ISBN: 978-93-88901-90-1

RESEARCH TRENDS IN LIFE SCIENCE VOLUME II

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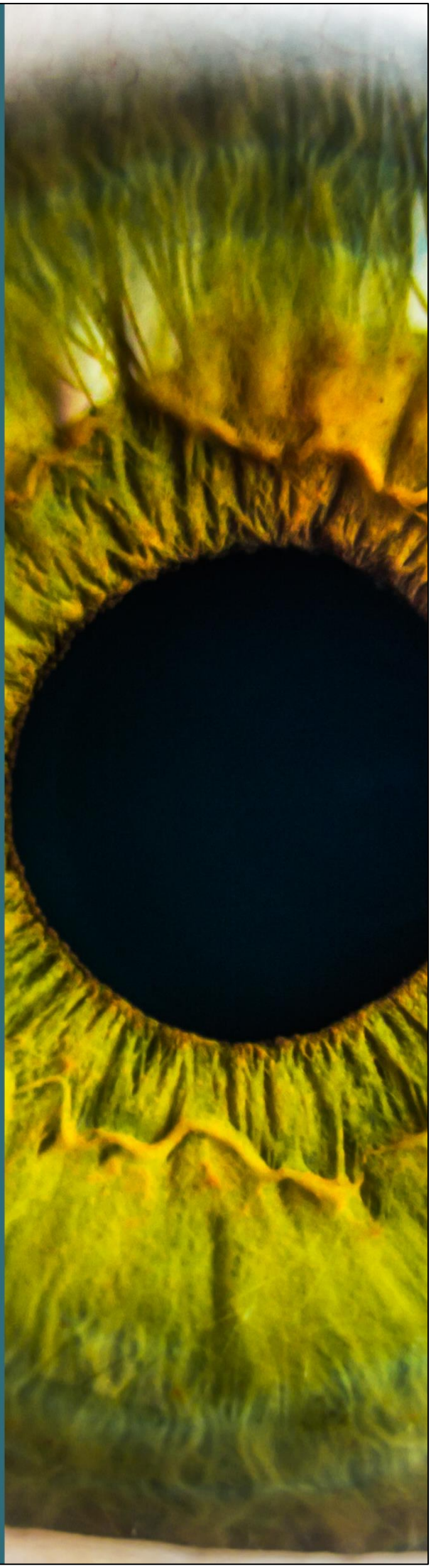

BHUMI PUBLISHING, INDIA
FIRST EDITION: SEPTEMBER 2023

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Bhumi Publishing

September 2023

First Edition: September, 2023

ISBN: 978-93-88901-90-1

Published by:

Bhumi Publishing,

Nigave Khalasa, Kolhapur 416207, Maharashtra, India

Website: www.bhumipublishing.com

E-mail: bhumipublishing@gmail.com

Book Available online at:

https://www.bhumipublishing.com/book/

PREFACE

The realm of life sciences encompasses an extraordinary array of disciplines, from molecular biology to ecology, genetics to neuroscience, and microbiology to environmental science. It is a dynamic and ever-evolving field, where researchers continually push the boundaries of knowledge and innovation. This book is a testament to the remarkable progress made in recent years and the exciting future that lies ahead. In this volume, we have gathered insights from leading experts, scholars, and practitioners who have dedicated their careers to advancing our understanding of the natural world and the living organisms that inhabit it. Their contributions span a wide spectrum of topics, from fundamental research that uncovers the intricacies of cellular processes to applied studies that address critical global challenges such as climate change, infectious diseases, and biodiversity conservation.

The chapters in this book delve into key research trends, methodologies, and breakthroughs that are shaping the life sciences landscape. From the revolutionary advances in genomics and gene editing technologies to the exploration of complex ecosystems and the impacts of human activities on biodiversity, these chapters provide a glimpse into the frontiers of life sciences research.

Furthermore, this book serves as a valuable resource for students, educators, and anyone with an interest in the fascinating world of life sciences. It offers a wealth of knowledge and insights that can inspire and inform future generations of scientists and researchers. We hope that this compilation of chapters will spark curiosity, foster collaboration, and encourage innovative thinking within the field.

As we embark on this journey through the intricate tapestry of life sciences, we invite you to explore the diverse and captivating topics presented in this volume. Whether you are a seasoned researcher, a student just beginning your academic journey, or simply a curious reader, we trust that you will find this book to be a valuable resource and a source of inspiration for your own exploration of the life sciences.

We extend our gratitude to all the authors who have generously shared their expertise and knowledge in these pages. Their dedication to advancing the frontiers of life sciences research is commendable, and we are honored to feature their contributions in this book.

Editors

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THEORY OF FISH STRESS

Rinkesh N. Wanjari*[1], Dhanalakshmi M[2], Shivkumar[2] and Harshavarthini M[2]
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Abstract:

The evolving concept of animal stress over the last decade considers its impact on physiology, psychiatric disorders, and ecosystems. The Anthropocene era's threats have led to a biodiversity crisis, particularly affecting marine life due to pollution, climate change, and habitat degradation. Fish, as ectotherms, are sensitive to temperature changes, impacting their behavior and physiology. Climate change's effects, including rising ocean temperatures and extreme events, pose significant risks to global fish populations, especially in traditional fisheries. These changes are driven by greenhouse gas emissions like carbon dioxide. Understanding stress's effects on individual fish is vital for conservation and aquaculture, as stress disrupts homeostasis and affects offspring quality. Overall, acknowledging the physiological responses of fish to stress sheds light on the urgent need to address climate change's consequences on ecosystems and livelihoods.

Keywords: Anthropocene, Climate change, ectotherms, Fish stress, homeostasis

Introduction:

The paradigm of animal stress has been context specific over the past decade in order to account for the consequences of the intermediate compound in cell and tissue physiology, severe psychiatric disorders, and ecological changes in communities. Because of the numerous threats the Anthropocene has brought, global ecosystems are presently experiencing an enormous biodiversity crisis (Reid *et al.,* 2019). The ichthyofauna has been directly impacted by a number of anthropogenic stressors, including fishing pollution, intense coastal activity, invasive species, climate change, and habitat degradation. These stressors disrupt marine species and ecosystems and alter the structure and operation of their trophic structure (Pauly *et al.,* 1998; Britten *et al.,* 2016). Fish species extinction is one of several ecosystem changes caused by global environmental change (Barletta *et al.,* 2010). One of the most severe environmental concerns is climate change, which is becoming a worldwide problem (Belkin, 2009; Lyman *et al.,* 2010; Ripple *et al.,* 2020; Weiskopf *et al.,* 2020). In the 21st century, global warming of 1.5^{0} C will be exceeded unless CO_2 and other greenhouse gas emissions are significantly reduced, according to the IPCC Sixth assessment report (IPCC, 2021). Fish are ectotherms, which implies that their body temperature is proportional to the temperature of their water, having a significant impact on their physiology, behavior, and metabolism, (Clarke and Johnston, 1999). The temperature has a wide range of impacts on the physiology of fish under stress. First, according to the Boltzmann-Arrhenius model, general thermodynamic influences on chemical reaction kinetics are predicted

to have an impact on the synthesis, release, and activities of stress hormones (Arrhenius, 1915; Boltzmann, 1972). This is especially crucial because global warming is also causing other aspects of aquatic habitat global change, like ocean acidity and salinity changes (IPCC, 2014). Fish populations have already been shown to be affected by global warming through changes in local abundance, extinctions, or migrations to colder places (Free *et al.,* 2019). So what is the root cause of these changes? Fish populations are being affected by global warming in ways that are indirect, such as through changes in prey-predator interactions or decreased oxygen availability (Breitburg *et al.,* 2018). Nonetheless, population shifts are considered to be primarily caused by a physiological response to temperature (Pörtner and Farrell, 2008). Both in the wild and in captivity, adult fish are subjected to stressful environments. Once fish have started feeding exogenously, the nature of the physiological reactions to stressors becomes stereotypical at a gross level among life cycle stages. Yet, depending on the fish species, stage of development, and nature and intensity of the stressor, the stress response might vary widely. A major global environmental emergency, the impact of climate change is having a far-reaching severe influence on the agriculture sector, including fisheries (Srinivasarao *et al.,* 2019). Global ocean temperatures are predicted to increase by 1-4° C by 2100, with potential effects on stress physiology. Besides continuous temperature rises and an increase in the frequency of intense heat wave occurrences, global warming is having an impact on animal populations all over the world. Fishes are ectotherms, which implies they are likely to be particularly vulnerable to climate change. One indicator of climate change is global warming. Long-term climate change will have an impact on the ocean's ecosystem, its ability to support fishing populations, and is anticipated to make marine fish species extremely stressed. The most likely to suffer are fisheries with limited mobility, such as small-scale traditional fisheries. Climate change has an impact on key oceanic weather systems such as sea surface temperature, salinity, pH, El Nino Southern Oscillation (ENSO), sea level, precipitation, frequency and intensity of cyclones, and droughts. Greenhouse gases, such as carbon dioxide, ozone, methane, and nitrous oxide, are the main causes of climate change. Understanding the impacts of stress on an individual is necessary to comprehend the implications of stressful events on populations. This knowledge is essential for conservation biology, managing wild populations, and aquaculture. The quantity and calibre of the broodfish's offspring can serve as a good indicator of the ecological and managerial factors affecting the quality of the parent fish. Stressful events can overwhelm a fish's homeostatic processes, putting additional strain on the body in an effort to make up for it and reach a higher degree of stasis.

What is stress?

It's astonishing how challenging it is to define the term stress. "It is a physiological response of the organism". The stressor, or environmental condition, is what effectively causes the response. Unfortunately, many people use the word "stress" differently. It might refer to the environmental change (stressor) either, the fish response, the population response, or even the ecosystem response (Pickering, 1981).

Stress definition

The physiological concept given forward by Selye (1950, 1973) is where the word "stress" first emerged: “stress is the nonspecific response of the body to any demand placed upon it.”

Or when an organism's natural capability to regulate its environment is surpassed, a situation known as stress results (Koolhaas *et al.*, 2011).

Physiological responses to stress are grouped as following

As primary, which include endocrine alterations such as quantifiable levels of circulating corticosteroids and catecholamines, and secondary, which include changes in characteristics related to metabolism, hydromineral balance, and cardiovascular, pulmonary, and immunological systems. In some cases, the endocrine reactions are directly in charge of the secondary reactions that lead to alterations in the concentration of blood components, such as metabolites and major ions, and, at the cellular level, the expression of heat shock or stress proteins. The primary and secondary responses may cause tertiary or whole-animal performance changes that may have an impact on survival, including growth, disease resistance, and behavior (Fig. 1).

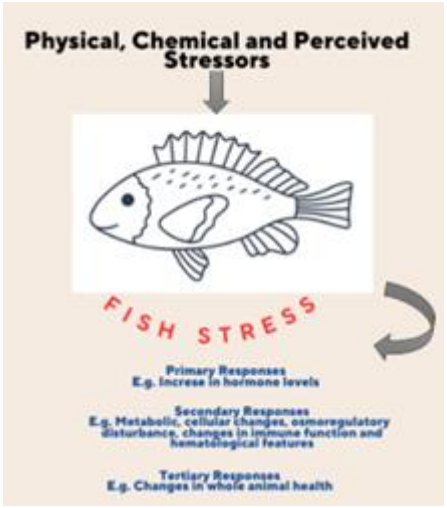

Fig. 1: Depicted the fish experience primary, secondary and tertiary responses as a result of the physical, chemical, and perceived stressors

Why stress is importance to measure?

How well a fish resists death and restores homeostatic norms in the presence of harmful stimuli is shown by stress measurements. To comprehend how animals are adapted to, or capable of adapting to, forthcoming stressors, this information is then converted into evolutionary and ecological theory. From a fundamental approach, assessing stress advances our understanding of carryover effects (O'Connor *et al.*, 2010), parental influences (Sopinka *et al.*, 2014), personality (Pottinger and Carrick, 2001; Ricklefs and Wikelski, 2002), and life history variation (Aubin-Horth *et al.*, 2012). In order to ascertain how interactions with humans are affecting the health, functionality, and well-being of fish, it is essential to measure stress. For instance, the stress in fish populations is commonly evaluated in hatcheries, farms, and aquariums with the aim of

minimizing stress to promote growth and survival. The empirical study of stress in fishes is actually rooted in aquaculture studies that investigate how handling, rearing, and transport as well as anesthesia (Iwama *et al.,* 1999; Trushenski *et al.,* 2012) affect captive broodstock health and production effectiveness (Barton *et al.,* 1980; Portz *et al.,* 2006).

Factors which are influence the stress in fish

For two reasons, interpreting changes in physiological variables can be more challenging than measuring responses. First, there are a number of genetic, developmental, and environmental factors that might influence the intensity and frequency of the stress response.

1. Genetic factors:

Fishes differ greatly in how they react to stimuli, notably in how their endocrine systems react (Barton and Iwama, 1991; Gamperl *et al.,* 1994). Because of their significance including both government and commercial aquaculture, studies on corticosteroid stress responses have tended to focus on freshwater fish, particularly salmonids (Barton and Iwama, 1991), but interest has probably turned to commercially important marine species (Barnett and Pankhurst, 1998). There are certain fish species that differ from this general trend, but for the majority of fish species studied, the peak plasma cortisol increase occurs within 0.5–1 hours of a stressful event (Barton and Iwama, 1991).

2. Developmental factors:

The fish's response to a stressor may also depend on where it is in its developmental cycles. The capacity of a fish to react to a disturbance begins to develop very early in life. Fish certainly appear to have increased reactions during times of metamorphosis, but there is little evidence to imply that these responses increase consistently as fish grow. For instance, during the parr-smolt transformation, a period of physiological metamorphosis when young salmon prepare for ocean migration, anadromous salmonid fishes appear to be particularly vulnerable to certain stresses, particularly physical interruptions.

3. **Environmental factors:**

Almost all environmental variables evaluated have the potential to affect how fish react to stressors. The acclimation temperature (Davis and Parker, 2004), the salinity (Barton and Zitzow, 1995), the time of day (Barton *et al.,* 1986), the wavelength of light (Volpato and Barreto, 2001) and even background color of the tanks (Gilham and Baker, 1985). The fish's nutritional status and the prevalence of disease (Barton *et al.,* 1986) are two internal environmental factors that may also influence the severity of the stress reaction.

How stress is affecting on growth of fish?

Stress affects a wide range of processes during the allocation of energy to grow. In many fish species, growth is a highly heritable characteristic, and selection for a quicker growth rate has led to higher production (Dunham, 2011). Faster fish growth is one of the most crucial selection factors in aquaculture (Gjedrem, 2005). Nutritional component: In addition to having an impact on stress reactions, the food's quantity and content may also contribute to intraspecific heterogeneity in the stress response profile. Considering that AAs and FAs have an impact on the

synthesis of neurotransmitters, the composition of membranes, and the excitability of neurons, it appears that the amino acid (AA) and FA composition of the food is especially significant. In general, a fish's reaction to stress depends on the severity and type of the stressors. Stressors can be short-lived (acute), such as getting trapped in a net or evading a predator, or long-lasting and even more or less permanent. Examples of the latter include being overcrowded in a tank or at the bottom of a social hierarchy.

Acute effects

Sudden exposure to high temperatures is perceived as stress by fish, leading to the release of catecholamines and cortisol (LeBlanc *et al.,* 2011; Cockrem *et al.,* 2019). Secondary stress responses are also observed upon acute temperature increase; glucose and lactate generally rise during the acute thermal challenge, along with alterations in blood osmolality and other haematological variables (Dengiz Balta *et al.,* 2017; Bard and Kieffer, 2019). Moreover, the fish immune system may have adverse effects (Dengiz Balta *et al.,* 2017). The endocrine stress systems also influence Heat Shock Protein (HSPs) release at the cellular level (Maloyan and Horowitz, 2002; Currie *et al.,* 2008). According to Currie *et al.,* (2008), the adrenergic system increased the HSP response in the red blood cells of rainbow trout *Oncorhynchus mykiss* (Walbaum 1792) while cortisol decreased the levels of HSPs brought on by heat stress (Basu *et al.,* 2001). Episodeal and intense maritime heat waves are becoming more common and more severe as a result of global warming (MHW; Meehl and Tebaldi, 2004; Hoegh-Guldberg and Bruno, 2010; Vasseur *et al.,* 2014; Frölicher *et al.,* 2018).

As a result of global warming, it has been proposed that these severe events may be more important in influencing population changes than a steady rise in average temperatures. Yet, it is impossible to estimate how frequently sudden temperature fluctuations occur in wild fish. According to Nivelle *et al.,* (2019), fish are known to actively seek their optimal temperature, however, depending on habitat conditions and species biogeography, this may not always be possible. Because of this, even though we believe that protocols looking into laboratory-induced acute (within hours) thermal shocks are worthwhile being conducted in the context of fundamental research (for example, to describe coping mechanisms) or aquaculture (for example, to describe effects on welfare or productivity), scientists should be careful when interpreting such results in the context of global warming. In certain sequential order, fish can frequently be subjected to the same acute stressor, as in mark-recapture studies.

Chronic effects

As temperature controls the rate of biological reactions, fish physiology is impacted by living in warmer water (Somero, 2004). Consequently, the basic activity of the HPI and BSC axes, basal discharge of stress hormones into the cardiovascular circulation, as well as neurotransmitter activity, can be expected to be increased by physiological acclimatization (or acclimatization) to a higher temperature. It may be challenging to distinguish these effects of temperature on biochemical reaction rates from effects brought on by a chronic stress response.

Review the data, however, to understand how continuous increases in water temperature affect the most prevalent fish stress markers.

Management of stress and response mechanism effects

The evaluation of the mechanisms by which stress affects the reproductive endocrine axis is made more difficult by the possibility of both direct effects of the hormone products of the HPI axis on reproductive performance and indirect effects resulting from the regulatory action that the HPI axis has on behavior, metabolism, and growth (Leatherland *et al.,* 2010). Despite this concern, it was a legitimate working assumption that similar to mammals, fish would experience effects at various stages of the endocrine cascade, with corticosteroids acting as a major mediator of many of these effects. GnRH neurons in the caudal telencephalon and POA of the brain, FSH- and LH-secreting cells of the pituitary, hepatocytes of the liver, and ovarian and testicular tissues are only a few of the reproductive axis locations where GRs have been located (Milla *et al.,* 2008). In addition, Borski *et al.,* (2001) revealed nongenomic effects of cortisol on prolactin-secreting cells in the pituitary of Mozambique tilapia, and mammalian investigations have shown membrane-bound corticosteroid receptors mediating nongenomic effects in a myriad of organs (Tasker *et al.,* 2006). This resulted in an initial focus on the role of cortisol in modulating stress effects on reproduction in fish.

The different potential stressors can be categorised into three groups: environmental, physical, and biological stressors. Environmental stressors mostly consist of unfavorable water conditions. Despite the fact that contaminants are prevalent environmental stressors, fish can also become stressed by harsh weather or variations in water quality indicators as dissolved oxygen, ammonia, hardness, pH, gas concentration and partial pressures, and temperature. Fish can become stressed and even die when there are high quantities of metals in the water, such as copper, zinc, cadmium, and iron. All salmonids are highly stressed by contaminants such as polychlorinated biphenyls, arsenic, chlorine, cyanide, and different phenols. Insecticides, fungicides, herbicides, and defoliants are other possible environmental stressors. These pollutants, which have an impact on fish at all stages of development, are most likely introduced to the environment by industrial, residential, and agricultural sources. Handling, crowding, imprisonment, transportation, or other physical disturbances are examples of physical stressors. Standard techniques to stress fish in physiological studies include chasing fish until they exhaust themselves or suspending fish in a net suspended in the air for a period of time (30s to 1min). This stress on fish is in part the result of angling. Dominance hierarchies that form amongst people in confined spaces, such as experimental tanks, or even in natural environments, can be a consequence of biological stressors. Biological stresses can also include disease infections.

According to the source, effect, environment, and stressor characteristics, fish responses to stressors in aquaculture differ (Akinrotimi *et al.,* 2009). Yet, most types of stressors share the characteristics of stress reactions. To give fish the best chance of surviving, the stress response in fish is a comprehensive response that combines behavioural, neurological, hormonal, and physiological components (Pickering, 1993). Moreover, Gabriel and Akinrotimi, (2011)

observed differences between male and female fish in their responses to stress. Hence, the manner in that fish react to stress depends greatly on their gender. Fish physiological reactions to stimuli in the environment have been roughly classified as primary, secondary, and tertiary (Barton, 2002).

Primary response

The sympathetic-chromaffin system and the hypothalamus pituitary-interrenal axis are activated during a stress reaction (Pickering, 1981). These systems' parameter changing are referred to as their principal stress responses (Vosyliene and Kazlauskiene, 1999). The primary response involves the initial neuroendocrine responses, which include the secretion of catecholamines from chromaffin tissues and stimulation of the hypothalamic-pituitary-interrenal (HPI) axis, which results in the release of stress hormones, catecholamines, as well as cortisol circulation (Randall and Perry, 1992; Reid *et al.,* 1998). (Wendelaar Bonga, 1997; Mommsen *et al.,* 1999). The interrenal tissue in the head (anterior) kidney releases cortisol in response to a number of pituitary hormones, but adrenocorticotrophic hormone (ACTH) has the strongest effect (Balm, 1997). Between 20 and 70 nmoles/L for adrenaline and 40 to 200 ng/ml for cortisol, respectively, are the plasma concentrations for salmonids at rest and during stressful situations (Iwama et al, 2004). These numbers could be used as a general baseline. The plasma values for the control and stressed states will change depending on individual factors such as species differences, general traits, prior rearing history, and local environmental factors (Barton *et al.,* 2002).

Secondary response

This response consists of associated changes in heat shock or stress proteins (HSPs), plasma and tissue ion and metabolic levels, and hematological characteristics. A similar 30-second aerial emersion stressor also affected the plasma cortisol concentrations of a few juvenile freshwater fishes, which affected changes in metabolism, acid-base status, respiration, immune function, hydromineral balance, and cellular responses (Pickering, 1981; Iwama *et al.,* 1997; Mommsen *et al.,* 1999; Barton, *et al.,* 2002). A number of metabolic pathways are activated by stress hormones in this kind of response, which changes blood chemistry and hematology (Randall and Perry 1992; Vijayan et al.; 1994; Iwama *et al.,* 2004). The plasma glucose concentration is also of significance because it has frequently been used to indicate the stressed state in fish and may be the most frequently studied secondary response parameter to stressors in fish (Barton *et al.,* 2002). Iwama *et al.,* (2006) found that the generation of glucose and the removal of it from the circulation both affect the plasma glucose concentration in the blood. When a fish is under stress, glucose is created, which provides energy to tissues like the brain, gills, and muscles so they can meet the increased energy demand. The liver serves as the primary site for glycogenolysis or gluconeogenesis, which produces glucose. Fish glucose production has been connected to the hormones cortisol and adrenalin (Vijayan *et al.,* 1994).

Tertiary response

Tertiary responses are characterized by changes in growth, condition, overall resistance to disease, metabolic range of activity, reduced reproductive potential, and eventually survival at the population and entire animal levels (Wedemeyer and McLeay, 1981; Wedemeyer *et al.,* 1990; Iwama *et al.*, 2004). According to Barton *et al.,* (2002), stress may be related to all of these changes. In order to meet the increased energy demand brought on by stress, mediated energy-repartitioning that shifts energy substrates away from essential life processes like reproduction and growth has a negative impact on cultured organisms. In a number of circumstances, stress poses a serious threat to the health and well-being of fish. Aquaculture, large-scale fisheries, recreational fishing, research, and the ornamental fish sector all stand to gain from maintaining fish welfare. Fish that are in better health yield higher economic returns, increase population numbers, produce reliable experimental data, are aesthetically beautiful to look, and never threaten public health. Fish welfare may be harmed by numerous actions that induce stress in each of these areas where fish are used.

Stress management strategy:

- Maintaining high standards for water cleanliness in the culture medium
- Appropriate stocking density
- Balanced diet
- Proper sanitation
- Proper management of fish during transportation
- Usage of Anesthetics

Consequences of stress in fish

- ✓ Being cold blooded, fish's metabolism accelerates when the water temperature rises.
    - Digest food more rapidly
    - Grow more quickly
    - Have more energy to reproduce
- ✓ To support this greater metabolism, fish need to have more food and oxygen.
- ✓ Fish tend to mature more rapidly in warmer waters.
- ✓ This faster way of living frequently results in lower body sizes and smaller broods.
- ✓ The ability to determine sex will be impacted by greater temperatures (e.g. more females).

Conclusions:

With rising seasonal water temperatures and more frequent intense heat wave events, global warming is now a reality that poses a threat to fish. In order to adapt to environmental changes, such as global warming, stress physiology plays a critical role. In the last few decades, there has been a significant advance in scientific understanding of what stress is in fish, particularly concerning the physiological mechanisms and reactions that affect growth and metabolism, immune system function, reproductive ability, and normal behavior.

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COMPONENTS OF ECOSYSTEM

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Introduction:

An ecosystem is a group or community of living and non- living things and their interactions. They can be Natural or Artificial (man -made). Ecologists study these interactions to understand the richness and diversity of life in Earth's ecosystems. Ecosystem diversity concerns the study of different ecosystems in a given location and their overall impact on humans and the environment as a whole. It is a type of species diversity along with species diversity, genetic diversity, and functional diversity. Ecosystems can be small, like the tide pools on the rocky coasts of many oceans, or very large, like the Amazon rainforest in South America. Fundamentally, it is the responsibility of ecologists studying ecosystems to define their boundaries in a way that is meaningful to the question of their interest.

Ecosystems include marine ecosystems, freshwater ecosystems, and terrestrial, or terrestrial, ecosystems. Marine ecosystems are the most prevalent on Earth, as the oceans and their inhabitants cover 75% of the Earth's surface. Freshwater ecosystems cover only 1.8% of the Earth's surface and are rare. Land, lands and ecosystems cover the rest of the planet. Ecosystems are dynamic systems, and static ecosystems become dead ecosystems just as static cells are dead cells. Energy is constantly flowing through ecosystems and chemical nutrients are constantly being recycled. At higher organizational levels, organisms die and are born, populations fluctuate, and climate patterns change seasonally and unpredictably.

Ecosystem diversity is concentrated in both terrestrial and aquatic ecosystems. Ecosystem diversity is called “maximum species diversity” because it has a large impact on both genetic diversity and species diversity. Grasslands, tundra, deserts, rainforests, terrestrial and marine ecosystems are examples of ecosystems that contribute significantly to creating a diverse and balanced environment.

The complex functioning of an ecosystem depends on its species richness and diversity. Defective or disrupted ecosystems can throw our biosphere out of balance. Ecosystems of many different species are often found on larger scales, but even the smallest life forms play important roles within the smallest ecosystems.

Ecological hierarchy

Ecological hierarchy theory describes the arrangement of the interrelationships of biological organisms. In the simplest level of the hierarchy the individual organisms are present. At the individual level, interactions with the other organisms are not to be considered. Moving up the hierarchy, ecologists have discovered more complex ways of describing relationships

between organisms. These culminate in the biosphere, which represents the totality of all life on Earth. The hierarchy of Ecology from smallest to largest in order:

Organism: (Individual)

Population: (Group of a Species)

Community: (Many different Populations in an area)

Ecosystem: (The living and nonliving things in an area)

Biome: (Collection of Ecosystems, categorized by amount of rainfall and temperature)

Biosphere: (Every part of the Earth that supports living things)

Individuals: The first level in the ecological hierarchy is the individual. This hierarchy level studies how organisms interact with their environment. Evolutionary aspects are widely used for this level of research. For example, scientists can study why giraffes have such long necks at the level of individual organisms. He can conclude that evolution gave giraffes long necks that enabled them to reach food sources in tall trees. Bioecology is concerned with the biological, morphological and physiological development of individual organisms in response to their natural environment.

Population and Communities: The second level includes population. A population consists of a group of individuals belonging to a species, living in a specific geographical area, and interacting with each other. Population ecology studies the interactions between individual members of a population. His third level of the ecological hierarchy represents communities. At the community level, we focus on the relationships between different species within the community. Predator-prey relationships play an important role in community-level analyses. Parasitism and competition between species are another important part of this ecological level. **Ecosystem:** The next level is the ecosystem. A community is part of an ecosystem, but it does not encompass the entire ecosystem. Non-living elements of the environment are included in ecosystems. Organisms within an ecosystem interact and interact with inanimate elements within the environment. Examples of ecosystems include single lakes, bounded forests, grasslands, and mountain peaks.

Biosphere: At the broadest level of analysis, the biosphere represents the whole that includes the interactions of everything on Earth, encompassing all ecosystems on Earth and how they interact. By default, the biosphere includes climate, geology, and marine and human pollution. This level of analysis may seem abstract, but it is often said that destruction of ecosystems such as the Amazon rainforest due to global climate change could result in global losses in climate regulation and affect livelihoods in regions of the world far from the Amazon.

Biotic and abiotic components

Every ecosystem has two components, a biotic component and abiotic component. Biotic compound means living things and whereas abiotic components are totally opposite of biotic that is non living things. Both the biotic and abiotic components are important as they maintain the ecological balance. These are of two types biotic and abiotic components which are constantly connected to each other.

Biotic components of ecosystem:

The living components of an ecosystem are known as the biotic components. Examples are plants, animals, fungi and bacteria. Based on the energy requirement source these biotic components are also further classified. They are three broad categories of biotic components Producers, Consumers, and Decomposers.

1. Producers are plants within an ecosystem that can generate their own energy needs through photosynthesis in the presence of sunlight and chlorophyll. All other living things depend on plants for their energy needs, such as food and oxygen.
2. Consumers include - Herbivores, Carnivores and Omnivores. Plant eaters are herbivores. Those who eat other living things are carnivores. Omnivores are animals that can eat both plants and animals.
3. Decomposers are saprophytic fungi and bacteria. They eat decaying organic matter and convert it into nitrogen and carbon dioxide. Saprophytes play an important role in recycling of nutrients so that they can be reused by producers.

Food chain

Food chain, in ecology, the series of transfers of matter and energy from one organism to another in the form of food. Since most organisms eat more than one species of animal or plant, food chains are locally intertwined to form food webs. Plants, which convert solar energy into food through photosynthesis, are the main food source. In a predatory chain, herbivores are eaten by carnivores.

In a parasite chain, smaller organisms eat part of a larger host, and may be parasitized by even smaller organisms. In the saprophytic chain, microorganisms live by eating dead organic matter. Land Food Chain Investigate how spiders protect plants by making amazing prey on herbivorous insects. Energy is lost in the form of heat at each stage or trophic level, so the chain usually stays at 4 or 5 trophic levels. Humans can increase the overall food supply by eliminating one step in the food chain. Instead of consuming grain-eating animals, humans themselves consume grain. Shortening the food chain increases the total amount of energy available to end users.

Food web

A complex network of interconnected and overlapping food chains that represent trophic relationships within a community. Food chains show how matter and energy from food are transferred from one organism to another, and food webs show how food chains are intertwined within an ecosystem. Food webs also show that most organisms eat or are eaten by multiple species, but this is often not seen in food chains.

In general, food energy within an ecosystem can be thought of as a pyramid structure with energy moving upwards, with each level of this energy pyramid corresponding to a nutrient (or food) level within the ecosystem. The Producers appear to form the base of the pyramid. Plants are the most prominent producers, but algae, phytoplankton, and other organisms also fall into this category. Most producers use photosynthesis to make food for other organisms. Oak

trees are examples of producers. It produces leaves that are eaten by insects and birds, and acorns that are eaten by squirrels and other mammals. The main consumers that form the second level of the pyramid are herbivores (such as leaf eating insects) that feed on producers. However, omnivores (animals that can eat both plants and other animals) such as possums and raccoons may also be considered primary consumers if they eat only plants. Secondary consumers, which make up the third tier, are carnivores or omnivores that prey on primary consumers (snakes, spiders, small predatory fish, etc.), while tertiary consumers are large carnivores (wolves, big cats, etc.). animals, birds, etc.). sharks and other large predators, predatory fish) capture secondary consumers. Other important members of the food web are spoilers and decomposers, whose activities remove dead material from ecosystems and convert it into raw materials that can be reused by producers. Detritivores scavengers (such as vultures and beetles) that feed mainly on the remains of the dead organisms. Decomposers (such as fungi and bacteria) convert organic material into basic organic and inorganic compounds made up of nitrogen, carbon, calcium, phosphorus, and other chemical elements that plants and other producers use to grow and break down into compounds.

Abiotic components of ecosystems

An abiotic factor is a physical or chemical factor that acts on an organism in any part of its life. This factor is known as Ecological factors. Physical and chemical factors are characteristics of the environment. Light, air, soil, nutrients, etc. form the abiotic components of ecosystems. Abiotic factors vary from ecosystem to ecosystem.

In aquatic ecosystems, abiotic factors include water pH, sunlight, turbidity, depth, salinity, available nutrients, and dissolved oxygen. Similarly, abiotic factors in terrestrial ecosystems include soil, soil type, temperature, precipitation, altitude, wind, nutrients, sunlight, etc. The sun is the source of energy here. Plants use this energy to synthesize food in the presence of carbon dioxide and chlorophyll. The sun's energy is converted into chemical energy through several chemical reactions.

Major ecosystem

The Earth is a vast ecosystem (biosphere) in which abiotic and biotic elements constantly interact and react, resulting in structural and functional changes. However, because these worst ecosystems are difficult to manage, nature is usually studied artificially subdivided into smaller units of ecosystems for the sake of simplicity. Ecosystems represent the highest level of energy-based ecological integration. A functional unit capable of converting, storing, and circulating energy. There are two categories in ecosystem –

1. Natural Ecosystem
2. Artificial Ecosystem

1. Natural ecosystem

An ecosystem formed on the basis of natural activity with only abiotic, biotic, and energetic elements and no human activity. Based on place of residence and water supply, these are further classified as: Terrestrial Ecosystem and Aquatic ecosystem.

Terrestrial Ecosystem: Terrestrial ecosystems are ecosystems found only on landforms. There are four major terrestrial ecosystems: tundra, taiga, desert, temperate and grassland. Major ecosystems under terrestrial as follows:

i) Forest ecosystem ii) Grassland ecosystem iii) Desert ecosystem

i) Forest ecosystem:

A forest ecosystem is a functional unit or system composed of soil, trees, insects, animals, birds, and humans as interacting entities. Forests are large and complex ecosystems and therefore have greater biodiversity. They are also much more stable and resistant to adverse change compared to smaller ecosystems such as wetlands and grasslands. Structural features of forest ecosystems. The two main structural features of forest ecosystems are:

Species composition: Refers to the identification and enumeration of plant and animal species in forest ecosystems.

Stratification: Refers to the vertical distribution of different species occupying different levels of a forest ecosystem. Each organism occupies a place in the ecosystem based on its food source. For example, in a forest ecosystem, trees occupy the top layer, shrubs occupy the second layer, and herbs and grasses occupy the bottom layer.

Importance of forest ecosystem: It can be used for bioenergy production It can sequester carbon. It also helps in the temperature regulation.

