

For UPSC and State Civil Services Examinations

Environment and Biodiversity

Helpful in IAS Preparation

**SECOND
EDITION**



 **Available on App**
➤ Environment Legislations
➤ Government Notified Rules to
Protect Environment

Environment and Biodiversity

for

UPSC and State Civil Services
Examinations

2e



Australia • Brazil • Canada • India • Mexico • Singapore • United Kingdom • United States



**Environment
and Biodiversity**

Second Edition

© 2022 Cengage Learning India Pvt. Ltd.

ALL RIGHTS RESERVED. No part of this work covered by the copyright herein may be reproduced or distributed in any form or by any means without the prior written permission of the copyright owner.

For product information and technology assistance, contact us at
india.support@cengage.com

For permission to use material from this text or product, submit all requests
online at
www.cengage.com/permissions

ISBN-13: 978-93-5573-040-4

ISBN-10: 93-5573-040-3

**Cengage Learning India Pvt. Ltd.
T-303, 3rd Floor
DAV Complex, Plot 3
Mayur Vihar Phase 1
Delhi-110091**

Cengage is a leading provider of customized learning solutions with employees residing in nearly 40 different countries and sales in more than 125 countries around the world. Find your local representative at **www.cengage.com**

Cengage is committed to creating inclusive and diverse products, including perspectives that represent the diversity of people across all backgrounds, identities, opinions, and experiences. If you have any feedback related to this, please contact us at **support.cengage.com**

To learn more about Cengage products, platforms and services, visit at **www.cengage.co.in**

Printed by:
Rajiv Book Binding House
D-1518, DSIIDC Industrial Complex, Narela, New Delhi 110040

Printed in India
Print Number: 01

Print Year: 2022

Contents

<i>Preface</i>	<i>xvii</i>
<i>Acknowledgements</i>	<i>xix</i>
<i>List of Videos</i>	<i>xxi</i>
<i>Chapter-wise Break up of Previous Year's Questions (Prelims)</i>	<i>xxii</i>

UNIT I ECOLOGY

1

ECOLOGY—BASICS

1.1–1.33

1 Ecology	1.1
<i>Biotic Component</i>	1.1
<i>Ecology and Ecosystem</i>	1.1
<i>Abiotic Component</i>	1.5
<i>Interactions Among Organisms</i>	1.5
<i>Interactions with Abiotic Components</i>	1.7
<i>Levels of Study in Ecology</i>	1.9
2 Community	1.10
3 Ecosystem	1.10
4 Biome	1.11
5 Biosphere	1.11
<i>Terminology related to Ecology and Ecosystem</i>	1.12
<i>Ecological Succession</i>	1.15
<i>Productivity (in Ecology)</i>	1.18
<i>Determinants of Species Behaviour: Genotype and Phenotype</i>	1.19
<i>Types of Species</i>	1.19
Practice Questions	1.22
Perfecting Past Prelims	1.30
Solutions	1.30

2

FUNCTIONS OF ECOSYSTEM

2.1–2.33

1 Food Chain	2.1
<i>Functions of Ecosystem</i>	2.1

	<i>Trophic Levels</i>	2.2
	<i>Beginning of Food Chain</i>	2.3
	<i>Food web</i>	2.6
2	Ecological Pyramids	2.7
	<i>Types of Ecological Pyramids</i>	2.7
	<i>Upright and Inverted Pyramids</i>	2.8
	<i>Bioaccumulation</i>	2.10
	<i>Bioconcentration</i>	2.10
	<i>Biomagnification</i>	2.10
3	Biogeochemical Cycle	2.10
4	Importance of Biogeochemical Cycles	2.11
	<i>Water Cycle (Hydrological Cycle)</i>	2.12
	<i>Carbon (C) Cycle</i>	2.14
	<i>Nitrogen Cycle</i>	2.15
	<i>Oxygen Cycle</i>	2.16
	<i>Phosphorus Cycle</i>	2.17
	<i>Sulphur Cycle</i>	2.18
5	Ecosystem Services	2.19
	Practice Questions	2.21
	Perfecting Past Prelims	2.28
	Solutions	2.30

3

TERRESTRIAL ECOSYSTEM

3.1–3.33

1	Terrestrial Ecosystem	3.1
	<i>Champion and Seth Classification</i>	3.1
	<i>Mangroves</i>	3.13
2	Important Tree Varieties of Each State and Union Territory	3.15
3	State of Forest Report, 2019	3.16
	<i>Details of the Report</i>	3.16
4	Types of Forests on the Basis of Protection	3.20
	Practice Questions	3.21
	Perfecting Past Prelims	3.29
	Solutions	3.31

4

AQUATIC ECOSYSTEM

4.1–4.28

1	Introduction	4.1
	<i>Abiotic Factors in Aquatic Ecosystem</i>	4.1
2	Ocean Ecosystem	4.3

3	Lake Ecology/Lake Ecosystem	4.5
	<i>Classification of Lakes</i>	4.5
4	Eutrophication	4.5
	<i>Cultural Eutrophication</i>	4.6
	<i>Consequences of Eutrophication</i>	4.6
5	Wetland Ecosystem	4.7
	<i>Importance of Wetlands</i>	4.7
	<i>Wetlands of India</i>	4.7
	<i>National Wetlands Conservation Programme (NWCP)</i>	4.8
	<i>Threats</i>	4.8
6	Estuary Ecosystem	4.8
	<i>Characteristics of Estuaries</i>	4.8
	<i>Estuaries in India</i>	4.8
7	Coral Reefs	4.9
	<i>Requirements for the Survival of Coral Organisms</i>	4.9
	<i>Symbiotic Relationship of Coral Organisms</i>	4.9
	<i>Advantages of Coral Reefs</i>	4.9
	<i>Classification and Location of Coral Reefs in India</i>	4.9
	<i>Coral Bleaching</i>	4.10
	<i>Techniques of Water Conservation</i>	4.13
	Practice Questions	4.16
	Perfecting Past Prelims	4.24
	Solutions	4.25

UNIT II ENVIRONMENTAL DEGRADATION AND SUSTAINABLE DEVELOPMENT

5

ENVIRONMENTAL DEGRADATION

5.1–5.52

1	Causes of Environmental Degradation	5.1
	<i>Social Factors</i>	5.1
	<i>Economic Factors</i>	5.2
	<i>Institutional Factors</i>	5.2
2	Pollution	5.4
	<i>Air Pollution</i>	5.4
	<i>Primary Pollutants</i>	5.4
	<i>Secondary Pollutants</i>	5.7
3	National Air Quality Index	5.8
	<i>AQI Category, Pollutants and Health Breakpoints</i>	5.8
	<i>List of Eight Pollutants under National AQI</i>	5.9
4	Graded Response Action Plan (GRAP)	5.10

	<i>Environment Pollution (Prevention and Control) Authority</i>	5.13
5	Comprehensive Environmental Pollution Index (CEPI)	5.16
6	Paddy stubble burning	5.17
	<i>Solutions</i>	5.18
7	Light Pollution	5.19
8	Vehicle Pollution	5.20
9	Bharat Stage norms	5.20
10	Persistent Organic Pollutants	5.22
11	Fly Ash	5.23
12	Green Crackers	5.23
13	Water Pollution—Point and Nonpoint Sources	5.25
	<i>Effects of Water Pollution</i>	5.26
	<i>Hazards of Groundwater Pollution</i>	5.28
	<i>Oil Spills</i>	5.28
14	Radioactive Pollution	5.29
	<i>Radioactivity</i>	5.29
	<i>Types of Radiations</i>	5.30
15	Electronic Waste	5.31
	<i>Types of e-Waste</i>	5.31
16	Solid Waste	5.32
	<i>Plastic Waste</i>	5.32
17	Environment-related Diseases	5.34
	<i>Minamata Disease</i>	5.34
	<i>Itai-Itai Disease</i>	5.35
	<i>Blue Baby Syndrome</i>	5.35
	<i>Pneumoconiosis Disease</i>	5.35
	<i>Asbestosis</i>	5.35
	<i>Silicosis</i>	5.35
	<i>Emphysema</i>	5.35
	<i>Sick Building Syndrome</i>	5.35
	<i>Health Effects of Certain Substances</i>	5.36
18	Desertification	5.36
	<i>Causes of Desertification</i>	5.37
	<i>Impact of Desertification</i>	5.38
	Practice Questions	5.39
	Perfecting Past Prelims	5.47
	Solutions	5.49

6

ENVIRONMENT IMPACT ASSESSMENT

6.1–6.49

1	Environment Impact Assessment	6.1
	<i>Evolution of EIA</i>	6.1

	<i>Environment Impact Assessment in India</i>	6.2
	<i>Stages of EIA</i>	6.5
	<i>List of Projects Requiring Environmental Clearance from the Central Government</i>	6.11
2	Environmental Impact of Coal	6.14
	<i>Coal Mining</i>	6.15
	<i>Mine Wastes</i>	6.15
	<i>Transportation</i>	6.15
	<i>Burning of Coal</i>	6.15
3	Water requirements of coal industry	6.16
4	Working of Thermal Power Plants	6.17
	<i>Components of Thermal Power Plant</i>	6.18
5	Acid Mine Drainage (AMD)	6.19
6	Underground Coal Mine Fires	6.21
7	'Clean Coal' Technologies	6.21
	<i>Coal Gasification</i>	6.21
	<i>Advantages of Coal Gasification</i>	6.22
	<i>Present Status of Coal Gasification</i>	6.22
8	Coal bed methane	6.22
	<i>What Actually Is Coalbed Methane?</i>	6.22
	<i>Extraction</i>	6.22
	<i>Context</i>	6.22
9	Natural Gas	6.23
	<i>Environmental Impact</i>	6.23
10	Crude Oil	6.27
	<i>Environmental Impact of Oil</i>	6.27
11	Unconventional Hydrocarbons	6.29
	<i>Shale Gas</i>	6.29
	<i>Black Shale</i>	6.30
	<i>Unconventional Oil and Natural Gas</i>	6.31
	<i>Gas Hydrates</i>	6.33
	<i>Oil Shale</i>	6.33
12	Environmental Impact of Sand Mining	6.34
	<i>Regulatory mechanism for sand mining in India</i>	6.35
	<i>Sustainable Sand Mining</i>	6.37
	<i>Practice Questions</i>	6.38
	<i>Perfecting Past Prelims</i>	6.46
	<i>Solutions</i>	6.47

7

ENVIRONMENT RESTORATION TECHNIQUES

7.1–7.16

1	Ecosystem Restoration	7.1
	<i>Difference between Environmental Restoration, Rehabilitation and Mitigation</i>	7.1

2	Treatment and Disposal of Solid Waste	7.1
	<i>Open Dumps</i>	7.1
	<i>Landfills</i>	7.2
	<i>Sanitary Landfills</i>	7.2
	<i>Incineration</i>	7.2
	<i>Pyrolysis</i>	7.2
	<i>Composting</i>	7.2
	<i>Vermiculture</i>	7.2
	<i>Pelletisation</i>	7.2
3	Bioremediation	7.3
	<i>Strategies of Bioremediation</i>	7.3
4	Bio-Toilets	7.5
5	Ganga Action Plan	7.6
	<i>Recent Efforts to Clean Ganga</i>	7.7
6	Habitat Fragmentation	7.8
7	Run-of-the-river (ROR) Hydroelectric Power Projects	7.8
8	Drawdown Technique of Desilting	7.9
	Practice Questions	7.10
	Perfecting Past Prelims	7.14
	Solutions	7.15

8

SUSTAINABLE DEVELOPMENT**8.1–8.48**

1	Sustainable Development	8.1
	<i>History of Sustainable Development</i>	8.2
	<i>Pillars of Sustainable Development</i>	8.2
	<i>What Are Sustainable Development Goals?</i>	8.3
	<i>Evolution of SDGs</i>	8.4
2	Measures of Sustainability	8.5
	<i>Carbon Footprint</i>	8.5
	<i>Ecological Footprint</i>	8.5
	<i>Comparison between Demand and Supply of Natural Resources</i>	8.5
	<i>Earth Overshoot Day (EOD)</i>	8.5
	<i>Social Cost of Carbon</i>	8.6
	<i>Biotic Potential</i>	8.7
	<i>Planetary Boundaries</i>	8.8
	<i>Principles to Protect Environment</i>	8.8
3	Eco-efficiency and Eco-effectiveness	8.9
	<i>How Eco-efficiency and Eco-effectiveness can be achieved?</i>	8.10
	<i>Difference between Eco-efficiency and Eco-effectiveness</i>	8.10
4	Circular Economy	8.11

	<i>Principles of Circular Economy</i>	8.12
	<i>Elements of Circular Economy</i>	8.13
5	Permaculture	8.14
	<i>Organic Farming</i>	8.14
	<i>History</i>	8.15
	<i>Integrated Pest Management</i>	8.18
	<i>Biopesticides</i>	8.18
	<i>Biofertilizers</i>	8.19
	<i>Weed Management</i>	8.20
	<i>What Does Organic Farming Exclude?</i>	8.20
	<i>Zero Tillage</i>	8.21
	<i>Allelopathy</i>	8.22
6	Zero Budget Natural Farming	8.22
	<i>Components of ZBNF</i>	8.23
7	Soil	8.25
	<i>Soil Profile</i>	8.26
	<i>Soil Degradation and Soil Erosion</i>	8.27
	<i>Soil Conservation</i>	8.28
	Practice Questions	8.30
	Perfecting Past Prelims	8.38
	Solutions	8.44

UNIT III BIODIVERSITY

9

BIODIVERSITY

9.1–9.14

1	Biodiversity	9.1
	<i>Levels of Biodiversity</i>	9.1
	<i>Why is Biodiversity Important?</i>	9.3
	<i>Global Biodiversity</i>	9.4
	<i>Biodiversity in India</i>	9.5
	<i>Modes of Conservation of Biodiversity</i>	9.5
	<i>Species Richness in India</i>	9.5
	<i>Variation in Biodiversity</i>	9.6
	<i>Megadiversity Countries</i>	9.6
	Practice Questions	9.8
	Perfecting Past Prelims	9.12
	Solutions	9.13

10

ANIMAL DIVERSITY

10.1–10.69

1	Invertebrates	10.1
	I. Protozoans	10.2
	II. Annelids	10.2
	III. Arthropods	10.2
	IV. Molluscs	10.3
	V. Echinoderms	10.4
2	Vertebrates	10.5
	I. Fishes	10.5
	II. Amphibians	10.6
	III. Reptiles	10.6
	IV. Birds	10.10
	V. Mammals	10.10
3	Endangered Species	10.11
	<i>Classification of Species by IUCN</i>	10.11
4	Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)	10.12
	<i>How CITES works?</i>	10.13
5	Convention on Conservation of Migratory Species (Bonn Convention)	10.15
	<i>How CMS works?</i>	10.15
6	List of important Animal Species Threatened in India	10.16
	<i>Birds</i>	10.16
	<i>Terrestrial Mammals</i>	10.25
	<i>Reptiles</i>	10.40
	<i>Fishes</i>	10.45
	<i>Aquatic Mammals</i>	10.47
	Practice Questions	10.50
	Perfecting Past Prelims	10.61
	Solutions	10.65

11

PLANT DIVERSITY

11.1–11.18

1	Plant Kingdom	11.1
	<i>Classification under Plant Kingdom</i>	11.2
2	Reproduction in the Flowering Plants	11.3
3	What are Herbs and Shrubs?	11.4
4	Effects of Abiotic Components on Plants	11.4
	<i>Effects of Light on Plants</i>	11.4
	<i>Effects of Temperature on Plants</i>	11.5
5	Insectivorous Plants	11.5

	<i>Why Do Insectivorous Plants Feed on Insects?</i>	11.5
6	Parts of a Tree	11.6
7	Marine Biodiversity	11.7
8	Planktons	11.7
	<i>Phytoplanktons</i>	11.7
	<i>Zooplanktons</i>	11.8
9	Sea Grass	11.8
10	Sea Weeds	11.9
11	Algaculture	11.9
	Practice Questions	11.10
	Perfecting Past Prelims	11.14
	Solutions	11.16

