are illustrated on the specimen answer booklet given on pages 13 and 14. Then, using an HB pencil (not ballpoint pen or an ink pen), shade the appropriate oval, which has the correct answer, against the serial number of the question. Please note that the oval should be dark enough and should be filled in completely. For example, if the answer to question no. (2) is answer (5), then the answer had to be shaded as follows:

How to Change Answers

If you wish to change your answer, erase completely the already darkened oval by using a good quality eraser and then blacken the new oval, which has your revised answer number. Therefore, you have to carry at least two HB pencils sharpened at both ends, along with a good quality pencil eraser. While changing the answer, it is extremely essential to erase the earlier answer completely. If it is not erased clearly and completely, smudge will be left on the previously marked oval (as shown in the following example). Further, the answer for that question will be considered invalid, as it has two answers. Therefore, the question will be ignored, even if one of them is absolutely correct.

Oval no. (5), in which smudge left due to poor quality eraser, and the new answer in oval no. (4) will be read as two answers, and therefore, no credit will be given even if answer no. (4) happens to be the correct answer.

Very Important: Please note that H, 2H, HH and 3H pencils should not be used. The marks made by such hard pencils will be too light, as shown in the following example, and will not be read by the computerized machine, which evaluates the answer sheets.

If very soft pencils (drawing pencils) such as B, BB and 3B are used, marking will be too dark. In such cases, changing the answers will be difficult, as there will be some residual marks or smudge left in the previously marked answer, as shown in the following example:

Therefore, use only HB pencils. The following section discusses about the wrong methods of marking your answers or filling up the information.

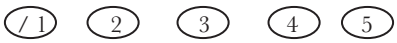
Some Examples for Wrong Methods of Marking Answers You have to ensure that you mark your answers only as mentioned above. The following are some of the methods that should not be followed while marking the answers:

1. Do not use the tick mark ✓

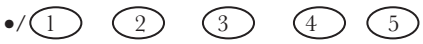
2. Do not use the cross mark ×

3. Do not use the dot mark •

4. Do not use the line mark /



5. Do not mark outside the oval



6. Do not leave half-filled oval

If any of the abovementioned methods are used, the answer sheet will not be evaluated, even if all questions have been attempted correctly.

How Your Answer Books are Evaluated

While the pass marks are fixed in university or degree examinations, which determine the candidates' division or grade, there are no pass marks fixed for competitive examinations. In a competitive test, it is merit that determines selection and the merit is governed by correct responses and the number of questions that have been attempted within the prescribed time.

In most cases, your answer booklet will be evaluated by a computer, which only reads correct answers; in other words, the ovals or circles (◯) those have been blackened with a pencil (as already discussed earlier). This machine is not equipped to judge the depth of your knowledge. It gives equal credit for both a difficult question or an easy one. Moreover, it gives equal credit for a guessed answer (where there is no negative marking) and a well-thought-out answer. The machine will only read the ovals or circles (◯) that have been blackened and each black oval or spot will be given one full mark, and no partial credit such 50% or 33.75% marks will be given. Therefore, consider the following points.

Remember, your merit in this test is determined by the number of questions you are able to answer and not on the depth of your knowledge. Therefore, your entire effort must be aimed at maximizing the total number of correct answers, without regard to any special question and without regard to the amount of thought that went into finding the answer. Therefore, try to pile up as many correct answers as you can, and as fast as you can, making sure that you cover all the sections of your Test Booklet.

TIPS FOR SURE SUCCESS IN TEST IN ENGLISH

Before Starting Your Test

Tip 1

Have a Overview of the Test Booklet: Take a few seconds to preview the test booklet instead of beginning to answer the question straightaway. This will give you an idea about what you are required to answer. Further, this will also make you to recognize certain familiar questions, which will boost your confidence and eliminate the fear.

Tip 2

Budget Your Composite Time: For all competitive examinations, there is a prescribed time limit or duration in which you have to attempt all the sections of the test paper. Therefore, budget your time by allocating fixed time periods for each section. Time is a very crucial factor for your success and it is very important that you budget your time carefully so that you are able to cover all the sections of your Test Paper.

After Starting Your Test

Tip 3

When You are Sure about the Answer: In objective type questions, if you recognize the correct choice, do not spend much time on other choices, which are necessarily incorrect. Mark the answer sheet with the choice that first 'hits' you.

Tip 4

Attempt Easy Questions First: At first, the participants should attempt all easy questions in all sections. As already said, all questions carry equal marks and attempting any difficult or hard questions does not give you any extra credit or extra mark. It is not necessary for you to spend even an extra second in answering a hard question, when there may be some easy questions left for you to answer. In other words, to increase your score, do not leave any easy questions at the cost of wasting your time on a difficult or hard question.