Depending on climate conditions, forest can be classified into the following types:

a. Tropical rainforest:

- Define –A tropical rainforest is a tropical rainforest that grows in the tropics having high amount of the rainfall.
- Location – The tropics, or rainforests, lie near the equator, the imaginary line that circles the earth and divides the northern and southern hemispheres. Two other imaginary lines run parallel above and below the equator. The tropical regions of the world lie within the Tropic of Cancer and Tropic of Capricorn. Tropical rainforests are home to more animal and plant species than any other habitat.
- Species – Many of these species will be lost as the world's rainforests are destroyed. Up to 50 percent of all species on earth live in rainforests. Flora – Orchids, Rattan Palm, Epiphytes, Bromeliads, Acai Palm and Carnauba Palm etc. Fauna – Jaguars, Anacondas, Harpy, Eagles, Poison Dart Frogs, Gorillas, Chimpanzees, Gaboon Vipers, Tigers, Orangutans, Hornbills, Tapirs, Pangolins etc.
- Types – Tropical rainforests are of different types. A "typical" rainforest is known as a *lowland rainforest*. Temperatures are high here, it rains almost all year round, and the atmosphere is humid. 4,444 mountain rainforests are located in the highlands. It is cool and often shrouded in fog. For this reason, they are often called "cloud forests". *Mountain rainforest* trees are often shorter than lowland rainforest trees. *Mangrove rainforests* grow in coastal areas where the land is often permanently flooded with salt water. *Forest*

flooding occurs where land is frequently flooded with freshwater. Also, in monsoon forests, seasonally high rainfall is interrupted by drought.

- Significance – Rainforests are also used to produce food, medicines and other products. Many rainforest products can be sustainably produced. However, commercial pressures often outweigh environmental concerns
- Examples – Amazon rainforest in South America, Congo rainforest in Africa, Daintree rainforest in Australia, Rainforests of Sumatra and Borneo.

Tropical deciduous forest:

Tropical Dry
Deciduous Forest

- Define – Deciduous forests are also known as Monsoon Forest and are considered as the regions having the most tree-covered areas and ecosystems with distinctive soil dynamics.
- Location – Deciduous Forest are located in Asia, Europe, and North America etc.
- Species – Due the unfavourable conditions in these regions the animals undergo the hibernation and migration. Flora– Peepal, Sandalwood, Mulberry, Bamboo, Cane and Mahua etc. Fauna – Tigers, Lions, Elephants, Bears, Tortoises, Snakes, Langurs, Deer and Monkeys etc.
- Types – Tropical Moist Deciduous Forest are found in areas where the annual rainfall range is 200- 100cm. The annual temperature is around 24°C. Second one is Tropical Dry Deciduous Forests where the annual rainfall range is 70 - 100 cm. The annual temperature is around 18°C due to low rainfall.
- Significance – They have economical important for timber like Teak and Sal.
- Examples – Trees of the genus Nothofagus, Northeast China Plain.

Temperate rainforest

- Species – Flora – Juglandaceae, Pinaceae, Betulaceae, Aceraceae. Fauna – Wolves, Bears, Small possums, Bandicoots, Slugs, Reptiles and Bats etc.
- Types – Temperate coniferous forest dominated by evergreen conifers such as spruce, fir, and cedar. Examples include the Pacific temperate rainforest in North America and the Valdivia temperate rainforest in South America. Temperate broadleaf (mixed forests) consisting of both broadleaf and evergreen trees such as oak, maple, beech and eucalyptus. Examples include the temperate rainforests of Tasmania, Australia, and the Appalachian Mountains of North America. Marine-born Forest influenced by the wet and mild climate of the nearby sea. Examples include the temperate rainforests in Olympic National Park's Quinault Valley, Quietts Valley, Ho Valley, and Bogatiel Valley.
- Significance – Serves as the world’s major source of timber and wood products.
- Examples – Pacific temperate Rainforest, the Valdivian temperate Rainforest and Tasmanian temperate Rainforest.

ii) Grassland Ecosystem

Terrestrial ecosystems dominated by grasses and herbaceous plants are called grassland ecosystems. Grass controls grassland ecosystems with few or no trees, not enough for forests and too many for deserts. Therefore, it is also called transitional landscape. Grassland ecosystems are considered the largest biome on Earth, covering approximately 10 percent of the Earth's surface. This is mainly found in areas with annual rainfall of about 15 to 75 cm, which is not enough to sustain forests, but more than true deserts. Grassland ecosystems go by different names in several regions, including pampas in South America, felts in South Africa, steppes in Europe and Asia, and downs in Australia. In India, these ecosystems are mainly found in the highlands of the Himalayas. The rest of India's grasslands consist mainly of savannas and grasslands. **Importance of grassland ecosystems** - Grassland ecosystems are a mixture of small herbs, weeds, grasses, shamrocks, dicots, shrubs and other legumes that contribute to a high degree of conservation. The economic importance of grassland ecosystems is that they help sustain crops for many domestic and wild herbivores such as cattle, sheep, goats, donkeys, pigs, horses, mules, camels, deer and zebras. These animals provide humans with food, milk, wool and transportation.

iii)Desert ecosystem

Despite several studies of life on other planets, it was concluded that Earth is the only planet with life. Survival requires certain types of atmospheres, topography, and ecosystems unique to Earth. Each continent on this planet has deserts and unique ecosystems, commonly known as desert ecosystems. The term desert refers to a largely barren, dry and desolate land devoid of flora and fauna in the sand. Desert can be cold or hot. Deserts are the driest regions on earth, with little rainfall per year. Precipitation is low throughout the year. Desert ecosystems are therefore the driest ecosystems on earth, and therefore have low biodiversity and very little vegetation. As part of the terrestrial ecosystem, it is home to flora and fauna that can survive in harsh weather conditions. Desert ecosystems have no rain or precipitation. Desert ecosystems are therefore communities of inanimate and living organisms living and interacting in a desolate environment. It is the interaction between the abiotic and biotic components of this environment.

Characteristics of desert ecosystem:

- Less rainfall or precipitation
- Aridity
- Wind velocity
- Extreme temperature
- Humidity
- Population density

Aquatic ecosystems:

Aquatic ecosystems contain groups of interacting organisms that depend on each other and the aquatic environment for nutrients and protection. Examples of aquatic ecosystems are oceans, lakes, and rivers. Aquatic ecosystems include freshwater habitats such as lakes, ponds,

rivers, oceans and streams, marshes, marshes, and marine habitats include oceans, intertidal zones, reefs, seabed, etc. Aquatic ecosystems are habitats for organisms that depend on water. Including animals, plants and microorganisms.

a) Marine ecosystems

Marine ecosystems occupy the largest surface area on earth. Two-thirds of the earth is covered by water and consists of oceans, seas, intertidal zones, reefs, seafloors, estuaries, hydrothermal vents and bedrock. Each life form is unique and specific to its habitat. This is because they are adapted to their habitat.

Aquatic animals cannot live outside water. There are still exceptional cases that provide another example of customization for example Mudskipper. Marine ecosystems are becoming increasingly rich in salinity that makes it difficult for freshwater organisms to survive. In addition, marine animals cannot live in freshwater. Your body is adapted to life in salt water. When placed in low-salinity water, the body swells (osmosis).

Ocean ecosystem: Our planet has five large oceans: Pacific Ocean, Indian Ocean, Arctic Ocean and Atlantic Ocean. Of these five oceans, the largest and deepest are the Pacific and Atlantic oceans. These seas are home to over 5,000 aquatic organisms. These ecosystems include shellfish, sharks, tubeworms, crabs, large and small marine fish, turtles, crustaceans, blue whales, reptiles, marine mammals, seabirds, plankton, corals and other marine plants.

Coastal ecosystem: These are open land and water systems that make up coastal ecosystems. Coastal ecosystems vary in structure and diversity. A wide variety of aquatic plant and algal species can be found at the bottom of coastal ecosystems. The fauna is diverse and mainly consists of crabs, fish, insects, lobsters, snails and shrimps. Plants and animals in aquatic ecosystems exhibit a variety of adaptations, including life cycle, physiological, structural and behavioural adaptations. Most aquatic animals are streamlined, which reduces friction and saves energy. Fins and gills are locomotive and respiratory organs. A special property of freshwater organisms helps to expel excess water from the body. Aquatic plants have different types of roots to survive in water. Some roots are buried in water. Some have roots and floating plants like water hyacinth.

b) Freshwater ecosystems

They cover only a small portion of the Earth, almost 0.8%. Freshwater includes lakes, ponds, rivers, streams, marshes, marshes, marshes, and temporary ponds. Freshwater habitats are classified as lot and lentic habitats. Bodies of water such as lakes, ponds, ponds, bogs, and other reservoirs are stagnant bodies of water and are called lenticular habitats. Lotic habitats, on the other hand, represent flowing water such as rivers and streams.

Lotic ecosystem: These primarily refer to unidirectional, fast-moving bodies of water, such as rivers and streams. These environments are home to numerous species of insects such as beetles, mayflies and stoneflies, as well as various species of fish such as trout, eels and minnows. In addition to these aquatic species, these ecosystems also contain various mammals such as beavers, river dolphins and river otters.

Lentic ecosystem: This includes all still water habitats. Lakes and ponds are prime examples of lentic ecosystems. The term lentic primarily refers to stagnant or relatively calm water. These ecosystems are home to algae, crabs, shrimp, amphibians such as frogs and salamanders, but root and leaf plants, and reptiles such as crocodiles and other water snakes can also be found here.

Wetland ecosystem: Wetlands are wetlands, sometimes covered with water, that are home to a wide variety of flora and fauna. Examples of plant species found in wetlands include swamps, marshes, marshes, black spruce, and water lilies. The wildlife in this ecosystem consists of dragonflies and dragonflies, birds such as herons, and fish such as pike.

2. Artificial ecosystems:

Ecosystems that arise based on human activity with the help of abiotic, biotic and energetic elements. Artificial ecosystems is the mimics of natural ecosystem.

Characteristics of artificial ecosystem:

1. Artificial ecosystems are completely man-made and require human care.
2. Most of them have very low genetic diversity of organisms in both animals and plants.
3. Artificial ecosystems are unable to sustain the development of the organisms that inhabit them.
4. Food chains and vegetative cycles are very short and mostly incomplete.

Functions: They are designed and built for a specific purpose. Some are made for aesthetic or recreational purposes, such as gardens and aquariums. Examples of artificial ecosystems such as fields and dams are created for food production and irrigation. Thanks to dams, it is also possible to supply dry areas with water and to generate electricity with hydroelectric power when needed. 4,444 zoos and forests help protect endangered plant and animal species, making them known and understood by more people. Finally, a wetland was created to allow the waste to be chemically cleaned before being discharged, keeping the environment cleaner.

Some of the examples are listed below

Zoos: Zoos or zoos are other well-known examples of the artificial ecosystems listed above. It is created and cared for by humans to keep animals and birds in the same habitat.

Crop fields: Fields established for agricultural purposes to grow food, vegetables, and edible plants are perhaps the most important of the examples of artificial

ecosystems listed. In the past, most fields were only grown with a single crop, but recently increased soil erosion has led farmers to switch to crop rotation

Garden: A garden is an artificial environment because it is man-made and does not exist in nature. It has a biotic component and an abiotic component, both of which are under human control. These are examples of artificial ecosystems that people simply create on their balcony, patio, or backyard. The garden can also be used for viewing purposes, displaying only rare flowers and plants. Ornamental, herbal and edible plants can be grown in home gardens

Dams: Dams are another example of man-made ecosystems. Built on top of a river, it stores water during the dry season and is also useful for hydroelectric power generation. To keep the

stagnant water clean, these dams are stocked with many fish and creatures that live under human care.

Aquariums: They are most commonly found in private homes and ornamental aquariums, but these are also man-made artificial ecosystems. These are saltwater, freshwater, or brackish water ecosystems created in glass aquariums of various sizes. Equipped with filters, it can house everything from plants, fish, corals and sea anemones to crustaceans and mollusks.

Fish farms: Aquaculture is an emerging industry among examples of man-made ecosystems. These farms are similar to fish farms where fish are specifically raised. These are ornamental fish, fish for consumption, bait, fodder, etc. This is usually done in small ponds dug and managed by farmers to house different types of fish.

Greenhouse: A greenhouse is usually understood to mean a glass chamber in which plants grow under constant conditions of constant temperature and humidity. Like the atmosphere, the greenhouse's glass walls let in heat but prevent it from escaping. This keeps the temperature constant and increases the humidity, making greenhouses ideal for growing tropical plants and crops in temperate or cold climates.

Some facts about ecosystem:

1. Half of all the world's species live in rainforests.
2. Coral reefs are beautiful as well as fragile.
3. Grasslands are everywhere.
4. Living in the desert requires saving water.
5. Rare species exist in freshwater ecosystems.
6. Tundra life is harsh (almost all tundra is in the northern hemisphere's Arctic)
7. There is a thriving community at the bottom of the sea
8. The boreal forest contains many trees.

Ways to save ecosystem

1. **Save the forest** - Growing more trees can help maintain the earth's temperature and prevent soil erosion. This can be achieved by regrowing trees (planting) on weathered ground or by growing new trees (planting) in barren or other needed areas.
2. **Save the wild animals** - Hunting of animals is illegal in many wildlife parks, but poaching is rampant these days. Strict action should be taken against people who hunt animals solely for the sake of hunting or exchange vital body parts of themselves.
3. **Control of factory dismissal procedures** - factories discharge hazardous chemicals directly into nearby bodies of water and vacant land. This leads to contamination of both water and soil. Many factory wastes are not treated properly and are simply thrown away. Authorities should keep an eye on the factory dismissal process.
4. **Garbage separation** - Waste classification helps you segregate your waste and choose which waste can be recycled. Biodegradable waste does not harm the environment. Sorting also minimizes waste and helps maintain ecological balance.

5. **Clean industry** - The development of greener industries minimizes the pollutants they generate.
6. **Compliance with global warming counter measures** - Global warming is beyond the control of ordinary people, and it is incumbent upon governments to take it seriously, rather than attending world summits just for discussion.
7. **Dangerous chemicals should be banned from home use** - Most countries use DDT powder to kill insects and prevent insects from entering the home. DDT is a highly toxic chemical whose effects are very long lasting and even affect human health. Many countries, including the United States, have already banned DDT. Substitute less harmful chemicals should be used.

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FUNDAMENTAL TO MODERN ADVANCES IN MEAT PRESERVATION

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The definition of meat is the animal flesh consumed as food. Meat provides a favourable habitat for the growth and spread of bacteria that cause common food poisoning due to its high concentration of nutrients, high moisture content, and neutral pH. Meat deterioration is virtually always caused by microbial development in addition to lipid oxidation and enzyme responses. Meat becomes unpleasant for human eating when the breakdown of the fat, protein, and carbohydrates cause the generation of off-flavours, off-odors, and slime. Therefore, it is crucial that the right preservation techniques are used to maintain its safety and quality. Food is typically preserved during times of abundance so that it can be used during times of scarcity. The primary goal of meat preservation is to prevent meat deterioration, which results in changes to the meat's texture, flavour, and aroma as well as a reduction in its wholesomeness. 'Fresh' meat has a better texture, flavour, aroma, and appeal to consumers. Consumers desire "safe" meat because unhygienic meat is more likely to contain pathogenic bacteria that could result in food poisoning. It is well known that the muscles of healthy animals are devoid of bacteria since the live animal's body has a number of defense systems that keep the microbes in control. However, when these systems fail due to illness, animal killing, or subsequent handling of the meat, particularly when conditions are unhygienic, it results in microbial contamination and meat deterioration. The manner in which animals are fed, how they are transported, the location in which they are killed, the practices used in the abattoir, and the handling and processing of the carcasses are all factors that affect the kind and degree of microbial contamination of meat. The following circumstances are those where meat is most likely to be contaminated by microbes and cause deterioration or food poisoning:

a. When meat comes from a diseased animal,
b. When meat is processed in unhygienic conditions,
c. When meat is stored in environments that encourage microbial growth.

It is evident from the foregoing that microorganisms have an impact on the preservation and safety of meat and meat products. To solve these issues, conditions that are unfavourable for microbial growth and survival are established, such as extreme cold or heat, decreased water activity, gases (oxygen, nitrogen, sulphur dioxide, carbon dioxide, etc.), chemicals, and increased medium acidity. Meat safety, spoiling management, and shelf life are all greatly improved by methods that are frequently used to store or preserve meat. These methods also significantly limit or retard microbial growth. To put it another way, meat preservation tries to enforce guidelines

that stop meat from degrading due to microbiological, chemical, and physical processes. It is challenging to completely eradicate meat contamination. Therefore, it is vital to reduce meat's microbial contamination to delay meat spoilage as well as to avoid any potential health risks associated with eating contaminated meat. The transportation of meat to far-remote areas of the country as well as to other countries has been substantially facilitated by modern methods of meat preservation, which primarily involve "cold-chain" with or without packing in proper material and environment.

Principles of preservation

Meat's shelf life and keeping quality are influenced by a number of interrelated factors, including holding temperature, ambient oxygen (O_2), endogenous enzymes, moisture, light, and, most significantly, microorganisms. The colour, smell, texture, and flavour of meat can all be negatively affected by any one of these factors acting alone or in combination. Although meat can degrade without the presence of microorganisms (for example, by oxidation, lipolysis, and proteolysis), microbial development is by far the most crucial element in regard to the shelf life of meat. Controlling microbial, enzyme, and lipid autooxidation deterioration are among the fundamentals of meat preservation. For that goal, we typically rely on the strategies listed below.

1. Temperature control
    A. Use of low temperature regime e.g., chilling, freezing etc.
    B. Use of high temperature regime e.g., thermal destruction, canning etc.
2. Moisture control e.g., dehydration
3. Direct microbial inhibition e.g., curing, smoking, irradiation, use of chemicals and antibiotics.

Methods of preservation

Meat preservation mostly depends on the objectives we have in mind, such as colour and flavour development, bloom protection, fat oxidation protection, etc. No single method is sufficient to preserve every type of meat, even though they can traditionally be divided into three general categories based on control of temperature, control of moisture, and more directly, by inhibitory processes (bactericidal and bacteriostatic, such as ionising radiation, packaging, etc.). Meat preservation methods that are frequently used include:

1. Chilling
2. Freezing
3. Superchilling
4. Drying
5. Intermediate moisture meats
6. Salting and curing
7. Smoking
8. Thermal processing
9. Irradiation
10. Chemical preservation

11. Antioxidant preservation
12. Biopreservation
13. High hydrostatic pressure
14. Vacuum packaging
15. Modified atmosphere packaging
16. Active packaging
17. Cold plasma

1. Chilling

Early civilizations understood the benefits of chilling as a method for preserving perishable food items like meat, which led to storage in natural caves with year-round at low temperatures. Commercial-scale operations based on mechanical refrigeration were in use 100 years after the principles of artificial ice generation and mechanical refrigeration were discovered, about 1750.When storing meat for a short period of time, chilling is an excellent technique that should be used immediately following animal slaughter and continued until consumption. It is the process of lowering the temperature of meat to a level just above its freezing point, or 0°C, in order to avoid putrefaction and increase its shelf life (the freezing point of meat is -1.5°C). The main goal of chilling is to prevent weight loss and surface discoloration caused by hemoglobinoxidation. It also slows down and almost completely stops microbiological, enzymatic, and chemical reactions. We frequently utilize ice layers to cool meat, particularly poultry meat, although ice by itself is ineffective for long-term preservation. To prevent mechanical harm to the muscle tissues, the ice's quality must be soft.

The recommended method for meat preservation may be air chilling in the form of refrigeration. In this procedure, from holding to final usage, we use refrigeration temperatures between 2 and 5^{o}C and air speeds between 0.25 and 3.0 m/s. In this method to work, the relative humidity needs to be around 90% to reduce the shrinkage. For uniform chilling by air circulation, the carcasses and pieces must have the proper air separation. Bacterial development is inhibited by chilling in air because it lowers the surface temperature of the carcass and speeds up the drying process. A faster airflow and/or a lower temperature shorten the chilling process. The challenge of quickly extracting heat from the deeper tissue of carcasses, however, is a limiting factor of this method. Forced-convection air chilling, which uses fans to move the air, is far more effective than natural-convection air chilling, which involves pumping refrigerant via cooling tubes. Rapid drying of the carcass surface reduces bacterial growth while rapid chilling of the carcass promotes product yield by reducing surface evaporation. On the other hand, ultra-rapid chilling of pre-rigor meat may cause cold-shortening and toughening. Spray-chilling can increase surface myoglobin's oxygenation while decreasing metmyoglobin, preserving skin brightness and preventing weight loss. The initial load of microorganisms on the carcass affects the meat's shelf life. In general, depending on the type of meat and starting microbe load, it is the best method for storing meat for 1 to 5 weeks. If we allow the pre-rigor meat to chill below 10^{o}C or lower, we run the risk of cold shortening in the carcass, especially in mutton and cattle.

Therefore, we keep the carcasses first at 15^{o}C to dissipate body heat before moving them to cold chambers maintained at 2^{o}C to 5^{o}C to limit the likelihood of cold shortening (toughening of muscle). Meat must be chilled at a constant temperature of not more than 7^{o}C for carcasses and 3^{o}C for offal.

2. Freezing

The first shipments of frozen beef and mutton from Australia arrived in Britain around 1880, marking the beginning of the widespread practice of meat preservation via freezing. At the time, the southern hemisphere had an excess of meat animals, particularly in New Zealand and Australia. Freezing provided a way to preserve meat throughout the lengthy journeys between the two regions. The benefits of temperatures below freezing point included extending the shelf life of meat and preventing microbiological and chemical alterations.

The preferred approach for long-term meat preservation is freezing, which is done at below-freezing temperatures. Meat is typically frozen between -10°C and -30°C temperature. However, meat can be preserved for several months at -10°C but -18°C is mostly preferred because at this temperature, practically all of the water found in animal tissues freezes. Beef and carabeef have an average shelf life of 12 months under freezing (-18^{o}C), veal somewhat less, chevon and sheep approximately 8 months, and pig and chicken about 6 months, all without noticeably degrading.

Freezing maintains the nutritional value of meat by stopping microbial development, slowing enzyme activity, and chemical reactions. However, very few nutrients actually end up in the drip as the meat is thawed. Blood-stained fluid known as drip mostly consists of water, salt, proteins, and broken blood cells. Most of the nutritional and sensory qualities are retained when freezing and thawing processes are done properly.

Prior to freezing, it is crucial to wrap fresh meat in the proper packaging material to prevent freezer burn. Freezer burn is an abnormal condition that develops as a result of the gradual surface dryness that concentrates meat pigments on the surface. Ice crystal sublimations are to blame for the discolouration in freezer burn meat. Freezer burn is an incurable condition that causes meat to be very tough and lack of juice when cooked. Meat should not be frozen before completion of rigor mortis since doing so causes thaw rigor, which causes noticeable muscle contractions and significant drip loss unless the muscle is held taut. Young chicken bones that have been frozen and thawed may develop a darkening condition as a result of hemoglobin seeping to surrounding tissues from the marrow of the porous chicken bone. These tissues appear grey or black after cooking, but other sensory qualities are unaffected.

Methods of freezing:

The rate of freezing has an impact on meat quality as well. Extracellular fluid freezes more quickly during slow freezing than intracellular fluid because of the lower solute content. Large extracellular ice crystals are formed as a result, which may injure the muscle tissue mechanically and cause it to seem deformed when it is frozen. In contrast, numerous ice crystals uniformly grow throughout the flesh tissue during quick freezing. Therefore, the issue of muscle

fiber loss and appearance distortion is not present. Additionally, because intracellular water freezes inside the muscle fiber itself, leak losses during thawing are remarkably low. The zone of maximum ice crystal formation occurs between -1°C and -4°C, which is the most conducive temperature range for ice crystals to grow to their largest size.

Freezing techniques

a) **Plate freezing:** A set of refrigerated metal plates are employed in this freezing process. Refrigerant is passed through the plate holding the meat as it is held in trays, lowering the surface temperature to -10^{o}C. Using this method, we can freeze meat that is 3-5 cm in size within 2-3 hours.

b) **Blast freezing:** Tunnels or chambers are employed for the high air circulation used in this freezing procedure. With this, cooled air is cycled through the chambers at a speed of 3-5 m/s to reach a temperature of -35^{o}C to -40^{o}C. In the chambers, 150–300 air circulation coefficients keep the relative humidity at 95% or more. Large slices of meat can be frozen quickly using this method, and the amount of time it takes to freeze depends on the size of the chunks. These days, major meat processing facilities employ this approach to quickly freeze hot meat right after slaughter without cooling it first.

c) **Cryogenic freezing:** According to this method, frozen meat should be stored at a temperature of -55°C to entirely prevent quality alterations. Few deteriorative changes will take place during storage at these low temperatures because enzymatic reactions, oxidative rancidity, and ice recrystallization are expected to be minor. Due to the significant temperature differential between the cryogen and the meat product and the rapid rate of surface heat transfer brought on by the boiling of the cryogen, cryogenic freezing enables quicker freezing times than standard air freezing. A cryogen tank and the appropriate spray equipment are all that are needed for cryogenic freezing. However, the cryogenic procedure may deform the product's shape to some extent, which could have an effect on its economic application.

3. Superchilling

Le Danois first discussed the superchilling process in 1920, however he did not use the terms "superchilling," "deep-chilling," or "partial ice formation". When a little portion of a product's water content is frozen, the processes are referred to as "superchilling" or "partial freezing". The product's temperature is decreased during superchilling, frequently by 1 to 2 degrees Celsius below its initial freezing point. Following initial surface freezing, the ice distribution balances out, giving the product a consistent temperature that it maintains throughout storage and delivery. The method has been successfully applied to seafood, and there is currently growing interest in using it to extend the chilled storage life of meat. Most microbial activity is hindered or stopped at superchilling temperatures. Chemical and physical changes may progress and, in some cases, even accelerate. As a commercial practice, superchilling can lessen the need for freezing and thawing as production buffers, which lowers manpower costs, energy costs, and product weight losses. Although the ice in super-chilled products protects the meat from

temperature increases in inadequate cold chains, some product drip loss may increase during storage. The capacity of this technology to increase the shelf life of meat by at least 1.4 to 4 times that of conventional meat-chilling techniques is the primary justification for its implementation. It is a challenging exercise to estimate temperature distributions and calculate the necessary superchilling periods in a chilling and freezing operation. Determining how much superchilling is necessary to extend shelf life and meet process requirements in order to achieve desired quality attributes is equally difficult. The potential for superchilling to be implemented in an industrial process will depend on the media employed to achieve it. It is challenging to transition from "traditional technologies" like chilling, freezing, and thawing to the more difficult superchilling technique. More accurate knowledge of product variation and flow is necessary for superchilling. Prior to and after the actual superchilling procedure, extra care must be taken.

4. Drying

Since antiquity, drying has been used as the primary and most straight forward method for meat preservation. The fundamental idea behind drying is to reduce the amount of water in the meat to a point where it is no longer available for microbial growth. Bacterial activity ceases when the meat's 75% water content is decreased to 25%, and below 15% can inhibit the growth of mould. Water activity (a_w) is the amount of water that is now available for a microorganism's growth and activity. The ratio of the water vapour pressure on the surface of the meat to the water vapour pressure of distilled water at the same temperature is known as water activity. Fresh meat has a water activity level exceeding 0.95. Therefore, a decrease in water activity below 0.95 will limit microbial activity, notably that of gram-positive rods; below 0.91, most spoilage bacteria are inhibited; below 0.88, most yeasts; and below 0.80, staphylococcus aureus and moulds are inhibited. Drying is the process of removing moisture from food, which results in a decrease in a_w. Water activity (a_w) of dried foods ranges from 0.50 to 0.60, and their final moisture content ought to be about 4%. When cooking dried meat, it is crucial to use meat that has been hygienically prepared and has a very low microbial profile.

Three basic methods of drying used todayare-

a. **Sun drying:** A traditional method in which foods dry naturally under the sun.
b. **Hot air drying:** Foods are exposed to a blast of hot air with regulated humidity.
c. **Freeze drying:** Frozen food is placed in a vacuum chamber to draw out the water by sublimation.

Although the sun drying method for meat preservation currently seems to have little significance and economic benefit, it is nevertheless used in the case of processed meat strips that are air dried for long-lasting proteins, such as Biltong. The risk of meat becoming contaminated with Salmonella germs during handling, preparation, and storage, as well as reports of the pathogen's survivability in infected products, make this practice problematic for public health. The destruction of parasite cysts, particularly cysticercoids found in meat, is aided by salt and heat treatment. The limitation of rehydrating dried meat chunks is a drawback of mechanical or hot air drying as well as solar drying.

In the process of freeze drying, frozen meat is placed in a specialized vacuum cabinet where water from the flesh is evaporate, similar to how ice turns from a solid to a vapour without melting. Pre-freezing, primary drying, and secondary drying are the three steps in the freeze-drying process for meat. At -40°C, meat is first frozen. After that, it is dried in a plate heat exchanger under vacuum for 9 to 12 hours at a low temperature while maintaining 1 to 1.5 mm of mercury pressure. Ice crystals sublimate into water vapour without causing a temperature increase. Meat's free and immobilized water (90–95 percent of the total moisture) is eliminated in the first drying stage. To eliminate the remaining 4-8% bound water, a second drying step is performed at a high temperature. Meat that has been freeze-dried may have a moisture level of 2% to 8% and a water activity value of 0.10 to 0.25. Freeze-dried foods must be packaged in moisture-proof, hermetically sealed containers under vacuum conditions in order to keep their original flavour, texture, and nutritional value after being rehydrated.

At room temperature, dried meats are more stable during storage, but they are still susceptible to microbial development and undesired chemical changes. Oxidative rancidity is a typical chemical deterioration that affects fatty meats. The maillard reaction, sometimes referred to as non-enzymatic browning, occurs in meats containing reducing sugars. This results from the interaction between the carbonyl groups of reducing sugars and the amino groups of proteins and amino acids. By limiting the amount of reducing sugars, keeping the moisture content as low as feasible, and using contemporary packaging techniques like vacuum packing or modified environment packaging, these chemical reactions can be minimized.

5. Intermediate Moisture Meats (IMM)

Another group of meats that are shelf-stable fall into this category, with moisture contents ranging from 30 to 50% and water activities (a_w) between 0.60 and 0.85. They are known as Intermediate Moisture Foods (IMF) because they fall somewhere between dried and fresh meals. Without refrigeration or thermal processing, the meats with an intermediate moisture level can be stored at room temperature. Lower a_w is achieved in these IMM products by the removal of water, by desorption, adsorption, and the inclusion of permissible additives (salts and sugars). Typically, humectants like glycerol, glycol, sorbitol, and sucrose are used to reduce a_w. Heat treatment is applied to meat products to inactivate enzymes and to further reduce water activity by partial dehydration. In addition to a_w, a number of other conditions are used as barriers (hurdle technology) to inhibit the growth of microorganisms and to improve the storage stability of IMM products. These conditions include pH alteration, the use of preservatives (such as propylene glycol and sorbic acid), fermentation, irradiation, and modern packaging systems. Gram-negative bacteria and the majority of Gram-positive bacteria, with the exception of certain cocci, some spore formers, and lactobacilli, would not be able to thrive at the a_w levels of IMM. Mould development is a typical issue in IMM.

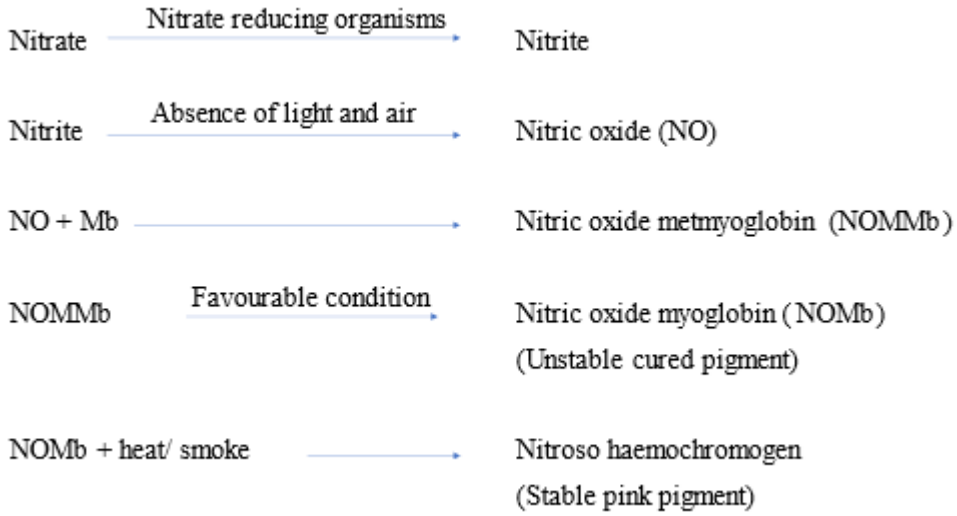
6. Salting and curing

Preservation of meat by heavy salting is an age-old practice and it was applied as thumb rule because refrigeration facility was not available. Salting is the process of preservation in

which meat is covered with salt to drain out water by osmosis. Common meat items preserved by salting include bacon, ham, frankfurters, corned beef, etc. When meat is "cured," it is subjected to some combination of salt, sugar, spices, vinegar, sodium nitrate, or nitrite. This causes the meat's pigments, primarily myoglobin to change into nitrosomyoglobin. Typical curing components include:

a. **Salt:** Salt is mostly employed in brine for wet curing or in the dry curing of bacon. Common salt (sodium chloride) kills and prevents the growth of germs through altering osmotic pressure and dehydrating cells (by pulling water out of both meat and microbe cells). Common salt contains chloride ions, which directly affect microbial cells. Proteolytic enzymes' activity is also slowed down by salt. Common salt interacts with fatty acids to improve flavour and responsible for tenderness of cured meat.

b. **Nitrate and nitrite:** These substances not only kill bacteria but also provide distinctive flavour and colour (pink) of meat. With the aid of nitrate-reducing bacteria, nitrate (NO_3), provided by potassium or sodium nitrate, and used as a source of nitrite (NO_2^-) synthesis. The nitrite continues to degrade in the meat to become nitric oxide (NO), which then binds to the iron atom in the centre of the heme group in myoglobin. This reduces oxidation and provides reddish-brown (Nitric oxide myoglobin) colour when raw. It takes on a distinctive pink colour after cooking due to formation of nitrosohaemochromogen. Colour reactions of cured meats can be summarized as follows:



The synthesis of benzonitrite and phenylacetonitrite by the interaction of nitrite with fatty acids is the cause of the flavour development when nitrate and nitrite are used. Nitrate and nitrite concentrations in finished products are restricted to 500 ppm and 200 ppm, respectively. These compounds work as preservatives by preventing the growth of various microorganisms, including *Clostridium botulinum*. These chemicals also retard the development of rancidity. However, it has been discovered that nitrite contributes to the production of nitrosamine, which is thought to be carcinogenic.

c. **Sugar:** It is used in curing solution to impart flavourand lessens the harsh, hardening effects of the salt. High sugar levels are needed to inhibit the growth of yeasts and moulds. It reduces the amount of free water available for bacterial growth. In the maillard reaction, also known as the browning reaction, sugar interacts with the amino groups of proteins. It acts in the formation of colour by serving as a source of nitrate-reducing bacteria in the cured meat. Additionally, it promotes the growth of beneficial microorganisms like lactobacillus. Sugar creates an acidic environment (pH 4.5) through the formation of lactic acid, which prevents the growth of other bacteria and accounts for the tangy flavour of some cured products.
d. **Ascorbate and erythorbate:** Cooked salts containing alpha-tocopherol, such as ascorbates or erythrobates, may be used to reduce the generation of nitrosamine. The suitable combination for this purpose is 550 ppm sodium ascorbate and 120 ppm sodium nitrite. By reducing metmyoglobin to myoglobin and nitrous acid to nitric oxide, it speeds up the curing process, particularly in the formation of colour. Additionally, it stops the cured meat's colour from fading since any remaining ascorbic acid keeps the exposed surfaces in a reducing environment, preventing colour fading. Ascorbate can be used to lower the nitrite level, which prevents the development of nitrosamines (carcinogenic compounds) in cured meats.
e. **Phosphates:** Phosphates are added to curing solutions to increase their ability to hold water and lower the development of rancidity. Polyphosphates and diphosphates, such as sodium tripolyphosphate, sodium pyrophosphate, and disodium phosphate, are the most common forms of phosphate that are employed. As the pH and water-holding capacity of the meat rise, it decreases the cooking loss of meat. Additionally, it maintains the flavour and colour of cured meat.
f. **Water:** Water acts as dispersing medium for salt, nitrite, sugar, phosphate and other curing ingredients and helps in uniform distribution of these ingredients in the meat. Water assists in preserving the final product's juiciness and compensates for moisture loss during heat processing. By increasing the final product's moisture content, it also assists in lowering product costs.
g. **Additional curing ingredients:** The curing solution may additionally contain sodium sorbate, monosodium glutamate, sodium, and potassium lactate. Monosodium glutamate is used as a flavour enhancer, and sodium sorbate is utilized as a *clostridium botulinum* and mould inhibitor. Pepper, cinnamon, clove, nutmeg, and other spices are put in the curing solution to give it a distinctive flavour.