UNIT IV BIODIVERSITY CONSERVATION EFFORTS

12

PROTECTED AREA NETWORK

12.1–12.33

1	Wildlife Sanctuaries and National Parks	12.1
	<i>Differences between National Park and Wildlife Sanctuary</i>	12.1
	<i>Procedure for Declaration of Protected Areas</i>	12.1
2	Conservation Reserves and Community Reserves	12.4
	<i>Conservation Reserves</i>	12.4
	<i>Community Reserves</i>	12.4
3	Biodiversity Heritage Sites	12.5
	<i>List of Biodiversity Heritage Sites in India</i>	12.6
4	International Initiative to Declare Protected Areas	12.8
5	Biosphere Reserves	12.8
	<i>Criteria for the Selection of Biosphere Reserves</i>	12.8
	<i>National Biosphere Reserve Programme</i>	12.12
	<i>How Is a Biosphere Reserve Declared?</i>	12.12
	<i>World Network of Biosphere Reserves</i>	12.13
	<i>Biosphere Reserves in India Recognised under MAB Programme</i>	12.13
	<i>Difference between Biosphere Reserves and Other Protected Areas Such As National Parks and Wildlife Sanctuaries</i>	12.13
6	Biodiversity Hotspots	12.14
	<i>Biodiversity Hotspots in India</i>	12.16
7	World Heritage Sites	12.17
	<i>Cultural Criteria</i>	12.17
	<i>Natural Criteria</i>	12.17
	<i>World Heritage Sites in India</i>	12.17

Practice Questions	12.20
Perfecting Past Prelims	12.28
Solutions	12.31

13**CONSERVATION EFFORTS FOR PARTICULAR SPECIES****13.1–13.20**

1 Project Tiger	13.1
<i>The NTCA</i>	13.1
<i>Tiger Census</i>	13.1
2 Project Elephant	13.4
<i>Elephant Census</i>	13.5
3 Asiatic Lion Conservation Project	13.5
4 Project Great Indian Bustard	13.5
5 Vulture Conservation efforts	13.6
6 National Conservation Strategy for the Indian One-Horned Rhinoceros	13.6
<i>Indian Rhino Vision 2020</i>	13.7
7 Project Snow Leopard	13.7
8 Sea Turtle Project	13.7
9 Indian Crocodile Conservation Project	13.8
10 Project Hangul	13.8
11 Ganges Dolphin	13.8
12 National Wildlife Action Plan (NWAP) for 2017-31	13.8
13 Integrated Development of Wildlife Habitats	13.10
Practice Questions	13.11
Perfecting Past Prelims	13.16
Solutions	13.18

UNIT V CLIMATE CHANGE**14****CLIMATE CHANGE****14.1–14.14**

1 Global Warming	14.1
<i>Greenhouse Effect or Glass House Effect</i>	14.1
<i>Important Greenhouse Gases</i>	14.1
<i>Factors Affecting Climate Change</i>	14.5
<i>Implications of Global warming</i>	14.5
<i>Evidence of Global Warming</i>	14.6
Practice Questions	14.6
Perfecting Past Prelims	14.11
Solutions	14.13

15**ACIDIFICATION****15.1–15.12**

- | | | |
|---|---|-------|
| 1 | Ocean Acidification | 15.1 |
| | <i>Factors Which Influence Ocean Acidification</i> | 15.1 |
| | <i>Buffering</i> | 15.1 |
| | <i>Impact of Ocean Acidification on Calcium Carbonate Shells of Marine Life</i> | 15.2 |
| | <i>Upwelling</i> | 15.2 |
| | <i>Overall Impact of Ocean Acidification</i> | 15.3 |
| | <i>Marine Species</i> | 15.3 |
| 2 | Acid Rain | 15.4 |
| | <i>Acidity of Polluted Rain Water</i> | 15.5 |
| | <i>Impact of Acid Rain</i> | 15.6 |
| | <i>Difference between Naturally and Anthropogenically Acidified Lakes</i> | 15.6 |
| | Practice Questions | 15.7 |
| | Perfecting Past Prelims | 15.10 |
| | Solutions | 15.11 |

16**OZONE HOLE****16.1–16.10**

- | | | |
|---|--|------|
| 1 | Ozone Depletion | 16.1 |
| | <i>Types of UV Radiation</i> | 16.1 |
| | <i>Impact of Ozone Depletion</i> | 16.1 |
| | <i>Ozone Hole</i> | 16.2 |
| | <i>Ozone Depleting Substances</i> | 16.2 |
| | <i>Role of Polar Stratospheric Clouds in Ozone Depletion</i> | 16.4 |
| | <i>Measurement of Ozone</i> | 16.4 |
| | Practice Questions | 16.5 |
| | Perfecting Past Prelims | 16.8 |
| | Solutions | 16.9 |

17**CARBON MITIGATION STRATEGIES****17.1–17.16**

- | | | |
|---|---|------|
| 1 | Carbon Sequestration | 17.1 |
| | <i>Techniques of Carbon Sequestration</i> | 17.1 |
| | <i>Carbon Sink</i> | 17.1 |
| 2 | Carbon Capture vs Carbon Sequestration | 17.2 |
| 3 | Geoengineering | 17.4 |
| 4 | Albedo | 17.5 |
| | <i>Impact of Insolation and Albedo</i> | 17.5 |
| | <i>Albedo and Climate Change</i> | 17.6 |

	Albedo and Day-to-Day Life	17.6
5	Cryosphere	17.6
	Role of cryosphere in climate change	17.6
6	Greenhouse Gas Protocol	17.7
	Calculation of GHG Emissions	17.7
7	Artificial Leaf Technology	17.8
	Practice Questions	17.9
	Perfecting Past Prelims	17.13
	Solutions	17.14

18

INDIA AND CLIMATE CHANGE**18.1–18.15**

1	National Action Plan on Climate Change or Measures of India to Reduce Climate Change	18.1
	<i>National Solar Mission or Jawaharlal Nehru National Solar Mission</i>	18.1
	<i>National Mission for Enhanced Energy Efficiency</i>	18.1
	<i>National Mission for Sustainable Habitat</i>	18.2
	<i>National Water Mission</i>	18.2
	<i>National Mission for Sustaining Himalayan Ecosystem</i>	18.2
	<i>National Mission for Green India</i>	18.3
	<i>National Mission for Sustainable Agriculture</i>	18.3
	<i>National Mission on Strategic Knowledge for Climate Change</i>	18.4
2	Other Initiatives to Reduce Climate Change	18.4
	<i>National Bioenergy Mission</i>	18.4
	<i>National Adaptation Fund for Climate Change (NAFCC)</i>	18.5
	<i>Net Metering Policy</i>	18.5
	<i>Star Labelling of Appliances</i>	18.5
	<i>Energy Conservation Building Code</i>	18.6
	<i>Green Building</i>	18.7
	<i>BSE Greenex</i>	18.7
	<i>Science Express Train</i>	18.7
	Practice Questions	18.10
	Perfecting Past Prelims	18.13
	Solutions	18.14

19

INTERNATIONAL EFFORTS TO REDUCE CLIMATE CHANGE EFFECTS**19.1–19.27**

1	UN Conference on Human Environment	19.1
2	Earth Summit	19.2

	<i>Kyoto Protocol</i>	19.3
3	Differences among Developed and Developing Nations on Emission Reduction Responsibilities	19.4
	<i>Views of Developed Nations</i>	19.4
	<i>Views of Developing Nations</i>	19.5
4	Paris Climate Change Agreement (2015)	19.5
5	Paris Agreement and India	19.7
6	23rd COP: Bonn Meet	19.7
7	24th COP: Katowice Meet	19.8
8	25th COP: Madrid Meet	19.10
9	26th COP: Glasgow Meet	19.11
10	Carbon Market Negotiations	19.12
11	The 1.5°C Debate	19.12
12	Climate Change Finance	19.14
13	Other Important Matters Related to Negotiations on Climate Change	19.15
14	Other Institutions to Deal with Climate Change	19.15
15	Carbon Tax	19.15
16	Emissions Gap Report	19.16
	Practice Questions	19.17
	Perfecting Past Prelims	19.21
	Solutions	19.25

UNIT VI ENVIRONMENT INSTITUTIONS

20

ENVIRONMENTAL INSTITUTIONS IN INDIA

20.1–20.22

1	Important Laws to Protect Environment	20.1
	<i>Wildlife Protection Act, 1972</i>	20.1
	<i>Environment Protection Act, 1986</i>	20.1
	<i>Coastal Regulation Zone Notification, 1991</i>	20.2
	<i>Forest Conservation Act, 1980</i>	20.2
2	Statutory bodies	20.3
	<i>National Green Tribunal</i>	20.3
	<i>National Board for Wildlife</i>	20.3
	<i>Animal Welfare Board of India</i>	20.4
	<i>Central Zoo Authority</i>	20.4
	<i>National Biodiversity Authority</i>	20.4
	<i>State Biodiversity Boards</i>	20.5
	<i>National Ganga River Basin Authority or the National Council for River Ganga</i>	20.5
	<i>Compensatory Afforestation and CAMPA</i>	20.5
	<i>Central Pollution Control Board</i>	20.6

	<i>Central Ground Water Authority</i>	20.7
3	Non-Statutory Bodies	20.7
	<i>Central Ground Water Board</i>	20.7
	<i>National Mission for Clean Ganga</i>	20.8
	<i>Wildlife Institute of India</i>	20.8
	<i>National Afforestation and Eco-development Board</i>	20.9
	<i>Zoological Survey of India</i>	20.9
	<i>Botanical Survey of India</i>	20.9
4	Other Measures by Government	20.10
	<i>Clean Energy Cess</i>	20.10
	<i>National Bamboo Mission</i>	20.10
	<i>Eco Mark</i>	20.11
	<i>Joint Forest Management</i>	20.11
	<i>Social Forestry</i>	20.11
	<i>Vanjeevan</i>	20.11
	<i>Traditional Knowledge Digital Library</i>	20.12
5	Non-Governmental Organisations	20.13
	<i>Bombay Natural History Society</i>	20.13
	<i>TERI</i>	20.13
	<i>Wildlife Trust of India</i>	20.13
	Practice Questions	20.13
	Perfecting Past Prelims	20.18
	Solutions	20.20

21

INTERNATIONAL EFFORTS FOR PROTECTION OF ENVIRONMENT

21.1–21.34

1	Agreements and Conventions	21.1
	<i>United Nations Conference on Environment and Development</i>	21.1
	<i>Convention on Biological Diversity</i>	21.1
	<i>Agenda 21</i>	21.1
	<i>Mangroves for the Future</i>	21.2
	<i>Vienna Convention</i>	21.3
	<i>Montreal Protocol</i>	21.3
	<i>Kigali Agreement</i>	21.3
	<i>Convention on International Trade in Endangered Species of Wild Flora and Fauna</i>	21.4
	<i>Convention on Conservation of Migratory Species (Bonn Convention)</i>	21.5
	<i>Basel Convention</i>	21.5
	<i>Rotterdam Convention</i>	21.5
	<i>Minamata Convention</i>	21.6
	<i>Globally Important Agricultural Heritage Systems</i>	21.6

	<i>Ramsar Convention</i>	21.7
2	International Environment Organisations	21.11
	<i>International Solar Alliance</i>	21.11
	<i>United Nations Convention to Combat Desertification</i>	21.12
	<i>United Nations Human Settlements Programme (UN-Habitat)</i>	21.12
	<i>United Nations Environment Programme (UNEP)</i>	21.13
	TRAFFIC	21.14
	<i>Coalition Against Wildlife Trafficking</i>	21.15
	<i>United Nations Forum on Forests</i>	21.15
	<i>Global Tiger Forum</i>	21.16
	<i>International Whaling Commission</i>	21.16
	<i>South Asia Wildlife Enforcement Network</i>	21.16
	<i>Billion Tree Campaign</i>	21.16
	<i>Biocarbon Fund</i>	21.17
	<i>Bird Life International</i>	21.17
	<i>World Wide Fund for Nature</i>	21.17
	<i>Wetlands International</i>	21.17
	<i>International Water Management Institute</i>	21.18
	<i>Consultative Group for International Agricultural Research</i>	21.18
	<i>Stockholm International Water Institute</i>	21.18
	<i>Sustainable Development Solutions Network</i>	21.19
	<i>Environmental Performance Index</i>	21.19
	<i>Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services (IPBES)</i>	21.19
3	Important International Events to Protect Environment	21.21
	<i>Earth Day</i>	21.21
	<i>Earth Hour</i>	21.21
	<i>International Day of Biological Diversity</i>	21.22
	<i>World Environment Day</i>	21.22
	<i>International Day for the Preservation of the Ozone Layer</i>	21.22
	<i>International Day of Forests</i>	21.22
	<i>World Habitat Day</i>	21.22
	Practice Questions	21.23
	Perfecting Past Prelims	21.28
	Solutions	21.32

UNIT VII ENVIRONMENT LEGISLATIONS

22

INDIAN FOREST ACT 1927

22.1–22.13

1	Important Features of the Act	22.1
	<i>Reserved Forests</i>	22.2
	<i>Village Forests</i>	22.4

<i>Protected Forests</i>	22.4
<i>Control Over Forests and Lands which are not a Part of Government Property</i>	22.6
<i>Timber and Forest Produce</i>	22.6
<i>Penalties and Procedures</i>	22.8
<i>Miscellaneous Provisions</i>	22.9
Practice Questions	22.10
Solutions	22.12

23**FOREST CONSERVATION ACT, 1980****23.1–23.8**

1 Constitutional Mandate and Forest Conservation	23.1
<i>Legislative Action</i>	23.1
2 Forest Conservation Act, 1980	23.1
<i>Applicability of the Act</i>	23.1
<i>Salient Provisions</i>	23.1
3 Forest (Conservation) Rules, 2003	23.4
<i>Salient features of Forest (Conservation) Rules, 2003</i>	23.4
Practice Questions	24.6
Solutions	24.8

24**WILDLIFE (PROTECTION) ACT, 1972****24.1–24.35**

1 Main Authorities Constituted Under Original Wildlife (Protection) Act, 1972	24.1
<i>Director of Wildlife Preservation</i>	24.1
<i>Chief Wildlife Warden and Other Wildlife Wardens</i>	24.1
<i>National Board for Wildlife</i>	24.2
<i>State Board for Wildlife (SBWL)</i>	24.4
<i>Hunting of Wild Animals</i>	24.5
<i>Protection to Specified Plants</i>	24.6
<i>Provisions related to Wildlife Sanctuaries</i>	24.7
<i>Provisions related to National Parks</i>	24.11
<i>Conservation Reserve and Community Reserve</i>	24.13
<i>Central Zoo Authority</i>	24.14
<i>National Tiger Conservation Authority</i>	24.17
<i>Tiger and other Endangered Species Crime Control Bureau</i>	24.21
<i>Ownership of Animals and Animal Articles</i>	24.22
<i>Other Provisions of Wildlife (Protection) Act, 1972</i>	24.25
2 Schedules to Wildlife (Protection) Act	24.29
Practice Questions	24.32
Perfecting Past Prelims	24.34
Solutions	24.35

25**THE PREVENTION OF CRUELTY TO ANIMALS ACT, 1960 25.1–25.13**

1	Salient Provisions	25.1
	<i>Applicability of the Act</i>	25.1
	<i>Duties of Persons having Charge of Animals</i>	25.1
	<i>Animal Welfare Board of India</i>	25.1
	<i>Cruel Treatment of Animals</i>	25.5
	<i>Destruction of Suffering Animals</i>	25.6
	<i>Experiments on Animals</i>	25.7
	<i>Restriction on Exhibition and Training of Performing Animals</i>	25.8
	Practice Questions	25.10
	Perfecting Past Prelims	25.12
	Solutions	25.13

26**THE WATER (PREVENTION AND CONTROL OF POLLUTION) ACT, 1974****26.1–26.26**

1	Introduction	26.1
	Fulfilment of International Obligations	26.2
	Applicability of the Act	26.2
2	Pollution Control Boards	26.3
	Central Pollution Control Board	26.3
	State Pollution Control Board	26.4
	Pollution Control Board for Union Territories	26.5
	Joint Boards	26.7
	Functions of Central and State Boards	26.9
	Directions to Central and State Pollution Control Board	26.11
3	Implementation of the Act	26.12
	Restriction in the Application of the Act to Certain Areas	26.12
	Powers of Entry and Inspection	26.12
	Prohibitions and Restrictions	26.13
	Intimation on Discharge of Poisonous Matter and Emergency Measures	26.14
	Power to give Directions	26.15
4	Accounts and Audit of Boards	26.15
	Fund of Central Board and State Board	26.15
	Budget	26.16
	Annual Report	26.16
	Audit of Accounts	26.16
5	Offences and Penalties	26.17
6	Central and State Water Laboratory	26.21
	Central Water Laboratory	26.21

State Water Laboratory	26.21
7 Supersession of Boards	26.22
Power of Central Government to supersede Central Board and Joint Boards	26.22
Power of State Government to supersede State Board	26.22
Practice Questions	26.23
Perfecting Past Prelims	26.25
Solutions	26.25