Tip 5

When You Come Across a Tough Question: If you come across a hard question, skip it straightaway and do not spend any time on it, but save that time for the next questions. Skipping hard questions helps you in two ways: (1) you will not leave any easy question unattempted at the cost of solving a difficult one, and (2) while attempting the next question, your subconscious mind may still be working on the hard question that you have skipped and there may be chances of you finding a correct answer in the meantime. Further, you will probably have time to return to the hard question later.

Tip 6

Speed is an Important Factor: Speed is an important factor in taking competitive examinations. Although accuracy is of prime importance, it is advisable to use time economically. If you cannot finish all the questions of a particular section of the test paper in the time you have earmarked for that section, do not panic. No one is expected to do all the questions correctly. It is wise to work as rapidly as possible without wasting any time on one particular question, as all questions carry equal marks.

Tip 7

When You Skip a Hard Question: If you skip any hard question, be sure to skip that serial number on the answer sheet also. Be sure that each answer marked is in the space numbered for the particular question you are answering in your test paper.

Tip 8

What about Intelligent Guessing?: There is no doubt and it is true that answers should be as accurate as possible, but probably true answers also count the same as absolutely sure answers. In both cases, you will get one mark in any case. If you are not sure of the correct answer but have some knowledge of the question and

are able to eliminate one or more of the answer choices as wrong, your chances of guessing the right answer are improved and it will be to your advantage to answer each question. Sometimes, intelligent guessing pays as the answer evaluating machine (in case answers are checked by a computer) or the examiner (if answers are checked manually) reads only the ovals you have blackened, without regard to whether you were sure or probably sure for an answer.

Caution: This is, however, not recommended in case negative marking has been specifically mentioned in the test.

Some Guessing Tricks: These are not specifically recommended, but may prove helpful in some cases, especially if there is no negative marking.

- It has been observed that mostly the correct answer choices are marked (c), (d) or (e) and/or (3), (4) and (5) and in very rare cases it is (a) or (b) and/or (1) or (2). Therefore, if you are making a guess and there is no negative marking, it is advantageous to choose any of the last choices as your guessed answer.
- If the answer you are guessing is in between two questions, which have identical responses as correct, do not choose the same number of response for your guessed answer. In other words, if the answer choices of the questions before and after the one you are going to guess is same, avoid choosing the same number. For example, if the answer choices of a question before and after the one you are guessing is (b), avoid marking (b) again as your guessed answer for the question in between the two questions till it is not absolutely sure and the correct choice.
- Do not leave the questions about which you are probably sure and you can eliminate one or more choices.

Tip 9

Save Fractions of Seconds: By attempting easy questions first, which may require less time to answer, you will be able to save fractions of seconds on each questions. Make use of those seconds to tackle and review the hard questions, which you have left unattempted.

Tip 10

Cover all Sections of the Test: As already mentioned, the test will have a minimum of four sections, each covering a different discipline. It is essential to tackle all the given sections. It will not pay if to answer all the questions of the first two or three sections and leave one or two sections totally unattempted. If you find that you are able to answer only 60%–65% questions of a particular section within the time you have earmarked from your total composite time for the entire test paper, go to the next section. It is much better to answer only 60%–65% questions of each section rather than leaving one section blank or unattempted. Hence, once you have attempted all the easy questions of one section, go to the next section without reviewing the hard or skipped questions of the first section now.

Towards the End of the Test

If there is some time before the supervisor announces the end of the test, spend the few remaining seconds or minutes as follows:

Tip 11

Check Unanswered Questions: Be sure that you have answered every question that you could. Make quick guesses now to answer the 'probably true' or 'may be correct' questions.

Tip 12

Check any Double Answers: Make sure that your answer sheet has only one response to each question. If at any place, through an oversight, two answer choices are marked, you will receive no credit, even though one of them may be absolutely correct. Carefully erase the double answers.

Tip 13

Check the Ovals: Ensure that the ovals or circles (◯) in your answer sheet are fully blackened as explained earlier. If required and you have extra time at your disposal, blacken them.

Tip 14

Check Your Roll Number/Code Numbers: Make sure that you have marked your roll number and code number correctly. It is always advisable to check it again before handing over the answer booklet to the supervisor.

Life Sciences

PART 3

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UNIT 1

Living and Non-Living

UNDERSTANDING LIFE

Origin of Life

The sun and its planets formed between 5 and 4.6 billion years ago as matter in our solar system. Due to the force of the gravity, they began to coalesce. By about 3.9 billion years ago, the Earth had an atmosphere containing the right mixture of hydrogen, oxygen, carbon, and nitrogen which where the fundamental essentials for the creation of life. Then these molecules organized and evolved to form the first simple forms of life. Before 3.8 billion years, conditions became right for the fossilization of the earth's early cellular life forms. These fossilized cells resemble present-day cyanobacteria. Such cells are known as prokaryotes. Prokaryotic cells are very simple, containing few specialized cellular structures and their DNA are not surrounded by a membranous envelope. The more complex cells of animals and plants, known as eukaryotes, first showed up about 2.1 billion years ago. Approximately 570 million years ago, an enormous diversification of multicellular life occurred known as the Cambrian explosion. During this period, all but one modern phylum of animal life made its first appearance on the earth.