Methods of curing:

a. **Dry cure:** Dry ingredients are rubbed into the meats as in curing bacon.
b. **Pickle cure:** Meat is submerged in a pickle-based ingredients solution. Like curing of pork shoulder.

c. **Injection cure:** A needle is used to inject a concentrated solution of the ingredients into the arteries and veins of the meat, then through an artery into the muscle tissue in various parts of the meat. e.g. curing of pork ham.

d. **Direct addition technique:** After grinding the meat, curing agents are immediately applied. e.g. luncheon meat.

Depending on the kind, size, and strength of the curing pickle, the curing process is allowed for 3 to 4 days in curing room maintaining a constant temperature of 3±1°C. To aid in their preservation, the majority of meats are smoked after curing. Others, such as corned beef, are chilled rather than smoked.

7. Smoking

An age-old method of flavour development and meat preservation known as smoking is frequently combined with curing. Surface dryness, a decrease in surface pH, and the antioxidant properties of smoke components all contribute to the preservation of smoked meat. Phenols, aldehydes, organic acids, alcohols, carbonyls, hydrocarbons, and a few gases like CO_2, CO, O_2, N_2, and N_2O are all present in smoke produced from hard wood. Phenols act as antioxidant, have bacteriostatic effect, contribute to smoky flavour and responsible for surface sheen. In addition to adding colour, aldehydes have bactericidal effect. Organic acids have an antibacterial impact, coagulate surface proteins, and hasten the cure reaction. Alcohol has bactericidal and bacteriostatic effects. Carbonyls contribute the product its smoky colour and flavour. Hydrocarbons present in the smoke are responsible for colour and flavour of the product, which is also thought to be carcinogenic. The production of carcinogenic substances like 1,2,5,6 phenanthrancene and 3,4 benzopyrine occurs at higher temperatures. The length of time, temperature, smoke density, and type of wood used to produce the smoke all affect the colour of the smoke result.

The optimal conditions for producing smoke of the highest quality are a combustion temperature of 343^0C to 399^0C and an oxidation temperature of 199^0C to 249^0C. For the formation of smoke, a high temperature of 300^0C is always preferable because it lessens the possibility of the development of compounds that are carcinogenic. The temperature of the smoking chamber should be 77^0C for 6 to 8 hours, or until the internal temperature of the meat is around 74^0C, to produce ready-to-eat smoked chicken. When the completed product needs to be cooked before eating, low temperature smoking (49^0C) may be used to reduce shrinkage loss. Meat that has been smoked has a storage life of 2 to 4 months at -18^0C.

Industrialists now prefer liquid smoke, which is made by pyrolyzing hard wood or sawdust after which polycyclic hydrocarbons are filtered out. It has some advantages over traditional smoke, including the ability to be employed directly in products, less pollution, a lower likelihood of the generation of hazardous substances, and quicker application. Any of the following methods may be used to apply liquid smoke:

a) Direct addition of liquid smoke to the meat emulsion is possible.
b) Items may be submerged in a smoke solution.
c) Spraying a smoke solution over the product.

d) Automizing it into a thick fog, injecting it into a smoke house.
e) Vaporizing the liquid smoke before using it.

8. Thermal processing

Heat processing is used to destroy germs that could ruin meat and meat products and potentially be harmful as well as inactivate endogenous enzymes that could result in deteriorative changes. Processed meats that have been heated to a moderate temperature (between 58^{o}C and 75°C) will inactivate some microorganisms and kill some of the bacteria present. Pasteurization is the term used to describe this procedure. Sterilization is the process of producing commercially sterile meat products by applying extreme heating (over 100^{o}C), which kills all potential spoiling germs. At room temperature in the tropics, commercially sterile meat products have a recommended shelf life of two years in cans and one year in retort pouches.

All conventional methods of thermal processing involve heat transfer by conduction, convection and/or radiation.

a. Conduction: Direct transfer of heat from particle to particle without use of medium other than the product itself.
b. Convection: Heat transfer by the mass movement of heated particles in a fluid such as air, steam or water.
c. Radiation: Heat energy is transfer through space.

Canning: When food is canned, it is carefully chosen and prepared, placed in a hermetically sealed container, heated for a set amount of time, and then cooled. The heat kills all spoilage germs, and the container's permanent sealing prevents recontamination. The sensory qualities of meat products, such as appearance, flavour, and texture, are greatly preserved by canning and have a two-year shelf life at room temperature. The steps involved in conventional canning are as follows:

a) **Preparation of meat and gravy:** Deboned carcass meat is cut into 4-5 cm chunks, and salt, tomatoes, spices, and other ingredients are used to make the gravy.
b) **Precooking:** Meat and gravy are both precooked for 15 minutes at 70 degrees Celsius. Meat that has been precooked has less volume, less microbial load, and has firmer flesh. Meat's 15% to 40% moisture is removed during precooking.
c) **Filling:** When manually or mechanically filling cans, make sure to leave an appropriate headspace of 1/8th of the can's height. The meat chunks are added first, then the remaining half of the gravy, and finally the remaining liquid. During the operation, extra care is necessary to prevent trapping of air.
d) **Exhausting:** This describes the process of removing air from a container before it is sealed. It is important to manufacture concave can ends, reduce the amount of oxygen in the can, and partially vacuum the cans in order to reduce the stain on the can seams caused by air expansion during heat processing. Sealing is done after exhausting, which can be accomplished using heat or vacuum.
e) **Seaming:** Usually, a double seaming machine does this. Depending on the product and the size of the can, the sealing temperature must not be less than 60°C or more than 80°C.

f) **Thermal processing:** Following hermetically sealing the canned meals, they receive their final heating. It is advised to store meat items in cans at a high temperature between 115° and 121°C. Spores of pathogenic bacteria that are not destroyed at 100^{o}C can grow and replicate in low acid products. Sterilization for 60 minutes or longer at 121^{o}C may be required to eradicate those spores. Spores will be eliminated below 115^{o}C, but it will take more time, and sterilization below 115^{o}C is typically not safe. A pressure canner or autoclave is required to sterilize at a temperature higher than 100^{o}C.

g) **Cooling:** To shock the thermophiles after retorting, the temperature is quickly lowered to 30^{o}C to 40^{o}C. The action of heat is reduced by cooling, which also lessens the can's significant internal pressure and prevents unwarranted changes in the texture and colour of meat products. To avoid the exposure of spoilage and dangerous microorganisms, cans must be cooled using bacteriologically safe water.

h) **Can washing:** Cans need to be washed in a bath with soap or saturated fatty alcohols and rinsed after cooling since they are greasy and unclean on the outside. This makes them easier to handle, lacquer and label.

i) **Outside lacquering:** A coloured varnish made for commercial use that contains synthetic or natural resin is called lacquer or enamel. If the cans are going to be used in humid locations, lacquer can be added to the outside of the tin to avoid external corrosion.

j) **Labelling:** Information regarding the product as well as other customer instructions should be included on the label of cans, including the batch number, date of manufacturing, expiration date, ingredients used, etc.

k) **Storage:** Cans should be kept dry and cool, ideally at a temperature of around 20°C.

9. Irradiation

Irradiation is the use of electromagnetic radiations and accelerated electrons to kill or inactivate a variety of microorganisms that cause meat to spoil or result in food-borne illness. Since around 1940, meat has been preserved using ionizing radiation as a direct microbial inhibitor. Irradiation is also known as "cold sterilization" since it sterilizes food without significantly altering its temperature. Radiation can kill bacteria by fragmenting their DNA molecules and causing ionization of inherent water within microorganisms into free radicals and hydrogen peroxide which leads to destruction of microorganisms. The amount of radiation energy absorbed by the meat products being irradiated is expressed in the unit of rad. The sterilization dose for meat products that can kill the majority of resistant spoilage organisms (Radappertization) is 4 to 5 megarads. A pasteurization dose of 50 to 100 killo rad (Radurization) can be used to extend the shelf life of fresh meat. The majority of bacteria that cause spoilage, as well as yeast and moulds, are easily diminished by pasteurization dosage. Because some germs develop spores, which make them exceedingly resistant to irradiation, complete sterilization does not take place. But it is possible to produce economically sterile meat products by cooking, vacuum-packaging, freezing to a temperature of around -40^{o}C, and irradiating them at a dose of 5 megarads or 50 kGy (kGy = killo Grays). However, the FDA has currently allowed radiation

levels that are 1 to 10 kGy in cold pasteurization as the most acceptable for achieving the minimal to no change in taste, smell, and colour of meat.

The strongest bactericidal non-ionizing radiation is UV light of wavelength 2650A^{o}, but due to its weak penetrating power, it is only used for surface sterilization of meat. Non-ionizing radiations like microwaves cause products to oscillate by rapidly changing the alternating current field. There are two microwave frequencies in use: 915 MHz and 2450 MHz.

Meat quality is affected by irradiation in the following ways.

a) **Effect on colour:** Fresh meat turns pink after sterilization because of a component called denatured globin haemochrome.
b) **Effect on flavour:** Radiation above 4 Mrad produces a sulphur compound that gives out a bad fragrance, such as "wet grain odour" or "wet dog hair odour."
c) **Effect on texture:** Cellular and muscle defragmentation causes radiation to alter the texture of meat with a dose of 2 Mrad or higher.
d) **Effect on nutritional quality:** Proteins become insoluble and denatured at high dose levels, which have an impact on nutritional quality. Oxidative rancidity may impact on lipid during ionizing radiation. Ionizing radiation causes the destruction of vitamins, particularly those in the B-complex groups and vitamin C.

10. Chemical preservation

Most modern methods of food preservation also utilize some form of chemical addition to lessen deterioration. Chemical additives are made to either destroy infections or stop their growth, or to stop or slow down chemical processes that cause food oxidation. Acids, especially organic acids, which are regarded as Generally Regarded As Safe (GRAS), are the most often utilized substances. By anaerobic fermentation of food substrates, many microorganisms produce organic acids and alcohols, which prevent other organisms from spoiling or making the food toxic. For instance, lactic acid is widely utilized as an efficient inhibitory agent in the preservation of fresh meat. With a dose rate of 0.1% to 0.2%, organic acids such citric acid, sorbic acid, benzoic acid, propionic acid, and their salts are potent yeast and mould inhibitors. Lactic acid and acetic acid (0.1 to 0.2%) stop the growth of bacteria. Sulphur dioxide inhibits insects and microorganisms at 450 parts per million. Sodium nitrite (200 ppm) is also effective bacterial inhibitor. Salts such as sodium lactate have been used in the meat industry because of their ability to increase flavour, prolong shelf life, and improve the microbiological safety of products. Because of their capacity to reduce water activity and the direct inhibitory effect of the lactate ion, lactates have antibacterial properties (Koos &Jansener, 1995).

11. Antioxidant preservation

Antioxidants are substances added to food to stop deterioration, rancidity, or discoloration brought on by lipid oxidation. The phenolic chemicals butylated hydroxy toluene (BHT), butylated hydroxy anisole (BHA), and tertiary butyl hydroquinone (TBHQ) are the most widely utilized antioxidants. To stop the enzymatic oxidation of meat, ascorbic and citric acid are utilized. Sulphur dioxide acts as a preservative and an antioxidant. Propyl gallate (PG) can be used to stabilize animal fat.

12. Biopreservation or natural antimicrobial preservation

In order to obtain "green label" products, natural preservatives such as essential oils, chitosan, nisin, and lysozyme have been investigated. Using natural or controlled microflora, among which Nisin and Natamycin are the most often used antibiotics in meat preservation, increases storage life and safety. Nisin works well against gram +ve bacteria and prevents *Clostridium botulinum* from growing. Natamycin inhibits the growth of mould and yeast. Numerous studies have been conducted on lactic acid bacteria (LAB) and their antimicrobial byproducts including lactic acid and bacteriocins. In meat and meat products, lactic acid fermentation results in the production of antibacterial substances such hydrogen peroxide, diacetyl, bacteriocins, and reuterin, which also serves as a preservative. Meat products have been preserved by using a variety of spices and essential oils with preservation characteristics. These include allyl isothiocyanate found in mustard seed and eugenol in cloves.

13. High Hydrostatic Pressure (HHP)

The use of high-pressure technologies (100-1000 MPa, or 1000–10000 bar) in biological and food systems is growing. HHP, a nonthermal technique, is of particular relevance since it may inactivate enzymes and spoilage microorganisms at low temperatures without altering the product's sensory or nutritional properties. HHP is a potent technique for reducing the dangers of *Listeria monocytogenes* and *Salmonella spp.* in raw or marinated meats. The efficiency of HHP for microbial control is influenced by process variables such as pressure level, temperature, and exposure time, as well as by intrinsic food variables including pH, microorganism strain and growth stage, and food matrix. HHP, in combined with a moderate temperature, causes changes in the mechanical characteristics and improves meat tenderness. However, due to denaturation of globin in myoglobin, heme displacement or release, ferrous oxidation, HHP even at low temperatures may have a negative impact on the colour of fresh meat.

14. Vacuum Packaging (VP)

Materials for vacuum packaging of primal cuts often consist of three-layered co-extrusions of ethyl vinyl acetate, polyvinylidene chloride, and ethyl vinyl acetate, which generally have a low O_2 permeability due to the polyvinylidene chloride layer. The lack of O_2 in packages may minimise the oxidative deteriorative reactions and reduce aerobic bacteria growth, and also causes pigments to be in the deoxymyoglobin state. Low O_2 vacuum packages for retail meat cuts are usually vacuum skin packaging (VSP) systems for placing the retail cut in a barrier styrene or polypropylene tray and vacuum sealing is done by barrier films that are heat shrunk to conform the shape of the product. Before closing the film layers with heat, VSP packaging equipment eliminates atmospheric air from the package or flushes it out with gaseous mixtures like N_2 and CO_2. The common construction for the top and bottom package webs is nylon barrier polymer of polyvinylidene chloride or ethylene vinyl alcohol, tie layer and ionomer. While the barrier layer prevents vapour permeation and the ionomer offers the essential seal qualities, nylon provides bulk, hardness, and a low melting point. In a variant of VSP, the lidding film has an inner layer that is air-permeable and an outside air tight barrier layer. Before retail display, the

outer barrier film layer is peeled away from the permeable layer, allowing air to touch the meat product and produce a blossomed hue.

15. Modified Atmosphere Packaging (MAP)

To maintain a steady package environment during storage, MAP for meat needs a barrier against both gas and moisture absorption. The typical atmospheric air composition must be altered or removed for any sort of MAP, which includes both aerobic and anaerobic meat packaging. VP is the most economical packaging, however low O_2 MAP has been easily accessible but less frequently utilized due to cost efficiency. In a tray-in-sleeve configuration, non-barrier overwrapped packets of meat can be contained, or they can be placed in a bigger barrier film master pack that holds several packages in the anoxic gas. When the overwrapped permeable film package is withdrawn from the master pack for retail display, the meat pigments are exposed to oxygen (Belcher, 2006). Using anoxic MAP, which has an inner air-permeable film and an outer barrier film sealed to the barrier tray or bottom web containing the meat, is another method. When the outer film is peeled before display, the meat is exposed to O_2 in the atmospheric air and subsequently blooms. Low O_2 retail packaging solutions have also made use of carbon monoxide (CO). The modest levels of CO are still sufficient to impart the desirable red meat colour, whether the meat is exposed to CO before packaging or CO is used to gas flush VSP packages before sealing. A high O_2 environment (about 80% O2) has been used for the bulk of MAP for fresh meat, allowing acceptable shelf life for processors and retailers with controlled distribution networks.

16. Active Packaging (AP)

While intelligent or smart packaging allows for sensing of the food properties or package environment to inform the processor, retailer, and/or consumer of the status of the environment or food, AP is the incorporation of specific compounds into packaging systems that interact with the contents or environment to maintain or extend product quality and shelf life. Although they may serve other purposes, the main active technologies in AP primarily improve the product's protection or shelf life in reaction to interactions between the product, package, and environment. AP may also involve purposefully changing the package environment by passive or active techniques at a specific moment or condition, but without the inputs and ongoing monitoring required for controlled atmosphere packaging (CAP). The components of intelligent packaging systems sense their surroundings, process the data, and then enable action to safeguard the product by carrying out communication functions. AP functions and technologies include moisture control, O_2- permeable films, O_2 scavengers or absorbers, O_2 generators, CO_2 controllers, odour controllers, flavour enhancement, ethylene removal, antimicrobial agents and microwave susceptors (Brody *et al.,* 2008; Brody, 2009) in addition to indicators of specific compounds (Vermeiren *et al.,* 1999) and temperature control packaging.

17. Cold plasma

A new non-thermal technology for enhancing food safety is cold plasma. Wide variety of industries, especially the food business, are very interested in this technology. Cold plasma is a unique non-thermal food processing technology that uses energetic, reactive gases to inactivate

contaminating bacteria on meat, poultry, fruits, and vegetables. This flexible sanitizing method uses electricity and a carrier gas, such as air, oxygen, nitrogen, or helium. The primary modes of action are due to UV light and reactive chemical products of the cold plasma ionization process. The food business is challenged to provide safe food with less processing as fresh product. Foods must be given free of any microbial contamination because many items are consumed uncooked. In the food manufacturing industry, cold atmospheric plasma has the potential to inactivate all types of pathogenic microorganisms at ambient temperatures with low operating costs, improving food safety without losing nutritional value or sensory appeal while also being environmentally friendly. Labelling is one of the areas of packaging where plasma is most frequently used. There is always one essential requirement: the glue must be water based and the adhesive junction must not loosen on its own. This is true whether it is for advertising stickers, information labels, or tamper evidence. A clear fibre tear should be visible when it is peeled off. Companies like Kraft and other top producers of foods and beverages use plasma technology to guarantee the label's stickiness.

It should be emphasized that modern meat processors don't rely just on one preservation method or technique. Meat preservation is frequently done using many antibacterial principles simultaneously. They employ a combination of preservative factors (hurdles) in a balanced manner to derive maximum benefit. Each principle may be regarded as a hurdle against microbial proliferation and combination of these processes so called hurdle technology can be devised to achieve particular objectives in terms of both microbial and organoleptic quality.

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OVERVIEW OF NANOTECHNOLGY

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Introduction:

The prefix 'nano' is used to describe a ' very small or tiny or dwarf entity ' (Joudeh and Linke, 2022). In 1947, the IUPAC conference adopted nano as a unit, representing a one-billionth part (10^{-9}). Japanese scientist Norio Taniguchi was first to coined the term ‘‘nano-technology’’ and Richard Feynman is the father of nanotechnology. Nanotechnology has emerged as one of the most important research areas in the early twenty-first century, as scientists exploit the unique features of atomic and molecular aggregates constructed at the nanoscale scale (McNeil1, 2005). Nanotechnology is a field of study that deals with the synthesis, engineering, and applications of nanomaterials (Joudeh and Linke, 2022). According to the US National Science and Technology Council, the core of nanotechnology is the ability to control and manipulate substances at the atomic, molecular, and supra-molecular levels to produce new structures and technologies (Patel *et al.*, 2015).

Nanomaterials are materials with particles having at least one dimension within the nanoscale range (1–100 nm) or less than one micrometer. Nanoparticles are particles with sizes ranging from one nanometer to hundred nanometer. The chemical, physical, and biological properties of nanoparticles or nanomaterials are different from those of their larger counterparts. Nanoparticles exhibit different optical, thermal, electrical, and magnetic properties. The unique characteristics of nanoparticles are their atomic level, increased relative surface area to volume ratio, and quantum confinement. One example is the color of gold, which ranges from purple to red depending upon the size; 20 nm gold particles show red color, whereas 80 nm gold nanoparticles show orange color.

Classification:

Nanomaterials and nanoparticles are classified into five categories based on their source, morphology, dimensions, material, and toxicity.

1.1 Source/origin- based

Nanomaterials are classified into three groups based on their origin: natural, artificial, and incidental.

1.1.1 Natural

Natural biogeochemical processes produce natural nanomaterials or nanoparticles (Mobeen *et al.*, 2022). All of Earth’s spheres, including the atmosphere (troposphere), hydrosphere (all bodies of water), lithosphere (soil, rocks, magma), and biosphere (all living

things), contain naturally occurring nanomaterials (Jeevanandam *et al.,* 2018). It has been found that nanomaterials are used by higher organisms for their protection and survival under adverse conditions.

1.1.2 Artificial

Nanomaterials have been purposefully synthesized with desired qualities through physical, chemical, biological, or mixed techniques (Jeevanandam *et al.,* 2018).

1.1.3 Incidental

Nanomaterials are produced accidentally owing to their natural, direct, or indirect anthropological activities. They are produced as a consequence of both man-made and natural processes, including volcanic venting, burning of fuels from automobiles, welding, forest fires, and photochemical reactions (Mobeen *et al.,* 2022). The quality of air, water, and soil are affected by their high toxicity.

1.2 Morphology-based

Nanomaterials are classified as Nanospheres, nanocages, nanoshells, nanowires, nanotubes, and nanostars based on morphology.

1.3 Dimension-based

Pokropivny and Skorokhod classified nanomaterials based on their dimensionality. In Dimension-based classification, nanomaterials are classified into four groups depending on the movement of electrons along the x-, y-, and z-axes in the nanoparticles (Mobeen *et al.,* 2022). The four groups are as follows.

1.3.1 Zero-Dimensional

Nanomaterials with all three dimensions within the nanoscale range are known as zero-dimensional nanomaterials (Mekuye and Abera, 2023). In this case, electron movement is restricted to all dimensions (Mobeen *et al.,* 2022). Gold and silver nanoparticles, fullerenes, nanospheres, and quantum dots are examples of zero-dimensional nanomaterials (Mobeen *et al.,* 2022; Mekuye and Abera 2023).

1.3.2 One-Dimensional

Nanomaterials have two dimensions within the nanoscale range and one beyond the nanoscale range (Mekuye and Abera, 2023). Electrons can move along only one axis (Jeevanandam *et al.,* 2018). Examples of one-dimensional nanomaterials include nanotubes, nanowires, nanofilaments, and nanorods.

1.3.3 Two-Dimensional

Nanomaterials with one dimension at the nanoscale and two other dimensions are not within this range. Electrons can move along the x-y-axis (Jeevanandam *et al.,* 2018). Examples of two-dimensional nanomaterials includes sheet-like materials, nanocoatings, and nanofilms.

1.3.4 Three-Dimensional

In three-dimension nanomaterials all three dimensions are outside the nanoscale range. The electrons can move along the x-, y-, and z-axes, respectively. Three-dimensional nanomaterials are also known as bulk materials. These bulk materials are composed of building

blocks that are in the nanoscale range so three-dimensional nanomaterials have three arbitrary dimensions beyond the nanoscale range. This includes the dispersion of nanoparticles, polycrystals, multi-nanolayers, and bundles of nanowires and nanotubes.

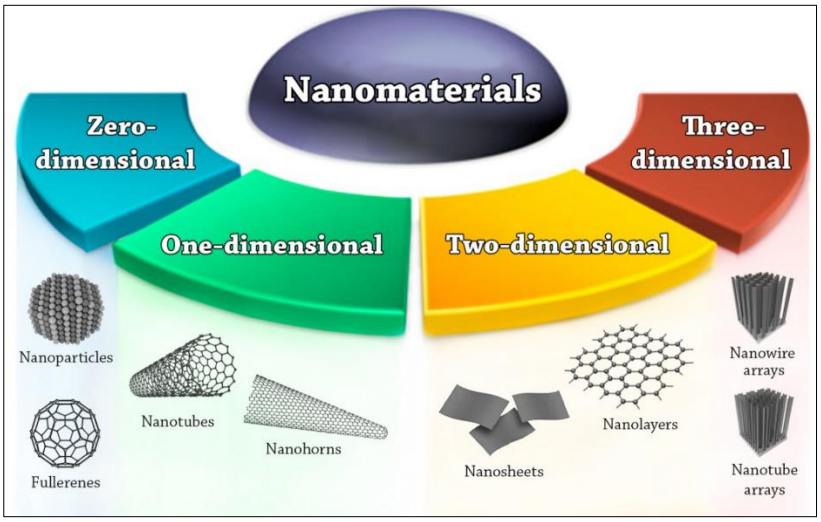

Fig. 1: Dimension-based classification of nanomaterials (Joudeh and Linke, 2022)

1.4 Based on materials

Based on type of materials used nanomaterials are classified into 4 groups: carbon-based nanomaterials, organic-based nanomaterials, inorganic-based nanomaterials and composite-nanomaterials.

1.4.1 Carbon-based nanomaterials

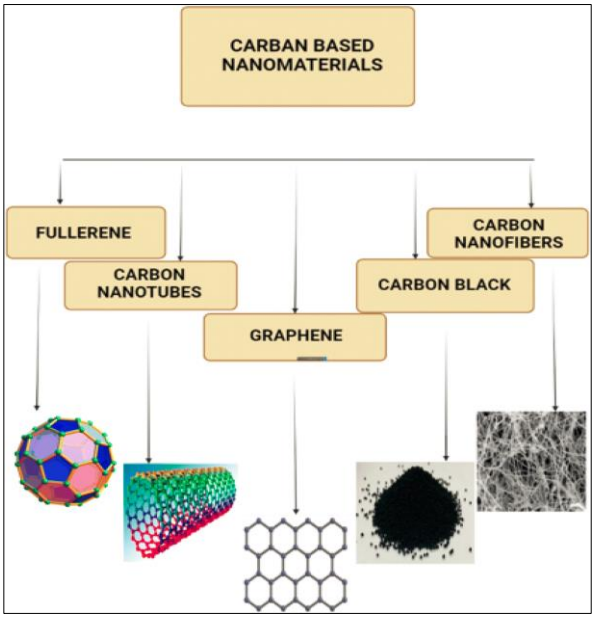

Fig. 2: Carbon-based nanomaterials (Alshammari *et al.*, 2023)

Nanomaterials composed of carbon are known as carbon-based nanomaterials. These nanomaterials are found in different structural configurations, such as spherical, hollow cylinder, and ellipsoidal. Fullerenes, graphene, carbon nanotubes, carbon nanofibers, and carbon black are carbon-based nanomaterials (Mekuye and Abera, 2023).

The three most crucial manufacturing procedures for the synthesis of carbon-based compounds are laser ablation, arc discharge, and chemical vapor deposition (CVD) (Jeevanandam *et al.,* 2018). Carbon-based nanomaterials transmit heat along their length but not across the tube (Mekuye and Abera, 2023). These nanomaterials have a broad range of application in healthcare and the environmental sector as antimicrobials and environmental sensors (Mobeen *et al.,* 2022).

1.4.2 Inorganic-based nanomaterials

Inorganic-based nanoparticles tend to be highly stable nanomaterials that are devoid of carbon atoms (Mekuye and Abera, 2023; Mobeen *et al.,* 2022). These nanomaterials are further classified into metal-based nanoparticles (including gold, copper, silver, and aluminum nanoparticles), metal oxide- based nanoparticles (including titanium oxide (TiO2) and zinc oxide (ZnO)), and semiconductor-based nanoparticles (including ceramic-based nanoparticles and lipid-based nanoparticles) (Mekuye and Abera, 2023).

They have a central inorganic core that exhibits fluorescent, magnetic, electrical, and optical properties) (Mobeen *et al.,* 2022). These nanoparticles are non-toxic and biocompatible (Mobeen *et al.,* 2022).

1.4.3 Organic-based nanomaterials

Organic-based nanomaterials are those that are made of organic matter that self-assemble through non-covalent interactions. Nanomaterials composed of organic compounds are non-toxic, biodegradable, and ecologically friendly. Examples of organic-based nanomaterials include liposomes, ferritin, micelles, dendrimers, and polymers. Liposomes, nanocapsules, and micelles have hollow interiors that make them sensitive to heat, electromagnetic (EM) radiation, and light. These polymeric nanoparticles are regarded as the best option for the delivery of drugs at the target site to treat diseases.

1.4.4 Composite-based nanoparticles

Nanomaterials composed of either nanoparticles combined with other nanoparticles or with bigger or bulky materials are known as composite nanomaterials. Composite nanomaterials can be a combination of organic, inorganic, or carbon-based nanomaterials with any form of bulky materials.

1.5 Toxicity

Nanomaterials are utilized to benefit humans; however they can potentially contribute to the development of diseases by producing harmful ions (Mobeen *et al.,* 2022). They can be classified into three groups, depending on their degree of solubility and toxicity. They are as follows:

1.5.1 Highly soluble nanoparticles

These nanoparticles cause damage to the lungs and other organs by releasing harmful ions such as zinc oxide (ZnO).

1.5.2 Poorly soluble low-toxicity nanoparticles

Compared to highly soluble nanoparticles, poorly soluble low-toxicity nanoparticles are less harmful. They promote fibrosis and cancer by releasing titanium oxide (TiO).

1.5.3 Poorly soluble high-toxicity nanoparticles

Poorly soluble high-toxicity nanoparticles, such as nickel oxide, lead to the development of fibrosis and cancer by producing reactive oxygen species (ROS).

Approaches for synthesis:

Nanoparticles were synthesized using one of the two approaches. There are as follows:

1. Top-down approach

A destructive approach called "top-down" breaks down larger bulk materials into tiny molecules, which are then transformed into nanoparticles (Mekuye and Abera, 2023). Top-down approach include ball milling, photolithography, arc discharge and laser ablation (Arole and Munde, 2014).

2. Bottom-up approach

A constructive approach called "Bottom up" Smaller atoms or molecules self-assemble or are driven by an external force to form a larger or more ordered system. Colloidal precipitation, electrodeposition, sol-gel synthesis, and hydrothermal synthesis. (Arole and Munde, 2014; Mobeen *et al.*, 2022).

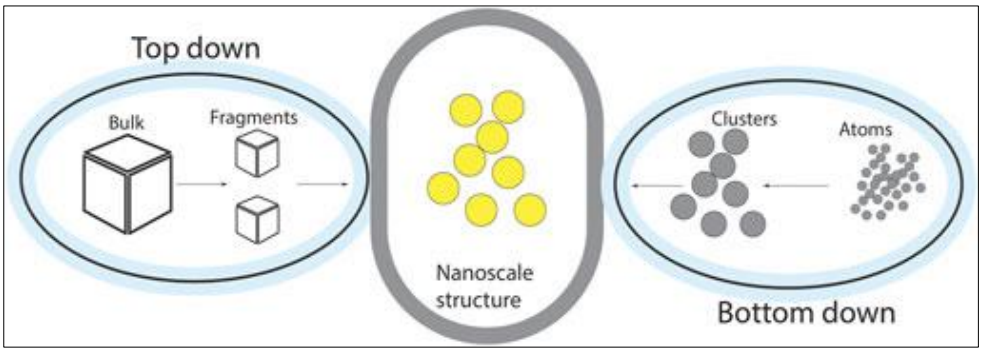

Fig. 3: Approaches for synthesis of nanoparticles (Mobeen *et al.*, 2022)

Methods of synthesis:

Nanomaterials and nanoparticles are synthesized using three methods: physical, chemical, and biological. They are as follows:

1. Physical

Synthesis of nanoparticles at high temperature or pressure. Methods are further classified as mechanical (High energy ball milling, milt mixing) and vapour (physical vapour deposition, sputter deposition, laser ablation)

2. Chemical

Simple, inexpensive, and low-temperature synthesis methods. However, the use of toxic reducing and stabilizing agents can be harmful. Sol-gel method, colloids and colloids in solution are examples of chemical methods.

3. Biological

Biological methods involve the use of microorganisms or plants for the synthesis of nanoparticles. This is an easy, efficient, and eco-friendly method that produces safer products and by-products. The size and shape of nanoparticles synthesized using plant extracts depend on several factors, such as plant species, ratio of salt to plant extract, temperature, and time.

Applications

The application of nanotechnology in agriculture, the environment, and the medical sector are discussed as follows:

1. Agriculture

Owing to an increase in population, decrease in fertile soil, and damage to crops by pests and insects, it is important to increase the productivity and pest resistances of plants to meet the increasing food demand. This can be achieved by using nanotechnology. Nanoparticles or nanocarriers are used in agriculture sector to deliver fertilizers, pesticides, plant growth promoters, and nutrients because of their characteristic targeted delivery and controlled release capacity **(**Mobeen *et al.,* 2022; An *et al.,* 2022). It has been found that Alginate/chitosan- GA-3 nanoparticles increase chlorophyll and carotenoid content in leaves (An *et al.,* 2022). Mesoporous silica particles (MSNs), gold nanoparticles (AuNPs), carbon nanotubes (CNTs), and layer double hydroxides (LDHs) are some examples of nanoparticles that have shown potential for efficient and species-independent delivery of genetic engineering tools in plants (Zhi *et al.,* 2022).

2. Environment

Carbon nanotubes, metallic nanoparticles, zinc oxide, and magnetic nanoparticles have the potential to be effective in the remediation and treatment of polluted water, soil, and air **(**Mobasser and Firoozi, 2016). In addition, nano-sensors can be used to monitor environmental changes.

3. Medical and healthcare

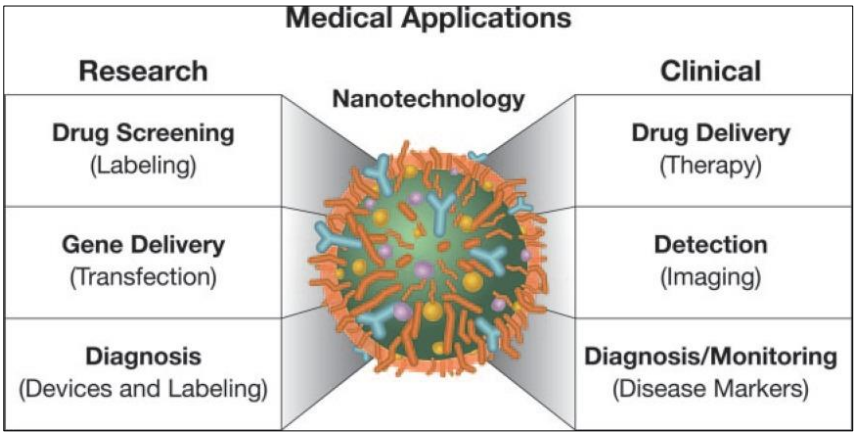

Fig.4. Application nanotechnology in medical sector (McNeil, 2005)

Nanoparticles are used as imaging agents to identify diseased tissue, carriers to deliver drugs, nano-sensors or nano-devices to monitor the disease, and as a tissue regeneration scaffolds. (Patel *et al.,* 2015). In myocardial infraction polyethylene glycol-based hydrogel scaffolds have been found to aid in the growth of transplanted heart cells (Patel *et al.,* 2015). To detect the early stages of disease, nanosensors and nanodevices have been developed that can monitor very low concentrations of biomolecules (Patel *et al.,* 2015). In addition, nanocrystalline silver has been used as an antimicrobial agent for wound treatment. Poly (D, L-Lactitide-co-glycolide)-(PLGA-)-based polymer have been used as carriers for insulin delivery in diabetic patients (Patel *et al.*, 2015).

