RRB

Railway Recruitment Board

Junior Engineer

CBT-2 : 2024

Computer Based Test - Stage II

General Awareness and Science & Technology

Comprehensive Theory *with* Practice Questions

MADE EASY PUBLICATIONS

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RRB-Junior Engineer : General Awareness and Science & Technology

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Preface

B. Singh (Ex. IES)

The post of Railway Recruitment Board-Junior Engineer has always been preferred by Engineers due to job stability. Indian Railways is one of the biggest Government employers in India. With the exam being just a few months away, it is time for the candidates planning to appear for the exam to pull up their socks and start their RRB-JE preparation.

The **RRB-JE CBT-2** exam subjects are shown in table given below:

Papers	Subjects	Maximum Marks	Duration
CBT-2 : Objective Type	(i) General Awareness	15 Marks	120 Minutes
	(ii) Physics and Chemistry	15 Marks	
	(iii) Basics of Computers and Applications	10 Marks	
	(iv) Basics of Environment and Pollution Control	10 Marks	
	(v) Technical Abilities (viz, CE, ME, EE, EC, CS etc)	100 Marks	
	Total	**150 Marks**	
Note: There shall be negative marking for incorrect answers in CBT-2. Each question carries 1 mark and 1/3rd of the marks alloted for each question shall be deducted for each wrong answer.			

This book comprises both the **General Awareness and Science & Technology** subjects including Computer Applications and Environment. MADE EASY has taken due care to present detailed theory and MCQs without compromising the accuracy of answers.

Apart from Railway Recruitment Board-Junior Engineer Exam, this book is also useful for Public Sector Examinations and other competitive examinations for engineering graduates. I hope this book will prove as an important tool to succeed in RRB-JE and other competitive exams.

I have true desire to serve student community by providing good source of study materials and quality guidance.

Any suggestion from the readers for improvement of this book is most welcome.

With Best Wishes

B. Singh (Ex. IES)

CMD, MADE EASY Group

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RRBJE

Railway Recruitment Board
Junior Engineer Examination

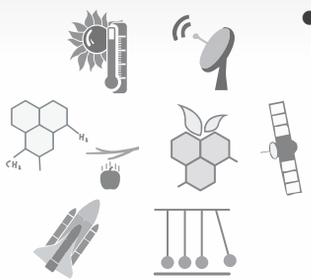
CBT-2

General Awareness

Section

A

Comprehensive Theory with
Practice Questions



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Chapter 1

History and Culture of India

ANCIENT INDIA

PREHISTORIC PERIOD

- The early prehistoric period was observed before the 8th millennium BCE.
- The period of the prehistoric agriculturalists and pastoralists was during approximately the 8th to the mid-fourth millennium BCE.
- The Early Indus or Early Harappan period witnessed the emergence of the first cities in the Indus River System (3500-2600 BCE).

Period/ Age	Remarks
Paleolithic Age	• People in Paleolithic age were dependent on hunting for their livelihood and used to travel from one place to another depending on the availability of natural resources for survival. • They developed sharp weapons of stone for hunting purpose.
Mesolithic Age	• During Mesolithic age, people were still hunter-gatherers, but were possibly starting to stay in one place. • Domestication of animals can be seen in this age.
Neolithic Age	• During Neolithic age, stone tools and weapons were also further modified and were sharpened by fine shedding of the stones. • It also contributed greatly in the field of transportation by an important invention of the wheel.
Chalcolithic Age	• The people of Chalcolithic age practiced agriculture. They used tools made up of copper and stone. • Painted pottery was the most distinguishing feature of all Chalcolithic cultures.

INDUS VALLEY CIVILIZATION

- Indus Valley Civilization is one of the oldest civilizations of the world. It flourished around the Indus river and its tributaries. The area consists of modern Pakistan and Northwestern India. Mohenjodaro is the largest site of the Civilization.
- Indus valley civilization is also called as Harappan civilization because Harappa was the first site to be excavated in 1921 under the supervision of **Daya Ram Sahni**.
- The known extent of this civilization in the west is upto Sutkagendor in Baluchistan; Alamgirpur (UP) in the east; Daimabad (Maharashtra) in South; and Manda (J and K) in the north.
- This civilization belongs to Bronge Age/ Chalcolithic Age. Hence, it is also called Bronze Age civilization.
- Contemporary civilizations of Harappan civilization are Mesopotamian or Sumerian civilization, Egyptian civilization and Chinese civilization.
- John Marshall was the first scholar to use the term “Indus Valley Civilization”.

Important Sites of Harappan Civilization

1. **Harappa**
   - People of Harappa knew the process of making tarcoal.
   - Main gate for the entry in the houses of Harappa was in the north direction.
   - R-37 cemetry have been found here.
   - Terracotta figurine of Mother Goddess have been found here.

2. **Mohenjo-daro**
   - Mohenjo-daro was discovered in 1922 under the supervision of **R.D. Bannerji**.

- The literal meaning of Mohenjo-daro in Sindhi language is **mound of the dead.**
- The Great Bath, a granary, big halls, a bronze statue of a dancing girl, idol of a yogi and numerous seals have been found here.
- Seven layers of Mohenjo-daro city directs that the city was destroyed and rebuilt seven times.

3. Lothal

- In 1954, Lothal was discovered by S.R. Rao in Gulf of Cambay in Gujarat.
- Red & black clay pots, copper tools, brick built tank like structure, a bead making factory and a seal from Iran have been found at Lothal.
- Linear scale of bronze have been found here.
- A dockyard has been found at Lothal.

4. Kalibangan

- Kalibangan was discovered in 1953. It is located in upper Rajasthan.
- It did not have a drainage system.
- A number of firepits *agnikundas* (firepits) have been found here.
- It saw two cultural phases viz. pre-Harappan and Harappan.
- A ploughed field have been found here.

5. Dholavira

- Dholavira in Gujarat was discovered in 1992 by **J.P. Joshi**.
- Dholavira shows all the three phases of Harappan civilization.
- A script consists of big alphabets has been found on a gate in Dholavira.

Major Harappan Sites and their Excavators

Site	River	District	Province/ State	Country	Excavators
Harappa	Ravi	Sahiwal	Punjab	Pakistan	Daya Ram Sahni (1921), Madho Swaroop Vatsa (1926), Wheeler (1946)
Mohenjodaro	Indus	Larkana	Sindh	Pakistan	Rakhal Das Bannerji (1922), Mackay (1927), Wheeler (1930)
Chanhudaro	Indus	Shaheed Benazirabad	Sindh	Pakistan	Mackay (1925), N.G. Mazumdar (1931)
Lothal	Sabarmati & Bhogva	Ahmedabad	Gujarat	India	S.R. Rao (1954)
Kalibangan (i.e., the bangles of black colour)	Ghaggar	Hanuman-garh	Rajasthan	India	Amalanand Ghosh (1951), B.B. Lai & B.K. Thapar (1961)
Banawali	Saraswati	Fatehabad	Haryana	India	R.S. Bist (1973)
Dholavira	Luni	Kutchh	Gujarat	India	J.P. Joshi (1967-68)

Major Harappan Sites and Archeological Findings	
Site	**Archaeological Findings**
Harappa	6 Granaries in row, Working floors, Workmen's quarters, Virgin-Goddess (seal), Cemetery (R-37, H), Stone symbols of Lingam (male sex organ) & Yoni (female sex organ), Painted pottery, Clay figures of Mother Goddess, Wheat & Barley in wooden mortar, Copper scale, Crucible for bronze, Copper-made mirror, Vanity box, Dice.
Mohenjodaro	Great Bath, Great Granery (the largest building of civilization), Assembly hall, Shell strips, Pashupati Mahadeva/Proto-Shiva (seal), Bronze Image of a nude woman dancer, Steatite image of bearded man, Human skeletons huddled together, Painted seal (Demi-God), Clay figures of Mother Goddess, A fragment of woven cotton, Brick Kilns, 2 Mesopotamian seals, 1398 seals (57% to total seals of civilization),Dice.
Chanhudaro	City without a citadel, Inkpot, Lipstick; Metal-workers', shell-ornament makers' and bead-makers' shops; Imprint of dog's paw on a brick, Terracotta model of a bullock cart, Bronze toy cart.
Kalibangan	Ploughed field surface (Pre-Harappan), 7 Fire altars, Decorated bricks, Wheels of a toy cart, Mesopotamian cylindrical seal.
Lothal	Dockyard, Rice husk; Metal-workers', shell-ornament makers' & bead-makers' shops; Fire altars, Terracotta figurine of a horse, Double burial (burying a male and a female in a single grave), Terracotta model of a ship, Dying vat, Persian/ Iranian seal, Baharainean seal, Painted jar (bird & fox).
Surkotada	Bones of horse, Oval grave, Pot burials.
Banawali	Lack of chess-board or gridiron pattern town planning, Lack of systematic drainage system, Toy plough, Clay figures of Mother Goddess.
Daimabad	Bronze images (Charioteer with chariot, ox, elephant & rhinoceros)
Dholavira	A unique water harnessing system and its storm water drainage system, a large well and a bath (giant water reservoirs), Only site to be divided into 3 parts, Largest Harappan inscription used for civic purposes, A stadium.

Important Features of Indus Valley Civilization

- **Town planning** was the most distinguishable feature of the Harappan civilization. Hence, this civilization is also called first urbanisation.
- Towns were divided into parts viz. citadel and lower town. Citadels were occupied by members of ruling class and lower town was inhabited by the common people.
- Harappan cities were developed in **Block Pattern/Chess Board Pattern** because roads of these cities used to cut each other at right angles.
- Most peculiar feature of town planning was their **drainage system.** Drains were built of burnt bricks and covered by stone lids and manholes for cleaning.
- Complete burial was the most common method of the disposal of the dead.
- They grew wheat and barley on a large scale. The other crops grown were pulses, cereals, cotton, dates, melons, pea, sesamum and mustard.
- No clear evidence of rice has been found, except from Rangpur and Lothal where some grains of rice were found, but they may be of later period.
- Harappan people were mostly peasants and thus the Harappan civilization was an agro-commercial civilization.
- Evidences of hoe and plough have been found in kalibangan and Banawali.

