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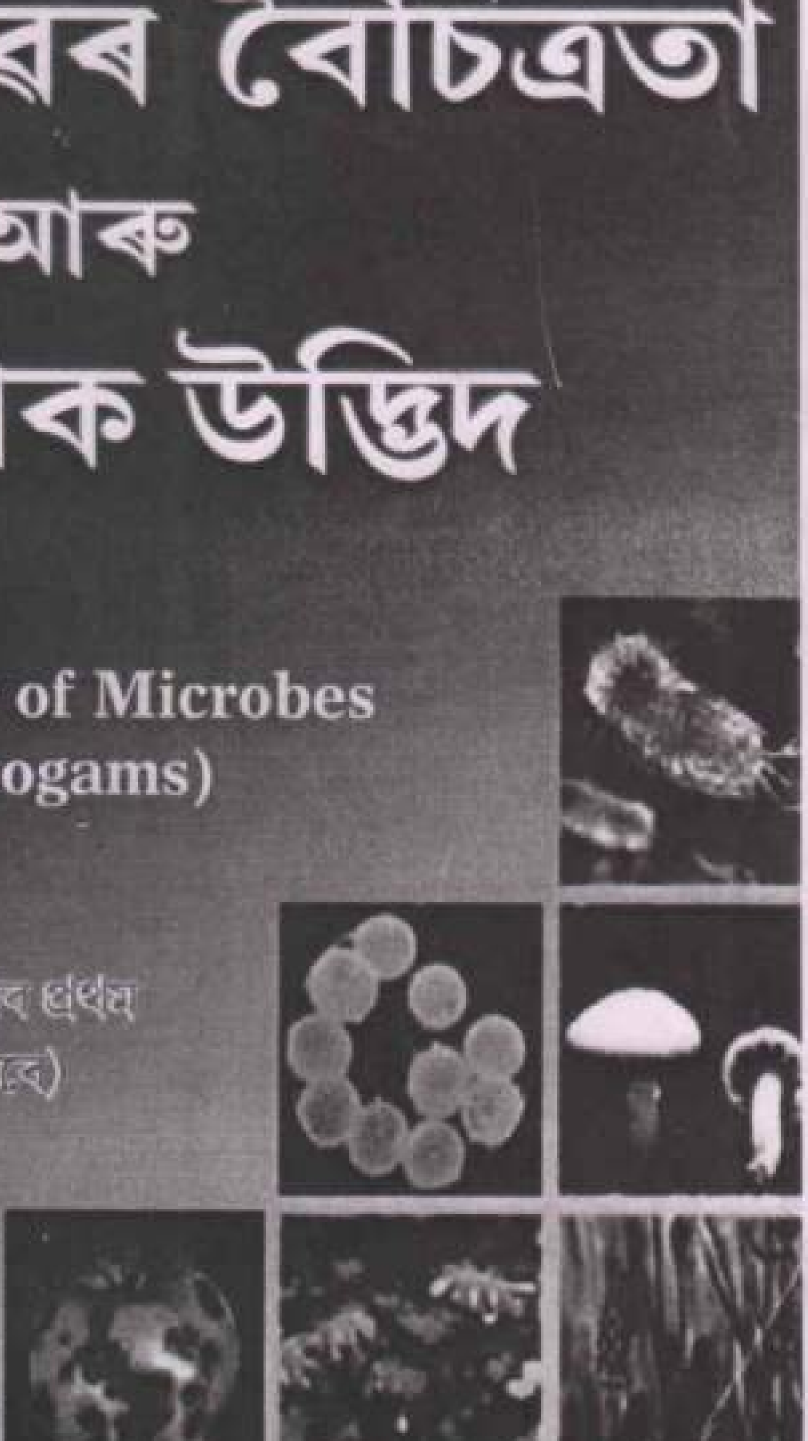

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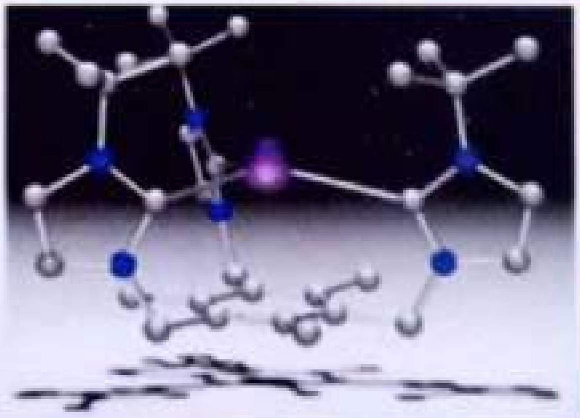

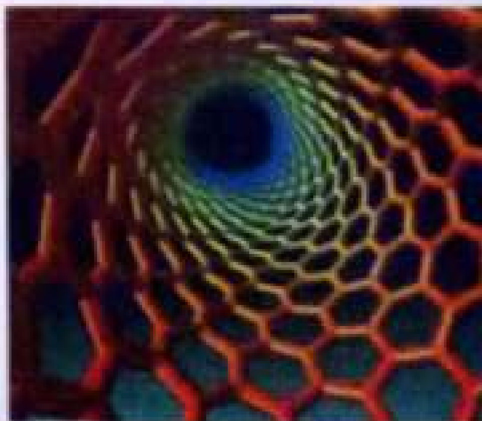

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Cultural Heritage of Assam

Editors

Sarit K. Chaudhuri

Mini Bhattacharyya Thakur

Indira Gandhi Rashtriya Manav Sangrahalaya
(National Museum of Mankind Bhopal)

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Appeasing the Bamboo Deity in Assam: A Study with Special Reference to Bhatheli

— Birinchi K. Medhi, Jilmil Bora

Introduction

Bamboo occupies an indispensable place in the socio-cultural life of the Assamese since time immemorial. It is highly auspicious for the people of Assam and it can be understood from its usage in most of the day-to-day affairs, especially in the Assamese folk life. When we look into the annals of history, we find that bamboo was regarded as a rich natural resource, as the forests of Assam were full of different species of bamboo. Almost all the Assamese people residing in the villages or rural areas have bamboo plantations at their backyards. This reflects the close association of the Assamese people with bamboo. There is a popular Assamese proverb in this regard:

Jar nai bah tar naisah i.e. one who does not possess bamboo, does not have courage also.

The typical pattern of a rural Assamese compound is as follows:

Pube hah
Pachime bah
Uttareguwa

Daksinedhoua, i.e., ducks or the tank in the east, bamboo plantations in the west, areca palms in the north and open space in the south. This indigenous compound pattern is very scientific. The eastern side is kept open for the passage of air and for the morning sunlight which are considered

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Parallelism between Greek and Indian Mythology: A Study of Select Greek Myths and Parallel Indian Myths

● Aparna Goswami*

Introduction:

Johann Wolfgang von Goethe's concept of '*Welt Literatur*' propagated in 1827 and later reinstated by Rabindranath Tagore in Indian context through his notion of *Vishwa Sahitya* in 1909,has provided the readers and critics new parameters for judging as well as understanding literature in a more effective way. This approach can also help in national and also at times international integration as we find many common points linking different communities in a single thread. This paper endeavors to bring out parallelism between select myths prevalent in ancient Greece and ancient India. The scope of study encompasses the parallels drawn between mythical characters, between the plot structure of the myths and also between some common motifs adopted by the select myths representing the two different cultures.

Parallelism in Mythical Characters:

Zeus, regarded as god of all gods among the Greek pantheon is directly comparable with *Indra*, the Indian mythical god of the same

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* Asst. Professor,Dept. of English, D.K College, Mirza

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The Role of Ojāpāli in Creating Social Awareness and the Need to Reinstate it in the Modern Assamese Society

— *Aparna Goswami*

Introduction to the North-East: Land and People

North-East India, geographically and topographically distinct from the mainland India has a peculiar identity of its own. It is a region of myriad variety of cultures as it has settlers from diverse parts of the land as some are from the regions like Kanouj in central India while some are from the ancient Mongol regions. All have contributed in building the composite culture of the region by adding to it the nuances of their respective traditions. While the earliest inhabitants were supposed to be different indigenous tribes of the Mongoloid stock like the Boros, Rabhas, Tiwas, Lalungs, Garos, Khasis, Hazongs, Tai-Turungs, Matchis, some Sonowal Kacharis etc., the coming of the Aryans in historical times and the resultant intermix gave the area the demographic character it has today. Today these indigenous communities, the non-tribal Hindus of different castes, some people subscribing to Islam and Buddhism and some other groups, inhabit the region. It is largely due to this, that the caste or community division in this area is not as rigid as in other parts of India. (Goswami, 2013)[1] The region has always been looked upon as 'An anthropologist's paradise' for its rich diversity of ethnic culture and is also considered 'A linguist's paradise' due to its multilingual continuum. Around forty five different languages are spoken by different communities in and around this area which is the meeting place of three different language families - as per the available data: Austro-

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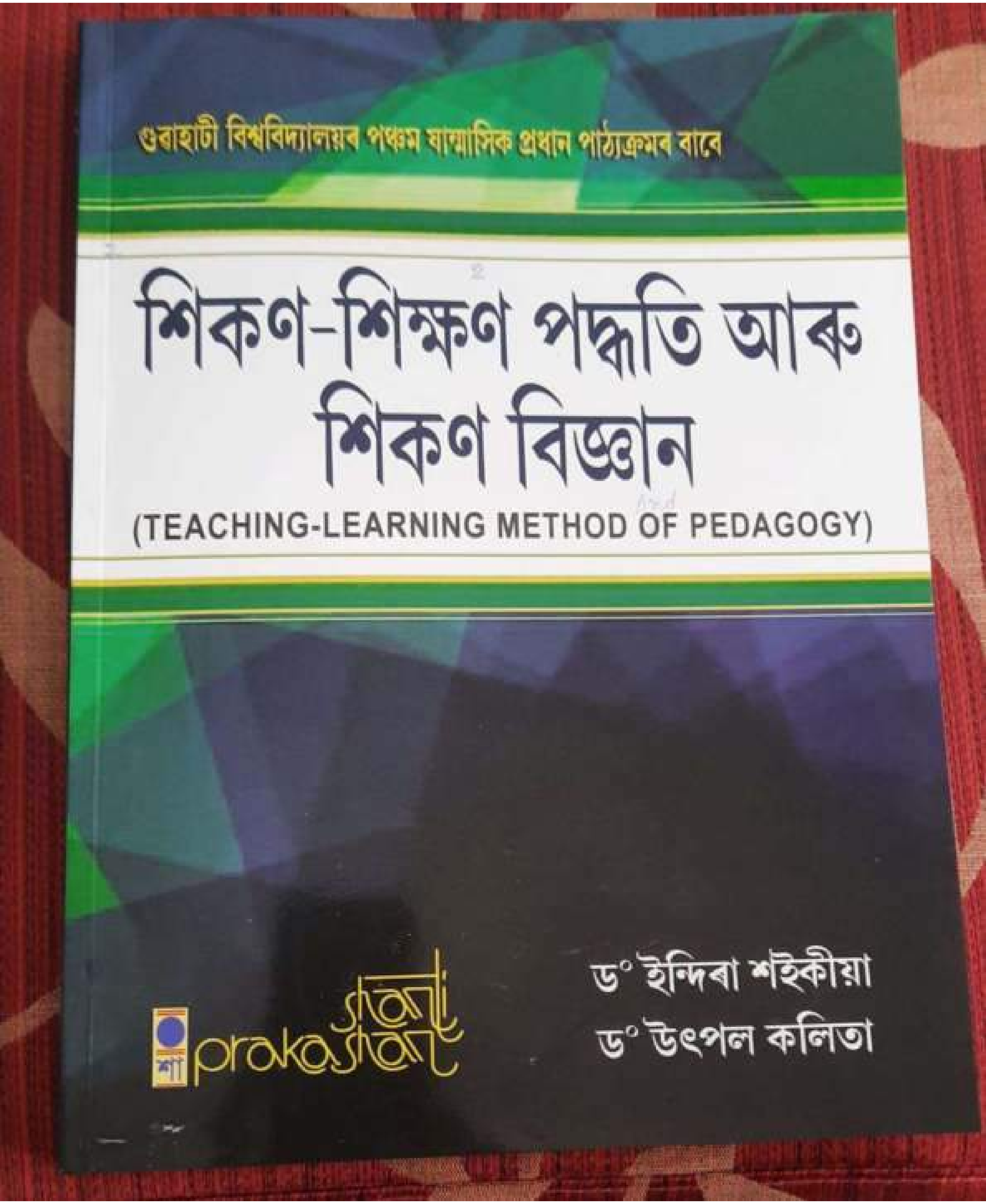

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Recent Trends in Life Sciences

Editors

Prof. Jogen C. Kalita
Prof. Partha P. Baruah

UGC - HRDC
Gauhati University, Guwahati

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II. Original Research Articles

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Pseudomonas fluorescens: nature's answer to plant disease management

Gargi Chakravarty*

Abstract

Pathogenic microorganisms affecting plant health are a major and chronic threat to food production. As agricultural production intensified over the past few decades, producers became more and more dependent on agrochemicals as a relatively reliable method of crop protection However, increasing use of chemical inputs causes several negative effects, i.e., development of resistance to the applied agents and their non-target environmental impacts. This has led to a search for natural substitutes for these products. Among the biocontrol agents, Pseudomonas fluorescens, a plant growth promoting rhizobacteria (PGPR) has been one of the most effective agents for plant disease management. This effect is the result of competitive exclusion of pathogens due to colonization of the rhizosphere, production of a number of secondary metabolites including antibiotics, siderophores and hydrogen cyanide as well as induced systemic resistance. However introduction in a suitable substrate carrier and proper method of application are required for using it in the field and for commercial success of the formulation.

Key words: *Pseudomonas fluorescens*, PGPR, Biocontrol

The continuous use of chemicals as fertilizers and pesticides has caused immense harm to the environment and ecosystem and has

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*Assistant Professor, Deptt. of Botany, D.K. College, Mirza, Corresponding author: - *gargichakravarty2008@gmail.com*

ENVIRONMENT :
Emerging Problems & Management
Part - II

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❑❑❑

3.1 Management of Environmental Problems

Dr. Gargi Chakravarty

Environmental problems cause environmental degradation which is a complex process involving transformation, alteration or material loss from any one of the environmental components. It may arise either by natural processes or by man-made activities.

Management of the environmental resources is linked to environmental protection, sustainability and integrated landscape management. The measures taken for management of problems associated with environment resources are listed below-

1. Management of land degradation and soil erosion:

The loss of the top soil or disturbance of soil structure is a grave environmental problem leading to loss of arable land and important soil microbial bioresources. Biological management of the problem include afforestation as root systems of trees supply organic material which helps to stabilize the soil while water uptake and canopy interception serve to reduce the frequency and intensity of surface run off. *Lawsonia alba, Agave americana, Ricinus communis, Dalbergia sissoo, Tamarindus indica* serve as useful windbreaks which check the blowing away of fertile top soil. Vegetation cover reduces the wind velocity near the ground while grasses such as *Cynodon dactylon* act as soil binders. Sustainable land use practices involve mixed cropping, crop rotation, cultivation of land parallel to the contours, reduced tillage, increased use of organic fertilizers, retention of landscape barriers such as tree lines, hedgerows and walls and comprehensive land husbandry programmes. Mechanical methods of management of the problem include contour terracing which is to construct channels along slopes to intercept and divert the runoff water.

2. Management of air pollution:

The air pollutants which are primarily particulates and gaseous pollutants should be checked at the source of emission. The NO_x and SO_x pollutants are generated from vehicles and industrial processes. This can be mitigated through electric and hybrid vehicles and decent public transportation systems reducing the vehicular traffic. Cleaner fuels based on hydrogen are being worked out for new engine technology thereby reducing harmful emissions into the air. Chlorofluorocarbons (CFCs) widely used as coolants in air conditioners and refrigerators and contributors of ozone layer depletion in the stratosphere are replaced by other devices such as 'ice cleaning'. Burning of coal and other fossil fuels which emit hazardous pollutants is being replaced by alternative cleaner forms of energy such as solar energy, wind energy, hydraulic

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Assistant Professor, Department of Botany, D.K. College, Assam

Issues and Challenges in Economics and Commerce : A Perspective

Editors:
Ratul Mahanta & Amrit Pal Singh

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Contents:

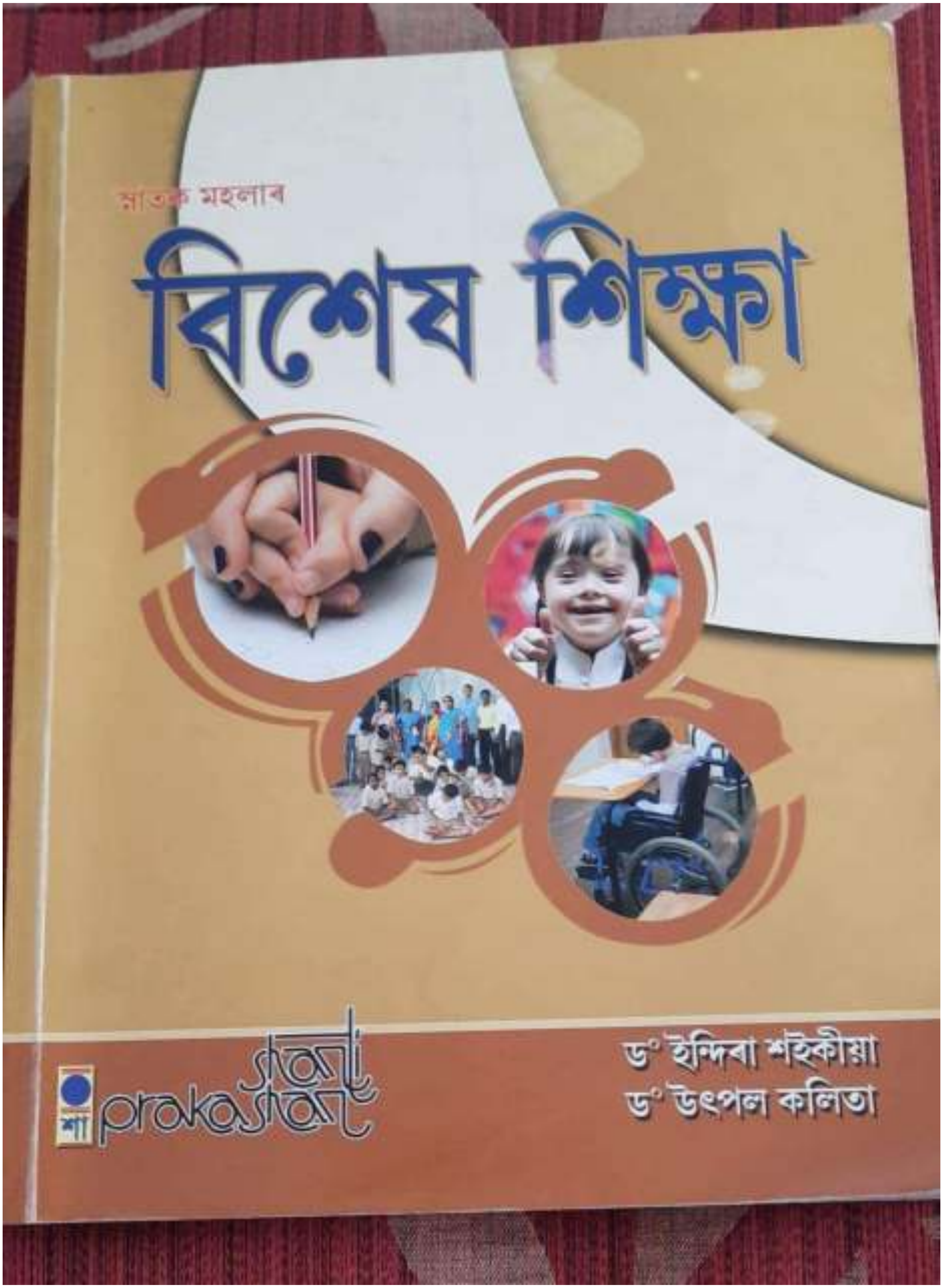
Role of ASHA (community health workers) in providing maternal health care services

a study in selected three districts of Assam

✍Jonali Nath

Abstract:

In 2005, Govt of India introduced National Rural Health Mission (NRHM) all over the country to provide easily accessible health care services to the rural poor people. And to achieve this Govt. introduce female Accredited Social Health Activist (ASHA) or every villages with at least 1000 population. The women who employed as a ASHA must be literate within the age group 25-45 years and should have good communicative skill so as to effectively link between community and primary health care services. In India Accredited social health activist (ASHA) are women selected and trained to work at the interface between member of their own community and the public health system (NRHM, GOI, 2012). To accelerate the expansion of basic health care coverage Govt. of India employed ASHA workers all over the country. The main objective of this paper is to access the role of ASHA to provide maternal health



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গুৱাহাটী-২১

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(গুৱাহাটী বিশ্ববিদ্যালয়ৰ স্নাতক মহলাৰ ষাণ্মাসিক পাঠ্যক্রম অনুসৰি
তৃতীয় বৰ্ষৰ ষষ্ঠ ষাণ্মাসিকৰ শিক্ষা বিষয় (প্ৰধান) শ্ৰেণীৰ (প্ৰথম
কাকত) ৰ বাবে প্ৰস্তুত)

বিকাশমূলক মনোবিজ্ঞান

(Developmental Psychology)

ষষ্ঠ ষাণ্মাসিক শ্ৰেণী (প্ৰধান)
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অশোক বুক ষ্টল
পাণবজাৰ, গুৱাহাটী ১

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মূল্য ঃ ১৮০.০০ টকা

মুদ্ৰণ ঃ ইলোৰা অফছেট
হেদায়েৎপুৰ, গুৱাহাটী -৩

Rethinking Colonialism and Globalisation

the historical saga of India from the 19th century onwards

Madhuri Saikia

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First Published 2018

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Contents

Socio-Demographic Impact of Immigration in Assam during the colonial Rule

Dhrubajyoti Gogoi

The most curious thing about Assam is the conspicuous ignorance about it on the part of the people of India. A brief review of the history of Assam under the British rule i.e. from 1826 onwards would reveal that far-reaching changes were brought about in the region during that period. Demographic structure of Assam during colonial period is an important source for understanding socio-demographic aspects and its related features like fertility, infant and child mortality, population composition, sex ratio etc. Analysing the course of population composition and transformation of Assam from the beginning of the colonial period to the end many scholars and social scientists agreed on the fact that migration was an important contributory factor for Assam's abrupt growth of population. The population of a country or region may increase through natural causes, such as excess of births over death or through immigration from other places. In Assam also, immigration played a vital role in the growth of population during the colonial period.

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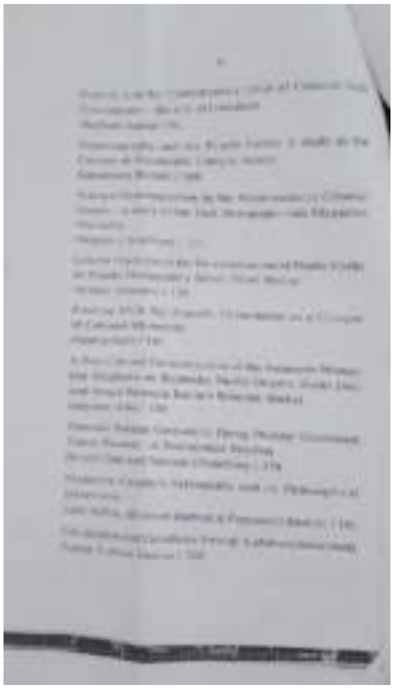
Gender Discourse in the Re-construction of Hindu Myths in Shashi Deshpande's Select Short Stories

Aparna Goswami

Introduction

If a brief review, of the myths incorporated in Hindu mythology is taken, we get to see that majority of the tales deal with the deeds of heroism accomplished by male protagonists. The role of a woman is often marginalised or is designed in such a way that suits the patriarchal set-up of the society. These myths, written by men about other prominent men of the past systematically keep the female characters at the background and those in the forefront are depicted as docile women who are either obedient daughters or loyal and patient wives. Shashi Deshpande, in her attempt to reinterpret some of these myths, gives the focal point to a female figure in the myth who from her status as a subaltern in the original version steps into the role of a protagonist only to reveal female perspective of the same myth. This perspective generates many questions that might be termed as iconoclastic as they pose strong challenges to the status quo maintained so far. Three stories by Shashi Deshpande are selected for the purpose

Rethinking Colonialism
and Globalisation



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Mahatma Gandhi's Satyagraha and its philosophical dimension

Jaba Kalita, Shivanee Kumari and Puspanjali Baruah

The period between 1917- 1947 witnessed the rise and growth of the Indian National Movement which, under the undisputed leadership of Mohandas .Karamchand Gandhi assumed a popular and mass character. During this period which is famous as the Gandhian era, Satyagraha was the key tool which was used by Gandhi to pave a new era in the history of the Indian National Movement. Gandhi had an innate belief that Satyagraha would be the only effective way to fight against the powerful British, because two centuries of colonial rule had economically, politically and morally emasculated the Indian people to such a degree that any other form of resistance was bound to fail. Gandhi believed that Satyagraha was the only legitimate way to earn ones political rights as well as spiritual freedom. It is a matter of great significance that Gandhi introduced religion into politics. By introducing religion into politics Gandhiji wanted to introduce morality into politics. The principles of Truth and Non-violence (Ahimsa and Satya) were the central features of Gandhiji's political activity

ভাৰতৰ ৰাজনীতি -I

Politics in India-I

For 3rd Semester (GENERAL)
Gauhati University

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মানস প্ৰতিম বৰুৱা

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দক্ষিণ কামৰূপ মহাবিদ্যালয়, মিৰ্জা, কামৰূপ।

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অসম বুক ডিপো
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ফোন ঃ ০৩৬১২৫৪৩৮৯৬

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প্ৰথম প্ৰকাশ ঃ আগষ্ট, ২০১৫
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শ্ৰীৰামপুৰ, হুগলী
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Contents

Application of Microbes in Augmenting Tea Production in Assam

Dr. Gargi Chakravarty

Abstract : *Tea is the most widely consumed beverage and the tea industry of Assam is a major foreign exchange earner for the country. With the practice of organic farming clearly established as the means for producing pesticide free food and drink and maintenance of sustainable environment, the exploration of indigenous microbes for crop productivity holds significance. Thus article gives an overview of the beneficial microbes in growth promotion of the tea plant and production of biofertilizers and biopesticides for disease management of the economically valuable crop.*

Keywords : Tea, Bacteria, Fungi, Biofertilizer, Biopesticide

Tea is the most widely consumed non-alcoholic, caffeinated beverage in the world. The tea industry is a major foreign exchange earner for India besides being a source of income for lakhs of workers.

The beverage is obtained from the tea plant (Camellia sinensis (L.) O. Kuntze)of the family Theaceae. The tea plantation is one of the oldest organized practices in India with massive plantation in the Northeast corner of the agro climatic belt. Assam is the largest tea producing state in India.

Since Tea is a long-duration crop it is prone to attack by several pests and pathogens that ultimately result in extensive annual crop loss (Mareeswaran *et al.*, 2015). Inorganic chemical-based fertilizers have been applied over the last few decades to remedy this situation (Adesmoyee and Kloepper, 2009).

However, the application of chemicals onto tea plantations is prohibited for several reasons, including deterioration of soil quality (Gurusubramanian *et al.*, 2005), air and groundwater pollution, undesirable residues in made tea (Muraleedharan *et al.*, 1988; Kodomari, 1993; Chaudhuri, 1999), escalating costs (Pimental *et al.*, 1992), resurgence of primary pests (Das, 1959; Hazarika et al., 2009), followed by an outbreak of secondary pests (Cranham, 1966) and resistance development (Kawai, 1997; Gurusubramanian *et al.*, 2008; Roy *et al.*, 2010; Saha and Mukhopadhyay, 2013), variation in susceptibility, impedance of natural regulatory agents and lethal effects in warm-blooded animals, including humans (Mobed *et al.*, 1992).

In this context agricultural practices employing indigenous beneficial microbes play a significant role not only to increase crop production but also to enhance the nutrient content of the crop and maintain soil health and productivity. This paper gives an overview of the application of microbes in varied aspects of tea crop plantation and production.