Conclusion:

Nanotechnology is a rapidly expanding field. This chapter describes about the classification, approaches, and methods of synthesis of nanomaterials and nanoparticles and their applications in the fields of agriculture, environment, and medical sector. In addition to the advantages of nanomaterials and nanoparticles, some nanomaterials or nanoparticles have shown toxic effects on living organisms. Research has been conducted in the field of nanotoxicology to identify harmful nanoparticles or determine dosage levels of nanoparticles that minimize risk and maximize benefits.

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NANOTECHNOLOGY IN NUTRACEUTICALS

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Introduction:

Thanks to advancements in nanoscience in virtually every scientific field, life is now easier. The study of structures and chemicals on nanometer ranges ranging from 1 to 100 nm is known as nanoscience. Nanotechnology is the branch of technology that applies nanoscience to practical fields like electronics. Beginning in the early 2000s, there was a rise in public discussion and knowledge of the topic, which prompted the development of commercial nanotechnology applications. Nanotechnologies have positive effects on the fields of physics, materials science, chemistry, biology, computer science, and engineering. Richard Feynman, a Nobel Prize-winning American scientist, is credited with coining the phrase "nanotechnology." Since Feynman originally uncovered this new area of research, which immediately caught the interest of other scientists, two techniques have been developed to characterize the many alternatives for the synthesis of nanostructures. These two categories can be used to separate top-down and bottom-up production strategies, which differ in terms of quality, speed, and cost.

Top-down

The top-down approach is used to extract nanoparticles from bulk materials. To produce nanoparticles, bulk material is essentially broken down using a top-down approach. Modern techniques recently developed and enhanced by business, such as precision engineering and lithography, can be used to achieve this. The majority of the microelectronics industry depends on precision engineering over the entirety of the manufacturing process, and high performance can be achieved by integrating various technological advances. These include improved servo-drive technologies, size, numerical, and control sensors, as well as advanced nanostructures based on diamond or cubic boron nitride. Lithography involves the patterning deposition of material on a surface by exposure to ions, electrons, or light.

Bottom-up

Using physical and chemical methods at nanoscales (1 nm to 100 nm) and under controlled conditions that manage atom and molecule self-assembly, the phrase "bottom-up approach" refers to the production of nanostructures from the ground up, atom by atom or molecule by molecule. Chemical synthesis is a method for producing basic materials that can be used either directly in products or as the building blocks of more sophisticated organized materials. In a bottom-up procedure known as self-assembly, atoms or molecules arrange themselves into structured nanostructures through chemical-physical interactions. Positional

assembly is the only process that permits the unconstrained insertion of a single atom, molecule, or cluster at a time.

Important parameters of nanoparticles

Nanoparticles' properties dictate how they work. These are a few of the key traits: The following parameters can be measured: (a) nanoparticle size; (b) zeta potential; (c) polydispersity index; (d) physical and chemical stability; (e) zeta potential analyzer; (f) transmission electron microscope; (g) scanning electron microscope; (h) zeta potential analyzer; (i) zeta potential analyzer; (j) zeta potential analyzer; (k) zeta potential analyzer; (k) (e) Encapsulation efficiency, which is calculated by dividing the mass of the compound inside the capsule by the complete compound's mass by 100%; and (f) Loading capacity, which is calculated by dividing the compound inside the capsule by the total mass of the nanoparticles.

Nanotechnology in nutraceuticals and nanomedicine

The fields of nanomedicine and nutraceuticals, which use nanotechnology to improve healthcare and nutrition, have shown promise. Targeted medication delivery, early illness detection, and tailored medicine are all made possible by nanomedicine. Additionally, nanotechnology-enhanced nutraceuticals allow for the efficient delivery of bioactive substances, increasing their absorption and bioavailability. Nutraceuticals and nanomedicine both have enormous potential to transform healthcare and advance general well-being. Nanotechnology's incorporation into nutraceuticals and nanomedicine improves their therapeutic and nutritional characteristics while also opening the door to the creation of cutting-edge, complex products. For instance, nanoscale sensors might enable ongoing health parameter monitoring and offer immediate input on dietary needs.\Additionally, the use of nanotechnology in gene therapy offers hope for the targeted delivery of genes or the use of gene editing to cure genetic problems. To solve safety issues, standardize manufacturing procedures, and maximize the effectiveness of these unique applications, additional study is required. We may anticipate a time when nanomedicine and nutraceuticals will play a big role in enhancing human health thanks to ongoing breakthroughs in nanotechnology.

Applications of nanotechnology in nutraceuticals

Nutraceuticals are those advantageous substances with medicinal or health benefits that can be found in food or as a component of food. In food sciences, nanoencapsulation and nanofabricated delivery systems are very useful approaches. The production of biocompatible active ingredients as well as nutraceuticals on a sustainable basis can improve the food grade and supports wellbeing. As a result, treating various diseases opens up new opportunities when drugs are combined with bioactive substances. Because they can enhance bioavailability, component solubility, and stability, nutraceuticals are frequently employed in nanotechnology. Nanoparticles have a number of special characteristics, including small size and a high surface-to-volume ratio. Additionally, the use of nanotechnology in nutraceuticals opens up substantial possibilities for customized nutrition and improved bioavailability. To increase their stability and absorption, nutraceuticals—which include nutritional supplements, functional foods, and herbal products—

can be created utilizing nanoencapsulation processes. Additionally, bioactive substances like vitamins and antioxidants can be better released into the body using nanostructured delivery systems, which will increase nutrient absorption and bioactivity. Nanomaterials have physico-chemical characteristics that have negative consequences on people's health. The toxicological evaluation of nanofabricated materials and their various methods of delivery for bioactive substances and nutraceuticals is of utmost importance. The use of nanofabricated materials may be associated with a number of safety concerns and require the implementation of practices that dangerously address safety and human health. Rapid expansion has effectively beaten back the use of nano-fabricated materials in food packaging, but there are still end-user regulatory and safety concerns that need to be carefully considered. There are few examples of applications:

Nanoparticles in food packaging:

Hybrid nanostructured materials with enhanced mechanical, thermal, and gas barrier qualities are known as bio nanocomposites. Bio nanocomposites can be used to package food in a way that not only preserves it and lengthens its shelf life, but also decreases the need for plastic packaging materials, making it a more environmentally responsible option. The majority of conventional packaging materials are made of nonbiodegradable materials, which not only use fossil fuels to produce them but also contribute to environmental degradation. But before they might replace conventional plastics and aid in the management of the world's garbage problem, alternative biodegradable films must significantly improve their mechanical and barrier qualities. Clay and other inorganic particles can be added to the biopolymeric matrix of a packaging material to increase its biodegradability. Layered silicate can also be modified with surfactants to influence how quickly a material degrades. Additionally, the utilization of inorganic particles enables the introduction of numerous functions, which could aid in improving the distribution of delicate micronutrients inside edible capsules. Due to its distinct characteristics and molecular structure, zein, a prolamin and the main component of corn protein, has been a significant material in research and industry. Biodegradable zein films with good tensile and water-barrier qualities can be made by dissolving zein in ethanol or acetone. Regarding mechanical and tensile qualities, it is essential to control the regularity and organization of zein films at the nanoscale. The food sector places a lot of emphasis on food preservation in addition to food packaging. With the help of so-called nanosensors, such as a collection of a thousand or so nanoparticles made to glow in a variety of colors when in contact with food pathogens, it is possible to identify food deterioration.

Nanoprobiotics:

Recent years have seen a major increase in interest in nanoprobiotics, and a number of cases illustrate their potential advantages. One such instance is the use of gold nanoparticles to improve probiotic distribution. Probiotic bacteria can be functionalized to adhere to gold nanoparticles, shielding them from harsh stomach conditions and enhancing their survival in the digestive system. Another illustration is the use of nanosized lipid vesicles called liposomes to deliver probiotics. Probiotics are kept alive throughout storage and transportation because of the

barrier provided by liposomes. Additionally, liposomes' nanosize enables improved intestinal absorption, boosting the probiotics' bioavailability. Nanoprobiotics have many advantages. Probiotics' medicinal potential is increased by enhancing their survival and delivery. Probiotics have been linked to a number of health advantages, including improved digestion, immune system support, and mental wellness. By ensuring probiotics reach and remain active at their intended places in the body, nanotechnology can assist enhance these advantages. Nanoprobiotics do, however, come with some difficulties. The safety of the nanoparticles utilized in their formulation is a significant area of concern. Although nanoparticles have demonstrated considerable promise, little is known about how they will affect the environment and human health in the long run. To assure the safety and effectiveness of nanoparticles, careful evaluation of their synthesis and characterization is also necessary. In conclusion, nanoprobiotics present a promising route to enhancing human health through improved probiotic delivery and efficacy. Liposomes and gold nanoparticles are two examples that highlight their potential advantages in terms of enhanced survival and absorption. Before widespread usage in healthcare settings, it is important to solve the issues with nanotechnology, such as safety worries.

Nanoencapsulation using polymers

1. **Chitosan**

Chitin, a naturally occurring polysaccharide that contains randomly dispersed (1–4)-linked N-acetyl glucosamine and glucosamine units, is transformed into chitosan (CH), a modified biopolymer. CH can be found as a white powder that is made up of nitrogen-containing polysaccharide chains that are hard, inflexible, and range in length and molecular weight. Because of its non-toxicity, biodegradability, and inherent antibacterial qualities, CH also has a variety of applications. CH has been utilized in the biomedical field, genetic engineering, the agricultural industry, environmental pollution reduction, food production, paper production, photography, and water treatment. CHNPs exhibit intriguing surface and interface phenomena as a result of their minuscule size. CH NPs may be employed as novel therapeutic options for viral infections, according to several research. Unlike chitin, CH can be dissolved in a weak acidic solution to produce a soluble cationic polymer that differs from other polysaccharides in terms of its characteristics. CH can dissolve in diluted acids like acetic, formic, lactic, or inorganic acids after being stirred for a long time. However, the solubility is affected by the amount of deacetylation, the molecular weight, the concentration of biopolymers, the pH, and the ionic strength. CH has a large number of main and secondary hydroxyl-groups at the C-2, C-3, and C-6 positions in addition to the primary amino groups, which exhibit strong interactions with water. CH benefits include biodegradability, hydrophilicity, bioactivity, and biocompatibility. It also comes from renewable and natural sources. It can be transformed into many forms for various uses, including solutions, mixes, sponges, membranes, gels, pastes, tablets, microspheres, or microgranules.

2. Poly (lactic-co-glycolic acid) (PLGA)

PLGA, often known as poly (lactic-co-glycolic acid), is a popular type of biocompatible and biodegradable polymer. The FDA has cleared the use of PLGA for the development of therapeutic devices due to its low systemic toxicity. The body may hydrolyze PLGA to produce biodegradable lactic acid and glycolic acid. Those phytochemicals may be adsorbed on the surface of PLGA nanoparticles or trapped inside of them. PLGA nanoparticles can be created using the solvent evaporation, emulsification-diffusion, and nanoprecipitation processes. Many phytochemicals, including quercetin and curcumin, have been transported using PLGA nanoparticles. The key ingredient in turmeric, curcumin, has been utilized in traditional medicine for many years. The anti-inflammatory, antioxidant, and anticancer effects of curcumin are well established. It has been demonstrated to influence a number of molecular targets implicated in the growth of cancer and inflammation. Additionally having neuroprotective properties, curcumin has shown promise in the treatment of neurodegenerative illnesses including Parkinson's and Alzheimer's. Red onions contain the flavonoid quercetin, which is a potent anti-inflammatory and antioxidant substance. Its potential to prevent and treat a variety of ailments has been researched. By preventing the development of cancer cells and causing cell death, quercetin has anti-cancer properties. Additionally, it has cardiovascular preventive properties by lowering blood pressure and preventing LDL cholesterol oxidation. In addition, quercetin has demonstrated promise in preventing allergic reactions and easing asthmatic and other respiratory disorders' symptoms.

Application of nanotechnology in nanomedicine

In terms of nanomedicine, nanoparticles may be created to deliver medications directly to specific locations within the body, enhancing their efficacy while reducing their negative effects. The treatment of numerous diseases, including cancer, neurological disorders, and cardiovascular ailments, offers considerable promise for this tailored drug delivery method. Furthermore, by using highly sensitive and targeted biosensors, diagnostics based on nanotechnology can identify diseases earlier, allowing for early intervention and better treatment results.

Nanotechnology in drug delivery system-

- **Treatment of arthritis**

Millions of people throughout the world suffer from osteoarthritis and rheumatoid arthritis, two chronic inflammatory diseases that cause pain, joint deformity, and disability. The effectiveness, safety, or patient compliance of traditional therapeutic methods like oral drugs or surgery are frequently constrained. It is now possible to control and manipulate matter at the nanoscale thanks to nanotechnology, which has expanded drug delivery's horizons. Nanotechnology-based injectable medication delivery systems provide various benefits for the treatment of arthritis. First off, by enabling focused therapeutic administration to the afflicted joints, these devices reduce systemic adverse effects and improve medication effectiveness. Drug concentrations at the site of inflammation can be improved by using nanoparticles, such as liposomes or polymeric micelles, to encapsulate and gradually release medications, decreasing

the need for repeated administration. Second, nanotechnology makes it possible to incorporate disease-modifying substances into drug delivery systems, such as chondroitin sulfate or hyaluronic acid. These substances have advantageous traits that may decrease the progression of OA and RA, such as encouraging cartilage regeneration or lowering inflammation. Nanotechnology also enables the creation of multipurpose drug delivery devices. As an illustration, therapeutic medications and imaging agents can both be incorporated into nanoparticles, allowing for real-time monitoring of drug distribution and efficacy within the joint. Additionally, ligands that specifically target receptors expressed on inflammatory joint tissues can be added to nanoparticle surfaces to modify them, enhancing drug delivery and tissue localization.

- **Developed ω-3 PUFA-containing Nano formulations for liver cancer prevention and therapy**

This uses DHA as the bioactive payload in low-density lipoprotein (LDL)-based nanoparticles.DHA-LDL nanoparticles are administered throughout the body together with pulsed focused ultrasound exposures. DHA is positioned inside the hydrophobic core of the LDL nanoparticles, where its stability and biological activity may be sustained. Since LDLs have a high capacity for carrying active chemicals and are naturally present in circulation, they are not identified and swallowed by mononuclear circulating phagocytes, which is a benefit of employing LDLs as -3 PUFA transporters to liver cells.Additionally, LDLs transport and provide lipids to cells under physiological conditions via LDL receptor-mediated endocytosis, and they appear especially well suited to deliver bioactive lipid factors to cancer cells, which exhibit a higher avidity for lipids than normal cells due to their sustained membrane turnover. The fact that these customized nanoparticles may selectively kill hepatocarcinoma cells while sparing their non-malignant counterparts makes them particularly intriguing. The fact that significant amounts of the cell growth inhibitor DHA were only found inside of cancer cells is likely what caused this specificity for cancer cells, which is extremely favourable for anti-cancer drugs. Particularly, the particular and potent anti-inflammatory and pro-resolving capabilities of the -3 PUFAs and their bioactive derivatives are used to explain the selective growth-inhibitory action of the LDL-DHA nanoparticles in liver cancer cells.

Conclusion:

Nanotechnology's incorporation into nutraceuticals and nanomedicine improves their therapeutic and nutritional characteristics while also opening the door to the creation of cutting-edge, complex products. For instance, nanoscale sensors might enable ongoing health parameter monitoring and offer immediate input on dietary needs. Additionally, the use of nanotechnology in gene therapy offers hope for the targeted delivery of genes or the use of gene editing to cure genetic problems. The possible hazards and ethical issues related to nanomedicine and nutraceuticals must be discussed along with these opportunities, though. Nanotechnology's potential environmental impact as well as safety issues surrounding the long-term effects of nanoparticles on the body must be carefully assessed and regulated.

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BIRD DIVERSITY OF RALAWATI DAM, SENDHWA, BARWANI (M.P.)

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Abstract:

The current investigation was conducted at Ralawati Dam Sendhwa in Madhya Pradesh. During this study, various bird families were observed. The results of our study show that in 2018-19, we observed the species count was 45 and the total number of orders found here were 12. The checklist of all the species in 2019-20 shows that we have observed at Ralawati Dam, Sendhwa, the species count was 46 and the total number of orders found here were 12. Birds serve as valuable bio-indicators, enabling the assessment of ecosystem health. They are often the first to exhibit signs of stress in response to environmental changes and play essential roles as bio-indicators, pollinators, seed dispersers, and scavengers. Additionally, they provide benefits to humans in agriculture by helping control populations of harmful pests that can negatively impact productivity.

Keywords: Birds, Ralawati, Diversity, Family, Order.

Introduction:

Birds responding to the seasonal changes is an important focus area for research among the community of ecologists. And several studies have been conducted for the same (Kwok and Corlett, 1999). In urban landscapes, parks, gardens and greenbelt are demonstrated as the hotspots of avian diversity (Adams *et al.,* 1994). It was found that species richness was lower in urban areas. The avian community in these areas were dominated by few species (Gavareski *et al.,* 1976).

Birds inhabit a vast range of the ecological positions both domestic and migratory birds have a varied range in central India. Worldwide there are over 10,000 distinguished bird species recorded (Sekercioglu *et al.,* 2012). Although there has been a decline in the bird species due to various factors, almost 16 million birds perish in a year noted. India holds the seventh rank with 88 vulnerable bird species over the world (Birdlife International, 2010).

Avian fauna is present in the suitable feeding and inhabitation conditions available in the areas around lakes, forest and especially in the national parks. The need of the time is to preserve these areas in order to reduce the threats to the fauna diversity (Pattimahu *et al.,* 2017). Different species of birds select different areas according to their environmental needs that directly relates to their survival success (Boyce *et al.,* 2016; Young *et al.,* 2019; Bailey and King, 2019).

Numerous attempts have been made to explore various factors of avifaunal variation in various parts of the world, according to the literature mentioned above. The mentioned content underlines the value of birds and the necessity to safeguard birds from the environment. The

majority of these birds live in urban settings, indicating that they might be used as environmental bioindicators, according to the literature. Finally, this research has the potential to go further into this information in order to do additional research.

Materials and Methods:

Study area:

Ralawati Dam, Sendhwa of Barwani District of Madhya Pradesh (India) was selected for our study.

Methodology:

- Line transect method was adopted.
- Classification of Birds: Birds were classified using the world database and nomenclature including their Common names, scientific names, family, order was written with the help of: Gill, F., D. Donsker, and P. Rasmussen (eds). 2020. IOC World Bird List (v10.2).
- Figure and table were prepared by using Microsoft Excel 2019.

Fig. 1: Study Location Ralawati Dam at Sendhwa

Study design:

The present study was based on the following analysis:

1. **Checklist of all the species:** were prepared for both the years 2018-19 & 2019-20. Their order and families were also tabulated.
2. **Percentage occurrence of all the species:** Family wise composition in percentage was calculated and presented from 2018-19 & 2019-20.
3. **Diet composition at each site:** Several bird species recorded have different food preferences. All bird species and their category were tabulated from both years 2018-19 & 2019-20.

4. **Species richness:** The species richness is calculated by simply counting the total number of bird species at that particular study location. The value of species richness can be different according to factors like total area, type of landscape, availability of food, vegetation, etc. Its value is same
5. **Species abundance:** It is the abundance of bird species at a particular study area. Few bird species are present in large population but few are present in less number.
6. **Frequency of species:** While doing regular studies, frequency of species can be estimated. If a bird species is observed regularly, it will have highest frequency but if a bird species is observed occasionally, it will have least frequency.

Diversity indices: Diversity indices are estimated for evaluating ecological health of that study area, and following indexes were calculated:

1. **Total Species Count:** In total species count, all bird individuals were counted on each visit. It varies with the type of landscape, food availability, temperature and vegetation.
2. **Simpson's Index**: Simpson's index (D) is used to evaluate diversity in a particular community.
   Whenever value of D increases, diversity decreases.
3. **Simpson's Index of Diversity:** We know that high value of D represents a community with low biodiversity but we can express Simpson's diversity index as 1 – D.
   This index is also called as "The Gini-Simpson index (or Simpson's index of diversity)" Simpson's index of diversity measures the probability that if two individuals are randomly selected, they belong to different species.
4. **Simpson's Reciprocal Index:** Simpson's Reciprocal Index is represented by 1/D. It is accounts for richness and evenness both. Whenever the value of D is more the value of 1/D is less. High value of 1/D represents large diversity.
5. **Margalef's Index** Margalef's index focuses on species richness of study area. It shows the increasing number of species with more numbers of organisms in each species sampled, by dividing the total species count by the natural log (of the number of sampled organisms).
6. **Shannon's Index:** The Shannon Index is a tool to evaluate the diversity of species of a community at an area. Species within a community. This index also gives information about the type of habitat and the index can be calculated by the following formula:
7. **Evenness Index:**
   Species evenness refers to the similarity in number of individuals among all species that too mathematically. Generally, it is measure of biodiversity which shows equality in number in a community. Species evenness considers the number of species and their relative abundance.

Results:

Checklist of all the species:

In our study site we found 45 species during 2018-19 and in 2019-20 we found 46 species (Table 1 and 2).

Table 1: List of birds recorded in the Ralawati Dam, Sendhwa study location during 2018-19

Ralawati Dam, Sendhwa				
S. No.	**Order**	**Family**	**English Name**	**Scientific Name**
1	Anseriformes	Anatidae	Indian Spot-billed Duck	*Anas poecilorhyncha*
2	Columbiformes	Columbidae	Spotted Dove	*Streptopelia chinensis*
3	Charadriiformes	Laridae	Common Tern	*Sterna hirundo*
4	Pelecaniformes	Ardeidae	Black Bittern	*Ixobrychus flavicollis*
5	Pelecaniformes	Ardeidae	Grey Heron	*Ardea cinerea*
6	Pelecaniformes	Ardeidae	Great Egret	*Ardea alba*
7	Pelecaniformes	Ardeidae	Little Egret	*Egretta garzetta*
8	Pelecaniformes	Ardeidae	Indian Pond Heron	*Ardeola grayii*
9	Accipitriformes	Accipitridae	Black-winged Kite	*Elanus caeruleus*
10	Coraciiformes	Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*
11	Passeriformes	Dicruridae	Black Drongo	*Dicrurus macrocercus*
12	Passeriformes	Hirundinidae	Dusky Crag Martin	*Ptyonoprogne concolor*
13	Passeriformes	Estrildidae	Red Munia	*Amandava amandava*
14	Anseriformes	Anatidae	Northern Pintail	*Anas acuta*
15	Anseriformes	Anatidae	Common Teal	*Anas crecca*
16	Charadriiformes	Turnicidae	Barred Buttonquail	*Turnix suscitator*
17	Ciconiiformes	Ciconiidae	Asian Openbill	*Anastomus oscitans*
18	Ciconiiformes	Ciconiidae	Woolly-necked Stork	*Ciconia episcopus*
19	Accipitriformes	Accipitridae	Black Kite	*Milvus migrans*
20	Strigiformes	Strigidae	Spotted Owlet	*Athene brama*
21	Passeriformes	Rhipiduridae	White-throated Fantail	*Rhipidura albicollis*
22	Passeriformes	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*
23	Passeriformes	Sturnidae	Common Myna	*Acridotheres tristis*
24	Passeriformes	Sturnidae	Bank Myna	*Acridotheres ginginianus*
25	Passeriformes	Cisticolidae	Ashy Prinia	*Prinia socialis*
26	Passeriformes	Leiothrichidae	Common Babbler	*Argya caudata*
27	Gruiformes	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*
28	Charadriiformes	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*
29	Charadriiformes	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*
30	Charadriiformes	Charadriidae	Little Ringed Plover	*Charadrius dubius*
31	Charadriiformes	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*
32	Charadriiformes	Scolopacidae	Green Sandpiper	*Tringa ochropus*

33	Passeriformes	Leiothrichidae	Jungle Babbler	*Argya striata*
34	Passeriformes	Sturnidae	Asian Pied Starling	*Gracupica contra*
35	Pelecaniformes	Ardeidae	Cattle Egret	*Bubulcus ibis*
36	Pelecaniformes	Ardeidae	Striated Heron	*Butorides striata*
37	Pelecaniformes	Ardeidae	Black-crowned Night Heron	*Nycticorax nycticorax*
38	Coraciiformes	Alcedinidae	Common Kingfisher	*Alcedo atthis*
39	Coraciiformes	Alcedinidae	Pied Kingfisher	*Ceryle rudis*
40	Piciformes	Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus*
41	Passeriformes	Dicruridae	Ashy Drongo	*Dicrurus leucophaeus*
42	Anseriformes	Anatidae	Ruddy Shelduck	*Tadorna ferruginea*
43	Columbiformes	Columbidae	Laughing Dove	*Streptopelia senegalensis*
44	Psittaciformes	Psittaculidae	Plum-headed Parakeet	*Psittacula cyanocephala*
45	Passeriformes	Rhipiduridae	White-browed Fantail	*Rhipidura aureola*

Table 2: List of birds recorded in the Ralawati Dam, Sendhwa study location during 2019-20

Ralawati Dam, Sendhwa				
S. No.	**Order**	**Family**	**English Name**	**Scientific Name**
1	Anseriformes	Anatidae	Indian Spot-billed Duck	*Anas poecilorhyncha*
2	Columbiformes	Columbidae	Spotted Dove	*Streptopelia chinensis*
3	Charadriiformes	Laridae	Common Tern	*Sterna hirundo*
4	Pelecaniformes	Ardeidae	Black Bittern	*Ixobrychus flavicollis*
5	Pelecaniformes	Ardeidae	Grey Heron	*Ardea cinerea*
6	Pelecaniformes	Ardeidae	Great Egret	*Ardea alba*
7	Pelecaniformes	Ardeidae	Little Egret	*Egretta garzetta*
8	Pelecaniformes	Ardeidae	Indian Pond Heron	*Ardeola grayii*
9	Accipitriformes	Accipitridae	Black-winged Kite	*Elanus caeruleus*
10	Coraciiformes	Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*
11	Passeriformes	Dicruridae	Black Drongo	*Dicrurus macrocercus*
12	Passeriformes	Hirundinidae	Dusky Crag Martin	*Ptyonoprogne concolor*
13	Passeriformes	Estrildidae	Red Munia	*Amandava amandava*
14	Passeriformes	Cisticolidae	Ashy Prinia	*Prinia socialis*
15	Pelecaniformes	Ardeidae	Cattle Egret	*Bubulcus ibis*
16	Anseriformes	Anatidae	Common Teal	*Anas crecca*

17	Anseriformes	Anatidae	Northern Pintail	*Anas acuta*
18	Charadriiformes	Turnicidae	Barred Buttonquail	*Turnix suscitator*
19	Ciconiiformes	Ciconiidae	Asian Openbill	*Anastomus oscitans*
20	Ciconiiformes	Ciconiidae	Woolly-necked Stork	*Ciconia episcopus*
21	Accipitriformes	Accipitridae	Black Kite	*Milvus migrans*
22	Strigiformes	Strigidae	Spotted Owlet	*Athene brama*
23	Passeriformes	Rhipiduridae	White-throated Fantail	*Rhipidura albicollis*
24	Passeriformes	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*
25	Passeriformes	Sturnidae	Common Myna	*Acridotheres tristis*
26	Passeriformes	Sturnidae	Bank Myna	*Acridotheres ginginianus*
27	Passeriformes	Leiothrichidae	Common Babbler	*Argya caudata*
28	Passeriformes	Acrocephalidae	Moustached Warbler	*Acrocephalus melanopogon*
29	Gruiformes	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*
30	Charadriiformes	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*
31	Charadriiformes	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*
32	Charadriiformes	Charadriidae	Little Ringed Plover	*Charadrius dubius*
33	Charadriiformes	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*
34	Charadriiformes	Scolopacidae	Green Sandpiper	*Tringa ochropus*
35	Passeriformes	Leiothrichidae	Jungle Babbler	*Argya striata*
36	Passeriformes	Sturnidae	Asian Pied Starling	*Gracupica contra*
37	Pelecaniformes	Ardeidae	Striated Heron	*Butorides striata*
38	Pelecaniformes	Ardeidae	Black-crowned Night Heron	*Nycticorax nycticorax*
39	Coraciiformes	Alcedinidae	Common Kingfisher	*Alcedo atthis*
40	Coraciiformes	Alcedinidae	Pied Kingfisher	*Ceryle rudis*
41	Piciformes	Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus*
42	Passeriformes	Dicruridae	Ashy Drongo	*Dicrurus leucophaeus*
43	Anseriformes	Anatidae	Ruddy Shelduck	*Tadorna ferruginea*
44	Columbiformes	Columbidae	Laughing Dove	*Streptopelia senegalensis*
45	Psittaciformes	Psittaculidae	Plum-headed Parakeet	*Psittacula cyanocephala*
46	Passeriformes	Rhipiduridae	White-browed Fantail	*Rhipidura aureola*

Order wise species distribution

In 2018-19 there were 12 groups at Ralawati Dam, Sendhwa of which Passeriformes order was the most dominant. Strigiformes, Gruiformes, Piciformes and Psittaciformes were the least dominant group. In 2019-20: At Ralawati Dam, Sendhwa, out of the 12 orders, Passeriformes was the most dominant one. The least dominant of them were Strigiformes, Gruiformes, Piciformes and Psittaciformes (Figure 2 and 3).

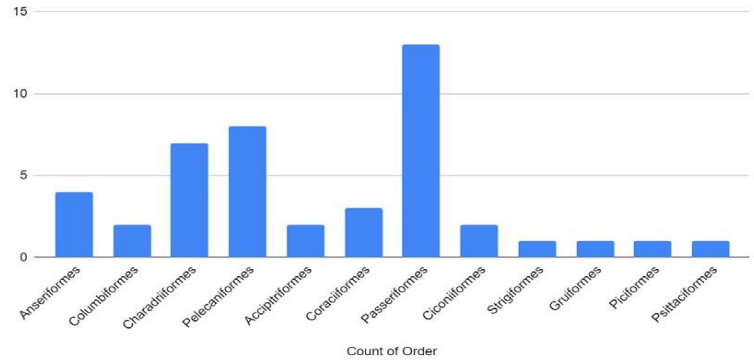


Fig. 2: Order wise species distribution (2018-19) at Ralawati Dam, Sendhwa

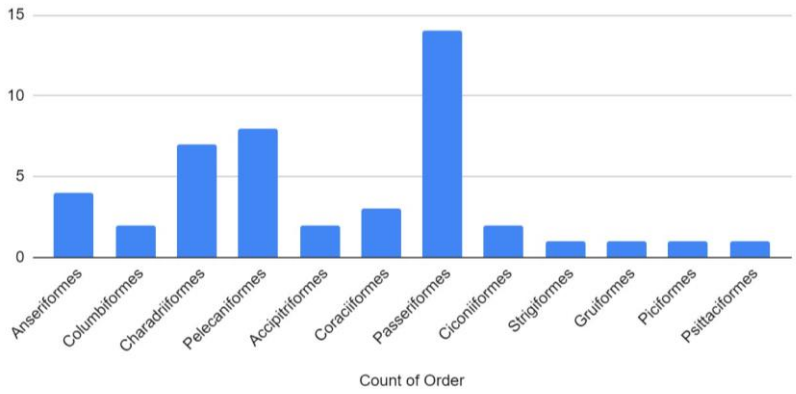


Fig. 3: Order wise species distribution (2019-20) at Ralawati Dam, Sendhwa

Checklist of birds based on diet:

2018-19: The percentage of at the Ralawati Dam, Sendhwa, insectivorous birds were 30% composition and omnivorous bird species were also 29% composition. in the present study area. Carnivorous birds' species were 25% and frugivorous species which depend on fruits as their food were 11% percent composition. The least contribution was seen by piscivorous bird species which is equal to 5% of the total bird diversity recorded at the study area 3.

2019-20: The percentage of at the Ralawati Dam, Sendhwa, insectivorous birds were 33% composition and omnivorous bird species were also 29% composition. in the present study area. Carnivorous birds' species were 24% and frugivorous species which depend on fruits as their food were 10% percent composition. The least contribution was seen by piscivorous bird species which is equal to 4% of the total bird diversity recorded at the study area.

Total species number

In 2018-19 the total species number was 537 and in 2019-20 the species number increased to 587.

Simpson index(d)

This is used to measure diversity of a study area. It is used for quantification of diversity. Its value lies between 0 to 1. In 2018-19 Simpson's index values at Ralawati Dam, Sendhwa was 0.1073612. In 2019-20 Simpson's index values at Ralawati Dam, Sendhwa was 0.0930164.

Simpson index of diversity

In 2018-19 value at Ralawati Dam, Sendhwa was 0.892638761 and in 2019-20, the value at Ralawati Dam, Sendhwa was 0.906983505.

Simpson reciprocal index

In 2018-19 the value at Ralawati Dam, Sendhwa was 9.3143485

In 2019-20 the value at Ralawati Dam, Sendhwa was 10.750781

Margalef index

This index is used to interpret two types of species richness values which is their evenness and dominance at that particular location.

In 2018-19 the value at Ralawati Dam, Sendhwa was 16.483671

In 2019-20 the value at Ralawati Dam, Sendhwa was 16.614666

Shannon index(h')

This index is a measure of diversity that combines species richness which is generally their relative abundance in that area.

In 2018-19 the value at Ralawati Dam, Sendhwa was 1.2174888

In 2019-20 the value at Ralawati Dam, Sendhwa was 1.2877480

Evenness index

This index shows how species of various birds are numerically distributed among that community.

In 2018-19 the value at Ralawati Dam, Sendhwa was 0.7364381

In 2019-20 the value at Ralawati Dam, Sendhwa was 0.774465

Discussion:

The results of our study show that in 2018-19, we observed at Ralawati Dam, Sendhwa, the species count was 45 and the total number of orders found here were 12. Kumar and Sahu (2019) reported 103 species of birds which belonged to 44 families and 15 orders at an agricultural landscape of Panipat Haryana. The checklist of all the species in 2019-20 shows that we have observed at Ralawati Dam, Sendhwa, the species count was 46 and the total number of orders found here were 12. Lodhi *et al.,* (2008) evaluated total species count at Ramauna Dam and recorded 391 individuals of all 28 species.

The Percentage composition of all the species at Ralawati Dam, Sendhwa (2018-19) is as follow: Accipitridae 4.4%, Alcedinidae 6.7%, Anatidae 8.9%, Ardeidae 17.8%, Charadriidae 4.4%, Ciconiidae 4.4% Cisticolidae 2.2%, Columbidae 4.4%, Corvidae 2.2%, Dicruridae 4.4%,

Estrildidae 2.2%, Hirundinidae 2.2%, Laridae 2.2%, Leiothrichidae 4.4%, Megalaimidae 2.2%, Psittaculidae 2.2%, Rallidae 2.2%, Recurvirostridae 2.2%, Rhipiduridae 4.4%, Scolopacidae 4.4%, Strigidae 2.2%, Sturnidae 6.7% and Turnicidae 2.2%. Adhikari *et al.*, (2019) recorded 19 bird species at Chitwan National Park and these species belonged to 9 families and 8 orders.