27

THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981

27.1–27.16

1 Introduction	27.1
2 Pollution Control Boards	27.1
<i>Central Pollution Control Board</i>	27.1
<i>State Pollution Control Boards</i>	27.2
<i>Pollution Control Board for Union Territories</i>	27.3
<i>Functions of Central and State Boards</i>	27.5
<i>Directions to Central and State Pollution Control Board</i>	27.6
3 Implementation of the act	27.7
<i>Air Pollution Control Areas</i>	27.7
<i>Intimation on Excess Discharge of Environmental Pollutant</i>	27.8
<i>Powers of Entry and Inspection</i>	27.8
<i>Power to Give Directions</i>	27.9
<i>State Air Laboratory</i>	27.9
<i>Appeal</i>	27.10
4 Accounts and Audit of State Boards	27.10
<i>Fund of each State Board</i>	27.10
<i>Budget</i>	27.11
<i>Annual Report</i>	27.11
<i>Audit of Accounts</i>	27.11
5 Offences and Penalties	27.12
6 Supersession and Dissolution of Boards	27.14
<i>Power of State Government to Supersede State Board</i>	27.14
<i>Supersession of the Central Board or the State Boards constituted under the Water Act</i>	27.15
<i>Dissolution of State Boards Constituted under the Act</i>	27.15
Practice Questions	27.15
Solutions	27.18

28**ENVIRONMENT PROTECTION ACT, 1986****28.1–28.11**

- | | | |
|---|--------------------------------------|-------|
| 1 | Salient Provisions | 28.2 |
| | <i>Powers of Central Government</i> | 28.2 |
| | <i>Restrictions and Prohibitions</i> | 28.4 |
| | <i>Environmental Laboratories</i> | 28.6 |
| | <i>Offences and Penalties</i> | 28.6 |
| | <i>Immunity to Officials</i> | 28.7 |
| | <i>Complainant in Court</i> | 28.7 |
| | <i>Rules Under this Act</i> | 28.8 |
| | Practice Questions | 28.8 |
| | Perfecting Past Prelims | 28.9 |
| | Solutions | 28.10 |

29**BIOLOGICAL DIVERSITY ACT, 2002****29.1–29.15**

- | | | |
|---|---|-------|
| 1 | Introduction | 29.1 |
| | <i>International Obligation</i> | 29.1 |
| | <i>Plan for Attainment of Objectives</i> | 29.2 |
| 2 | National Biodiversity Authority | 29.2 |
| | <i>Functions of National Biodiversity Authority</i> | 29.3 |
| 3 | State Biodiversity Board | 29.5 |
| | <i>Functions of State Biodiversity Board</i> | 29.6 |
| 4 | Biodiversity Fund | 29.7 |
| | <i>National Biodiversity Fund</i> | 29.7 |
| | <i>State Biodiversity Fund</i> | 29.7 |
| 5 | Duties of Central and State Governments | 29.8 |
| | <i>Duties of Central Government</i> | 29.8 |
| | <i>Duties of State Government</i> | 29.9 |
| 6 | Biodiversity Management Committees | 29.10 |
| | <i>Local Biodiversity Fund</i> | 29.10 |
| 7 | Offences and Penalties | 29.10 |
| | Practice Questions | 29.13 |
| | Solutions | 29.15 |

30**FOREST RIGHTS ACT 2006****30.1–30.13**

- | | | |
|---|----------------------|------|
| 1 | Introduction | 30.1 |
| | <i>Objective</i> | 30.1 |
| | <i>Applicability</i> | 30.1 |

2	Forest Rights	30.2
	<i>Individual Rights</i>	30.2
	<i>Community Rights</i>	30.3
	<i>Exceptions</i>	30.4
	<i>Rights of Dwellers in Critical Wildlife Habitats</i>	30.5
	<i>Conditions for Recognition and Vesting of Forest Rights</i>	30.6
	<i>Duties of Forest Rights Holders and Village level Institutions</i>	30.6
3	Authorities and Procedure for recognition of forest rights	30.7
4	Offences and Penalties	30.8
5	Rules Under this Act	30.9
	Practice Questions	30.10
	Perfecting Past Prelims	30.12
	Solutions	30.13

UNIT VIII RULES

31

WETLAND RULES 2017

31.1–31.10

1	Introduction	31.1
	<i>Definitions for the Purpose of Rules</i>	31.1
	<i>Applicability of the Rules</i>	31.2
2	Restrictions of Activities in Wetlands	31.2
3	Wetland Authorities	31.3
	<i>Powers and Functions of the Wetlands Authority</i>	31.4
4	National Wetlands Committee	31.5
	<i>Functions of National Wetlands Committee</i>	31.6
5	Important Changes introduced in 2017 Rules	31.7
	Practice Questions	31.7
	Perfecting Past Prelims	31.9
	Solutions	31.10

32

COASTAL REGULATION ZONE RULES

32.1–32.19

1	Introduction	32.1
	<i>Background of CRZ Rules</i>	32.1
	<i>Objectives of the Rules</i>	32.1
2	Coastal Regulation Zone (CRZ)	32.2
	<i>Classification of CRZ</i>	32.3
	<i>Special Consideration Areas in the CRZ</i>	32.4

3	Activities Allowed and Prohibited within CRZ	32.5
	CRZ-I Areas	32.5
	CRZ-II areas	32.6
	CRZ-III areas	32.7
	CRZ-IV areas	32.8
	Prohibited Activities in the CRZ	32.10
	Special Consideration Areas	32.10
	Coastal Zone Management Plan (CZMP)	32.11
	CRZ Clearance for Permissible and Regulated Activities	32.12
4	Annexures and Forms Under CRZ Rules	32.13
5	Comparison between 2019 and 2011 CRZ Rules	32.13
6	Relaxation of CRZ rules and Blue Flag beaches	32.15
	Practice Questions	32.17
	Solutions	32.19

33

SOLID WASTE MANAGEMENT RULES 2016

33.1–33.21

1	Introduction	33.1
	<i>Solid Waste</i>	33.1
	<i>Applicability of the Rules</i>	33.1
2	Duties under the Rules	33.2
	<i>Duties of Waste Generators</i>	33.2
	<i>Duty of Manufacturers or Brand Owners of Disposable Products, Sanitary Napkins and Diapers</i>	33.4
	<i>Duties of Ministry of Environment, Forest and Climate Change (MOEFCC)</i>	33.5
	<i>Duties of Various Ministries under Rules</i>	33.5
	<i>Duties and Responsibilities of Local Bodies</i>	33.7
	<i>Duties of other Authorities</i>	33.11
	<i>State Level Advisory Body</i>	33.15
	<i>Annual Reports</i>	33.16
	<i>Accident Reporting</i>	33.17
3	Important Changes Introduced in 2016 rules	33.17
	Practice Questions	33.19
	Perfecting Past Prelims	33.21
	Solutions	33.21

34

HAZARDOUS AND OTHER WASTES (MANAGEMENT AND TRANSBOUNDARY MOVEMENT) RULES, 2016, AS AMENDED IN 2019

34.1–34.7

- | | | |
|---|--|------|
| 1 | Introduction | 34.1 |
| | <i>Problems of Unscientific Disposal of Hazardous and other Waste</i> | 34.1 |
| | <i>Definition of Hazardous Waste</i> | 34.2 |
| 2 | Responsibility for Management of Hazardous Waste | 34.3 |
| | <i>Responsibilities of the Occupier</i> | 34.3 |
| | <i>Responsibilities of State Government for Environmentally Sound Management of Hazardous and other Wastes</i> | 34.4 |
| | <i>Responsibility of Operator, Occupier in Treatment, Storage and Disposal of Hazardous Wastes</i> | 34.4 |
| 3 | Changes in 2016 and 2019 Rules | 34.5 |
| | <i>Changes in 2016 Rules</i> | 34.5 |
| | <i>Amendments in 2019 Rules</i> | 34.5 |
| | Practice Questions | 34.6 |
| | Solutions | 34.7 |

35

PLASTIC WASTE MANAGEMENT RULES 2016, AS AMENDED IN 2018

35.1–35.15

- | | | |
|---|--|-------|
| 1 | Introduction | 35.1 |
| | <i>Definitions</i> | 35.1 |
| | <i>Applicability of the Rules</i> | 35.2 |
| | <i>Exceptions</i> | 35.2 |
| | <i>Conditions to be followed</i> | 35.3 |
| 2 | Responsibilities under the Rules | 35.3 |
| | <i>Responsibility of Waste Generators</i> | 35.3 |
| | <i>Responsibility of Local Bodies</i> | 35.4 |
| | <i>Responsibility of Importers, Producers and Brand Owners</i> | 35.5 |
| | <i>Responsibility of Retailers and Street Vendors</i> | 35.5 |
| | <i>Marking and Labelling Criteria</i> | 35.5 |
| 3 | Implementation, Monitoring and Advisory Authorities | 35.6 |
| 4 | Reporting Requirements | 35.7 |
| 5 | Salient features of the Plastic Waste Management Rules: Table for comparison | 35.9 |
| | Practice Questions | 35.13 |
| | Solutions | 35.14 |

36**E-WASTE (MANAGEMENT) RULES, 2016****36.1–36.16**

1	Introduction	36.1
	<i>Meaning of e-waste</i>	36.1
	<i>Applicability of the Rules</i>	36.1
2	Responsibilities of Various Parties for e-waste management	36.3
	<i>Responsibilities of the Manufacturer</i>	36.3
	<i>Responsibilities of the Producer</i>	36.4
	<i>Responsibilities of Collection Centres</i>	36.6
	<i>Responsibilities of Dealers</i>	36.6
	<i>Responsibilities of the Refurbisher</i>	36.6
	<i>Responsibilities of Consumer or Bulk Consumer</i>	36.7
	<i>Responsibilities of the Dismantler</i>	36.7
	<i>Responsibilities of the Recycler</i>	36.8
	<i>Responsibilities of State Government for Environmentally Sound Management of E-waste</i>	36.8
3	Procedure for seeking and grant of authorization for management of e-waste	36.9
	<i>Procedure for Grant of Authorization to Producer</i>	36.9
	<i>Procedure for Grant of Authorization to Manufacturer</i>	36.10
	<i>Procedure for Grant of Authorization to Dismantler or Recycler</i>	36.10
	<i>Procedure for Grant of Authorization to Refurbisher</i>	36.11
	<i>Power to Suspend or Cancel an Authorization</i>	36.11
4	Storage and Reduction in use of e-waste	36.11
	<i>Procedure for Storage of e-waste</i>	36.11
	<i>Reduction in the use of Hazardous Substances</i>	36.11
	<i>Liability of Manufacturer, Producer, Importer, Transporter, Refurbisher, Dismantler and Recycler</i>	36.12
	<i>Appeal</i>	36.12
5	Schedules	36.12
	<i>Practice Questions</i>	36.13
	<i>Perfecting Past Prelims</i>	36.15
	<i>Solutions</i>	36.16

37**BIO-MEDICAL WASTE MANAGEMENT RULES, 2016****37.1–37.12**

1	Introduction	37.1
	<i>Applicability</i>	37.1
	<i>Exceptions to the Rules</i>	37.1
2	Obedience of Bio-Medical Waste Management Rules	37.2
	<i>Duties of Occupier</i>	37.2
	<i>Duties of the Operator of a Common Bio-medical Waste Treatment and Disposal Facility</i>	37.3

3	Authorities under Bio-medical Waste Management Rules	37.4
	<i>Implementing Authorities</i>	37.4
	<i>Advisory Authorities</i>	37.4
	<i>Monitoring Authorities</i>	37.5
4	Requirements Under the Rules	37.5
	<i>Provisions for Segregation, Treatment and Disposal of Bio-medical Waste</i>	37.5
	<i>Reporting Requirements</i>	37.5
	<i>Liability of Occupier or Operator of a Facility</i>	37.6
	<i>Appeal</i>	37.6
5	Schedules of Bio-Medical Waste Management Rules	37.7
	Practice Questions	37.10
	Solutions	37.12
	 <i>Introduction to Mains Answer Writing</i>	 A.1–A.7
	<i>Mains Solutions: Environment and Biodiversity</i>	S.10–S.54

Preface

If you ever happen to be walking down the streets of places where preparation for Civil Services is done, it will not be uncommon for you to come across or make the acquaintance of ‘several’ starry eyed yet completely committed IAS aspirants. Yet, ‘several’ would be an understatement given the number that runs into lakhs! But when we say committed, we mean it; these young men and women are ready to sacrifice almost all their youthful follows including sleep, comfort and even a semblance of a normal life to achieve one goal—IAS!

Sadly, this dream remains a distant one for a large majority of these aspirants in spite of the endless hours of study and sleep forsaken nights. When we tried to unravel WHY, the responses were almost synchronous:

“The subject was so vast that there was too much to cover and I could never complete it.”

“I read so much but could not retain it.”

“I studied something but was quizzed on something else in the exam.”

“I kept reading but did not attempt to solve the past year papers or give a mock exam.”

“Subscribing to several sources of information/preparation such as a coaching class, the internet and books was futile; after all there are only 24 hours in a day.”

“My almirah was full of too many books, but I could barely complete a few.”

And while the candid answers stated above clearly gave us a challenging problem—we did not attempt to solve it. We instead focused on a holistic solution—the synchronizing of effort i.e. Learning and Positive Results!

It is with this aim that we—PrepMate collaborated with Cengage India—are continuously striving to develop a comprehensive learning model that is a combination of print and digital product so as to effectively address the issues that most aspirants grapple with.

About the Online–Offline Learning Model

The learning model initiates the process with a series of books targeted at cracking the UPSC exam. The books stand apart from others available because of the following unique features:

- We use a conceptual approach, simple language, explain concepts with diagrams, cite sufficient examples, pose pertinent questions in a reader friendly format—to ensure that the contents of these books can be read and assimilated in a time-bound manner.

- The content is specially designed taking into account the trend in UPSC exams in recent years. We have also included the previous years' questions (with solutions) after every chapter.
- The Practice Questions at the end of each chapter are exhaustive to provide sufficient preparation to crack the exams.
- We have tried to encapsulate all that is required to be learnt for a particular subject into a single book.

Usually, an aspirant purchases a book, but never gets a chance to contact the authors. We believe that the contact among aspirants and authors is important for learning and motivation of the aspirants. That is precisely why we have developed an application and a web portal to answer your queries and provide you with continuous support during your preparation.

It is through this online system that we provide the following services:

1. Videos covering important and difficult topics
2. Daily prelims quiz
3. Assistance in interview preparation
4. Regular updates
5. Daily current affairs
6. Monthly current affairs magazine
7. Radio news analysis
8. Educational videos
9. Previous years' papers and solutions
10. Free study materials

Looking forward to being your partner in the journey towards achieving your dream!

In case you have any specific queries or constructive feedback you can always share the same with us via e-mail at info@prepmate.in.

PrepMate

Acknowledgements

“We cannot accomplish all that we want to do without working together”

The complete UPSC learning module by PrepMate has been the culmination of more than a year of ideation and brain storming with a lot of people. It is only natural that we should gratefully acknowledge their valuable contribution sincerely. Nirmal Singla, Ramnik Jindal, Sharat Gupta, Subhash Singla and Vijay Singla—thank you for your continuous support and motivation.

We would also like to thank Maninder Mann, Rajinder Paul Singla and Sundeep Singh Garha who helped us in first conceiving and later developing the synergistic print–digital model of the project—without you we would be missing our competitive edge.

Implementation of strategy can more often than not prove challenging and the development of the online module did prove to be tougher than we had envisaged. But our technical team was focused on enabling our dream and delivering the best and they surely did. With a specific mention to the testing of both the website and the application, we would like to thank Parth, Tanvir and Surabhi who did their job patiently and effectively in spite of the road blocks.

Our videos and books could not have been possible without the help of our graphics design team—Sandeep, Manjeet, Sukhjinder, Roshni and Uday toiled endlessly to ensure the best designed audio-visuals.

It is an understatement to state that the sourcing and reviewing of existing content and the generation of missing content was the most crucial part of this project and the backbone of our Learning Module. This would just not have been possible without our team of content contributors: Isha Gupta, Shelly Jindal, Gurdeep, Surabhi, Shantnu, Tanvir, Anmol, Kriti, Tanya, Sahil, Suraj and Dilshad, who left no stone unturned in their pursuit of excellence—your pivotal contributions are gratefully acknowledged.

We would like to extend a special thanks to our staff members Geeta, Jitender, Manoj and Pinki, who helped us in the most laborious job i.e. typing through the several manuscripts of our books—your contribution is sincerely appreciated.