Chapter 3

Indian Polity

Constitutional Developments

- It was in 1934 when the idea of Constituent Assembly for India was put forward for the first time by M. N. Roy (A pioneer of communist movement in India).
- In 1935, the Indian National Congress (INC) demanded a Constituent Assembly to frame the Constitution of India.
- In 1938, Jawaharlal Nehru, on behalf of INC declared that the Constitution of Free India must be framed without outside interference and by a Constituent Assembly elected on the basis of Adult Franchise. The demand was accepted by British Government during August Offer in 1940.
- In 1942, Sir Stafford Cripps, a member of the British Cabinet came to India with draft proposal of the British Government on the framing of an independent Constitution which to be adopted after the World War II.
- The Cripps Proposals were rejected by the Muslim League which wanted India to be divided into two autonomous States with two separate Constituent Assemblies.
- Finally, the Constituent Assembly was constituted in November,1946 under the scheme formulated by the Cabinet Mission Plan.

Important British Acts of Constitutional Significance

Regulating Act, 1773

- The Regulating Act, 1773 was the first step taken by the British Government to control and regulate the affairs of the East India Company in India.
- It designated the Governor of Bengal as the 'Governor-General of Bengal' and created an Executive Council consisting of four members to assist him. The first Governor-General of Bengal was Lord Warren Hastings.
- It made a provision of Supreme Court at Fort William in Calcutta, comprising one Chief Justice and three other judges.
- It strengthened the control of the British Government over the East India Company by requiring the Court of Directors which was a governing body of the Company to report on its revenue, civil and military affairs in India.

Pitt's India Act, 1784

- This Act created a new body called Board of Control to manage the political affairs while Court of Directors were allowed to manage the commercial affairs. Thus, Pitts's India Act made a provision of separation in company's political and commercial activities.
- It empowered the Board of Control to supervise and direct all operations of the civil and military affairs and revenues of the British possessions in India.
- The Company's territories in India were for the first time called **British Possessions in India.**

Charter Act, 1793

- This Act recognised the courts and redefined their jurisdictions. Accordingly, the revenue administration was separated from the judiciary functions. This provision led to disappearing of the Maal Adalats (Revenue courts).
- Salaries of the members of the Board of Control to be drawn from the Indian exchequer.

Charter Act, 1813

- The East India Company's monopoly over trade was abolished in India but its monopoly over trade with China and for trade in tea retained.
- This Act asked Company to spend one lakh rupees every year on the education of Indians.
- Christian missionaries were permitted to propagate their religion in India.

Charter Act, 1833

- This Act made the Governor-General of Bengal as the Governor-General of India and vested in him all civil and military powers. Lord William Bentinck was made the first Governor-General of India.
- The East India Company lost its monopoly over trade with China also and it was asked to close the commercial business. The Company became a purely administrative body.
- This Act asked government to abolish **slavery** in India.

Charter Act, 1853

- This Act had provisions of separation of executive and legislative functions of the Governor General's Council. It provided for addition of six new members called Legislative Councillors to the **Indian (Central) Legislative Council.**
- For the first time, the local representation in the Indian (Central) Legislative Council was allowed.
- An open competition system of selection and recruitment of civil servants was introduced. For the first time, Indians were allowed to take part in Civil Services recruitment process. Consequently, the Macaulay Committee (the Committee on the Indian Civil Service) was appointed in 1854.

Government of India Act,1858

- It brought an end to the Company's rule and transferred all powers to the British crown.
- The system of **Dual government** (Board of Control and Court of Directors) introduced by Pitt's India Act was abolished by this Act.
- A new office of **Secretary of State for India** was created and he was vested with complete authority and control over Indian administration. He was a member of the British Cabinet and was ultimately responsible to the British Parliament. Lord Stanley was the first Secretary of State for India.

Indian Councils Act, 1861

- The Viceroy was empowered to issue ordinances in case of emergency without the concurrence of the legislative council. The life span of such ordinances was six months.
- This Act also introduced the 'portfolio' system. Under this, a member of the Viceroy's council was made in-charge of one or more departments of the government.

Indian Councils Act, 1892

- This Act empowered the Universities, district boards, municipalities, zamindars and chambers of Commerce to recommend members to the Provincial Legislative Council which were to be nominated by governors.
- According to this Act, the members of the Legislatures were for the first time entitled to take part in debate over Annual Statement of Revenue and Expenditure i.e. Budget. They could also put questions within certain limitations.

Indian Councils Act, 1909 (Morley-Minto Reforms)

- This Act is also known as **Morley-Minto Reforms.** Morley was the then Secretary of State for India and Lord Minto was the then Viceroy of India.
- Muslims were given separate representation and hence Lord Minto came to be known as the **Father of Communal Electorate.**
- A provision was made for the association of Indians with the Executive Council of the Viceroy and Governors. **Satyendra Prasad Sinha** became the first Indian to join the Viceroy's Executive Council. He was appointed as Law Member.

Government of India Act, 1919 (Montague-Chelmsford Reforms)

- This Act is also known as **Montague-Chelmsford Reforms or Montford Reforms.** Montague was the then Secretary of State for India and Chelmsford was the then Viceroy of India.
- All administrative subjects were divided into two groups viz. central and provincial subjects. Provincial subjects were further divided into two parts- transferred and reserved. The **transferred subjects** were to be administered by the Governor with the aid of ministers responsible to the Legislative Council whereas Governor was not responsible towards Legislative Council in the discharge of **reserved subjects.**
- This dual scheme of governance was known as 'dyarchy', a term derived from the Greek word diarche, which means double rule.
- For the first time, Indian Central Legislature was made **bicameral** (two Houses).

- For the first time, **direct elections** in the country were introduced. It granted franchise to a limited number of people on the basis of property, tax or education.
- It also provided for the establishment of the Public Service Commission, which was established in 1926.

Government of India Act, 1935

- The Act divided the powers between the Centre and provinces in terms of three lists, namely Federal List (for Centre, with 59 subjects), Provincial List (for provinces, with 54 subjects) and the Concurrent List (for both, with 36 subjects).
- Council of States having 260 members (156 from British India & 104 from Indian States) was to be permanent House with 1/3 members to retire every three years.
- A Federal Assembly to have 5 years duration consists of 375 members (250 from British India and 125 from provinces).
- This Act introduced bicameralism in six out of eleven provinces. Thus, the legislatures of Bengal, Bombay, Madras, Bihar, Assam and the United Provinces were made bicameral consisting of a legislative council (upper house) and a legislative assembly (lower house).
- It abolished dyarchy in the provinces and introduced provincial autonomy in its place. By these provisions, the provinces were allowed to act as autonomous units of administration in their defined spheres in which the Governor was required to act with the advice of ministers responsible to the provincial legislature.
- The Act provided for the establishment for a Federal Court which was set up in 1937.
- It also provided for the adoption of dyarchy at the Centre.
- It provided for the establishment of Reserve Bank of India to control the currency and credit of the country.
- It also provided for the establishment of Federal Public Service Commission, Provincial Public Service Commission and Joint Public Service Commission for two or more provinces.

Indian Independence Act, 1947

- The Indian Independence Act, 1947 ended the British rule in India and declared India as an independent and sovereign state from August 15, 1947.
- This Act provided for the partition of India and creation of two independent dominions of India and Pakistan.
- It abolished the office of Viceroy and provided, a Governor General for India and Pakistan separately, who was to be appointed by the British Monarch on the advice of the cabinet of both countries.

Interim Government 1946

- In the interim government formed in 1946, the Viceroy continued to be the head of Executive Council. However, Jawaharlal Nehru was designated as the Vice-President of the council and he also headed the interim cabinet.
- The members of the Interim Government were members of the Viceroy's Executive Council. The specific portfolios was allotted to each member.

Member from Indian National Congress

(i) Jawaharlal Nehru (External Affairs and Commonwealth relations)
(ii) Sardar Vallabhbhai Patel (Home, Information and Broadcasting)
(iii) Dr. Rajendra Prasad (Food and Agriculture)
(iv) Sardar Baldev Singh (Defence)
(v) Jagjivan Ram (Labour)
(vi) C. Rajagopalachari (Education and Arts)
(vii) Dr. John Mathai (Industries and Supplies)
(viii) C. H. Bhabha (Works, Mines and Power)
(ix) Asaf Ali (Railway and Transport)

Member from Muslim League

(i) Liaquat Ali Khan (Finance)
(ii) Abdur Rab Nishtar (Posts and Air)
(iii) I.I. Chundrigar (Commerce)
(vi) Ghazanafar Ali Khan (Health)
(v) Joginder Nath Mandal (Law)

Framing of Constitution of India

- The Constituent Assembly which was set up in 1946 as per the Cabinet Mission Plan, was given the task of framing of Constitution of India.
- The members of Constituent Assembly were elected indirectly by the provincial assemblies in the ratio of one member per million population.

Important Terms used in ECONOMICS

Bank Rate

Bank rate is the rate charged by the Reserve Bank of India for lending funds to commercial banks. It influences lending rates of commercial banks. Higher bank rate will translate to higher lending rates by the banks. In order to curb liquidity, the central bank can resort to raising the bank rate and vice versa.

Gross Domestic Product

GDP is the final value of the goods and services produced within the geographic boundaries of a country during a specified period of time, normally a year. GDP growth rate is an important indicator of the economic performance of a country.

Gross National Product

Gross National Product (GNP) is Gross Domestic Product (GDP) plus net factor income from abroad. It measures the monetary value of all the finished goods and services produced by the country's factors of production irrespective of their location. It includes taxes but does not include subsidies.

Wholesale Price Index

Wholesale Price Index (WPI) represents the price of goods at a wholesale stage i.e. goods that are sold in bulk and traded between organizations instead of consumers. WPI is often used as a measure of inflation.

Inflation

Inflation is the percentage change in the value of the Wholesale Price Index (WPI) on a year-on year basis. It effectively measures the change in the prices of a basket of goods and services in a year. It occurs due to an imbalance between demand and supply of money, changes in production and distribution cost or increase in taxes on products. When economy experiences inflation the price level of goods and services rises and the value of currency reduces.