But at Ralawati Dam, Sendhwa (2019-20) percentage is as follow: Accipitridae 4.3%, Acrocephalidae 2.2%, Alcedinidae 6.5%, Anatidae 8.7% Ardeidae 17.4%, Charadriidae 4.3%, Ciconiidae 4.3%, Cisticolidae 2.2%, Columbidae 4.3%, Corvidae 2.2%, Dicruridae 4.3%, Estrildidae 2.2%, Hirundinidae 2.2%, Laridae 2.2%, Leiothrichidae 4.3%, Megalaimidae 2.2%, Psittaculidae 2.2%, Rallidae 2.2%, Recurvirostridae 2.2%, Rhipiduridae 4.3%, Scolopacidae 4.3%, Strigidae 2.2%, Sturnidae 6.5% and Turnicidae 2.2%.

Singh *et al.*, (2021) studied the Avian Diversity and habitat use of Sultanpur National Park, Haryana, India. The data indicated that 82 species were residents, whereas the remaining 29 seem to be either winter or summer migratory. Sultanpur National Park has 41 (36.9%) omnivore birds, 29 (26.1%) carnivorous birds, 24 (21.6%) insectivorous birds, 9 (8.1%) granivorous birds, 6 (5.4%) frugivorous birds, while 2 (1.8%) nectarivores birds.

The percentage of at Ralawati Dam is insectivorous birds were 30% composition and omnivorous bird species were also 29% composition. in the present study area. Carnivorous birds' species were 25% and frugivorous species which depend on fruits as their food were 11% percent composition. The least contribution was seen by piscivorous bird species which is equal to 5% of the total bird diversity.

In the year 2019-20, the percentage of at Ralawati Dam, insectivorous birds were 33% composition and omnivorous bird species were also 29% composition. in the present study area. Carnivorous birds' species were 24% and frugivorous species which depend on fruits as their food were 10% percent composition.

Family wise species distribution in 2018-19:

There were 12 groups at Ralawati Dam, Sendhwa of which Passeriformes order was the most dominant. In 2019-20, Ralawati Dam, Sendhwa, out of the 12 orders, Passeriformes was the most dominant one.

Results of Simpson index shows that in 2018-19, Ralawati Dam, Sendhwa: 0.107361. In 2019-20, Ralawati Dam, Sendhwa: 0.0930164. Adhikari *et al.*, (2019) estimated Simpson species dominance index was highest in Block A (0.248) and Block D (0.2431).

After evaluating Simpson index of Diversity in 2018-19, Ralawati Dam, Sendhwa: 0.892638761. In 2019-20, Ralawati Dam, Sendhwa it was 0.906983505.

Results of Simpson reciprocal index showed in year 2018-19, Ralawati Dam, Sendhwa value was 9.314348, In 2019-20, Ralawati Dam, Sendhwa value was 10.750781. The reason for such values can be Local species of an area migrate to other regions during the summer season in order to protect themselves from intense sunlight as there is a lack of permanent water source in the area. Also, during the summer season many trees that have dense foliage shed their leaves.

Factors like rainfall, humidity and temperature act as a vital role in disrupting and supporting bird populations annually. Therefore, the present study showed that with a slight change in temperature (seasonal) the birds' richness varied. There has been a reduction in population of wetlands birds because of lack of resources and dense presence of predators in the region.

Margalef Index is used to interpret two types of species richness values which is their evenness and dominance at that particular location. In 2018-19, value was 16.483671. In 2019-20, value was 16.614666. Menon and Mohanraj (2015) estimated species evenness at Southern city of India, their value was 0.65 ± 0.18. They also estimated the Simpson Diversity Index, Shannon Index and Margalef Index. The values were respectively 0.42,0.84 and 0.99.

Shannon index is a measure of diversity that combines species richness which is generally their relative abundance in that area. In 2018-19 value was 1.2174888. In 2019-20, value was 1.2877480.

Puppalwar and Telkhade (2017) studied Avifauna diversity around Moharli lake of Chandrapur. They observed 65 species in a period of one year by adopting traditional survey methods and they belonged to several residential categories like resident migrant etc.

Evenness Index shows how species of various birds are numerically distributed among that community. In 2018-19 value was 0.7364381. In 2019-20 Ralawati Dam, Sendhwa value was 0.774465.

Less avian fauna is found in summer and rainy season and highest avian diversity was observed in winter season, as there are ample food resources available for birds of different guilds. Lodhi *et al.,* (2017) studied the status of wetland birds at Tighra Reservoir Gwalior district Madhya Pradesh. They reported 56 wetland birds which belonged to 17 different families and 8 orders.

Joshi and Sharma (2012) calculated avian diversity in all four seasons the Tawa Reservoir using the Shannon Weiner Index (H'). They computed H'=1.33766 diversity in the summer period (S=56) and H'=1.33549 diversity in the winter season (S=58). Balapure *et al.,* (2012) employed other statistical techniques and found that species richness was highest at station 4 (S=6.14), while Shannon Weiner Index was H'= 2.554 (Highest) at Station 4. They also established Jaccard’s resemblance group on the basis of monitoring of the bird region's population, Margalef’s abundance and diversity and Simpson’s Index was estimated.

Conclusion:

Bird species checklist: Total number of species in 2018-19 data shows that at Ralawati Dam, Sendhwa, 45 species were counted and they belonged to 12 orders. In 2019-20 data showed that in Ralawati Dam, Sendhwa, the species count was 46 and the total number of orders found here were 12. Order wise species composition at the sites: In the year 2018-19, There were 12 groups at Ralawati Dam, Sendhwa of which Passeriformes order was the most dominant. Strigiformes, Gruiformes, Piciformes and Psittaciformes were the least dominant group.

Order wise species distribution in 2019-20: At Ralawati Dam, Sendhwa, out of the 12 orders, Passeriformes was the most dominant one. The least dominant of them were Strigiformes, Gruiformes, Piciformes and Psittaciformes. Relative Diversity at the sites concludes that: The Percentage composition of all the species at Ralawati Dam, Sendhwa (2018-19) showed that family Ardeidae 17.8% was dominant in this study location. In 2019-20: The Percentage composition of all the species at Ralawati Dam, Sendhwa (2019-20) showed that Ardeidae 17.4%was dominant.

Checklist of birds based on diet: In 2018-19: - The percentage of at Ralawati Dam, Insectivorous birds were 30% composition and the least contribution was seen by Piscivorous bird species which is equal to 5% of the total bird diversity recorded at the study area 3. 2019-20: - The percentage of at the study area number 3, insectivorous birds were 33% composition and the least contribution was seen by piscivorous bird species which is equal to 4% of the total bird diversity recorded at Ralawati Dam. At Ralawati Dam, Sendhwa, the highest percentage of Carnivore was observed.

Species Richness: Ralawati Dam, Sendhwa: 45. In 2019-20, Ralawati Dam, Sendhwa: 46. Simpson index(D): In 2018-19, Ralawati Dam, Sendhwa: 0.1073612 In 2019-20, Ralawati Dam, Sendhwa: 0.0930164.

Simpson index of diversity: In 2018-19; Ralawati Dam, Sendhwa: 0.892638761. In 2019-20, Ralawati Dam, Sendhwa: 0.906983505. Simpson reciprocal index: In 2018-19, Ralawati Dam, Sendhwa: 9.3143485, in 2019-20, Ralawati Dam, Sendhwa: 10.750781. Margalef Index: This index is used to interpret two types of species richness values which is their evenness and dominance at that particular location. In 2018-19, Ralawati Dam, Sendhwa:16.483671. In 2019-20, Ralawati Dam, Sendhwa: 16.614666. Shannon index (H'): This index is a measure of diversity that combines species richness which is generally their relative abundance in that area. In 2018-19, Ralawati Dam, Sendhwa: 1.2174888. In 2019-20, Ralawati Dam, Sendhwa: 1.2877480. Evenness Index: This index shows how species of various birds are numerically distributed among that community. In 2018-19, Ralawati Dam, Sendhwa:0.7364381. In 2019-20, Ralawati Dam, Sendhwa: 0.7744651. The present study highlights the importance of water bodies in cities. These areas are species-rich and require regular monitoring and development to increase its existing biodiversity.

Photographs of birds

Indian Paradise-flycatcher
Terpsiphone paradisi

House Crow
Corvus splendens

Green Warbler
Phylloscopus nitidus

Indian Robin
Copsychus fulicatus

Little Forktail
Enicurus scouleri

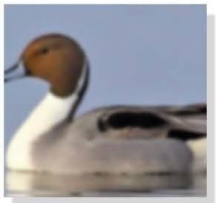
Taiga Flycatcher
Ficedula albicilla

Pied Bushchat
Saxicola caprata

Brown Rock Chat
Oenanthe fusca

House Sparrow
Passer domesticus

Citrine Wagtail
Motacilla citreola



Northern Pintail
Anas acuta

Common Teal
Anas crecca

Red Munia
Amandava amandava

Cattle Egret
Bubulcus ibis

Striated Heron
Butorides striata

Black-crowned Night Heron
Nycticorax nycticorax

Common Kingfisher
Alcedo atthis

Pied Kingfisher
Ceryle rudis

Coppersmith Barbet
Psilopogon haemacephalus

Ashy Drongo
Dicrurus leucophaeus

Blue-tailed Bee-eater
Merops philippinus

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EXPLORING EARTH'S AQUATIC BIOMES

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Aquatic biomes:

1. Marine biome: The marine biome is the largest and most diverse biome on Earth, covering about 71% of the planet's surface. It includes all the bodies of saltwater that make up the world's oceans and seas. The marine biome is incredibly varied, containing a wide range of ecosystems, from the shallowest coastal waters to the deepest parts of the ocean.

Some aspects of Marine Biome:

- **Saltwater environment:** The defining characteristic of the marine biome is the presence of saltwater, which contains dissolved salts and minerals. This saltwater provides a unique environment for marine organisms, and the composition of the water can vary in different parts of the ocean.
- **Diverse ecosystems:** The marine biome encompasses a multitude of ecosystems, including coral reefs, kelp forests, intertidal zones, open ocean, deep-sea hydrothermal vents, and more. Each of these ecosystems has its own set of environmental conditions and species adapted to them.
- **Abundant life:** Marine biomes support an incredibly diverse array of life forms. They are home to an estimated 80% of all known species on Earth. From the tiniest plankton to the largest whales, marine organisms have evolved to thrive in this watery environment.

  Primary producers: Phytoplankton, microscopic photosynthetic organisms, are the primary producers in the marine biome. They form the basis of the marine food web, providing energy for many other organisms through photosynthesis.
- **Ocean currents:** Ocean currents play a crucial role in the marine biome. They transport heat, nutrients, and organisms throughout the world's oceans, influencing both climate and the distribution of marine life.
- **Challenges:** The marine biome faces a range of challenges, including overfishing, pollution (such as plastic pollution and oil spills), habitat destruction, and climate change.

These threats can have devastating effects on marine ecosystems and biodiversity.

- **Conservation:** Conservation efforts are critical to protect the marine biome and its inhabitants. Marine protected areas, sustainable fishing practices, and efforts to reduce pollution and combat climate change are among the strategies employed to safeguard the health of the oceans.
- **Human dependence:** Humans rely on the marine biome for a variety of resources, including seafood, transportation, recreation, and even pharmaceuticals derived from

marine organisms. Sustainable management is essential to ensure the continued availability of these resources.

2. Freshwater biome: A freshwater biome is a type of aquatic ecosystem characterized by low salt concentrations. These biomes include various bodies of freshwater such as rivers, lakes, ponds, streams, and wetlands. Freshwater biomes are essential for sustaining life on Earth and are home to a wide variety of plants and animals.

Some aspects of Freshwater biome:

Water source: Freshwater biomes are primarily characterized by their low salt concentration, typically less than 1%. The primary source of water in these biomes is usually precipitation, which can fill and replenish lakes, rivers, and other freshwater bodies.

- **Temperature variation:** Water temperature in freshwater biomes can vary widely depending on the region, time of year, and depth of the water body. Shallow areas tend to have more temperature fluctuations than deep areas.

  Plant life: Freshwater biomes support a diverse range of aquatic plants, including submerged, floating, and emergent species. Common examples include water lilies, cattails, and various species of algae.
- **Animal life:** These biomes are home to a wide variety of animal species, including fish, amphibians, reptiles, insects, and mammals. Fish are particularly abundant in freshwater ecosystems, with numerous species adapted to different water conditions.
- **Nutrient cycling:** Freshwater ecosystems play a crucial role in nutrient cycling. They can act as filters, removing pollutants and excess nutrients from the water, which helps maintain water quality and benefits downstream ecosystems.
- **Human impact:** Freshwater biomes are under threat due to human activities. Pollution, habitat destruction, overfishing, and the introduction of invasive species are some of the major challenges facing these ecosystems.
- **Wetlands:** Wetlands are a vital component of freshwater biomes. They serve as transitional zones between terrestrial and aquatic ecosystems and provide essential habitat for various plants and animals. Wetlands also help regulate water flow and reduce flooding.
- **Threats and conservation:** Conservation efforts are essential to protect and preserve freshwater biomes. Measures include reducing pollution, conserving water resources, protecting wetlands, and establishing protected areas.
- **Unique ecosystems:** Different types of freshwater biomes exist, each with its own unique characteristics. For example, the ecosystems found in a slow-moving river are distinct from those in a fast-flowing stream or a stagnant pond.

3. Coral reefs: Coral reefs are unique and diverse marine ecosystems often referred to as the "rainforests of the sea" due to their incredible biodiversity and vibrant, colorful appearance. These biomes are found in warm, shallow waters, typically in tropical and subtropical regions, where conditions are optimal for coral growth.

Some aspects of Coral reefs:

- **Biodiversity:** Coral reefs are among the most biologically diverse ecosystems on the planet, providing habitat for a wide range of marine life. They are home to thousands of species of fish, invertebrates, corals, sponges, molluscs, and many other organisms.

  Coral polyps: Coral reefs are primarily built by tiny, soft-bodied organisms called coral polyps. These organisms secrete calcium carbonate, which forms hard, limestone-like structures known as coral colonies. Over time, these colonies grow and create the complex reef structures we see.
- **Symbiotic relationships:** Coral polyps have a symbiotic relationship with photosynthetic algae called zooxanthellae. The algae live within the coral tissues and provide the corals with nutrients through photosynthesis. In return, the corals offer protection and access to sunlight to the algae.
- **Coral bleaching:** Coral reefs are highly sensitive to changes in water temperature and quality. When water temperatures rise or become polluted, corals may expel their zooxanthellae, causing the corals to lose their vibrant colors and potentially die. This phenomenon is known as coral bleaching and is a significant threat to reef health.
- **Structure and diversity:** Coral reefs come in various forms, including fringing reefs (near the coast), barrier reefs (separated from the shore by a lagoon), and atolls (ring-shaped reefs surrounding a central lagoon). Each type has its own unique structure and species composition.
- **Nutrient cycling:** Coral reefs play a vital role in nutrient cycling and the overall health of marine ecosystems. They filter and recycle nutrients in the water, benefiting nearby coastal ecosystems such as seagrass beds and mangroves.
- **Human impact:** Coral reefs face numerous threats from human activities, including overfishing, coastal development, pollution, and climate change. These threats can disrupt the delicate balance of these ecosystems and lead to coral degradation and loss.
- **Conservation:** Conservation efforts are critical to protect and preserve coral reefs. Strategies include establishing marine protected areas, regulating fishing practices, reducing pollution, and mitigating climate change through global efforts to reduce greenhouse gas emissions.

4. Estuaries: Estuaries are unique and dynamic ecosystems that occur at the interface between freshwater and saltwater. These transitional environments are typically found in coastal areas where rivers and streams meet the ocean. Estuaries are characterized by a combination of both marine and freshwater influences, creating a highly productive and biologically diverse biome.

Some aspects of Estuaries:

- **Mix of saltwater and freshwater:** Estuaries are known for the mixing of saltwater from the ocean and freshwater from rivers, streams, and creeks. This mixing creates a range of salinity levels, which can vary with tides, weather conditions, and freshwater inflow.

- **Nutrient-rich:** Estuaries are highly productive ecosystems due to the influx of nutrients from upstream sources. As freshwater flows into the estuary, it carries nutrients like nitrogen and phosphorus, which support the growth of algae and other primary producers.
- **Biodiversity:** Estuaries are home to a diverse array of species, making them some of the most biologically rich ecosystems on Earth. Many species of fish, birds, invertebrates, and plants are adapted to the varying salinity levels and abundant food resources found in estuaries.
- **Nursery grounds:** Estuaries serve as essential nursery grounds for many commercially and recreationally important fish and shellfish species. The protected, nutrient-rich waters provide a safe environment for juvenile fish and other aquatic organisms to grow and develop.
- **Sediment accumulation:** The slow-moving waters of estuaries allow sediment to settle out of the water, creating muddy or sandy substrates. These sediments provide habitat for burrowing organisms like clams, worms, and crustaceans.
- **Salt marshes:** Some estuaries contain salt marshes, which are vegetated wetlands that can tolerate saltwater. Salt marshes provide habitat for various species, help stabilize shorelines, and filter pollutants from the water.
- **Human impact:** Estuaries are threatened by human activities such as coastal development, pollution from runoff and industrial sources, overfishing, and climate change. These stressors can disrupt the delicate balance of estuarine ecosystems.
- **Conservation and restoration:** Conservation efforts are vital to protect and restore estuaries. Strategies include establishing protected areas, implementing water quality regulations, and restoring degraded habitats. Healthy estuaries are not only important for biodiversity but also for the many ecosystem services they provide, including water filtration, shoreline protection, and recreational opportunities.

5. Mangroves: Mangroves are unique and highly specialized ecosystems found along coastlines in tropical and subtropical regions. These biomes consist of salt-tolerant trees, shrubs, palms, and other vegetation that are adapted to survive in the challenging and dynamic conditions of brackish or saline water.

Some aspects of Mangroves

- **Salt-tolerant vegetation:** Mangrove trees and plants have adapted to thrive in high salinity environments. They have specialized mechanisms to filter out salt and excrete it through their leaves or roots, making them capable of growing in areas with fluctuating water salinity.
- **Unique root systems:** Mangrove trees have complex root systems that help anchor them in the soft, muddy soils of coastal areas. These roots can also trap sediment and organic matter, stabilizing coastlines and preventing erosion.

- **Biodiversity:** Mangroves support a diverse range of species, including fish, crabs, mollusks, birds, and insects. Many commercially important fish and crustacean species use mangroves as breeding and nursery grounds.
- **Coastal protection:** The dense network of mangrove roots and vegetation serves as a natural barrier that helps protect coastlines from erosion, storm surges, and tsunamis. They act as a buffer between land and the sea, reducing the impact of waves and floods.
- **Water quality improvement:** Mangroves filter and purify water as it flows through their root systems, removing pollutants and excess nutrients. This improves water quality and benefits both marine life and nearby communities.
- **Human uses:** Mangrove ecosystems are valuable to local communities and economies. They provide resources such as timber, honey, and traditional medicines. Additionally, mangroves support tourism and recreational activities, including birdwatching and kayaking.
- **Threats:** Mangrove ecosystems are threatened by human activities, including deforestation for urban development, aquaculture, and agriculture, as well as pollution and overharvesting. Climate change and rising sea levels also pose a significant threat to these coastal habitats.
- **Conservation:** Conservation efforts are essential to protect and restore mangrove ecosystems. Strategies include the establishment of protected areas, sustainable harvesting practices, and community-based management approaches.

6. Kelp forests: Kelp forests are underwater ecosystems characterized by large, brown algae known as kelp. These forests are found in cold, nutrient-rich coastal waters, typically in temperate and subarctic regions around the world. Kelp forests are some of the most productive and ecologically important marine biomes.

Some aspects of Kelp Forest:

- **Kelp dominance:** The defining feature of kelp forests is the dominance of various species of kelp, particularly giant kelp (Macrocystis spp.). These large, brown algae can grow rapidly and form dense underwater forests that extend from the seafloor to the ocean's surface.
- **Biodiversity:** Kelp forests support a diverse array of species, including fish, invertebrates, sea otters, seals, sea lions, and numerous bird species. Many species are specially adapted to life within the kelp, using it for food and shelter.
- **Complex habitat:** The intricate structure of kelp provides shelter and refuge for various marine organisms. Fish, in particular, use the kelp as a nursery habitat for their young. The dense kelp canopy also helps protect organisms from predators.
- **Nutrient cycling:** Kelp forests play a crucial role in nutrient cycling within marine ecosystems. The growth and subsequent shedding of kelp fronds contribute nutrients to the water, benefiting other marine life and supporting productive food webs.

- **Threats:** Kelp forests face various threats, including warming ocean temperatures, ocean acidification, pollution, and invasive species. Climate change can disrupt the balance of these ecosystems, potentially leading to shifts in species composition and ecosystem health.
- **Harvesting:** Kelp is harvested for various purposes, including food, cosmetics, and biofuel production. Sustainable harvesting practices are essential to ensure the long-term health of kelp forests involve establishing marine protected areas, implementing sustainable management practices, and monitoring the health of these ecosystems.
- **Climate change impact:** Climate change can affect kelp forests in multiple ways. Warming waters can lead to declines in kelp abundance, while ocean acidification can affect the growth and survival of kelp. Additionally, changes in ocean currents can influence nutrient delivery to kelp forests.

7. Deep Sea: The deep-sea biome refers to the vast and largely unexplored regions of the world's oceans that exist in deep, dark, and extreme conditions. This biome comprises the oceanic zone, typically starting at depths of around 200 meters (656 feet) and extending to the ocean floor, which can reach depths of over 10,000 meters (32,800 feet). The deep-sea biome is one of the most mysterious and least understood ecosystems on Earth.

Some aspects of deep sea:

- **Extreme pressure**: As you descend into the deep sea, water pressure increases significantly due to the weight of the overlying water. At the deepest parts of the ocean, pressure can be over 1,000 times greater than at the surface.
- **Cold and dark:** Sunlight does not penetrate to the depths of the deep sea, resulting in perpetual darkness and very cold temperatures. The temperature typically ranges from just above freezing to a few degrees Celsius.
- **Biodiversity:** Contrary to popular belief, the deep sea is not a barren wasteland. It is home to a surprising diversity of life forms, many of which are specially adapted to the extreme conditions. This includes deep-sea fish, giant squid, and a wide variety of invertebrates such as deep-sea corals, sponges, and sea cucumbers.
- **Bioluminescence:** Many deep-sea organisms have evolved the ability to produce their own light through a process called bioluminescence. This adaptation is used for camouflage, communication, attracting prey, or deterring predators in the pitch-black environment.
- **Unique adaptations:** Deep-sea organisms have developed various adaptations to survive in this harsh environment, including pressure-resistant bodies, slow metabolism, and special feeding mechanisms.
- **Hydrothermal vents:** One of the most remarkable features of the deep sea is the presence of hydrothermal vents. These are fissures on the ocean floor where superheated water rich in minerals gushes out. They support unique ecosystems of extremophiles

(organisms adapted to extreme conditions), including giant tube worms and chemosynthetic bacteria.

- **Cold seeps:** Similar to hydrothermal vents, cold seeps are areas where methane and other hydrocarbons seep out of the ocean floor. Cold seep ecosystems support a variety of unique and specialized organisms.
- **Deep-sea mining:** Human activities, such as deep-sea mining for minerals like polymetallic nodules, manganese, and rare earth elements, pose a threat to the deep-sea biome. These activities can disrupt deep-sea ecosystems and affect the organisms that call this environment home.
- **Research challenges:** The exploration and study of the deep-sea biome are challenging due to the extreme conditions and technological limitations. However, advances in deep-sea submersibles, remotely operated vehicles (ROVs), and autonomous underwater vehicles (AUVs) have allowed scientists to make significant discoveries in recent years.
- **Conservation:** Conservation efforts for the deep sea are focused on protecting vulnerable ecosystems like hydrothermal vents and cold seeps, as well as regulating deep-sea mining and other potentially harmful activities to minimize their impact on this fragile and unique biome.

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AN OVERVIEW OF PROTEINS

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Abstract:

Proteins are complex, organic compounds composed of many amino acids linked. Together through peptide bonds and cross – linked between chains by sulfhydryl bonds, hydrogen bonds and van der waals forces. There is a great diversity of chemical composition in proteins than in any other group of biologically active compounds.

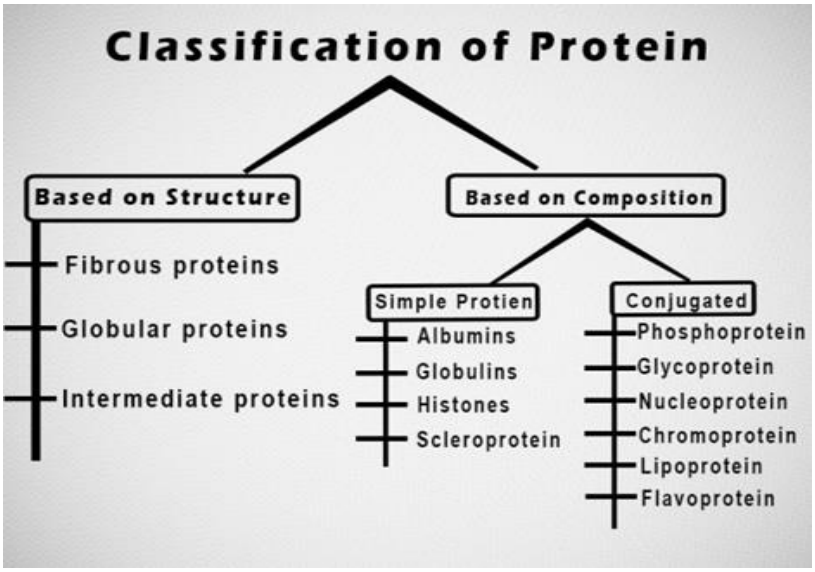
Keywords: Protein, classification, properties, mechanism, structure, function.

Introduction:

Proteins are known as the building blocks of life because they are the most abundant molecules present in the body and form about 60% of the dry weight of cells. They make up the majority of the cells in all living things. Aside form cells, proteins make up the majority of the body's structural, regulatory and enzyme components They are therefore crucial for an individual's growth and development. Food like eggs, pulses, milk and other milk products form the major high – protein food for the body.

Classification of proteins:

Like carbohydrates and lipids, proteins could not be classified only on the basis of structural similarities. Because protein molecules possessses great structural complexities.



1) **Fibrous:**
   Elongated proteins, eg. Silk, fibroin, keratin etc.
2) **Globular:**
   Spherical, compact proteins, eg. Egg albumin, casein and most enzymes.

- Fibrous proteins tend to be insoluble in water and other solvents, whereas globular proteins are soluble in water and in solution of salt and water.

Nowdays, there are two alternative methods of protein classification:

1) According to the composition of the protein and.
2) According to the function of the protein.

1) Classification according to the composition

In this process, proteins are classified into two groups.

a) Simple proteins and
b) Conjugated proteins.

a) Simple proteins:

- A simple prteins is composed of only α- amino acids, thus, produces exclusively α-amino acids upon hydrolysis.
- These proteins are further subdivided according to their solubility.
- According to their soluility in various solvent. Different simple proteins are-

1) Albumin:
   - These are soluble in water and in dilute salt solutions.
   - Albumins constitute the most important and the most common group of simple proteins.
   - These are present in egg white (egg albumin) and in blood (serum albumin).
2) Globulins:
   - These are insoluble in water but are soluble in dilute salt solutions.
   - They are widely distributed group of simple proteins.
   - They are present as antibodies in blood serum and as blood fibrinogen.
3) Histones:
   - They are soluble in water and insoluble in dilute ammonium hydroxide.
   - Histones contain a high proportion of basic amino acids clysine or arginine.
   - These are found in association with nucleic acid in the nucleoprotein of the cell.
4) Scleroproteins (albuminoids):
   - These are chracterised by their insolubility in water and other solvents.
   - Scleroproteins have structural and protective functions in the body.
   - The examples of scleroproteins are keratin (Present in hair, skin and nails), collagen (present in bone, tendon and cartilage) and elastin (elastic fibers of connective tissues)

b) Conjugated proteins:

- These are formed of α- amino acids and a non – protein materials.
- The non – proteins materials of the conjugated protein is called prosthetic group.
- Different types of conjugated proteins are subdivided on the basis of their prosthetic group.
- Different conjugated proteins are follows.

1) Phosphoproteins:
   - These are compound of α- amino acids and phosphoric acids so, their prostheitic group is phosphoric acid.
   - Caesin, present in milk, is an important member of this group.
2) Glycoproteins:
   - They contain a carbohydrate or a carbohydrate derivative as prosthetic group. Mucin, a consitituent of saliva, is a glycoprotein.
3) Chromo – proteins:
   - Their prosphetic group is a pigment compound.
   - Example: Haemoglobin
   - Its possesses the iron – containing pigment haemeco – ordinated to the simple protein globin.
4) Necleoproteins:
   - Here prosthetic groups are complex polymers of high molar masses and are called nucleic acids (DNA and RNA)
   - Nucleo – proteins are present in all the cells of plants and animals.
5) Lipoproteins:
   - They consist of cholesterol esters and phospholipids attached to the protein molecules.
   - They are frequently classified as compound lipids.
   - Most of the lipid in mammalian blood is transported in the form of lipoprotein complexes.
   - The electron transport system in the mitochondria contains large amount of lipoproteins.
   - These are also found in egg yolk, myelin sheath of nerves and different cell organelles.

Classification on the basis of functions.:

Proteins are classified into six groups on the basis of their functions.

Classification of proteins according to their biological functions

Class	Functions	Examples
1. Transport Proteins	Transport of oxygen, glucose and other nutrients	Haemoglobin, Lipoproteins
2.Nutrient and storage Proteins	Store proteins required for the growth of embryo	Gliadin (wheat) Ovalbumin (egg) Casein (milk)
3. Structural Proteins	Give biological structures, strength or protection	Keratin (Hair, nails, etc.) Collagen (cartilage)
4. Defence Proteins	Defend organisms against invasion by other species	Antibodies Snake venoms
5. Enzymes	Act as catalysts in biochemical reactions	Trypsin, Pepsin
6. Regulatory Proteins	Regulate cellular or physiological activity	Insulin

A) Structural Proteins:

- These proteins participate in the formation of different body parts. More than half of the total proteins of the mammalian body is collagen found in skin, cartilage and bone.

B) Contractile proteins:

- These special types of proteins are responsible for the contraction and relaxation of muscle cells, e.g, actin and myosin.
- These proteins are also present in the unicellular animals.

C) Enzymes:

- They represent the largest class of proteins. Nearly 2,000 different kinds of enzymes are known.
- The enzymes are called biological catalyst and are vital for any activity in the living organism.

D) Hormones:

- Many of the hormones are protein in nature, e.g insulin
- Some other hormones are steroid.

E) Antibodies:

- Higher organisms (Birds, mammals produce antibodies to destroy any foreign material (antigen) released into the body by an infectious agent.
- Gamma globulins are example of antibodies in mammals.

F) Blood proteins:

The albumins, globulins and fibrinogen are the three major protein constituents of blood.

Properties of proteins.:

1) Solubility in Water:

- The relationship of proteins with water is complex.
- The secondary structure of proteins depends largely on the interaction of peptide bonds with water through hydrogen bonds.
- Hydrogen bonds are also formed between protein (alpha and beta structures) and water.
- The proteins rich static ball is more soluble than the helical structures.
- At the tertiary structure, water causes the orientation of the chains and hydrophilic radicals to the outside of the molecule, while the hydrophobic chains and radicals tend to react with each other within the molecule. (hydrophobic effect).

2) Denaturation and Renaturation:

- Proteins can be denatured by agenst such as heat and urea that cause the unfolding of polypeptide chains without causing hydrolysis of peptide bonds. The denaturing agents destroy secondary and tertiary structures, without affecting the primary structure.
- If a denatured protein returns to its native state after the denaturing agent is removed, the process is called renaturation.
- Some of the denaturing agents include.
- Physical agents: Heat, radiation PH.

- Chemical agents: urea solution which forms new hydrogen bonds in the proteins, organic solvents detergents.

Coagulation:

- When proteins are denatured by heat, they form insoluble aggregates known as coagulum.
- All the proteins are not heat coagulable, only a few like the albumins, globulins are heat coagulable.

Isoelectric point:

- The isolelectric point is the PH at which the number of positive charges equals the number of negative charges, and overall charge on amino acid is zero
- At this point, when subjected to an electric field the proteins do not move either towards anode or cathode, hence this property is used to isolate proteins.

Molecular weights of proteins.:

- The average molecular weight of an amino acid is 110.
- The total number of amino acids in a protein multiplied by 110 gives the approximate molecular weight of that protein.
- Different proteins have different amino acid compositions and hence their molecular weights differ the molecular weights of proteins range from 5000 to 109 Daltons.

Chemical properties of proteins:

1) **Biuret Test:**

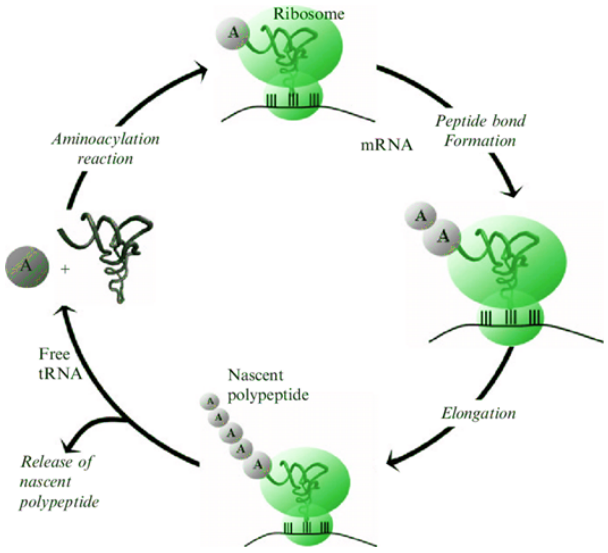
When 2ml of test solution is added to an equal volume of 10% NaoH and one drop of 10% CuSo4 solution, a violet colour formation indicates the presence of peptide linkage.

2) **Ninhydrin test:**

When 1 ml of Ninhydrin solution is added to 1ml proteins solution and heated, the formation of a violet color indicates the presence of α-amino acids.

Mechanism of protein:

The process of transcription and translation has some similarities and differences between eukaryoties and prokaryotes.



Transcription:

- Transcription begins in the nucleus with the formation of the preinitiation complex. First transcription II D (TFIID) binds to the TATA box through the TATA-binding protein (TBP) Then five other transcription factors (TFIIA, TFIIB, TFIIE, TFIIF, And TFIIH) along with RNA polymerase II, combine through a series of stages to from the pre – initiation complex.
- Specifically, TFIIH has a role in nucleotide excision repair and separating the opposing strands of double – stranded DNA. This strand is read by RNA polymerase in the 3' – 5' direction and is transcribed in the 5'-3' direction.
- During this process, RNA pol II attaches complementary base pairs to the template strand Adenine on the DNA strand is paired with thymine, guanine is paired with cytosine and cytosine is paired with guanine However, whenever this enzyme reaches a thymine base pair on the DNA strand, it substitutes the original adenine complement base pair with a uracil base instead.

Splicing and pre-mRNA modifications:

- Splicing occurs within the nucleus; several steps are catalyzed by large (60s) molecules called spliceosomes composed of small ribonucleoproteins (snRNPs) and splicing factors.
- These enzymes excise the introns out of the mRNA transcript while leaving exons in the transcript alone.
- Spliceosomes shuffle around these exons, depending on the type of protein that needs to be synthesized.
- After splicing the 5' abd 3' tails are modified to help the translation process.