Definition of Life

Scientists currently recognize four groups of biological entities:

(i) *Archaea* are single-celled organisms that are similar in app earance to bacteria. However, they are biochemically and genetically very different from bacteria. Many books and other forms of scientific literature refer to them as archaebacteria.

(ii) *Bacteria* are simple single-celled organisms that generally lack chlorophyll (an exception is cyanobacteria). Bacteria have a prokaryotic cell type. Bacteria such as Rhizobium spp. and cyanobacteria play an important role in fixing the atmospheric nitrogen. Without these bacteria, ecosystems would be severely short of nitrogen for plant and animal growth. The oldest fossils of life on earth are bacteria-like organisms.

(iii) *Eukaryote* are all organisms with a eukaryotic cell type. This group of life includes the kingdoms Protista, Fungi, Animalia and Plantae.

(iv) *Viruses* are fragments of DNA or RNA that depend on host cells that they infect for their reproduction. They are not cells. Viruses are thought to be parts of the genetic code. These code fragments contain enough genetic information for self-existence. At times, viruses are metabolically inert and technically non-living. In humans, they can cause smallpox, chicken pox, influenza, shingles, herpes, polio, Ebola, AIDS, rabies and some types of cancer.

These four main types of biological entities share some unique characteristics that can allow us to distinguish them from non-living things.

Living and Non-living

In addition, a living organism is able to maintain and even increase its own energy content. In contrast, dead organic matter tends to disintegrate as a result of the chemical and physical forces of the environment. In order to maintain themselves and prevent such disintegration, living organisms have an inbuilt self-regulating system to ensure that there is no net energy loss. This control is referred to as homeostasis and operates at all levels of biological organization from the molecular level to the community level.

Chemical Basis of Life

Living organisms and inanimate objects are all composed of atoms. These atom are arranged into more complex molecules and

the interaction of those molecules determines whether something is alive or not. Approximately 100 elements can be found on earth and in the rest of the universe. If you divide any element into its smallest part, you will have what we call an *atom*. An *element* is made up of one and only one type of atom (although trillions of these same atoms exist even in a tiny piece of the element).

Elements are arranged according to the number of *protons* they have in their nucleus. Thus, hydrogen, with only one proton, is the first element. The number of *electrons* equals the number of protons. Electrons are exchanged and shared in chemical reactions, but protons remain untouched during such reactions. The *neutrons* in the *nucleus* also remain untouched. The number of neutrons varies and along with the protons, they contribute to the mass of the atom. The electrons are so small that their mass is not included in the mass of the whole atom.

Molecules of Life

The molecules of life are most commonly made from a dozen or more elements. Because they very often contain carbon, they are also referred to as *organic molecules*. The most important biological molecules are lipids, proteins, carbohydrates, and nucleic acids.

Lipids are also called fats and they act as an energy reserve and as a protective cushion for vital organs. Sometimes, lipids will combine with other molecules to form important compounds. The membranes around cells are composed of molecules called *phospholipids*. Hormones such as oestrogen and testosterone are lipid-type molecules and they are known as *steroids*. Cholesterol is also a lipid-type molecule.

Proteins are complex molecules and represent about half of the dry weight of an animal's body. Proteins are made from a series of small molecules called *amino acids*. Proteins have two very valuable functions in living organisms. They form structures like muscles, bones, and other organs, and they are specialized molecules called *enzymes*. Enzymes are molecules that facilitate chemical reactions to make them more efficient. The enzymes are not used up in the chemical reaction and are not part of the final product.

Carbohydrates are made up of only carbon, hydrogen and oxygen. Carbohydrate molecules provide energy (although less than lipid molecules) and structural components of organisms (especially plants). The main type of carbohydrates is *sugars*, which provide abundant and quick energy for all cells. Brain cells are exclusively dependent upon a constant source of sugar molecules. Starch-type carbohydrates are more complex than sugars and are not soluble in water; thus, they act as a long-term storage depot of energy. In animals, this storage form of carbohydrate is called *glycogen* and is somewhat different in composition than the starch found in plants.

Cellulose is a special carbohydrate found in plants, and it is primarily responsible for the structural support of plants. Because many plants in the world have so much cellulose, it is one of the most abundant organic molecules on the earth.