Liquidity

Liquidity means how quickly one can get his cash in hand. In simpler terms, liquidity is to get your money whenever you need it. It might be emergency savings account or the cash lying with you that you can access in case of any unforeseen happening or any financial setback.

Non-Performing Assets

A non-performing asset (NPA) is a loan or advance for which the principal or interest payment remained overdue for a period of 90 days.

Monetary Policy

Monetary policy is the macroeconomic policy laid down by the Reserve Bank of India. It involves management of money supply and interest rate and it is the demand side economic policy used by the government of a country to achieve macroeconomic objectives like inflation, consumption, growth and liquidity.

Purchasing Power Parity

Purchasing Power Parity aims to determine the adjustments needed to be made in the exchange rates of two currencies to make them at par with the purchasing power of each other. It is the expenditure on a similar commodity must be same in both currencies when accounted for exchange rate. It is used worldwide to compare the income levels in different countries.

Repo Rate

Repo rate is the rate at which the Reserve Bank of India lends money to commercial banks in the event of any shortfall of funds. For RBI point of view it is called as short term lending and from banks point of view it is short term borrowing.

Statutory Liquidity Ratio (SLR)

It is the ratio of total deposits of a commercial bank which it has to keep with itself in the form of liquid assets. Liquid assets may consist of cash in hand, gold, reserves with RBI, excess reserves, government securities and other encumbered securities, etc.

Sovereign Risk

Any risk arising on chances of a government failing to make debt repayments or not honouring a loan agreement is a sovereign risk.

Service Tax

Service tax is a tax levied by the government on service providers on certain service transactions, but is actually borne by the customers.

PRACTICE QUESTIONS

Q.1 SEBI is a
(a) statutory body
(b) advisory body
(c) constitutional body
(d) non-statutory body

Q.2 Which of the following is known as narrow money?
(a) M_1 (b) M_2
(c) M_3 (d) M_4

Q.3 Who is the Chairman of NDC?
(a) Finance Minister
(b) Prime Minister
(c) President
(d) Lok Sabha Speaker

Q.4 The base year of present Consumer Price Index (CPI) for industrial labourers is
(a) 1980 (b) 1981
(c) 1991 (d) 2012

Q.5 Economic Planning is in
(a) Union List (b) State List
(c) Concurrent List (d) Not any specified list

Q.6 The main aim of fifth five-year plan was
(a) Poverty elimination
(b) Self reliance
(c) Both (a) and (b)
(d) None of the above

Q.7 Which of the following is a direct tax?
(a) Sales Tax (b) Excise Duty
(c) Custom Duty (d) None of these

Q.8 Which pair is not correct?
(a) I Plan ..... (1951-56)
(b) III Plan ..... (1966-71)
(c) VI Plan ..... (1980-85)
(d) X Plan ..... (2002-2007)

Q.9 Which Indian Commercial Bank became the first in providing mobile ATM service?
(a) ICICI Bank (b) IDBI Bank
(c) HDFC Bank (d) SBI

Q.10 Indian Railways earn the maximum revenue from
(a) passenger fare (b) freight
(c) traffic Tax (d) none of these

Q.11 Finance Commission is appointed by the President under Article
(a) 256 of Constitution
(b) 280 of Constitution
(c) 380 of Constitution
(d) 356 of Constitution

Q.12 National Income estimates in India is prepared by
(a) Planning Commission
(b) RBI
(c) Finance Ministry
(d) CSO

Q.13 The Annual Financial Statement is laid before the two Houses of Parliament in accordance with
(a) Article 74
(b) Article 112
(c) Article 268
(d) Article 370

Q.14 Who is the Chairman of 16th Finance Commission?
(a) Amitabh Kant (b) Arvind Panagariya
(c) N.K. Singh (d) Raghuram Rajan

Q.15 The birth rate measures the number of births during a year per
(a) 100 of population
(b) 1000 of population
(c) million of population
(d) none of these

Chapter 6

General Knowledge

Basic General Knowledge of
India & World

NATIONAL SYMBOLS

National Flag

- The National Flag of India is a horizontal tricolour of deep saffron (Kesaria) at the top, white in the middle and dark green at the bottom in equal proportion. The ratio of width of the flag to its length is 2:3. In the centre of the white band a navy-blue wheel is located which represents the Chakra.
- It was adopted by Constituent Assembly of India on July 22, 1947.
- A tricolour flag was first accepted by the Indian National Congress in 1931, having Charkha in place of today's Chakra.
- The horizontal colour strip of deep Saffron at top represents courage, sacrifice and renunciation, White at middle shows truth and purity in thoughts and dark Green at the bottom is the symbol of life abundance and prosperity.
- A wheel (Chakra) in centre of the white strip is the symbol of progress and movement. It has 24 spokes.
- Supreme Court declared the right to hoist flag as a Fundamental Right under Article 19 (i) (a) of the Constitution in 2002. Flag hoisting in India is regulated by Flag Code of India, 2002.
- The Flag was designed by **Pingali Venkayya** and first time, the flag was hoisted by **Sacchindra Prasad Bose** in 1906 in Calcutta and later on in the year 1907 an another tricolour flag was unfurled by **Madam Bhikaji Cama** in Stuttgart, Germany.
- The first flag committee was headed by **Dr. Rajendra Prasad**.

National Emblem

- The National Emblem of India is an adaptation from the Sarnath Lion Capital of Ashoka. It was adopted by the Government of India on January 26, 1950.
- In this emblem, only three lions are visible, the fourth lion being hidden from view. The wheel appears in relief in the centre of the abacus with a **bull** on **right** and a **horse** on **left**. The bell shaped lotus (as in the original) has been omitted. The other animals present in the emblem are an Elephant and a Lion.
- The words *Satyameva Jayate* are inscribed below the abacus in Devanagri script. These words are taken from *Mundaka Upanishad.*

National Anthem

- The song *Jana gana mana* is the National Anthem of India which was composed by **Rabindra Nath Tagore**, originally in Bengali.
- It was adopted by Constituent Assembly on January 24, 1950 in its Hindi version.
- The song Jana gana mana was first published in January, 1912 under the title **'Bharat Vidhata'** in Tattva Bodhini Patrika.
- The song was translated in English in 1919 with the title **"Morning Song of India''.**
- It was first sung at the Calcutta Session of Congress on December 27, 1911.
- Playing time of full version of National Anthem is 52 seconds while it is 20 seconds for first and last lines of the stanza.

National Song

- "*Vande Mataram*" is the National song of India, which was composed by **Bankim Chandra Chatterjee**, originally in Sanskrit.
- It was adopted on January 24, 1950, providing it equal status with National Anthem *Jana gana mana.*
- It is taken from his novel **Anand Math** published in 1882. Its English translation was done by Sri Aurobindo.
- It was sung for the first time at the Congress Session of 1896.

National Calendar

- National Calendar is based on Saka Era (began on 78 A.D.) with Chaitra as its first month and Phalguna as its last month with a normal year of 365 days adopted from March 22, 1957 along with the Gregorian Calendar.
- First day of Chaitra normally falls on March 22 and on March 21 in leap year.

National Animal

- The Tiger (Panthera Tigris) is the National Animal of India. It has a thick yellow coat of fur with dark stripes.
- Lion was the National Animal of India till 1972. Later on, it was replaced by Tiger.

Other Indian National Symbols	
National Bird	Peacock *(Pavo Cristatus)*
National Flower	Lotus *(Nelumbo Nucipera Gaertn)*
National River	Ganga
National Tree	Banyan *(Ficus Benghalensis)*
National Fruit	Mango *(Mangifera Indica)*
National Aquatic Animal	Ganges River Dolphin
National Heritage Animal	Elephant
National Game (De-facto)	Hockey

National Emblems of Countries	
Country	**Emblem**
India	Sarnath Lion Capital
Australia	Kangaroo
Bangladesh	Water Lily
Canada	White Lily
France	Lily
Germany	Corn flower
Iran	Rose
Italy	White Lily
Japan	Chrysanthemum
Pakistan	Crescent
Spain	Eagle
Sri Lanka	Sword & Lion
Russia	Sickle and Hammer
Norway	Lion
United Kingdom	Rose
USA	Golden Rod

Significance of Signs and Symbols	
Symbol	**Meaning**
Red triangle	Family planning
Red cross	Hospital/Ambulance
Red light	Danger/Emergency
Green light	Line clear signal
Olive branch	Peace
Black arm-band	Sign of mourning/protest
Dove	Peace
Black flag	Demonstration of protest
Red flag	Sign of danger, revolution
Yellow Flag	Displayed by ship with infectious disease on board or ship in quarantine.
White Flag	Truce
Tricolour	National Flag of India

Gaseous Equation of State

It is obtained by combining both Boyle's and Charle's Law.

$$P \propto \frac{T}{V}, \text{ when } T \text{ and } V \text{ both vary}$$

$PV = RT$, Where R is a constant called Universal gas constant.
It is called gaseous equation of state.

Dalton's Law of Partial Pressure

It states that the total pressure of a gaseous mixture of a definite volume of the gas is equal to the sum of partial pressure of the component gases.
If there are three gases A, B and C whose partial pressures are P_A, P_B and P_C then according to Dalton's law of partial pressure total pressure (P) of the gas = $P_A + P_B + P_C$.

Avogadro's Law

It states that the volume occupied by an ideal gas is directly proportional to the number of molecules of the gas present in the container.

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

Where, n = number of molecules of gas or moles of gas. V = volume of gas

Graham's Law of Diffusion

The rate of diffusion of various gases is inversely proportional to the square roots of their densities at constant temperature and pressure.

$$\text{Rate of diffusion} \propto \sqrt{\frac{1}{\text{Density}}} \quad \text{or,} \quad r\sqrt{\frac{1}{d}}$$

$$\text{or,} \quad \frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}}$$

Where r_1 = rate of diffusion of gas 1 (Lighter gas)
r_2 = rate of diffusion of gas 2 (Denser gas)
d_1 = density of gas 1; d_2 = density of gas 2

Application: The phenomenon of the gaseous diffusion are used at various occasion like in the production of Ansa's marsh gas, in the separation of the gaseous mixtures in the determination of vapour densities of the gases, in the separation of the isotopes etc.