It is imperative that we thank Isha Gupta, Shelly Jindal, Anjum Diwan, Rajesh Goel, Shikha Sharma and Ravinder Indoura, for their critical yet constructive feedback that identified and subsequently rectified the errors that crept in during the development process. We will never be able to thank them enough for this—you fortified the very foundation of our model.

We sincerely acknowledge the initiatives and support from the entire editorial team of Cengage India in the process of publishing this book.

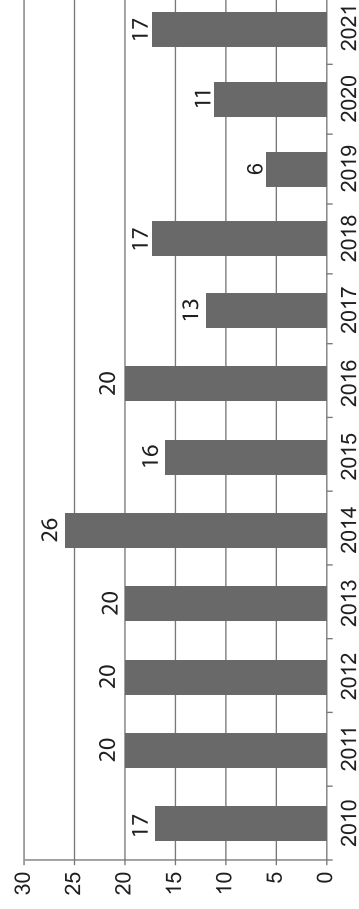
PrepMate


List of Videos

1.	Carbon (C) Cycle
2.	Tropical Evergreen Forest (or Tropical Rainforests)
3.	Coral Reefs
4.	Bioremediation
5.	Classification of Animals
6.	List of Important Animal Species Threatened in India
7.	Plant Diversity
8.	Ocean Acidification
9.	Ozone Depletion

Chapter names	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	Total
27. Air (prevention and control of pollution) Act, 1981													0
28. Environment Protection Act, 1986			1			1	1						3
29. Biodiversity Act, 2003													0
30. The Scheduled Tribes and other Traditional Forest Dwellers Act	1		1	1					1				4
31. Wetland Rules			1										1
32. Coastal Regulation Zone Notification													
33. Solid Waste Management Rules			1										1
34. Hazardous Waste Management Rules													0
35. Plastic Waste Management Rules													0
36. E-waste Management Rules			1										1
37. Bio-Medical Waste Management Rules													0
Total	17	11	6	17	13	19	18	28	21	21	20	17	208

Number of Questions Asked under Environment Section





Unit - I

ECOLOGY

CHAPTER

1

Ecology and Ecosystem

1 ECOLOGY

Every organism interacts with other organisms and its physical environment. The organism interacts with other organisms of the same species or of other species. The interaction among the organisms of the same species are called intra-species interactions. The example of intra-species interaction include copulation in order to produce offspring.

The example of inter-species interaction includes competition between two animals of different species for the same resource. In other words, competition between goat and deer for the same patch of grass is an example of inter-species competition.

The physical environment of an organism consists of land, water resources, climatic characteristics such as sunlight, temperature, humidity and so on. Like organisms interact with each other, they also interact with their physical environment. For instance, sunlight is essential for the plants to produce their food. In the absence of sunlight, plants may even die.

The above mentioned interactions of organisms with each other and their physical environment is the subject matter of **ecology**. In other words, ecology is the study of how living organisms interact with each other and their environment.

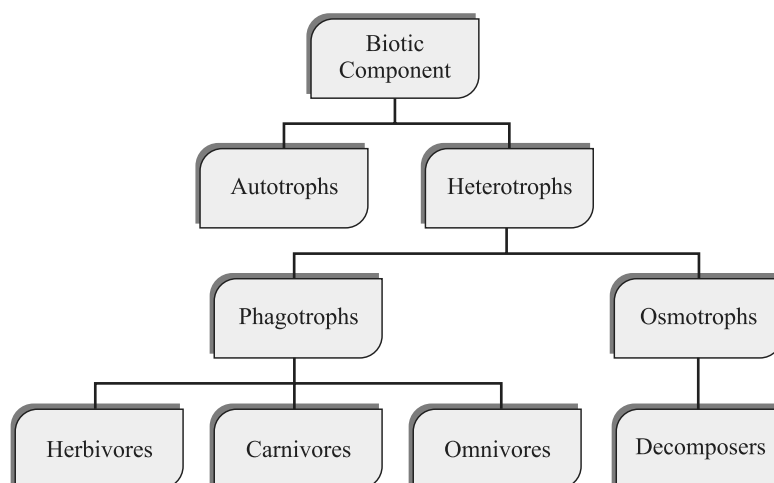
If we break down this definition, then we can identify that the subject matter of ecology consists of three aspects:

1. Living organisms (Biotic component)
2. Physical environment (Abiotic component)
3. Interactions of organisms

Let us understand each aspect one by one.

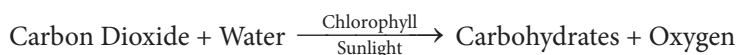
Biotic Component

The word 'biotic' is derived from the word 'bio' which means life. The word 'biotic' literally means 'relating to living organisms'. Thus, the biotic component of the ecosystem refers to living organisms including human beings, animals, plants and microorganisms. The biotic component is the main focus of study of ecology. Biotic component can be further divided into autotrophs and heterotrophs on the basis of the ability of organisms to produce food.



1. **Autotrophs:** Autotrophs are those organisms which have the ability to produce their own food. As these organisms have the ability to produce food, they are also called producers. Autotrophs are able to produce food by the process of photosynthesis. Examples of autotrophs include green plants and algae.

Photosynthesis is the process in which the producers such as plants use CO_2 and water and convert them into carbohydrates and oxygen in the presence of sunlight and chlorophyll. The carbohydrates produced during the process of photosynthesis, provide energy to a plant to carry out its day-to-day activities. The unused carbohydrates are stored in the form of starch which serves as a food reserve. The oxygen produced by plants is released into the atmosphere. The process of photosynthesis can be depicted by the following formula:



2. **Heterotrophs:** Heterotrophs are those organisms which do not produce their own food. Heterotrophs consume plants or other animals, whether living or dead for their food requirements. Since heterotrophs cannot produce their own food, they are also regarded as consumers. All animals and plants which cannot cook their food are examples of heterotrophs.

When heterotrophs consume plants or other animals, they are able to secure carbohydrates. These carbohydrates act as energy sources for heterotrophs.

Heterotrophs can be further classified into phagotrophs and osmotrophs. They can also be classified into biophages and saprophytes.

Phagotrophs and Osmotrophs

Phagotrophs: As compared to osmotrophs, phagotrophs are more evolved organisms. They have the ability to digest complex food substances obtained from plants, animals or both. In other words, phagotrophs have the ability to undertake chemical breakdown of the complex food substances into simpler substances. Once the food substances are broken down into simpler substances, they are absorbed by phagotrophs.

It is to be noted that digestion is the process of chemical breakdown of the complex food substances into simpler substances. Once the process of digestion is complete, it is followed by absorption. In this process, food substances in their simpler forms are absorbed by the body.

Phagotrophs are also called **macro-consumers**. The word 'macro' means large. Phagotrophs are called macro-consumers because they can consume large or complex food substances.

Phagotrophs are further of three types:

- a. **Herbivores:** Herbivores literally mean those animals which feed on plants. In other words, a herbivore is an animal that gets its energy from eating plants only. Many herbivores have special digestive systems which let them digest all kinds of plants, including grasses. As herbivores need a lot of energy to survive, many of them such as cows and sheep eat for long hours. Thus, herbivores require a lot of plants in their environment for their survival.
- b. **Carnivores:** Carnivores literally mean those animals which feed on other animals. In other words, a carnivore is an animal that gets food by eating other animals. Examples of carnivores include tiger, lion, wolf, leopard and hyena. Carnivores generally eat herbivores, but they can also eat omnivores, and even occasionally other carnivores.
 - . Since carnivores survive on hunting other animals, they are strong and swift. Consequently, their energy requirements are high. This means that they have to eat many other animals over the course of their lifetime. Thus, for the survival of carnivores, it is essential that the number of herbivores and omnivores should exceed the number of carnivores.
- c. **Omnivores:** Omnivores literally mean those animals which feed on both plants and animals. In other words, an omnivore is an animal that gets food by eating both animals and plants. Omnivores include a diverse group of animals. Examples of omnivores include birds, dogs, foxes, certain insects, and humans. Omnivores are regarded as opportunistic feeders since they derive their energy by both plants and animals.

Like herbivores, omnivores also eat plants. However, omnivores can't digest all the plants and plant parts. Omnivores generally eat only the fruits and vegetables produced by fruit-bearing plants. Omnivores usually do not eat grass.

Like carnivores, omnivores hunt and eat other animals. Usually, Omnivores eat herbivores and other omnivores. Some omnivores are scavengers. Scavengers are animals that feed on the remains of dead animals. For instance, bears eat twigs and berries apart from hunting small animals. Many omnivores also eat eggs of other animals.

It is to be noted that animals which eat other animals such as carnivores and omnivores are important to any ecosystem, because they prevent overpopulation of other species. At the same time, it is important that an ecosystem has enough herbivores, so that it can support the population of carnivores and omnivores.

Osmotrophs: As compared to phagotrophs, osmotrophs are less evolved organisms. They do not have the ability to break down complex food substances into simpler substances within their body. Consequently, they consume food only after it is broken down into simpler substances. In other words, osmotrophs undertake only absorption (not digestion) of food.

Thus, osmotrophs are those organisms who convert their food into simple substances outside their body and then absorb those substances. Osmotrophs are also called **micro-consumers**. The word 'micro' means small. Osmotrophs are called micro-consumers because they can consume only small or simple food substances.

Decomposers such as bacteria and fungi which decompose the organic matter to gain nutrients are also included within osmotrophs.

Biophages and Saprophytes

Heterotrophs can also be classified into biophages and saprophytes.

- a. **Biophages:** Organisms that derive the nourishment for their existence from other living organisms are called biophages. In other words, these organisms hunt their prey down and consume them. Herbivores and carnivores such as tigers are examples of biophages.
- b. **Saprophytes:** An organism that derives nourishment by feeding on dead organisms are called saprophytes. In other words, these organisms usually do not hunt other animals down in order to consume them. Decomposers, detritivores and scavengers are examples of saprophytes. Mushrooms, molds, yeast, *Aspergillus* and *Rhizopus* are examples of saprophytes.

Differences between Decomposers and Scavengers

Both the decomposers and scavengers survive on dead organisms. Scavengers are the organisms which consume large chunks of dead plants and animals and break down the dead plants and animals into smaller parts. Vultures are examples of scavengers. Scavengers do not break down dead organic matter into chemicals such as nitrogen and carbon.

Decomposers, on the other hand, take over the dead matter after the scavengers. This means, after scavengers break down the dead organic matter into smaller particles, decomposers further break the dead organic matter into chemical nutrients such as nitrogen and carbon. These chemical nutrients become part of the soil and can then be used by living plants and animals that consume them. Thus, decomposers play an important role in nutrient cycling. Bacteria, microbes and fungi are examples of decomposers. Decomposers (other than fungi) cannot be seen with naked eye and are observed only under a microscope.

Criteria	Scavengers	Decomposers
Definition	Scavengers consume large chunks of dead plants and animals and break down the dead plants and animals into smaller parts	After scavengers break down the dead organic matter into smaller particles, decomposers further break the dead organic matter into chemical nutrients such as nitrogen and carbon.
Conversion of dead remains	Scavengers break the dead remains into smaller particles	Decomposers further break these smaller particles into chemical nutrients such as nitrogen and carbon.
Example	Vultures	Bacteria, microbes and fungi

Difference between Decomposers and Detritivores

Detritus refers to dead organic matter or wastes such as fecal material. Though the terms detritivores and decomposers are used interchangeably, there exists a difference between them. Detritivores generally ingest the organic matter and digest them using their internal organs. Decomposers, on the other hand, externally break down the organic matter into simpler substances by secreting enzymes and thereafter absorb nutrients. Earthworms, beetles, woodlice and dung flies are examples of detritivores. Earthworms are detritivores which feed only on plant detritus.

Criteria	Detritivores	Decomposers
Digestion	Digestion takes place within the body due to evolved internal organs	Large part of digestion takes place outside the body. The organic matter is converted into simpler substances outside the body by secreting enzymes.
Example	Earthworms, beetles, woodlice and dung flies	Bacteria, microbes and fungi

Abiotic Component

The word 'abiotic' literally means relating to non-living things. Thus, the abiotic component refers to the physical environment of organisms, which includes sunlight, precipitation, humidity, wind pattern, topography, temperature and so on. The abiotic factors play a major role in determining the type of organisms that live in a particular ecosystem.

For instance, factor such as temperature play a critical role in determining the species composition of an ecosystem. Many organisms are accustomed to live in a particular range of temperature. Temperature affects the metabolic activity and other physiological functions of organisms. Organisms which can survive in a wide range of temperatures are called **eurythermal organisms**. Organisms which can survive in a narrow range of temperatures are called **stenothermal organisms**.

Other factors such as sunlight, precipitation and soil properties also determine the species composition of an ecosystem such as the nature of vegetation in a region. The vegetation of a region in turn determines the type of animals that can be supported. In terrestrial ecosystem, the temperature and precipitation play a major role. In aquatic ecosystem, sunlight penetration and difference in density of water play a major role.

Interactions Among Organisms

In an ecosystem, living organisms continuously interact with each other. Based on their outcome for the living organisms which are involved, interactions can be divided into positive interactions, negative interactions and neutral interactions.

Negative interactions

If any species suffers any harm on account of interaction, then it is regarded as a negative interaction. In some negative interactions, both the organisms may suffer harm. In other negative transactions, one organism may benefit and the other may suffer harm. Negative interactions are further classified into:

1. **Competition:** Competition is described as a relationship in which different individuals attempt to use the same limited resource. Competition usually has negative outcomes for all the individuals who are affected by it. Competition may occur among the individuals of the same species. It can also occur among the individuals of different species.

Moreover, competition can occur both directly and indirectly. For example, indirect competition can occur between two birds that feed on the same insect, but one species eats at day and the other at night. Direct competition occurs between deer and goat in grassland for the same food sources and territory.

2. **Predation:** This type of interaction occurs when one organism, the 'predator' feeds upon another organism, known as 'prey'. In this interaction, one organism benefits while the other organism is harmed. Predation is a complex web to understand, for one predator can be the prey of many species.
3. **Parasitism:** The relationship between the parasite and the host is known as parasitism. Parasitism is similar to predation in that it does cause harm to its host but does not necessarily "kill" its host. Usually, parasite is dependent upon host for fulfilment of its nutrient requirements. Some common parasites are ticks, fleas, tapeworms and leeches.

Parasites that survive on the external surface of the host organism are called **ectoparasites**. The most familiar examples of this group are the lice on humans and ticks on dogs. **Endoparasites** are those parasites that live inside the host body at different sites.

Brood parasitism is another example of parasitism in which the parasitic bird lays its eggs in the nest of its host (bird who has made nest) and lets the host incubate them. The eggs of the parasitic bird resemble the host's egg size and colour. This makes it difficult for the host bird to detect and eject these eggs from the nest. The most familiar example of brood parasitism is female cuckoos laying their eggs in the nests of other bird species. The cuckoo's eggs hatch earlier than the crow's. The young cuckoo usually throws the other host eggs out of the nest, getting rid of any competition for the parent's attention.

4. **Amensalism** is any relationship between organisms of different species in which one organism is inhibited or destroyed while the other organism remains unaffected. A common example of amensalism is the release of chemical toxins by plants that can inhibit the growth of other plant species.



Stratification

Competition negatively impacts both the organisms in the interaction. Hence, to ensure optimal utilisation of the resources and minimise interspecies conflict, organisms use stratification as a strategy. Stratification means the arrangement or classification of something into groups.

For example, in forests, vegetation can be observed in distinct layers. The bottom layer is a ground layer made of mosses, liverworts, dead leaves and other organic matter. The next layer is the lower layer, which is made of grass, short and tall shrubs. The next layer is the middle layer consisting of shorter trees. The topmost layer consists of medium and taller trees.

On the ground level, soil fauna is present. In the lower layer, those animals live which descend to the floor for short periods. The middle layer is occupied by organisms, which rarely come down to the floor. The topmost layer is occupied by flying organisms. As a result of this stratification, interaction is minimised among the species occupying different layers. Each species depends on its respective layer to gather food and nutrients.