Translation

- Translation of mRNA normally occurs in the cytoplasm or the rough endoplasmic reticulum. However it can happen in any compartment of the cell that has ribosomes.
- The process of initiating eukaryotic translation begins with the formation of the 80s initiation complex.
- The eukaryotic initiation factor 4F (elF4F) protein complex initially recognizes the 5' – cap structure of mRNA molecule.

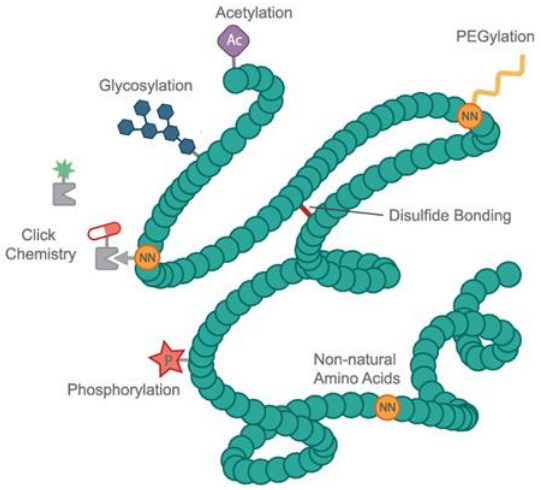
Post Translational Modifications

- These types of modifications can occurs during any step of the proteins life some modifications occurs right after transcription, while other modifications occur after protein folding by chaperones. Below is a list of some modifications that can be added to the side chains of amino acids in polypeptide chain.
    1) Glycosylation – attachment of a carbohydrate group through N – glycosidic or O – glycosidic bonds
    2) Acetylation – Attachment of acetyl groups (-COCH3)
    3) Methylation – attachment of methyl groups (-CH3)
    4) Carboxylation – attachment of carboxylic acid groups (-COOH).
    5) Hydroxylation – attachment of hydroxyl groups (-OH)

6) Phosphorylation – attachment of phosphate residues (-OPO2)

Protein Modifications:

Proteins can be glycosylated (glycoproteins) or associated with lipids (lipoproteins)



1) Glycoproteins:

- Glycoproteins have attached carbohydrate moleuces (residues)
- Carbohudrate residues are added to the protein structure and modified during and following protein synthesis.
- There are many different carbohydrate sequences found in glycoproteins, many of which have functional consequences,
- In general, most proteins that are secreted from cells are glycosylated.
- Most of the proteins in serum are glycosylated as are the proteins found in saliva and the digestive juices of the gastrointestinal tract.

Carbohydrates:

- Have many hydroxyl (-OH) groups that bind to water molecules, and thus increase stability.
- Thus the glycoproteins of saliva tend to lubricate the food chewed, in part to allow easier swallowing of food and its passage through the esophagus.
- The glycoproteins secreted – in the stomach protect the lining of the organ from its acidic environment.
- This protective role of carbohydrates is also apparent for the serum glycoproteins.

Structure of proteins:

Structure of proteins can be divided into four levels.

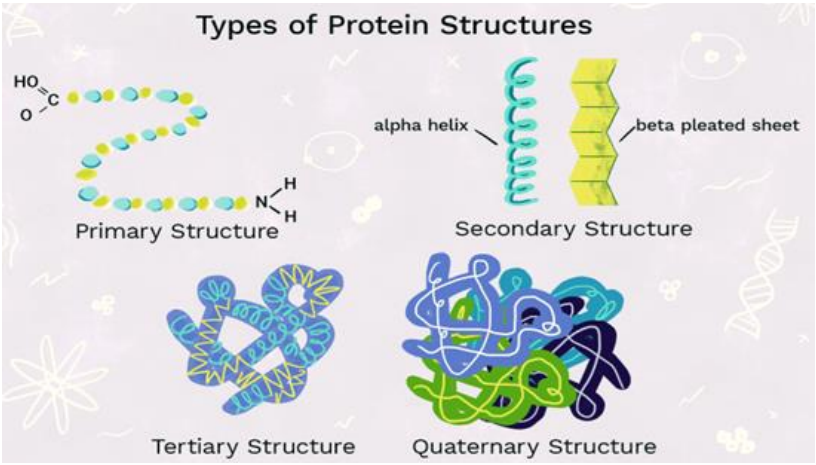
1) Primary structure:

- The primary structure of a proteins consists of the amino acid sequence along the plypetide chain.
- Amino acids are joined by peptide bonds
- Because there are no dissociable protons in peptide bonds, the charges on a polypeptide chain are due only to the N – terminal amino group, the C-terminal carboxyl group, and the side chains on amino acid residues.

- Primary structure determines the further levels of organization of protein molecules.

2) Secondary Stricture:

- The secondary structure incudes various types of local conformations in which the atoms of the side chains are not involved
- Secondary structures are formed by a regularly alpha – helix and beta pleated sheets.
- Example: Myglobin
- There are some types of secondary structure.
- Alpha Helix.
- Beta plated sheet.
- Strand.
- Loops.



Tertiary Structure:

- The tertiary structure of proteins is in the form of a 3 Dimentional structure of the monomeric and multimeric structure.
- Three dimetnsion structure of a polypeptide is simply called the tertiary structure of the protein.
- This tertiary structure is because of the lowest energy and greatest stability state of the polypeptide chain. The tertiary structure come from folding secondary structure of the proteins.

Functions of Tertiary structure:

It has a unique function like interacting with other molecules.

Quaternary Structure:

- The quaternary structure of protein is in the form of a 3 Dimensional structure of macromolecules which is a combination of individual polypeptide chains.
- This Quaternary structure is also formed a special combination of tertiary structures.
- Quaternary structure is also known as oligometric proteins
- Example: Hemoglobin.
- Functions of quaternary structure
- It helps in the chromosome replication process.

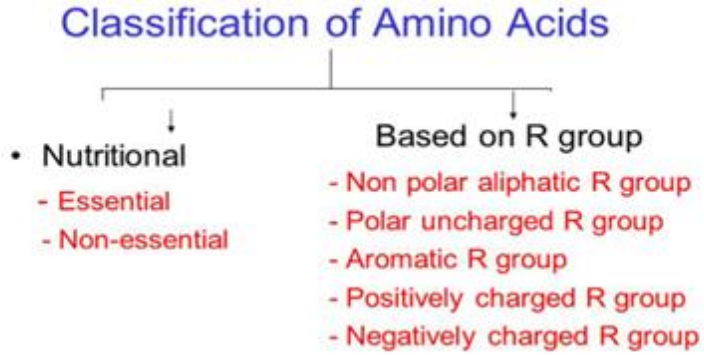
- It helps in metabolism.

Importance

- Protein helps in maintaining good shape and ift for our body protein repairs the body's damaged tissues.
- Protein is used to build bones, skin and muscles.
- The basic unit of protein – amino acids.
- Amino acids are the basic structural unit of protein.
- Amino acids consist of the carbon atom, a carboxyl group (COOH), and Hydrogen atom.

Amino acids are classified as follows

1) Aromatic: Tyrosine, Tryptophan phenylalanine.
2) Positively charged: Lysine, Arginine, Histidine.
3) Negatively Charged: Aspartate, Glutamate.
4) Nonpolar: aliphatic: Leucine, Methionine, Isoleucine.



Fucntions

Enzymatic Protein

The functions of enzymatic protein

1) It accelerates the metabolic process in our cells.
2) It also accelerates the metabolic process in stomach digestion, liver functions and blood clotting.

Hormonal protein:

The function of hormonal protein.

- Hormonal proteins are protein – based chemicals secreted by endocrine glands.
- By using hormonal proteins each hormone affects particular cells in the body.

Structural protein:

- The function of structural protein structural proteins are very important for the body because they are fibrous proteins.
- It helps in developing muscles, bones, skin and cartilage.

Defensive protein:

- The function of defensive protein
- These defensive proteins help in developing antibodies for attacking
- These antibodies are developed in white blood cells to attack bacteria.

Storage protein:

The function of storage protein

- Storage protein stores minerals like potassium.
- Storage protein contains ovalbumin and casein found in milk and egg whites.

Transport protein:

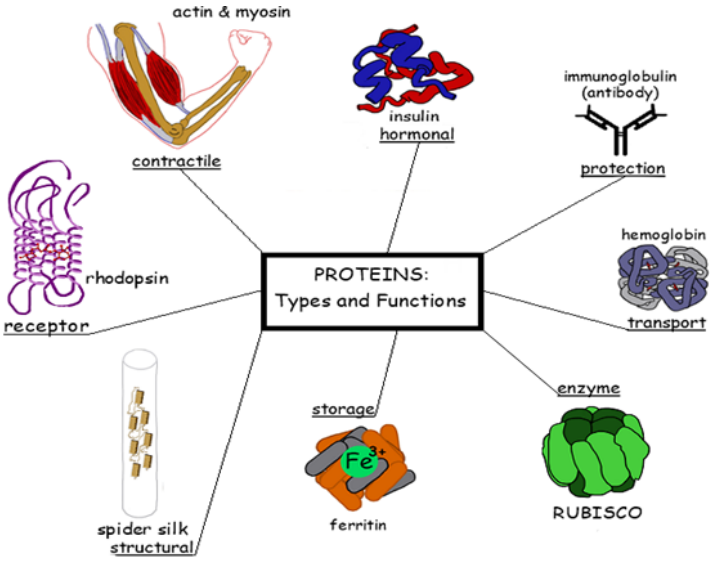
- The function of transport protein
- Transport protein called calbindin which is useful for absorption of calcium from intestinal wall
- Transport proteins carry important materials to the cells of the body.

Receptor protein:

It controls the substances which enter and leave the cells.

Contractile protein:

The function of contractile protein. It helps in regulating the strength, speed of the heart, and muscle contractions. Contractile proteins cause heart complications of the heart produces severe contractions.



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ANTIFUNGAL ACTIVITY OF *CLERODENDRUM INFORTUNATUM* EXTRACT

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Abstract:

Clerodendrum infortunatum (*C. infortunatum*), a perennial shrub, popularly known as hill glory bower or the bhat, belongs to the Lamiaceae family. It has been used in a variety of ways in Ayurveda, the Unani medical system, and homeopathy to treat conditions like diarrhea, skin conditions, venereal and scrofulous complaints, wounds, postnatal complications, as a vermifuge, laxative, and cholagogue, to get rid of ascarids in anus, as external applications on tumors, etc. (Bhattacharjee *et al.*, 2011). This chapter describes the efficacy and prospective uses of an extract of the fungus-fighting plant *Clerodendrum infortunatum*. An overview of this subject has been created using findings from numerous studies that are specifically focused on the antifungal action of this plant.

Keywords: *Clerodendrum infortunatum*, antifungal agent, gallic acid, t-cinnamic acid, Phytopythium vexans

Introduction:

The use of herbal items as complementary treatment is widespread around the world. These herbal remedies, which are made from medicinal plants, have greatly advanced human health and wellbeing. Studies on a number of traditional herbs have demonstrated the presence of many substances, or phytochemicals, in plant extracts that maintain human health and prevent a wide range of illnesses. Individuals and many tribal communities use a variety of plant species for the treatment of various ailments. The bioactive phytochemical components of these plants are primarily responsible for their therapeutic benefits since they have physiological impacts on people (Dutta *et al.*, 2016). The environment, agricultural productivity, and human health are all severely impacted by fungal infestations. There is an urgent need to investigate new sources of antifungal chemicals given the emergence of drug-resistant fungus strains and the limits of current antifungal medicines. The herb *Clerodendrum infortunatum*, also called "Bharangi" in Ayurvedic medicine, has drawn interest because of its potential antifungal effects. The studies on the antifungal properties of *Clerodendrum infortunatum* extract, mostly leaf extract, and its implications for diverse applications are covered in this chapter.

The medicinal herb *Clerodendrum infortunatum* is indigenous to Southeast Asia, Sri Lanka, and India. It's been used for a very long time in traditional medical practices like Ayurveda and Siddha. The plant's leaves, roots, and stems have all been used to cure a variety of illnesses, such as fever, skin infections, and respiratory problems. Due to the researchers' curiosity in this ancient usage, its pharmacological properties have been investigated. This plant's

leaves and roots are widely used to treat skin conditions and tumors. The plant also protects against scorpion stings and snake bites. In the rural areas of northern India, *Clerodendrum infortunatum* has long been utilized as a tonic and an anthelmintic agent. Additionally, diuretic, analgesic, anti-inflammatory, anti-tumor, and antibacterial properties have been linked to this plant's root (Dutta *et al.*, 2016).

Extraction and characterization of active compounds

Researchers have extracted and characterized the active components in *Clerodendrum infortunatum* extract in order to examine its antifungal potential. Phenolic acids, alkaloids, flavonoids and essential oils are some of these substances. These bioactive substances have been shown in numerous studies to have antibacterial properties, making them interesting options for treating fungus infections. Parts of the plant, typically the leaves, are milled and dried for the extraction process while also being fractionated. These substances are analyzed utilizing a variety of methods, including bioassays and LC-MS/MS analyses. Bioassays included testing using the technique of poisoned food and their impact on the prevention of fungal growth.

The antifungal activity of the extracted compound was assayed by testing by poisoned food technique and its effect on fungal growth inhibition was recorded. Following this, the bioassay of various Clerodendrum formulations was evaluated against the plant pathogenic test organism Phomopsis vexans. Mancozeb, a dithiocarbamate non-systemic agricultural fungicide with multi-site, protective action on contact, was compared to these bioassays.

Antifungal activity:

Total phenol and total flavonoid content recovered from the chloroform extract were identified and quantified. Gallic acid, p-coumaric acid, t-cinnamic acid, and benzoic acid were among the phenolic acids found in the Clerodendrum leaf extract fractions. The largest concentration of gallic acid was discovered in one of the fractions, followed by p-coumaric acid and benzoic acid. By comparing the retention periods in LC-MS with those of the respective standards, it was possible to determine the presence of each of the various phenolic acids in the various chromatographic fractions, which was then validated by the MS-MS analysis. On the fungus Phytopythium vexans, the growth-inhibitory effects of several formulations made from mother extract and its various chromatographic fractions were noted. By increasing the treatment doses (from 50 to 400 mg/mL) for both the botanicals and the common fungicide, mancozeb (5-50 mg/mL), the growth inhibition (GI) of the fungus was raised. Each of the typical phenolic acids' contributions to growth inhibition showed that their antifungal activity increased in a dose-dependent way, that they were all more effective than mancozeb, and that they induced different types of growth inhibition. Numerous studies have demonstrated comparable different anti-fungal properties of phenolic acids such caffeic acid, ferulic acid, cinnamic acid, salicylic acid, and gallic acid. Several researchers have also noted that a number of flavonoids found in plant extracts, such as catechin, luteolin, and quercetin, have antifungal properties. Since phenolic compounds can penetrate biological membranes due to their lipid solubility, the varied antifungal activity associated with various formulations containing varying proportions of different

phenolic acids appeared to be related to this. Meanwhile, the phenolic hydroxyl group's weakly acidic character may act as uncouplers of oxidative phosphorylation in respiration. With no phenolic hydroxyl group, benzoic acid had the strongest antifungal effects. Again, t-cinnamic acid devoid of any phenolic hydroxyl group came in second place in terms of activity among the conventional phenolic acids examined for their potency. Both benzoic and t-cinnamic acids exhibit a similar degree of lipophilicity and function as weak acids. Additionally, some functional groups on proteins can interact with phenolic acids with hydroxyl and carboxylic groups to form complexes with lower solubility, making them less vulnerable to proteolytic attack than the same protein alone. The phenolic acids' ability to block nutrient absorption may also be connected to the fungus' ability to thrive (Saha *et al.,* 2018).

Benzoic acid alone is a non-specific antimicrobial agent having a wide range of activity against human pathogenic fungi and bacteria and varying minimum inhibitory concentrations (MIC) values. Additionally, it was being tested as a potential inhibiting agent of enzyme carbonic anhydrase, a novel molecular target which is found in Cryptococcus neoformans and C. albicans (Kubo *et al.,* 2002). T-cinnamic acid's antifungal properties relied on its ability to inhibit CYP53A15, a special fungus enzyme known to be involved in demethylating lanosterol and so fostering microbial development (Aderibigbe and Ruwizhi 2020).

Other benefits of *Clerodendrum infortunatum* extract

Clerodendrum infortunatum extract is also associated with anticancer activity against Ehrlich's ascites carcinoma (EAC). Treatment with Methanol extract of *C. infortunatum* (MECI) results in a considerable reduction in tumor cell volume and an extension of life.

Clerodendrum infortunatum Lectin (CIL) has a modest ability to slow the proliferation of AGS, a type of human stomach cancer cell. This impact can be achieved through cytotoxic or anti-proliferative effects. As a result, CIL may be thought of as a possible biomolecule in glycobiology and tumor research due to its exceptional features (Sannigrahi et al.2012).

U-doped ZnO Nanoparticles from aqueous extracts of *Clerodendrum infortunatum* possess potent and desirable biological properties such as antimicrobial, antifungal, anticancer and antioxidant activities (Khan *et al.,* 2018).

Conclusion:

Benzoic acid and t-cinnamic acid, which were isolated from the leaves of *Clerodendrum infortunatum*, were the substances that showed antifungal properties. The brinjal pathogen Phomopsis vexans was well combatted by the EC formulations prepared from chromatographic fractions of Clerodendrum leaf extract. Additionally, it appears that the phenolic makeup of the fractions in question is related to the antifungal activity linked to certain fractions. Botanical formulations' potency was lower than that of mancozeb, but they could serve as a useful benchmark for future formulation potency improvements. As a result, preparations made from *Clerodendrum infortunatum* leaf extracts might be employed in a variety of applications and as potent anti-fungal agents.

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EXPLORING EARTH'S TERRESTRIAL BIOMES

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Introduction:

Biomes are large, distinct ecological regions on Earth characterized by specific climate patterns, vegetation types, and animal communities. They play a crucial role in shaping the planet's biodiversity and influencing the distribution of life forms across the globe. Understanding biomes is essential for ecologists, environmental scientists, and anyone interested in the natural world, as they provide valuable insights into how organisms adapt to their surroundings and how ecosystems function.

Here's an introduction to some of the key aspects of biomes:

1. **Climate**: Climate is a fundamental factor that defines biomes. It includes temperature, precipitation, humidity, and seasonal variations. Different biomes have specific climate patterns that significantly impact the types of organisms that can thrive there.
2. **Vegetation:** The dominant plant life in a biome is closely tied to its climate. For example, deserts are characterized by low rainfall and are often covered by drought-resistant plants like cacti and succulents. In contrast, rainforests have abundant rainfall and are lush with diverse plant species.
3. **Animal communities**: The types of animals that inhabit a biome are also influenced by climate and vegetation. Each biome supports a unique array of species that have evolved to adapt to the specific conditions and available resources.
4. **Terrestrial and aquatic biomes**: Biomes can be categorized into terrestrial (land-based) and aquatic (water-based) types. Terrestrial biomes include deserts, grasslands, forests, and tundras, while aquatic biomes encompass oceans, freshwater lakes, rivers, and wetlands.
5. **Human impact:** Human activities, such as deforestation, pollution, and climate change, have had a significant impact on many biomes. Human-induced changes can disrupt the delicate balance of these ecosystems, leading to habitat loss and the extinction of species.
6. **Biodiversity hotspots**: Some biomes are known for their exceptional biodiversity, making them critical areas for conservation efforts. For example, tropical rainforests are considered biodiversity hotspots due to their high species diversity.
7. **Biome interactions**: Biomes are not isolated entities but are interconnected through various ecological processes. For example, rivers originating in mountainous regions can affect downstream freshwater biomes, and nutrient cycling in one biome can influence adjacent ecosystems.

8. **Biome maps**: Scientists use biome classification systems to categorize and map Earth's diverse regions. These maps help researchers understand global patterns of life and ecosystems and are valuable tools for conservation and environmental management.

In summary, biomes are essential components of Earth's ecosystem, and studying them provides insights into the planet's biodiversity, the effects of climate change, and the importance of conservation efforts to preserve these unique environments

Some well-known biomes include the tropical rainforest, desert, grassland, taiga (boreal forest), temperate deciduous forest, tundra, freshwater lakes, coral reefs, and the open ocean. Each of these biomes has its own unique characteristics, which are shaped by geographical factors and climatic conditions.

There are several types of biomes around the world, each characterized by distinct climate, vegetation, and animal communities. Here are some of the major terrestrial and aquatic biomes:

Terrestrial biomes

1. Tropical rainforest: A tropical rainforest is a type of biome characterized by high levels of precipitation, warm temperatures, and lush vegetation. These rainforests are located near the equator and can be found in various parts of the world, including South America, Central Africa, Southeast Asia, and parts of Australia.

Some aspects of tropical rainforest

- **Location**: Tropical rainforests are primarily found in regions near the equator, including parts of South America (Amazon Rainforest), Central Africa (Congo Basin), Southeast Asia (Indonesia and Malaysia), and Oceania (Papua New Guinea).
- **Climate:** These regions have a warm and humid climate with temperatures ranging from 77°F to 88°F (25°C to 30°C) year-round. They receive heavy rainfall, often exceeding 80 inches (200 cm) per year, and have distinct wet and dry seasons.
- **Biodiversity:** Tropical rainforests are known for their incredible biodiversity. They are home to a vast array of plant and animal species, many of which are unique to these ecosystems. Some well-known inhabitants include jaguars, toucans, sloths, and various species of monkeys.
- **Flora:** The rainforest canopy is composed of tall trees that form a dense, multi-layered structure. You'll find a wide variety of plant species, including orchids, epiphytes, and numerous medicinal plants.
- **Importance**: Tropical rainforests play a crucial role in maintaining global ecological balance. They help regulate the Earth's climate, store large amounts of carbon, and are often referred to as the "lungs of the Earth" due to their oxygen production.
- **Threats:** Unfortunately, tropical rainforests are under threat from activities like deforestation, logging, agriculture, and mining. These activities have led to habitat destruction, loss of biodiversity, and increased carbon emissions.

- **Conservation:** Various organizations and governments are working to protect and conserve tropical rainforests. Initiatives include setting up protected areas, promoting sustainable logging practices, and supporting indigenous communities who live in these areas.

2. Desert: A desert biome is characterized by arid or semi-arid conditions, where there is limited precipitation and often extreme temperatures. Deserts can be found on every continent, and each has unique features and adaptations to the harsh environment. Here is some information about desert biomes.

Some aspects of Desert:

- **Location:** Deserts are distributed worldwide, including regions in North America (e.g., Sonoran Desert), South America (e.g., Atacama Desert), Africa (e.g., Sahara Desert), Asia (e.g., Arabian Desert), and Australia (e.g. Simpson Desert).
- **Climate:** Desert climates are characterized by low annual precipitation, usually less than 250 millimetres (10 inches) of rain per year. Temperatures in deserts can vary widely, with scorching daytime heat and cold nights. Some deserts experience extreme temperature fluctuations.
- **Vegetation:** Desert plants have evolved unique adaptations to conserve water and thrive in arid conditions. Examples include succulent plants like cacti and agave, which store water in their tissues.

  Some desert plants have deep root systems to access underground water sources.
- **Wildlife:** Desert animals are adapted to survive in harsh conditions. Many are nocturnal to avoid the intense daytime heat. Common desert animals include lizards, snakes, camels, scorpions, and various rodent species. Some desert animals, like the fennec fox, have physical adaptations such as large ears to dissipate heat.
- **Ecosystem services:** Despite their challenging conditions, desert ecosystems provide valuable services. They serve as carbon sinks, support unique biodiversity, and can be important for scientific research and tourism.
- **Threats:** Deserts are vulnerable to human activities like overgrazing, agriculture, and mining, which can disrupt fragile desert ecosystems.
- **Conservation efforts:** Conservation organizations work to protect desert ecosystems and the unique species that inhabit them. This includes the establishment of protected areas and efforts to combat desertification.
- **Cultural significance:** Deserts have cultural significance for many indigenous peoples who have adapted their lifestyles and traditions to thrive in these environments.
- **Unique desert types:** There are various types of deserts, including subtropical deserts, cold deserts, coastal deserts, and rain shadow deserts, each with its own characteristics.
- **Notable deserts:** Some well-known deserts include the Sahara Desert (Africa), the Mojave Desert (North America), the Gobi Desert (Asia), and the Atacama Desert (South America).

3. Grassland: Grasslands, also known as prairies, steppes, savannas, or meadows, are terrestrial ecosystems dominated by grasses and other herbaceous plants rather than large, woody vegetation like trees and shrubs. They are found on every continent except Antarctica and can vary widely in terms of climate, vegetation, and biodiversity.

Some aspects of Grassland:

- **Grass-dominated vegetation:** Grasses are the primary vegetation in grassland ecosystems, and they come in various species and forms, from short, fine grasses to tall, coarse ones. Herbs and wildflowers may also be present.
- **Limited tree coverage:** Unlike forests, grasslands have relatively few trees or may even be treeless in some cases. Trees in grasslands are usually scattered, and they often grow along watercourses or in areas with slightly more moisture.
- **Climate variation:** Grasslands can be found in a range of climate zones, from tropical to temperate to arid regions. They typically experience distinct seasons with fluctuations in temperature and precipitation.
- **Fire adaptation:** Many grassland ecosystems are adapted to periodic fires, which help control the growth of woody plants and promote the growth of grasses. Fire can also release nutrients into the soil.
- **Biodiversity:** Grasslands support a diverse range of wildlife, including mammals like bison, pronghorn, and kangaroos, as well as birds, insects, and reptiles. These animals have evolved to thrive in open grassy habitats.
- **Ecosystem services:** Grasslands provide important ecosystem services, including carbon storage in plant roots and soil, water filtration, and habitat for pollinators. They are also valuable for recreational purposes and as sources of food and fibre.
- **Conservation challenges:** Many grassland ecosystems are threatened by habitat destruction, overgrazing, invasive species, and urban development. Conservation efforts often focus on preserving and restoring native grasslands and their associated biodiversity.
- **Types of grasslands:** There are different types of grasslands, each with unique characteristics. Some examples include temperate grasslands (e.g., the Great Plains of North America), tropical grasslands (e.g., the African savanna), and alpine meadows (found in mountainous regions).

  Cultural significance: Grasslands have cultural importance for many indigenous communities around the world. They may have traditional uses for hunting, gathering, and cultural ceremonies associated with these landscapes.

4. Temperate deciduous forest: A temperate deciduous forest is a type of biome characterized by distinct seasonal changes and a variety of deciduous tree species. These forests are found in regions with moderate temperatures and abundant precipitation throughout the year, including areas of North America, Europe, and parts of Asia.

Some aspects of Temperate Deciduous Forest

- **Climate:** Temperate deciduous forests experience four distinct seasons: spring, summer, autumn (fall), and winter. Summers are warm, and winters are cold, with temperatures ranging from below freezing in the winter to mild or warm in the summer.
- **Flora:** The dominant vegetation in temperate deciduous forests consists of deciduous trees that shed their leaves in the fall. Common tree species include oaks, maples, beeches, birches, hickories, and various types of fruit trees. These trees are adapted to withstand cold winters and take advantage of the available sunlight in the spring and summer.
- **Fauna:** These forests support a diverse range of animal species. Mammals like white-tailed deer, squirrels, raccoons, and various species of rodents are common. Bird species such as robins, sparrows, owls, and hawks are also prevalent. Amphibians and reptiles like frogs, salamanders, and snakes can be found in the forest understory, along with various insects.
- **Understory and shrubs:** Beneath the canopy of tall trees, you'll find an understory of shrubs, smaller trees, and herbaceous plants. These include species like dogwoods, rhododendrons, and ferns. The forest floor is often covered with leaf litter.
- **Seasonal changes:** One of the defining characteristics of temperate deciduous forests is the seasonal changes in vegetation. In the fall, the leaves of deciduous trees change color and eventually drop, creating vibrant displays of red, orange, and yellow foliage. In the spring, new leaves and flowers bloom, and the forest comes to life with fresh growth.
- **Biodiversity:** These forests are known for their high biodiversity, with a wide variety of plant and animal species coexisting. This diversity is partially due to the distinct seasonal changes, which create niches for different species at different times of the year.
- **Human impact:** Many temperate deciduous forests have been significantly impacted by human activities, including deforestation for agriculture, urbanization, and logging. Conservation efforts have been implemented to protect and restore these ecosystems.

5. Taiga (Boreal Forest): The taiga, also known as the boreal forest, is one of the largest terrestrial biomes on Earth, covering vast stretches of land in the high northern latitudes of North America, Europe, and Asia.

It is characterized by a cold climate and consists mainly of coniferous trees and various other plant and animal species adapted to harsh, subarctic conditions.

Some aspects of Taiga (Boreal Forest):

- **Climate:** The taiga experiences long, cold winters and short, cool summers. Winter temperatures can drop significantly, often falling below freezing, while summer temperatures are relatively mild, with occasional warm spells.
- **Vegetation:** Coniferous trees are the dominant vegetation in the taiga. Common tree species include spruce, fir, pine, and larch. These trees have needle-like leaves that are adapted to conserve water and withstand the harsh winter conditions.

- **Biodiversity:** While conifers are the primary trees, the taiga is not a homogeneous forest. There can be variations in tree species composition and understory vegetation. Mosses, lichens, and ferns are common on the forest floor.
- **Wildlife:** The taiga is home to a variety of wildlife adapted to cold climates. Iconic animals include moose, reindeer (caribou), wolves, lynx, and brown bears. Bird species like owls, eagles, and various waterfowl are also present. Many of these animals have thick fur or feathers to insulate themselves from the cold.
- **Seasonal changes:** The taiga experiences distinct seasonal changes. During the brief summer, the forest comes alive with blooming plants and active wildlife. In contrast, the long, harsh winters are characterized by frozen landscapes and reduced biological activity.
- **Human impact:** The boreal forest has been historically impacted by human activities, including logging, mining, and resource extraction. Indigenous communities and local populations have relied on the taiga's resources for centuries. Conservation efforts are ongoing to protect the boreal forest and its ecosystems.
- **Ecological significance:** The taiga plays a crucial role in global carbon cycling. Its vast expanse of trees stores significant amounts of carbon, helping to mitigate climate change. Additionally, it provides habitat for numerous species, some of which migrate to or from the taiga seasonally.
- **Challenges:** The taiga faces various challenges, including climate change, which can alter temperature and precipitation patterns, affecting both the forest and its wildlife. Additionally, industrial activities can have significant environmental impacts if not managed sustainably.

6. Tundra: The tundra is one of the Earth's most extreme and challenging biomes, characterized by its harsh environmental conditions, low temperatures, and limited vegetation. It is found primarily in the high latitudes of the Northern Hemisphere, including regions of North America, Europe, and Asia, as well as some high-altitude areas in mountain ranges.

Some aspects of tundra:

Climate: The tundra experiences extremely cold temperatures, with long, harsh winters and very short summers. Winter temperatures can plunge well below freezing, while summer temperatures, although relatively brief, may reach just above freezing.

- **Vegetation:** Tundra vegetation is limited due to the cold climate and permafrost (permanently frozen soil) that prevents deep-rooted plants from establishing themselves. The dominant plants are typically low-growing and include mosses, lichens, grasses, and hardy shrubs.
- **Permafrost:** Permafrost is a defining feature of the tundra biome. It consists of soil, rock, and sediment that remains frozen year-round, except for the surface layer that thaws during the short summer season. Permafrost plays a crucial role in shaping the landscape and limiting plant growth.

- **Wildlife:** Tundra ecosystems are home to a variety of cold-adapted wildlife. Iconic animals of the tundra include caribou (reindeer), muskoxen, Arctic foxes, Arctic hares, lemmings, snowy owls, and various migratory birds. Polar bears are also found in the coastal areas of the Arctic tundra.
- **Seasonal changes:** Tundra ecosystems experience dramatic seasonal changes. During the brief summer months, when the sun is above the horizon for most of the day, the tundra bursts into life with blooming plants and increased animal activity.
- **Human impact:** While the tundra is relatively remote and sparsely populated, it is not immune to human impact. Climate change is a significant concern, as rising temperatures can lead to permafrost thaw, disrupting ecosystems and releasing stored greenhouse gases. Human activities such as oil and gas exploration can also have environmental consequences in tundra regions.
- **Adaptations:** Flora and fauna in the tundra have evolved unique adaptations to survive the extreme conditions. Animals often have thick fur or feathers for insulation, and some hibernate during the winter. Plants tend to be small and low to the ground to reduce exposure to cold winds.
- **Conservation:** Protecting the tundra and its fragile ecosystems is a priority for conservation efforts. Efforts are made to reduce human impact and study how climate change is affecting the tundra's delicate balance.

7. Chaparral: The chaparral biome is a specific type of terrestrial ecosystem characterized by its unique combination of climate, vegetation, and ecological features. It is often associated with regions that have a Mediterranean climate, which includes areas with hot, dry summers and mild, wet winters. The term "chaparral" is commonly used in North America to describe this biome, especially in California. However, similar ecosystems with variations in plant species and climate can be found in other parts of the world, including the Mediterranean Basin, South America, and Australia.

Some aspects of chaparral:

- **Climate**: Mediterranean climates, which are typical of chaparral biomes, have distinct wet and dry seasons. Summers are hot and dry, while winters are mild and wet. This seasonal pattern of rainfall contributes to the unique flora and fauna of the biome.

  Vegetation: Chaparral vegetation is adapted to the harsh climate conditions. It is dominated by dense, evergreen shrubs and small trees with small, tough leaves. Common plant species found in chaparral include manzanita, chamise, sagebrush, various species of oak, and Mediterranean herbs like rosemary and lavender.
- **Fire adaptations**: Many plants in the chaparral biome have evolved to withstand and even rely on wildfires for reproduction. Some plants have seeds that are stimulated to germinate by fire, while others have fire-resistant bark or are able to resprout quickly after a fire.

- **Wildlife**: The chaparral biome is home to a variety of wildlife adapted to this environment. Animals like coyotes, bobcats, mule deer, and various species of birds, reptiles, and insects can be found here. Some of these species have developed specific adaptations to cope with the challenges of the chaparral, such as heat tolerance and the ability to find food and water during dry periods.
- **Human impact**: Chaparral regions often face challenges related to human development, agriculture, and wildfires. Human activities can disrupt natural fire cycles and lead to increased wildfire risk. Conservation efforts are crucial to protect and preserve the unique biodiversity of the chaparral biome.
- **Ecological importance**: Despite the challenging conditions, chaparral ecosystems are biologically diverse and play important ecological roles. They contribute to carbon and nutrient cycling, provide habitat for various species, and have cultural significance in regions where they are found.

8. Temperate Rainforest: The temperate rainforest biome is a lush and verdant ecosystem characterized by moderate temperatures and high rainfall throughout the year. Unlike tropical rainforests, which are found near the equator, temperate rainforests are located in regions with cooler climates and distinct seasons. These biomes are known for their incredible biodiversity, unique flora and fauna, and important ecological roles.

Some aspects of Temperate Rainforest:

- **Climate:** Temperate rainforests experience relatively mild temperatures year-round. Summers are cool and moist, while winters are mild but wetter. The consistent rainfall, often exceeding 100 inches (250 centimetres) annually, creates the conditions necessary for lush plant growth.
- **Vegetation:** One of the defining features of temperate rainforests is the presence of towering trees covered in mosses and ferns. Dominant tree species in these forests include evergreen conifers like Douglas fir, western hemlock, and Sitka spruce. Additionally, deciduous trees like maples and alders are also found in some temperate rainforests.
- **Biodiversity:** Temperate rainforests are home to a wide range of plant and animal species. These biomes support numerous species of birds, mammals, amphibians, and insects. Iconic species that inhabit temperate rainforests include black bears, cougars, bald eagles, salmon, and various species of owls and songbirds.