Absolute Temperature: The absolute temperature is equal to –273°C. In terms of Kelvin, it is equal to 0 K.

Standard Temperature and Pressure (STP):
0°C or 273K is called standard temperature, whereas 760 mm (76 cm) of mercury (Hg) is called standard pressure.

ideal Gas (perfect gas)

An ideal gas (perfect gas) is those whose molecules (particles) are point masses (masses without volume) and which do not attract each other. This is basically a hypothetical concept which do not exist in reality. In fact almost all gases existing in nature are real (not ideal). The gases like hydrogen, oxygen, helium etc which can not be liquefied are called permanent gases.

The main properties of an ideal gas are given as below:

- An ideal gas strictly obeys Boyle's law, Charle's law and the law of pressure under all conditions of temperature and pressure.
- The pressure coefficient and volume coefficient of an ideal gas is exactly equal to each other.
- An ideal gas can not be converted into liquid or solid state, because a force of attraction is required among the molecules of liquid or solid state.

Real Gases

Those gases are real which have definite volume and intermolecular forces of attraction. In fact no real gas is truly ideal. The real gases follow the gaseous laws (behave ideally) only at high temperature and low pressure.

Kinetic Theory of Gases

Firstly in 1738 a Swiss mathematician J.Bernoulli explained about the behaviour of gases. Later Rudolph Clausis and James Clark Maxwell developed the kinetic theory of gases in order to explain the gaseous laws, nature, character and behaviour of the gases in terms of the motion of gaseous molecules.

The molecular details regarding gases can be visualised with the help of kinetic theory of gases which is based on the following assumptions

- A gas having extremely small discrete identical particles, called the molecules moving throughout the container.

- The gaseous molecules are so small and so far apart that the actual volume of the molecules is negligible as compared to the total volume of the gas.
- The gaseous molecules are in constant random motion with higher velocities. The gaseous particles move in straight lines with uniform speed and change directions on collision with other molecules or with the walls of the container.
- The existing intermolecular forces among gaseous molecules are negligible. Thus gaseous molecules can move freely, independently of each other.
- All the collisions of gaseous particles are perfectly elastic, so there is no loss of kinetic energy takes place during the collision. Although there may be redistribution of energy during such a collision.
- The gravitational effect on the motion of the gaseous particles (molecules) is negligible in comparison to the effect of collision.
- As gaseous molecules collide to each other, the change in momentum takes place. Thus according to Newton's 2nd law of motion the rate of change of this momentum appears like a force which is exerted on the wall of the container inside which gas is kept. This exerted force on the wall of the container appears as gaseous pressure for each unit area.
- An any instant it may be that different molecules of a gaseous sample have different speed and hence different kinetic energies. But the average value of kinetic energy of the gaseous molecules is directly proportional to the absolute temperature.

METALS & METALLURGY

Metals

Metals have the capability to lose electrons and provide cations. They are located towards the left and in the middle in the periodic table.

Minerals

The natural solid materials containing compounds of metals in a combined state along with impurities and found abundantly beneath the earth's surface are called mineral.

Alloy

It is the homogeneous mixture of two or more metals or metals and non-metals. Alloys have a lower melting point than the original metals.

Metals and their Ores

Metals	Ores	Formula
Iron (Fe)	Haemetite	Fe_2O_3
	Magnetite	Fe_3O_4
Uranium (U)	Pitchblende	U_3O_8
Lead (Pb)	Galena	PbS
Mercury (Hg)	Cinnabar	HgS
Zinc (Zn)	Calamine	$ZnCO_3$
Gold (Au)	Calaverite	$AuTe_2$
Sodium (Na)	Borax	$Na_2B_4O_7.10H_2O$
	Chile Saltpeter	$NaNO_3$
Aluminium (Al)	Bauxite	$Al_2O_3.2H_2O$
	Corundum	Al_2O_3
	Cryolite	$Na_2Al_4F_6$
Calcium (Ca)	Dolomite	$CaCO_3.MgCO_3$
	Gypsum	$CaSO_4.2H_2O$
Magnesium (Mg)	Dolomite	$MgCO_3.CaCO_3$
	Epsom Salt	$MgSO_4.H_2O$
Potassium (K)	Potassium Nitrate	KNO_3
	Carnallite	$KMgCl_3\ 6(H_2O)$

Metallurgy

The process of extraction of a particular metal from its ore is known as metallurgy.

Terms related to Metallurgy

Gangue or Matrix : The ore from which metals and its compounds are obtained has some impurities in it is called gangue or matrix.

Smelting : The process of heating an ore above its melting point with coke and flux in order to fuse the whole mixture and reduce the ore to metal, is called smelting. The smelting is a chemical changing process.

Basics of
Environment & Pollution Control

Introduction

The word 'environment' has been derived from French word "*Environner*" which means "*to encircle" or " to surround*", whereas "Nature" word is derived from Latin word "*Natura*" which refers to characteristics of plants, animals and other creatures.

Components of Environment	
Abiotic	**Biotic**
• Energy • Radiation • Temperature and heat flow • Water • Atmospheric gases and wind • Fire • Gravity • Topography • Soil • Geological substratum	• Green plants • Non-green plants • Decomposers • Parasites • Symbionts • Animals • Man

All organisms (from virus to man) are obligatorily dependent on the environment for food, energy, water, oxygen, shelter and for other needs.

Environment is total sum of all conditions which affect evolution and development of life on Earth's surface where organisms live including abiotic components (soil, water, air, etc.) and biotic components (plants, animals, microorganisms, etc.).

Biosphere

Biosphere is the part of the earth's crust, hydrosphere, and atmosphere that supports life. It is formed through the interaction of atmosphere, lithosphere and hydrosphere.

The area of contact and interaction between these three components are the basic requirement for the biosphere to exist.

Atmosphere

The atmosphere is the body of air which surrounds earth. Most of the atmosphere is located close to the earth's surface where it is most dense.

The atmosphere is divided into a series of concentric shells of sphere due to the variations in temperature and pressure at various altitude.

Air Composition

Nitrogen and oxygen are the most abundant gases in the Troposphere, constituting about 78% and 20.9% of total gaseous volume respectively. The remaining 1 % consists of argon, water vapour, CO_2 and ozone. These gases occur in minute quantities in the atmosphere, but are essential for maintaining life on the earth.

Carbon dioxide, water vapour and ozone play an important role in maintaining the heat balance of the earth.

Normal Composition of Gases in Air

Constituents	Chemical Symbol	Mole Percent
1. Nitrogen	N_2	78.084%
2. Oxygen	O_2	20.947%
3. Argon	Ar	0.934%
4. Carbon dioxide	CO_2	0.038%
5. Neon	Ne	0.001818%
6. Helium	He	0.000524%
7. Methane	CH_4	0.00017%
8. Krypton	Kr	0.000114%

Lithosphere

The Lithosphere is the solid, rocky crust covering entire earth. This crust is inorganic and is composed of minerals.

Geologically, Lithosphere refers to the combination of earth's crust and outer mantle. It provides the platform and habitat to the biotic elements of the ecosystem. It covers the entire surface of the earth from the top of Mount Everest to the bottom of the Mariana Trench.

Hydrosphere

The Hydrosphere is composed of all of the water on or near the surface of earth. This includes the oceans, rivers, lakes, and even the moisture in the air. Water is considered to be the most important constituent of biotic elements.

97% of the earth's water is in the oceans, and remaining 3% is fresh water. The three-quarters of the fresh water is solid and exists in ice sheets.

Biosphere has also been divided in different Bio-geographical realms at sub-global levels. Bio-geographic realms are large spatial regions within which ecosystems share a broadly similar biological evolutionary history.

Ecosystem

An ecosystem is a complex set of relationship among the living resources, habitats, and residents of an area. It includes plants, trees, animals, fishes, birds, micro-organisms, water, soil, people, etc. Everything that lives in an ecosystem is dependent on the other species and elements that are also part of ecological community.

Ecosystems include living organisms, the dead organic matter produced by them, the abiotic environment within which the organisms live and exchange elements (soils, water, atmosphere), and the interactions between these components.

When an ecosystem is healthy (i.e., sustainable) it means that all the elements live in balance and are capable of reproducing themselves.

The term 'ecosystem' was first coined by A.G. Tansley in 1935.

The concept of ecosystem was initially given by E.P. Odum who is widely considered as "Father of ecosystem/ ecology".

Structure of Ecosystem

Ecosystem is a subset of Biosphere, wherein various species, their populations and communities interact with each other along with non-living things like land, sunlight, wind, humidity, etc., called as abiotic elements, whereas, the living things are called as biotic elements.

Abiotic Components

Abiotic components are the inorganic and non-living parts of an ecosystem. These consist of soil, water, air, light energy, etc. They also involve a large number of gases like oxygen, nitrogen, etc. and physical processes including volcanoes, earthquakes, floods, forest fires, climate and weather conditions.

Abiotic factors are the most important determinants of where and how well an organism exists in its environment.

Some of the important abiotic factors are:

(i) **Energy (Sunlight):** Sunlight is the primary source of energy in nearly all ecosystems.

(ii) **Water:** Water is essential for all living beings. It helps to regulate body temperature.

(iii) **Temperature:** Temperature is a critical factor of the environment which greatly influences survival of organisms.

(iv) **Atmospheric gases:** Atmospheric gases like oxygen, nitrogen and carbon dioxide are imperative for the survival of flora and fauna of this planet.

(v) **Soil (Edaphic factors):** These factors include soil texture, soil temperature, soil water, soil solution and pH, together with soil organisms and decaying matter.

(vi) **Climate:** Climate of a region includes the average rainfall, temperature and the patterns of winds that occur. Climate is one of the most important abiotic factors of an ecosystem.

Biotic Components

Biotic components are classified according to their functional attributes into producers and consumers.

(i) **Producers**

Producers are also known as autotrophs, or self-feeders. Producers manufacture the organic compounds that they use as sources of energy and nutrients. Most producers are green plants or algae that make organic compounds through photosynthesis.