Nucleic acids are large molecules made up of small molecules called *nucleotides*. The most familiar example of nucleic acids is the DNA molecule. DNA is *deoxyribonucleic acid* and is responsible for carrying and transmitting genetic information. Thus, nucleic acids are responsible for two of the hallmark characteristics of life: reproduction and evolution.

Life Performs Actions

One general way to view living things is to notice that they carry out functions and undergo changes, often self-directed. A rock may undergo changes during erosion, and it may even move in a stream or during an earthquake. However, none of these changes or movements is self-directed. The rock is passive and things happen to it.

A living organism moves when it needs to and performs a full range of other functions, some at a visible level (such as movement or eating) and others at a small, less visible scale (such as the chemical reactions of digestion or the changes in a neuron during nerve signal transmission). Therefore, in this sense, the level of complexity indicates whether something is living or not.

Life has Levels of Complexity

A television set or a computer may seem complicated, but each really consists of only a few chemical elements and a few dozen parts. Rocks, for example, are made of one or a few chemical elements. However, simple, single celled microorganisms like a bacterium is made of dozens of chemical elements and molecules. These molecules are built up into thousands of more complex molecules and form dozens of structures.

Large, multi-celled plants or animals (like ourselves) have a dizzying array of molecules and interrelated parts. Living things are based on cells, the smallest unit of life. These cells are grouped together to form *tissues*, as, for example, millions of liver cells grouped together form a liver tissue. Different tissues are grouped together to form an organ, so liver tissue, blood tissue, and connective tissue all combine to form the organ we call the liver. Many organs will be grouped together to form organ systems. For example, in a liver, we can group it with the intestines, the pancreas, and the stomach to form what we call the digestive system. This layering of ever-increasing complexity is a hallmark characteristic of life.

Life Reproduces Itself

Inanimate objects can last for a very long time and even appear to be indestructible. Living things do not last forever; they wear out or die. However, life continues because organisms can reproduce. New organisms (offspring) are produced when the original organisms (parents) reproduce. Although the parents will die, their offspring will produce even more offspring to continue life.

Even if you break a rock into half, you do not really have more rocks; you just have two pieces instead of one. Further, the rock does not decide to break itself; the action is not self-directed as in the reproduction of living organisms. Thus, another indicator of life is the ability to reproduce.

Life Reacts to Environmental Stimuli

Living organisms are irritable; they can take notice even a small disturbance. When the environment provides a stimulus, an organism can react to it. Environmental stimuli can be the changes in temperature, light, moisture, or many other variables. Inanimate matter like a rock totally lacks the ability to do this. At best, a rock undergoes some simple change in the position (when a strong water current moves it), or it undergoes simple changes in the chemical composition (when it crumbles during freezing and thawing).

Animals continually respond to stimuli by moving, migrating to a different place for a whole season, running, hiding, seeking or building shelter, and in thousands of other ways. Thus, irritability or the ability to react to an environmental stimulus is another hallmark characteristic that differentiates life from nonlife.

Life Evolves

An organism's ability to respond to its environment can be very valuable. Organisms that are good at doing this will be more likely to survive and reproduce more offspring. When such successful organisms reproduce, they will pass their characteristics on to their offspring. These offspring will also survive well. Organisms that do not react well to their surroundings will most likely die and not reproduce as often. As this slow process continues for a long time, we will see changes in whole populations of organisms. This change over time will result in the evolution of new populations. Thus, the process of evolution is another distinct characteristic of living beings. Inanimate objects do not engage in this survival of the fittest type of evolution.

CLASSIFICATION AND TAXONOMY

Systems of Classification

Life first appeared on earth as very simple, very tiny microorganisms. These creatures were mostly groups of organic molecules surrounded by a membrane. However, they could feed themselves in some fashion and were able to grow and reproduce. Gradually, over time and through the process of evolution, organisms assumed new forms. Eventually, life on earth developed into many diverse forms and formed complex relationships.

We have been able to organize life into five large groupings called *Kingdoms*. Each kingdom contains organisms that share significant characteristics that distinguish them from organisms in the other kingdoms. The five kingdoms are Animals, Plants, Fungi, Protists and Bacteria.

Linnaeus System of Classification

The term species has its origin in the ancient Latin language, in which it means kind. A more technical definition of species is a group of interbreeding organisms that do not ordinarily breed with members of other groups. Biologists estimate that about 10 – 40 million different species inhabit the earth. Of these species, approximately 1.5 million have been classified yet.

Classification is grouping things together on the basis of certain features, and the science of classification is called taxonomy. Taxonomy has two branches: nomenclature (the naming of the organisms) and systematics (the placing of organisms together).