  Importance of rain: The consistent rainfall in temperate rainforests plays a vital role in the health of these ecosystems. It sustains the lush vegetation, nourishes the forest floor, and supports the many aquatic species that rely on streams and rivers originating in these forests.
- **Conservation:** Due to their unique biodiversity and ecological significance, temperate rainforests are important areas for conservation efforts. Human activities such as logging and urban development have threatened these ecosystems in various parts of the world,

including the Pacific Northwest of North America and parts of New Zealand and Chile. Conservation initiatives aim to protect and preserve the remaining temperate rainforests.

- **Cultural importance:** In addition to their ecological value, temperate rainforests often have cultural significance for indigenous communities who have lived in these regions for generations. These forests provide food, materials for traditional crafts, and are central to the cultural identity of many indigenous groups.

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A REVIEW ON HERBAL VETERINARY MEDICINAL PLANTS

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Abstract:

Ethnoveterinary medicine refers to the traditional knowledge and practices used by local communities to treat various diseases of their domestic animals. These practices have been developed over centuries and are deeply rooted in the cultural beliefs, tradition of tribal people. Ethnoveterinary medicine practices has gained recognition as a valuable field for research study, as it provides insights into indigenous knowledge about medicinal plants and can contribute to the development of sustainable and culturally appropriate veterinary practices. This growing interest in veterinary traditional practices had been encouraged by the recognition of some efficacious medicinal plants for further pharmacological uses. The main objective of the review paper was to prepare documentation of veterinary traditional healing methods and medicinal plants used by local people.

Keywords: Ethno veterinary, medicine plant, tradition, livestock

Introduction:

Mc Corkle coined the term Ethnoveterinary in 1986, in 1996 it was defined as "the holistic interdisciplinary study of local knowledge, skills, practices, beliefs, professionals, associated social structures about health care, healthy eating, work and culture." Ethno-veterinary medicine is the knowledge developed by local livestock holders to treat various diseases of their animals. It deals with the natural and traditional method or inter-relationships between human and plants, domesticated animals (Pawar and Vidhyamandirs, 2020).

The history of the utilization of plants in medication can be followed back to the old progress or pre-Rigveda. Traditional knowledge is being forgotten these days; hence some researchers are attempting to document this important knowledge as written documents. Due to easy availability and low cost of medicinal plants, the livestock owners of the remote areas use them as a first aid for their animals. It also can lead to reduction of use of antibiotics and other chemical drugs and associated residues in the animal products and microbial resistance (Balakrishnan *et al.,* 2017). Documentation of traditional ethnoveterinary knowledge is a requirement due to increasing demand for herbal drugs in the veterinary field along with some known side effects of allopathic products (Patole, 2021).

This survey can potentially bring out many different clues for the development of effective, inexpensive traditional healing methods. Veterinary medicine is prepared from a

different variety of plant materials such as leaves, stems, roots, bark, fruit with their traditional healing method. Naturally they may contain biologically active ingredients and are utilized for treating illness (Pawar and Vidhyamandirs, 2020). Traditions of collecting, processing and applying plant-based medications are maintained by indigenous societies for long and carefully (Patil *et al.,* 2010). This traditional knowledge has been transferred from one generation to the next generation. Due to lack of proper documentation and overuse of these plants by healers, the natural resources along with related traditional knowledge are reduced day by day.

The Younger generation is not aware about their traditional knowledge and lifestyle of herbal healers. In recent years research workers have given importance to traditional knowledge pertaining to ethno-veterinary from different states. It is observed that several research work documented ethnoveterinary practices in various districts and states of India; with different lines of research in Ethnoveterinary plant species used in curing the various ailments of livestock.

Research on ethnoveterinary medicinal plant

Patil and Patil (2013) found 20 plant species belonging to 16 families of angiosperms used for ethno- veterinary purposes. This ethnoveterinary medicinal plants parts such as leaves, roots, stems, stem bark, underground parts, succulent leaves, flowers, fruits, fruit pericarp etc. are used against the ailments of domestic animals. It shows the knowledge of local people about the ethno-veterinary uses of the plant parts with their method of preparation of medicine and the amount of appropriate doses for particular ailment. It will help in the investigation of crude drugs on pharmacological and clinical lines to develop potential drugs.

Savale *et al.,* (2012) reported 21 plant species belonging to 21 genera and 15 families having ethno-veterinary significance. This work is very important as well as helpful in preservation and passing of the traditional ethno-veterinary knowledge from the tribals to the next generations. Efforts should be taken in conservation and maintenance of the plants which are on the verge of extinction due to deforestation, global warming, industrialization and urbanization. Few plants of the locality possess potential of better economic exploitation. Some of them are *Pergularia daemia* (Forssk) Chiov., *Momordica dioica* Roxb.ex.Willd., *Salanum xanthocarpum* Schrad & Wend., *Syzygium cumini* (L.) Skeels., *Abelmoschus manihot* (L.) Medik., *Cissampelos pareira* Linn., *Jatropha podogrina* Linn., *Terminalia bellirica* (Gaertn.) Roxb., *Anogeissus latifolia* (Roxb. ex DC.) Wall.ex Guill. & Perr., *Corallocarpus epigaeus* (Rottl.) C.B.Cl., *Chlorophytum borivilianum* (Roxb.) Baker, *Asparagus adscedens* Roxb. Since all these plant species were used in more or less proportion throughout the world, there is wide scope for their bio-prospecting. Thereafter our prime duty becomes to protect and conserve these plants via ex-situ or in-situ ways urgently in a proper way.

Pawar and Vidhyamandirs (2020) reported A total 17 species belonging to 14 genera and 13 families were collected from the study area with the help of information given by vaidyas, bhagat and elderly village people, which was used by local people as folk medicinal plants in treating their animals for various ailments and diseases. In this work, the plants located in the study area bark decoction of *Acacia catechu* is used for washing sore and cracked nipples of

cows, buffaloes and goats and to treat broken horn of domestic animals, *Annona reticuta* to remove ticks and mites, *Annona squamosa* to repel lice of hen's nest, *Hardwickia binata* used for lactation and improving milk quality, *Ipomea mauritiana* (Roxb.) Planch. Jacq. to increase milk flow and to treat breast infections in cattle, *Holoptelia integrifolia* L.to treat inflammation, eczema, ringworm and skin diseases, *Jatropa gossypifolia* L. to kill germs in tooth cavities and to treat stomach disorders.

Deshmukh *et al.* (2011) stated that there are various plants and ingredients with their traditional methods used by local herbalists to treat livestock. The study of this work reveals 36 ethnoveterinary medicinal plant species belongs to 33 families. The paper is an enumeration of herbal medicinal remedies used to treat these diseases along with dosage and method of administration. In some ailments like removal of intestinal worms, tympani, for achieving furrore, bronchitis, cataract, hemorrhagic septicemia, three-day sickness only single plant species is used for the treatment. Combinations of two or more medicinal plants are used to treat specific diseases like arthritis and pneumonia. Local application or external use of various drugs, i.e. paste of leaves was the common way for treatment but in some cases, drugs were orally administered along with fodder. Ethnoveterinary information is in danger of extinction because of the current rapid changes in communities all over the world. Due to globalization, population explosion, migration leads to rapid change in cultural scenario which ultimately changed rural life in India. This changed scenario is causing a threat to ethnoveterinary knowledge and there is an urgent need to record the information before it is lost forever.

Patole (2021) documented total 40 plant species for different ailments purposes from the study area. In this work reported that, some farmers used the fresh juice of *Tridax procumbens* L.in large injuries. This plant was reported to exhibit antiseptic and antihemorrhagic activity. These activities of this plant might be due to the presence of steroids and triterpenes. Another report from one of the farmers indicated use of fresh decoction of *Prosopis juliflora* leaves when an animal suffered from infectious diseases. Phytochemical analysis of *Prosopis juliflora* revealed the presence of four piperidine alkaloids with good antibacterial and antifungal activities. One of the widely distributed plants from this region is *Achyranthes aspera L.* which has been used by livestock owners and farmers for gastric disturbance in animals. Various pharmacological actions like wound healing, spermicidal activity and hepato protective activity were reported. The stem bark of *Butea monosperma* used in chronic diseases like abdominal tumor and other intestinal conditions. But it was surprising to note the use of the plant for instant wound healing purpose, in which stem bark powder was applied to the fresh injury of animals. Though the mechanism of action is still unknown the presence of palastrin, isobutein and other flavonoids, as well tannins might help in wound healing through antioxidant and astringent mechanisms. Use of various parts of *Azadirachta indica* leaves, stem bark in itching and other skin-related diseases. Triterpenes like nimbin, azadirachtin, limonoid present in neem could be responsible for this therapeutic activity. This shows that Ayurveda system of medicine

constituted traditional knowledge that passed from generation to generation since long and its very important to make its documented for futher use in pharmaceutical purpose.

Pranjale and Dube (2016) found 28 common plants which belonged to 24 families. This ethnoveterinary medicinal plants were useful for curing 17 types of diseases with like Enteritis, Anthrax, Black quarter, Conjunctivitis, Dysentry, Maggoted wound, Fracture, Tympani, Hemorrhagic septicemia, Mouth and Foot diseases, Pneumonia, Sunstroke, Wounds, Galse, Pankawse & Mowase with their traditional method. The work reveals that the leaves, roots, stems, bark, underground parts, flowers, fruits, etc. are used for curing diseases. In various studies we obsesrved that leaves were mostly used for the treatment. It shows the understanding of local people about ethno-veterinary uses of plants, their knowledge about ailments, method of preparation of medicine and the amount of appropriate doses for particular ailments.

Kulkarni *et al.* (2014) surveyed from Local people in study area there are 46 plants used in common diseases treatment like cuts & wounds, dysentery, cough, bloat, control of maggots from wounds, etc. *Gardenia gummifera*. L. f. used for the treatment of maggoty wounds, Fruits of *Semicarpus anacardium* L. f. were used for dental treatment. *Cayratia trifolia* (L.) Domin leaves and bark both were used for wound healing treatment, Bark of *Acacia leucophloea* (Roxb.) Willd. Used to control diarrohea. Herbalist Cleistanthus *collinius* Roxb. as insecticides, *Datura metel* L. used for wound healing purpose. Use of Cissus quandrangularis L. and *Viscum angulatum* Heyne ex DC. for bone fracture healing. Extract of *Chloroxylon swietenia* DC. Leaves used for fumigation to control flies and insects. Using the root of *Ficus bengalgenesis* L. for dental treatment, leaves of *Holoptelea integrifolia* (Roxb.) used to control blood dysentery.

Somkuwar *et al.* (2015) documented a total of 198 plant species distributed in 79 families has been recorded in the study region. The various plant parts used include leaves, stem, root, bark, bulb, tuber, rhizome, flower, and gum etc. Leaves (30.158%) constituted the major portion of plant parts used for treatment of various diseases, root (15.079%) and bark (13.09%). In this survey there are 10 plant species belonging to family Pappilionaceae, family Euphorbiaceae, Solanaceae, and Liliaceae with 08 plant species. With 06 plant species of each family Apocynaceae, Asteraceae, Caesalpiniaceae, Cucurbitaceae, Lamiaceae, Rubiaceae and Verbenaceae. From this research work shows considerable potential for further scientific and phytochemical research on these plant species, which can lead to development of traditional natural and more efficacious drugs for future use not only to cattle but also can be useful to humans too.

Patil *et al.* (2010) documented various plant species which belong to 90 families medicinally useful for various purposes such as food, fodder, timber, seed and medicinal. From that only 80 plant species from 44 families are useful for the different ailments. Some species useful for animal medicine are also useful multipurposely e.g. *Annona squamosa L. Calotropis gigantea (L)* Dryand, *C. procera L, Ocimum tenuiflorum L, Ricinus communis L. Tamarindus indica L, Butea monosperma and Hardwickia binata. L* There are some specific plants used on some diseases like *Calotropis procera* cures for ailments viz., bone fracture, twisting of leg,

colic and flatulence. *Semecarpus anacardium L* useful against four complaints e.g. mouth ulcer, eye-complaints, lal-khurguti and throat swelling. *Tamarindus indica* L is beneficial against three ailments e.g. bone fracture, cramp and as vermicide for wounds.

Gadpayale *et al.* (2014) reported 41 plant species belonging to 36 genera of 27 families which are used in ethnoveterinary. *Gardenia resinifera.* Roth is a plant which is not enumerated still for the Ethnoveterinary use by any tribe, this is a first report where the tribal peoples of Bhandara district use this plant to treat the ailments of domestic animals. The leaves are the predominant part utilized in the treatment of veterinary diseases and most of the plants are used to treat fever in livestock. Further this plant can be used in different diseases. There are different methods of treatment like decoction, paste, powder and mixture of plants are employed for the preparation of medicinal plants. Most of the reported Ethnoveterinary medicinal plants are used to treat fever, wounds and dysentery.

Jambu and Wath (2018) studied ethnoveterinary healthcare practices used by rural people from Akola district, in that they documented 93 plant species representing 83 genera and belonging to 43 families. All documented plant species are used in the treatment of different animal diseases and disorders. Majority of preparations are from Leaves (47), Underground parts (20), Stem bark (20), Fruits (13), Seeds (19), Whole plant (7) and others (15). The traditional system of treatment is one of the most important prevailing systems in the area where modern veterinary health care facilities are rare or in very poor conditions. There is a need to transfer knowledge from one generation to another. The documentation of traditional knowledge is valuable for the communities and their future generations and for scientific consideration of wider uses of traditional knowledge in treating livestock. Therefore, it is necessary to record this valuable information for the utilization of community and for further scientific pursuit.

Wath and Jambu (2014) documented ethnoveterinary medicinal plants with their herbal therapy for treating livestocks. In this work they found 49 plant species belonging to 32 families used by traditional healers, mode of treatment varies with type of animal and its diseases. Diseases can be treated either with the whole plant, specific plant parts or in combination of different plants. In preparation of the material use of salt, calcium carbonate, jaggery, sugar, coconut oil was found to be a common way of treatment. Most of the plants commonly used for treatment of humans are also being used for similar conditions affecting animals. eg. *Cissus quadrangular* L. used to cure bone fracture in both human beings and animals. This study of ethnoveterinary in detail with pharmacological investigations will be helpful for developing the new veterinary drugs.

Dhore and Undal (2017) surveyed on Medico- botanical studies in relation to veterinary medicinal plants from Akola district Maharashtra. There are 26 plant species belonging to 20 families which are used to cure various diseases such as mastitis, dysentery, arthritis, eye injury, milk disorder, wounding, bone fractures, fever etc in domestic animals. The plant parts used were leaves, root, bark, flowers, stem, seed, whole plant, fruit, pod and latex used as a remedy purpose. In the process of making decoction plant material heating in water to boiling point

whereas infusion involves soaking in water at ambient temperature overnight. In these both preparations plant materials were crushed prior to boiling or soaking in water. Boiling of plant materials extracts water soluble compounds, it could also degrade or alter actives and could also result in detoxification of some noxious plants, depending on the toxins involved.

Kamble and Kulkarni (2016) documentation of traditional practices of herbal medicines with their mode of preparation on different ailments. Sometimes healers are using some additives like salt, jaggery, buttermilk, butter, oil and Vaseline, etc. for preparation of medicine. In this research work they found 36 plant species which belong to 25 families with 33 genera. There are so many plants used for diseases, some are like leaves of *Azadirachta indica* Juss for wound healing and to control maggots from wounds. Powder of *Curcuma longa* L rhizome and fruits of *Datura stromonium* L are used for wound healing of the animals. It is very important to note that people are using *Woodfordia fruticosa* (L.) Kurz. *Colebrookea oppositifolia* J.E. Smith., *Pogostemon benghalensis* (Burm. f.) O. Ktze. *Tridax procumbens* L., *Azadirachta indica* A. Juss., *Annona squamosa* L. for wound healing and *Lobelia nicotianifolia* Roth exRoem, *Lavandula bipinnata* (Roth.) O.Ktze., *Luffa acutangula* (L.) Roxb., *Clematis gouriana* Roxb. ex DC, *Gardenia gummifera* L. f. used for controlled maggots. Documentation of this knowledge is valuable for the communities and their future generations.

Naarayana and Narasimha Rao (2015) studied on ethnoveterinary Practices and Phytochemical Analysis of Some medicinal plants. In this investigation a total of 30 plant species samples for preliminary phytochemical analysis. Preliminary phytochemical screening of plants was done following the standard procedures/tests adopted/pioneered by Chhabra *et al.* (1984) and Harborne (1984). Preliminary phytochemical analysis was conducted on the crude extracts, obtained from different polar solvents like hexane, chloroform and methanol. In the present study, the stem bark of *Abrus precatorius* is used in curing anthrax, the root is used for dysentery and wounds. leaves used for insect bite, retained placenta and seeds for yoke gall; the root and stem of this plant contain Alkaloids, Flavonoids, Steroids, Terpenoids. The stem bark and leaf of *Chloroxylon swietenia* plant were screened for phytochemical analysis which reveals Alkaloids, Tanins compound, this plants leaf and stem bark used for wounds and yoke gall, whereas leaf used to treat ephemeral fever. Stem, root and leaf of *Cocculus hirsutus* contain Alkaloids, Steroids, Terpenoids; it used for diarrhoea and also in removal of external parasite. The phytochemical analysis of *Dillenia pentagyna* stem bark showed the presence of Glycosides. This plant leaf and rhizome for anthrax and impaction, root is used for sores. Whole plant of *Euphorbia hirta* contain Alkaloids, Glycosides, Tanins, Terpenoids, Phenolic Compounds and it used for sore and ranikhet. Qualitative phytochemical analysis of root, flower and seed of plant *Gloriosa superba* revelaed the presence of Alkaloids, Glycosides, Steroids; leaves used for foot, mouth diseases and ectoparasites. The wood, bark and leaf of *Holoptelea integrifolia* plant for contain Steroids, Glycosides; leaf used for bronchial disorders, treat musculair pain, ophthalmic diseases for ephemeral fever and tympany. Phytochemical analysis of *Morinda pubescens* roots contain Glycosides compound and it is used for renderpest whereas

leaf paste for wounds. The Root, leaf of *Pergularia daemia* plant were accesed for qualitative estimation of phytocompounds which showed the Glycosides, Steroids; entire plant used for gout/inflammation while leaf for fractures and anthrax, bark juice for anthelmintic. The seed, Leaf, seed oil of *Schleichera oleosa* plant were screened for phytochemical analysis which reveals Steroids, Glycosides, Phenolic compound, leaves used to treat Maggot-wounds, rheumatism and arthritis, ephemeral fever. *Smilax zeylanica* root and leaf contain Glycosides, it is used for dysentery while flower is for wounds. The whole plant of *Trichosanthes tricuspidata* is a remedy for bloat, ephemeral fever; this plant contains Glycosides, Saponins phytocompounds. Stem, bark and Leaf of *Wattakaka volubilis* plant showed the Glycosides coumpund, leaf to treat yoke galls, galactagogue whereas stem bark for ephemeral fever.

Hatil and Elshikh (2015) performed phytochemical analysis of 27 plants used in Ethnoveterinary medicine in both ethanolic and aqueous extracts to analysis of carbohydrate, reducing sugars, monosaccharide, tannins, saponins, flavonoids, terpenoids, alkaloid, proteins, amino acid and anthraquinones. Plants were found free of reducing sugar in both ethanolic and aqueous extracts, such as *Trigonella foenum-graecum* (seeds), *Cymbopogon schoenanthus* (arial parts), *Cucurbita pepo* (seeds), *Conocarpus erectus* (leaves), *Nicotiana rustica* (arial parts) and *Citrullus colocynthis* (seeds). The plant species such as *Camellia sinensis* (leaves), *Acacia nilotica* (fruit), *Acacia mellifera* (stem park) and *Conocarpus erectus* (leaves) contained tannins phytocompund in both the ethanolic and aqueous extracts. The phytochemical analysis of *Ziziphus spina-christi* (leaves) revealed that tannin was found in ethanolic extract only. The existence of the flavonoids appeared in a few of the plants, *Camellia sinensis* (leaves), *Hibiscus sabdariffa* L (fruit), in both ethanolic and aqueous extracts. The alkaloids were abundant in most plant species except only five, namely; *Maerva crassifolia* (stem park), *Pennisetum orientale* (seeds), *Balanites aegyptiaca* (fruit), *Cucurbita moschata* (seeds) and *Conocarpus erectus* (leaves).

Usha *et al.* (2021) studies on *Plumbago zeylanica* Linn. belongs to the family Plumbaginaceae, an Ethnoveterinary Plant. The main aim of this work is to investigate the phytochemicals, antioxidant and antimicrobial activities of the crude extract of *Plumbago zeylanica* leaves. It is a rich source of secondary metabolites such as flavonoids, glycosides, cardiac glycosides, phenols, tannins, saponins, Steroids and quinones. This plant also has prominent antioxidant activities. the high frequency of antibacterial activity in the methanolic extracts of *Plumbago zeylonica*. The phenolic compounds are known for their antimicrobial properties. This research work is helpful as a preventive agent in the pathogenesis of some Ethno-Veterinary diseases.

Odelu (2015), reported a total 68 plant species belonging 61 genera and 36 families. They mainly concentrate with the diseases like dysentery, fever, cold, foot infections, jaundice, snake and scorpion bite, swelling, tonsils, ulcers, wounds, twitching etc. The positive side of livestock health care improves lactation, vitality, and easy delivery. In this traditional method of making the products some are administered alone and combinations of two are more. They use

some wood made apparatus to be administered with help of Konkae-made with wood of bamboos'). Some formulations are applied in the form of juice, powder, and paste. Traditionally foot and mouth disease is controlled by the use of *Syzzigium cummini* L. Mastisis is common in dairy cattle, for this curing of it by using of *Azadiracta indica* Neem., *Memordica charantia* L. The leaf juice of *Adathoda vassica* L., leaf paste of *Azadiracta indica* used for more lactation. Documentation of such traditional knowledge valuable for future generations and scientific research purposes in veterinary medicines.

Naik *et al.* (2012) they gave some reports on Ethno-veterinary uses of medicinal plants among the Lambani community in Chitradurga district, Karnataka. They enumerated about 39 plant species belonging to 24 families used in traditional ethnoveterinary practices by local inhabitants. The interesting therapeutic properties of this medicinal plant species in treating various veterinary ailments such as stem of *Ficus benghalensis* L. against maggot wounds; *Aloe barbadensis* leaves use for anoestrus. Fruit of *Solanum indicum* L. use in treatment of eye problems and *Solanum nigrum* leaves and fruit for fever. The Lambani tribe also uses the combination of plant species - a mixture of *Tylophora indica* (Burn. F), *Allium sativum*, *Datura metel*, *Aegle marmelos*, *Piper nigrum* and mustard being used together for lack of appetite in animals; fruit of *Datura metel* and Ragi balls also used in curing lack of appetite. Seed of *Terminalia chebula* and *Tamarindus indica* for curing bloat. *Caralluma laciantha* and *Curcuma longa* are used in treatment of Mastitis. Stem of *Caralluma adscendens* var. *Fimbriata* and coconut oil are used together by the Lambani tribes to cure paralysis and joint pain. The leaves of *Sida acuta* used for cuts and wounds. This type of research survey is important in finding some miraculous medicines for curing various veterinary diseases.

Conclusion:

Medicinal plants play a key role in veterinary diseases and improvement in their health. More such research surveys are needed in future to be carried out in order to know the different plant species with their immense value in animal disease and also in humans. At the same time there is a need to study the phytochemical, pharmacological and clinical aspects of ethno-veterinary plants for confirmation of their medicinal uses. The documentation of Ethnoveterinary medicine from regions of India is needed in recent times. This type of research work enriches the wealth of the traditional knowledge of ethnoveterinary medicinal plants and gives information regarding present bioactive compounds; would explore potential for research and discovery of new medicines so as to cure the diseases of animals as well as humans.

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INSECT REPRODUCTION AND LIFE CYCLES

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Abstract:

Insects, with their staggering diversity and numerical dominance in terrestrial ecosystems, have evolved an array of reproductive strategies and life cycles that are nothing short of remarkable. This chapter delves into the intricate world of insect reproduction and life cycles, shedding light on the mechanisms that drive their survival and perpetuation.

The chapter begins by exploring the reproductive strategies of insects, ranging from sexual reproduction with intricate courtship rituals to asexual reproduction via parthenogenesis. These strategies, honed over millions of years, influence genetic diversity and adaptation in insect populations.

Next, the chapter delves into the various stages of the insect life cycle: eggs, larvae, pupae, and adults. Each stage boasts unique morphological and physiological adaptations tailored to their specific roles in the insect's life history. Eggs exhibit astonishing diversity in shape and structure, while larvae, with their varied forms, are the primary feeding stage. Pupation marks a transformative period, showcasing the marvel of metamorphosis, which ultimately leads to the emergence of the adult insect, the pinnacle of their life cycle.

Environmental influences on insect reproduction and life cycles are also examined in detail. Factors such as temperature, photoperiod, humidity, and resource availability play pivotal roles in shaping these processes. Temperature, for instance, affects developmental rates and can even determine the sex of offspring in certain species. Photoperiod cues insects to undergo seasonal changes, leading to adaptations known as seasonal polyphenism.

This chapter underscores the importance of understanding insect reproduction and life cycles not only for scientific curiosity but also for practical applications, including pest management and conservation efforts. The intricate interplay between insects and their environment continues to captivate researchers, offering valuable insights into the intricacies of Earth's most abundant and diverse organisms. As we peer deeper into this entomological realm, we unlock secrets that contribute to our broader understanding of ecosystems and inspire awe for the miniature wonders that share our world.

Keywords: Insect reproduction, Insect life cycles, Reproductive strategies, Mating behaviour, Metamorphosis, Environmental influences, Parthenogenesis, Seasonal polyphenism, Insect ecology, Pest management

Introduction:

Insects, with their astonishing diversity and ubiquity across the planet, have long captivated the curiosity of scientists, entomologists, and naturalists. Their remarkable success as a group, boasting over a million described species and potentially millions more awaiting discovery, is a testament to their adaptability and resilience. At the heart of this success story lies the intricate world of insect reproduction and life cycles.

In this chapter, we embark on a journey into the fascinating realm of entomology, specifically focusing on the intricate processes that govern how insects reproduce and progress through the various stages of their lives. Insects, despite their diminutive size, play monumental roles in terrestrial ecosystems. They are pollinators, decomposers, herbivores, and predators, intricately woven into the ecological tapestry of our world. To comprehend their influence and significance, we must first unravel the mysteries of their reproductive strategies and life histories.

Our exploration begins with an examination of the diverse reproductive strategies employed by insects. From complex courtship rituals and sexual reproduction to the intriguing world of asexual reproduction through parthenogenesis, the strategies insects employ are as diverse as the environments they inhabit. These strategies profoundly impact the genetic diversity and adaptability of insect populations, allowing them to thrive in environments ranging from tropical rainforests to arid deserts.

Moving beyond reproduction, we delve into the various stages of the insect life cycle. Each stage, from the humble egg to the awe-inspiring transformation of metamorphosis, serves a distinct purpose in the insect's overall life history. Eggs, often overlooked in their importance, exhibit astonishing diversity in size, shape, and structure. Larvae, the voracious feeding machines of the insect world, take on a multitude of forms and adapt to various niches. Pupation marks a critical period of transformation, where the larva undergoes a metamorphic change that leads to the emergence of the adult insect—a pinnacle of evolutionary achievement.

Environmental influences on insect reproduction and life cycles are a central theme in our exploration. Temperature, photoperiod (day length), humidity, and resource availability all serve as environmental cues that insects have evolved to interpret. These cues profoundly affect the timing of developmental stages and the success of reproduction. Temperature, in particular, plays a pivotal role in determining developmental rates and even the sex of offspring in some species. Photoperiod, meanwhile, governs the seasonal shifts that lead to adaptations known as seasonal polyphenism, enabling insects to thrive in changing conditions.

Understanding insect reproduction and life cycles goes beyond mere academic curiosity. It has real-world applications in agriculture, conservation, and our broader understanding of ecosystems. As we uncover the mysteries of these remarkable creatures, we gain valuable insights into managing pest species, conserving endangered insects, and appreciating the intricate interplay between these tiny wonders and the environment they inhabit.

As we journey deeper into this entomological exploration, we unlock secrets that contribute to our appreciation of the natural world's complexity and inspire a profound sense of wonder for the myriad miniature marvels that share our planet.

Reproductive strategies in insects

1. Sexual reproduction:

Sexual reproduction is a common and intricate process among insects, involving the union of male and female gametes (sperm and egg) to produce offspring. This section explores the fascinating aspects of sexual reproduction in insects:

Mating behavior and courtship rituals: Insects exhibit an astonishing diversity of mating behaviors and courtship rituals, often tailored to the specific needs of their species. These behaviors serve several purposes:

- **Species recognition:** Mating rituals help insects recognize and choose suitable mates of the same species.
- **Mate attraction:** Through displays of colors, sounds, or pheromones, insects attract potential partners.
- **Sperm transfer:** Courtship often involves transferring sperm from the male to the female, a crucial step in sexual reproduction.

Examples of mating behavior range from the intricate aerial dances of dragonflies to the intricate vibrational signals used by certain beetles. The diversity of mating rituals in the insect world is a testament to their evolutionary adaptations to ecological niches.

Reproductive anatomy of insects: Understanding the reproductive anatomy of insects is key to comprehending how sexual reproduction takes place. Key features include:

- **Genitalia:** Insects possess specialized reproductive organs that allow for copulation and the transfer of sperm. These structures can be highly complex, with variations across species.
- **Sperm storage:** Female insects often have specialized structures for storing sperm received during copulation. This allows them to fertilize multiple batches of eggs over time.
- **Egg-laying mechanisms:** The female reproductive system includes adaptations for laying eggs in various environments, whether it be inside a host plant, in water, or in soil.

The diversity in reproductive anatomy reflects the remarkable adaptability of insects to a wide range of habitats and lifestyles.

2. Asexual reproduction

While sexual reproduction is prevalent among insects, asexual reproduction also occurs in certain groups and under specific circumstances:

Parthenogenesis and its occurrence: Parthenogenesis is a form of asexual reproduction where females produce offspring without mating with males. In parthenogenesis, unfertilized eggs develop into viable offspring. It's observed in several insect orders, including aphids, bees, and

some species of ants and wasps. This reproductive strategy is particularly advantageous when populations are isolated or when conditions are not conducive to finding a mate.

Clonal reproduction in select insect groups: Clonal reproduction refers to the production of genetically identical offspring from a single parent. Insects such as aphids and stick insects are known to reproduce clonally under certain circumstances. In these cases, females can produce offspring without the need for fertilization, leading to the rapid expansion of populations under favorable conditions.

Asexual reproduction can be a highly effective strategy for insects in specific contexts, but it often limits genetic diversity, which can have both advantages and disadvantages in terms of adaptation and survival.

Understanding these reproductive strategies, whether sexual or asexual, is crucial in unraveling the complex life histories and ecological roles of insects. It highlights the incredible diversity of life strategies that have evolved within this immensely successful group of organisms.

Insect life cycles

1. Egg stage

The egg stage is the starting point in the life cycle of insects, and it plays a crucial role in determining an insect's survival and success. This stage involves:

Diversity of insect egg morphology: Insects exhibit an astonishing diversity of egg shapes, sizes, and structures. These variations are often adapted to the ecological niche and reproductive strategy of the species. For example, some insect eggs are tiny and spherical, while others are elongated, ovoid, or even have intricate sculpturing on their surfaces. The diversity in egg morphology reflects the diversity of habitats and reproductive strategies that insects have evolved.

Behaviors and strategies for egg-laying: Insects have evolved a wide range of behaviors and strategies for laying their eggs in suitable environments. These strategies are often finely tuned to the needs of the offspring. For instance:

- Some insects deposit eggs directly onto host plants, where the hatching larvae will find immediate food.
- Others bury their eggs in the soil, protecting them from predators and adverse environmental conditions.
- Parasitic insects may lay their eggs on or within other insects, ensuring a ready source of food for their developing young.

The choice of egg-laying strategy is influenced by factors such as food availability, predation risk, and environmental conditions.

2. Larval stage

The larval stage is one of the most dynamic phases in an insect's life cycle, marked by rapid growth and development. This stage includes:

The various forms and adaptations of larvae: Larvae exhibit an astonishing array of forms, each adapted to the species' specific ecological niche. For example:

- Caterpillars, the larvae of butterflies and moths, have segmented bodies and chewing mouthparts ideal for consuming plant material.
- Fly larvae (maggots) are legless and adapted for feeding on decomposing organic matter.
- Aquatic insect larvae, such as mosquito larvae and dragonfly nymphs, have specialized structures for life in water.

These diverse forms enable larvae to occupy various niches and exploit different food sources.

Larval feeding habits and growth patterns: Larvae are primarily feeding machines, and their habits vary widely. Some are herbivorous, feeding on plants, while others are carnivorous or scavengers, consuming decaying matter or other insects. Larvae typically undergo a series of molts, shedding their exoskeletons to accommodate their increasing size. This process, known as metamorphosis, leads to the pupal stage.

3. Pupal stage

The pupal stage is a period of transformation, during which the larva undergoes a dramatic change to become an adult insect. There are two primary types of pupation:

Complete metamorphosis: In species exhibiting complete metamorphosis, the larva undergoes a significant transformation into an entirely different adult form. Examples include butterflies and beetles. The pupa, often encased in a cocoon or chrysalis, protects the developing insect as it undergoes this remarkable change.

Incomplete metamorphosis: In species with incomplete metamorphosis, the transition from larva to adult is more gradual. The nymph or juvenile stages resemble miniature versions of the adults and typically differ in size and the presence of wings. Examples include grasshoppers and dragonflies.

The diversity of pupal forms and behaviors is astonishing, reflecting the wide range of strategies insects have evolved to survive and thrive in various environments.

4. Adult stage

The adult stage is the culmination of an insect's life cycle, marked by various characteristics and behaviors:

Characteristics of adult insects: Adult insects exhibit diverse forms, sizes, colors, and structures, reflecting their adaptation to specific ecological roles. These adaptations include wings for flight, specialized mouthparts for feeding, and sensory organs for finding mates and suitable habitats.

Reproductive organs and mating behaviors: Reproduction is a primary focus of the adult stage. In this stage, insects develop specialized reproductive organs and exhibit a wide array of mating behaviors and courtship rituals. These behaviors serve to identify suitable mates and ensure successful mating.

Longevity and aging processes: The adult stage's duration and longevity vary widely among species. Some insects have short adult lives, measured in days or weeks, while others may live for months or even years. Aging processes in insects may involve physiological changes, such as a decrease in reproductive capacity or flight ability, as the insect reaches the end of its life span.
Understanding these distinct life stages in an insect's life cycle is crucial for comprehending their ecological roles, behavior, and adaptations to their environment. It also underscores the marvel of metamorphosis, a hallmark of insect biology.

Environmental influences on reproduction and life cycles

1. Temperature and development

Temperature plays a fundamental role in regulating insect development, impacting their growth rates, metabolism, and even reproductive processes. This section examines two important aspects related to temperature:

Thermoregulation in insects: Insects are ectothermic organisms, meaning their body temperature is primarily determined by the external environment. However, many insects have evolved sophisticated mechanisms for thermoregulation, allowing them to optimize their body temperature for various activities.