(ii) **Consumer**

Consumers are incapable of producing their own food. These are also known as Heterotrophs or phagotrophs (other nourishing). Consumers depend on organic food derived from plants, animals or both.

(a) Macro Consumers

Herbivores (Primary Consumers)

The consumers or organisms that feed on autotrophs are called herbivores. Examples: Deer, rabbit, cow, goat, grasshopper, rat, etc. All the herbivorous animals which directly consume the plants are called primary consumers.

Carnivores (Secondary Consumers)

Carnivores are further subdivided into First, Second and Third order. These animals predate on herbivorous animals.

Omnivores (Tertiary Consumers)

Omnivorous animals eat herbivorous animals as well as plants. Examples: Sparrow, crow, fox, wolves, cat, dogs, snakes etc. belong to this category. Human being is the best example of omnivores because they can take their food from any stage of food chain i.e. they are dependent on autotrophs as well as on heterotrophs.

(b) Micro Consumers

Micro consumers are popularly known as decomposers or detritus. They breakdown complex compound of dead remnants of flora and fauna. They also decompose tissues of plants and animals into micro-nutrients. These are also known as Saprotrophs.

There are regular change in the activities of plants and animals, caused by factors such as light and heat from the sun, the tides, season and phases of the moon and the rotation of the earth. These regular, rhythmic changes are called biorhythms.

Biotic Interactions

Biotic interactions are the effects the organisms in a community have on one another. These interactions can involve individuals of the same species (intraspecific interactions) or individuals of different species. The species may interact once in a generation (e.g. pollination) or live completely within another (e.g. endosymbiosis).

The types of biotic interaction can be classified further as follows:

(i) **Competition:** The competition is defined as the process in which the organism fights for the same resources.

(ii) **Predation:** This is an interaction between the members of different species, in which one member catches the prey and kills them.

(iii) **Parasitism :** The parasitism is defined as the process in which two organisms of different species are present and in which one of the organism acts as a parasite and the other organism acts as a host.

(iv) **Mutualism:** Mutualism is the associations between pairs of species that bring mutual benefit. The individuals in the populations of each mutualist species can grow, survive and reproduce at a higher rate.

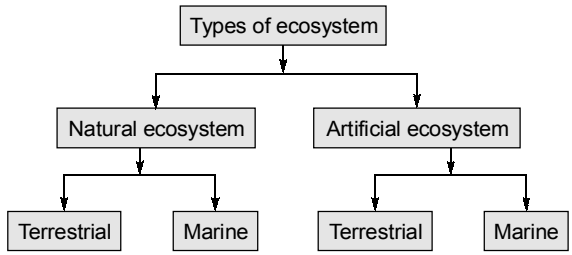
(v) **Commensalism :** The commensalism is a process in which two organisms of different species are present and in which one organism is benefitted while the other one acts as a neutral organism which is neither harmed and nor benefitted.

(vi) **Amensalism :** The amensalism is a process in which two organisms of different species are present and in which one organism do not allow, the other organism to survive.

(vii) **Neutralism :** Neutralism is a process in which neither population directly affects the other. It is the most common type of inter-specific interactions.

Types of Ecosystem

There are essentially two types of ecosystems: Natural and Artificial. These are further divided into terrestrial and marine ecosystems.



Terrestrial Ecosystems

Terrestrial Ecosystem is an ecosystem that exists on land, rather than on water. Such ecosystem is a community of organisms existing and living together on the land.

Terrestrial Ecosystem	
1. Tropical evergreen	7. Taiga/Coniferous
2. Savanna grassland	8. Tundra
3. Hot desert	9. Polar ice-capped
4. Monsoon	10. Montane
5. Mediterranean biome	11. Cold desert
6. Temperate grassland	

Forests Ecosystem

Forest Ecosystem represent the largest and most ecologically complex systems. They contain a wide variety of trees, plants, mammals, reptiles, amphibians, invertebrates, insects and micro-organisms which vary depending on the climate. They are the major carbon sink and provide enormous amount of food and resources to the mankind.

Forests have further been divided into following four types:

(i) **Equatorial Rainforest**: These are found in and around equator regions, and characterised by ample heat and heavy rainfall throughout the year. The major areas containing such forests are - Congo Basin, Cameroon highlands, Rainforests of the Amazon and Orinoco, Central America, Malaysia, Borneo and Indonesia.

(ii) **Tropical Deciduous Forest**

These types of forests are found in the areas having distinct dry season and heavy concentration of rainfall within few months. These areas have typical seasonality ranging from cool winters, hot and dry summer to rainy season.

(iii) **Temperate Forest:** These are found in areas with a milder, shorter winter season.

(iv) **Boreal forests (Taiga)**

This type of forests is found between 50° and 60° north latitudes. These forests can be found in the broad belt of Eurasia, North America, Siberia, Scandinavia, Alaska, and Canada. Here, seasons are divided into short, moist, and moderately warm summers and long, cold and dry winters. Boreal Forests are dominated by conifers, especially spruces and firs.

A plant hardiness zone is a geographically defined area in which a specific category of plants is capable of growing, by withstanding the minimum temperature of the zone.

Terrestrial Vegetation in India

India has a diverse range of forests, from the rainforest of Kerala in the south to the alpine pastures of Ladakh in the north, from the deserts of Rajasthan in the west to the evergreen forests in the north-east.

(i) **Moist Tropical Forests:**

(a) **Wet evergreen forests:** These are found along the Western Ghats and Andaman and Nicobar Islands and all along the north-eastern region. Such forests found in regions with rainfall over 250 cm per annum.

(b) **Semi-evergreen forests:** These are found along the Western Ghats, Assam and lower attitudes of Eastern Himalayas, Odisha, Malabar Coast, Andaman & Nicobar Islands. Such forests have a mixture of the wet evergreen trees and the moist deciduous trees. Here, rainfall varies from 200-250 cm.

(c) **Littoral and swamp forests:** Such type of forests are found along the Andaman and Nicobar Islands and the delta area of the Ganga and the Brahmaputra. It consists mainly of Whistling pines, Mangrove, Palms, and Bulletwood. They have roots that consist of soft tissue so that the plant can breathe in the water.

The littoral forests occur all along the sea coasts and along the sandy bars of deltas of the larger rivers.

(d) **Moist deciduous forests:** These forests are found throughout India in the regions of typical rainfall range of 150-200 cm annually except in the western and the north-western regions.

(ii) **Dry Tropical Forests:**

(a) **Dry deciduous forests:** These forests are found throughout the northern part of the country except in the North-east. It is also found in Madhya Pradesh, Gujarat, Andhra Pradesh, Karnataka, and Tamil Nadu. All the

forests of North India i.e., Bihar, U.P., Punjab, Haryana come under this.

(b) **Thorn forests:** This type of forests is found in areas with black soil. These are found in areas having 25-75 cm of rainfall every year. Spurge, caper, and cactus are typical trees of this region.

(iii) Montane Sub-Tropical Forests:

(a) **Dry evergreen forests:** These types of forests normally have a prolonged hot and dry season and a cold winter. These forests are found in the Shivalik hills and foothills of the Himalayas up to a height of 1000 metres.

(b) **Pine forests:** These are found in the steep dry slopes of the Shivalik hills, Western and Central Himalayas, Khasi, Naga, and Manipur Hills. The trees predominantly found in these areas are the Chir, Oak, Rhododendron, and pine.

Grassland Ecosystem

Grasslands are characterized as lands dominated by grasses rather than large shrubs or trees.

Grasslands ecosystems emerge due to low levels of sporadic precipitation that is only substantial enough to support smaller plants. Grass survives in these arid conditions because of its deep and highly elaborate root system that enables it to access moisture hidden deep in the soil. There are two main types of grasslands -- tropical and temperate -- with several subcategories within each type.

Savanna

Savanna is grassland with scattered individual trees. Savannas of one sort or another cover almost half the surface of Africa (about five million square miles, generally central Africa) and large areas of Australia, South America, and India. Climate is the most important factor in creating a savanna. Savannas are always found in warm or hot climates where the annual rainfall is from about 50.8 to 127 cm (20-50 inches) per year.

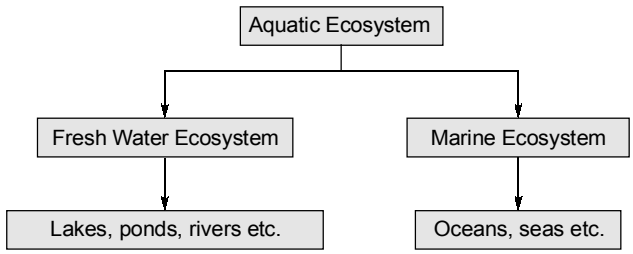
Temperate grasslands

Temperate grasslands are characterized as having grasses as the dominant vegetation. Trees and large shrubs are absent. Temperatures vary more from summer to winter, and the amount of rainfall is less in temperate grasslands than in savannas.

The major manifestations are the veldts of South Africa, the puszta of Hungary, the pampas of Argentina and Uruguay, the steppes of the former Soviet Union, and the plains and prairies of central North America.

Aquatic Ecosystem

Aquatic ecosystems are a group of interacting organisms dependent on one another and their water environment for nutrients (e.g., nitrogen and phosphorus) and shelter. Examples of aquatic ecosystem are ponds, lakes and rivers, but these also include areas such as flood-plains and wetlands which are flooded with water for all or only parts of the year.



Aquatic ecosystems are the biggest eco-systems, which cover around 71% of earth's surface and contain 97% of planet's water. Marine ecosystems contain high amounts of minerals and salts dissolved in them.

Fresh Water Ecosystems

Freshwater regions have been divided in two categories - standing bodies of water, which includes lakes, ponds etc. and moving bodies of water, i.e. rivers, streams etc.

The fresh water ecosystem is limited by solar radiation and temperature.

Ponds and Lakes:

Lakes are often classified according to their production of organic matter. Lakes have been classified in following three categories on the basis of their nutrient content or productivity.