As different species occupy different layers of the vegetation, this reduces the chances of conflict. Hence, stratification is used as a practical strategy by the organisms to minimise the competition.

Positive interactions

The positive interactions are those in which either one organism is benefited and there is no effect on the other or both the organisms are benefited. In other words, in a positive interaction either one or more organisms are benefited and none of the organisms experience any harm.

1. **Mutualism:** Mutualism is an interaction in which both the species are benefited. In certain cases, mutualism between two species is so intimate that one cannot survive without the other. Such an interaction is called **symbiosis**. Example of symbiosis is termite and their intestinal flagellates. Termites feed on wood but they don't have the necessary enzymes to digest the wood. The flagellate protists (protozoans) in their intestines have the necessary enzymes to digest the cellulose of the wood eaten by termites. These flagellates convert it into sugar and use some of it for their metabolism, leaving enough for the termites. The flagellates and termite cannot survive without each other.

One more example of mutualism is the presence of intestinal bacteria in the human body. In the human body, intestinal bacteria use the warm, nutrient rich walls of the intestine for its survival. In turn, the bacteria improve our digestion by breaking down the foods which we cannot digest on our own.

2. **Commensalism:** There are also certain relationships in which one organism benefits, while the other organism involved in the relationship is not affected. This is known as commensalism. For example, vultures closely follow tigers, to feed on the tiger's kills.

Neutral interactions

Neutral Interactions or neutralism refers to those interactions in which there is no effect on either of the species. However, in nature, it is difficult to find an absolutely neutral interaction. Hence, the usage of this term is restricted to those interactions which have insignificant or negligible impact on the organisms.

Interactions with Abiotic Components

The organisms adapt in multiple ways to the changes in their abiotic environment. Particularly significant is the way in which different organisms respond to changes in temperature. The organisms cope with the changes in environment by various mechanisms such as:

1. **Homeostasis:** For efficient physiological and biochemical reactions in the body, evolved organisms maintain a relatively constant internal environment such as constant temperature, osmotic pressure

and so on. Even when the external environmental conditions vary, organisms try to maintain a constant internal environment. This maintenance of constant internal environment is called homeostasis.

2. **Regulate:** Organisms attempt to attain homeostasis by regulating their body variables such as temperature, fluid balance and so on. Regulation refers to responding with suitable reactions in order to make adjustment to the external or internal environment. For example, humans maintain a constant body temperature of 37°C. In summers, when the temperature is high, sweating occurs. Sweating cools down the body, reducing its temperature. In winter, shivering generates heat and raises body temperature. Such mechanisms are generally used by mammals. Plants and less evolved animals don't have such mechanisms in place.
3. **Conform:** Majority of organisms (99%) cannot maintain a constant internal environment. They conform to the external changes. In these organisms, their body temperatures and osmotic concentrations change with changes in the external environment. Thus, such organisms can survive with the changes in the external environment, only if the changes in the external environment are favourable to them.

Conform explains why smaller animals are normally not found in polar regions. As the surface area of smaller animals is larger, relative to their volume, they tend to lose heat quickly in colder temperatures. In some cases, when the organisms cannot regulate or conform, they either migrate or suspend certain body functions.

4. **Migrate:** Organisms temporarily move to a different place and return back to the original place when the environment is more suitable. For instance, during winters, Siberia is extremely cold. As a result, Siberian cranes migrate to India during winters. As summers approach, these birds fly back to Siberia.
5. **Suspend:** Organisms may hibernate or aestivate under unfavourable conditions. If an organism sleeps and reduces bodily functions in winter, it is termed **hibernation**. Polar bears go into hibernation in winters. During this time, they don't eat much, their body temperature drops, and heartbeat and breathing slows down. As a result, they do not need much energy and can survive without going outside for food. **Aestivation** refers to organisms going into a dormant state in summers, to escape heat. Snails and fish go into aestivation. In other cases, organisms may delay their development. This is called **diapause**. Zooplankton species in ponds and lakes undergo diapause, as a response to unfavourable conditions.
6. **Evolution:** Any organism evolves over the course of time to live in a particular environment. Unlike regulate, conform and other adaptations mentioned above, adaptation by evolution is a long-term process. For instance, camels have evolved over millions of years to be able to live in deserts. An adaptation by evolution can be defined as certain characteristics that an organism develops over time which enables it to survive in a particular environment. It can be in the form of its physical appearance or behaviour evolved by an organism or even the way an organism lives.

Flowers that bloom at night are generally white in colour and fragrant. The white colour and fragrance enhance visibility of flowers to pollinating agents, which helps in attracting them. If these flowers would have been of dark colours, then they would be unnoticeable by the pollinating agents. The white colour and fragrance in flowers is an example of adaptation by evolution.

Levels of Study in Ecology

The interactions occur not just between individual organisms but also between species, population, community, ecosystem, biome, and even biosphere as a whole. Consequently, ecology not only studies the interactions of individual organisms with their environment, but also that of population, community, ecosystem, biome, and biosphere. Consequently, individual, species, population, community, ecosystem, biome, and biosphere comprise various levels in the study of ecology.

1. **Individual:** Individual refers to a single organism. It can be a plant, animal or any other living organism. An individual can belong to any species.
2. **Species:** The most common definition of a species is a group of organisms capable of interbreeding and producing an offspring. Thus, only member of a same species can reproduce through copulation. However, individuals of a species interact with other individuals, both intra and inter species, in a variety of ways.
3. **Population:** In ecology, population refers to all the organisms of the same species, which live in a given geographical area. In other words, we use the word 'population' to refer the number of organisms of a particular species within a given area.

From the above definition, we can say that the term 'population' is expressed with the help of three characteristics:

- a. **Species:** The term population is used in reference to particular species. We have learnt that a particular species consists of all the individuals that have capability of interbreeding amongst themselves.
- b. **Number of individuals:** The count of population is based on the number of individuals belonging to a particular species.
- c. **Geographical area:** The term population is used to express the number of organisms of a particular species within a geographical area. Geographical area may be of any size. It may be a local region or the whole earth.

Let us take an example. We can say that the population of tigers in a particular forest is 40. Here, 'species' is tigers, 'area' is forest and the 'number of individuals' of the species is 40. Thus, the population is expressed with the help of three characteristics: description of species, geographical area and number of individuals in the species.

Characteristic features of Population group

Let us understand the features of every population group. These are as follows:

- a. Every population group utilizes the common resources. For example, tigers in a forest feed upon the same group of organisms.
- b. A small group of population has high chances of extinction than that of a large group. Moreover, it is important for the survival of species that the population of the species is dispersed across multiple regions. A species concentrated in a single region may get extinct with adverse effect on that particular region.

- c. Members of a population are affected by same natural and man-made phenomena. For example, all the tigers in a forest get affected due to the reduced availability of prey.
- d. In a population, individuals are of different age. The proportion of individuals in each age group is called **age structure of that population**.

2 COMMUNITY

In ecology, a community is an assemblage of populations of different species, interacting with one another. In other words, populations of different species which live and interact together in a given area, form a community.

Members of a particular community interact in various ways such as competition, predation, mutualism, etc. These interactions affect community structure. **Community structure** refers to composition of a community, including the number of species in that community and the number of individuals in each community. A community's structure is described with the help of two terms: Species richness and Species diversity.

Species richness refers to the number of species present in the community. For instance, a community with 124 species has less species richness than the community with 138 species.

Species diversity considers both species richness and species evenness. In other words, species diversity is calculated on the basis of both species richness and species evenness. **Species evenness** refers to the number of individuals in various species. In other words, species evenness refers to the relative numbers of various species.

3 ECOSYSTEM

An ecosystem is a community of living organisms in conjunction with the non-living components of their environment (such as air, water and soil). The community of living organisms (biotic component) continuously interacts with its physical environment (abiotic component). These biotic and abiotic components are linked together through nutrient cycles and energy flow.

Ecosystem can be of any size but usually encompass specific, limited spaces. Although, some scientists say that the entire planet is an ecosystem.

Difference between Ecology and Ecosystem

As we have discussed earlier, ecology is the study of interactions between individual living organisms and their environment. Ecosystem is the functional unit of nature in which organisms interact with each other and with their environment. In simple words, the ecosystem is the place where the interactions take place, and ecology studies these interactions.

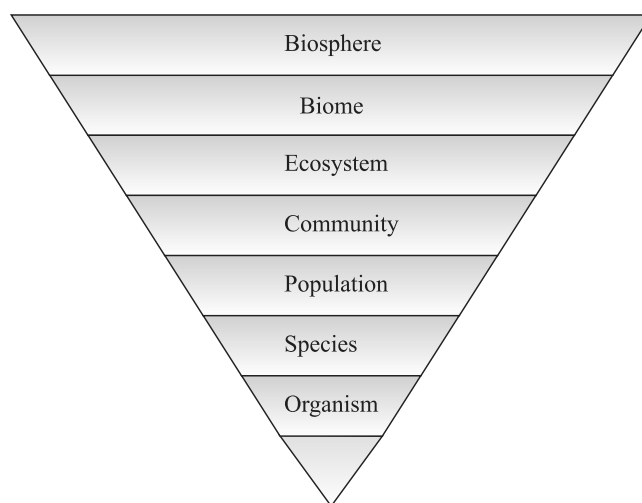
4 BIOME

Biome refers to large regions sharing similar climatic conditions, soil type, flora and fauna. In other words, on account of similarity in terms of climatic conditions, soil type and flora and fauna, large region is grouped together as a biome. India has been divided into five major biomes. These biomes are:

- a. **Tropical humid biome:** This type of biome is found in tropical regions with more than 200 cm of average annual rainfall such as Western Ghats and Eastern Himalayas.
- b. **Tropical deciduous biome:** This type of biome is found in tropical regions with 50 to 200 cm of average annual rainfall. This type of biome covers the largest part of India.
- c. **Desert and semi-desert type biome:** This type of biome is found in Southern Punjab, Central and Western Rajasthan where average annual rainfall is less than 50 cm.
- d. **Coniferous biome:** This type of biome is found in colder climate of Himalayas between altitudes of 1500 m and 3000 m.
- e. **Alpine biome:** Alpine biome start at an elevation of above 3000 m on Himalayas and grow up to the region which is just below the snowline.

5 BIOSPHERE

The biosphere (from Greek word '*bios*' = life and '*sphaira*' = sphere) is the layer of the planet Earth where life exists. This layer ranges upto the height of 10 kilometres above the sea level, used by some birds in flight, to ocean depths of more than 8 kilometres such as the Puerto Rico trench. The layer of the Earth containing life is thin because the upper atmosphere has little oxygen and very low temperature, which are not conducive for the survival of life. Similarly, ocean depths deeper than 1000 m are dark, cold and lack oxygen.



Levels of study in Ecology

Terminology related to Ecology and Ecosystem

Ecotone

Ecotone is a zone of junction between two or more diverse ecosystems. This zone can be local or regional, narrow or wide in size. In an ecotone, the conditions are intermediate of the two adjacent ecosystems. For instance, the coastal areas represent an ecotone between marine and terrestrial ecosystem.

Ecotone is also transition zone between two diverse ecosystems. In other words, there is no clear-cut boundary between two diverse ecosystems. Consider a coastal region. The exact boundary between land and sea is not clear because the level of the sea varies on account of multiple factors such as tides.

Let us take example of a forest. It is difficult to clearly demarcate the boundaries of a forest. Gradually, the density of a forest reduces and the forest land merges with the non-forest land. Thus, in most cases, the boundaries of ecosystems are not clearly defined.

Often, ecotone has ecological conditions to support species of adjoining ecosystems. In fact, an ecotone may possess species which are not present in adjoining ecosystems. Thus, ecotone may have larger biodiversity as compared to adjoining ecosystems. This phenomenon is called **edge effect**.

In other words, the edge effect is an ecological concept which explains why there is a greater diversity of life in the region where the edges of two adjacent ecosystems overlap.

Edge effect is possible because ecotone offers unique ecological conditions which are not there in the adjoining ecosystems. For instance, coastal regions have larger biodiversity as compared to the adjoining terrestrial and marine ecosystem.

Ecocline

Ecocline is a physical transition zone. It represents a zone that occurs due to variations in the physico-chemical environment. In other words, ecocline is formed when there is change in one or two physico-chemical factors. Such physico-chemical factors include temperature, chemicals, salinity level and so on. Changes in any one or more of these factors create an ecocline. An ecocline can be a thermocline (caused due to temperature gradient), chemocline (caused due to chemical gradient), halocline (caused to salinity gradient) or pycnocline (caused due to variations in density of water induced by temperature or salinity). Example of thermocline is change of water temperature in a pond. Water on the surface of the pond is warmer than the water at the lower levels in the pond.

Types of Ecocline	Reason behind formation of Ecocline
Thermocline	Change in temperature
Chemocline	Change in chemical intensity
Halocline	Change in Salinity
Pycnocline	Change in density of water

Difference between Ecotone and Ecocline

Ecotone is a transition zone between two ecosystems. It is the place where communities of adjacent ecosystems co-exist. On the other hand, Ecocline is a physical transition zone. It refers to variation in the physico-chemical environment due to change in one or more physico-chemical factors.

To conclude, ecotone is related with the variation in prevalence of species while ecocline is related with the variation in the physico-chemical environment.

Niche or Ecological Niche

A *niche* refers to the unique functional role of a species in an ecosystem. It describes the role of species in production and consumption of food resources. A species' niche also includes the physical, biological and chemical environment to which it is adapted. In other words, the role of species is understood in context of its physical, biological and chemical environment.

Niche construction is the process by which an organism alters its own (or another species) environment. These alterations can be a physical change to the organism's environment or can even happen when an organism leaves one habitat for another.

Fundamental and Realized Niche

Both fundamental and realized niche are related to the conditions needed for the survival of a given organism and its role in an ecosystem. However, there are significant differences between the two terms.

Fundamental niche is the entire set of conditions under which an organism can survive and reproduce itself. **Realized niche** is the set of conditions actually used by a given organism, after taking into account interactions (especially competition) with other species.

The set of conditions described under fundamental niche consider the various potential roles of the species. On the other hand, the set of conditions described under the realized niche consider the actual roles performed by the species. Thus, the fundamental niche is larger than the realized niche. The realized niche can be called as a subset of fundamental niche. When the species interact with other species, they face various pressures. Thus, they are forced to live in narrower niche. This narrower niche is the realized niche. In other words, it is the realized niche where a species actually exist.

Criteria	Fundamental niche	Realized niche
Definition	Entire set of conditions under which an organism can survive and reproduce itself	Actually available conditions under which an organism would survive or grow
Wider/Narrower	Fundamental niche is wider in scope because it considers potential conditions	Realized niche is narrower in scope because it considers actual available conditions
Relation with Organism	If an organism lives under Fundamental niche, then it can perform larger roles.	An organism in the realized niche performs limited roles. In other words, due to various restrictions and limitations, the actual roles performed by an organism are limited.
Example	If there is no competition, an organism would have more choices and availability of prey.	Due to competition and other constraints, the freedom to reproduce and the availability of prey is limited.

Niche width and Realized niche width

The niche width of an organism refers to the potential space which a given organism can inhabit to live and to use in order to access the resources. Niche width does not consider competition. The niche width is determined on the basis of biotic and abiotic factors such as availability of food sources and suitability of climate respectively.

The niche width often differs from the area that a species actually inhabits. *Realized niche width* is used to define the actual space that an organism inhabits and uses to access the resources on account of pressure from other organisms such as competition for same space.

Thus, the realized niche width is the actual space where organisms live and access the resources that are not used by other species. Within realized niche width, all the fundamental requirements of an organism are fulfilled in order to make successful living such as food, mate, and shelter. An organism's realized niche width is much narrower than its theoretical niche width as it is forced to adapt its niche on account of competition from other organisms.

Niche overlap

Niche overlap occurs when two organisms use the same resources or other environmental variables. The organisms which experience niche overlap engage in interactions with each other. These interactions may result in symbiotic relationships, competition, predation and so on. Niche overlap is studied to determine which species can coexist in a single habitat.

Habitat

A habitat is an ecological or environmental area that is inhabited by a particular species of animal, plant, or any other type of organism. The term typically refers to the zone in which the organism lives and where it can find food, shelter, protection and mates for reproduction.

Home Range

A home range is the area in which an animal lives and moves on a periodic basis. An associated concept is the **utilization distribution** which examines where the animal is likely to be at any given time. Earlier, data for mapping a home range used to be gathered by careful observation, but nowadays, the animal is fitted with a transmission collar or a GPS device.