- **Basking behavior:** Some insects engage in basking behavior, where they expose themselves to sunlight to raise their body temperature. This is particularly common among butterflies and dragonflies.
- **Microclimate selection:** Insects may choose specific microenvironments within their habitat to regulate their temperature. For example, they might seek shade or cooler spots during hot weather or warm locations during cooler periods.
- **Behavioral thermoregulation:** Insects can also adjust their activity levels to avoid extreme temperatures. For instance, they may become more active during cooler parts of the day or night.

Temperature-dependent sex determination: In some insect species, particularly reptiles, and a few types of fish, temperature can determine the sex of offspring. This phenomenon is known as temperature-dependent sex determination (TSD). While not common in insects, it has been observed in a few cases.

- **Example:** In certain species of turtles, the temperature at which the eggs are incubated can lead to the development of either male or female offspring. Higher temperatures during incubation tend to produce females, while lower temperatures result in males.

Understanding how temperature influences development and sex determination is crucial, as it can have significant implications for population dynamics and conservation efforts in certain insect species.

2. Photoperiod and seasonal variation

Photoperiod, or the length of daylight in a 24-hour period, plays a critical role in regulating various physiological and behavioral processes in insects. This section delves into how photoperiod influences insect life cycles:

Perception of day length in insects: Many insects have evolved the ability to perceive changes in day length, often using photoreceptors in their eyes or other sensory structures. The perception of day length serves as a crucial environmental cue, signaling the changing seasons and triggering specific developmental responses.

- **Diapause induction:** Diapause is a state of dormancy or suspended development that insects enter to survive adverse conditions. Shortening day length, typically associated with the approach of winter, can trigger diapause in certain species. This helps insects avoid unfavorable environmental conditions.

Seasonal polyphenism and its ecological significance: Seasonal polyphenism refers to the phenomenon where a single insect species can produce distinct phenotypes (physical forms) in response to different seasons or environmental cues. These phenotypes often have specific adaptations suited to the conditions they will face.

- **Example:** In some butterflies, individuals born during the spring and summer might have bright, vibrant colors suitable for foraging and mating. However, those born in the fall may display subdued colors and different behaviors to prepare for migration or hibernation.

Understanding how photoperiod and seasonal cues influence insect behavior and development is essential for predicting life cycle timing, migration patterns, and population dynamics. It also highlights the intricate ways in which insects have adapted to their environments and the challenges they face due to seasonal changes.

Practical applications and significance

The importance of understanding insect reproduction and life cycles:

Understanding insect reproduction and life cycles is of paramount importance for several reasons:

1. **Ecosystem dynamics:** Insects play essential roles in ecosystems as pollinators, decomposers, herbivores, and predators. Their life cycles and reproductive strategies have direct impacts on ecosystem dynamics, including nutrient cycling, plant-pollinator relationships, and food webs.
2. **Biodiversity conservation:** Knowledge of insect life cycles helps in conserving endangered or threatened species. By understanding the specific requirements of different insect species during their various life stages, conservationists can implement targeted measures to protect their habitats and breeding sites.
3. **Pest management:** Insect pests can cause significant damage to crops, livestock, and structures. Understanding the life cycles and reproductive behaviors of pest species is critical for developing effective pest management strategies. This knowledge enables the timing of control measures, such as the application of pesticides or the introduction of natural predators.
4. **Invasive species control:** Invasive insects, when introduced to new ecosystems, can disrupt native species and cause ecological imbalances. Understanding their life cycles

and reproductive strategies is essential for devising strategies to control and manage invasive species.

Applications in pest management, agriculture, and conservation:

1. **Integrated Pest Management (IPM):** Knowledge of insect life cycles is central to IPM strategies, which aim to minimize the ecological and economic impacts of pests while reducing reliance on chemical pesticides. IPM involves monitoring pest populations at different life stages to determine the best timing for control measures, such as releasing natural predators or applying targeted treatments.
2. **Crop pollination:** In agriculture, understanding the life cycles of pollinating insects, such as bees and butterflies, is crucial for crop production. Farmers can implement practices to enhance pollinator habitats and ensure the availability of pollinators during critical periods, thus improving crop yields.
3. **Conservation planning:** Conservationists use knowledge of insect life cycles to design and manage protected areas, ensuring that habitats are suitable for both larval and adult stages of target species. This promotes the survival of endangered or threatened insects.
4. **Biocontrol:** In biological pest control, natural enemies of insect pests, such as parasitoids or predators, are employed to reduce pest populations. Understanding the life cycles of these natural enemies helps in releasing them at the most vulnerable stages of the pest's life cycle.

Contributions to our broader understanding of ecosystems:

Understanding insect reproduction and life cycles contributes significantly to our broader knowledge of ecosystems and ecological interactions:

1. **Indicator species:** Insects often serve as indicator species, meaning their presence or absence can reflect the health and stability of an ecosystem. Monitoring changes in insect populations and life cycles can provide early warnings of environmental disturbances or pollution.
2. **Food web dynamics:** Insects occupy various trophic levels in food webs, affecting both plants and animals. Studying their life cycles helps elucidate the intricate relationships and energy flow within ecosystems.
3. **Biodiversity studies:** Investigating the diversity of insect life cycles contributes to our understanding of overall biodiversity patterns. Insects represent a significant portion of global biodiversity, making them valuable subjects for biodiversity research.

Summarization of key points in the chapter:

1. **Reproductive strategies:** Insects exhibit a remarkable diversity of reproductive strategies, including sexual and asexual reproduction, with complex mating behaviors and courtship rituals.
2. **Life cycle stages:** Insect life cycles consist of several distinct stages, including the egg, larva, pupa, and adult stages, each with unique morphological and ecological adaptations.

3. **Environmental influences:** Temperature and photoperiod play crucial roles in regulating insect development and behavior. Temperature affects growth rates and can even determine the sex of offspring, while photoperiod cues seasonal changes and influences insect life cycle timing.
4. **Practical applications:** Understanding insect reproduction and life cycles has practical applications in pest management, agriculture, conservation, and invasive species control. It helps optimize timing for control measures, conserving biodiversity and pollinators while minimizing damage from pests.
5. **Contributions to ecology:** Knowledge of insect life cycles enriches our understanding of ecosystems, including food web dynamics, biodiversity patterns, and ecological interactions. Insects serve as indicators of ecosystem health.

Reflection on the marvels of insect reproduction and life cycles:

Insect reproduction and life cycles are nothing short of wondrous. These small creatures, with their seemingly infinite diversity and adaptations, provide us with a window into the intricacies of life on our planet. Their reproductive strategies, from the elegant courtship rituals of butterflies to the resilience of parthenogenesis in certain ants, showcase the versatility of life.

The different life stages, from the delicate eggs to the voracious larvae, the transformative pupae, and the intricate adults, are testaments to the beauty of adaptation and evolution. Insects have honed their life cycles over millions of years to navigate a wide range of habitats and ecological niches. Moreover, the impact of environmental cues, such as temperature and day length, on insect development and behavior highlights the interconnectedness of these tiny organisms with the larger natural world. They are finely attuned to the changing seasons, shaping their life strategies accordingly.

The ongoing relevance of entomological research:

Entomological research into insect reproduction and life cycles remains highly relevant for several reasons:

1. **Ecosystem health:** Insects are integral to ecosystem functioning. Understanding their life cycles helps us monitor and preserve the health of ecosystems, particularly in the face of environmental changes.
2. **Agriculture and food security:** Insects are crucial for crop pollination and can also be agricultural pests. Research into their life cycles aids in sustainable agriculture and ensuring global food security.
3. **Conservation:** Many insect species are threatened by habitat loss and climate change. Studying their life cycles is essential for conservation efforts aimed at preserving biodiversity.
4. **Pest management:** Insect pests can have devastating economic impacts. Knowledge of their life cycles informs effective pest management strategies that minimize ecological harm.

5. **Scientific discovery:** Insects serve as model organisms for various scientific studies. Their life cycles offer insights into broader biological processes, genetics, and development.

In conclusion, insect reproduction and life cycles are an endless source of wonder, providing valuable insights into the natural world and offering practical applications with far-reaching consequences. Entomological research in this field continues to be vital, ensuring that we can navigate the complex web of interactions between insects and their environments in an ever-changing world.

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STATUS OF WETLAND BIRDS IN AND AROUND PANVEL, NAVI MUMBAI, MAHARASHTRA

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Abstract:

Wetlands help to counter balance the human effect on rivers by rejuvenating them and surrounding ecosystems. Many animals that live in other habitats use wetlands for migration or reproduction. A total 23 bird species was recorded during the study. Out of these14 are migratory. Three species were found under threatened category. Painted stork, Black tailed godwit, Black headed Ibis. Destruction of habitats, wetlands and mudflats, human interference, rapidly changing environment has put these species under threat of extinction. So there is great need to maintain and restore wetlands.

Keywords: Navi Mumbai, Threatened, Birds, Wetland, Migration.

Introduction:

India has a wealth of wetland ecosystems that support diverse and unique habitats. These wetlands provide numerous ecological goods and services but are under tremendous stress due to rapid urbanization, industrialization and agricultural intensification, manifested by the shrinkage in their areal extent, and decline in the hydrological, economic and ecological functions they perform (Basi *et al*., 2014). Wetlands are considered to have unique ecological features which provide numerous products and services to humanity (Prasad *et al*., 2002). Ecosystem goods provided by the wetlands mainly include: water for irrigation; fisheries; non-timber forest products; water supply; and recreation. Major services include: carbon sequestration, flood control, groundwater recharge, nutrient removal, toxics retention and biodiversity maintenance (Turner *et al.*, 2000).Wetlands provide a wide range of ecosystem services such as groundwater recharge, attenuated nutrient runoff, habitat generation, and contaminant stabilization. Navi Mumbai is a city on the west coast of Maharashtra, India.

The site is approachable from Mumbai-Pune Highway via an approach road from Navi Mumbai. The international Airport area will be surrounded by 10 villages, viz. Kombad Bhuje, Ganeshpuri, Ulve, Mulgaon, Vaghiliwada, Owle, Pargaon, Kopar, Koli and Chinchpada. One of the best known functions of wetlands is to provide a habitat for birds. Humans have known of the link between birds and wetlands for thousands of years. Prehistoric people drew pictures of birds and wetlands on cave walls, scratched them onto rocks, and used them in the design of important for bird habitats, and birds use them for breeding, nesting, and rearing young. Birds also use wetlands as a source of drinking water and for feeding, resting, shelter, and social interactions. Some waterfowl, such as grebes, have adapted to wetlands to such an extent that their survival as individual species depends on the availability of certain types of wetlands within their

geographic range. Other species, such as the northern pintail or the American widgeon, use wetlands only during some parts of their lives. Wetlands help to counter balance the human effect on rivers by rejuvenating them and surrounding ecosystems. Many animals that live in other habitats use wetlands for migration or reproduction (Mitsch, W., 2010). Herons nest in large old trees, but need shallow areas in order to wade for fish and aquatic life. Amphibians often forage in upland areas but return to the water to mate and reproduce. While wetlands are truly unique, they must not be thought of as isolated and independent habitat. To the contrary, wetlands are vital to the health of all other biomes and to wildlife and humans everywhere. Unlike most other habitats, wetlands directly improve other ecosystems. Because of its many cleansing benefits, wetlands have been compared to kidneys. The analogy is good one. Wetlands are amongst the most productive ecosystems on the Earth, and provide many important services to human society (Brink *et al.*, 2012). Wetlands exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant species, and soil and sediment characteristics (Space Applications Centre, 2011).

Material and Methods:

Initially the area includes mangroves and backwaters near villages such as Kombadbhuja, Ulve, Dungi, Pargaon, Chinchpada and Kolhi Kopar, as well as creeks of Kharghar, Gadhi, Ulve, Kalamboli and Panvel were selected for the study area. Data was collected from wetlands, creeks, paddy fields, mangroves, mudflats,

The areas were surveyed using binoculars and digital camera for proper bird records during 2015-2016. Direct observations were made by walking along roads, wetlands, mangroves. Identification of birds has been carried out by using binocular and telescope. Some species of birds have also been shot. The birds were identified according Evans (1994), Harris *et al*. (1991) and Hudec (1990). The study on bird's habitats number was carried out by regular visit in the morning between 6.30 to 9.30 a.m. Birds were also identified following Ali and Ripley (1983), Grimmett *et al.* (2000) and Rasmussen and Anderton (2005).

Results and Discussion:

A total of 23 bird species was recorded during the survey. Out of them 14 were resident and 9 were migratory (Table1). Three species were found under threatened category, Painted stork, Black tailed godwit, Black headed Ibis (Table 2). Some birds depend on wetlands almost totally for breeding, nesting, feeding, or shelter during their breeding cycles. Birds that need functional access to a wetland or wetland products during their life cycle, especially during the breeding season, can be called "wetland dependent". Other birds use wetlands only for some of their needs, or they might use both wetland and upland habitats. The loss of ecosystem services of wetlands can have both economic and environmental consequences. Multiple authors acknowledge, vast variety of literature has been published. Attempting to give wetlands an economic value (Mitsch and Gosselink, 2000; BenDor *et al.*, 2008). In India, wetland ecosystems support diverse and unique habitats and are distributed across various topographic and climatic regimes. Wetlands not only support large biological diversity but also provide a wide array of

ecosystem goods and services (Wetlands Rules, 2010). The loss and degradation of habitat is the greatest threat to the long term survival of water birds. Irreversible loss of wetland continues at an alarming rate (Finlayson and Rea, 1999). An overall loss of biodiversity with decline in productivity adversely affecting the livelihood of the community. The preservation of wetlands is crucial for the survival of both resident and migratory birds because they provide the birds with specialized microhabitats and different kinds of food sources. Loss of wetlands and introduction of new age chemicals in agriculture is threatening the life support system because of large scale habitat destruction (Kupekar *et al*., 2014).

Table 1: List of Birds Found on Wetland of Panvel and nearby area

Sr.No	Common Name	Scientific Name	Status	Sites
1	Great cormorant	*Phalacrocorax carbo*	LC	All wetland area
2	Eastern cattle Egret	*Babulcus coromandus*	LC	All wetland area
3	Grey Heron	*Ardea cinerea*	LC	All weland area
4	Spot billed duck	*Anas poecilorhyncha*	LC	All wetland area
5	Northern shoveler	*Anas clypeata*	LC	Kharghar creeks
6	Black shouldered kite	*Elanus caeruleus*	LC	All wetland area
7	Western marsh harrier	*Circus aeruginosus*	LC	All wetland area
8	Red wattled lapwing	*Vanellus indicus*	LC	All wetland area
9	Little ringed plover	*Charadrius dubius*	LC	All wetland area
10	Common redshank	*Tringa tetanus*	LC	All wetland area
11	Wood sandpiper	*Tringa glareola*	LC	All wetland area
12	Common sandpiper	*Tringa hypoleucos*	LC	All wetland area
13	Marsh sandpiper	*Tringa stagnatilis*	LC	All wetland area
14	Black winged stilt	*Himantopus himantopus*	LC	All wetland area
15	Gull billed thern	*Gelochelidon nilotica*	LC	All wetland area
16	Brown headed gull	*Larus brunnicephalus*	LC	All wetland area
17	Black headed gull	*Larus ridibundus*	LC	All wetland area
18	White breasted kingfisher	*Halcyon smyrnensis*	LC	All wetland areaz
19	Common kingfisher	*Alcedo atthis*	LC	All wetland area
20	Flamingo	*Phoenicoptonus major(needs correction)*	LC	All wetland area

*LC: Least concern

Table 2: List of Threatened Spiece

Sr. No	Common Name	Scientific Name	Status	Sites
1	Painted stork	*Mycteria leucocephala*	NT	Pargaon, Kombadbhuje
2	Black headed Ibis	*Threskiornis melanocephalus*	NT	All wetland area
3	Black tailed godwit	*Limosa limosa*	NT	Khraghar creeks

*NT: Near Threatened

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SHORT REVIEW ON UNDERUTILISED INDIAN RED GOOSE BERRY

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Abstract:

Red amla, also known as Indian gooseberry or "Rakt Amla," is a variant of the traditional green amla (*Emblica officinalis*). It shares many of the health benefits with its green counterpart but also offers some unique advantages due to its red color. It has much more medicinal as well as culinary properties. These traditional variety of amla are found in South India especially Kanyakumari district and Kerala. When the amla gets riped it turns in to red colour and once when over riped it turns in to reddish brown colour giving a sour mixed with little sweet taste. In this short review the authors describes the various uses of red amla.

Keywords: Red Amla, Culinary Uses, Medicinal Uses

Introduction:

Green lefy vegetables, fruits and seeds contribute to the fibre content of the diet. Carotene is present in the dark green leafy vegetables, red and yellow fruits and vegetables except citrus friuits. Flavanoids naturally occuring in fresh fruits, vegetables, tea and wine are powerful antioxidants. β carotene,the provitamin A, is important for its antioxidant properties.It is abundant in the colour vegetables and fruits.

Photo graph showing red amla

Flacourtia indica is believed to be a plant native of tropical Asia. They are commonly available and cultivated in India, Africa, Philippines and Bangladesh. In India trees are very rare but they can be observed in South India especially Kerala and Tamil Nadu. Also called as red goose berry in village side.

Other names

English	-	Governors Plum
India	-	Loika, Lavalolika (Malayalam), Sivapau Nellikai (Tamil)
Malaysia	-	Lovi-Lovi
Philippines	-	Bakota Plum

Description

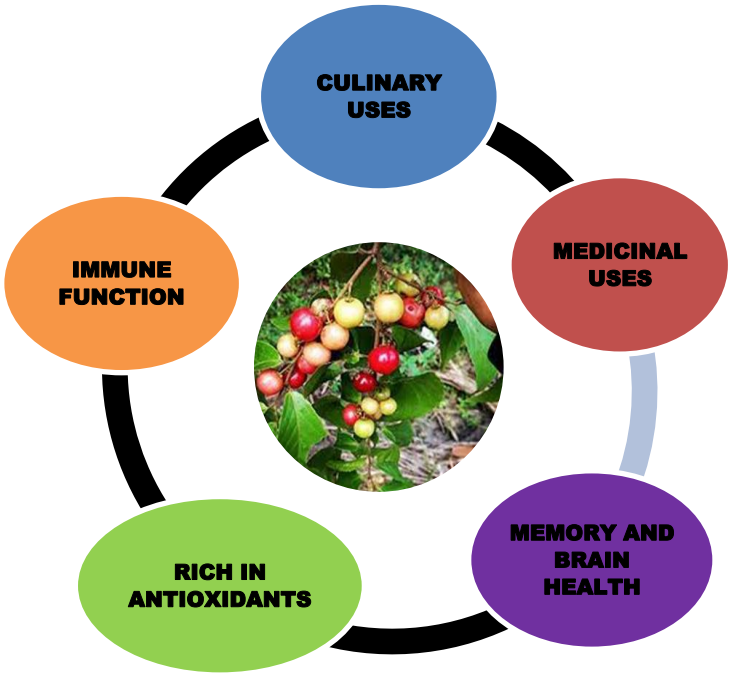
Usually, these trees grow in to a medium sized tree of height of nearly 15-50 feet. They adapt any type of climate and even grown in drought conditions. They can be cultivated in sandy and coastal soil.

Leaves of this tree is long when compared to other varieties. Tree looks beautiful when new leaves arises, the reason behind this is due to the colour of the leaves changing in combination with brown and green. Woods of the tree is only used as fire wood and not entertained for making for furniture. Most *flacoutria* species have small thorns, but rukam varieties lacks thorns.

They flower once in a year. They also yield fruits in the month of March to July. Almost all varieties of *Flacoutria* are very sweet and sour taste and have special taste, texture, flavor and aroma. Fruits look like brunches of cherries and are shiny and attractive. At the time of under ripened the fruit look like green tough skin but while ripening these fruits may change their colour in to pink to red.

When over ripened they again change their colour in to dark brown with sweet and sour taste. Red amla resembles plum in nature. People may suddenly get confused with red amla and plums since it resembles the same. Taste of the fruit is acidic. Fruits get ripened from 3 months from flowering.

Benefits of red amla



1. Culinary uses

Fruits can be pickled or made in to jam. In country side some people may choose taking red amla with salt and chilies to improve its taste. In rural areas these fruits are fermented to make wine.

2. Medicinal uses

Fruits are used in the treatment of dysentery and diarrhea.

3. Rich in antioxidants

Red amla is rich in antioxidants which may help in curing degenerative diseases.

4. Memory and brain health

Phytonutrient in red amla fight against free radicals and increase memory power

5. Immune function

Since amla contain phytonutrients like flavonoids, polyphenols and alkaloids along with vitamin C, it always keeps good immune function and protects the body.

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BIRD MIGRATION AND NAVIGATION

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Bird migration is one of the most spectacular events of the bird's life. It has intrigued mankind for many centuries, man has looked up in wonder as clouds of migrating birds darkened the skies. Avian migration is a natural process, where by different birds fly over distances of hundreds and thousands of kilometers in order to find the best ecological conditions and habitats for feeding, breeding and raising their young ones. Bird migration is the regular seasonal movement, often north and south, along a fly way, between breeding and wintering grounds. many species of bird migrate. migration carries high costs in predation and mortality, including from hunting by humans and is driven primarily by the availability of food. In bird migration, to find their way accurately in the process of navigation, it is a co-related with one another.

Animal navigation or bird navigation is the ability of many animals, to find their way very accurately without maps or the instruments. In different species obey different internal and external signals that cue their migration. Animals find their way by using an internal compass and mental maps, as well as other cues, to help them navigate. In navigation, of the seasonal migratory birds to find their way with the help of, landmarks, smell, the sun, and stars, or a mysterious quantum – physics-based ability to sense magnetic fields their journeys are inspiring.

German scientist or ornithologist, Gastav Kramer, migratory birds travel or migrate during the day orient themselves by the position of sun. Such as great river, valleys, coastal lines, chains of oceanic islands and mountain ranges. The large number of birds are migrating season, or some birds travel at night, they are nocturnal or night fliers, migrate with the help of constellations of stars.

Mechanism of navigation:

In sun compass, early discoveries animal navigation was that, the sun and stars provide important cues for orientation. During the day time, the sun shifts its position from east to west, north of the equator. If a bird is headed south, the sun should be kept on its left side in the morning and its right side in the afternoon. This means that, the migratory animals, what time of day, it is in order to use sun compass. Some birds are migrating in the night time, they use star compass and found their way, in Magnetic Cues discover Viginer 1882, birds detect the three essential components, intensity, inclination and declination. It is found in honeybee and pigeon. Honey can detect and magnetic changes of less than 10^{-3} gauss. Some birds are microsmatic having the sense of smell are highly developed. for eg. Pigeon might learn the direction of

different odor arriving at their home. It is concluded that, the way of navigation is different in different types of birds is also different.

Birds employ various mechanisms for navigation, often relying on a combination of innate abilities and learned behaviors.

1. Innate navigation:

Birds are equipped with innate abilities that enable them to navigate over long distances. They often have a built-in sense of direction and orientation. This is facilitated by:

Magnetic sensing: Birds can detect Earth's magnetic field using specialized cells containing magnetite. This allows them to sense the magnetic field lines and use them as a guide.

Sun compass: Birds use the sun as a reference point. They can compensate for the sun's movement throughout the day, allowing them to maintain a consistent direction.

Star navigation: During the night, birds can navigate by the stars. They are capable of recognizing specific constellations and using them for orientation.

Polarized light: Some birds are sensitive to polarized light patterns in the sky, especially during dawn and dusk. This helps them determine direction and time.

2. Learned Navigation:

In addition to their innate abilities, birds can also learn and adapt their navigation strategies based on experience. This includes:

Visual landmarks: Birds learn to recognize visual landmarks such as rivers, mountains, and coastlines. These landmarks serve as points of reference during migration.

Social learning: Young birds often learn migration routes and navigation techniques by following older, more experienced individuals. This social learning is particularly important for species with complex migration patterns.

Migratory corridors: Some bird species follow specific migratory corridors, taking advantage of favorable wind patterns and geographic features. This learned behavior helps optimize their routes.

In summary, the navigation in birds is a complex interplay of innate and learned mechanisms. These avian navigators utilize a combination of magnetic cues, celestial references, and learned landmarks to undertake impressive migratory journeys across vast distances.

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VIRUSES AND THEIR IMPACT ON CANCER FORMATION

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Introduction:

The determination that infection by a specific subset of human viruses is the primary cause of a substantial fraction of human. It was recently estimated that a virus infection is the central cause of more than 1,400,000 cancer cases annually, representing approximated 10% to 15% of the worldwide cancer burden. Some studies suggest that viruses are the leading causes of nearly 10%–15% of all cancers worldwide.

The widely accepted human oncoviruses are:

Human papilloma viruses (HPV), hepatitis B virus (HBV), hepatitis C virus (HCV), Epstein–Barr virus (EBV), Kaposi's sarcoma-associated herpesvirus (KSHV) (also called human herpesvirus 8), human T-cell lymphotropic virus (HTLV-1), and Merkel cell polyomavirus. An additional 5% of worldwide cancers, mostly gastric cancer, are attributed to infection by the bacterium *Helicobacter pylori*. The number of worldwide incident cases associated with specific virus varies widely, from 640,000 for HPV to 3000 for HTLV. Many different types of cancers are induced by human oncoviruses, and the fraction of each cancer type attributed to a viral infection varies widely. HPVs normally infect stratified epithelium and are causally associated with a number of anogenital carcinomas, including cervical, anal, vulvar, vaginal, and vulvar, and also carcinomas of another mucosal epithelium, most notably oropharyngeal. HBV and HCV have a strict tropism for hepatocytes and together are the cause of three-quarters of hepatocellular carcinomas. EBV normally infects B lymphocytes and epithelial cells and induces about half of Hodgkin's lymphoma and Burkitt's lymphomas. Almost 90% of HPV-induced cancers occur in females, while approximately, two-thirds of HBV, HCV, and EBV cancer occur in men (Table 1).

Table 1: Number of new cancer cases attributable to specific viral infections by gender
Data from (Plummer *et al.*, 2016)

Virus	Total	Females	Males
HPV	636,000	570,000	66,000
HBV	420,000	120,000	300,000
HCV	165,000	55,000	110,000
EBV	120,000	40,000	80,000
KSHV	43,000	15,000	29,000
HTLV	2,900	1,200	1,700

Oncogenic mechanisms: The oncogenic mechanisms of many tumour viruses involve the continued expression of specific viral gene products that regulate proliferative, anti-apoptotic, and/or immune escape activities through an interaction with cellular gene targets. Although some viral infections can increase the risk of cancer, they do not necessarily cause the progression of cancer. Some common viral carcinogenic features of cancer development include (i) direct transformation through the expression of viral genes, (ii) encoding oncoproteins, (iii) inactivating regulators of genome stability, (iv) interference in cell viability and cell cycle, (v) inactivating p53 and retinoblastoma proteins (pRB), (vi) activation of the DNA damage response, and (vii) changes to cellular levels of reactive oxygen species (ROS) and induction of oxidative stress (OS).

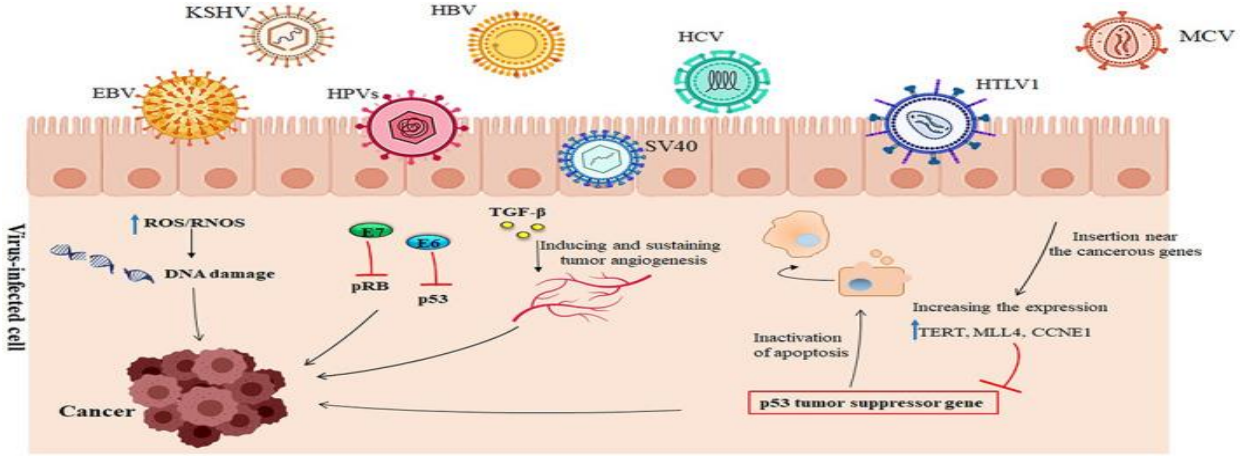

Figure: Oncogenesis mechanisms of viruses in cancer development. Viruses induce their carcinogen activity via insertion near the cancer genes such as telomerase reverse transcriptase (TERT), cyclin A2 (CCNA2), and cyclin E1 (CCNE1), and increase their expression, which results in inactivating the p53 and apoptosis mediated by that. Moreover, viruses, by increasing the expression of some factors like TGF-β, can the tumor development due to the inducing and sustaining tumor angiogenesis. In addition, these viruses change and increase ROS production and induce oxidative stress (OS), resulting in DNA damage and then increasing the risk of tumor development.

Types of viruses that can cause cancer

Both DNA and RNA viruses have been shown to be capable of causing cancer in humans.

Human tumour viruses:

Virus infection also is generally not sufficient for cancer, and additional events and host factors, such as immunosuppression, somatic mutations, genetic predisposition, and exposure to carcinogens must also play a role. Epstein-Barr virus, human papilloma virus, hepatitis B virus, and human herpes virus-8 are the four DNA viruses that are capable of causing the development of human cancers. Human T lymphotrophic virus type 1 and hepatitis C viruses are the two RNA viruses that contribute to human cancers.

Hepatitis B and C viruses:

Hepatitis C virus is an enveloped RNA virus of the flavivirus family. It is capable of causing both acute and chronic hepatitis in humans by infecting liver cells. It is estimated that approximately 3 percent of the world's population are hepatitis C carriers. The hepatitis B virus of the family hepadnaviridae is a DNA virus, but the features of its resulting disease share many similarities with hepatitis C virus. Hepatitis B virus also is a blood-borne pathogen that can result in acute and chronic hepatitis. Chronic hepatitis, that is, infections lasting more than three months, can lead to cirrhosis and liver failure. Chronic infection also can lead to the development of hepatocellular carcinoma.

Epstein-Barr virus (EBV) and human herpesvirus 8 (HHV-8):

EBV and HHV-8 (also known as Kaposi sarcoma herpesvirus) are both herpesviruses that possess large double-stranded DNA genomes. Both are associated with naturally occurring tumors in humans. The KSHV is well known as the causative agent of primary effusion lymphoma and is common in AIDS patients.

Human Papillomavirus (HPV):

HPV are small non-enveloped DNA tumor viruses that commonly cause benign papillomas or warts in humans. Persistent infection with high-risk subtypes of human papillomavirus (HPV) is associated with the development of cervical cancer. Cervical cancer is the second leading cause of cancer mortality in women worldwide, causing 240,000 deaths annually. HPV infects epithelial cells, and, after integration in host DNA, the production of oncoproteins, mainly E6 and E7, disrupts natural tumor suppressor pathways and is required for proliferation of cervical carcinoma cells. HPV also is believed to play a role in other human cancers, such as head and neck tumors, skin cancers in immunosuppressed patients, and other anogenital cancers. According to the reports, the DNA of HPV is observed in more than 90% of malignant squamous lesions of the uterine cervix. The HPV16, HPV18, HPV31, and HPV33 are the most common members of this family that are involved in more than 90% of all cervical cancer cases. However, HPV type 16 is considered the most diagnostic type, having been observed in more than 50% of all cervical cancer cases.

Merkel cell polyomavirus:

Merkel cell polyomavirus (MCV) belongs to the double-stranded DNA polyomaviruses, which are well known as causative agents of Merkel cell carcinoma (MCC). The MCV induces its anticancer activity by encoding the tumor-associated antigens and protein complexes that can target multiple tumor suppressor proteins, like pRB and p53.

Human T lymphotropic virus type I (HTLV-1):

HTLV-1 is a slow transforming, single stranded RNA retrovirus and is associated with adult T-cell leukemia. It possesses a diploid genome similar to other retroviruses: two long terminal repeats flanking gag, pol, and env genes as well as a number of accessory genes. HTLV-1 has a worldwide distribution, with an estimated 12 to 25 million people infected.

However, disease is only observed in less than 5 percent of infected individuals. It is transmitted through blood transfusions, sexual contact, and during parturition.

Simian virus 40:

Simian virus 40 (SV40) is another oncogenic DNA virus associated with brain tumors, osteosarcomas, malignant mesothelioma, and lymphomas.

Human T-cell leukemia virus-1:

Human T-cell leukemia virus-1 (HTLV-1), well known as RNA oncovirus, belongs to the family Retroviridae and the genus Delta retrovirus and is associated with fatal T-cell leukemia (adult T-cell leukemia) and progressive myelopathy (HTLV-1-associated myelopathy/tropical spastic paraparesis HAM/TSP).

Viruses in Cancer Therapy:

Virotherapy refers to using viruses to treat cancer that can find and destroy tumor cells specifically through different mechanisms without affecting normal cells. This method converts viruses into therapeutic agents by using biotechnology and reprogramming them to treat cancer. Virotherapy can be divided into three main groups, namely: (i) anticancer oncolytic viruses, (ii) viral vectors for gene therapy, and (iii) viral immunotherapy. All these approaches are based on therapeutic methods, including overexpression of the specific genes, usage of RNA methods to silence or decrease the expression of cancerous genes called gene knockout, and usage of the virus as a vector to deliver the gene that induces apoptosis and death in tumor cells, also known as “suicide gene delivery.”

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Research Trends in Life Sciences Volume II (ISBN: 978-93-88901-90-1)

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Dr. Srikanta Guria is presently serving as Assistant professor (W.B.E.S) of Post Graduate Dept. of Zoology, Barasat Govt. College, Govt. of West Bengal, Barasat, Kolkata (West Bengal)- 700124. He did B.Sc. (Zoology Hons.) in 2002, M.Sc. (Zoology) in 2004 from University of Calcutta. He qualified SLET(SET) (2005) and NET (2006). He did Ph.D. (Zoology) from University of Calcutta (Title of the Thesis-Assessment of Thyroid Peroxidase (tpo) Gene Polymorphism in Hypothyroid Patients). He was selected for Jr. Research Fellow (JRF), UGC –RFSMS at Department of Zoology, University of Calcutta. He taught in Darjeeling Govt. College, prior to Barasat Govt. College. His area of research is in the field of Genetics, Cell Biology, Immunology & Endocrinology. His total publications in peer reviewed journals are 59. He secured 1 st position in oral presentation in national seminar at Rishi Bankim Chandra College, Naihati, W.B. dt. 27-28th April, 2023. He secured 1st position in competitive poster presentation in national seminar organized by Raja Peary Mohan College with SEBA on 2nd August 2019. He received best senior scientist award for oral presentation at national seminar at University of Kalyani on 24th November 2013. He received award for outstanding paper presentation at national symposium organized by Department of Zoology, University of North Bengal on March 08-09, 2013.

Bhumi Publishing

ISBN 978-93-88901-90-1
9 789388 901901