A swedish naturalist Carl Linnaeus was the first individual to propose an orderly system for classifying the variety of organisms found on our planet (1707–1778) in 1753 AD. Linnaeus suggested that every organism should be classified with a unique binomial name. The first term in this system is the organism's generic name or Genus (beginning with upper case). The second term is the organism's specific name or species designation(beginning with lower case). For example, humans are biologically named Homo sapiens: the genus is Homo and the species is sapiens. Many a times, the genus name for humans is abbreviated as H. sapiens.

The order of nomenclature for a few organisms is illustrated below.

Classification	Frog	Dog	Man
Kingdom	Animalia	Animalia	Animalia
Sub-kingdom	Metazoa	Metazoa	Metazoa
Phylum	Chordata	Chordata	Chordata
Sub-phylum	Vertebrae	Vertebrae	Vertabrae
Class	Amphibia	Mammalae	Mammalae
Order	Anura	Carnivora	Primate
Family	Ranidae	Canidae	Hominidae
Genus	Rana	Canis	Homo
Species	pipiens	familiaris	sapiens

Modern Classification Systems

Modern classification systems are much more complicated having many levels of hierarchical organization. These systems are also taxonomic (structural and physiological connections between organisms), and phylogenetic (classification based on genetic connections between organisms), and they are structurally based on Darwin's theory of evolution that go from general to specific. The table given in the following section describes the detailed classification of the tree red maple. Note that each level of organization is based on some biological characteristics that the organism possesses.

Levels of Classification A grouping as large as a kingdom is not very specific and contains organisms defined by broad characteristics. Other levels of classification become gradually more specific until we define an actual specific organism. To classify organisms, we generally start out by grouping them into the appropriate kingdom. Within each Kingdom, we further subdivide organisms into other groupings. As an example, let us take the wolf.

Kingdom	Animal
Phylum	Chordates (This means the wolf had a notochord that developed into its backbone.)
Class	Mammals (This means the wolf has hair, bears live young, and nurses them with mammary glands.)
Order	Carnivores (This means the wolf is a meat eater.)
Family	Canids (This means the wolf has nonretractable claws, a long muzzle, and separatetoes.)
Genus	Canis (This means the wolf is a member of the dog family.)
Species	lupus (This refers to a particular type of wolf known as the European wolf.)

The previous categories form the most common scheme for classifying organisms, although other groupings and other categories are often used. The reason for developing a classifying system is that we have consistency in how we refer to an organism. If we didn't have this system, then the European wolf described previously would be called wolf in English, *lobo* in Spanish, and *loup* in French. This leads to confusion and a loss of scientific accuracy.

Binomial Nomenclature The system illustrated here is based on a system developed by Carlos Linneaus. It is called *binomial nomenclature* because in this system, any organism can be positively identified by two Latin words. The other words used previously illustrate where the named organism fits into the whole scheme, but it is only the last two, the Genus and species words that specifically name an organism. The Genus name is always capitalized and written in italics, whereas the species name is written lowercase but also in italics.

Thus, the European wolf is *Canis lupus Canis familiaris* is the common dog, *Felis tigrina* is a tiger, *Felis domesticus* is a common cat, and humans are *Homosapiens*.

Other Important Types of Classifications

Artificial Classification It is based on one or a few easily observed characteristics and is usually designed for practical purpose with an emphasis on convenience and simplicity.

Category	Name	Characteristics
Kingdom	Plantae	Organisms with rigid cell walls and those that possess chlorophyll
Sub-kingdom	Embryophyta	Plants forming embryos
Phylum	Tracheophyta	Vascular Plants
Sub-phylum	Pterophytina	Large, conspicuous leaves, complex vascular system
Class	Angiospermae	Flowering plants, seed enclosed in ovary
Sub-class	Dicotyledoneae	Embryo with two seed leaves
Order	Sapindaies	Soapberry order consisting of a number of trees and shrubs
Family	Aceraceae	Maple family
Genus	Acer	Maples and box elder
Species	rubrum	Red Maple

Natural Classification It tries to use natural relationships between organisms. It considers more evidence than artificial classification, including internal as well as external features.

Phylogenetic Classification It is based on evolutionary relationships. In such a system, organisms belonging to the same groups are believed to have common ancestors. The phylogeny (evolutionary history) of a group can be shown by means of a family tree.