Microbial inoculants as plant growth promoters :

With the rising trend towards organic agriculture there is increased dependence on soil

Assistant Professor, Department of Botany, D.K. College, Mirza, Kamrup

B. A. & B. Com

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Edited by
Dr. Gargee Chakraborty

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(প্ৰথম ষাণ্মাসিক)

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পাণবজাৰ, গুৱাহাটী-৭৮১০০১

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জি এন বি ৰোড, শিলপুখুৰী
গুৱাহাটী-৭৮১০০৩

স্নাতক পাঠ্যক্ৰমৰ

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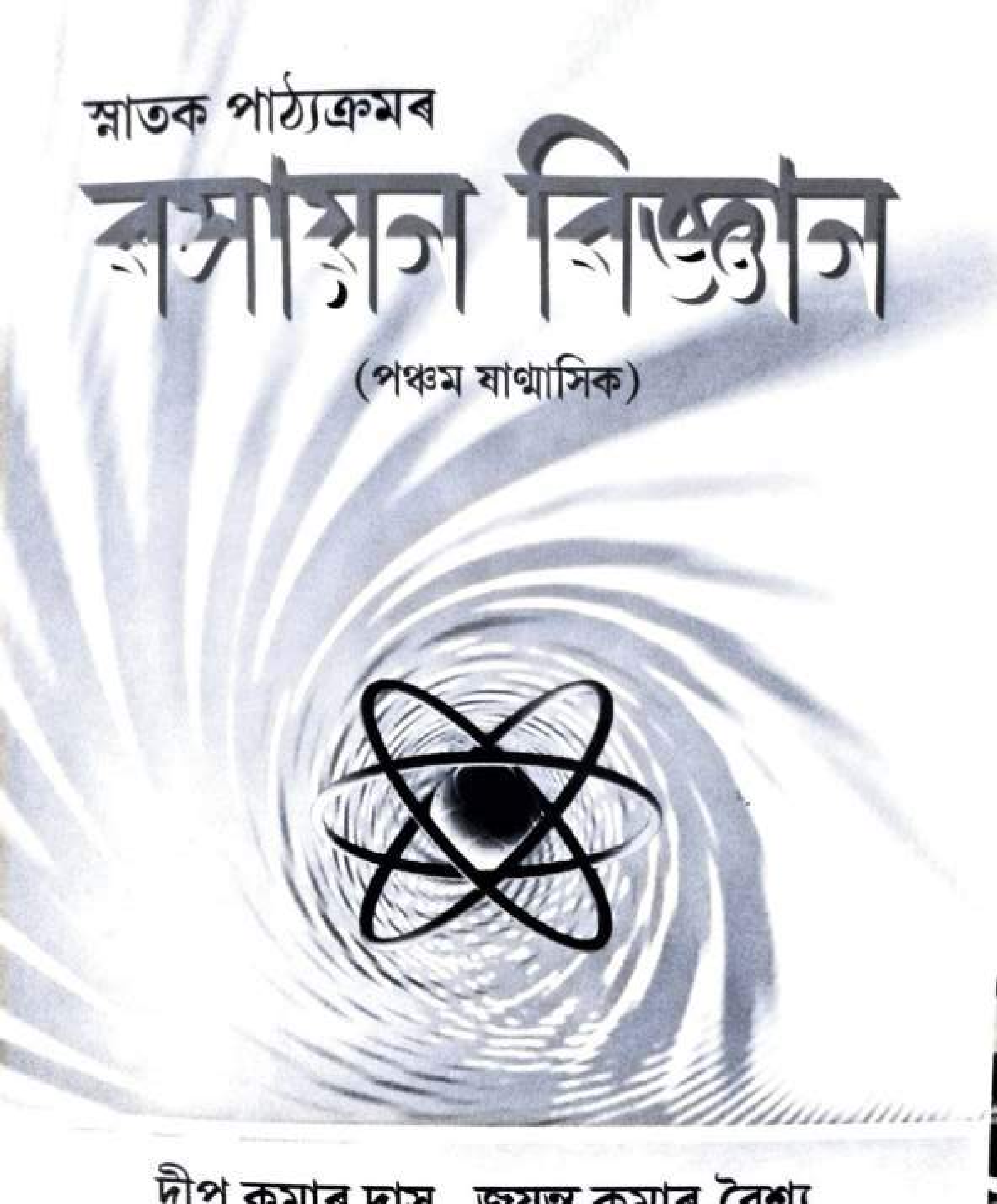
(পঞ্চম ষাণ্মাসিক)



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পঞ্চম প্ৰকাশ ঃ ২০১৯

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মুদ্ৰক ঃ
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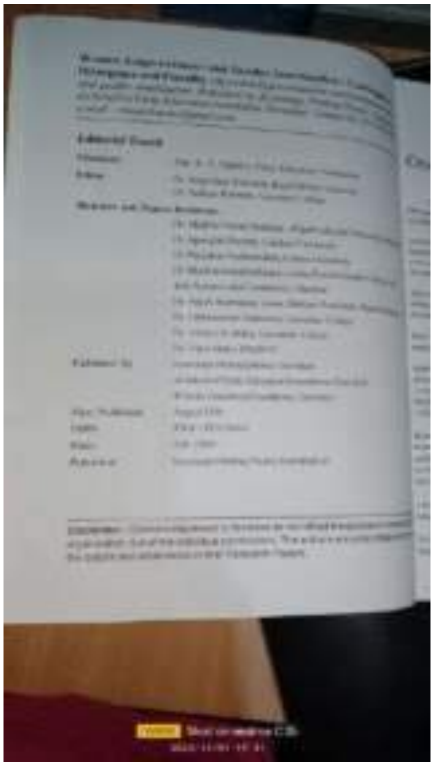
গুৱাহাটী-৭৮১০০৩


Women Empowerment
&
Gender Sensitization
Convergences, Divergences
and Plurality



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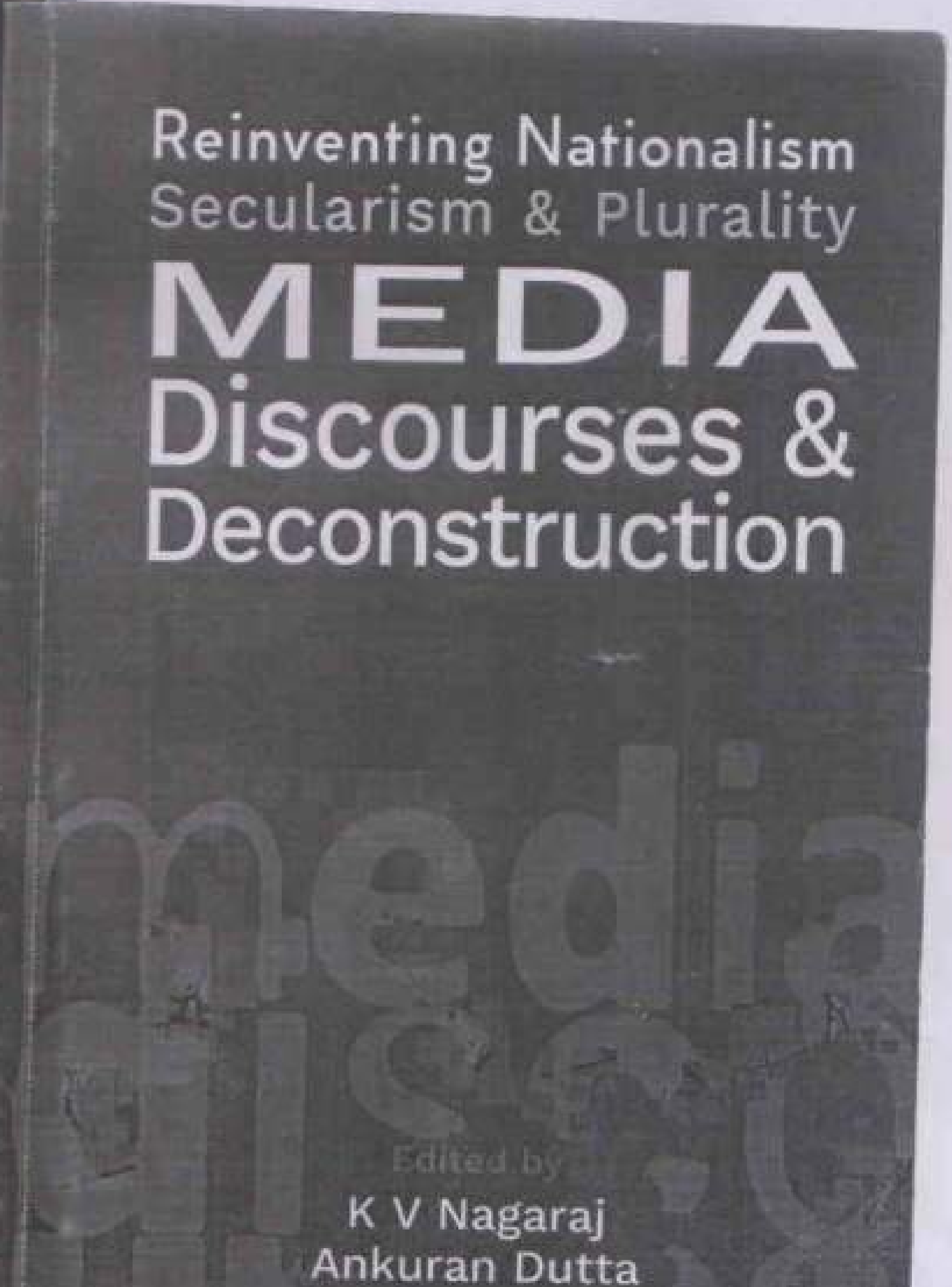

Reinventing Nationalism
Secularism & Plurality

MEDIA
Discourses & Deconstruction

Edited by
K V Nagaraj
Ankuran Dutta

Nationalism, secularism and plurality are the notions under constant scrutiny in any geographical polity, democratic or otherwise. These have been conveniently used in power politics all over the world, as they appeal to human emotions. We in India have been endlessly debating through all public fora for mass political acceptance of our perspectives. Mass media, on their part, have not lagged behind in their reportage and analysis. Though these concepts have been borrowed from the West, in reality, they did exist in our political philosophy, but camouflaged differently. The ancient Indian political didactics mentioned the use of many political traps in pursuit of power. As the geo-political consternations become coarser and coarser, shriller and shriller, as of now, the discourse on these concepts has acquired expanded semantics. Of course, this has also contributed for a state of confusion. On one side, we propose support to a global village which is technologically determined, and on the other, clamour for de-Westernisation of every other thing in the world, be it political or cultural. This includes the notions of nationalism, secularism and plurality. The range of media discourses on these encompasses print, electronic and social media as well. The present volume is a sincere effort to present variegated perceptions of different ideological hues, as varied as India. The ultimate value of the volume is in its academic 'mindfulness' to the future path finders in media research.

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Impact of Secularism Vs Nationalism Views through Social Network Platforms on Integrity of India as a Nation

Shabnam Shahin

Abstract:

According to the Indian constitution, India is a secular country and every citizen of India is granted the right to follow any religion they wish to follow without hurting the sentiments and beliefs of other religious communities residing in the country. Whereas nationalism on the other hand, is something which is deep rooted in the soul of every citizen. Nationalism is the respect and devotion shown by a citizen towards its nation to uphold its superiority over other countries.

Today, the dynamics of secularism have been affected to a great extent as every small instances of religious display or even food habits of communities are being scrutinized by anybody and everybody on the social networking sites. As social networking sites have minimal level of gatekeeping, the harshness displayed through these mediums leads to conflict and agitation among people of different religious backgrounds. The social networking sites like facebook, twitter gives free access to anybody who has an account to put their views on display for others to see and comment on it. Such an open display of secular or nationalist views might give rise to debates which gives way to open display of intolerance and verbal hatred. Such instances are a subject to this study and how these online display of secularism and nationalism view through verbal debates have put Indian integrity in a low light among the world.

Introduction

India being a secular country is known to all, but with the passage of time the meanings of terms like secularism and nationalism have changed in the people's sub consciousness. Now when someone puts forward a "secular" view or opinion, people tend to believe it is against the "nationalistic" view of others.

India has historically been a repository of people from varied religious and cultural backgrounds and languages; inevitably, the range of opinions is equally diverse.

The introduction of social networking sites has afforded the common people a platform to put forward their views and opinions uninhibitedly for the whole world to see. Originally envisaged as media of communicating and sharing information, social media have morphed into a controversy-generator. Insignificant issues start 'trending' by getting linked to religion and nationalism, and end up provoking wide sections of the populace.

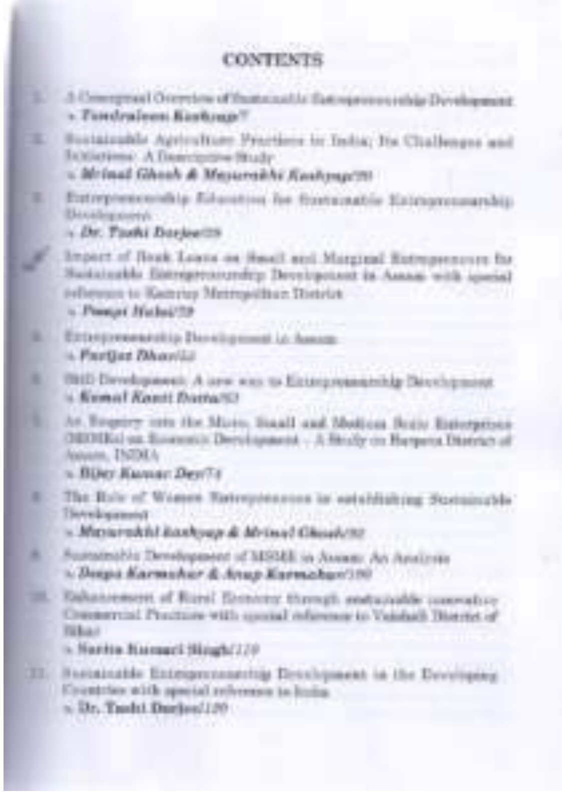
Many controversies of sort had their genesis on social networking sites that snowballed into 'breaking news' in the mainstream media. These media milk controversial posts or discussions on social network sites to generate TRP, but in doing so they have also stirred religious intolerance among the general public, positing a new binary of secularism versus nationalism. Social media posts with conflicting opinions and views become fodder for news debates; what's more, the broadcast media often leverage social network platforms to connect with the general public and boost ratings on these debates.

A country with a billion-plus people following varied cultures, religions, food habits and others is bound to have conflicting views and opinions as aforementioned, but the issue here is how the lengths to which people go to justify their views on religious issues on social media.

Prominence of Sustainable Entrepreneurship Development in Recent Times in India

Editor

Dr. Bhabananda Deb Nath



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জৈৱ বৈচিত্ৰ্য

(অণুজীৱ, শেলাই, ভেঁকুৰ আৰু আৰ্কিগ'নিয়েট)

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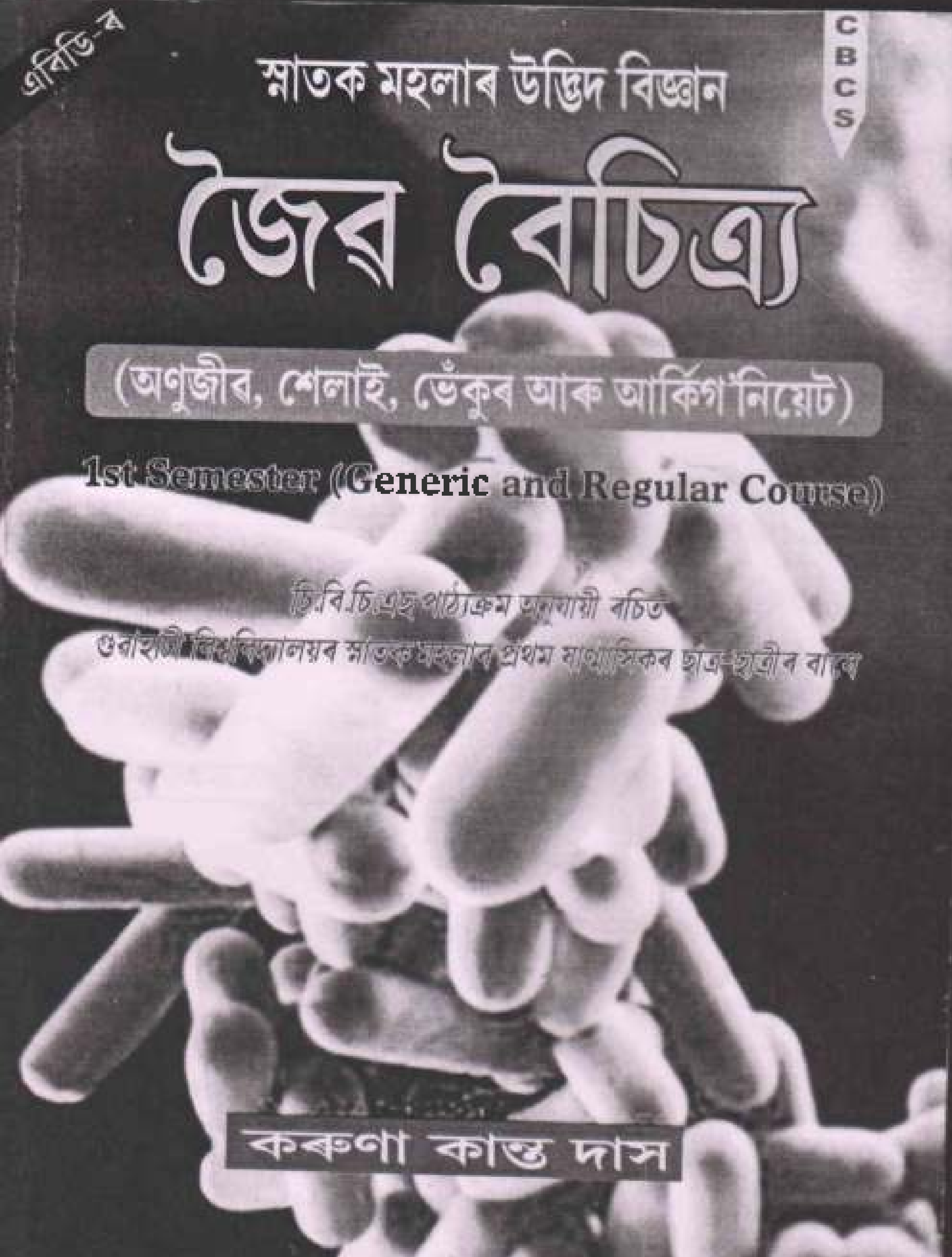

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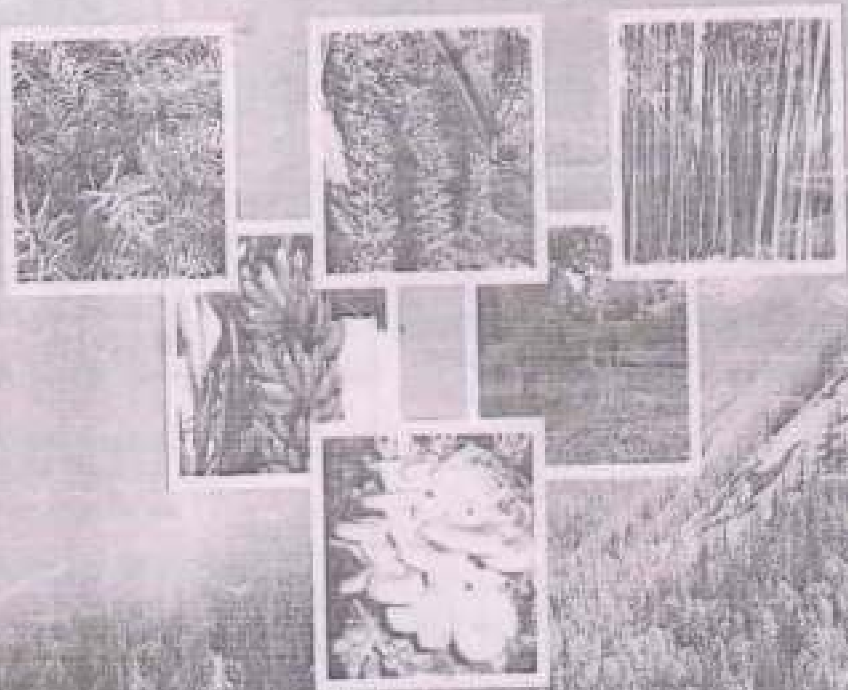
CONSERVATION AND MANAGEMENT OF BIO-RESOURCES FOR RURAL DEVELOPMENT



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A Review On The Studies on a few ethno-medicinal plants used by the *Jaintia* Tribe of Dima Hasao District

Rinti Roy and **Karabi Barman**
Assistant Professor (Ad-hoc), Department of Botany,
Jagiroad College, Morigaon -782410, Assam
E-mail : rinti21@gmail.com

Abstract

The Dima Hasao district is the only hill station of Assam, covering an area of 4890 sq km. The region is one of the richest region in the world in terms of natural resources. More than 1[illegible] ethnic tribes namely Dimasa, Zeme, Biate, Jaintia, Hrangkhol, Hmar, Vaiphei, Khelma etc. live harmony with one other. The tribal people have deep faith in their traditional knowledge and in most cases prefer them to modern systems of medicine. In the present study, a total of 10 plants species curing 12 types of ailments have been reported in addition to their parts used, phytochemical content, mode of preparation and dosage for curing disease like diabetes, skin infection, dyspepsia, piles, diarrhea etc. prevalent among the Jaintia tribe has been investigated. The study also underlines the need for documentation of the ethno-medical plants along with their conservation.

Keywords: *Jaintia tribe, Ethnic, Ethno-medical, Conservation, Documentation.*

Rinti Roy

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CONSERVATION AND MANAGEMENT
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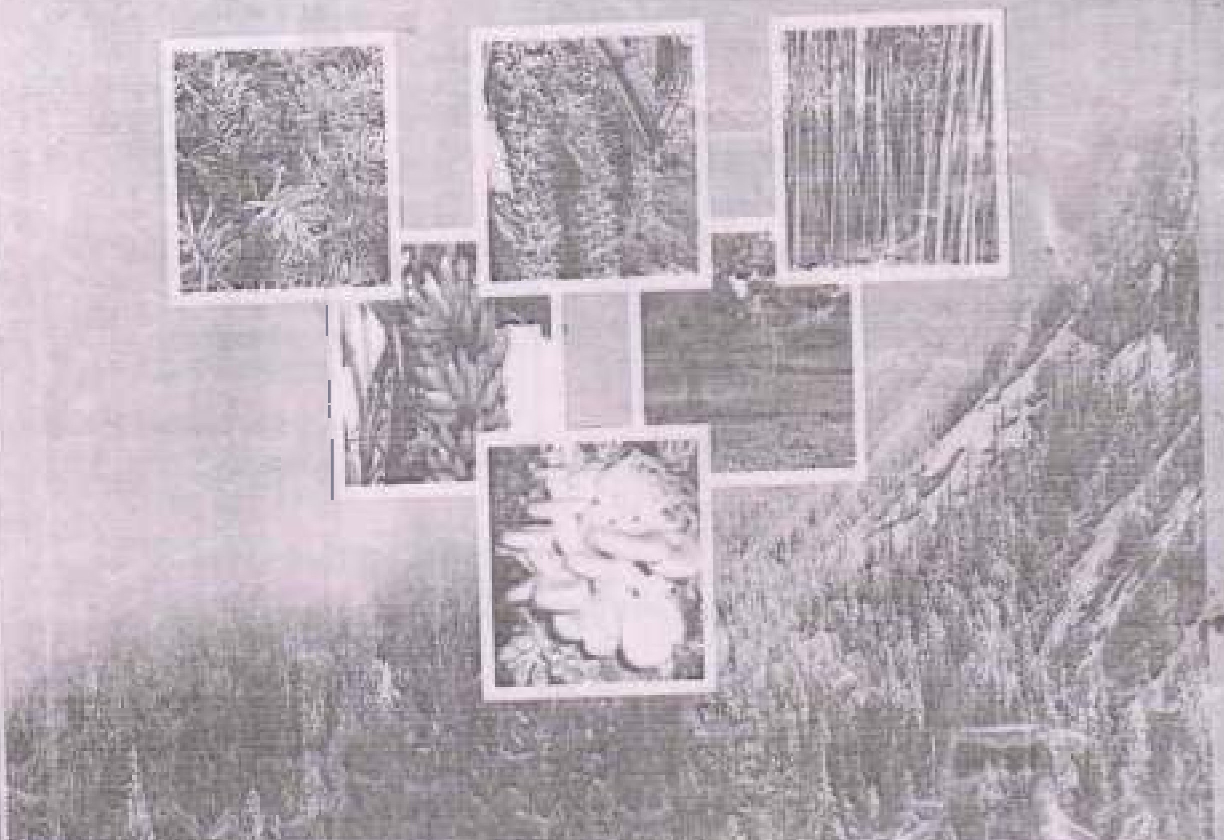

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Phytochemical screening and cytotoxic effe of seed of *Thevetiaperuviana* (pers.) K.Schum

Nilofer Sheikh[1*], A. Narula[2] and R. Roy[3]
[1,2] Department of Botany, University of Science and Technology, Meghalaya
[3] Department of Botany, Jagiroad College, Morigaon-782410, Assam
*E-mail : nilofersheikh83@gmail.com

Abstract

Qualitative phytochemical screening of seed of Thevetiaperuviana was done which confirmed the presence of various compounds like Terpenoids,steroids,alkaloids and cardiac glycoside in three aqueous extracts of methanol, ethyl acetate and water. The result suggested the presence of maximum phytochemical compounds in ethyl acetate than in the other two extract. The use of plants by the general populations for different purposes is still wide spread which makes the studies on cytoxicityessential. The cytotoxic effects of Thevetiaperuviana seed extract were evaluated using Allium cepa rootchromosome aberration study. Seeds extracts suppressed the mitotic activity of Allium roots after 5h, 8h, 12h, 24h and 48h at 35ml concentrations each. Analysis of data indicated about various chromosomal aberration in dividing and non-dividing cells such as anaphase bridge, sticky prophase, sticky metaphase, sticky anaphase, micronucleus,multiple nuclear lesion, nucleus showed disintrigation, c-metaphase, ball metaphase and chromosome vagrant. The infusion for higher time showed significant effect on cell division on the onion cell. The phytochemical and cytotoxic activity of this plant provides valuable information about the safety or non-safe use of them for different purposes.

Keywords: cytotoxic, *Thevetiaperuviana*, chromosome aberration, phytochemical, *Allium cepa*.

Roy

CONTEMPORARY ISSUES IN ASSAM ECONOMY

Editor

Dr. Devajit Mahanta

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as compared to the joint families, in unitary families the senior citizens get more opportunity to participate in the decision making. According to most of the senior citizens, the overriding effect of retirement benefits on their lives is that it removes their compulsion to continue working even after attaining retiring age.

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·Empowering Women through Entrepreneurship·

Dr. Archana Mali
Associate Professor, D.K. College, Mirza, Assam

Abstract

In traditional society, role of women were confined to household management. But with the spread of education among women, they do not keep themselves within the four boundaries of house. Now women are engaged in all types of activities. They are also entering into entrepreneurship which was once considered to be the field dominated by men. This paper attempts to study the factors motivating women entrepreneurs, and impact of entrepreneurship in empowering women in Assam. Attempt is also made to study the strategy for development of women entrepreneurs in the state. To study the motivating factors and impact on empowerment, data are collected from 117 women entrepreneurs (both registered and unregistered) from Kamrup (Rural) and Kamrup (Metro) of Assam.

Keywords: Empowerment, Entrepreneur, Entrepreneurship

1. Introduction

In traditional society, role of women was just confined to the household management. They are simply considered as the queen of the kitchen and seen as 'home makers' (Rao, 2007). Women have to look after their family and do all the domestic chores. But, their contributions are not converted into money terms, therefore, due importance was not given to them in the family decision making process. Educational backwardness is another reason because of which women lag behind. As per 2011 census report, the female literacy rate in India was 65.46 percent as compared to 82.14 percent of male literacy. In many cases women are unaware of the potentiality they harbour within themselves.

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Contexts and Perspectives

Dr. Jilmil Bora

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A Study in Utilisation of Maternal Health Care Services in Assam

Dr. Jonali Nath

Introduction

Motherhood is one of the most cherished and important stage in a woman's life. It is a stage where woman require special care, attention, support and nutrition. But the road to a safe motherhood is not a smooth one for every women across the globe.

The Maternal Mortality Ratio (MMR) is the one of the most important indicator of the health status of a woman in the society. The World Health Organisation (WHO) estimates that over 500,000 women & girls die from complications arising out of pregnancy and childbirth every year, worldwide, with approximately 99% of these deaths occurring in developing countries. As per the National Family Health Survey (NFSH-3, 2005-06) and Sample Registration Survey (SRS) estimation in 2009 the maternal mortality rate in Assam is recoded as highest (390 per 100000 live births) in the country.

In India Maternal Mortality Rate (MMR) declined to 301 in 2001-03 and to 212 in 100000 live births in 2007-09; it is still quite high in Assam (390 in 2009). During 2004-06 MMR in Assam was 480, which fell to 381 in 2010-11 as per annual health survey report Assam; there is a total 99 point drop of MMR during National Rural Health Mission (NRHM) (2005-06 to 2011-12) period which is the

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Major Issues

Edited by

Dr Nazmul Hussain Laskar

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Preface

"Democracy is more than a social system; it is an attitude of mind, a philosophy of life."

– Dr. B.R.Ambedkar

Democracy stands for full prevalence of rule of law with full accountability and transparency. People's participation in the affairs of the government is an essential aspect of democracy. Democracy must ensure responsible and responsive administration. It must try to guarantee good governance because good governance is the key to development of a nation. In India, in recent times we have new element in our political system that is criminalisation of politics and politicisation of crimes. Previously, we had dedicated bunch of politicians for national cause. But these days they have become rare species. They are more for power and perks. They take help of criminals to win election and then try to maintain their hegemony in the community. Now criminals have moved from periphery to the centre stage in order to grab the political power and authority for themselves. Thus, in order to obtain desired results in the field of development we have to do away with all incoherence and incompetence in the field of good governance. For this, not only strong, viable and vital super structures are needed but strong and dedicated leaders are also needed. With active and effective people's participation, complete and coherent decentralisation of powers, responsible and responsive administration, determined and dedicated political will, democratisation with a spirit of compromise and consensus, we can embrace and embark on efficient and effective governance which is critical and crucial for any vibrant and dynamic democratic political system.

Part III. Human Rights

Part IV. Geo-Politics

Part V. Ethnic Studies

Part VI. Covid-19 Pandemic & India

Dnath

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Marginalisation of the Tea Garden Workers with Special Reference to Women Workers

Dulumoni Nath

Introduction

Marginality is often described on a social process where people are referring to the periphery or margin of the society. It is defined as historical processes, in which individuals or communication are socially excluded and denied access to participate in social, economic, cultural and political processes of Assamese society. Marginalisation stalls a person, a group, a section or a community to enjoy rights privileges opportunities and resources that are normally available to members of society.

This paper is about the women of tea garden. They faced a difficult journey of struggles, conflicts, Acrimony with little support from the centre and population that kept to itself holding its affinity to its own land based practices and cultural norms.

The north eastern region of India was characterised by a low population, poor economy with low production and low output, in the beginning of the 19th century up to the 1920s. The economic backwardness of the region as well as the sense of distrust and reluctance of the peasantry to join the work force resulted in the colonial rules bringing in labour from neighbouring areas of Assam, such as Bengal Orissa and Chottanagpur, the erstwhile east Bengal including the border areas of eastern Bihar and Nepal, to be precise

post-independence brought in a bureaucracy, which had scant understanding of north east region. This was neither too encouraging nor did it incite any sensitive thought of development by administrators and the bureaucracy. Nonetheless witnessed more migration, new encroachments and of course a tremendous increase in population by the beginning of the 20th century.

This paper will factor the lives of adivasis particularly the women who lived and still live lives of deprivation discrimination and extreme vulnerabilities. The tea garden women of Assam have been marginalised in different spheres in the tea gardens in general and house and society I particular. Women's work has traditionally been divided in to the area of production both economic and social and reproduction from time immemorial. The living conditions of tea garden workers are very miserable and pathetic because of the implications of tea garden management, especially for female workers. They are more vulnerable in term of economic and social status.

Objectives of the Study

a) Assess the tea garden women's livelihood and their efforts towards living life.