(i) **Oligotrophic:** A newly formed lake generally has a small supply of plant nutrients and is called an oligotrophic lake. Such a lakes are not very productive and hence do not contain much life.

(ii) **Eutrophic:** A lake with a large or excessive supply of nutrients (mostly nitrates and phosphates) is called a Eutrophic (well nourished) lake. These lakes typically are shallow and have murky brown or green water with poor visibility.

(iii) **Mesotrophic:** Many lakes fall somewhere between two extremes of nutrients enrichment and known as Mesotrophic lakes. They have moderate nutrient content and moderate amount of phytoplankton, reasonably productive.

Lakes and ponds are divided into following zones:

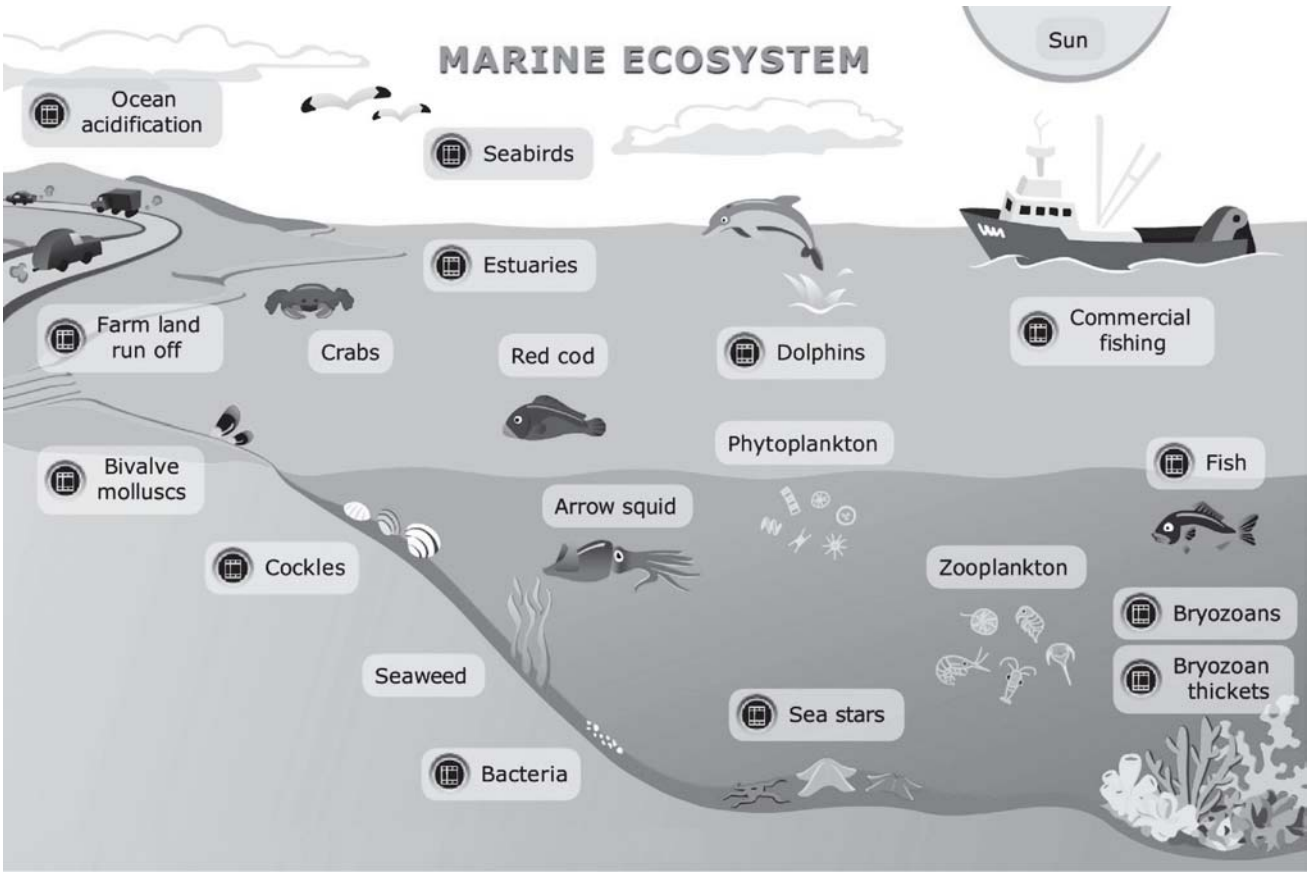
(i) **Littoral zone:** The topmost zone near the shore of a lake or pond is the Littoral zone. This zone is the warmest as it is shallow and can absorb more of the Sun's heat. This zone is rich in biodiversity which includes algae, rooted and floating aquatic plants, insects, fishes, and amphibians.

(ii) **Limnetic zone:** The near surface open water surrounded by the littoral zone is the limnetic zone. This zone is farther from the shore, extending to depth penetrated by light. This zone is occupied by phytoplankton, zooplankton, and produces food and oxygen that supports most of consumers in the lake.

(iii) **Profundal zone:** The deepest zone of the lake is the profundal zone. It consists of deep, aphotic regions, lacking in oxygen and are too dark for photosynthesis.

(iv) **Benthic zone:** This zone is actually bottom of lake, inhabited by organisms that can tolerate cool temperatures and low oxygen levels. Mostly decomposers, detritus feeders and fish that swim from one zone to other inhabit this zone.

Nektons are the top predators in most marine food chains of the community ecology. The vast majority of nektons are verte brates (e.g., fishes, reptiles, and mammals), molluscs, and crustaceans.
Plankton are the numerous, primarily micro-scopic inhabitants of the pelagic environment. They provide nutrition for the nekton (e.g., crustaceans, fish, and squid) and benthos (e.g., sea squirts and sponges). Benthos are abundant in surface sediments of the continental shelf and in deeper waters.



Functions of an Ecosystem

Ecosystems perform certain functions, which are given below:

1. **Energy Flow:** Ecosystems maintain themselves by cycling energy and nutrients obtained from external sources. At the first trophic level, primary producers use solar energy to produce organic plant material through photosynthesis. Herbivores make up the second trophic level. Predators that eat herbivores comprise the third trophic level. Organisms that feed at several trophic levels (for example, hawk that eats snake) are classified at the highest of the trophic levels at which they feed.
2. **Biogeochemical Cycles**

   Biogeochemical cycles are pathways for the transport and transformation of matter within biosphere.

   Biogeochemical cycles can be divided into following two categories:–

   (i) **Gaseous cycles:** These involve the transportation of matter through the atmosphere.

   The following types of gaseous cycles are:

   Carbon Cycles: Carbon is the major chemical constituent of most organic matter, from fossil fuels to the complex molecules (DNA and RNA) that control genetic reproduction in organisms.

   Carbon is released from ecosystems as carbon dioxide gas by the process of respiration.

   Carbon dioxide enters the waters of the ocean by simple diffusion.

   Once dissolved in seawater, the carbon dioxide can remain as it is or can be converted into carbonate or bicarbonate. Certain forms of sea life biologically fix bicarbonate with calcium to produce calcium carbonate. This substance is used to produce shells and other hard body parts by organisms such as coral, oysters, some protozoa, and some algae.

   Nitrogen Cycle:

   The nitrogen cycle represents one of the most important nutrient cycles found in ecosystems. Nitrogen is a required nutrient for all living organisms to produce a number of complex organic molecules like amino acids, the building blocks of proteins, and nucleic acids, including DNA and RNA.

   The ultimate store of nitrogen is in the atmosphere, where it exists as nitrogen gas (N_2).

   Oxygen Cycle:

   The oxygen cycle describes the movement of oxygen within and between its three main domains of biosphere.

   The main driving factor of the oxygen cycle is photosynthesis and because of this, oxygen and carbon cycles are usually linked and the two cycles are collectively called oxygen-carbon cycle.

   (ii) **Sedimentary cycles:** These cycles involve the transportation of matter through the ground to water; i.e., from the Lithosphere to the Hydrosphere.

   The following types of sedimentary cycles are:

   Phosphorous Cycle

   The phosphorus cycle is the biogeochemical cycle which characterizes the transport and chemical transformation of phosphorus through the biosphere.

   Unlike many other biogeochemical cycles, the atmosphere does not play a significant role in the movement of phosphorus-based compounds as they are typically solids at the normal ranges of temperature and pressure found on Earth.

   Sulphur Cycle

   Every protein needs disulphide bridges to make long three-dimensional polypeptide chains whose complex folds allow proteins to be engaged in countless biochemical reactions.

   Biogenic sulphur is produced on land by both sulphur-oxidizing and sulphate-reducing bacteria present in water, mud, and hot springs. Some volcanic eruptions are very large sources of sulphate.

3. Trophic Level

Trophic levels are the feeding position in a food chain in organisms such as primary producers, primary consumers, secondary consumers, tertiary consumers, etc.