Feature	Prokaryotes	Eukaryotes
Organisms	Bacteria	Protista, fungi, plants and animals
Kingdom	Monera	Protista, fungi, Plantae, Animalia
Form	Mainly unicellular	Mainly multicellular (except Protista, many of which are unicellular)
Cell size	Average diameter: 0.5–10 mm	10–100 mm; commonly 1,000–10,000 times bigger than prokaryotic cells
Cell division	Mostly binary fission no spindle	Mitosis, meiosis, or both; spindle form amino acids; murein is the main strengthening compound
DNA location	DNA is circular; lies free in cytoplasm (no true nucleus)	DNA is linear; contained in a nucleus
DNA form	DNA is naked (not associated with proteins or RNA to form chromosomes)	DNA is associated with proteins and RNA to form chromosomes
Cell walls	Rigid and contain polysac-charides with amino acids; murein is main strengthening compound	Cell walls of green plants and fungi rigid and contain poly saccharides; cellulose is the main strengthening compound of plant walls and chitin in fungal walls (non in animal cells)

Feature	Prokaryotes	Eukaryotes
Respiration	Mesosomes in bacteria, except cytoplasmic membrane in blue-green	Mitochondria for aerobic respiration
Photosynthesis	No chloroplast; takes place on membranes that show no stacking	Chloroplasts containing membranes, which are usually stacked into lamellae or gamma
Nitrogen fixation	Some have the ability	None have the ability
Evolutionary origin	3.5 thousand million years ago	1.2 thousand million years ago; evolved from prokaryotes

Phenetic Classification If there is little or no fossil evidence, it can be very difficult and very controversial to establish evolutionary relationships. Phenetic classification is based solely on observable characteristics, and all characteristics used are considered of equal importance.

Numerical Taxonomy Computer-assisted taxonomy is known as numerical taxonomy.

Five Kingdoms

Traditionally, all living organisms were classified under two main kingdoms: the plant kingdom and the animal kingdom. In 1969, R H Whittakar classified all living organisms into five main kingdoms and this is now receiving wide acceptance. According to the system, the five kingdoms are:

(i) Monera (true-bacteria, blue-green algae);
(ii) Protista (golden algae, yellow-green algae);
(iii) Fungi (slime moulds, bread moulds, sac fungi);
(iv) Plantae (plants);
(v) Animalae (animals).

Prokaryotes and Eukaryotes

According to Margulis and Schwartz, all cellular organisms seem to fall into two groups: prokaryotes and eukaryotes. The terms prokaryotes and eukaryotes refer to difference in location of the DNA (the genetic material). In prokaryotes, the DNA is not enclosed by nuclear membranes and lies free in the cytoplasm. Therefore, the cell lacks true nuclei (pro means before and karyon means nucleus). However, the cells of eukaryotes do contain nuclei (eu means true). The eukaryotes have evolved from prokaryotes. The evolutionary relationships between the five kingdoms and the trend towards multicellular organisms, the first appearing among the Protista, is shown in Figure 3.1.

Kingdom Monera

The Monera are a biological kingdom, including all living things that have a prokaryotic cell organization. Moneran cells lack specialized parts called organelles and thus differ from other living cells. Reproduction is asexual, by simple cell division. For these reasons, many biologists classify Monera as a separate kingdom. Some classify monerans as part of either the protist or plant kingdom. Prior to its creation, these were treated as two separate divisions: the Schizomycetes or Bacteria, including most prokaryotes and considered fungi, and the Cyanophyta or blue-green algae. The latter are now considered a group of bacteria, typically called the cyanobacteria. Recently, DNA and RNA sequence analysis has demonstrated that there are actually two major groups of prokaryotes, the Bacteria and Archaea, which do not appear to be closer in relationship to each other but they top the eukaryotes. These may be treated as subkingdoms, but most new schemes tend to abandon the Monera and treat these as separate domain or kingdom.

Classification of Monera Kingdom

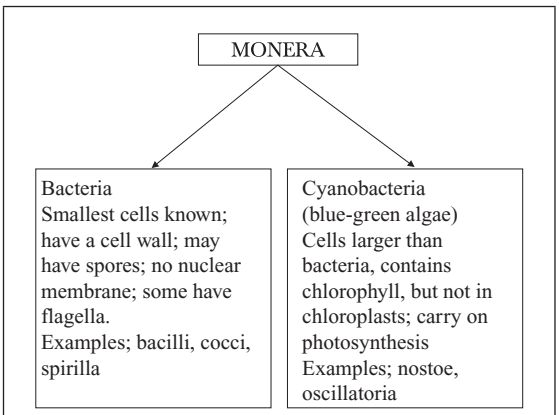

Fig. 1 *Monera Kingdom*

Bacteria

Bacteria are the most ancient group of organisms, having appeared about 3,500 million years ago, and they are the smallest organisms with a cellular structure. Bacteria range between the lengths of 0.1 – 10 μm. Their average diameter is about 1 μm. They occupy many environments such as soil, dust, water, air, in and on plants and animals.