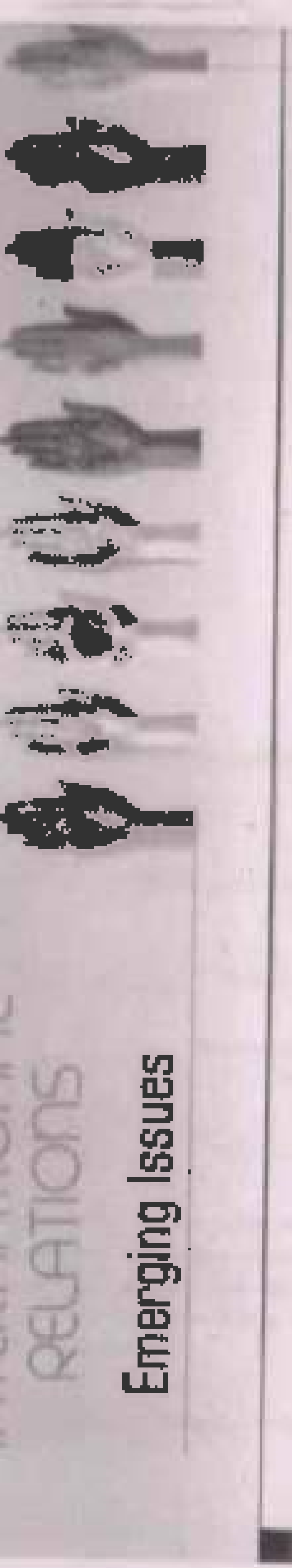
b) The study to evaluate improving condition of tea garden workers of Borduar tea garden Kamrup, Assam.

Methodology of Study

This paper is written based on the primary and secondary sources. The secondary sources include different printed books, journals, articles etc. These sources are also collected from internet these are used as secondary source. Under primary sources included personal interview of tea garden workers to better understand their conditions.

Discussion

Marginality of tea garden women is existing in literature. Many feminist scholars reconstructed their works through the condition



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Preface

The book is primarily designed to address various dimensions and issues related to International Relations. This volume covers wide range of topics like – India's relations with her neighbors, Foreign Policy of India, Globalisation, Climate Change, Terrorism, Human Rights, UNO, Regional Organisations, Citizenship, UNO and its Agencies, Environmental Issues, Migration, Ethnic Cleansing, Covid-19 & New World Order, Gender Studies etc.

A modest attempt has been made to write in a comprehensive and consolidated form. Special care has been taken to bring facts and figures up to date.

The author is grateful to all the chapter contributors without their valuable contribution this book may not have been the light of the day.

I hope this book will be favorably received at the hands of the students, scholars, teachers as well as the general readers.

Nazmul Hussain Laskar

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11/11/2020

: INTERNATIONAL ORGANISATIONS

I: GENDER POLITICS

II: MIGRATION AND CITIZENSHIP

PART IX: GLOBALISATION

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Non Alignment Movement: A Study

DULUMONI NATH

Introduction

The Non alignment Movement (NAM) was created and founded during the collapse of the colonial system and the independence struggles of the peoples of Africa, Asia, Latin America and other region of the world and at the height of the cold war. Throughout its history, the movement of non-aligned countries has played a fundamental role in the preservation of world peace and security. The movement of non-aligned countries has waged a ceaseless battle to ensure that peoples being oppressed by foreign occupation and domination can exercise their inalienable right to self-determination and independence.

During it's nearly 50 years of existence the movement of non-aligned countries has gathered a growing number of states and liberation movements which, in spite of their ideological, political, economic, social and cultural diversity, have accepted its founding principles and primary objective and shown their readiness to realise them. Historically, the non-aligned countries have shown their ability to overcome. Their differences and found a common ground for action that leads to mutual cooperation and the upholding of their shared values.

The creation and strengthening of the socialist block after the defeat of fascism in world war II, the collapse of colonial empires, the emergence of bipolar world and the formation of two military blocks (NATO and the Warsaw Pact) brought about a new international content that led to the necessity of multilateral coordination for a between countries of the south.

In the context the underdeveloped countries, most of them in Asia and Africa, felt the need to join efforts for the common defense of their interests, the strengthening of their independence and sovereignty and the cultural and economic revival or salvation of their peoples and also to express a strong commitment with peace by declaring themselves as "non-aligned" from either of the two nascent military blocks.

Objectives of the Study are

a) Analyse on the formation and the role of non-alignment movement.

b) Assess the objectives of NAM.

c) Evolution in to the movement.

Methodology of Study

The study depends on both of sources primary and secondary. As a primary sources include cotemporary writings of historians, politicians, scholars and so on. Secondary source includes different magazines, articles and newspaper, books.

Discussion

There were certain important events that had taken place before the inception of the NAM. There were the international Brussels congress of 1927 and the first Afro-Asian relations conference of 1947. Brussels congress was an international meet of the representatives of the national liberation movements against imperial domination and was attended by Jawaharlal Nehru. In this meet an anti-imperialist league was formed to unify the national struggle movements and enlarge its base.

In 1947 an internal conference was held in Delhi on the initiative of Nehru. The delegations of 28 Afro-Asian countries had attended it. They were representatives of the freedom movement of their respective countries.

With the independence of India an era of independence had ushered in all Afro-Asian countries. Though their leadership however remained pre occupied with the national problems but the idea furthering co-operations among all the newly independent countries still remained active in determining their policies. India under the leadership of Nehru took initiative in forging a broad based unity of the Afro Asian nation and a comprehensive policy was evolved by him.

The Bandung conference was held in Indonesia on April 1955 and was attended by 29 Afro Asian countries. The five principles of Bandung declaration, which was considered as the birth place of the non-aligned movement. The main objective of Bandung conference was to strive for the world peace and right of nation to determine their own destiny.

The Bandung meeting has been considered as the most immediate antecedent of the founding of the movement of non-aligned countries, which finally came in to being six year later on a wider geographical basis when the first summit conference was held in Belgrade on September 1 to 6,

GENDER, ENVIRONMENT AND GLOBALIZATION

Jayashri Roy
Assistant Professor in Geography
Vidyasagar Teachers' Training College
Paschim Medinipur, West Bengal

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In Loving Memory of
My Father
Who Spent his Life for
Education

by my mother Mrs. Maudira Roy, my sister Banashri Roy, my husband Mr. Debjeet Roy, my daughters Srishtish Roy, Saisha Roy and son Srijish Roy.

11th October 2020 **Jayashri Roy**

List of Contributors

1. **Ms Nani Umie:** Assistant Professor, Rajiv Gandhi University, Rono Hills, Doimukh, Arunachal Pradesh
2. **Kasimang Moyong:** Assistant Professor, Rajiv Gandhi University, Arunachal Pradesh
3. **Sanat Kumar Purkait:** Assistant Professor of Geography, Raidighi College, Diamond Harbour, South 24 Parganas, West Bengal
4. **Dr. Jayashri Roy:** Assistant Professor, of Geography of Vidyasagar Teachers' Training College, West Bengal
5. **Dr. Kavita Chahal:** Assistant Professor, Department of Botany, Government College Bichhua, Chhindwara, M.P
6. **Mrittika Nandy:** Assistant Professor, Department of Political Science, Serampore Girls' College, West Bengal
7. **Rashmi Shekh:** Assistant Professor of Geography Department, Mass Education Teachers Training Institute (B. Ed. & D. El. Ed.), South 24 Parganas, West Bengal
8. **Toton Ghosh:** Assistant Professor, State Aided College Teacher-I, Katwa College, Department of Geography, Katwa, West Bengal
9. **Anurupa Saha:** Research Scholar, Department of Geography, West Bengal State University, Barasat, West Bengal,
10. **Koushik Das:** Student, studying in M.Ed, University of Calcutta, West Bengal
11. **Tamal Chatterjee:** Assistant Professor, Department of Management Science, Bengal Institute of Science & Technology Affiliated to Sidho-Kanho-Birsha University, Purulia, West Bengal
12. **Ms Dulumoni Nath:** Assistant Professor in History, Dakshin Kamrup College, Mirza, Assam

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SECTION-2: ENVIRONMENT

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FOLK CULTURE OF RABHAS SPECIALLY THE RABHA OF KAMRUP DISTRICT (ASSAM)

Dulumoni Nath

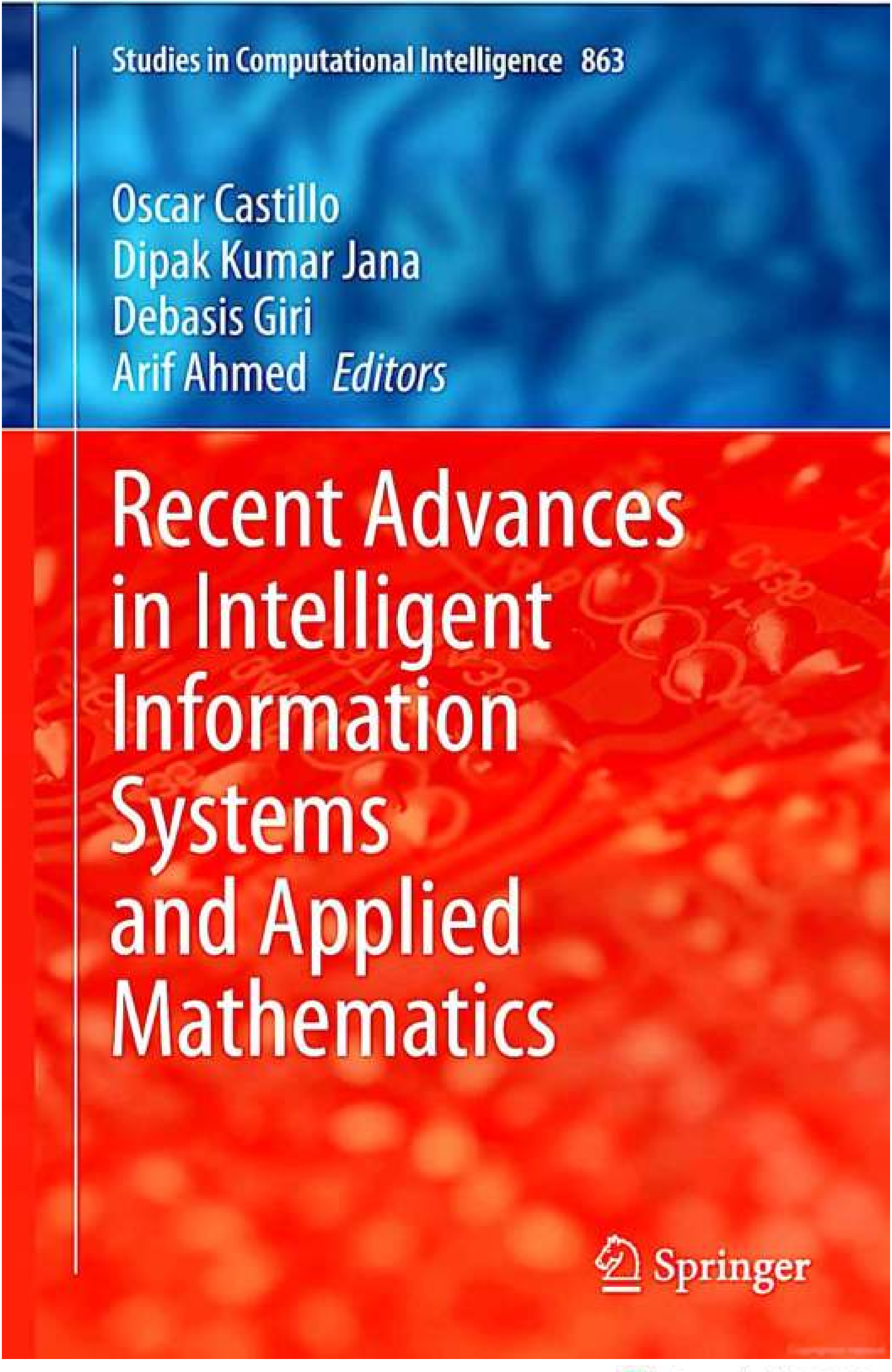
Abstract

This is an abstract for present a theme of a paper which related with North Eastern region of India. India is a meeting ground of diverse races, cultures, civilization, religions, languages, ethnic groups and societies. Here want to write about tradition, culture and rituals of Rabhas special reference with Rabhas of kamrup district of Assam. They have many special traditions, which are following since very early period of them and Rabhas are culturally very rich. They celebrated some special occasions in some special time of a year. They are basically related with agriculture. Their occasions, cultured, rituals are based on agriculture. Rabhas has so many sub-tribes. In kamrup district of Assam we found well famous pati rabha. Pati rabha has own traditional background, culture as well as rituals. Rabhas has particular marriage system, burial system and also they have different food habits and dresses are different. But these are looking very beautiful.

Keywords: *Rabha, Tradition, Culture, marriage, burial, dress*

Introduction

The Rabhas are considered as one of the most important and significant plain tribes of Assam. As one of the aborigines and earliest known inhabitants of Assam, west Bengal and Meghalaya Rabhas are



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Mousumi Gupta
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East Sikkim, Sikkim, India

Debanjan Konar
Department of Computer Science
and Engineering
Sikkim Manipal Institute of Technology
East Sikkim, Sikkim, India

Siddhartha Bhattacharyya
Department of Information Technology
RCC Institute of Information Technology
Kolkata, West Bengal, India

Sambhunath Biswas
Machine Intelligence Unit
Indian Statistical Institute
Kolkata, West Bengal, India

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Integrating Diverse Aspects of
North East India
Contexts and Perspectives

Dr. Jilmil Bora

"Integrating Diverse Aspects of North East India: Contexts and Perspectives", a collection of twenty six scholarly articles, is a volume which is interdisciplinary in nature with a sociological approach. It covers a wide range of topics concerning politics, economics, sociology, environment, history, literature, law, educational, geography, folklore and women studies pertaining to North East India. The volume focuses mainly on Assam along with other states of the North East. Some articles incorporated in the volume have nationalistic relevance. The articles are empirical, analytical and explorative in perspective keeping the door open for further discussion and research. The contributors' deep insights and variegated perspectives have rendered the much needed distinctiveness to the volume and it will definitely be useful to students, teachers, research scholars, academia and the general readers who nurture a deep interest in North East India.

Jilmil Bora (b.1972) is an Associate Professor in the Department of English, Dakshin Kamrup College, Mirza, under Gauhati University, Assam. She completed her graduation in English from Gauhati University, post graduation in American Literature from Pune University and Ph.D. in Folklore from Gauhati University. Her teaching career spans for about 23 years. She has a number of scholarly papers published in various books and journals of regional as well as national repute. She has also contributed a number of popular articles in various magazines besides co-authoring a book "Principles of Effective Writing".

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Spiritual Approach to Nature – A Tool for Environmental Protection: Its reflection in the Socio-Religious Beliefs of the Bodos

Dr. Aditi Devi Choudhury

Introduction

Our environment is a matter of great concern for us. The word 'environment' refers to the external conditions or surroundings of both animate and inanimate objects. It is a system in which various living beings as well as non living things can exist with proper relationship. Man being an integral part of environment, influences the environment by his activities whether positive or negative. In the same way man is influenced by the environment. Environment is individual's life space. Our environment can remain in stable condition when all the parts of the environments are in perfect harmony. Organisms can survive, grow and reproduce only in such a stable environment. So it is the moral responsibility of every individual to protect the environment.

Environmental degradation and the notion of spirituality

Our ancestors could fully realize the importance of conserving nature. Their way of life seemed to be more eco-friendly than that of the modern people. However, with the help of science and technology people have been developing a sense of superiority over nature and are trying to make themselves master of the earth. People, being proud of their achievements have destroyed the

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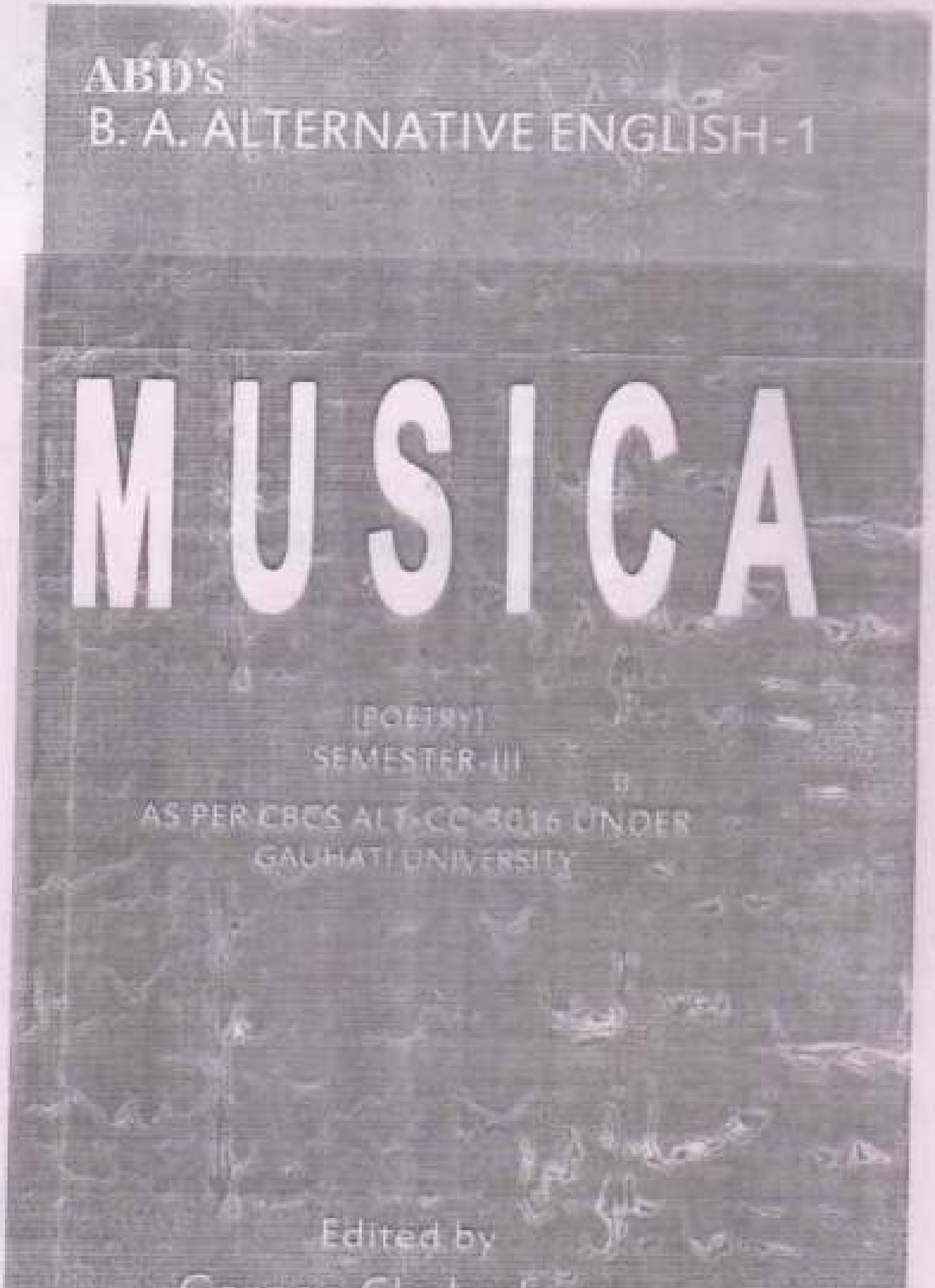

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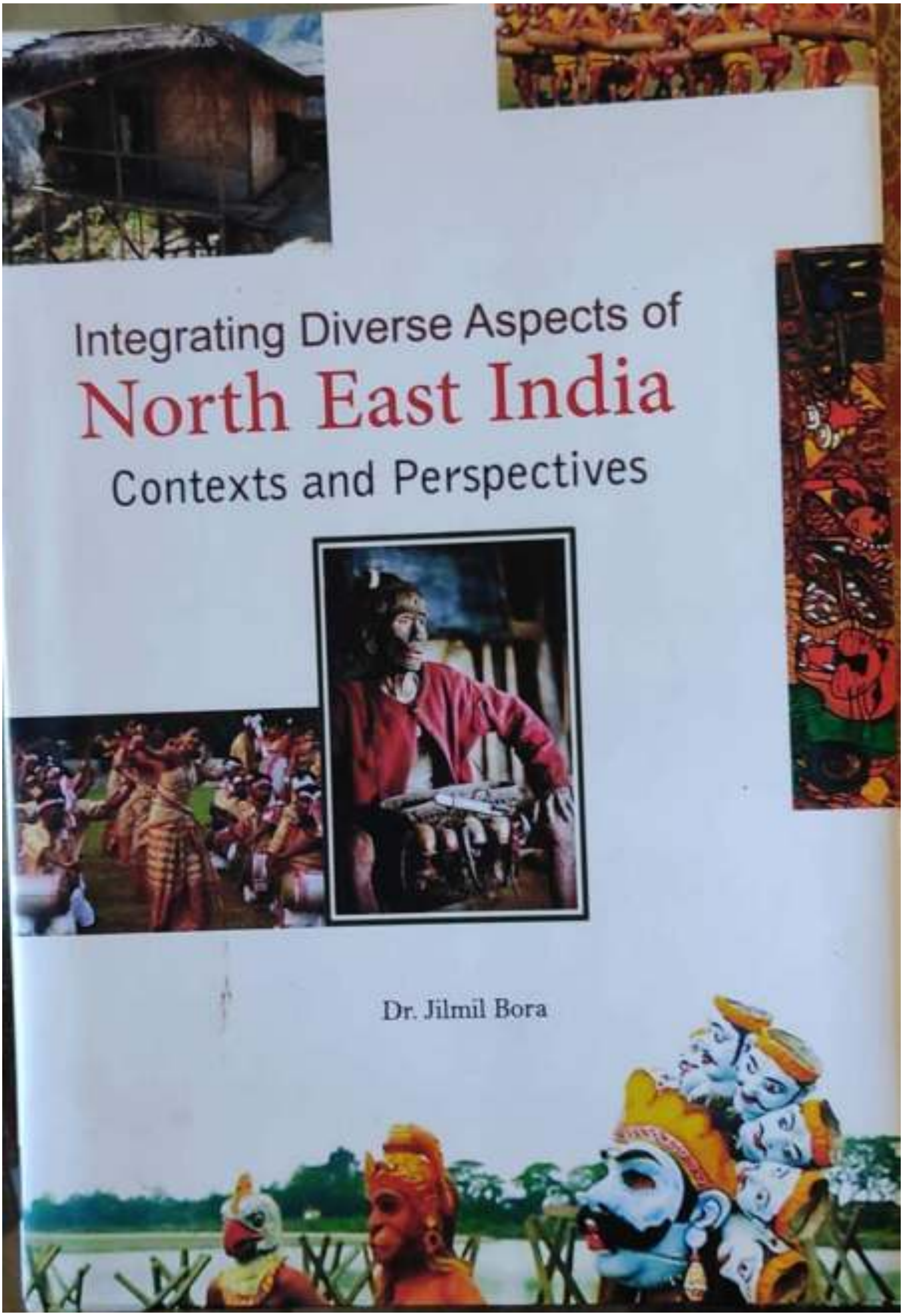

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এ.বি.ভি.ৰ

উচ্চতৰ মাধ্যমিক

ৰাজনীতি বিজ্ঞান

(সমসাময়িক বিশ্ব ৰাজনীতি আৰু স্বাধীনোত্তৰ ভাৰতৰ ৰাজনীতি)

(AHSEC/NCERT পাঠ্যক্রমৰ আধাৰত)

(দ্বিতীয় বাৰ্ষিকৰ বাবে)

শৰ্মা ▪ জামান ▪ বৰুৱা

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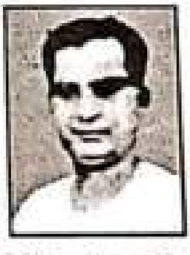

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এবিচিৰ

উচ্চতৰ মাধ্যমিক

ৰাজনীতি বিজ্ঞান

(ভাৰতীয় সংবিধান কার্য আৰু ৰাজনৈতিক তত্ত্ব)

(AHSEC/NCERT/NCF পাঠ্যক্রমৰ আধাৰত)

(প্ৰথম বাৰ্ষিকৰ বাবে)

শৰ্মা ▪ জামান ▪ বৰুৱা

অসম উচ্চতৰ মাধ্যমিক শিক্ষা সংসদে ২০১০-১১ চনৰ শিক্ষাবৰ্ষৰ পৰা প্ৰৱৰ্তন কৰা প্ৰথম বাৰ্ষিকৰ নতুন পাঠ্যক্ৰম (AHSEC/NCERT) ৰ ভিত্তিত প্ৰণীত আৱশ্যকীয় পাঠ্যপুথি।

বৰ্জিত

উচ্চতৰ মাধ্যমিক

ৰাজনীতি বিজ্ঞান

[ভাৰতীয় সংবিধানৰ কাৰ্য আৰু ৰাজনৈতিক তত্ত্ব]

।। প্ৰথম বাৰ্ষিকৰ বাবে।।

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অৱসৰপ্ৰাপ্ত বিভাগীয় মুৰব্বী, ৰাজনীতি বিজ্ঞান বিভাগ
আৰ্য বিদ্যাপীঠ কলেজ, গুৱাহাটী।

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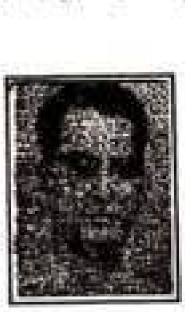
অৱসৰপ্ৰাপ্ত বিভাগীয় মুৰব্বী, ৰাজনীতি বিজ্ঞান বিভাগ
গোৱালপাৰা মহাবিদ্যালয়, গোৱালপাৰা।

মানস প্ৰতিম বৰুৱা
বিভাগীয় প্ৰধান, ৰাজনীতি বিজ্ঞান বিভাগ
দক্ষিণ কামৰূপ মহাবিদ্যালয়, মিৰ্জা, কামৰূপ।



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ISBN : 978-93-82384-11-3

ডি. টি. পি ঃ
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ফোন ঃ ০৩৬১২৫৪৩৮৯৬
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পুনৰ্মুদ্ৰণ ঃ ২০২০

মূল্য ঃ ১৭০.০০ টকা।

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[As per AHSEC/NCERT Syllabus]

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Head of the Department, Deptt of Political Science
D. K. College, Mirja, Kamrup

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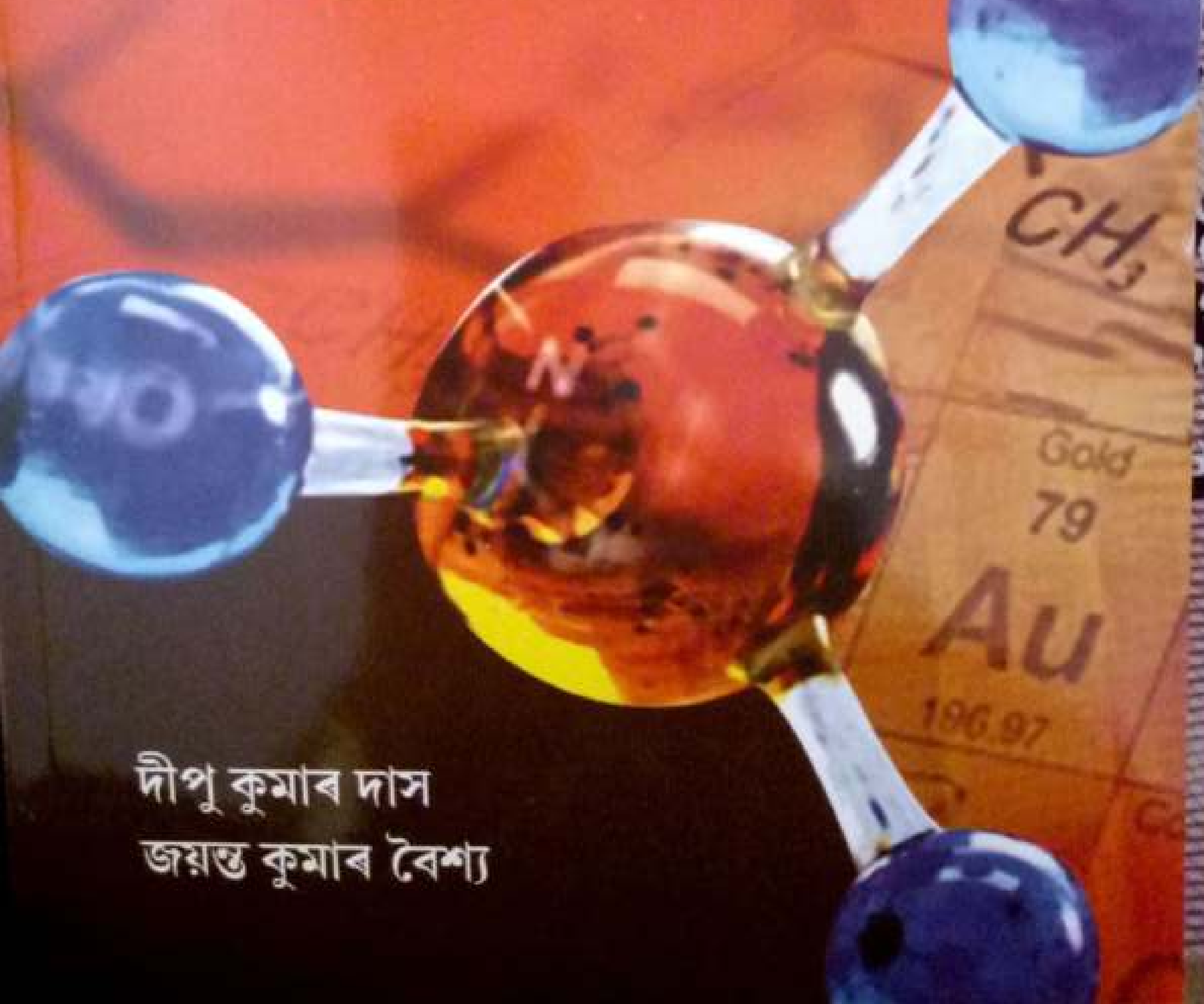

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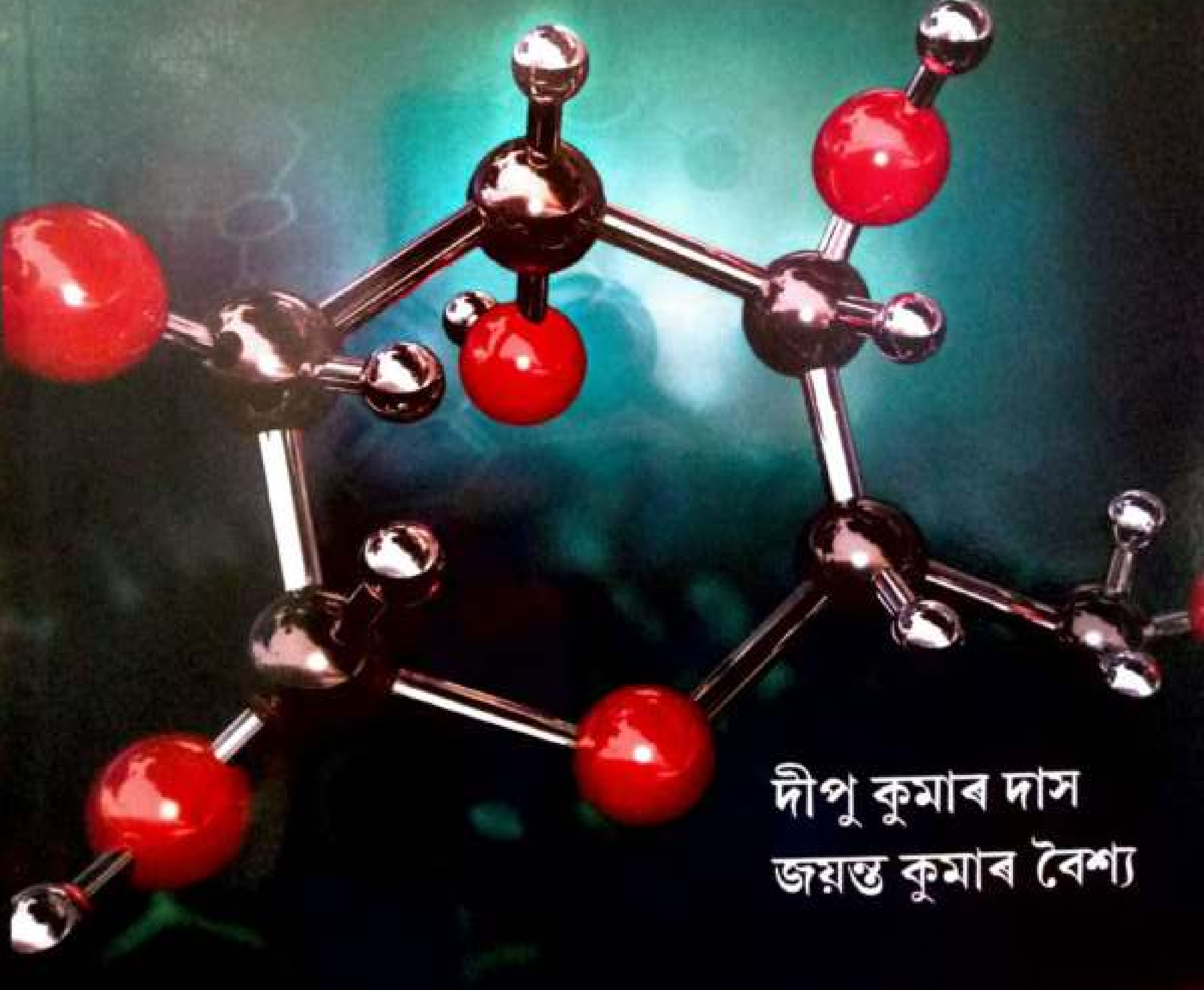

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Integrating Diverse Aspects of North East India

Contexts and Perspectives

Dr. Jilmil Bora

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13

Achieving food security in North East India through Sustainable Agriculture

— Dr. Gargi Chakravarty

Sustainable Agriculture- Its significance

Widespread adoption of sustainable practices in agriculture and food supply chains is essential to meet current and future threats to food security and environmental resilience. In the coming decades, agriculture must produce more food to feed a growing population while adapting to climate change, an increasing threat to agricultural yields (Foresight 2011; INRA/CIRAD 2011; IAASTD 2009; Lobell *et al.* 2011; The Hague Conference 2010). In agricultural production, greenhouse gases (GHGs) contributing to climate change originates from fertilizers, ruminant digestion (cattle, sheep and goats), rice cultivation and fuel use. Land clearing for agriculture, particularly deforestation, can also contribute significantly to Green-house gas impacts (Smith *et al.* 2007). Alternative agricultural practices, suitable in different regions, can reduce net GhG emissions while maintaining or improving yields and adapting to more extreme weather (Pretty *et al.* 2011).