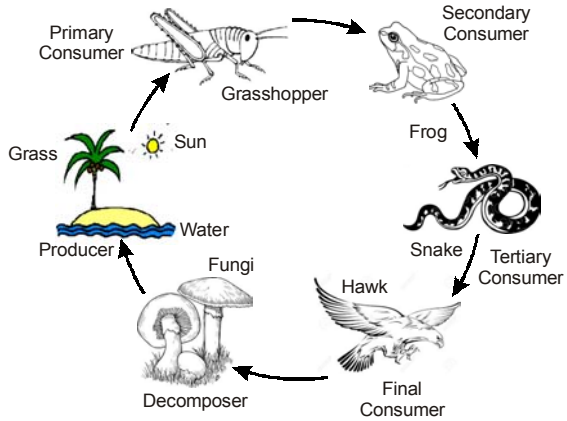
The trophic level interaction involves following three concepts:

1. Food Chain
2. Food Web
3. Ecological Pyramids

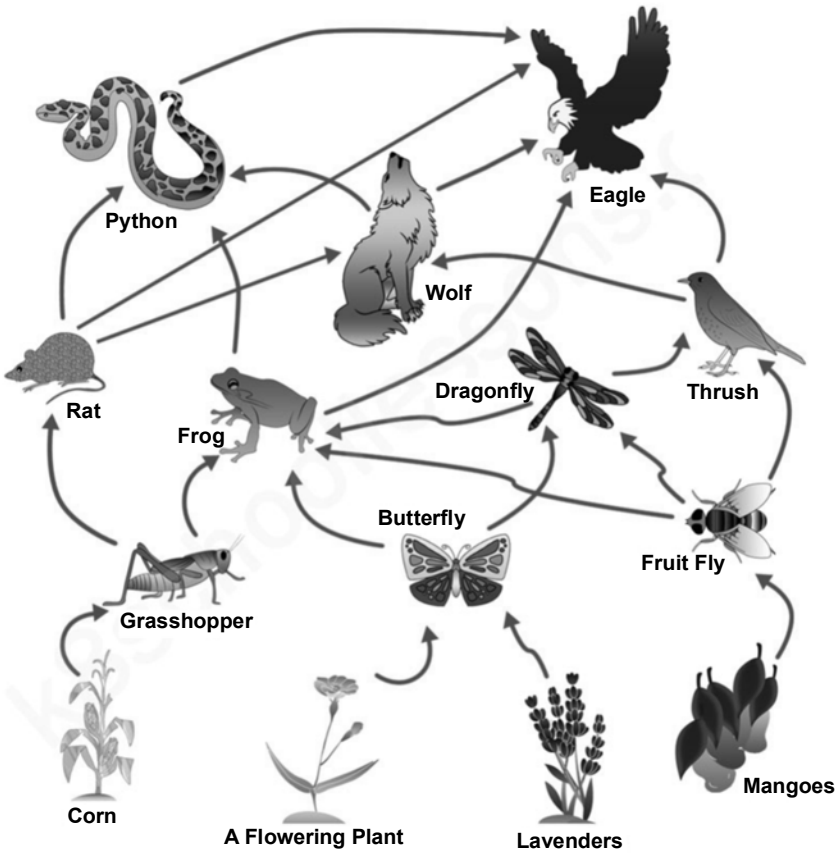
4. Food Chain

The Food chain is defined as the unidirectional transfer of food energy from the producer to consumer through a series of organism (herbivores to carnivores to omnivores to decomposers) with repeated eating and being eaten process. It is the sequence of who eats whom in an ecosystem to obtain nutrition.

A food chain starts with the primary energy source, usually the sun. The next link in the chain is an organism that makes its own food from the primary energy source. These are called autotrophs or primary producers. The next organisms are those who eat the autotrophs; these organisms are called herbivores or primary consumers.



The next link in the food chain is animals that eat herbivores, called secondary consumers (For example: a frog or rat that eat grasshoppers). Then, these animals are eaten by larger predators, called



Food Web

tertiary consumers (For example: a snake that eats rats). These tertiary consumers are eaten by quaternary consumers (For example: a hawk that eats snakes).

The arrows in a food chain show the flow of energy, from the sun to a top predator. As the energy flows from organism to organism, energy is lost at each step.

5. Food Web

Food web is a graphical description of feeding relationship among species in an ecological community i.e., of who eats whom. It is also means of showing how energy material flow through a community of species as a result of these feeding relationships.

Trophic levels in an ecosystem are not linear rather they are interconnected and make a food web. All of the interconnected and overlapping food chains in an ecosystem make up a food web.

Food web offers an important tool for investigating the ecological interactions that define energy flows and predator-prey relationship. Most food webs are complex and involve many species with both strong and weak interactions take place.

Difference Between Food Chain and Food Web

S.No.	Food Chain	Food Web
1.	It is the single pathway through which food energy travels in the ecosystem.	It consists of number of interconnected food chains through which food energy travels in an ecosystem.
2.	Usually members of higher trophic level feed upon a single type of organisms of lower trophic level.	Usually members of higher trophic level feed upon many organisms of lower trophic level.
3.	Isolated or separate food chains increases the instability of the ecosystem.	Presence of complex food webs increases the stability of the ecosystem.
4.	It does not have any effect on improving the adaptability and competitiveness of the organisms.	More complex food webs improves the adaptability and competitiveness of the organisms.

6. Ecological Pyramid

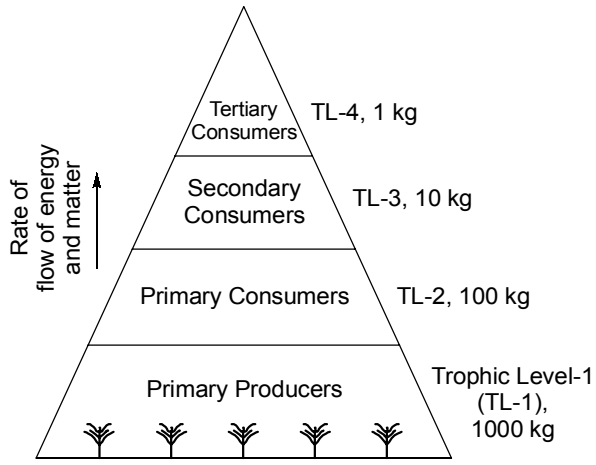
Ecological pyramids are diagrams that illustrate how ecologically important factors, such as energy, biomass, and population size vary between trophic levels in an ecosystem. The size of the portion of diagram associated with each trophic level illustrates the amount of energy, biomass, or number of individuals found in each trophic level. The concept of ecological pyramid was developed by Charles Elton. These pyramids are also known as Eltonian pyramids.

The ecological pyramids may be of following three kinds:

(i) **Pyramid of energy:** It shows the rate of energy flow and/or productivity at successive trophic levels.

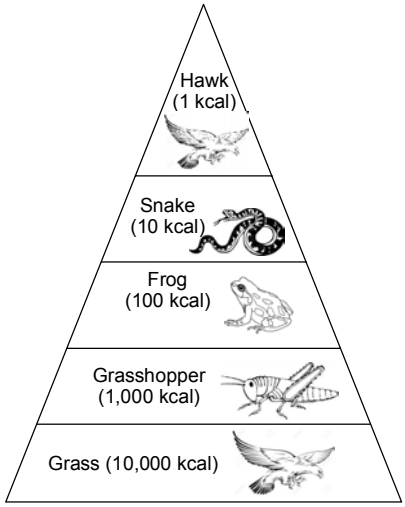
(ii) **Pyramid of numbers:** It shows the number of individual organisms at each level.

(iii) **Pyramid of biomass:** It shows the total dry weight and other suitable measure of the total amount of living matter.



Ecological Pyramid

Pyramid of Energy



Pyramid of Energy

The pyramid of energy shows how the amount of energy entering each level varies across trophic levels. It shows that energy is maximum at producer level and minimum at the consumer level. The consumers are at the top of a food pyramid, means they have much less energy available to support them than those closer to the bottom. Eventually, the amount of useful energy left cannot support another level. That's why energy flow is depicted in the shape of a pyramid.

At every successive trophic level, there is a loss of energy in the form of heat, respiration etc.

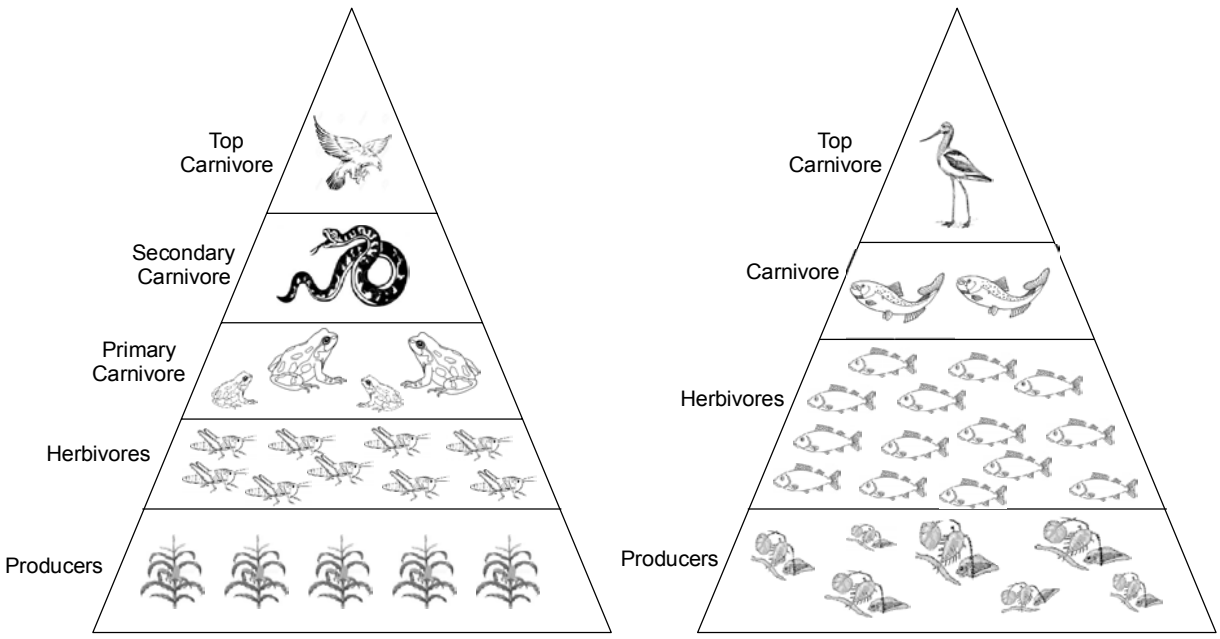
The pyramid of energy is always upright and erect.

Lindeman's Law (10% Law)

- According to Raymond Lindeman, in an ecosystem when energy is transferred from one trophic level to another, then 90% energy is used in maintenance of metabolic processes and only 10% energy is transferred from one trophic level to another.
- A metabolic process means the energy used in digestion respiration and locomotion etc.

Ecological Efficiency

- Ecological Efficiency refers the percentage of energy transferred from one trophic level to another.
- Energy transfer from one trophic to another varies from 5% to 35%. In case of terrestrial ecosystem, rate of transfer is 10%, whereas in case of marine ecosystem, it is about 20%. In marine ecosystem, ecological efficiency is higher because of the rich biodiversity, that is why consumers don't move longer distance for their food intake. Therefore, in this ecosystem less energy is used by consumer to maintain their metabolic processes.