Nearly, all kinds of bacteria are enclosed by a tough protective layer called the cell wall. The cell wall gives the bacterium

its shape and protects it in a wide range of environments. Some species are further enclosed by a 'capsule'—a slimy layer outside the capsule makes the cell wall resistant to destructive chemicals. All bacteria have a cell membrane, an elastic, bag-like structure just inside the cell wall. Small molecules of food enter the cell through pores in this membrane, but large molecules cannot pass through. Inside the membrane is cytoplasm, a soft jelly-like substance. The cytoplasm contains chemicals called enzymes, which helps to breakdown food and build cell parts. Like the cells of all living things, bacterial cells contain deoxyribonucleic acid (DNA). DNA controls a cell's growth, reproduction, and all other activities. The DNA of a bacterial cell forms an area of the cytoplasm called the nuclear body. In all other organisms except the blue-green algae, the DNA is in nucleus, a part of the cell separated from the cytoplasm by a membrane. Other parts of bacteria's cell structure are: mesosomes—unfoldings of the cell surface membrane; ribosomes—the sites for protein synthesis; pilus—the numerous fine protein rods that are concerned with attachment to specific cells or surfaces; plasmids—small, self-replicating circles of extra DNA processing a few genes that give extra survival and flagellum—the tail-like structure enabling the movement of bacteria cells.

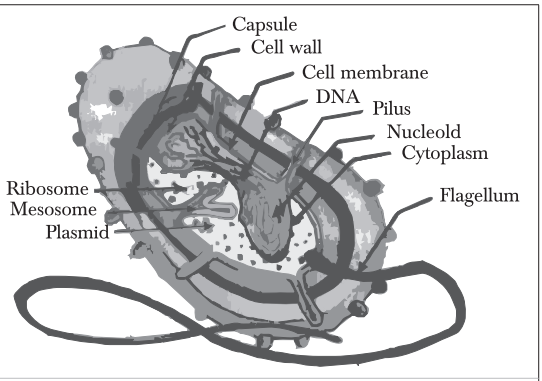

Fig. 2 *The Structure of Bacteria*

Historical Development in the Field of Bacteriology

The study of bacteria is called *Bacteriology.* The Dutch microscope maker Antoni Van Leeuwenhoek became the first person to systematically study bacteria. French biologist Louis Pasteur, who showed that microbes do not arise from non-living matter, and German scientist Robert Koch, who showed the bacteria could cause disease. In 1940s, the American scientist Selmen Waksman discovered a wide range of soil bacteria that produce antibiotics. Till then, the bacteria were considered microscopic fungi (called Schizomycetes), except for the photosynthetic cyanobacteria, which were considered a group of algae (called Cyanophyta or blue-green algae). It was only with the study of detailed cell structure that it was realized that they formed a fundamental group, separate from the other organisms. In 1956, Copeland gave them their own kingdom Mychota, later named Monera, Prokaryota, or Bacteria. During 1960s, the concept was redefined and bacteria (now including cyanobacteria) were recognized as one of two major divisions of the living world, together with the eukaryotes. Eukaryotes were generally believed to have evolved from bacteria, later from assemblies of bacteria.

The advent of molecular synthesis challenged this view. In 1977, Woese divided the prokaryotes into two groups called the kingdom eubacteria and archaebacteria. He argues that each of these and the eukaryotes all evolved separately, and in 1990, he emphasized this by promoting them to domains, which were renamed as Bacteria, Archaea, and Eukarya. This redefinition has generally been accepted by molecular biologists but criticized by some others, who maintain that he over-emphasized a few genetic differences and that both archaebacteria and eukaryotes probably developed within the eubacteria.

Importance of Bacteria

(i) *Helpful Bacteria:* Certain types of bacteria live in the intestines of human beings and other animals. These bacteria help in digestion and also produce vitamins for the body. Bacteria that live in soil and water play a vital role in recycling carbon, nitrogen, sulphur and other chemical elements used by living beings. Many bacteria help decompose (break-down) dead organisms and animal waste into chemical elements; others help change chemical elements into forms that can be used by plants and animals. For example, certain bacteria convert nitrogen in the air and soil into nitrogen compounds that can be used by plants. This is called the nitrogen cycle. Other uses include fermentation—a chemical process caused by bacteria—to make alcoholic beverages, cheese, etc. Sewage treatment plants use bacteria to purify water. Bacteria is also used in making drugs.

(ii) *Harmful Bacteria:* Some bacteria cause diseases in humans preventing the body from functioning properly by destroying healthy cells. Only a small fraction of the thousands of species of bacteria on earth cause diseases in humans. Bacterial infection can be prevented by killing bacteria by heat, as in sterilization and pasteurization. If a bacterial infection does occur, doctors may treat it with antibiotics.

However, overuse of antibiotics in recent years has enabled the development of strains of bacteria that are resistant to antibiotics, such as Mycobacterium tuberculosis, which causes tuberculosis.