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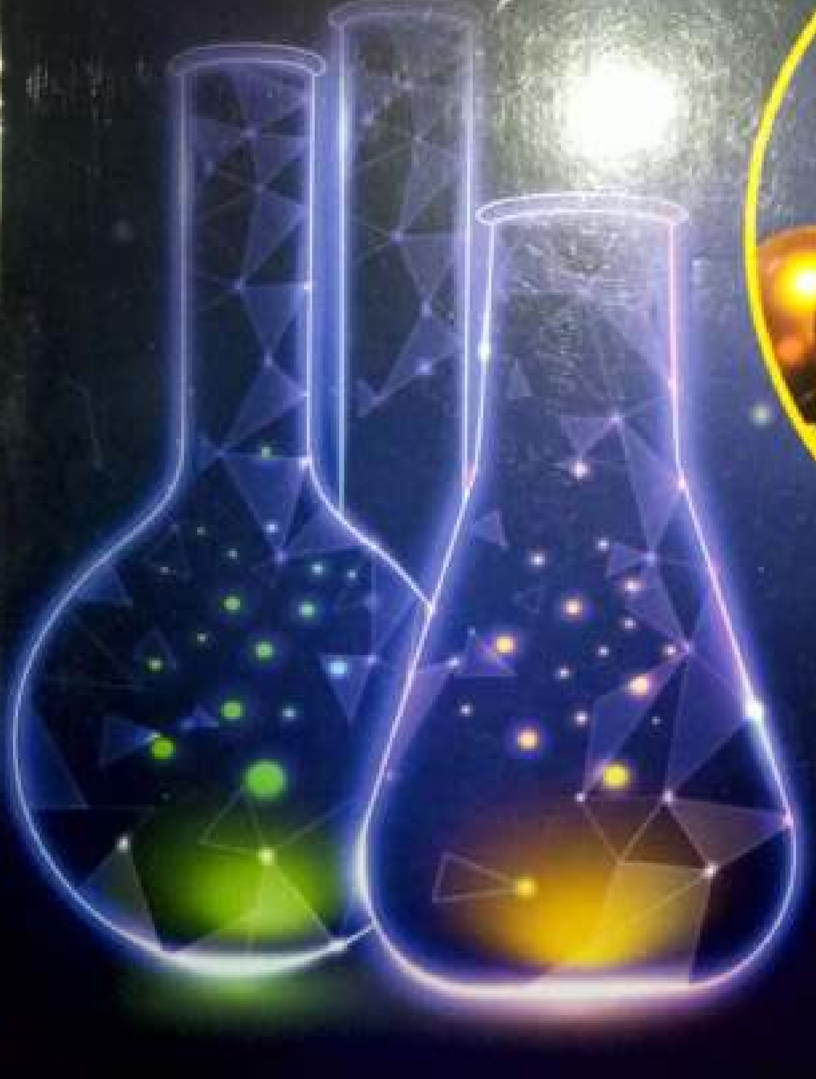

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ডিটিপি ঃ মুকুল বৰুৱা

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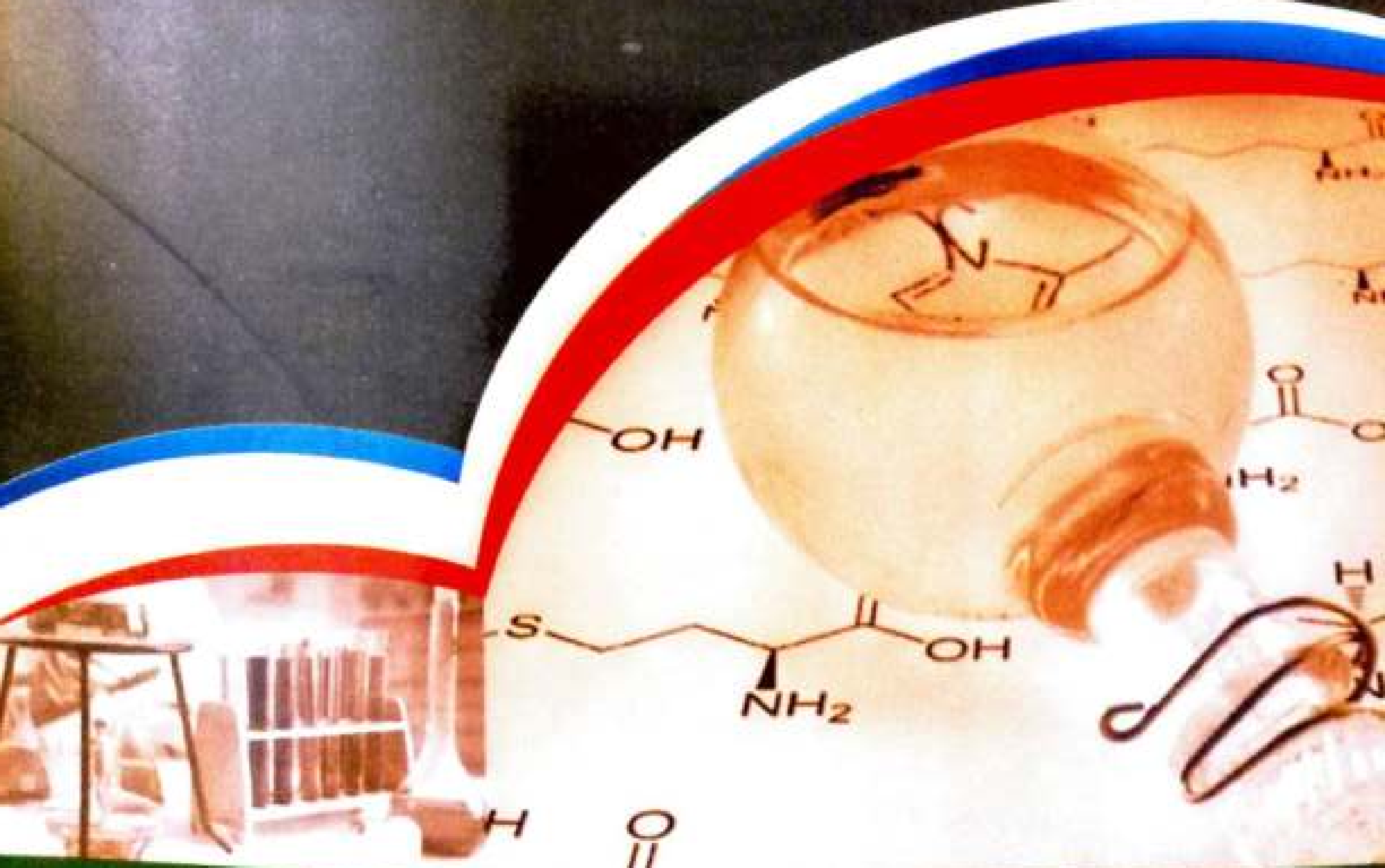

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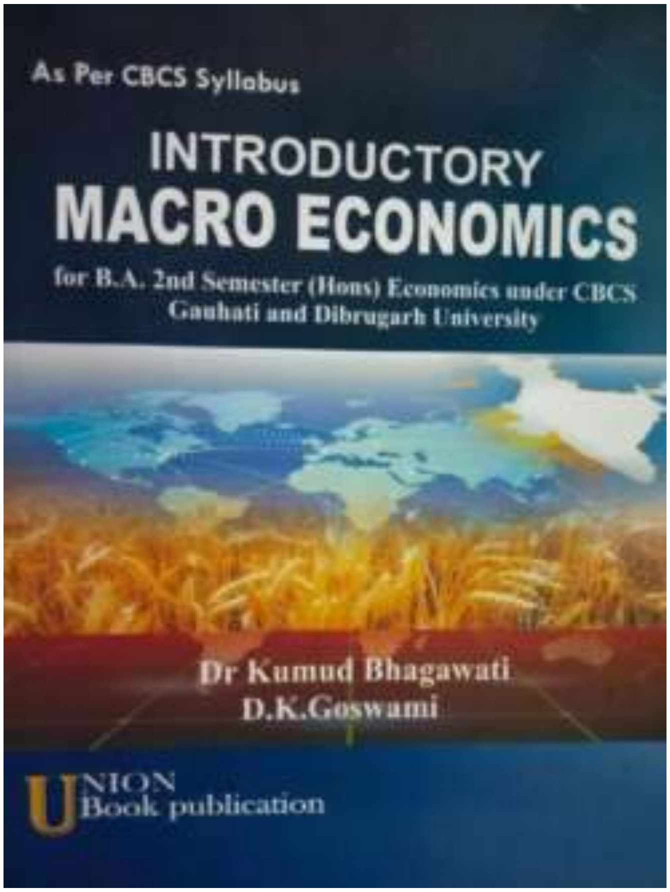

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INTRODUCTORY MACRO ECONOMICS

for B.A. 2nd Semester (Hons) Economics under CBCS
Gauhati and Dibrugarh University

Dr Kumud Bhagawati
D.K.Goswami

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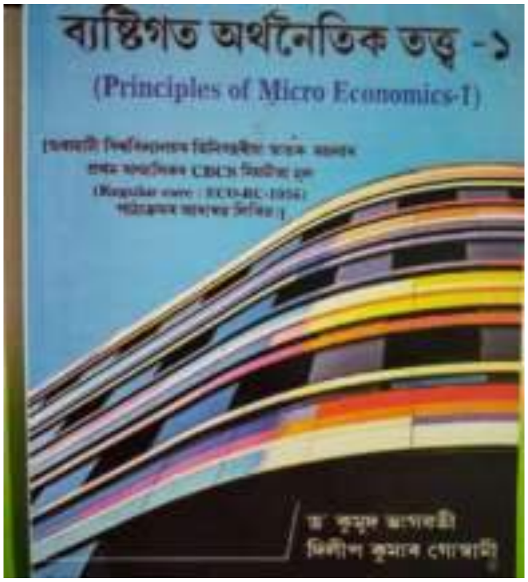

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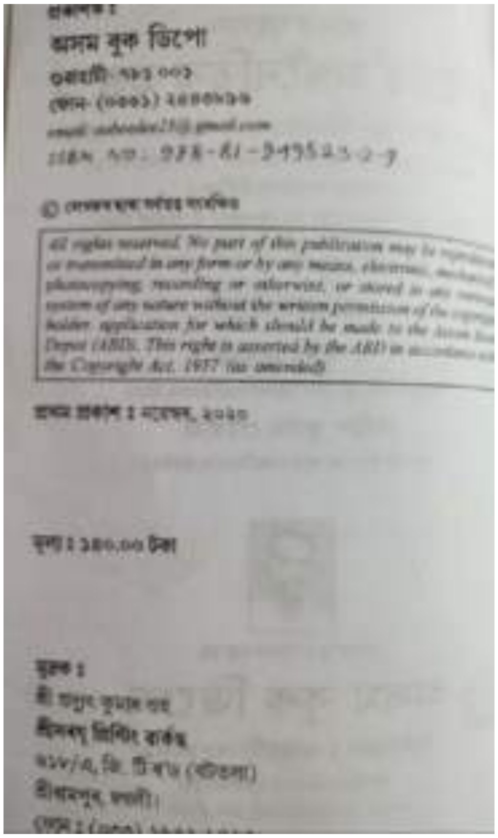

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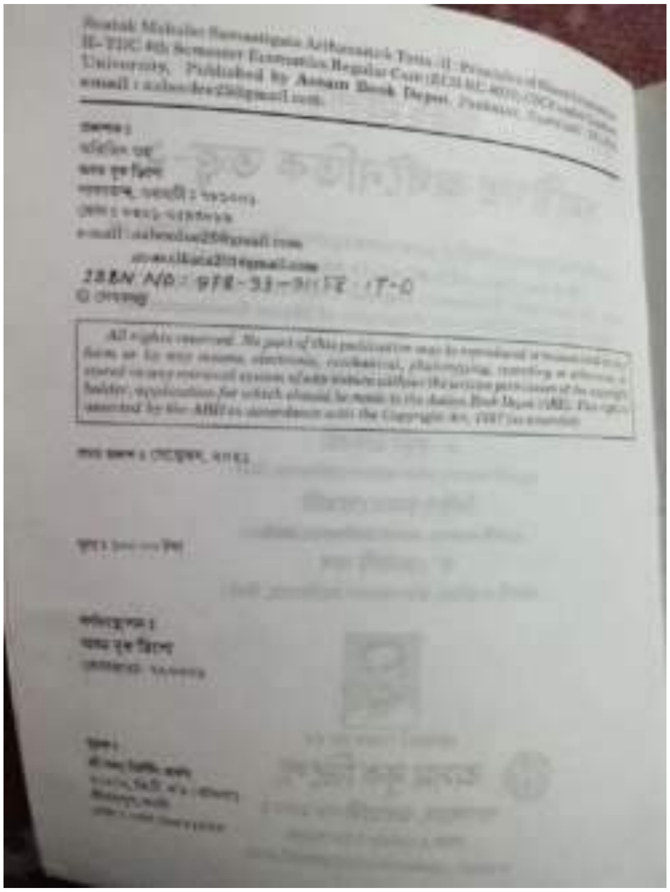

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MULTIDISCIPLINARY RESEARCH IN HUMANITIES, ART AND CULTURE: NORTH EAST INDIAN CONTEXT

A COLLECTION OF BOOK CHAPTERS ON
DIFFERENT AREAS OF HUMANITIES, ART AND
CULTURE OF NORTH EAST INDIA

Chief Editor
DR. HAR KUMAR NATH

Associate Editors
DR. SUSMITA NATH
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CHAPTER 15

Role of Community Level Factors Affecting the Utilisation of Maternal Health Care Services in Assam: A Study in Three Selected Districts of Assam

Jonali Nath

Summary

Most of the public health studies, in developing countries assessing the determinants of maternal health care services focus on household and individual level factors. But, at present, there has been a trend to study the health care services in association of community level factors. Community has great impact on the behaviour of individual and society. Community characters influence individual decision making with respect to various aspects. It is well recognized that disparities of health outcome may arise not only from differences in the characteristics of families but also from differences in the socio-economic attribute and communities where they live (Fosto and Kuate- Defo, 2005. Kravdal, 2004, Robert, 1999).

It is clear from various studies that maternal health seeking behaviour is not only associated with the individual and household level factors, but also with community level factors, such as place of residence, community poverty, community level education, community mass media exposure among others which may affect the maternal health care behaviour. In this paper an attempt has made to assess the role of community level factors affecting the utilisation of maternal health care services in Assam.

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Covid-19: Negotiating the Immediate and Beyond...

Editor
Dr. Sangeeta Das

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continues to be the highly affected pop[illegible]

they have no hold of themselves or are weak, but [illegible] certain norms of the society that still persist, [illegible] flexibilities, and various conditionings under which they [illegible] always functioned.

While there is a section of society which tries to steal [illegible] capacities into disbelief, there are people who believe [illegible] strengths and capabilities of women.

Furthermore, due to the presence of both announced [illegible] unannounced societal pressures women have been [illegible] more, but chances that they will manage to overcome [illegible] hindrances, and will rise and contribute in the ways [illegible] are greater.

Studies like these are important for proper and [illegible] knowledge of the on-goings. If taken into account, such [illegible] definitely aid in bringing about much needed changes [illegible] on the psychological or any other level possible.

In this research, I have tried to utilise the best of my [illegible] scope and time to study and present the given topic. [illegible] further scope of study on this given topic by taking into [illegible] other factors or by placing more emphasis at specific [illegible]

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"Why Women, Peace and Security" https://www.peacewomen.[illegible]

[illegible] Pandemic

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[illegible] Palashbari, Kamrup®, Pin:781122.
[illegible] dulumoninath2@gmail.com

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The purpose of this paper is to delimitate involvement of [illegible] in handloom industry in Assam, India and its impact [illegible] socio-economic life. During the pandemic Covid-19 [illegible] weaving womens' condition is going to very bad. The [illegible] industry constitutes a timeless facet of the rich cultural [illegible] of Assam. Highest proportion of weavers in India can [illegible] in Assam and around 99 percent of them are women. [illegible] in almost every assamese family have at least one [illegible] woman and some place we find weaving men also. [illegible] area of Assam famous for handloom; for example: [illegible] That industry has been badly affected during Covid-[illegible] The analysis clearly shows that such as income [illegible] livelihood positively correlate with involvement of women [illegible] weaving.

[illegible] - handloom, involvement, women, condition, [illegible] 19.

[illegible]: The hand loom sector plays a very important [illegible] India's economy. It is a part of our culture and heritage [illegible] of the largest economic activities after agriculture

Women Law and Remedies

Editor

Anjali Dixit
Assistant Professor
Faculty of Juridical Sciences
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men Law and Remedies
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PREFACE

The woman who follows the crowd will usually go no further than the crowd. The woman who walks alone is likely to find herself in places no one has ever been before. The story of women's struggle for equality belongs to no single feminist nor to any one organization but to the collective efforts of all who care about human rights.

Around the globe, policymakers and activists are working to empower women as agents of peace and to help address the challenges they face as survivors of conflict. When women are involved in peace negotiations, they raise important issues that might be otherwise overlooked. When women are educated and enabled to participate in every aspect of their societies—from growing the economy to strengthening the security sector—communities are more stable and less prone to conflict. Every moment of every day our world is becoming more interconnected, and we are wise to engage all stakeholders in finding solutions to our most difficult challenges. Acknowledging the barriers many societies still impose on women's participation and encouraging the potential of women to promote peace—in their own countries and around the world—are parts of this process.

Women Law and Remedies is an edited book, this collection of essays by eminent professors, activists and research scholars seeks to map the field of women and law from an interdisciplinary perspective' and, in the process, puts forth on paper the continuing denial of justice to women under the Indian legal system. By

1.

Superstitious Belief and Witchcraft in India : A Legal Study

Anjali Dixit*

Introduction

Superstition has persisted throughout human history, and has been present in virtually every human society throughout history. In scientific era superstition belief exists worldwide. Although, many scientific discoveries and inventions try to vanish this black magic belief.

Superstitions are self-imposed selfish imaginary beliefs. Witchcraft or witch hunting is one of them. Worldwide developing non- developing and poor countries are victim of this superstitious belief. According to Shakespeare's Macbeth witches were those persons who had made a spiritual pact with devil in exchange for supernatural powers.

Witchcraft and Witch Hunt

Witchcraft is a multifaceted religious, cultural phenomenon with its nature, causes and outcomes worldwide. Most of literate or illiterate, urban or rural residents in India even in 21st century would still consult a witch Doctors (tantric or an astrologer) to cure their

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*Assistant Professor, Faculty of Juridical Sciences, Rama University, Kanpur.

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14.

Violence Against Women and its Remedies

Dulumoni Nath*

Introduction

The world has entered into a new millennium but from the dawn of civilization till date the women of the patriarchal society of India continues to be oppressed and ill treated. She is dependent weak exploited and faces gender discrimination in every sphere of threatens the well being, dignity and rights of women, extends across social, cultural, economic and regional boundaries.

Instances of violence against women in ancient India are mentioned. Mahabharata cites the violence meted out to Dropodi. Yudhistir staked his wife Dropodi in gambling and lost her following which Duryadhana ordered his brother to do strip her in the royal palace and he attempt to do so, but lord Krishna came to her rescue. Kans killed seven new born babies of his sister Devaki. In modern societies also violence against women is a major public health affecting women and children.

Violence against women is a grave violence of the fundamental

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*Assistant Professor, Department of History, Dakshin Kamrup College, Mirza.

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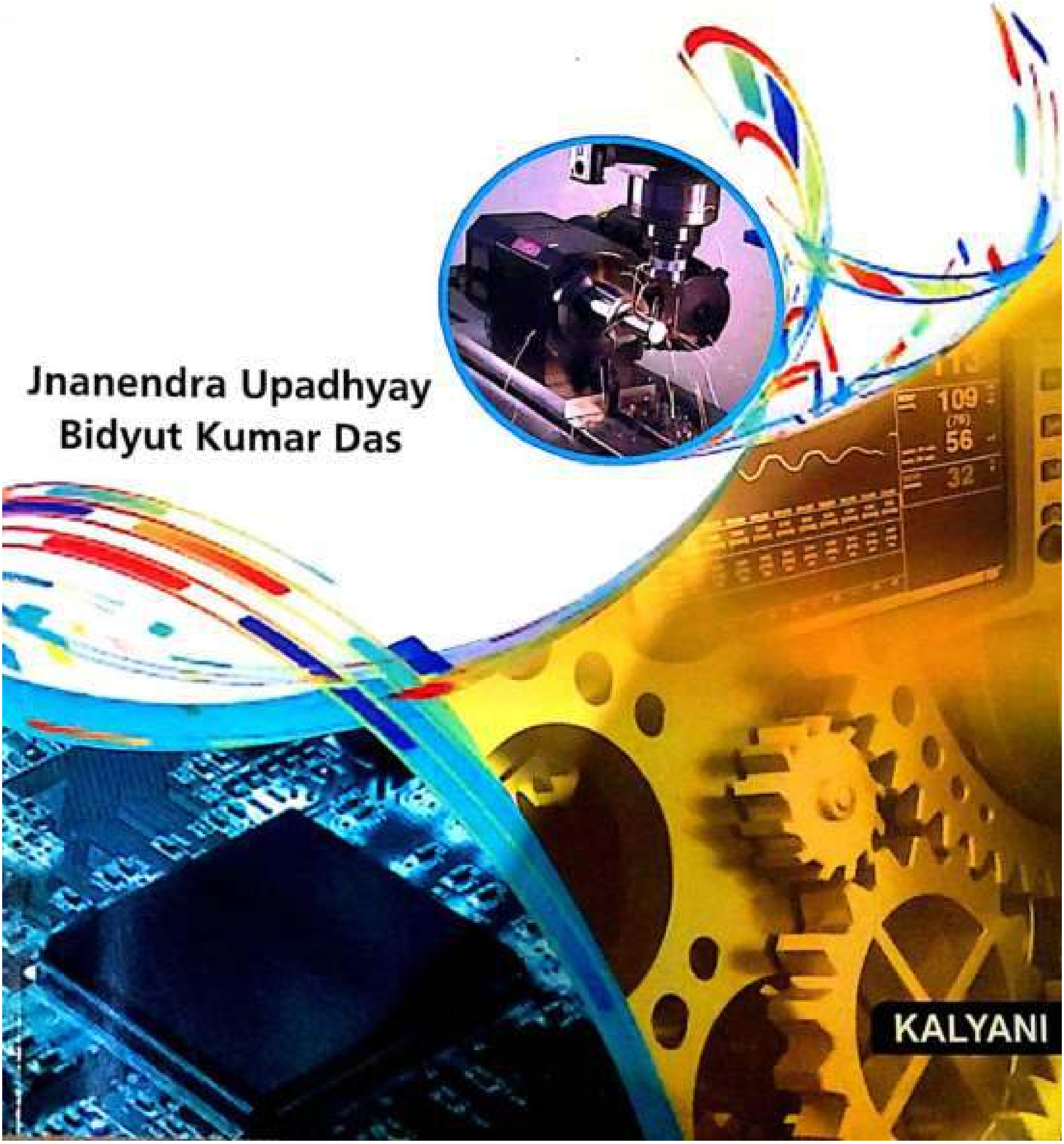

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Trends in Stimuli Responsive Biomaterials in Tissue Engineering

Rajiv Borah, Jnanendra Upadhyay, and Birru Bhaskar

Abstract

Native tissues and organs coordinate and execute their activities via dynamic, interlinked clusters of biochemical and biophysical attributes, which are differed throughout biological processes spatiotemporally. Passive biomaterials, developed with tunable structural, mechanical and biochemical properties, cannot mimic the dynamic features of the cellular environment and therefore, often lack of efficiency in tissue regeneration to restore full functionality. With the perspective to address this notion, stimuli responsive biomaterials have evolved as effective tool that replicate essential static and dynamic features of native tissues due to their capacity to alter physicochemical characteristics in response to physical/chemical/biological stimuli compatible to tissues and organs, facilitating on demand cell microenvironmental manipulation. The current chapter focuses on trends of stimuli responsive biomaterials explored for tissue engineering (TE) applications. Special emphasize has been devoted to those stimuli responsive biomaterials (e.g. electroactive biomaterials), which are sensitive to the stimuli that match with the native biophysical cues of tissues and can regulate those biophysical cues to modulate the regeneration associated cellular processes for faster and efficient tissue regeneration. Each category of stimuli responsive biomaterials has been discussed with a brief introduction and the mechanism of

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R. Borah (✉)
Life Sciences Division, Institute of Advanced Study in Science & Technology, Guwahati, Assam, India
e-mail: rajiv.borah@iasst.gov.in

J. Upadhyay
Department of Physics, Dakshin Kamrup College, Mirza, Kamrup, Assam, India

B. Bhaskar
Brien Holden Eye Research Centre, LV Prasad Eye Institute (LVPEI), Hyderabad, India

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functionality followed by its applications in various TE applications. Biomaterials that respond to chemical and biological stimuli, have also been briefly addressed in the light of TE potential. The chapter also highlights the advantages-limitations and future directions of stimuli responsive biomaterials at the end.