Home range includes the territory of an animal. **Territory** is an area which an animal, or group of animals, protects from incursions by other members of its species. Territorial boundaries may be marked by sounds such as bird song, or scents such as pheromones secreted by the skin glands of many mammals.

Speciation and Extinction

The species present in the world today are a result of speciation and extinction. Speciation refers to formation of new species. Speciation can occur on account of one or more factors such as geographic isolation, ecological isolation, reproductive isolation and mutation.

Geographic isolation: When different populations of a species are isolated due to a geographic barrier such as mountain, ocean, river, etc., it is termed as geographic isolation. Because of the physical barrier,

the populations cannot interbreed with each other. Over time they evolve as distinct species incapable of interbreeding. The most common way a population undergoes speciation is by geographic isolation.

Example: One of the best examples of speciation is Kaibab squirrels and Abert squirrels that live on opposite sides of the Grand Canyon. Though they originally belong to the same species, they evolved into two distinct species over a course of time. It is assumed that about a million years ago, when the Colorado river changed its course, the original population of squirrels was split into two, creating a geographical barrier. As a result of different environment on either side of the canyon, the two populations developed distinct characteristics. Over the years, the genetic differences became so large that the two populations of squirrels emerged as two separate species. These species look different from each other and are not capable of interbreeding.

Ecological isolation: When different populations of a species are isolated from each other as a result of differences in temperature, humidity, pH level etc in the environment, it is termed as ecological isolation.

Reproductive isolation: When different populations of a species cannot interbreed due to a reproductive barrier, it is termed as reproductive isolation. This may occur when two populations become sexually receptive at different times, members are not attracted towards one another or failure of pollination mechanisms. For example, though they occur in the same area, the population of frogs that breed in May is reproductively isolated from frogs that breed in July.

Extinction

Extinction refers to the disappearance of a species' population from an area or the disappearance of complete species itself. It can be a result of natural or anthropogenic (man-made) factors. In recent times, threats to different species as a result of human actions, has become a major global concern. Natural factors such as tsunami, volcano etc may result in extinction of species. In certain cases, extinction may happen at a faster rate than speciation. At a particular point of time, widespread extinction may occur leading to disappearance of a wide range of species. Such events are termed as mass extinctions. So far, Earth has witnessed five mass extinctions.

Scientists argue that anthropogenic activities such as over exploitation of resources, global warming and climate change are leading to the ongoing sixth mass extinction, also known as Anthropocene extinction. While the earlier five mass extinctions were believed to be caused by natural reasons, the sixth one is seen to be a result of human activities.

Ecological Succession

Ecological succession refers to progressive changes in the species composition of a particular area with the passage of time. In other words, plant and animal communities in a particular area are replaced over time by a series of different communities.

Ecological succession undergo more or less orderly and predictable changes. For instance, in a barren land, rainfall and bird droppings lead to growth of lichens. Lichens are composite organisms of algae and fungi and/or cyanobacteria. The first species to grow in an area are called **pioneer species**. In our example, lichens are the pioneer species. Pioneer species is the first to colonize an area and it also sets the foundation for development of other species.

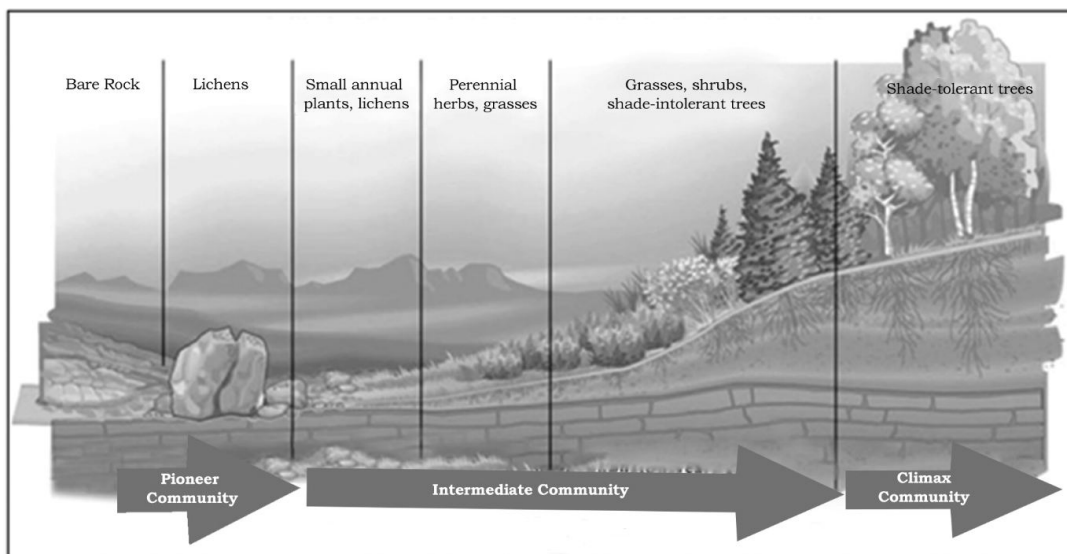
Lichens secrete acid that breaks down rock and soil formation takes place. As lichens die, their mass add organic matter to the soil. Thereafter, mosses develop in the area. They trap soil blown by the winds. When mosses die, they add more organic matter to the soil.

Thereafter, seeds arrive in the area, which are either dropped by birds or by winds, begin germinating and eventually develop into small plants. These small plants are gradually replaced by large and complex plants with passage of time.

At each stage, new species adds to the community and replace the previous species. This way, this progressive succession reaches a stable point when there is no more change in the species composition of a place. This stable point is called **Climax of the Ecosystem**.

The time scale for ecological succession can be decades (for example, after a wildfire), or even millions of years after a mass extinction, or the initial colonization of a new habitat.

In ecological succession the pioneer community gets replaced by another community, which is again replaced by a different community. This process continues until a final stable community evolves in the region. This final community is called the **climax community**. The transitional communities in between the primary and climax community are called **seral communities** or **intermediate communities**. The entire sequence of these successive communities in a given area is termed sere. With each stage of succession, the biodiversity of species and the total biomass of the community tend to increase.



Kinds of Ecological succession

Succession may be initiated either in a new, unoccupied habitat or by some form of disturbance in an existing habitat. Succession that begins in new habitats, uninfluenced by pre-existing communities is called **primary succession**, whereas succession that takes place after disruption of a pre-existing community is called **secondary succession**.

Secondary succession unlike primary succession doesn't start from a bare land. In this type of succession, there was a community which existed previously. This earlier community may have been removed, disturbed or destroyed by natural reasons (hurricane, forest fire) or by anthropogenic reasons (tilling, harvesting of land). The formation of a new community after the existing community is destroyed or removed, is called secondary succession. Unlike primary succession, secondary succession is relatively fast as the necessary conditions such as soil and nutrients are already present.

It is to be noted that complete replacement of the existing species may or may not happen in a secondary succession. However, the dominant species of the community do undergo a change even in case of secondary succession.

Differences between Primary Ecological Succession and Secondary Ecological Succession

Criteria	Primary ecological succession	Secondary ecological succession
1. Definition	When barren land is colonized by living beings for the first time, it is called primary ecological succession.	This succession takes place in an area where a community had already existed previously. It is the development or succession of new community after the destruction of existing community.
2. Determining factors	Soil formation takes place along with this kind of succession. This succession begins with most basic plant (pioneer) species. The time period of primary succession depends mainly upon climatic conditions.	Soil is already present for this kind of succession. Seeds, roots and other parts of plants may also be present. Thus, the time period for secondary succession depends upon the already present soil and plant species, and climatic conditions.
3. Speed of succession	The time period of primary ecological succession is usually longer as compared to secondary ecological succession. For instance, it takes millions of years for a barren land to transform into a forest.	The time scale of secondary ecological succession is highly variable; it could be decades or even millions of years. For instance, after a forest fire, succession might take place in few decades. On the other hand, succession after mass extinction might take millions of years.

Some of the types of succession are given below:

Xerarch Succession: The succession that occurs on land with low moisture content is called xerarch succession. In xerarch succession, the succession moves from xerarch (dry) to mesic (medium water) conditions.

Hydrarch Succession: The succession that occurs in wet areas, water bodies such as ponds or lakes is called hydrarch succession. In hydrarch succession also, succession move from hydrarch to mesic conditions.

In both xerarch and hydrarch succession, the climax community is mesic i.e., community of medium water conditions.

Climax Ecosystem

The final stage of succession of an ecosystem is called Climax ecosystem. Ecological succession continues till a stable community structure is achieved. For example, a barren land over time transforms into a forest ecosystem. Here, the forest is a stable and mature stage of succession that resulted after millions of years and is an example of climax ecosystem.

It is important here to mention that climax ecosystem may still undergo change. It can be disturbed by changes in the climate or invasion of new species. In case, it happens, the process of ecological succession starts again.

Productivity (in Ecology)

In ecology, productivity or production refers to the rate of generation of biomass in an ecosystem. It is usually expressed in units of mass (or volume of biomass) per unit area per unit time, for instance grams of biomass per square metre per day. Productivity of autotrophs such as plants is called **primary productivity**, while that of heterotrophs such as animals is called **secondary productivity**.

Primary Productivity

Primary productivity is the rate of synthesis of new organic material from inorganic molecules such as water and carbon dioxide. It is dominated by the process of photosynthesis which uses sunlight to synthesise organic molecules such as sugars. Organisms responsible for primary production include plants, algae and some bacteria (including cyanobacteria).

Gross Primary Productivity (GPP)

GPP is the total amount of organic matter synthesized by producers per unit area in unit time. It also includes the organic matter which has been used by autotrophs to carry out respiration and other day to day functions. In other words, it refers to the total synthesis of organic matter by autotrophs including the energy utilized for respiration by the autotrophs.

Mathematically, $\text{GPP} = \text{Rate at which organic matter is synthesised by autotrophs} = \text{Rate at which organic matter is utilised by autotrophs to carry out day to day functions} + \text{Rate at which organic matter is retained (or stored) by autotrophs}$

It is to be noted that GPP is calculated with respect to a particular area and particular time period. The use of the word 'rate' in the formula implies that GPP is calculated with respect to a particular area and particular time period.

Net Primary Productivity (NPP)

It is the amount of organic matter stored (or retained) by autotrophs per unit area in unit time. In other words, if we exclude organic matter utilised by autotrophs to carry out day to day functions from total organic matter synthesis by autotrophs, we get Net Primary Productivity. Mathematically,

NPP = Rate at which organic matter is synthesised by autotrophs – Rate at which organic matter is utilised by autotrophs to carry out day to day functions

It is to be noted that NPP is also calculated with respect to a particular area and particular time period.

Secondary Productivity

Secondary productivity is the rate of generation of biomass by heterotrophs (consumers) in an ecosystem. Secondary productivity is driven by the transfer of organic material through the trophic levels in a food chain and represents the quantity of new tissue created due to consumption of food.

Organisms responsible for secondary productivity include animals, protists, fungi and many bacteria.

Determinants of Species Behaviour: Genotype and Phenotype

Genotype is the complete heritable genetic identity. The word genotype can also refer just to a particular gene or set of genes carried by an individual. For example, if one carries a gene linked to diabetes, one may refer to his genotype just with respect to this mutation without consideration of all the other gene variants that one may carry.

In contrast, phenotype is a description of actual physical characteristics. This includes not only straightforward visible characteristics like height and eye colour, but also overall health, and even our behaviour.

Most phenotypes are influenced by both genotype and by the unique circumstances in which one has lived, including one's experiences. Thus, our phenotype is the result of two inputs: "nature," the unique genome we carry, and "nurture," the environment in which we have lived our life.

Types of Species

On the basis of the role played by species in their ecosystem, the species can be known by the following titles:

Keystone Species

A keystone species is a species that plays a critical role in maintaining the structure of an ecological community. In other words, keystone species affects many other species in an ecosystem and plays an important role in determining the types and numbers of various other species in the community. Without keystone species, the ecosystem would be dramatically different or cease to exist altogether. For instance, tigers are keystone species in the terrestrial ecosystem. If the population of tigers decreases in the ecosystem, the deer population would rise. The increase in deer population means more consumption of grass and thus, other species dependent upon grass may not be able to survive.

Flagship species

A flagship species is a species selected to act as an ambassador, icon or symbol for a defined habitat, issue, campaign or environmental cause. Flagship species are usually relatively large and considered to be charismatic.

The concept of flagship species has its genesis in the field of conservation biology. The flagship species concept holds that by raising the profile of a particular species, it can successfully leverage more support for biodiversity conservation.

Foundation Species

Foundation species is a species that plays an important role in determining composition of a community. A foundation species can be at any trophic level in a food web. In other words, foundation species can be primary producers, herbivores or predators.

Since foundation species has an important role in determining composition of a community, impact on foundation species also has impact on the overall community. Thus, environmentalists focus on foundation species to rapidly understand how a community as a whole would react to disturbances, such as pollution or introduction of alien species, instead of choosing the extremely difficult task of tracking the responses of all community members simultaneously.

Indicator species

An indicator species is any biological species that defines a trait or characteristic of the environment. For example, a species may delineate an ecoregion or indicate an environmental condition such as a disease outbreak, pollution, species competition or climate change. Indicator species can be among the most sensitive species in a region, and sometimes act as an early warning to monitoring biologists. For instance, coral bleaching (or whitening of corals) is considered as an indication of climate change.

Indigenous species

In biogeography, a species is defined as indigenous or native to a given region or ecosystem if its presence in that region is the result of only natural process, with no human intervention. A species may be introduced by human activity; it is then referred to as an introduced or alien species.

Endemic Species

In ecology, endemic means exclusively native to a particular region. In other words, an endemic species is exclusive to a particular region or utmost a few regions. An indigenous species may occur in areas other than the one under consideration. Thus, an indigenous species is not necessarily endemic.

The terms “endemic” and “indigenous” do not imply that an organism necessarily originated or evolved where it is found.

Introduced or Exotic species

An introduced, alien, exotic, non-indigenous, or non-native species, or simply an introduction, is a species living outside its native distributional range, which has arrived there by natural or human activity, either deliberate or accidental. Non-native species can have positive, negative or no effects on the local ecosystem. One popular example of exotic species having a negative effect on the ecosystem is that of Water hyacinth.

Water hyacinth (scientifically referred to as *Eichhornia crassipes*) is an exotic shrub and an aquatic plant which survives well in hot and humid conditions. It is mainly found in the parts of Bengal. It is

called the terror of Bengal because it destroys other plant and animal species especially fish population in its vicinity.

In comparison to other species, Water hyacinth utilises and consumes aquatic nutrients at a fast pace. This fast utilisation and consumption of nutrients leads to higher Water hyacinth biomass production and reduces the availability of nutrients for other species. Fish is the vital food in Bengal. However, due to higher consumption of nutrients by water hyacinth, the nutrients available for fish are few, leading to decline in the fish population.

Invasive species

Introduced species that become established and spread beyond the place of introduction are called invasive species. Most introduced species may have no negative effect or only minor impact on native species. However, some invasive species may bring significant changes in community structure of an ecosystem.

Edge species

Evolutionarily Distinct and Globally Endangered (EDGE) species represent a disproportionate amount of unique evolutionary history. They have few close relatives, are often the only surviving member of their genus, and sometimes the last surviving genus of their evolutionary family. Some examples of EDGE species are elephants and pandas.

Species are identified as EDGE species on the basis of the following process:

1. Every species in a particular taxonomic group (e.g. mammals or amphibians) is given an ED score and GE score. **ED (Evolutionary Distinctiveness)** score is given according to the uniqueness of evolutionary history and **GE (Global Endangerment)** score is given according to its conservation status.
2. These scores are then combined to calculate an EDGE score of each species.
3. Those species with high ED and GE get the highest EDGE scores and are generally prioritised for conservation efforts.

Umbrella Species

Umbrella species are species selected for making conservation-related decisions, typically because protecting these species indirectly protects the many other species that make up the ecological community of its habitat.