Reproduction in Bacteria

Bacteria reproduce only asexually, not sexually. Specifically, they are reproduced by binary fission or simple cell division. During this process, one cell divides into two daughter cells with the development of a transverse cell wall. However, independent of sexual reproduction, genetic variations can occur within individual cells through recombinant events such as mutation

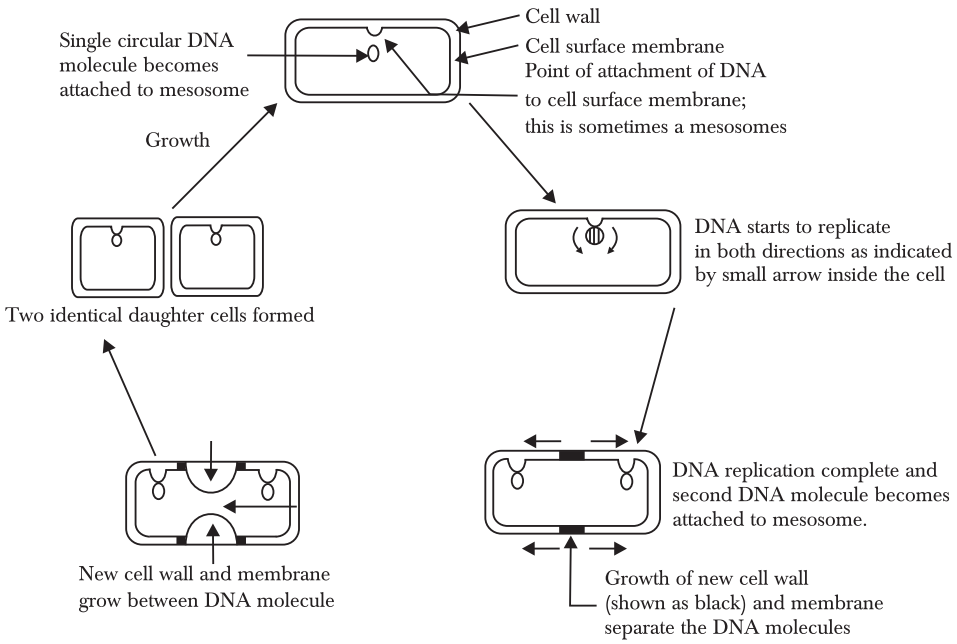

Fig. 3 *Binary Fission in a Bacterium, E. coil*

(random genetic change within a cell's own genetic code). Similar to more complex organisms, bacteria also have mechanisms for exchanging genetic material. Although not equal to sexual reproduction, the end result is that the bacterium contains a combination of traits from two different parental cells. Through mixing genetic material, bacteria develop new traits, including the ability to withstand acidity and high temperature and acquire resistance to antibiotics. Three different modes of exchange have thus far been identified in bacteria:

1. *Transformation*: The transfer of naked DNA from one bacterial cell to another in solution (this can include dead bacteria);
2. *Transduction*: The transfer of viral, bacterial, or both bacterial and viral DNA from one cell to another via bacteriophage;
3. *Bacterial conjugation*: The transfer of DNA from one bacterial cell to another via a special protein structure called a conjugation pilus.

Many bacteria harbour plasmids that contain extrachromosomal DNA. Under favourable conditions, bacteria may form aggregates visible to naked eyes, like bacterial mats.

Nutrition in Bacteria

Most types of bacteria are heterotrophic bacteria, that is, they feed on other organisms. Some species, known as autotrophic bacteria, manufacture their own food. For example, photosynthetic bacteria make food from carbon dioxide, sunlight and water. Certain bacteria are both autotrophic and heterotrophic, depending upon the food available. The majority of heterotrophic bacteria feed on dead organisms. Such bacteria are called saprotrophic bacteria. Saprotrophic bacteria and fungi constitute the decomposers and are essential in bringing about decay and recycling of nutrients. Bacteria that use light to synthesize their organic requirements are called phototrophs and those that use chemical energy are called chemotrophs.

Cyanobacteria

Cyanobacteria or blue-green algae is a photosynthetic bacteria that contains chlorophyll. For many years, they were classified in the plant kingdom along with algae, but discoveries made possible by electronic microscope and new biochemical techniques have shown them to be prokaryotes more similar to bacteria than to plants, and they are now placed in the kingdom Monera. Cyanobacteria are familiar to many as a component of pond scum.

Nitrogen-fixing cyanobacteria need only nitrogen and carbon dioxide to live. It is believed that the first chloroplasts were ancient cyanobacteria that were taken up by other cells. These bacteria have chlorophyll, and use two photosystems that split water and yield oxygen gas like a plant's photosynthesis. They lack flagella and can be single, colonial or multicellular, with a division of labour similar to that may have produced the first true multicellular species. They are usually present in water that has been polluted, often with phosphates and nitrates from runoff, because they thrive in water that has extra nutrients in it, and often explode in 'algal blooms'.