Keywords

Tissue engineering · Stimuli responsive biomaterials · Electroactive biomaterials · Tissue regeneration

Abbreviations

0D	Zero dimensional
1D	One dimensional
2D	Two dimensional
3D	Three dimensional
5-FU	5-fluorouracil
ADSCs	Adipose derived stem cells
Alg	Alginate
$BaTiO_3$	Barium Titanate
BT	Barium titanate
C	Cellulose
Ch	Chitosan
CNFs	Carbon nanofibers
CNTs	Carbon nanotubes
Co	Cobalt
Col	Collagen
CPs	Conducting polymers
CS	Chondroitin sulfate
DDF	Dermal fibroblasts
DLC	Diamond-like carbon
DMAEMA	Dimethylaminoethyl methacrylate
DNA	Deoxyribonucleic acid
ECM	Extracellular matrix
ES	Electrical stimulation
Fe	Iron
G	Graphene
Gel	Gelatin
GelMA	Gelatin methacryloyl
GO	Graphene oxide
HA	Hydroxyapatite
HEMA	2-hydroxyethyl methacrylate
LCEs	Liquid crystalline elastomers

LCST	Lower critical solution temperature
MAP	Microporous annealed particle
MEH-PPV	Poly(2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene)
MS	Magnetic stimulation
MWCNT	Multiwall carbon nanotube
NB	Nitrobenzene
NCD	Nanocrystalline diamond
Ni	Nickel
P3HT	Poly-3-hexyl-thiophene
PAN	Polyacrylonitrile
PAni	Polyaniline
PAs	Peptide amphiphiles
PCBM	Phenyl-C61-butyric acid methyl ester
PCL	Polycaprolactone
PCLF	Polycaprolactone fumarate
PDMS	Polydimethylsiloxane
PEDOT	Poly(3,4-ethylenedioxythiophene)
PEG	Poly(ethylene glycol)
PEGS	Poly(ethylene glycol)-co-poly(glycerol-sebacate)
PEO–PPO–PEO	Poly(ethylene oxide)-poly(propylene oxide)-poly (ethylene oxide)
PGA	Polyglycolide
PGS	Poly(glycerol-sebacate)
PHBV	Poly(3-hydroxybutyric acid-co-3-hydroxy valericacid)
PHEMA	Poly(2-hydroxyethyl methacrylate)
PLA	Polylactide
PLGA	Poly(lactic-co-glycolic)
PLGA/HA	Poly(lactic-co-glycolic acid)/hyaluronic acid
PLLA	Poly-L-lactic acid
PLLA-PEG-PLLA	Poly (L-lactic acid)-poly(ethylene glycol)-poly(L-lactic acid)
PNiPAAm	Poly(N-isopropylacrylamide)
PNVC	Poly(N-vinylcaprolactam)
POxs	Poly(2-oxazoline)s
PP	Polypropylene
PPy	Polypyrrole
PSS	Poly(4-styrene sulfonate)
PT	Polythiophene
PTCDI-C8	N,N′-dioctyl-3,4,9,10-perylenedicarboximide
PTFE	Polytetrafluoroethylene
PVA	Poly(vinyl alcohol)
PVDF	Polyvinylidine fluoride
PZT	Lead Zirconate titanate
RGCs	Retinal ganglion cells
rGO	Reduced graphene oxide
SF	Silk fibroin

Si	Silicon
SMPs	Shape-memory polymers
TCP	β-tricalcium phosphate
TE	Tissue engineering
TrFE	Trifluoro ethylene
UCST	Upper critical solution temperature
UV	Ultraviolet

9.1 Introduction

Tissue engineering (TE) has evolved as a realistic alternative to donor-dependent organ transplantation or autografting and allografting to repair a damaged organ or tissue. It is meant to develop living, functional tissues that can be employed to substitute, or repair tissues impaired because of disease, aging, congenital defects or physical damage by integrating biomaterial scaffold, cells and bioactive compounds (Vacanti and Langer 1999). Therefore, the choice and design of biomaterial is essential for the regeneration of new cells in vitro and in vivo, while ensuring its biocompatibility, bioactivity, durability, degradability, porosity, and flexibility at the same time. In TE, the biomaterial scaffold should act as the artificial extracellular matrix (ECM) capable to mimic the native cellular microenvironment of the particular cell type, which is needed to be regenerated. Hence, the spatiotemporal modulation of the physical and chemical properties of biomaterial scaffold is necessary to support favorable tissue regeneration. The native ECM interacts with cells dynamically through close co-ordination with the biophysical and/or biochemical cues for normal tissue function including regeneration. A biomaterial scaffold is also required to function in a dynamic fashion for effective and efficient tissue regeneration, which paved the way for “smart” or “stimuli responsive” functional materials in TE applications.

Throughout the designing and creation of new materials that are able to respond to particular stimuli, nature provides countless touchstones that are configurable, reliable, and replicable. In reality, many living system substances vary spontaneously as per the environmental circumstances and their processes and actions to maintain and regulate normal functions. It involves alteration in form, dimensions, appearance or rigidity and depends on complicated models for feedback. Over the last decade academic and industrial research has thus been inspired to create new functional materials that imitate the sensitivity of natural living systems. Subsequently, the understanding of endogenous physiological behavior of cells and tissues along with the existence of several important physical and chemical cues, inspired researchers to develop a new generation of biomaterials, termed as “Smart” or “Stimuli responsive” biomaterials. Prior to this new generation of biomaterials, most of the biomaterials were used in a passive way, just as support for the cells and tissues through their bioactivity and suitable physiochemical properties such as biodegradability, mechanical stability, and porosity. Therefore, there is a growing interest in stimuli responsive materials for TE and regenerative medicine with the capacity to communicate and interact with cells.

Stimuli responsive materials, also termed as "smart" or "intelligent" materials, are those, which can sense and respond to external stimuli or any alternation in the external environment (Cardoso et al. 2017). In rebuttal to single or multiple external stimuli, this exceptional category of materials exhibits variations in one or more of their physicochemical properties, i.e., size, shape, solubility, permeability, hydrophilicity, surface charge, electrical, magnetic, mechanical, and optical, etc. These external stimuli can be classified as physical (temperature, electrical, magnetic, mechanical stress, light, ultrasound, etc.), chemical (pH, ionic strength, electrochemical, etc.) and biological (enzymes, glucose, antigen, growth factors, receptors etc.) stimuli (Fig. 9.1). Physical stimuli can induce modifications in the energy dynamics of the materials, whereas the chemical stimuli modulate molecular interaction within the material or between the material and the surrounding environment. Biological stimuli associate with the specific biological functions such as enzymatic reactions, receptor recognition, activating regeneration associated processes, etc. Additionally, there are dual and multi-stimulus-responsive materials that respond to more than one stimulus concurrently.

In regard to TE applications, stimuli responsive materials hold potential to elicit beneficial effect at cellular level through changes in their physiochemical properties upon any change in external stimuli, which can activate regeneration associated processes by modulating various important biochemical or biophysical events at cellular and molecular level. Therefore, it is important that the stimulus dependent behavior of a potential stimuli responsive biomaterial should be able to induce the beneficial effect during in vitro cell culture or in vivo to enhance the tissue regeneration and function. Although, there are a range of stimuli responsive biomaterials with respect to their sensitivity towards specific stimulus type, the real time cellular response is significantly observable and therefore, well explored with the stimuli responsive biomaterials, which can respond to electrical stimulation (ES) and magnetic stimulation (MS). The concept of these biomaterials is based on the intrinsic biophysical cues already present in the tissue. In fact, there are two approaches of using stimuli responsive biomaterials for tissue repair purposes. In the first case, the stimulus is used during fabrication of the biomaterials and there is hardly any or rare evidence of utilizing that particular stimulus in real time during in vitro cell culture or in vivo. In the latter's scenario, the stimulus, which matches with the intrinsic biophysical/biochemical cues of tissues, is utilized to mimic the dynamic cell microenvironment. The present chapter mainly focuses on the stimuli responsive biomaterials of the second category with their underlying mechanisms of stimuli dependent actions in the light of cellular processes, and hence, a detailed discussion on electroactive and magnetoresponsive biomaterials, followed by thermoresponsive and photoresponsive biomaterials, has been presented. The chapter also summarizes the TE applications of chemical and biological stimuli responsive biomaterials along with dual and multi-stimuli responsive biomaterials. Notwithstanding, most of the stimuli responsive biomaterials were explored largely in diagnostic applications and

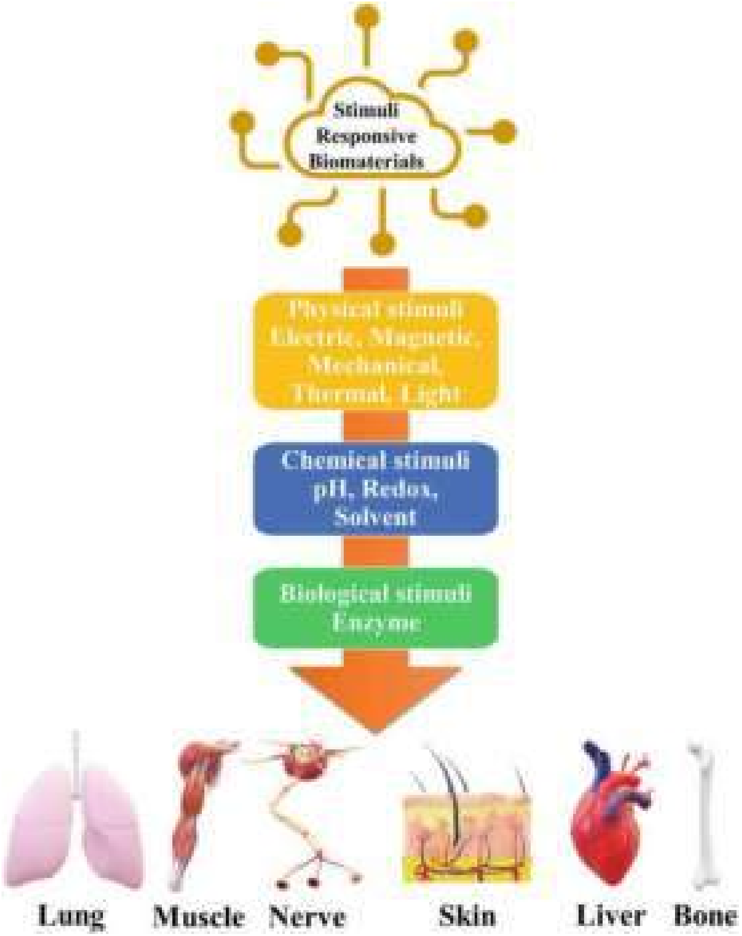


Fig. 9.1 Concept of stimuli responsive biomaterials for effective tissue regeneration and functional recovery in combination of physical/chemical/biological stimuli

on demand delivery of drugs, protein, gene, and cell (Cabane et al. 2012), which are not within the scope of the present chapter.

9.2 Stimuli Responsive Biomaterials in Tissue Engineering

9.2.1 Electroactive Biomaterials

Bioelectricity holds a pivotal role in our body's normal operation including movement, thinking, sensation, visualization with eyes, blood transportation through our circulatory system and healing of an injury (Ghasemi-Mobarakeh et al. 2011). Cargo phenomena including movement of ions through the plasma membranes and electrons along biomolecules regulate all the biological processes in the body. Electrical potentials (−60 mV to −100 mV) exist inside and outside cells. The changes in the transmembrane potential influence cellular functions as depicted in Fig. 9.2 (Qian et al. 2019). Biological tissues, particularly heart, neural, skin, bone, and muscles, are used to regulate their physiological behaviors and to propagate electrical potential by means of their electrical conductivity mechanisms such as accumulation and flow of charge (Balint et al. 2014). Electrical activities are associated in modulation of range of molecular events in these tissues, engaged in the development, adaptation, repair, and regeneration of tissues. There are growing evidences of significant positive contribution of ES in a range of important biological processes relevant to TE, viz. angiogenesis, cell division, cell signaling, nerve sprouting, prenatal development, and wound healing (Balint et al. 2013). This inspired the development of electroactive biomaterials, because of their excellent contact with bioelectric fields in cells and tissues, for a faster pace than traditional non-conductive biomaterials, for improving regenerations, differentiation or function of both in vitro and in vivo.

Electroactive biomaterials enable cells to obtain direct electrical, electrochemical, and electromechanical stimulation. Possible clinical uses of ES include wound care, bone regeneration, nervous repair, and ulcer care of the diabetic and bedridden patients with pressure sores. Some of the electroactive biomaterials were clinically translated as non-biodegradable cardiac pacemakers, cochlear implants, electrodes for deep brain stimulation, etc. These smart biomaterials simultaneously can be stimulatory to the tissues as well as can trigger controlled/responsive release of therapeutics loaded into them. Such systems offer an effective delivery method for physicians and scientists in wound care, making it easier for patients to implement

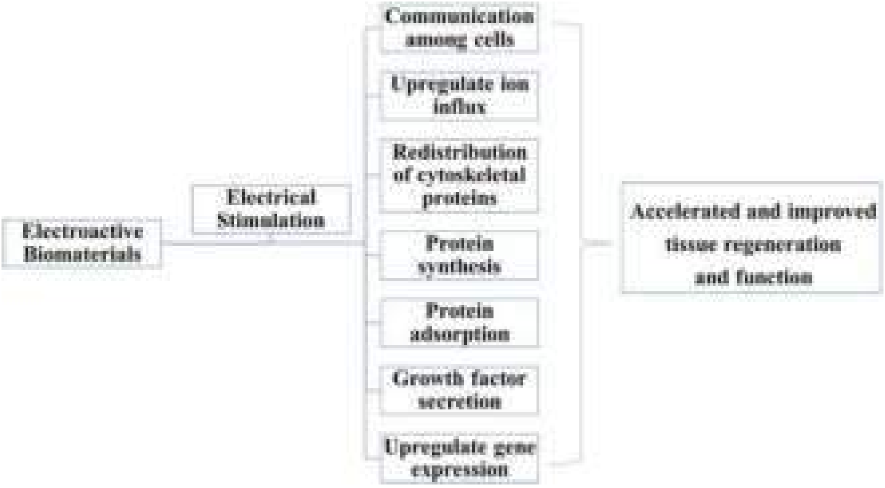


Fig. 9.2 Scheme of cellular response elicited by electrical stimulation (ES) through electroactive biomaterials based scaffolds for improved tissue regeneration and function (Qian et al. 2019)

new therapeutic approaches. Electroactive biomaterials can adapt their chemical, electrical, and physical properties to the specific needs of their application. The electroactive biomaterials family includes conducting polymers (CPs), piezoelectrics, electrets, and photovoltaics, which are discussed in the following subsections.

9.2.1.1 Conducting Polymers

CPs are the latest class of organic polymers integrating the electrical, magnetic, and optical properties of metals and inorganic semiconductors with conventional polymers' mechanical properties, processability, etc. (Shimano and MacDiamid 2001). This fourth generation polymers are completely distinct structurally from conventional polymers or mixture of insulating polymer with a conductive material such as a metal or carbon powder. Alternating single and double bonds along the strongly conjugated backbone of CPs enable electron mobility and charge movement within and between polymer chains, which results in strong electrical conductivity (Shirakawa et al. 1977). While the electrical conductivities of insulating polymers are much weaker (10^{-20}–10^{-6} S/cm), CPs possess much greater conductivities in the range of 1–10^3 S/cm (Le et al. 2017). Essentially, electrical conductivity in CPs is aided by two important features, which are its intrinsic conjugated alternation of single and double bonds and doping (Heeger 2001). Fundamentally, the electronic configuration CP's backbone is unique from other insulating polymers due to the former's conjugated alternating single-double carbon-carbon or carbon-nitrogen bonds (Skotheim et al. 1997). The CP backbone contains a strongly localized "sigma" (σ) bond and a weakly localized "pi" (π) bond with sp^2 hybridized carbon atom. This sp^2 hybridized carbon atom with a single s and two p orbitals, facilitates one non-boned electron (π electron) as shown in Fig. 9.3. Electron delocalization occurs due to the formation of π-band by the overlapping of the unpaired out-of-plane p_z orbitals. Usually, two of the *2p* orbitals (p_x and p_y) hybridize with 2s orbital to form three sp^2 hybridized orbitals leaving one p_z orbital unhybridized (Fig. 9.3). These sp^2 hybridized orbitals are arranged at an angle of 120° among them in a same plane, while the unhybridized orbital remains perpendicular to the plane. The head-

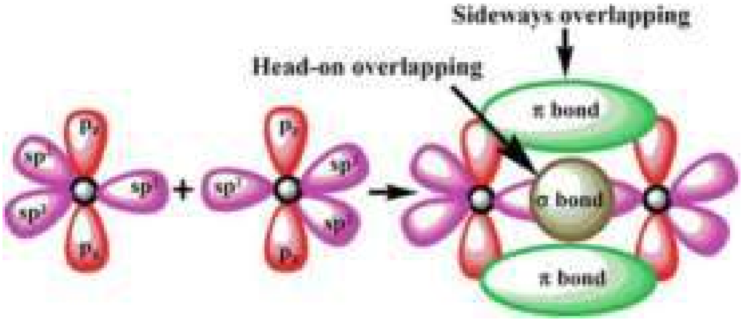


Fig. 9.3 Formation of σ and π molecular orbitals from two sp^2 hybridized carbon atoms in conducting polymers (CPs)

on overlapping of the hybridized orbitals gives rise to strong σ (sigma) bonds contributing to the polymer chain configuration. On the other hand, the unhybridized p_z orbitals of two carbon atoms undergo sideways overlapping and form π (pi) bonds. The electron cloud in the π bond are highly delocalized, which enables charge mobility along the polymer chain and between the neighboring chains. Therefore, the charge delocalization in π-band has vital role in defining the semi-conducting or sometimes, metal like electrically conductive nature of CPs.

Besides the single-double bond alteration in CPs, they are naturally non-conducting. Doping is the second essential requirement to impart electrical conductivity in CPs, which can be done by using anionic or cationic chemical species. However, the doping mechanisms in CPs are unique. Contrary to the substitutional doping in inorganic semiconductors, the process of doping in CPs is interstitial (Macdiarmid et al. 1985). Doping in CPs is nothing more than a charge transfer reaction, resulting in the partial reversible oxidation or less often reduction of the polymer. Doping can modify an insulating or semi-conducting polymer into a polymer with conductivity in the metallic regime. During doping, the loosely organized electrons hop along the polymer chain in the conjugated network. The peculiar conjugation of bonds in CP's backbone allows the electrons to delocalize, culminating them being shared by several atoms. The delocalized electrons, therefore, serve as charge carriers, which render conductivity. Actually, such delocalization of charge modifies the band structure of CPs creating localized defects such as polarons, bipolarons, solitons, and defect bands. When electrons are extracted or added from a polymer chain, cations or anions are formed. These cations or anions under the influence of an electrical field can hop from one position to another leading to higher electrical conductivity.

9.2.1.1.1 Conducting Polymers in Tissue Engineering

The increasing popularity of electrical and electromagnetic stimulation in medical field stems from the perception of the inherent bioelectric features of body tissues. Living tissues create electromotive forces, preserve the necessary potential difference, and turn the current on and off by regulating current flow and storing charge (Ghasemi-Mobarakeh et al. 2011). With this understanding, application of ES externally was well explored to various cellular activities including cell adhesion (Li et al. 2017), proliferation (Enayati et al. 2020), cell migration (Tai et al. 2018), and protein synthesis for tissue regeneration (Wake et al. 2011). The utilization of electrical signals to regulate the local cell microenvironment is, therefore, essential in activating specific cell behavior to particular phenotypes in order to achieve tissue functionality for longer run. CP-based biomaterials bring outstanding scaffolding features by assisting ES to cells, which are needed to promote regenerating mechanisms in the case of specific stimuli responsive cells (i.e., neurons, myotubes, cardiomyocytes) (Balint et al. 2014). CPs have many benefits in terms of excellent extent and period regulation of electrical stimuli, formidable electrical and optical properties, a high conductivity/weight ratio, and the ability to catch and controllably release biological molecules through reversible doping, to alter charges from a biochemical reaction and to easily alter their electrical, chemical, physical, and other properties necessary for intended application. In addition, CPs can be rendered biocompatibility, biodegradability, and porosity, which can be further altered and regulated even after synthesis by stimulation (e.g., electricity, light, pH) or various chemical based material modification techniques. Thus, several CPs such as polypyrrole (PPy), polyaniline (PAni), poly(3,4-ethylenedioxythiophene) (PEDOT), polythiophene (PT), and poly(2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene) (MEH-PPV) were shown to effect positively various cellular activities including cell adhesion, proliferation and migration, DNA synthesis and protein secretion both in vitro and in vivo. Given the potential advantages, CPs were explored for various TE applications including neural, cardiac, bone, muscle, and wound healing, which are summarized in Table 9.1.

9.2.1.2 Piezoelectric Material

Piezoelectricity refers to the phenomenon of surface charge accumulation on a material exhibiting a net dipole moment and no center of symmetry under a mechanical stress, which was first discovered by Pierre and Jacques Curie in 1880 (Jacob et al. 2018). Materials displaying such property are termed as piezoelectric materials. This unique category of materials can convert mechanical energy acting on it into electrical energy and vice versa. The generation of transient surface charges in presence of mechanical deformation (e.g. compression, tension) is known as direct piezoelectric effect and the deformation due to externally applied electrical signal (e.g. applied voltage, reversed polarity) is known as indirect or converse piezoelectric effect, as shown in Fig. 9.4 (Tandon et al. 2018). They can be categorized as piezoelectric polymers and piezoelectric ceramics, which may be natural materials or hydrogel systems. The dipoles are randomly oriented in a piezoelectric material and in order to fully utilize its piezoelectric feature, the dipoles should be rearranged so as to yield a net electric dipole moment through a dipole alignment process, called poling. This can be achieved by application of a strong electric field at a temperature above the glass transition temperature of the material followed by cooling under the same electric field.

9.2.1.2.1 Piezoelectric Materials in Tissue Engineering

The piezoelectric property has gained significant attention in the evolving TE strategies to provide in vivo microenvironment for enhanced cell-biomaterial interaction and modulating the cellular response towards desired tissue or organ regeneration. Mechanical deformation induced transient electrical stimuli within piezoelectric biomaterial makes it one of the best approaches in delivering ES to cells without any external power source and devising any external electrical connections. Tissues like bone, cartilage, tendon, dentin, and keratin, have the piezoelectric property. Mostly, all these tissues composed with collagen, it is the fibril structure responsible for piezoelectric behavior (Halperin et al. 2004). The significance of piezoelectric behavior on cell behavior, tissue regeneration, and remodeling was explored, which has driven the research towards the development of novel piezoelectric biomaterials for TE.

Table 9.1 TE applications of various CP-based biomaterials

CP-based biomaterial	Fabrication technique	Application	Outcome	References
Graphene oxide/polypyrrole/poly-L-lactic acid (GO/PPy/PLLA)	Electrospinning and electrochemical deposition	Neural TE	• GO/PPy/PLLA conduit in conjunction with ES successfully repaired 10 mm rat sciatic nerve defect with improved re-innervated gastrocnemius muscle and nerve conduction velocity. • In addition, myelin sheath thickness and axon diameter in GO/PPy/PLLA conduit with ES was comparable to autograft.	Chen et al. (2019)
Aligned polypyrrole/graphene (PPy/G) nanofibers	Polymerization-enhanced ball milling method	Neural TE	• Aligned PPy/G nanofibers with ES supported enhanced viability, neurite outgrowth and anti-aging ability of retinal ganglion cells (RGCs) suggesting possibilities for regeneration of optic nerve via ES on these electroconductive nanofibers.	Yan et al. (2016)
Poly (3,4-ethylenedioxythiophene) (PEDOT)	Electrochemical polymerization	Neural TE	• ES through PEDOT significantly improved viability, morphology and neural differentiation of PC12 cells.	Molino et al. (2018)
Poly[2-methoxy-5-(2-ethyl-hexyloxy)-1,4-phenylene vinylene]/polycaprolactone (MEH-PPV/PCL) nanofibers	Electrospinning	Neural TE	• MEH-PPV/PCL nanofibers with ES offered significant enhancement in neurite formation and neurite outgrowth of PC12 cells.	Borah et al. (2018)
Polyaniline/poly(glycerol-sebacate) (PAni/PGS)	Solvent casting method	Cardiac TE	• Electrically conductive PAni/PGS films offered. • Good attachment, growth and proliferation of C2C12 myoblasts, while invoking no harmful effect on cells through its acidic leachants.	Qazi et al. (2014)
Poly (3,4-ethylenedioxythiophene)/alginate (PEDOT/Alg)	In situ polymerization of PEDOT in chemically cross-linked Alg matrix followed by freeze drying	Cardiac TE	• Macroporous PEDOT/Alg scaffolds supported good attachment and proliferation of adipose derived stem cells (ADSCs). • Under ES through these conductive scaffolds promoted cardiomyogenic differentiation of ADSCs.	Yang et al. (2020)

(continued)

Table 9.1 (continued)

CP-based biomaterial	Fabrication technique	Application	Outcome	References
Silk fibroin/polypyrrole (SF/PPy)	In situ polymerization of PPy over nanopatterned silk Fibroin films fabricated by capillary force lithography technique	Cardiac TE	• Nanopatterned SF/PPy scaffolds mimicking the native myocardial ECM topography, maintained viability of cardiomyocytes for 21 days leading to increased cellular organization and sarcomere development with upregulated expression and polarization of connexin 43, a critical regulator of cell-cell electrical coupling.	Tsui et al. (2018)
Poly (3,4-ethylenedioxythiophene: poly(4-styrene sulfonate) (PEDOT:PSS)	Freeze drying	Bone TE	• Osteogenic precursor cells differentiated into osteogenic phenotype on porous PEDOT:PSS scaffolds with elevated expression of bone regeneration associated genes. • The electrically conductive porous scaffolds also facilitated cell infiltration, increased ECM mineralization, and osteocalcin deposition.	Guex et al. (2017)
Polypyrrole/alginate/chitosan (PPy/Alg/Ch)	Lyophilization and oxidative polymerization	Bone TE	• PPy/Alg/CS scaffolds were cytocompatible as assessed with MG-63 cells and facilitated biomineralization.	Sajesh et al. (2013)
Polyaniline/polyacrylonitrile (PAni/PAN) nanofibers	Electrospinning	Muscle TE	• PAni/PAN electrospun nanofibrous showed higher proliferation of primary myosatellite cells and myogenic differentiation as compared to PAN nanofibers.	Hosseinzadeh et al. (2016)
Polypyrrole/collagen/chondroitin sulfate (PPy/Col/CS)	Directional lyophilization	Muscle TE	• Aligned and 3D PPy/Col/CS scaffolds provided guided myoblast growth and organization with enhanced myotube formation and maturation.	Basurto et al. (2019)
Poly(3,4-ethylene-dioxythiophene): polystyrene-sulfonate/gelatin (PEDOT:PSS/Gel)	Ink-jet printing	Muscle TE	• PEDOT:PSS/Gel scaffold demonstrated good metabolic activity, adhesion, differentiation, and alignment C2C12 myoblast cells than those on pure Gel scaffold. • The conductive scaffold along with ES promoted cell alignment and enhance myotubes differentiation.	Fortunato et al. (2018)

Poly(2-hydroxyethyl methacrylate)/polypyrrole (PHEMA/PPy) hydrogel	Photo-polymerization and sol-gel technique for PHEMA hydrogel formation followed by oxidative polymerization of PPy	Wound healing	• The conductive hydrogel was found to be superior to the commercial Hydrosorb$^{@}$ dressing in terms of anti-bacterial activity and protein absorption. • In vitro ES through the hydrogel promoted fibroblast migration, while faster healing was observed in rat diabetic wound model with in vivo ES.	Lu et al. (2019)
Polypyrrole/poly(L-lactic acid) (PPy/PLLA) conductive membranes	Oxidative polymerization of PPy followed by sol-gel and solvent casting technique	Wound healing	• ES through the PPy/PLLA conductive membranes to primary human fibroblasts demonstrated upregulation of various genes associated with cell adhesion, remodeling and spreading, cytoskeletal activity, extracellular matrix metabolism, while repressed production of inflammatory cytokines/chemokines and improved growth factor secretion and signal transduction.	Park et al. (2015)
Chitosan/polyaniline/poly(ethylene glycol)-co-poly(glycerol-sebacate) (Ch/PAni/PEGS) hydrogel	Sol-gel technique	Wound healing	• The electroactive and self-healable hydrogels showed good free radical scavenging capacity, biocompatibility, and anti-bacterial activity. • The hydrogel demonstrated promotion of tissue granulation thickness and collagen deposition in a full thickness skin defect model with enhanced healing efficacy and blood clotting capacity as compared to commercial dressing through elevation of various growth factor associated genes.	Zhao et al. (2017)

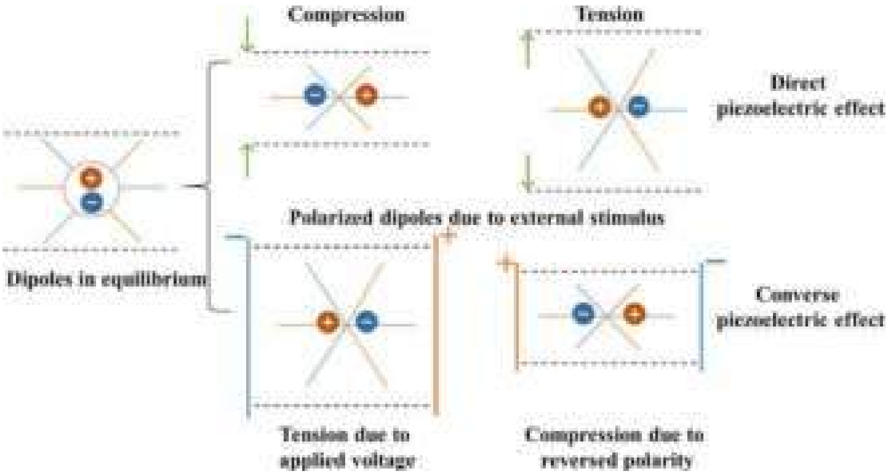


Fig. 9.4 Mechanisms of direct and converse piezoelectric effect. [Redrawn from Tandon et al. 2018]

All the tissues in human body are subjected to mechanical stimuli, and the mechanical forces via gated channels responsible for the activation of signaling cascades augments for tissue repair and regeneration. The conversion of mechanical stimuli into biological signal, called as mechanotransduction, is exerted in physiological functions like muscle and bone homeostasis, regulation of blood flow, respiratory and kidney systems. The mechanical forces including compression, torsion, tension, and shear stress exerted on cells cause changes in voltage and ion concentrations, which result in change in gene expression. Several membrane associated molecules such as cell junction molecules, ion channels, G-Protein coupled receptors, and cytoskeleton proteins are involved under mechanical stimuli and initiate the biological response by activation of signaling cascades (Zaszczynska et al. 2020). In particular, ion channels contribute for piezoelectric response. The cationic channels including monovalent (Na^+ and K^+) and divalent (Ca^{+2} and Mg^{+2}) channels are activated immediately after activation of piezo channels. The advances in the material science, physiology, and stimuli responses in tissue repair and regeneration has developed the strategies to develop synthetic, natural or composite biomaterials, which are appropriate to facilitate the physical niche to stimulate the cell proliferation and differentiation. The inherent piezoelectric property exerted in various tissues of human body augmented to develop a variety of composite biomaterials having piezoelectricity and tested for their suitability in various tissue engineering applications depicted in Table 9.2. The characteristic features of ideal biomaterials for specific tissue application also have been considered while developing the piezoelectric biomaterials. For example, the mechanical property varies depending on the tissue type. The mechanical strength of the composites modulated with enhanced piezoelectric property is the adopted strategy for the development of piezoelectric biomaterials for bone TE application. Likewise, the low mechanical

Table 9.2 TE applications of various piezoelectric biomaterials.