Pyramids of Numbers : (a) In a Grassland, (b) In a pond

Pyramid of Numbers

Pyramid of numbers shows the relationship between producers, herbivores and carnivores at successive trophic levels in terms of their number.

In grassland ecosystem, the producers which are mainly grasses are always maximum in number. This number then shows a decrease towards apex as the primary consumers (like rabbits, mice etc.) are lesser in number than the grasses. Consequently the secondary consumers (like snakes and lizards) are lesser in number than the primary consumers. Finally, the top consumer (like hawks or other birds) are least in number. Thus, the pyramid becomes upright.

In a forest ecosystem, the producers, which are mainly large-sized trees, are lesser in number, and form the base of the pyramid. The herbivores, which are usually birds, elephants, deer etc. are more in number than the producers. Thereafter, there is a gradual decrease in number of successive carnivores, thus, making the pyramid again upright. Hence, in this case, Pyramid of Numbers is partly upright and partly inverted.

In a pond ecosystem, the pyramid is upright. Here, the producers which are mainly the phytoplankton (like algae, fungi etc.) are maximum in number. The herbivores (like smaller fishes) are lesser in number than producers and the secondary consumers (like bigger fishes), are lesser in number than the herbivores.

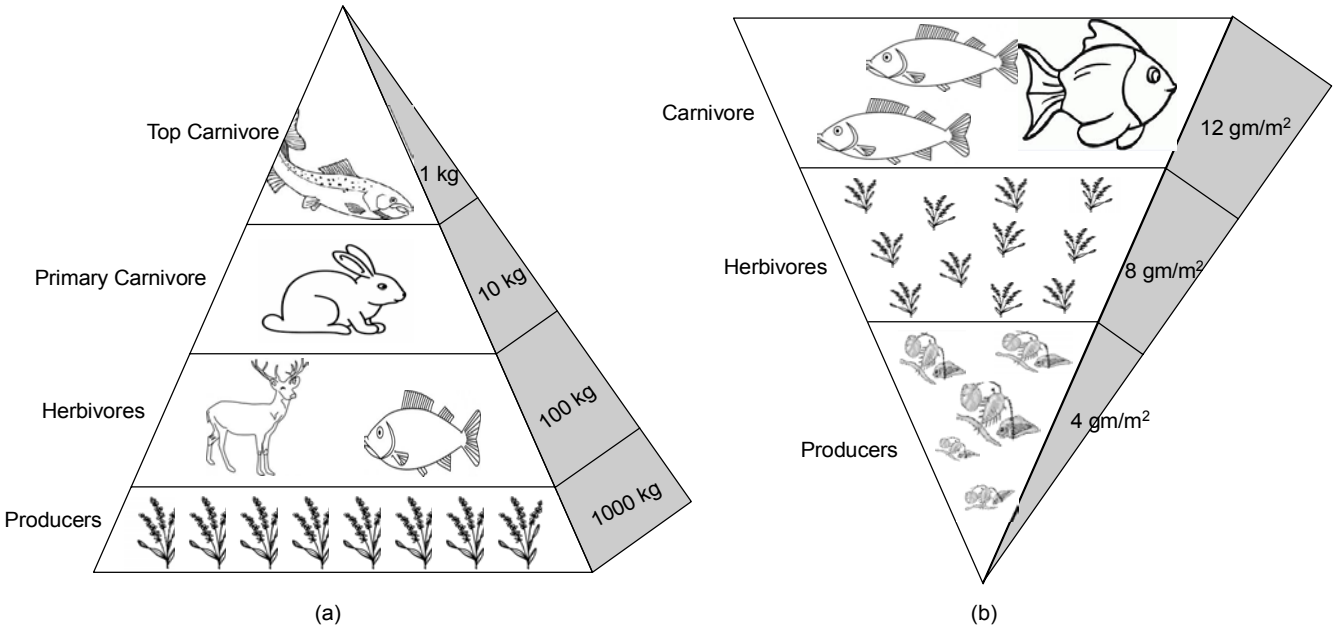
Finally, the top consumers. (like heron) are least in number.

In a parasitic food chain, the pyramids are always inverted. This is because a single plant may support the growth of many herbivores and each herbivore in turn may provide nutrition to several parasites which support many hyper-parasites. Thus, from the producer towards consumers, the number of organisms shows an increment, thus making the pyramid inverted in shape.

Pyramid of Biomass

The pyramid of biomass shows how the biomass of living organisms varies across trophic levels. This dry weight (biomass) represents the amount of organic matter.

In grassland and forest ecosystems, there are generally a gradual decrease in biomass of



Pyramid of biomass: (a) In a Forest Ecosystem (b) In a Pond Ecosystem

organisms at successive levels from the producers to the top carnivores, making the pyramid upright.

In a pond ecosystem, as the producers are small organisms, their biomass is least, and this value gradually shows an increase towards the apex of the pyramid, thus making the pyramid inverted in shape.

Transfer of Bio-toxins in Trophic level

7. Productivity

Productivity of ecosystem refers to the rate of formation of energy and matters which is stored in different species of different trophic levels.

There are two types of productivity:

(i) **Primary Productivity:** It refers to the rate at which chemical energy is produced from solar energy. It is measured in dry weight gm calories/unit area/unit time. e.g. for the whole earth, mean net primary productivity is 320 dry gm cal./m^2/year.

Table 2.6: Primary Productivity for Different Ecosystem

Ecosystem	Primary Productivity
Desert	Less than 2
Deep oceans	Less than 4
Grasslands	2 – 12
Deep lakes	2 – 12
Continental shelf	2 – 12
Mountain forest	2 – 12
Dry farming	2 – 12
Rainforests	12 – 40
Shallow lakes	12 – 40
Humid grassland	12 – 40
Wet cultivation	12 – 40
Estuaries	40 – 100
Springs	40 – 100
Coral reef	40 – 100
Alluvial plains	40 – 100
Annual crops like sugarcane	40 – 100

Gross Primary Productivity (GPP) is the total amount of organic matter that it produces through photosynthesis.

Net Primary Productivity (NPP) describes the amount of energy that remains available for plant growth after subtracting the fraction that plants use for respiration.

(ii) **Secondary Productivity:** It refers to the rate with which energy is stored at different levels in consumers.

8. Ecotone

Ecotone is a transition area between two biomes (vegetational communities), where two communities meet and integrate. It may be narrow or wide, or may be local zone between field and forest, or regional zone between forest and grassland.

An ecotone may appear on the ground as a gradual blending of two communities across a broad area, or it may manifest itself as a sharp boundary line. It describes variation in species of flora and fauna.

Ecocline

Ecocline is a gradation from one ecosystem to another when there is not sharp boundary between the two. It is the joint expression of associated community and complex environmental gradients. It refers variation in physio-chemical environment of ecotone i.e. an ecocline indicates thermocline (temperature gradient), chemocline/chemical gradient, halocline (salinity gradient) or pycnocline (variations in density of water).

It describes variation in forms of species based on genetic differences.

The term was coined by the English evolutionary biologist Julian Huxley in 1938.

9. Biological Spectrum

The biological spectrum consists of all living organisms divided into three domains which are co-existing across various levels of biological organization. The three domains are bacteria, archaea and eukaryota, which are further subdivided into kingdoms. All three domains exist on various levels of biological organization, from a cellular level to its biosphere.

10. Ecological Niche

Ecological niche refers to the web of relationship of a member of flora and fauna in a given environment. It is the way in which an organism

fits into an ecological community or ecosystem. An ecological niche is the role and position a species has in its environment like how it meets its needs for food and shelter, how it survives, and how it reproduces.

Do you know? Ecological niche of herbivores is smaller than carnivores, whereas ecological niche of omnivores is largest.

Ecology

Ecology is a branch of biology that attempts to understand the relationship between living organisms and their environment, and the associated energy flows. The word 'Ecology' is derived from Green word "*Oikos*" which means habitation and "*logos*" means study.

Ecology is a science which studies the interaction of flora and fauna among themselves on one hand and interaction of flora and fauna as a whole to their environment on the other hand.

Under ecology, the study of three features of ecosystem is done:

(i) Interaction of organism as a whole with their physical environment.

(ii) Interaction among members of different species.

(iii) Interaction among members of a particular species.

Ecology was first described as a separate field of knowledge in 1866 by German zoologist Ernst Haeckel. He invented the word "*Oeckologie*" for the relation of animal to its organic as well as inorganic environment.

Do you know? Taxonomy means classification, naming and description of organisms.

Significance of Ecology

Ecology basically provides insight about

(i) Life processes, interaction and adaptation.

(ii) The movement of material and energy through living communities.

(iii) Successional development of ecosystem in environment.

(iv) Extent of biodiversity can be analysed.

Ecological Footprint

An ecological footprint is a measure of human impact on ecosystems of earth. It is typically measured in area of wilderness or amount of natural capital consumed each year. It refers demand of resources by human population from nature to survive.

The ecological footprint tracks the use of six categories of productive surface area: Cropland, fishing grounds, grazing land, built-up land, forest area, and carbon demand on land.

Ecological footprint concept was given by *William Rees* in 1992.

Ecological Succession

Ecological succession refers the entire process of directional and sequential change of either plant community or the whole ecosystem over a period of time in an orderly and predictable sequence along definite pathway towards the predictable end situation. It is also known as Biotic succession or ecological development.

Ecological succession is the gradual process by which ecosystems change and develop over time. There are two main types of succession: primary and secondary.

Types of Ecological Succession

Ecological succession breaks down into three fundamental phases: Primary Succession, Secondary Succession and a Climax Community.

(i) **Primary Succession:** Primary succession occurs when organisms colonize an area devoid of life, usually after a catastrophic natural event that leaves the land barren. Often the first organisms to take hold are algae, fungi and simple plants such as lichens and mosses.

Pioneer Community : It is a group of organisms that invade a new area in the process of ecological succession. These organisms are typically plants, animals and fungi. They are the first to move into a new habitat and often make the habitat more hospitable for future inhabitants.

(ii) **Secondary Succession**

Secondary succession occurs when an area that has previously had an ecological community is so