Practice Questions

- The biomass available for consumption by the herbivores is called:
 - Gross primary production
 - Net primary production
 - Secondary production
 - None of the above
- Amensalism is an association between two species where:
 - One species is harmed and the other is benefitted.
 - One species is harmed and the other is unaffected.
 - One species is benefitted and the other is unaffected.
 - Both the species are harmed.
- A high density of tiger population in an area can result in:
 - Predation on one another
 - Mutualism
 - Intra species competition
 - Inter species competition
- Which one of the following terms is related to the impact of an organism on biotic and abiotic components of its ecosystem?
 - Ecotone
 - Ecological niche
 - Ecocline
 - Trophic level
- A transition zone or region separating two biomes is known as:
 - Ecocline
 - Ecological niche
 - Ecotone
 - Ecotype
- Which of the following statements correctly explains the phenomenon of amensalism?
 - One species kills to feed on the other species.
 - An organism benefiting from the other organisms.
 - Production of secretions by an organism which is harmful to other organisms.
 - Competition between organisms of the same species.
- Which among the following correctly describes 'homeostasis'?
 - It refers to the gradual process by which communities in the ecosystems change and develop over time.
 - It is the process by which an organism maintains a stable internal environment despite changes in external conditions.
 - It is the process of transfer of energy from one trophic level to another in a grazing food chain.
 - It is the gradual process through which energy requirement in an ecosystem is balanced with the energy available to the ecosystem.
- Which of the following best describes an indicator species?
 - It is a species that has a disproportionately large effect on the ecosystem in which it occurs.
 - It is a species which is of invasive nature.

- (c) It is a species which is introduced to balance the species composition in an ecosystem.
- (d) It is a species whose presence, absence or abundance reflects a specific environmental condition.
9. Which one of the following is the best description of the term 'ecosystem'?
- (a) Flora of a particular geographical area.
- (b) Flora and fauna of a geographical area.
- (c) Flora and Fauna along with their environment.
- (d) Flora and fauna of a continent.
10. The ability of an ecosystem to self regulate itself is
- (a) Accommodation
- (b) Adaptation
- (c) Homeostasis
- (d) Evolution
11. In an ecotone, the species which is expanding to other ecosystems on its own are called:
- (a) Invasive species
- (b) Edge species
- (c) Keystone species
- (d) Adaptive species
12. Two animals can be conclusively said to belong to the same species if they:
- (a) Have same biological evolution
- (b) Have similar genetic makeup
- (c) Look similar and possess similar physical makeup
- (d) Can reproduce freely with each other

13. Which of the following is **not** an example of mutualism?
- (a) Algae and fungus
- (b) Rhizobium bacteria and leguminous plants
- (c) Coral polyps and Zooxanthellae algae
- (d) Leech and cattle

14. Consider the following pairs:

Interaction		Explanation
1	Mutualism	Both the species are benefitted
2	Competition	Both the species are harmed
3	Commensalism	One species is harmed and the other is unaffected
4	Amensalism	One species is benefitted and the other is unaffected

Which of the pairs given above is/are correctly matched?

- (a) 1 and 2 only (b) 3 and 4 only
- (c) 1, 2 and 3 only (d) 1, 2, 3 and 4
15. With reference to keystone species, consider the following statements:
1. A keystone species exhibits disproportionately large effect on its environment relative to its abundance.
 2. Tigers are keystone species as they determine the species composition in a forest.

Select the correct answer using the codes given below:


- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

16. Which of the following is/are the types of positive interaction in a biotic community?

1. Colonisation
2. Competition
3. Protocooperation

Select the correct answer using the codes given below:

- (a) 1 and 2 only (b) 2 and 3 only
(c) 3 only (d) 1 and 3 only

 **Note:** Colonisation or colonization is the process in biology by which a species spreads to new areas. Colonisation often refers to successful immigration, where a population becomes integrated into a community, having resisted initial local extinction.

Protocooperation is a form of interaction which is beneficial for the interacting species. It is to be noted that though protocooperation is beneficial for the interacting species, it is not necessary for growth and survival of interacting species. In other words, protocooperation is a form of mutualism, but the interacting species do not depend on each other for survival.

Interaction between flowers of plants and insects is an example of protocooperation. The plants, especially those with large, bright, colourful flowers bearing nectar glands, undergo pollination because of the activities


of the insects. This interaction is also beneficial to the insects as they get the food supply of pollen and nectar.

17. Consider the following statements with reference to primary productivity of ecosystem:

1. Net primary productivity is gross primary productivity minus the amount of biomass consumed by the primary consumers.
2. Primary productivity of water bodies is more than the terrestrial environment.

Which of the statements given above is/are correct?

- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

 **Note:** Presently, 85% of biomass is produced in terrestrial environment and only 15% biomass is produced in aquatic environment.

18. Which of the following are the abiotic components of the ecosystem?

1. Water
2. Insolation
3. Winds
4. Decomposers
5. Soil

Select the correct answer using the codes given below:

- (a) 1 and 5 only
(b) 1, 2, 3 and 5 only
(c) 2, 3 and 4 only
(d) 1, 3, 4 and 5 only

19. Consider the following statements:

1. Ecotone is the transitional area between two biomes or diverse ecosystems.

2. Ecological niche is the role of a species in an ecosystem.
3. Ecocline refers to the combination of all physical and chemical factors that play a role in an ecosystem.
- Which of the statements given above is/are correct?
- (a) 1 only (b) 2 and 3 only
(c) 1 and 2 only (d) 1, 2 and 3
20. Consider the following statements:
1. A dominant species refers to a species which contributes to the highest percentage of biomass in an ecosystem.
 2. A keystone species is one that has the greatest effect on all the other species in an ecosystem.
- Which of the statements given above is/are correct?
- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2
21. In which of the following relationships does one species benefit by harming another species?
1. Parasitism
 2. Predation
- Select the correct answer using the codes given below:
- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2
22. Which of the following terms defines the gradual change in certain characteristics exhibited by communities along with the gradual change in one or more environmental gradients?
- (a) Ecotone
(b) Ecocline
(c) Ecotype
(d) Ecological niche
23. Which of the species became extinct because of anthropogenic factors?
- (a) Dodo Bird (b) Dinosaurs
(c) Mammoth (d) Dire wolf
24. Which of the following is an example of saprophytic mode of nutrition?
1. Yeast
 2. Aspergillus
 3. Mushroom
- Select the correct answer using the codes given below:
- (a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3
25. **Assertion (A):** No two species in a habitat can have the same niche.
- Reason (R):** If two species occupy the same niche, they will compete with one another until one is displaced.
- In the context of the above two statements, which one of the following is correct?
- (a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true and R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true
26. Which of the following pairs are correct?
1. Algae- Autotroph
 2. Lice- Parasite
 3. Cow- Phagotrophic

Select the correct answer using the codes given below:

- (a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

27. Which of the following correctly defines the term speciation?

- (a) Speciation is the process by which nature selects a particular species.
(b) Speciation is the process by which biologists classify species into different categories.
(c) Speciation is the process by which new species are formed
(d) None of the above

28. The death of a variety of species due to phenomenon such as tsunami, volcano, environmental change or competition is termed:

- (a) Natural selection
(b) Extinction
(c) Evolution
(d) Adaptation

29. Which of the following are examples of both plants as well as parasites?

1. Dodder plant
2. Mistletoe
3. Ascaris

Select the correct answer using the codes given below:

- (a) 1 and 2 only (b) 2 and 3 only
(c) Both 1 and 2 (d) Neither 1 nor 2

30. Consider the following statements:

1. Neutralism describes the relationship between two species which do interact but do not affect each other.

2. In nature, true neutralism is extremely unlikely and impossible to prove.

Which of the statements given above is/are correct?

- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

31. Which of the following is known as the 'terror of Bengal', on the basis of water pollution caused by it?

- (a) Water Hyacinth
(b) Planktonic algae
(c) *Prosopis juliflora*
(d) Locust swarm

32. Parasites that feed on the external surface of the host organism are called:

- (a) Ectoparasites
(b) Endoparasites
(c) Hyperparasites
(d) None of the above

33. A cuckoo lays its eggs in the nest of a crow and lets the crow incubate the eggs. This is an example of:

- (a) Symbiosis (b) Brood Parasitism
(c) Predation (d) Competition

34. Consider the following statements:

1. EDGE species are usually extremely distinct in the way they look, live and behave as well as in their genetic make-up.
2. EDGE species are identified based on a combined score of their unique evolutionary history (calculated by Evolutionary Distinctiveness, or ED) and their conservation status (Global Endangerment, or GE).

Which of the statements given above is/are correct?

- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

35. Which of the following correctly describes the relation between Gross primary productivity and Net Primary Productivity?

- (a) Gross primary productivity is always less than Net Primary Productivity
(b) Gross primary productivity is always more than Net Primary Productivity
(c) Gross primary productivity is less than Net Primary Productivity only when the ecological pyramid is inverted
(d) None of the above

36. The net amount of primary productivity after the costs of respiration by plants, heterotrophs, and decomposers is called as:

- (a) Gross Primary Productivity
(b) Net Primary Productivity
(c) Net Ecosystem Productivity
(d) Rate of photosynthesis

37. Corals are an example of:

- (a) Keystone species
(b) Indicator Species
(c) EDGE Species
(d) Flagship Species

38. The 3 species of warbler birds search for insects as food in the forest at different levels of a tree. Blackburnian warbler relies on the topmost regions of

the trees. Bay-breasted warbler feeds on the middle sections of the tree. Myrtle warbler feeds near the root region. These birds, hence, can be said to have:

1. Same habitat

2. Different niche

Select the correct answer using the codes given below:

- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

39. Reproductive isolation plays an important role in creating new species. Two populations of a species may be unable to interbreed due to reproductive barrier. Which of the following, do you think, are the causes of reproductive isolation?

1. Members of different populations of the same species are not attracted by courtship behaviour towards one another.
2. Two different populations become sexually receptive at different times of the year.
3. Pollination mechanism fails, between flowers of two populations.

Select the correct answer using the codes given below:

- (a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

40. Which of the following are the mechanisms used by organisms to cope or manage changes related to temperature in their environment?

1. Regulation
2. Diapause
3. Migration
4. Aestivation

5. Hibernation

Select the correct answer using the codes given below:

- (a) 1, 2 and 3 only
- (b) 3, 4 and 5 only
- (c) 1, 3, 4 and 5 only
- (d) 1, 2, 3, 4 and 5

41. Consider the following statements:

- 1. Hydrarch succession starts from wet areas and moves to mesic conditions.
- 2. Xerarch succession starts from mesic conditions and moves to wet areas.

Which of the statement(s) given above are correct?

- (a) 1 only (b) 2 only
- (c) Both 1 and 2 (d) Neither 1 nor 2

42. Lichens, which invade a bare rock and secrete acids to dissolve rock, enable weathering and soil formation, are an example of:

- (a) Pioneer species
- (b) Climax species
- (c) Intermediate species
- (d) Invasive species

43. Which of the following best describes the stratification as a strategy used by the species?

- (a) Minimise symbiotic association
- (b) Minimise interspecies competition
- (c) Maximise homeostasis
- (d) None of the above

44. Which of the following is not an example of invasive species in India?

- (a) Malabar Lily
- (b) *Prosopis juliflora*
- (c) Eucalyptus
- (d) *Acacia demissa* (Wattle)

45. In an association known as mycorrhizal association between the fungus and plants, the fungus resides in the root tissues of the host plants. The term mycorrhiza refers to the role of the fungus in the plant's rhizosphere, the region of soil in the vicinity of plant roots. Fungus absorbs soil minerals and water and gives them to the plant roots and the plant roots provide food to fungus. This is an example of:

- (a) Parasitism (b) Predation
- (c) Mutualism (d) Competition

46. To conserve the Greater Yellowstone Ecosystem (GYE), the U.S. government eradicated Grey wolves from the GYE. The last remaining wolf pups in Yellowstone were killed in 1924. This resulted in a top-down trophic cascade in the Greater Yellowstone Ecosystem. Lacking an apex predator, elk populations in Yellowstone exploded. The competition among the Elk herds led to overgrazing and negatively impacted other species such as beaver, songbirds etc which also depend on the plants. Stream banks eroded as wetland plants failed to anchor valuable soil and sediments. Lake and river temperatures increased as trees and shrubs failed to provide shaded areas. Starting in

the 1990s, the U.S. government began reintroducing wolves to the Greater Yellowstone Ecosystem. The results have been noteworthy. Elk populations have shrunk, willow heights have increased, and beaver and songbird populations have recovered. The Grey wolves, is an example of:

- (a) Keystone species
- (b) Flagship species
- (c) Pioneer species
- (d) Climax species

47. In an ecotone, there is a larger biodiversity compared to the adjoining ecosystems. This phenomenon is called:

- (a) Edge effect
- (b) Niche effect
- (c) Speciation effect
- (d) Evolution effect

48. Consider the following pairs:

Type of Ecocline	Explanation
1 Thermocline	Ecocline caused by temperature gradient
2 Halocline	Ecocline caused by salinity gradient
3 Pycnocline	Ecocline caused by chemical gradient

Which of the pairs given above is/are correctly matched?

- (a) 1 and 2 only (b) 2 and 3 only
- (c) 1 and 3 only (d) 1, 2 and 3

49. Two different populations of a species are isolated from each other as a result of differences in temperature, humidity, pH level etc in the environment. This is termed as:

- (a) Ecological isolation
- (b) Geographic isolation
- (c) Reproductive isolation
- (d) Chemical isolation

50. Consider the following statements:

1. Lichen is a symbiotic association of cyanobacteria and fungi.
2. The fungus provides the cyanobacteria protection from strong sunlight and gain nutrients in return.

Select the correct answer using the codes given below:

- (a) 1 only (b) 2 only
- (c) Both 1 and 2 (d) Neither 1 nor 2

PERFECTING PAST PRELIMS

1. Which one of the following terms describe not only the physical space occupied by an organism, but also its functional role in the community of organisms? (2013)

(a) Ecotone
(b) Ecological niche
(c) Habitat
(d) Home range

2. Which one of the following is the best description of the term 'ecosystem'? (2015)

(a) A community of organisms interacting with one another.
(b) That part of the Earth which is inhabited by living organisms.
(c) A community of organisms together with the environment in which they live.
(d) The flora and fauna of a geographical area.

3. In nature, which of the following is/are most likely to be found surviving on a surface without soil? (2021)

1. Fern
2. Lichen
3. Moss
4. Mushroom

Select the correct answer using the code given below:

(a) 1 and 4 only (b) 2 only
(c) 2 and 3 (d) 1, 3 and 4

4. Which of the following are detritivores? (2021)

1. Earthworms
2. Jellyfish
3. Millipedes
4. Seahorses
5. Woodlice

Select the correct answer using the code given below:

(a) 1, 2 and 4 only
(b) 2, 3, 4 and 5 only
(c) 1, 3 and 5 only
(d) 1, 2, 3, 4 and 5

5. Which of the following have species that can establish a symbiotic relationship with other organisms?

1. Cnidarians
2. Fungi
3. Protozoa

Select the correct answer using the codes given below: (2021)

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3



ANSWER KEYS

Practice Questions

1. (b)	2. (b)	3. (c)	4. (b)	5. (c)
6. (c)	7. (b)	8. (d)	9. (c)	10. (c)
11. (a)	12. (d)	13. (d)	14. (a)	15. (c)
16. (d)	17. (d)	18. (b)	19. (c)	20. (c)
21. (c)	22. (b)	23. (a)	24. (d)	25. (a)
26. (d)	27. (c)	28. (b)	29. (a)	30. (c)

31. (a)	32. (a)	33. (b)	34. (c)	35. (b)
36. (c)	37. (b)	38. (c)	39. (d)	40. (d)
41. (a)	42. (a)	43. (b)	44. (a)	45. (c)
46. (a)	47. (a)	48. (a)	49. (a)	50. (c)

Perfecting Past Prelims

1. (b)	2. (c)	3. (b)	4. (c)	5. (d)
--------	--------	--------	--------	--------

Solutions

Practice Questions

3. (c) Intra-species competition is the competition between the same species. Increase in population of tigers will lead to an increase in competition among tigers for various resources.
4. (b) Ecological niche of an organism includes all of its interactions with the biotic and abiotic factors of its environment and the impact it has on them.
7. (b) Homeostasis is the maintenance of a constant internal environment of a system in response to changes in the external environment.
8. (d) An indicator species is any biological species that defines a trait or characteristic of the environment.
9. (c) An ecosystem is a community of living organisms in conjunction with the non-living components of their environment (things like air, water and mineral soil), interacting as a system.

12. (d) A species is a group of closely related organisms that can interbreed freely to produce offspring.
13. (d) Leech and cattle
Leech feeds on the blood of cattle; so cattle is harmed and leech is benefitted. Therefore, it is parasitism and not mutualism.
15. (c) Statement 1 is correct: A keystone species is a species that plays a critical role in maintaining the structure of an ecological community. Without keystone species, the ecosystem would be dramatically different or cease to exist altogether.
17. (d) Statement 1 is incorrect: Net primary productivity (NPP) is the amount of organic matter stored by producers per unit area in unit time. In other words, it refers to the net productivity that is converted into organic matter excluding the energy utilised for respiration and other purposes by the producers.