Piezoelectric biomaterial	Fabrication technique	Application	Outcome	References
Polyvinylidine fluoride (PVDF)	Scaffolds synthesized by electrospinning at different voltages (12–30 kV)	Bone TE	Higher alkaline phosphatase activity and mineralization was observed on PVDF-25 kV scaffolds.	Damaraju et al. (2013)
Hydroxyapatite (HA)-barium titanate (BT) composite implant	Press sintering	Bone TE	Bone formation was noticed on the implant surface, exhibited direction dependent growth.	Jianqing et al. (1997)
Ormocomp-BT nanoparticles composite scaffold	Two-photon lithography	Bone TE	Piezoelectric and topographic cues improved the bone regeneration, herein BT nanoparticles induced piezoelectric cues.	Marino et al. (2015)
Poly(3-hydroxybutyric acid-co-3-hydroxy valericacid) (PHBV)- BT composite scaffold	Electrospinning	Cartilage TE	Improved chondrocyte activity, gene expression of collagen-II higher. Piezoelectric cues supports cartilage regeneration.	Jacob et al. (2019)
PVDF-trifluoro ethylene (TrFE) scaffolds	Electrospinning	Neural TE	Human neural progenitor stem cells differentiated into β-III tubulin cells and enhanced neurite extension exhibited in micron-aligned- annealed scaffolds.	Lee and Arinzeh (2012)
PVDF/graphene oxide (GO)	Non-solvent induced phase separation method	Neural TE	GO addition improved piezoelectric and mechanical properties supported cell adhesion, proliferation and differentiation of PC12 cell. This scaffold served as nerve conduit channel and stimulated cell function.	Abzan et al. (2019)
Gold nanoparticles/PVDF	Electrospinning	Neural TE	Addition of au nanoparticles improved piezoelectric properties in the composite fibrous scaffold and supported enhanced cell adhesion and growth.	Motamedi et al. (2017)

strength is required for soft tissue, wherein the attainment of improved piezoelectric property in the composite material is the vital factor to be considered. The piezoelectric ceramics include barium titanate ($BaTiO_3$), lead zirconate titanate (PZT), and lead metaniobate have already been studied for biomedical applications, while toxicity and brittle nature of these materials limited their application in biomedical field (Nguyen et al. 2014). Piezoelectric polymers have gained the attention over piezo ceramics owing to the biocompatibility, easy fabrication, tunable mechanical properties, etc. and therefore, found extensive applications in various TE areas such as bone, cartilage, neural, etc.

9.2.1.3 Electrets

Unlike the transient surface charges in piezoelectric materials, electrets are dielectrics possessing quasi-permanent electric charges or molecular dipoles capable to generate electric fields within and outside. The concept of electrets was first proposed by Oliver Heaviside in 1885, while the first electret was first fabricated by Mototaro Eguchi in 1919 (Mascarenhas 1980). Electrets are considered as electrostatic equivalent of a permanent magnet owing to their ability to store charges for extended periods of time. Depending on the situation, however, the amount of charges decays over time. The electrets fabrication process is similar to the poling process of piezoelectric materials. For that, a dielectric material is electrically polarized by applying a high electric field and heating to softening temperature followed by cooling to room temperature. While maintaining the same field strength (Goswami and Sen 2018). The externally applied high electric field induces ordered charge accumulation inside the dielectric substrate as shown in Fig. 9.5. The induced charge accumulation process involves displacement of internal and external charges, which ultimately get trapped inside and prevents internal charge relaxation resulting in prolonged electrization. Figure 9.5 depicts the four ways of electric polarization of a dielectric material to form electrets according to Kohlrausch (Jefimenko and Walker 1980). He asserted that polarization due to alignment of molecular dipoles in the dielectric is more stable than the polarization due to internal charge migration to surface or various layers within the dielectric and atomic charge migration to the opposite ends of the molecules in the dielectric. Examples of electrets include organic materials such as ebonite, naphthalene, polymethyl-methacrylate, and many polymers, and inorganic materials such as sulfur, quartz, glasses, steatite, and some ceramics.

9.2.1.3.1 Electrets in Tissue Engineering

The role of electret based materials in TE has gained considerable attention due to the ability of delivering ES to tissues without the need of external power source as in the case of piezoelectric materials. However, electrets have a static charge storage mechanism in contrast to dynamic charge generation in piezoelectric materials, which offers prolonged stability of the electret effect. The electret state has been used as a basis for understanding membranes, neural signals, biological memory in regeneration, electrically mediated tissue growth, and other phenomena in different biophysical models. Now more than 50 years of knowledge of bioelectrets, electret

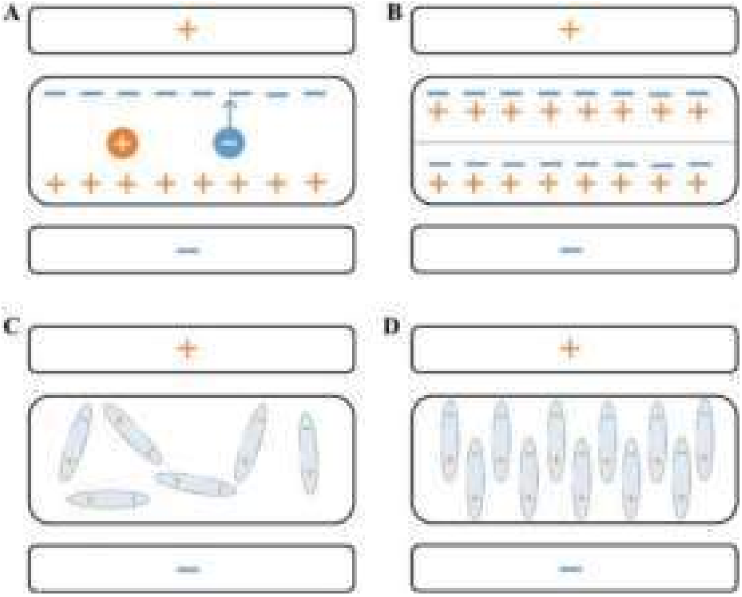


Fig. 9.5 Electric polarization in dielectric as suggested by Kohlrausch through (**a**) internal charge migration to dielectric surface, (**b**) charge migration within different layers of dielectric, (**c**) charge migration at molecular level, and (**d**) orientation of molecular diploes within the dielectric. [Redrawn from Goswami and Sen 2018]

effect was found in various biologically important molecules or polymers, viz., proteins, polysaccharides, polynucleotides, collagen, hemoglobin, DNA, and chitin (Mascarenhas 1980). The electret effect was observed in hydroxyapatite (HA), which forms about 60–70% of the bone mass of humans and animals. HA is thought to modulate bone formation and resorption, as well as promotes the regeneration of endothelial tissue (Bauer 2011). Depending on the amount of surface charges retained, electret based materials may deliver specific electrical signals to the tissue, giving rise to electrostatic fields and microcurrents to facilitate tissue regeneration processes. Therefore, various electret based biomaterials including natural and synthetic polymers were explored for range of TE applications such as bone, skin, artificial muscles and neural nerve, which are summarized in Table 9.3.

9.2.1.4 Photovoltaics

Photovoltaic material is another class of electroactive materials, which can convert solar energy into electrical energy through photovoltaic effect and was demonstrated first in 1839 by Edmond Becquerel (Goetzberger et al. 2003). A photovoltaic material, semi-conducting in nature with two regions, namely n-type and p-type separated by pn junction (Fig. 9.6), is able to absorb a large spectrum of solar energy. Upon light absorption, electron–hole pairs are created. They migrate towards opposite directions towards each other and reach the pn junction, where an electric field is

Table 9.3 TE applications of various electret based biomaterials

Electret based biomaterial	Fabrication technique	Application	Outcome	References
Polytetrafluoroethylene (PTFE)	Extrusion based method; Corona poling at 14 kV	Neural TE	• After 4 weeks of implantation in a 4 mm mice sciatic nerve gap model, the cable area, blood vessel area and myelinated axons were significantly more in the regenerated nerves on positively and negatively charged PTFE tubes as compared to the uncharged PTFE tubes (diameter = 0.9 mm). • PTFE tubes elicited minimal immune response.	Valentini et al. (1989)
Poly(lactic-co-glycolic) (PLGA)	Solution casting method (films) and lyophilization (channels); Corona poling at 8, 20 and 24 kV	Neural TE	• Enhanced neurite outgrowth in mouse neuroblastoma cells grown on poled PLGA film compared to unpoled control film. • PLGA guidance channels with outer diameter 4 mm and internal diameter 2 mm, were implanted in 1 cm rat sciatic nerve gap models, which after 4 weeks demonstrated poled channels displayed regenerated nerves with greater conduction velocity and numbers of axons as compared to the unpoled guidance channel.	Bryan et al. (2004)
Chitosan/hydroxyapatite (Ch/HA) nanocomposites	Hydrothermal & Freeze drying method; grid controlled corona charging at 8 kV	Bone TE	• Improved primary rat cranial osteoblasts adhesion, proliferation, and differentiation capacity on composite electret membranes when compared to those on the uncharged membranes.	Qu et al. (2014)
Hydroxyapatite/β-tricalcium phosphate (HA/TCP) nanocomposites	Commercial nanocrystalline HAP/TCP; Corona poling at 5 kV	Bone TE	• Improved osteoblast-cell adhesion, proliferation, and ECM formation on negatively poled nanocomposites.	Tarafder et al. (2011)
Hydroxyapatite/silk fibroin (HA/SF) composite	Lypholization; poling at 4 kV	Wound healing	• Accelerated closure of a full thickness wound in porcine with poled HAP/SF gel. • Poled HAP/SF gel showed enhanced wound healing, re-epithelization, and matrix formation than the unpoled and pure SF gel. • Poled HAP/SF promoted maturation of fibroblast cells.	Okabayashi et al. (2009)

Polypropylene/5-fluorouracil (PP/5-FU) patches	Gridcontrolled corona charging of PP film of thickness 13 μm at 15 kV; 5-FU patches were fabricated over the poled PP film	Wound healing	• In vitro scar permeation study showed PP/5-FU patch promoted higher permeation and retention of 5-FU through and in scar skin for hypertrophic scar (HS) inhibition. • In vivo study demonstrated significant reduction in collagen type I, collagen type III, TGF-β1 and HSP47 when PP/5-FU patches were applied onto the wound.	Yuan et al. (2018)

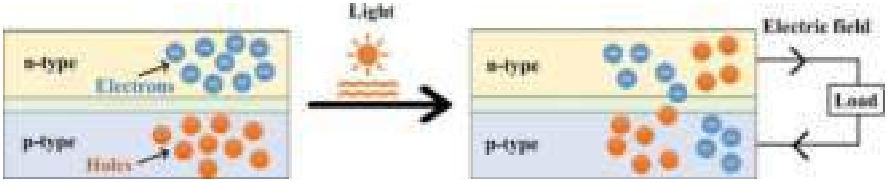


Fig. 9.6 Photovoltaic mechanism depicting light mediated migration of electron–hole pairs to opposite polarities in a traditional photovoltaic cell leading to production of electric current. [Redrawn from Tandon et al. 2018]

generated (Fig. 9.6). Photovoltaic devices consist usually of composite mixtures of semiconductor nanoparticles with conjugated polymers, wherein one component acts as electron donor and the other as electron acceptor (Goetzberger and Hebling 2000).

9.2.1.4.1 Photovoltaic Materials in Tissue Engineering

Various semi-conducting materials showing photovoltaic activity are found to possess important features of an ideal biomaterial and hence, emerging TE strategies also include photovoltaic biomaterials for providing ES for tissue regeneration. The light absorption generated electric field, as described above, modulates the bioelectrical environment of cells or tissue, which controls ion influx processes through the plasma membrane. In a particular report, it was stated that the generated electric field induces Ca^{2+} ion translocation through voltage-gated calcium channels, which upregulates of cystolic Ca^{2+} leading to elevated activation of calmodulin (Jin et al. 2011). The elevated activation of calmodulin drives the nucleotide synthesis and cell proliferation.

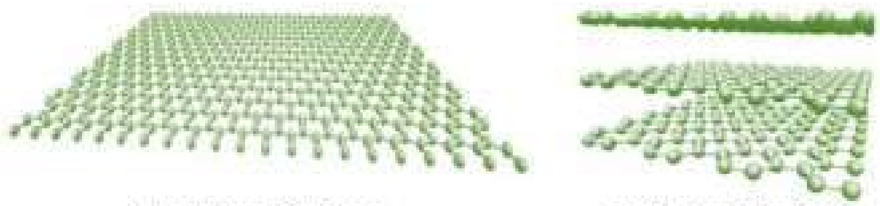
Photovoltaic polymer poly-3-hexyl-thiophene (P3HT) with phenyl-C61-butyric-acid-methyl ester (PCBM) was assessed successfully to light mediated ES of neuronal activity of primary hippocampal neurons (Ghezzi et al. 2011). Similarly, P3HT based photovoltaic implants were reported to stimulate action potentials in explanted rat retinas (Ghezzi et al. 2013) and embryonic chick retinas (Gautam et al. 2014) through photoelectric stimulation. The light induced electrical energy generation was demonstrated by subcutaneous implantation of commercially available nonresorbable solar cells for powering pacemakers in vivo (Haeberlin et al. 2014, 2015). Subsequently, a bioresorbable and biocompatible silicon and magnesium based thin film solar cell was demonstrated for in vivo power supply (Kang et al. 2015). A group of researchers of USA in a breakthrough attempt used photovoltaic subretinal implants with 70 μm pixels for localized ES of retinal neurons when illuminated by near-infrared light (Lorach et al. 2015). This paved away the potential of photovoltaic biomaterials for stimulation of other tissues. However, photovoltaic biomaterials as TE scaffolds were scarcely explored for regeneration of nerve, bone, skin, and wound healing. Some of the interesting studies involving photovoltaics-based biomaterials are summarized in Table 9.4.

Table 9.4 TE applications of various photovoltaics-based biomaterials

Photovoltaics-based biomaterial	Fabrication technique	Application	Outcome	References
β-Carotene/N,N′-dioctyl-3,4,9,10-perylenedicarboximide (β-carotene/PTCDI-C8) and poly(3-hexylthiophene)/phenyl-C61-butyric acid methyl ester (P3HT/PCBM)	Spin coating	Neural TE	• The fabricated photovoltaics devices were able to provide NIR light induced electric field of 220–980 mV/mm. • Enhanced neurite extension by 64% and also effected direction of extension.	Hsiao et al. (2016)
Poly(3-hexylthiophene) (P3HT) and the phenyl-C61-butyric acid methyl ester (PCBM) based organic photovoltaic patch	Patterning technique	Wound healing	• The disposable photovoltaic patches delivered visible light induced ES to skin wound in mice. • In vivo study showed that the patch promoted. • Cutaneous wound healing via enhanced host-inductive cell proliferation, cytokine secretion, andprotein synthesis.	Jang et al. (2018)
Silicon (Si) microcell	Photolithography	Bone TE	• Visible light induced photocurrent was successfully used to stimulate the intracellular calcium transients in osteoblast cells.	Vargas-Estevez et al. (2018)
Poly(3-hexylthiophene)/Polycaprolactone (P3HT/PCL)	Electrospinning	Skin TE	• Under light induced ES, P3HT/PCL nanofibers demonstrated enhanced proliferation and healthier morphology of human dermal fibroblasts.	Jin et al. (2011)
Monocrystalline silicon (Si)	Photolithography	Wireless power supply for implantable medical devices	• The Si based photovoltaic energy harvesting device was bioresorbable and induce no immune response, while capable to generate 60 μW in vivo.	Lu et al. (2018)

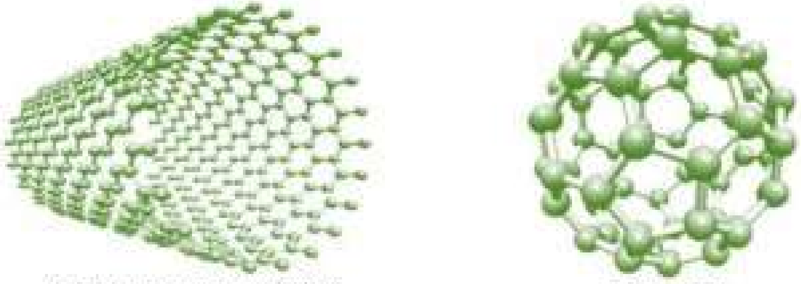
9.2.1.5 Carbon Based Nanomaterials

Carbon based nanomaterials possess highest electrical conductivity in the family of electroactive materials. Based on their structures, carbon based nanomaterials can be 0D (fullerenes, particulate diamonds, and carbon blacks), 1D (carbon nanotubes (CNTs), carbon nanofibers (CNFs) and diamond nanorods), 2D (graphene, graphite sheets, and diamond nanoplatelets), and 3D (nanocrystalline diamond (NCD) films, nanostructured diamond-like carbon (DLC) films, and fullerite (Lin et al. 2016). Among all, CNTs and graphene are the most attractive carbon allotropes for various technological applications due to their unique mechanical, thermal, and exceptional electrical properties. Graphene with single layer of a polycyclic aromatic hydrocarbon network sheet is the basic structural origin of other carbon allotropes, where sp^2 hybridized carbon atoms are arranged in a honeycomb grid sheet (Fig. 9.7). Three of the four outermost valence electrons (2 s, $2p_x$, $2p_y$, and $2p_z$ orbitals) in carbon atoms form covalent bonds with three neighboring carbon atoms, while the remaining electron in p_z orbital (perpendicular to the sheet) forms pi (p) bond through sideways overlapping, which is highly mobile and this gives rise to high electrical conductivity (Wang and Weng 2018). Graphene sheet can be rolled up into a hollow cylindrical structure to get 1D CNT with the hexagonally arranged carbon atoms remains unchanged. The electrical conductivity of graphene and CNTs are comparable to the metallic conductors such as silver and copper, which are of order 10^7.



Monolayer Graphene

Multilayer Graphene



Carbon nanotube (CNT)

Buckyball

Fig. 9.7 Structures of different carbon based nanomaterials as indicated. [Redrawn from Lloyd-Hughes and Jeon 2012]

9.2.1.5.1 Carbon Based Nanomaterials in Tissue Engineering

Carbon based nanobiomaterials have some unique characteristics in regard to their potential use as TE scaffold. These include their size resembling with several biological components such as collagen, ultrahigh mechanical strength, and electrical conductivity. Nanotopography and electrical conductivity of CNTs mimic the native ECM (Eivazzadeh-Keihan et al. 2019). Carbon based nanobiomaterials offer the strongest material on earth till date and hence, they can be used for development of mechanically robust and durable biomaterial scaffolds. Thus, TE applications of carbon based nanobiomaterials are focused on exploring their mechanical strength and stiffness, high electrical conductivity, and complex physical properties. For instance, nanotopography and stiffness of carbon based nanobiomaterials are capable of modulating cellular activities including cell adhesion, proliferation, migration and differentiation. Likewise, these nanobiomaterials induce favorable cell-biomaterial interactions owing to their intrinsic electrical conductivity and were shown to boost cellular communication among electrically excitable cells such as neurons (Huang et al. 2012). Moreover, they can be modified with desired functional groups or molecules to improve desired cell-biomaterial interactions and also be tethered with other natural/synthetic biomaterials to boost their biocompatibility, biodegradability, bioactivity for TE applications. Researchers across the world explored various techniques such as coating, hydrogel blending, wet/dry-spinning procedures, and 3D printing to make 2D or 3D carbon nanobiomaterials based scaffolds for wound healing, neural, cardiac, bone, and cartilage TE. Few salient studies of carbon based nanobiomaterials in diverse TE areas are summarized in Table 9.5.

9.2.2 Magnetoresponsive Biomaterials

Similar to ES, magnetic stimulation (MS) has proved to positively effect biological functions at cellular and molecular level (Qian et al. 2019). Pulsed MS induces increased blood flow in capillary bed, serum ceruloplasmin expression, and improves angiogenesis. It has been established that MS effects ion influx through plasma membrane, various important protein and growth factor synthesis/secretion related to tissue regeneration (Fig. 9.8) (Qian et al. 2019). For example, low level electromagnetic field was shown to modulate cellular activities by influencing ionic transport across cellular membrane and action potential (Lacy-hulbert et al. 1998). Another study showed increased intracellular calcium concentration mediated tissue regeneration (Grassi et al. 2004).

Magneto-responsive biomaterials contains active magnetic component within biomaterial network that can be manipulated spatiotemporally via an external magnetic field. This class of smart materials rely mostly on composites constituted by magnetic particles whose size allows them to become embedded into a polymer matrix to confer a magnetic response. The magneto-responsive behavior of scaffolds is especially controlled with magnetic nanoparticles of iron (Fe), nickel (Ni), cobalt (Co), and their oxides having a size less than 100 nm. The incorporation of magnetic

Table 9.5 TE applications of various carbon based nanobiomaterials

Carbon nanomaterial based biomaterial	Fabrication technique	Application	Outcome	References
Carbon nanotubes (CNTs) ropes	Chemical vapor deposition; ropelike structure with a diameter of 1 mm was prepared	Neural TE	• As a viable substrate, CNT rope supported neural stem cell (NSC) growth and neurite outgrowth occurred favorably in the direction of the spiral topography on the CNT rope. • Electrical stimulation through CNT ropes accelerated the neurite outgrowth and early differentiation of NSCs into mature neurons.	Huang et al. (2012)
Polycaprolactone fumarate/carbon nanotubes (PCLF/CNTs)	UV cross-linking	Neural TE	• Enhanced PC12 cell proliferation, neural differentiation, neurite outgrowth, cell migration, and intracellular connections on PCLF/CNT sheets upon ES (100 mV/mm and 20 Hz for 2 h/day).	Zhou et al. (2018)
Silk fibroin/reduced graphene oxide (SF/rGO) microfibers	Electrospinning	Neural TE	• SF/rGO microfibers supported PC12 cell viability and adhesion. • Electrical stimulation through SF/rGO promoted faster neural differentiation than those obtained by using nerve growth factor (NGF).	Aznar-Cervantes et al. (2017)
Carbon nanotube/gelatin methacryloyl (CNT/GelMA) hydrogels	Dielectrophoresis and UV cross-linking	Cardiac TE	• Aligned CNT/GelMA hydrogels offered enhanced the cardiac differentiation of the mouse embryoid bodies (EBs) compared with the pure GelMA and GelMA-random CNT hydrogels. • EBs activity was further enhanced under application of ES through aligned CNT/GelMA hydrogels.	Ahadian et al. (2016)
Polydimethylsiloxane/multiwall carbon nanotubes (PDMS/MWCNTs) 3D composites	Template assisted method	Cardiac TE	• 3D PDMS/MWCNT scaffold exhibited mechanical and conductive properties similar to the native heart muscle. • Further, it provided a suitable environment for enhanced viability, structural, and electrophysiological maturation, and proliferation of cardiomyocytes.	Martinelli et al. (2018)
Carbon nanofibers (CNFs)	Electrospinning of polyacrylonitrile (PAN) followed by carbonization at a 1000 °C	Bone TE	• The fabricated electrospun CNFs is cytocompatible and suitable for cell culture and proliferation. • ES significantly enhanced the proliferation and the osteogenic activity of the bone cells.	Samadian et al. (2020)

Graphene/cellulose (G/C) scaffold	Graphene oxide (GO) synthesized by modified Hummers method followed by deposition over cellulose paper	Bone TE	• G/C electrodes possessed lower impedance and higher charge injection capacity than gold (au) electrodes, with high stability. • G/C scaffolds combined with ES supported enhanced ADSC proliferation, mineral deposition and ALP. • Expression compared to control samples without ES.	Li et al. (2020)
Spider silk/carbon nanotubes (silk/CNTs)	Electrospinning	Wound healing	• Silk/CNTs electrospun fibers combined with ES demonstrated elevated activity of diabetic dermal fibroblasts (DDF) for enhanced production of collagen with low COLI/COLIII ratio and inhibited synthesis of matrix metalloproteinases (MMPs) leading to accelerated wound healing.	Chi et al. (2019)
Reduced graphene oxide/chitosan/silk fibroin (rGO/Ch/SF)	Freeze drying	Wound healing	• rGO/Ch/SF scaffold demonstrated radical scavenging ability, intracellular anti-oxidant activity in vitro and in vivo. • ES through rGO/Ch/SF offered improved adhesion and proliferation of C2C12 cells. • rGO/Ch/SF demonstrated improved in vivo wound regeneration.	Tang et al. (2019)
Chitosan/poly(vinyl alcohol)/graphene oxide (Ch/PVA/GO) composite nanofibers	Electrospinning	Cartilage TE	• Incorporation of GO increased the tensile strength of the nanofibers. • Ch/PVA/GO nanofibers promoted growth of mouse chondrogenic cells indicating the potential for cartilage TE applications.	Cao et al. (2017)
Polycaprolactone/gelatin/multi-walled carbon nanotubes (PCL/Ge/MWCNTs)	Electrospinning	Cartilage TE	• Addition of MWNTs led to an increase in the hydrophilicity and tensile strength of the electrospun nanofibers along with the bioactivity. • Offered enhanced viability of adult chondrocytes.	Zadehnajar et al. (2020)

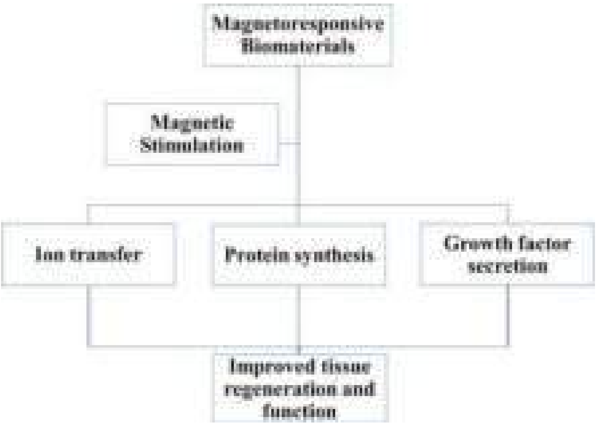


Fig. 9.8 Scheme of cellular response elicited by magnetic stimulation (MS) through electroactive biomaterials based scaffolds for improved tissue regeneration and function (Qian et al. 2019)

nanoparticles in cells/tissues/scaffolds allows for magnetic force-based manipulation of these components to build more complex systems. In addition, integration of magnetic nanoparticles in scaffolds followed by the application of tensile or compressive forces using a magnetic field has been shown to induce functionality in certain cells. In contrast to ES, MS enables actuation at a distance on nanoscale and cell level. Furthermore, the magnetic field can penetrate deep into tissues, reaching a single cell and acting directly on its organelles; unlike the electric field, which is shielded by the membrane potential. For these reasons MS is gaining importance and intensively investigated in applications including tissue regeneration, targeted drug delivery, cancer therapy agent, etc. Among these different possible applications, this article mainly emphasizes on the applications of magneto-responsive scaffolds for different types of TE including bone, cardiac, cartilage, neural, etc.

Different magneto-responsive scaffolds were prominently investigated in recent years for TE due to its ability to deliver direct mechanical stimulation to individual cells. Scaffolds based on the biological components such as bacterial cellulose, chitosan, or silk fibroins were proven to enhance cell proliferation, and differentiation under appropriate MS. These scaffolds not only provide a biocompatible environment for cell growth but also trigger desire cellular activities under MS. Hydroxyapatite (HA) due to its excellent biological activity, good biocompatibility, and bone conductivity has been considered as an obvious choice for bone replacement material. HA-based magnetic composites have also been investigated for bone (Torgbo and Sukyai 2019), cartilage (Huang et al. 2018) TE as well as for growth of human mesenchymal stem cells (D’Amora et al. 2017). Studies show that the combined effect of HA-based magnetic substrate and magnetic field exposure enhances cell proliferation, cell viability, and stimulates gene expression. In addition, magneto-active three-dimensional (3D) porous scaffold possessing a proper bone mimicking morphology has also been investigated for the adhesion and proliferation of preosteoblasts. It has been found that the application of magnetic stimuli increases the cell viability on the scaffolds, inducing a solid spiderlike network of cells, with the growth of cells on the scaffolds (Fernandes et al. 2019).

Similar studies have also been conducted by developing 3D matrix of collagen hydrogel with magnetic nanoparticles to promote neural growth and cartilage TE. Investigation shows that these magnetically responsive 3D scaffolds can effectively induce the growth of neural cells and directed to form neural networks. Table 9.6 summarizes some of the recent findings in the field of TE using magneto-responsive scaffolds.

9.2.3 Thermoresponsive Biomaterials

One of the important/notable physical stimuli of which a relatively broad variation in its intensity can be withstood by body physiology is temperature (Doberenz et al. 2020). Interestingly, a small variation in temperature is able to cause alteration in size or shape of a unique class of materials, mainly polymers, which are known as thermoresponsive materials or polymers (Cabane et al. 2012). These polymers undergo a change in their miscibility or solubility at a critical temperature through a dramatic transition in the hydrophobic and hydrophilic interactions between their chains and the aqueous media (Cardoso et al. 2017). It leads to the dislocation of intra- and intermolecular hydrophobic and electrostatic interactions, causing the polymer chains to collapse, shrink, or expand. Intermolecular forces such as hydrogen bonding and hydrophobic forces in aqueous solution play a major role in the formation of micelle, hydrogel shrinking, and the physical cross-linking of thermoresponsive polymers. At critical temperature, thermoresponsive polymers change from monophasic (become completely soluble) to biphasic or vice versa. Thermoresponsive polymers, which dissolve completely to become monophasic above the critical temperature and show a phase separation below the critical temperature, are classified as thermoresponsive polymers with upper critical solution temperature (UCST). While polymers, which exhibit opposite behavior are regarded as thermoresponsive polymers with lower critical solution temperature (LCST). Another class of thermoresponsive polymers has been reported, known as thermally induced shape-memory polymers (SMPs) with non-UCST and non-LCST features but undergo changes in their shape and size under temperature fluctuations (Kim and Matsunaga 2017). Some common examples of thermoresponsive polymers are poly (N-isopropylacrylamide) (PNiPAAm), poly(N-vinylcaprolactam) (PNVC), poly (2-oxazoline)s (POxs), poly (L-lactic acid)-poly(ethylene glycol)-poly(L-lactic acid) (PLLA-PEG-PLLA), poly(ethylene oxide)-poly(propylene oxide)-poly (ethylene oxide) (PEO–PPO–PEO), etc.

Applications of thermoresponsive polymers in TE applications are motivated by their thermally induced hydrophobic/hydrophilic properties to induce controlled cell attachment and detachment (Nagase et al. 2018). Compatibility of thermoresponsive polymers in TE is encouraged by another important fact that there is no harmful effect on cells and proteins over a temperature variation of 0–42 °C (Doberenz et al. 2020). PNiPAAm is the most widely investigated thermoresponsive biomaterial with LCST behavior at 32°C, which is close to physiological condition (Yamada et al. 1990). PNiPAAm was explored as coating on cell culture dishes for collecting

Table 9.6 TE applications of various magnetoresponsive biomaterials

Magnetoresponsive biomaterial	Fabrication technique	Application	Outcome	Reference
Chitosan/glycerophosphate/iron oxide nanoparticles	Oxidative hydrolysis synthesis of magnetic nanoparticles followed by lyophilization and mixing	Neural TE	• Nanocomposites able to support cell adhesion and spreading and further promote proliferation of SCs under magnetic field exposure. • Moreover, a magnetic field applied through the scaffold significantly increases the gene expression and protein secretion.	Liu et al. (2014)
Collagen hydrogel/magnetic nanoparticles	Embedding magnetic particles in collagen followed by solidification under magnetic field	Neural TE	• The magnetic elements have aggregated into magnetic particle strings along the magnetic lines within the gel. • These lines served as physical cues for neurons that developed in close proximity to the particles, leading to elongated and directed growth pattern.	Antman-Passig and Shefi (2016)
Bacterial cellulose/Fe_3O_4/hydroxyapatite	Co-precipitation method followed by ultrasonic irradiation	Bone TE	• Biocompatible and promote osteoblast attachment and proliferation.	Torgbo and Sukyai (2019)
Silk fibrion/Fe_3O_4	Co-precipitation synthesis of magnetic nanoparticles followed by electro-gelation	Bone TE	• Physical conjugation of basic fibroblast growth factor (bFGF) to Fe_3O_4 nanoparticles significantly enhanced the viability and growth of SaOS-2 cells on the scaffold. • Both human serum albumin coating and bFGF conjugation improves alkaline phosphate activity, total protein synthesis, and collagen synthesis.	Karahaliloglu et al. (2017)
Collagen/hyaluronic acid/polyethylene glycol/magnetic nanoparticles	Co-precipitation	Cartilage TE	• The synthesized matrix exhibits similar microstructure and chemistry as hyaline cartilage and is cytocompatible with BMSCs in vitro after 24 h of culture period.	Zhang et al. (2015)
Poly(vinyl alcohol)/nano hydroxyapatite/Fe_2O_3 nanoparticles	Ultrasonic dispersion freeze-thawing cross-linking molding process	Cartilage TE	• BMSCs show uniform growth on the surface of the magnetic nanocomposite hydrogel and high rates of proliferation. • BMSC growth is also enhanced by the addition of Fe_2O_3 and also significant stimulated chondrocyte-related gene expression.	Huang et al. (2018)

seeded cells and layers of cells just by regulating the temperature without using enzymes like trypsin. Traditional enzymatic degradation methods for cell separation reduce the cell function by affecting receptors, transport proteins and ECM and thus, integrity between confluent cell layers becomes weak leading to reduced efficiency for therapeutic applications. In the contrary, thermoresponsive biomaterials can provide intact cell sheet through non-enzymatic cell separation with retention cellular structure and function (Cooperstein et al. 2015). These intact cell sheets can be used as a fresh cell culture dish, applied to wound sites and host tissues, without requiring any sutures (Matsuda et al. 2007). Therefore, thermoresponsive biomaterials give spatial distribution of cells by layering sheets derived from various cell types or by layering monolayer cell sheets, creating 3D tissue constructs. Thermoresponsive biomaterials may be used as hydrogel, injectable gelling material, 3D printing or cell layer development by biomaterial surface modification.

9.2.4 Photoresponsive Biomaterials

Inspired by natural phenomena such as photosynthesis, researchers have been using light driven reactions to control biological functions and as a result, clinical implication of phototherapy using low level lasers, light-emitting diodes, and natural light, has increased in the last few years (Jin et al. 2011). Light, which is an electromagnetic radiation, is found to induce various regeneration associated molecular biology reactions such as increase in the cytosolic Ca^{2+} level in cells. Phototherapy has been proven to reduce inflammatory reactions, promote cell proliferation, and growth factor secretion (Desmet et al. 2006). Several researchers demonstrated light stimulation mediated accelerated wound healing, axonal regeneration, and spinal cord repair (Rochkind et al. 2002). These findings motivated scientists and researchers to explore photoresponsive biomaterials for various TE applications.

Photoresponsive biomaterials, with light-sensitive molecules (chromophores) in them, when irradiated by light, are able to reversibly and frequently switch their physical and/or chemical properties, such as geometrical structure, refractive index, dielectric constant, conformation, solubility, and surface hydrophilicity, etc. in real time and spatiotemporal manner. Light stimulation through a photoresponsive biomaterial is a relatively straightforward, non-invasive technique to modulate dynamic cell microenvironment. Progress of such biomaterials in TE areas are summarized in this section.

A photoresponsive culture surface composed of poly(N-isopropylacrylamide) (PNIPPAAM) with spiropyran chromophores as side chains was demonstrated to promote cell adhesion, when irradiated by ultraviolet (UV) light (wavelength: 365 nm) (Edahiro et al. 2005). Cells remained attached to the irradiated surface even after subsequent cooling and washing indicating better cell attachment due to UV irradiation. Acrylate based light-sensitive liquid crystalline elastomers (LCEs) were developed to assist cardiac muscle contraction (Ferrantini et al. 2019). The contraction was modulated in terms of light intensity, stimulation frequency, and time to on/off ratio in order to fit different contraction amplitude/time courses, including those of the human heart. Furthermore, LCE strips were successfully mounted in parallel with cardiac trabeculae, to improve muscular systolic function, with no impact on diastolic properties. Photoresponsive polysaccharide-based hydrogels obtained from radical polymerization was assessed for cartilage TE (Giammanco et al. 2016). These hydrogels become softer and more porous upon irradiation, presenting changes in their swelling and transport properties. Moreover, chondrogenic ATDC5 cells grown on the hydrogels showed a greater than two-fold increase in the production of sulfated glycosaminoglycans in the gels irradiated for 90 min compared to the dark controls. Poly(ethylene glycol) (PEG) hydrogel based micropatterned smart template was developed by spin coating method for culture of epithelial cells offering good cell adhesion and extended cell morphology (Gong et al. 2013). The study described the photoresponsive PEG hydrogel micropatterned smart template, which displayed transparency based photolithography to induce reversible control of cell adhesion with UV irradiation in defined areas. A 3D printable UV responsive cross-linking system based on polypeptides incorporating glutamic acid, isolycine, and nitrobenzene (NB) protected cysteine groups in a random and block copolymer was reported (Murphy et al. 2019). According to the report, the polypeptide with block architecture was more desired mechanical properties, gelled at lower concentration (3.0 wt %), and could easily deposit more than ten layered structures with high fidelity and resolution through 3D extrusion printing. In vitro cytotoxicity evaluated with human dermal fibroblasts cells revealed no toxic effect with fibroblasts.

9.2.5 Chemical Stimuli Responsive Biomaterials

Chemical stimuli responsive biomaterials respond to external chemical triggers such as pH, redox, and solvent. Since, these chemical stimuli are some important features of body physiology, chemical stimuli responsive biomaterials were also explored for various TE applications, which has been discussed in brief in this section.

pH responsive materials contain ionizable groups for which they are able to accept or donate protons under any change in pH in the environment (Cardoso et al. 2017). Any pH change generate charges, which induces ionic interactions through electrostatic repulsion among them and ultimately causes physical or chemical changes in the material such as swelling, shrinking, dissociation, degradation, or membrane fusion and disruption (Gil and Hudson 2004). Researchers are motivated by the intrinsic pH variations present in living tissues to develop pH responsive biomaterial scaffold for various TE applications. For example, an injectable tissue scaffold based on branched nanofibers of peptide amphiphiles (PAs) with serine and histidine peptides conjugated to a single fatty acid tail, were shown to switch from solution state to hydrogel form at a pH above 6.5, which is within the physiological pH range (Lin et al. 2012). Another study demonstrated pH responsive C_2-cyclohexane based low molecular weight hydrogels guided cell detachment with mild reduction in pH of the culture medium (Dou et al. 2012). Subsequently, a series of pH responsive tissue scaffolds composed of dimethylaminoethyl methacrylate (DMAEMA) and 2-hydroxyethyl methacrylate (HEMA) were shown to improve the oxygen and nutrient transport through expansion in response to a local pH change (You et al. 2015). The DMAEMA/HEMA composite scaffolds supported enhanced cell deposition and survival in vitro and subcutaneous implantation in rats showed upregulation of pro-healing genes indicating enhanced angiogenesis, granulation tissue formation, and tissue remodeling.

Redox responsive materials possess redox sensitive group and they respond to any change in redox gradient of their surrounding environment by changing the oxidation state of the redox sensitive group (Cardoso et al. 2017). Application of redox responsive biomaterials in TE applications is inspired by the natural existence of redox potential in living tissues and glutathione/glutathione disulfide couple are the reducing agents available in abundance in animal cells. Redox responsive biomaterials under varying redox environment undergo changes in structure and shape. Therefore, TE applications of redox responsive biomaterials are mainly focused on utilizing the redox mediated degradation and drug/growth factor release properties. For instance, poly(ethylene glycol) (PEG) based cryogel containing disulfide-containing building blocks displayed the characteristics of a potential tissue scaffold such as biocompatibility and porosity (Dispinar et al. 2012). The cryogel demonstrated stability in physiological condition, but it degraded within few hours in presence of a reducing agent (glutathione), while the degraded by products did not affect cell viability. PEG based scaffold with redox mediated degradability and growth factor release features, was evaluated successfully in a rabbit radius critical defect for bone TE application (Yang et al. 2013). Same group also reported redox mediated degradable PEG based injectable hydrogel for bone regeneration (Yang et al. 2014).

9.2.6 Biological Stimuli Responsive Biomaterials

Biomaterials responsive to stimuli inherent to living tissues or cells are always advantageous. It is highly favorable for biomaterials to possess specific adaptive behavior in vivo. Alterations in conformation and degree of self-assembly of several important biomacromolecules in presence of specific chemical species in their surroundings, inspired scientists to develop innovative biomaterials that are responsive to biomacromolecules present in living systems. For that biomaterials are designed in such a way that it contains a functional group, which specifically interacts with biomacromolecules or sometimes, in conjugation with specific biological components. Although biological stimuli responsive biomaterials have not been studied extensively for TE applications, there are few evidences of using enzyme or glucose responsive biomaterials as potential tissue scaffolds. For example, an injectable self-healing hydrogel composed of phenylboronic acid and cis-diol modified PEG was demonstrated to release protein therapeutics in response to glucose, while also evoking no immune response in vivo (Yesilyurt et al. 2016). In another report, kartogenin, a chondrocyte differentiation inducing agent, was loaded into poly(lactic-co-glycolic acid)/hyaluronic acid (PLGA/HA) hydrogel for inducing differentiation of mesenchymal stem cells into chondrocytes (Shi et al. 2016). The kartogenin loaded hydrogel was demonstrated to play a major role in cell homing including recruitment of host's endogenous cells in vivo without needing any cell transplantation. An injectable microporous annealed particle (MAP) gel based on PEG/vinyl sulphone for accelerated wound healing was demonstrated, wherein the microgel was cross-linked to cysteine-terminated matrix metalloprotease-sensitive peptide sequences for cell controlled biodegradability and resorption (Griffin et al. 2015).

9.3 Conclusions and Future Outlook

The current chapter provides a discussion on various types of stimuli responsive biomaterials in regard to their exploitation as potential tissue scaffolds with a special emphasize on physical stimuli responsive biomaterials such as electroactive and magnetoresponsive biomaterials. These biomaterials were explored extensively due to their potential to manipulate the intrinsic bioelectrical cues of the native tissue. TE is a more complex process and biomaterials are required to mimic the dynamic environment of the native tissue to support the natural regeneration processes. Hence, electroactive or magneto-responsive biomaterials discussed in the present chapter, have greater evidences as potential smart tissue scaffolds as compared to the chemical and biological stimuli responsive biomaterials including photoresponsive and thermoresponsive biomaterials. Moreover, CP and carbon based nanobiomaterials have emerged as superior smart biomaterial scaffolds among other electroactive biomaterials due to their intrinsic electrical conductivity, which is an important bioelectrical cue present in tissues and ES through such scaffolds were demonstrated for faster tissue regrowth and effective functional recovery both in vitro and in vivo. One of the major limitations of piezoelectric and electret based biomaterials is the requirement of poling the scaffold for dipole alignment sometimes for several hours above their glass transition temperature in presence of a high electric field of the order of kV (Shastri et al. 2000). It is only after the poling process for which piezoelectric and electret based biomaterials are usable for ES for finite length of time. Additionally, the electromagnetic signal, which is utilized by the systems such as photovoltaic, magnetoresponsive, and photoresponsive biomaterials, does not remain localized on the damaged area but gets penetrated to the surrounding areas of the injury site. In contrast, electroactive CP and carbon based nanobiomaterials offer focused ES with remarkable control over the level and duration of the stimulation. Chemical (pH and redox) and biological (glucose and enzyme) responsive biomaterials were scarcely explored as TE scaffold as compared to the formers.

Besides the stimuli responsive feature, smart biomaterials should be flexible enough to be integrated with advanced biofabrication techniques such as photolithography, microcontact printing, 3D bioprinting, micromolding, and microfluidic-assisted patterning etc., to be precisely mimic structure and other physical properties of the natural tissues (Mohamed et al. 2019). Future research should also focus to optimize the biophysical signal parameters within safe limit for living tissues to modulate the cell microenvironment. A successful technology to reach the end user needs to demonstrate robust clinical safety and efficacy for acquiring regulatory approval. Although, CP and carbon based biomaterials have demonstrated minimal immune response and biocompatibility, their one of the major constraints for use in TE is their non-degradability. Therefore, it is important to undertake strategies such as blending with natural or synthetic FDA approved other biomaterials to regulate the degradability feature.

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Chapter 70
Phenomenological Study of Two-Zero Textures of Neutrino Mass Matrices in Minimal Extended Seesaw Mechanism

Priyanka Kumar and Mahadev Patgiri

Abstract In this chapter, we study the phenomenology of two-zero textures of 4×4 neutrino mass matrices $M_\nu^{4\times4}$ in the context of the Minimal Extended Seesaw (MES) mechanism. The MES mechanism is an extension to the canonical type-I seesaw mechanism which incorporates an extra gauge singlet field 'S' apart from the three right-handed neutrinos. The MES mechanism deals with 3×3 forms of Dirac neutrino mass matrix (M_D), right-handed Majorana mass matrix (M_R) and 1×3 row matrix (M_S) which couples the right-handed neutrinos and the sterile singlet 'S'. In our work, we realize the two-zero textures of $M_\nu^{4\times4}$ within the context of the MES mechanism by considering a $(5+4)$ scheme, where the digits in the pair represent the number of zeros of M_D and M_R, along with a one-zero texture of M_S. We find that out of 15 allowed two-zero textures, only 6 two-zero textures can be realized under the $(5+4)$ scheme. On enforcing zeros, the neutrino mass matrix $M_\nu^{4\times4}$ yields a number of correlations. We check the viability of each texture by scanning their correlations under recent neutrino oscillation data. We find that certain textures are allowed only for some selected ranges of values of $\sin\theta_{34}$. We present scatter plots as a viability check for each of the textures.

70.1 Introduction

From the proposition of massless neutrinos by Wolfgang Pauli to massive neutrinos confirmed by a number of solar, atmospheric and reactor experiments, neutrino physics have appreciably progressed with time. Untiring efforts from experimentalists have succeeded in providing solid and precise information about the mass-squared differences (Δm_{21}^2, Δm_{31}^2) and mixing angles ($\theta_{12}, \theta_{23}, \theta_{13}$) in case of the three active neutrinos. There are, however, a number of problems which are still

P. Kumar (✉) · M. Patgiri
Department of Physics, Cotton University, Guwahati 781001, Assam, India
e-mail: prianca.kumar@gmail.com

M. Patgiri
e-mail: mahadevpatgiri@mail.com

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Assam College Teachers' Association

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Contents :

Two Performing Art Forms: *Ojapali* of Assam and *Keertan* of Maharashtra

Dr. Aparna Goswami[3]
Dr. Mrinal Medhi[4]

Abstract :

Performing art forms, to a large extent contain in their dynamics the identity of the community that they represent. The socio-cultural communication that takes place through the art forms reveals not only the way of life of a community but also showcases their worldview and the evolutionary process through which they have passed. Present paper attempts to juxtapose two performing art forms representing two distant regions of India namely Assam in the East and Maharashtra in the West. The performing art forms selected in the purview of discussion are Ojapali of Assam and Keertan of Maharashtra. Both the art forms trace their origin from the Vedic tradition and have performed an important role in the oral tradition of their respective societies. Their presentation is based on the plots selected from the epics: Ramayana and Mahabharata as well as on different Puranas and popular legends. The performers take resort to multimodal way of presentation leading to incorporation of dance, songs, dialogues and narratives structured on the above mentioned plots. Audiences can be gauged as active participants in the communication

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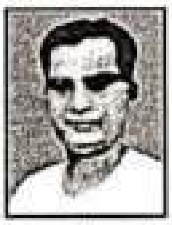

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ভাৰতবৰ্ষত সাংবিধানিক চৰকাৰ আৰু গণতন্ত্ৰ

Constitutional Government and Democracy in India

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(CONSTITUTIONAL GOVERNMENT AND DEMOCRACY IN INDIA)

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Prospects of Algal Bioresources in Carbon Mitigation and Green Technology

Author

Dr. Gargi Chakravarty
Assistant Professor, Department of Botany, Dakshin Kamrup College, Mirza, Kamrup, Assam, India

Chapter - 7

Prospects of Algal Bioresources in Carbon Mitigation and Green Technology

Dr. Gargi Chakravarty

Abstract

Alteration in the global carbon cycle has been a subject of worldwide attention and potential research in the present times. In these alarming scenario microalgae seems to be an attractive medium for capturing the excess CO_2 present in the atmosphere generated from different sources such as power plants, automobiles, volcanic eruption, decomposition of organic matters and forest fires. This chapter gives an overview of the prospect of biomitigation of carbon by algal resources. Due to their efficient CO_2 fixation mechanism as compared to terrestrial plants, these are of immense utility in green technology. Strain selection, mass cultivation and harvesting of algal bioresources are pre requisites for carbon mitigation and further processing. Carbon fixed by microalgae is incorporated into carbohydrates and lipids which can be used for the production of chemicals, foods, or biofuel. The chapter establishes the tremendous potential of microalgae in green house gas abatement and reaffirms its added benefits as a bio-refinery that could produce an array of coproducts including oils, protein and carbohydrates along with biofuel.

Keywords: algae, climate change, carbon mitigation, green technology

Introduction

Climate Change is the core issue among the global environmental problems and has manifold negative ramifications. Greenhouse gases occur naturally in the atmosphere and keep the sun's warmth from reflecting back into space and making the Earth habitable. But after more than a century and a half of industrialization, deforestation and large scale agriculture, quantities of greenhouse gases in the atmosphere have risen to record levels not seen in three million years. With the growth of population and economies the concentration of green house gases has risen steadily and the mean global temperature along with it. The Intergovernmental Panel on

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About the Author

Dr Sweety Singh has completed her M.Sc. M. Phil. and PhD in Botany from Dr Bhimrao Ambedkar University Agra. She got selection through UP Higher Education Service Commission, Allahabad and got appointment in Narain College, Shikohabad in the year 2010. She holds more than 11 year of experience in the field of teaching, research and academic administration. She attended many UGC Orientation and Refresher Programs, FDPS, National / International Conferences / Seminar and presented papers. She has also published many research papers in National / International Journals. Presently she is working in the capacity of Assistant Professor and Head of Department in Narain College, Shikohabad.

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Edible Phytoresources of North-East India

Aparna Deka, Nripendra Kumar Choudhury
Assistant Professor, Department of Zoology.
Dakshin Kamrup College, Mirza, Assam, 781125
Mail ID: aprnadeka99@gmail.com

Abstract: *The North Eastern part of India is the home for diverse species of flora and fauna. Many species are still undiscovered and unidentified in this region of the country. Phytoresources or plant resources from wild are used mostly by the indigenous people for different purposes. A huge number of wild Flora is taken as food also. Two main reasons are there for consumption of phytoresources: to cure ailments and for nutrition. The knowledge of using plants as medicine has been passing from generation to generation in various indigenous groups of people. Due to advancement of facilities in the medical field, the knowledge of using of phytoresouces as cure is decreasing. In this present review, an effort has been made to highlight the different wild edible plants of North-East India with medicinal and nutritional value. A thorough investigation of the different properties of the plants may lead to discovery of some very important medicine to some diseases.*

Key Words: North East India, flora and fauna, phytoresources, wild edible plants, tribes.

INTRODUCTION

India is very rich in floral resources. According to IUCN, more than 45,000 plant species have been recorded in our country. In the northen eastern part of India there is a rich heritage of indigenous traditional knowledge on biodiversity and bioresources (Chaudhury *et al.*, 2021). North East India comprises eight states – Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. There are about 427 tribal communities all over India, of which about 145 major tribal communities and total subtribes of 300 (Kala, 2005) are found in North East India. Abor, Garo, Bodo, Nishi, Angami, Khasi, Kuki, Naga, Apatani, Adi, Hmar, Mizo, Reang, Chorei, Tripuri, Deori etc. are some of the tribes from this region of the country.

In North East India, 51 different types of forests are found which are broadly classified under 6 categories: Tropical moist deciduous forest, Tropical semi evergreen forest, Tropical wet evergreen forest, Subtropical forests, Temperate forests and Alpine forests. 8,000 flowering plants reside in this area which include: 40 species of gymnosperms, 500 species of pteridophytes, 825 species of orchids, 80 species of rhododendrons, 60 of bamboo and 25 species of canes. This region has over 28 conifers, 500 mosses, 700 ferns and 728 lichen species (Prabha and Jain, 2018). There are about 800 different species of wild edible crops in India, out of which about 300 species are used mostly by the tribal and rural population of the

আমাৰ প্ৰকাশনৰ দ্বাৰা প্ৰকাশিত স্নাতক মহলাৰ (কলা, বিজ্ঞান আৰু বাণিজ্য শাখা) গ্ৰন্থসমূহ।

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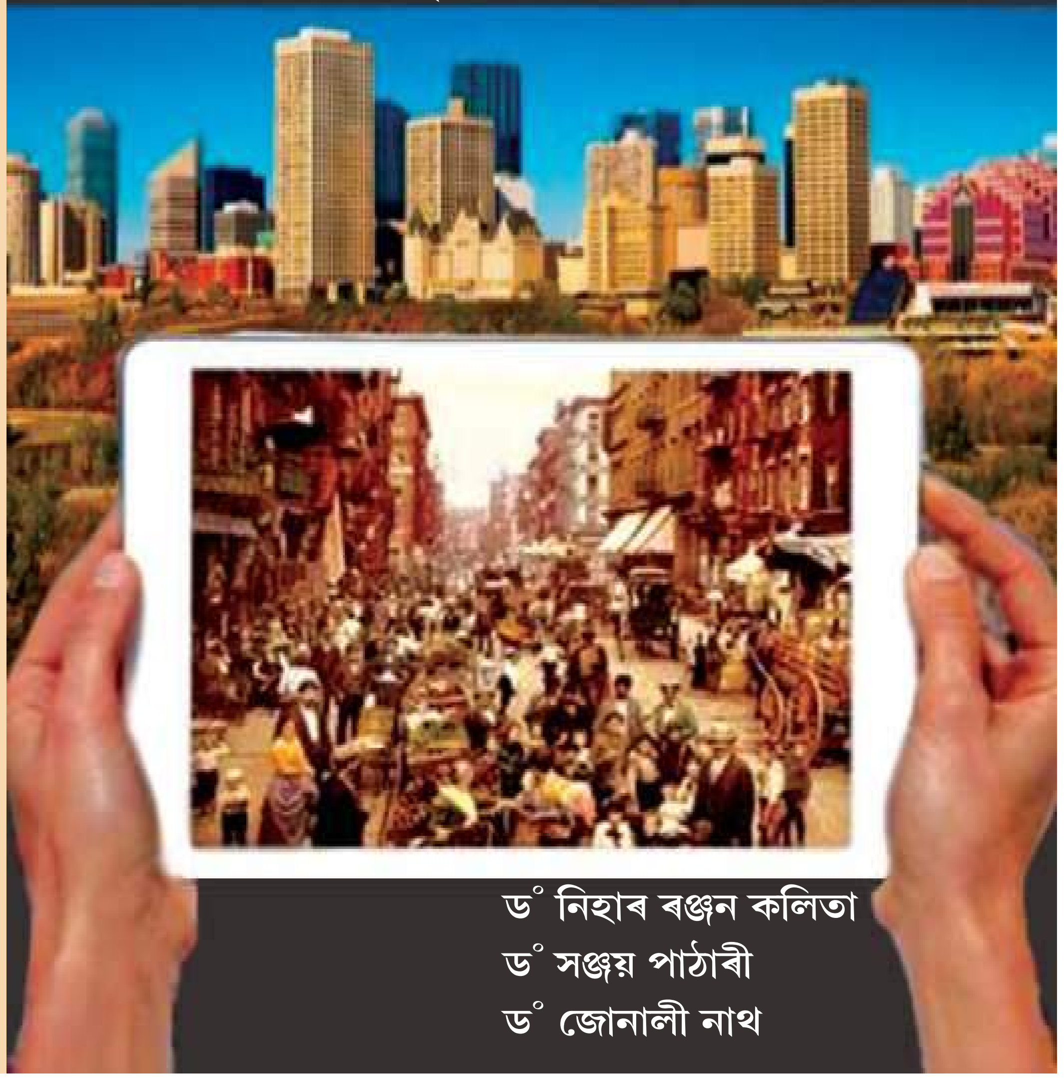

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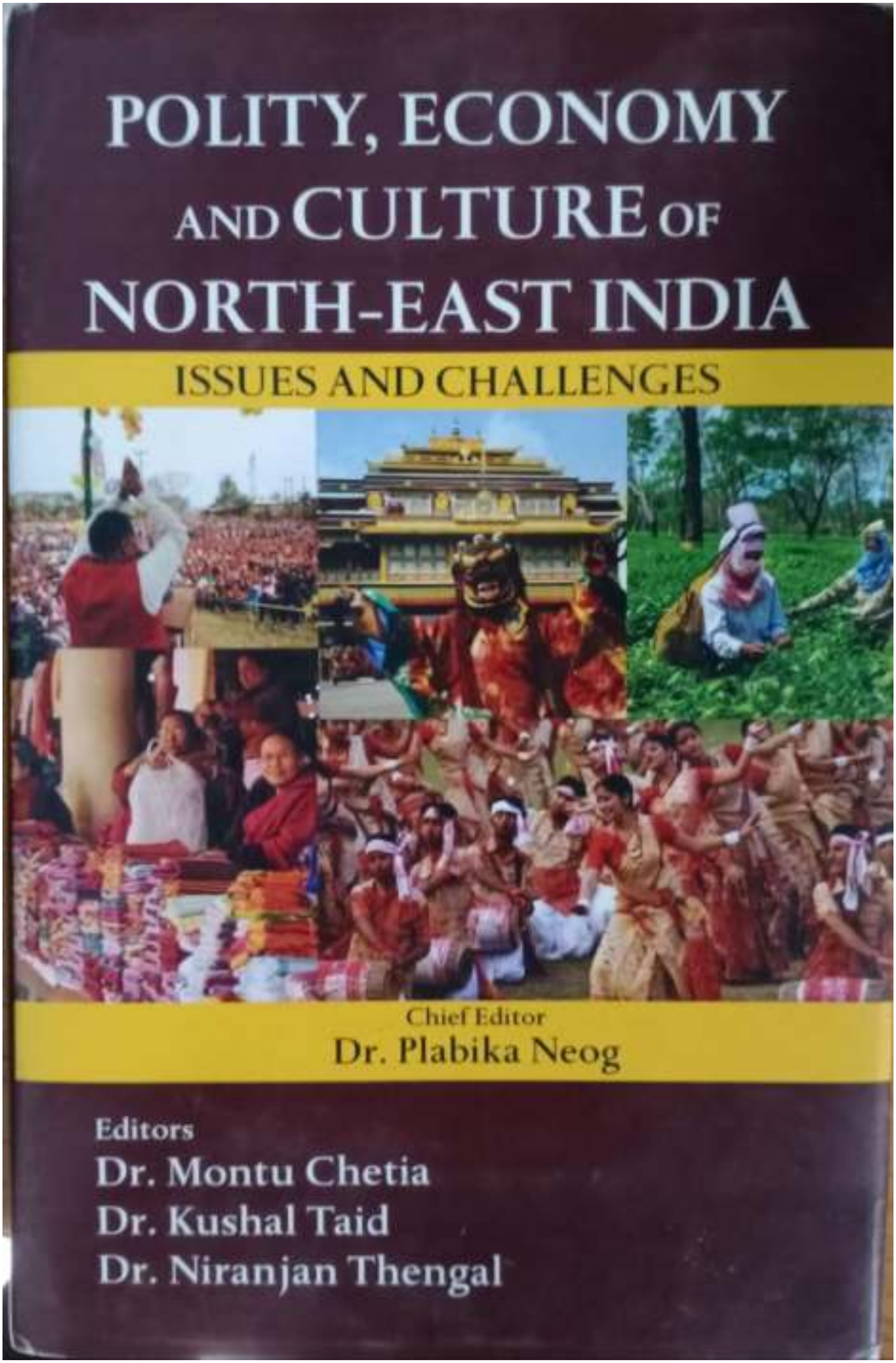

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ISSUES AND CHALLENGES

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Dr. Niranjan Thengal

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Issues and Challenges

Dr. Plabika Neog

Dr. Montu Chetia   Dr. Kushal Taid   Dr. Niranjan Thengal

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Perspectives on Fieldwork in Mising Autonomous Council areas in Assam

Dr. Bhasker Pegu

ABSTRACT

Researchers of Political Science conducting field studies gain divergent experiences, which remain unexplored on the path to scholasticism. Many a time researchers face an array of complexity in their field. Empirical studies as a part of one's methodology needs much more delicate handling in the field. As researchers in Political Science, approaching either through qualitative or quantitative methodology, we hardly have a choice to compromise our objectives while pursuing a study. When a researcher goes to the field, he is caught between the urge for objectivity and subjectivity. While attempting to explore the "real world problems", an investigator in the field finds oneself in a position of situational complexity. Field experience sometimes turns out to be emotional. A field investigator has to reconsider