Statement 2 is incorrect: Presently, 85% of biomass is produced in the terrestrial environment and only 15% biomass is produced in the aquatic environment.

18. (b) Abiotic components are the non-living components; so decomposers are not included in the list.
19. (c) Statement 3 is incorrect: Ecocline is a variation in the physical and/or chemical environment. It is not the combination of all physical and chemical factors.
20. (c) Statement 1 is correct: Dominant species is that which predominates in an ecological community, particularly when they are in majority or form a bulk of biomass.
23. (a) Dodo bird, which inhabited the island of Mauritius, became extinct as a result of indiscriminate hunting by humans.
24. (d) Yeast, *Aspergillus* and Mushroom derive nutrition by feeding on dead organisms and thus, are examples of saprophytic mode of nutrition.
26. (d) Cow is a herbivore as it feeds on plants. Herbivores, carnivores and omnivores are sub-divisions of phagotrophs.
29. (a) Plants like the dodder plant (*Cuscuta*) and mistletoe (*Loranthus*) are parasites that live on flowering plants. *Ascaris* or roundworms (animal parasite) are internal parasites found in the human intestine.
33. (b) Brood parasitism is an example of parasitism in which the parasitic bird lays its eggs in the nest of its host and lets the host incubate them. The eggs

of the parasitic bird resemble the host's egg size and colour, making it difficult for the host bird to detect and eject these eggs from the nest. Female cuckoos lay their eggs in the nests of other bird species. After the eggs are hatched, the young cuckoo may usually throw the other host eggs out of the nest, getting rid of any competition for the parent's attention. This is possible as cuckoo's eggs hatch earlier than the crow's eggs.

34. (c) Species are identified as EDGE species on the basis of the following process: every species in a particular taxonomic group (e.g. mammals or amphibians) is given a ED score and GE score. ED (Evolutionary Distinctiveness) score is given according to the uniqueness of evolutionary history and GE (Global Endangerment) score is given according to its conservation status. These scores are then combined to calculate an EDGE score of each species. Those species with high ED and GE get the highest EDGE scores and are generally prioritised for conservation efforts.
35. (b) The relationship between GPP and NPP is as follows: $NPP = GPP - \text{Respiratory Loss}$. Hence GPP is always more than NPP.
36. (c) Net Ecosystem Productivity, NEP, is the net amount of primary production after deducting respiration by plants, heterotrophs, and decomposers.
Therefore, $NEP = GPP - (R_p + R_h + R_d)$ where
 R_p = Respiration by plants

R_h = Respiration by heterotrophs

R_d = Respiration by decomposers (the microbes)

37. (b) Corals indicate the relative health and pollution levels a water body. When corals are stressed by changes in conditions such as temperature, light, or nutrients, they expel the symbiotic algae living in their tissues, causing them to turn completely white. This is called coral bleaching. Coral bleaching may indicate factors such as: increase in pollution, warming of waters, rise in acidity or salinity levels.
38. (c) Statement 1 is correct: 3 species of warbler birds, given in the question statement, share the same habitat because they feed on insects at trees. The term habitat typically refers to the zone in which the organism lives and where it can find food, shelter, protection and mates for reproduction. Statement 2 is correct: 3 species of warbler birds have different niche because they feed on insects at different sections of trees. A niche refers to the unique functional role of a species in an ecosystem. A species' niche also includes the physical, biological and chemical environment to which it is adapted. Different sections of trees constitute the physical environment of the species.
40. (d) All the given mechanisms namely Regulation, Diapause, Migration, Aestivation and Hibernation are used by organisms to cope or manage changes related to temperature in their environment.
41. (a) Statement 2 is incorrect: Xerarch succession starts from dry conditions and moves to mesic conditions.
42. (a) Lichens are pioneer species because they are the first species to grow in an ecosystem.
43. (b) Stratification helps in minimising interspecies competition. For instance, some species survive on feeding insects in the soil and some other species survive on feeding insects at trees. The competition among these two types of species is negligible.
44. (a) Malabar Lily is endemic to India. Eucalyptus, Lantana, Prosopis juliflora, Parthenium hysterophorus, Eupatorium odoratum and wattle are examples of invasive species which are threatening the ecological diversity of Western Ghats.
45. (c) Both fungi and the plants are benefitted here. Hence, it is an example of mutualism. It is to be noted that in some cases, fungus acts as parasite in the plant roots.
48. (a) Pair 3 is not correctly matched. Pycnocline is caused due to variations in density of water induced by temperature or salinity.
50. (c) Lichen is a symbiotic association of a fungus and an algae or cyanobacteria. The fungus provides protection to cyanobacteria. The cyanobacteria are capable of photosynthesis and provides nutrients to the fungus.

Perfecting Past Prelims

1. (b) An ecological niche refers to the unique functional role or place of a species in an ecosystem. A species niche includes the physical, biological and chemical environment to which it is adapted as well as its role as a producer and consumer of food resources.
2. (c) An ecosystem is a community of living organisms in conjunction with the non-living components of their environment.
3. (b) In a barren land, rainfall and bird droppings lead to growth of lichens. Lichens are the pioneer species. Pioneer species is the first to colonize an area and it also sets the foundation for development of other species.
4. (c) Statement 1 is correct: Earthworms are an example of detritivores.
Statement 2 is incorrect: Jellyfish feed on small plants, shrimp, or fish. They are considered carnivores.
Statement 3 is correct: Millipedes are detritivores as they feed on decaying leaves and other dead plant matter.

Statement 4 is incorrect: Seahorses are carnivores. They feed on plankton, small fish, shrimp, copepods and the like.

Statement 5 is correct: Woodlice is an example of detritivores.

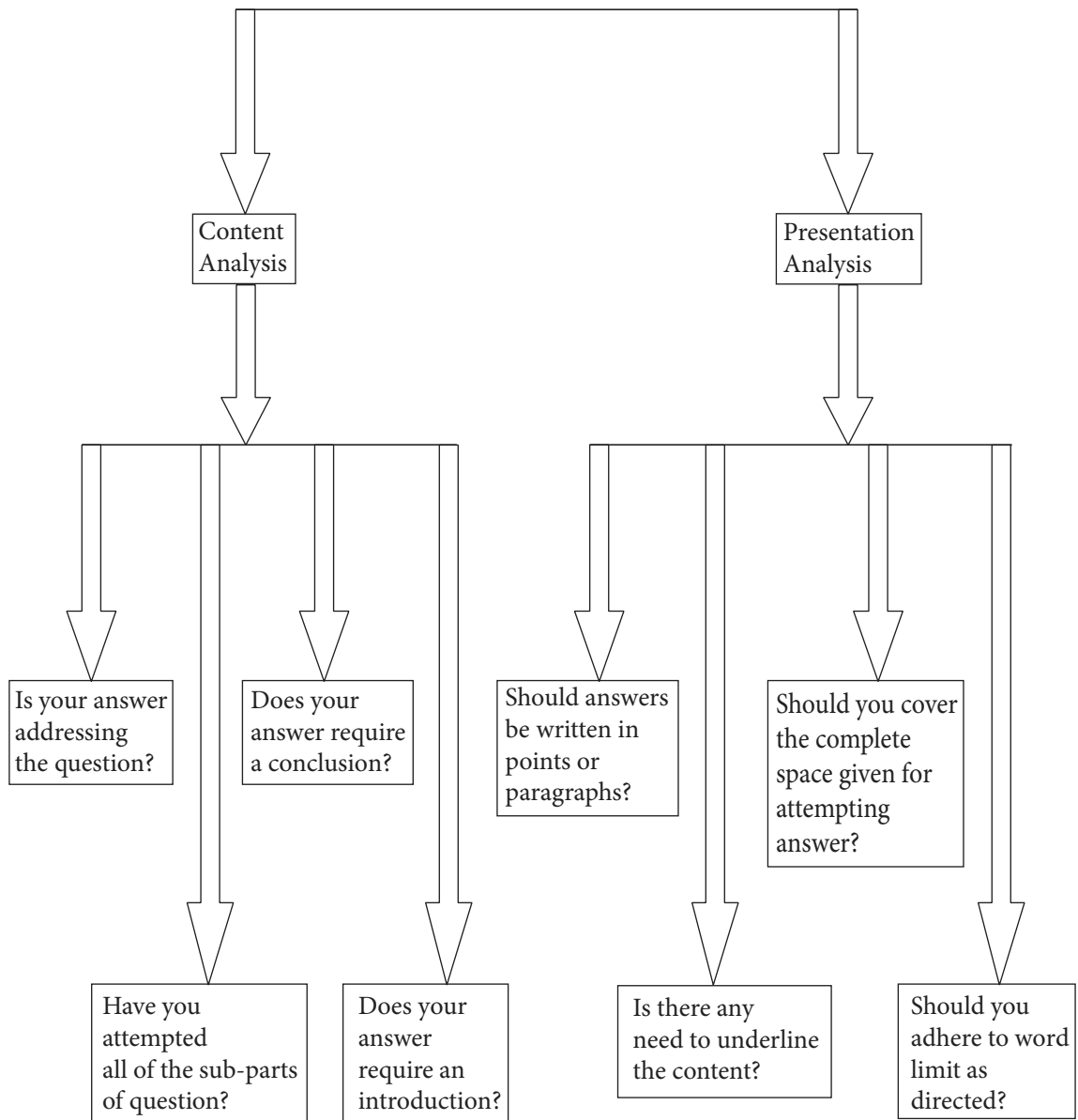
5. (d) Statement 1 is correct: Cnidarians refer to members of the phylum Cnidaria. Some of the examples of the members of this phylum include corals, sea anemones, jellyfish and hydra. Corals have a symbiotic relationship with zooxanthellae. Sea anemones, jellyfish and hydra are also found to have symbiotic relationships with algae.

Statement 2 is correct: Fungi can be found in symbiotic relationships with algae, plant roots etc. For instance, fungi and plant roots are in a symbiotic relationship in mycorrhiza. Another common example is lichens where fungi and cyanobacteria are in a symbiotic relationship.

Statement 3 is correct: Protozoa also exhibit symbiotic relationships. For instance, termites and protozoa that live in the insect's gut is an example of symbiotic relationship.

INTRODUCTION
TO MAINS
ANSWER WRITING

A Good answer is based on the following aspects



Let us discuss each aspect mentioned in the above diagram on one by one basis.

1. Is your answer addressing the question?

The most common reason to blame for a low score is lack of candidate's ability to address the question. Have you ever come across a candidate who attempted almost all (or all the questions), yet could not clear Mains examination? If yes, you have probably met the candidate who wrote answers, which did not address the questions.

To understand how to address question appropriately, we can classify each question into two parts: 'Statement' and 'Directive'.

For example:

India is well-endowed with fresh water resources. Critically examine why it still suffers from water scarcity. (12.5 marks, 200 words, 2015 Mains, GS Mains Paper I)

In this question, the Statement is 'India suffers from water scarcity despite possessing well-endowed fresh water resources' and the directive is 'Critically examine'.

Various candidates interpret 'Critically examine' in different manner. Some will attempt to provide positives and negatives and some will attempt to identify various aspects of the topic being asked. So, which one is correct here? Let us learn by going through the document.

It is to be noted that a particular directive may be attached to a sub-part of a question. In a single question, there can be as many directives as there are number of sub-parts.



So What All Directives UPSC Can Use? What Do These Directives Mean?

Here is a simple list for you. We will further learn about their application by attempting past year questions in the coming pages.

1. **Enumerate:** Mention a number of things one by one or give the list of things.

Enumerate the National Water Policy of India. Taking river Ganges as an example, discuss the strategies, which may be adopted for river-water pollution control and management. What are the legal provisions of management and handling of hazardous wastes in India? (10 marks, 200 words, 2013 Mains, GS Mains Paper III)

2. **Highlight:** Draw special attention to something.

The frequency of urban floods due to high intensity rainfall is increasing over the years. Discussing the reasons for urban floods, highlight the mechanisms for preparedness to reduce the risk during such events. (12.5 marks, 200 words, 2016 Mains, GS Mains Paper III)

3. **Outline:** Give a summary of something.

4. **Discuss:** Write about a topic in detail, taking into account different issues or ideas.

How far do you agree that the behaviour of the Indian Monsoon has been changing due to humanizing landscape? Discuss. (12.5 marks, 200 words, 2015 Mains, GS Mains Paper I)

5. Explain: What is meant by a word, text, concept or action?

The effective management of land and water resources will drastically reduce the human miseries. Explain. (12.5 marks, 200 words, 2016 Mains, GS Mains Paper I)

6. Justify: Show or prove something.

7. Comment: Express an opinion or reaction.

8. Examine: Inspect someone or something thoroughly in order to determine their nature or condition.

9. Elucidate: Make something clear; explain.

10. Illustrate: Explain with the help of examples.

11. Evaluate: Give the pros and cons of the subject matter and draw a conclusion.

12. Assess: Estimate the nature, ability, or quality of person, situation or any other thing. It may also mean evaluate in some questions.

13. Analyse: Examine (something) methodically and in detail, typically in order to explain and interpret it.

14. Critically Evaluate/Analyse: Give the pros and cons of the subject matter and explain why the negative weighs more than the positive. However, in some situations positives can weigh more than negatives. In some questions, critically evaluate may mean thorough analysis of various parts.

The states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand are reaching the limits of ecological carrying capacity due to tourism. Critically evaluate the issue. (12.5 marks, 200 words, 2015 Mains, GS Mains Paper I)

15. Critically examine/Discuss critically: The question requires break up of issue or situation into various parts and thorough analysis of these parts.

Critically evaluate the various resources of the oceans, which can be harnessed to meet the resource crisis in the world. (10 marks, 150 words, 2014 Mains, GS Mains Paper I)

2. Have you attempted all of the sub-parts of a question?

A typical UPSC question consists of one or more than one part. A candidate's score can drastically reduce if he/she does not address all the parts of a question. Let us understand with example. Consider the following question.

Discuss the *Namami Gange—National Mission for Clean Ganga (NMCG)* programmes and causes of mixed results from the previous schemes. What quantum leaps can help preserve the river Ganga better than incremental inputs? (12.5 marks, 200 words, 2015 Mains, GS Mains Paper III)

How many parts does this question have? Answer is 3.

Part I: Discuss the *Namami Gange—National Mission for Clean Ganga (NMCG)* programmes

Part II: Discuss the causes of mixed results from the previous schemes

Part III: What quantum leaps can help preserve the river Ganga better than incremental inputs?

If you leave any part of the question un-attempted, then marks will be deducted accordingly.

3. Does your answer require a conclusion?

The main body of your answer should lead to a logical conclusion. Conclusion is important only in the questions that demand candidate's opinion, evaluation or analysis. In these questions, candidate is required to consider various aspects, pros and cons and then take final view of the matter. For instance, consider the following question.

Should the pursuit of carbon credits and clean development mechanisms set up under UNFCCC be maintained even though there has been a massive slide in the value of a carbon credit? Discuss with respect to India's energy needs for economic growth. (12.5 marks, 200 words, 2014 Mains, GS Mains Paper III)

On the other hand, conclusion is not important in those questions which demand simple enumeration of facts, aspects or reasons for particular situation or condition. For instance, consider the following question.

What are the economic significance of discovery of oil in Arctic Sea and its possible environmental consequences? (12.5 marks, 200 words, 2015 Mains, GS Mains Paper I)

4. Does your answer require an introduction?

In earlier Mains, GS Paper I, II and III consisted of 20 questions each with 200 words limit. In 2017 Mains, GS Paper I, II and III consisted of 20 questions each with word limit of either 150 words or 250 words. A question usually contains sub-parts. If all the sub-parts are addressed with proper explanation, along with conclusion, the candidate tends to cross the prescribed word limit.

Thus, it is not advisable to waste more than 30 words just on introducing the answer. Remember! The introduction will not fetch you marks; It is the body and conclusion (where required) that will determine your score.

All you can do is: write a simple introduction in one line. Introduction could be as simple as definition of something; the various factors behind this cause are, etc.

5. Should answers be written in points or paragraph?

The Point-form enables candidate to express views in an objective manner. From the examiner's point of view, the Point-form presentation brings out clearly the contents of the answer. Thus, it is advisable to write in Point-form. However, there are certain questions which cannot be presented in Point-form. Consider the question given below:

What are the consequences of illegal mining? Discuss the ministry of environment and forests' concept of "GO AND NO GO" zones for coal mining. (5 marks, 100 words, 2013 Mains, GS Mains Paper III)

The first part of the above question can be addressed in Point-form. The second part of above question can only be addressed in paragraphs. For paragraph writing, it is advisable to split your answer into