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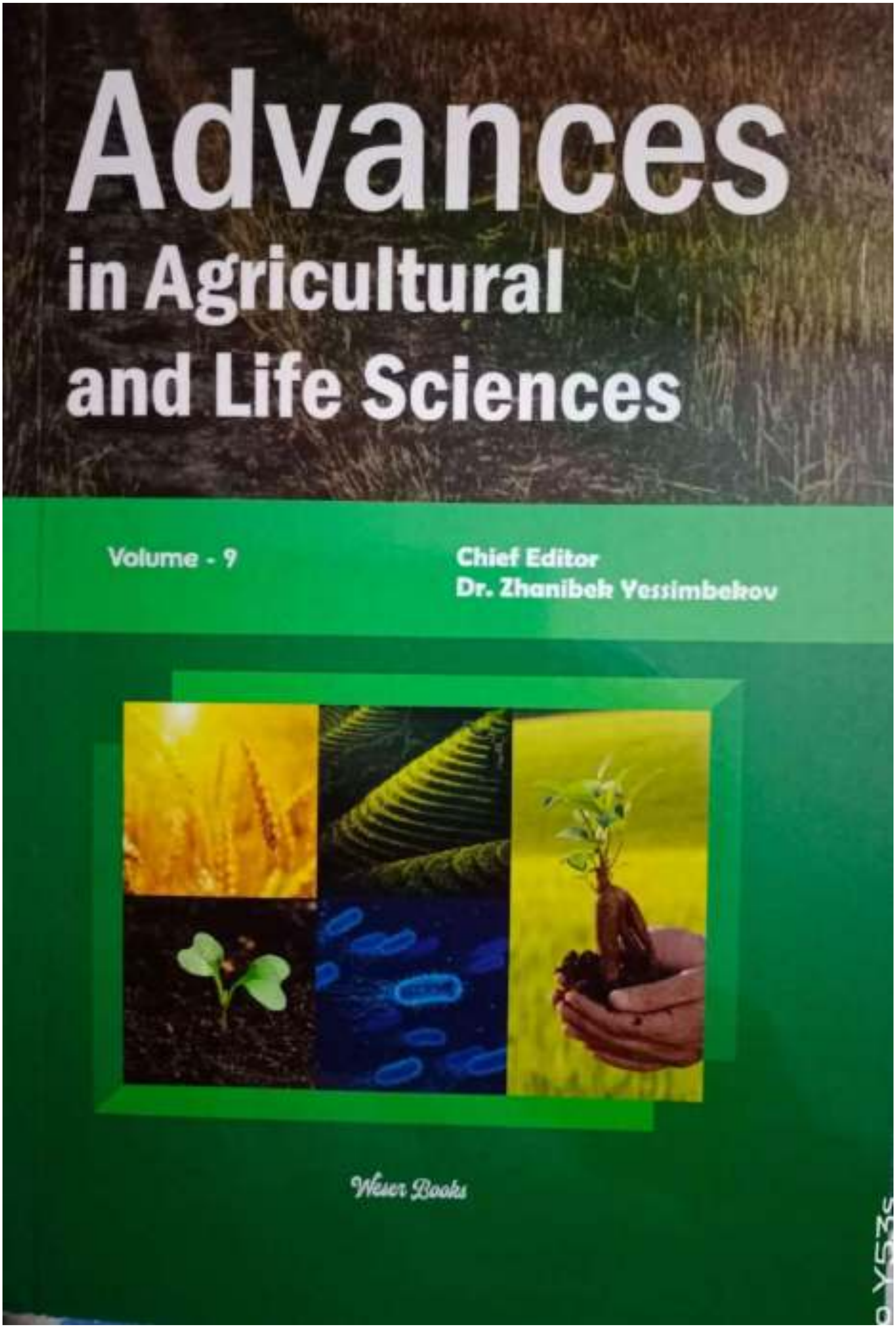
Assistant Professor, Department of Political Science, Dakshin Kamrup College, Mirza



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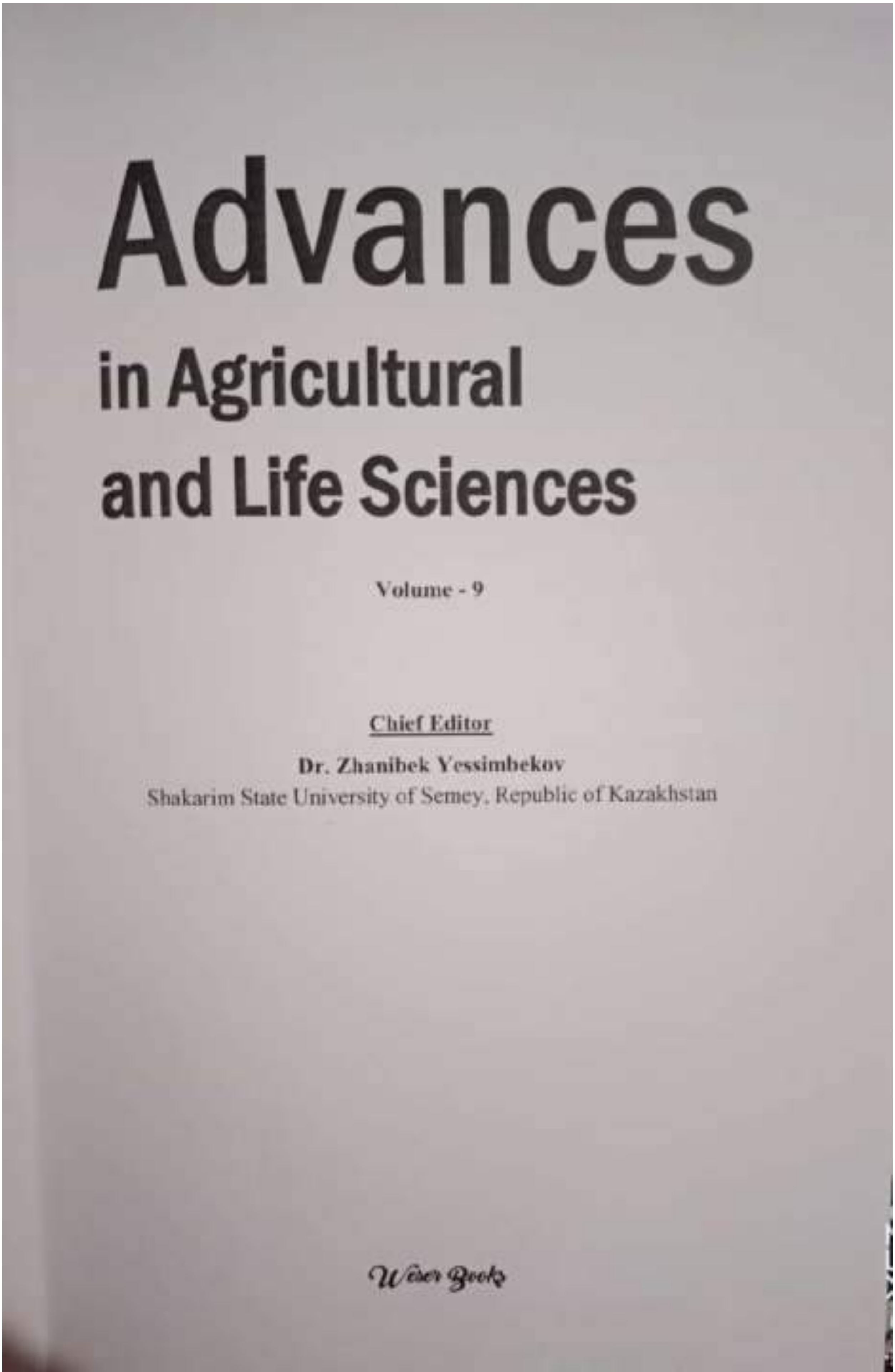

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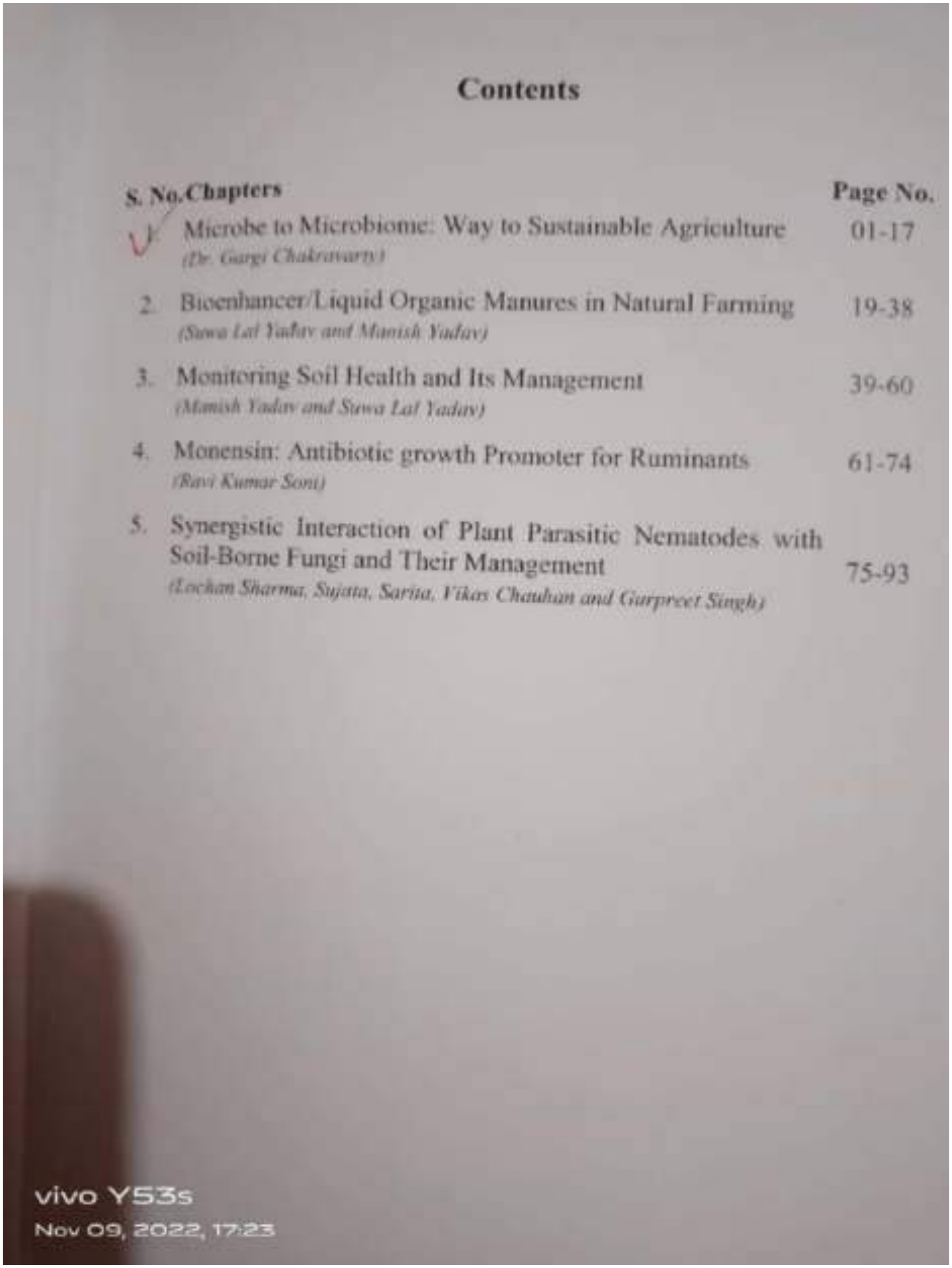

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Chapter - 1

Microbe to Microbiome: Way to Sustainable Agriculture

Dr. Gargi Chakravarty

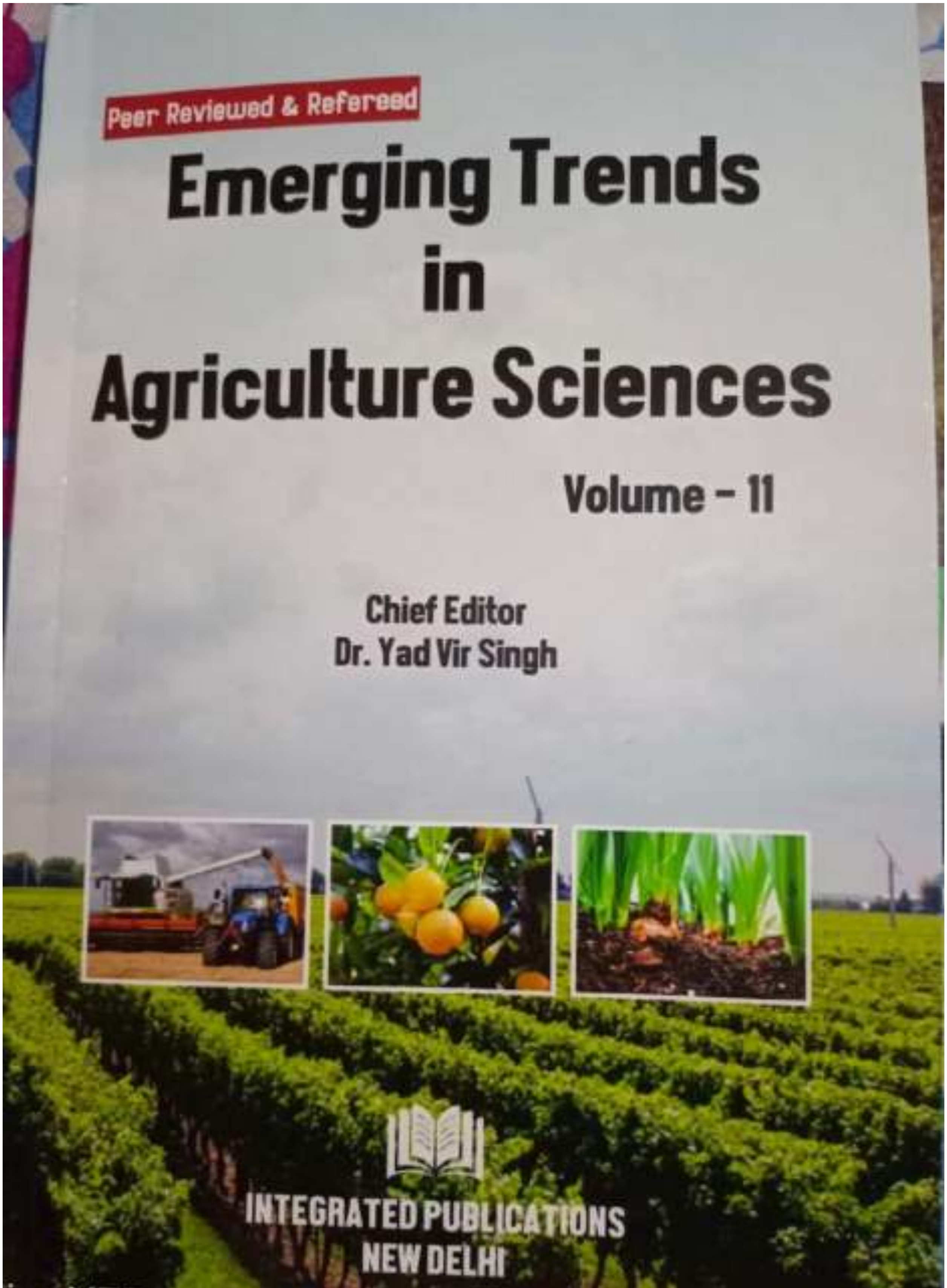
Abstract

Sustainable agriculture is a big challenge and its success lies in new approach to accomplish the goals of growing crops with minimal environmental pollution. The microorganisms are the best natural resources and their contribution to agriculture is established. Plants and soil harbour millions of microorganisms, which collectively form a microbial community known as the microbiome. An effective microbiome can offer benefits to its host, including plant growth promotion, nutrient use efficiency, and control of pests and phytopathogens. Traditionally only specific microbes have been studied and applied as inoculants in eco friendly agriculture practice. But these have yielded only limited results due to complexity of interactions with the native microbiota. Therefore, there is an immediate need to bring functional potential of plant-associated microbiome and its innovation into crop production. In addition to that, new microbial techniques give structural and functional data on the microbiome and offer opportunities for the design of more efficient microbial consortia that can optimize crop yield and fulfil the goal of sustainable agriculture.

Keywords: Microorganism, microbiome, sustainable agriculture

Introduction

The continued use of fertilizers and water to meet the demand of future global food requirements is not sustainable. In the last five decades, the total area of cultivated land worldwide has increased over 500% in the last five decades with a 700% increase in fertilizer use and a several-fold increase in pesticide use [1]. Maintenance and preservation of natural resources including diverse and functional microbial population in the soil is essential to sustainable agriculture [2]. There are about 6000 different bacterial genomes per gram of soil taking the genome size of *Escherichia coli* as a unit [3]. Despite, the huge bacterial population in soil, only few have been cultured and used in agriculture as biofertilizers, biocontrol and bioremediation agents. Vast pools of microorganism which are unculturable have remained



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Contents

Chapter - 6

Farm to Table: Management of Crop loss through Post Harvest Technology

Dr. Gargi Chakravarty

Abstract

There has been an increase in the production of horticultural crops along with the production of cereals and pulses, due to the increased demand following preference, rise in income and urbanization. After production in the farm, the produce undergoes a series of post harvest operations before they reach the consumers. Each post-harvest stage results in some losses as a result of which, the value distribution between the consumer and producer is affected. From the time of harvest till the end use, there is quantitative (decreased weight or volume) and qualitative (unwanted changes in the cosmetic features of food and reduced nutrient value) losses along the supply chain. Research and development on effective post harvest management strategies at each stage of harvesting, handling, storage, processing packing, transportation and cold chain maintenance are required to minimise the loss between production and consumption levels.

Keyword: Post harvest crop loss, management strategy

Introduction

India's food system has been transitioning with an increasing demand for high value horticulture and livestock products with rising income and urbanisation, along with the demand for cereals and pulses. Farmers, in this demand-led system, however, have not received commensurate benefits from this transition. Value chains remain poorly developed, in terms of storage - facilities at the farm level, transportation, and food processing units, especially in case of the perishables. Due to this, farmers incur higher losses compared to wholesalers, processors and retailers. Farmers' incomes have fallen progressively below that of the non-farm sectors. Most farmers in India remain stuck in a low-income trap.

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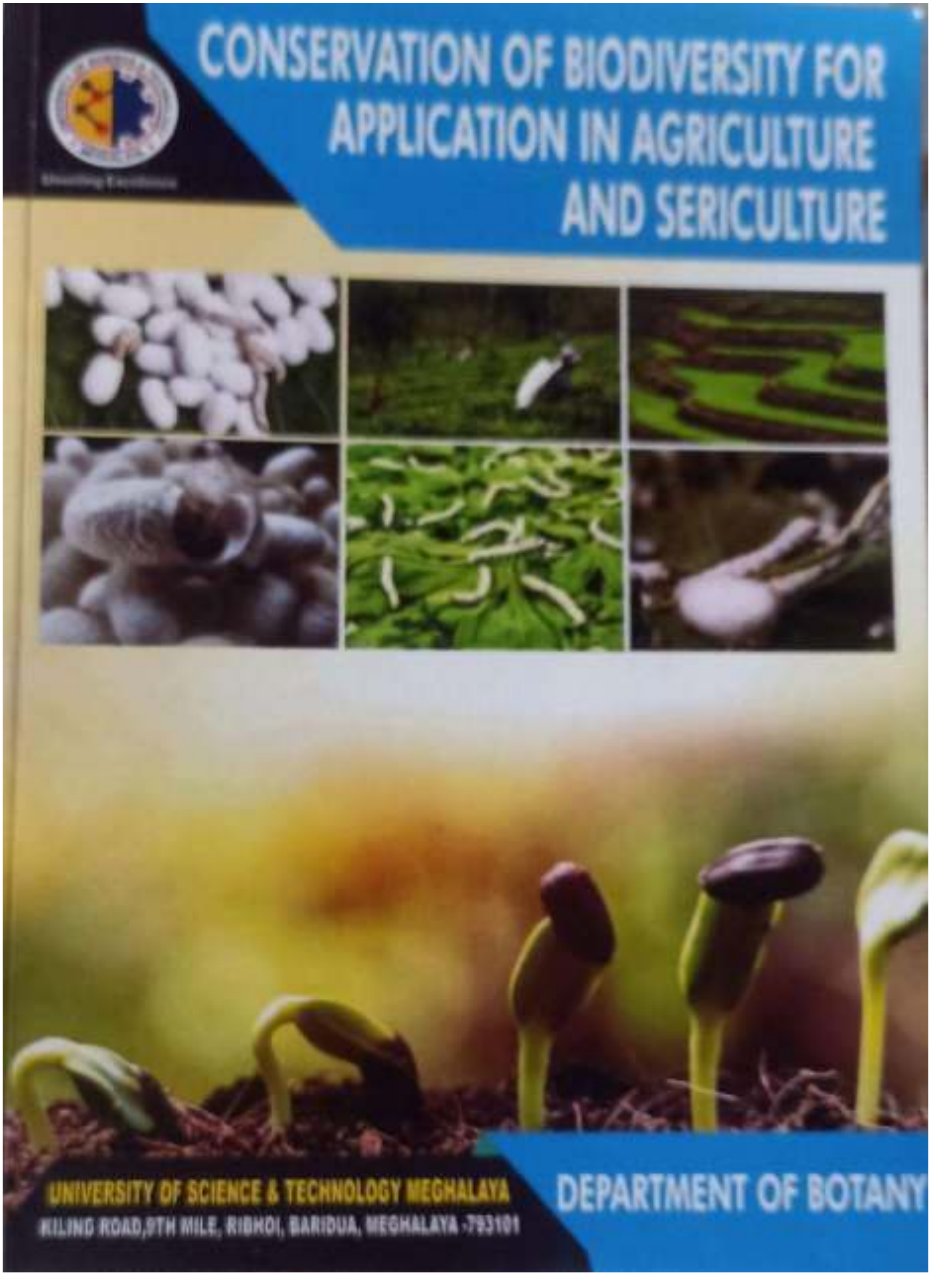

CONSERVATION OF BIODIVERSITY FOR APPLICATION IN AGRICULTURE AND SERICULTURE

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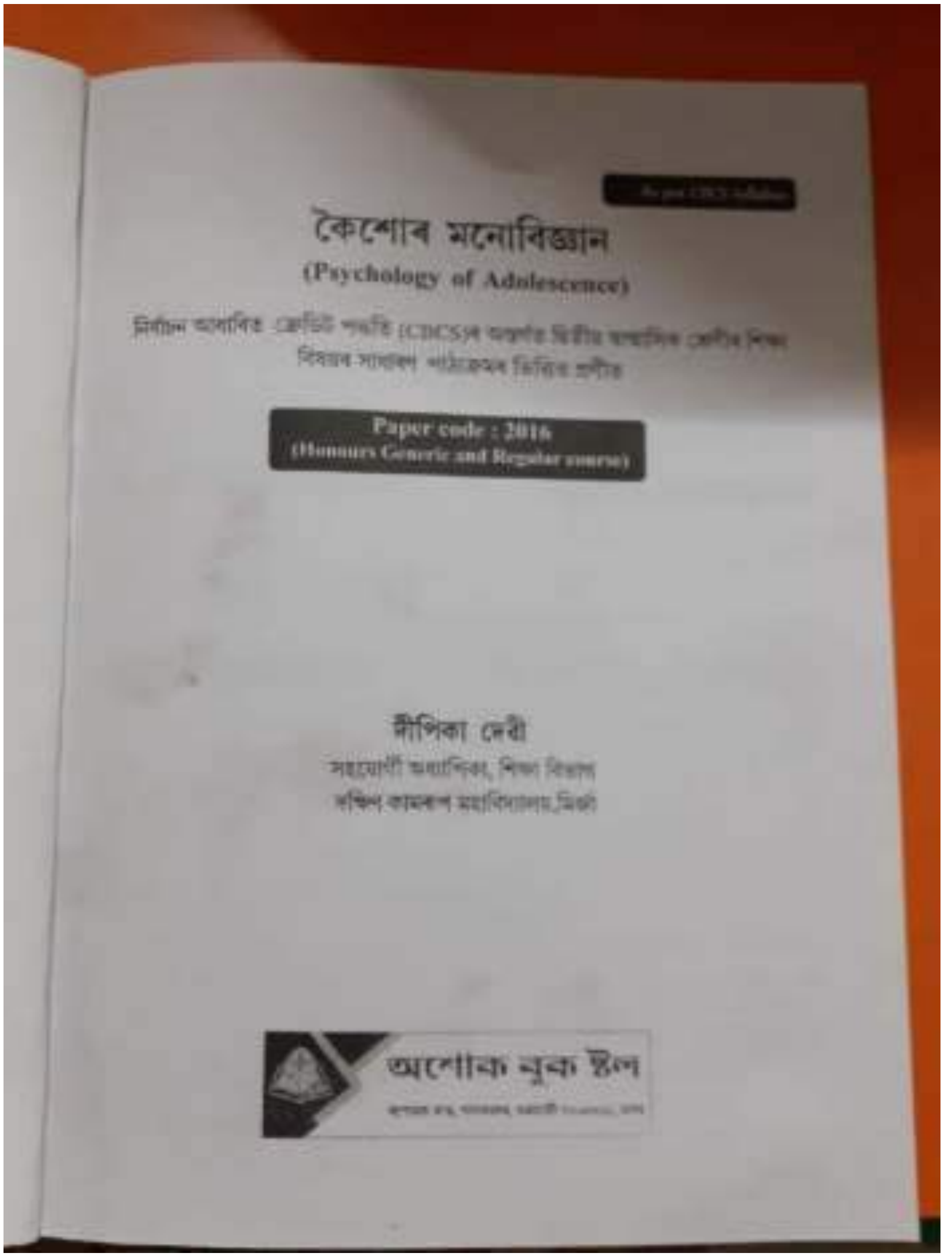
Current Advancement of Bioremediation and its Future Prospects in India

Nilofer Sheikh[1], Seydur Rahman[2], Rinti Roy[3] and Subrata Paul[4]
[1] Department of Botany, Biswanath College, Biswanath Chariali, Assam
[2] Department of Zoology, Assam Down Town University, Guwahati, Assam
[3] Department of Botany, Dakshin Kamrup College, Mirza, Assam
[4] Department of Botany, Jagiroad College, Morigaon, Assam
E-mail : nilofersheikh83@gmail.com

ABSTRACT

India, one of developing country in the world is facing severe environmental pollution issues which has arisen due toincreased human activity on energy reserves, dangerous farming methods and rapid industrialization over the last few decades. It has become outmost necessary to delimit the continuous xenobiotic and associated recalcitrant compound contamination from the environment. The key to removing persistent pollutants from the environment is bioremediation. In the past two decades, there have been recent developments in bioremediation techniques with the decisive goal being to successfully restore polluted environments in an economic and eco-friendly approach.Heavy metals, nuclear wastes, pesticides, greenhouse gases, and hydrocarbons are among the contaminants that cause environmental and public health concerns due to their toxicity.Because of its environmentally benign characteristics, bioremediation of polluted places has proven to be effective and trustworthy.Depending on the situation, bioremediation might be done ex situ or in situ.Ex situ



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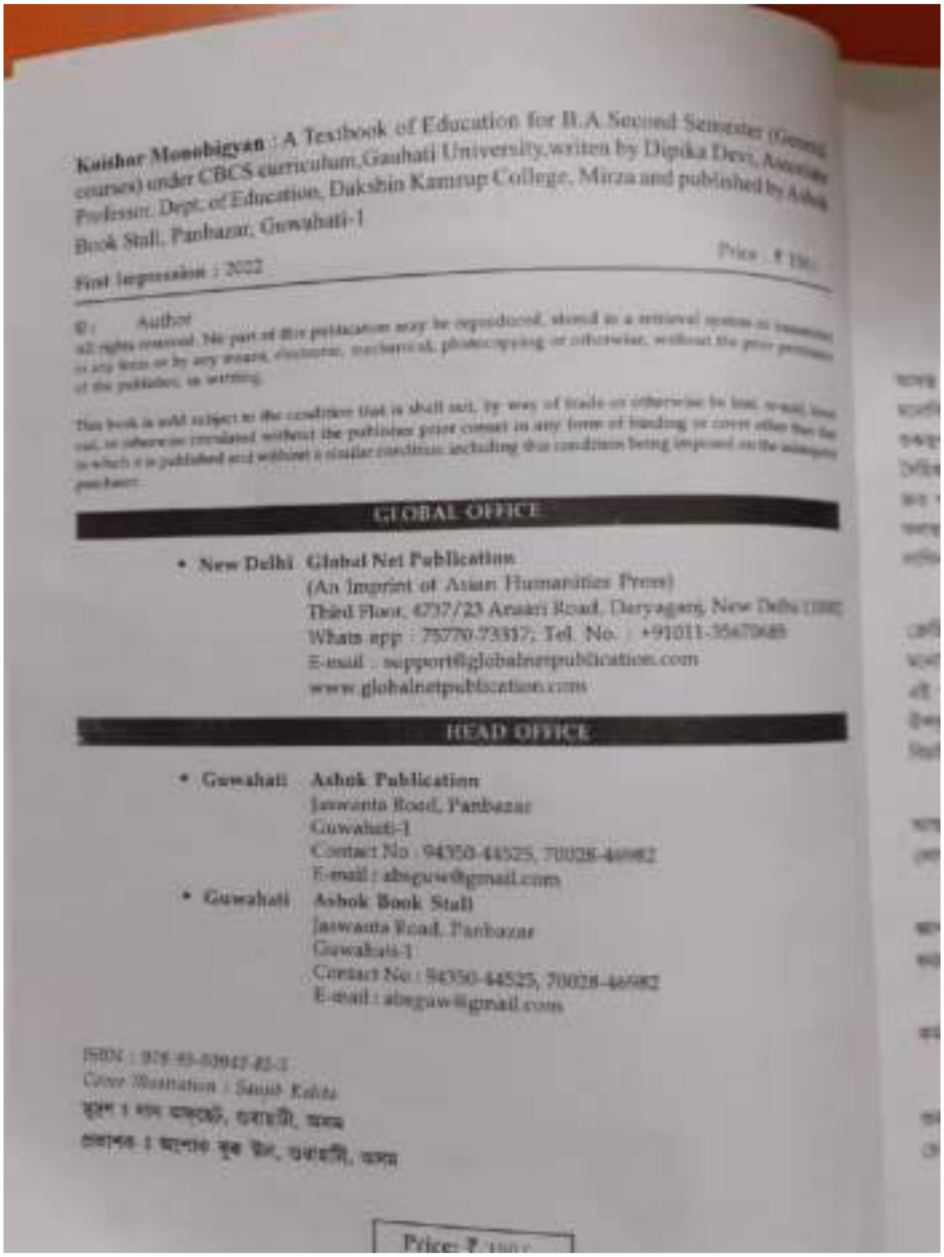

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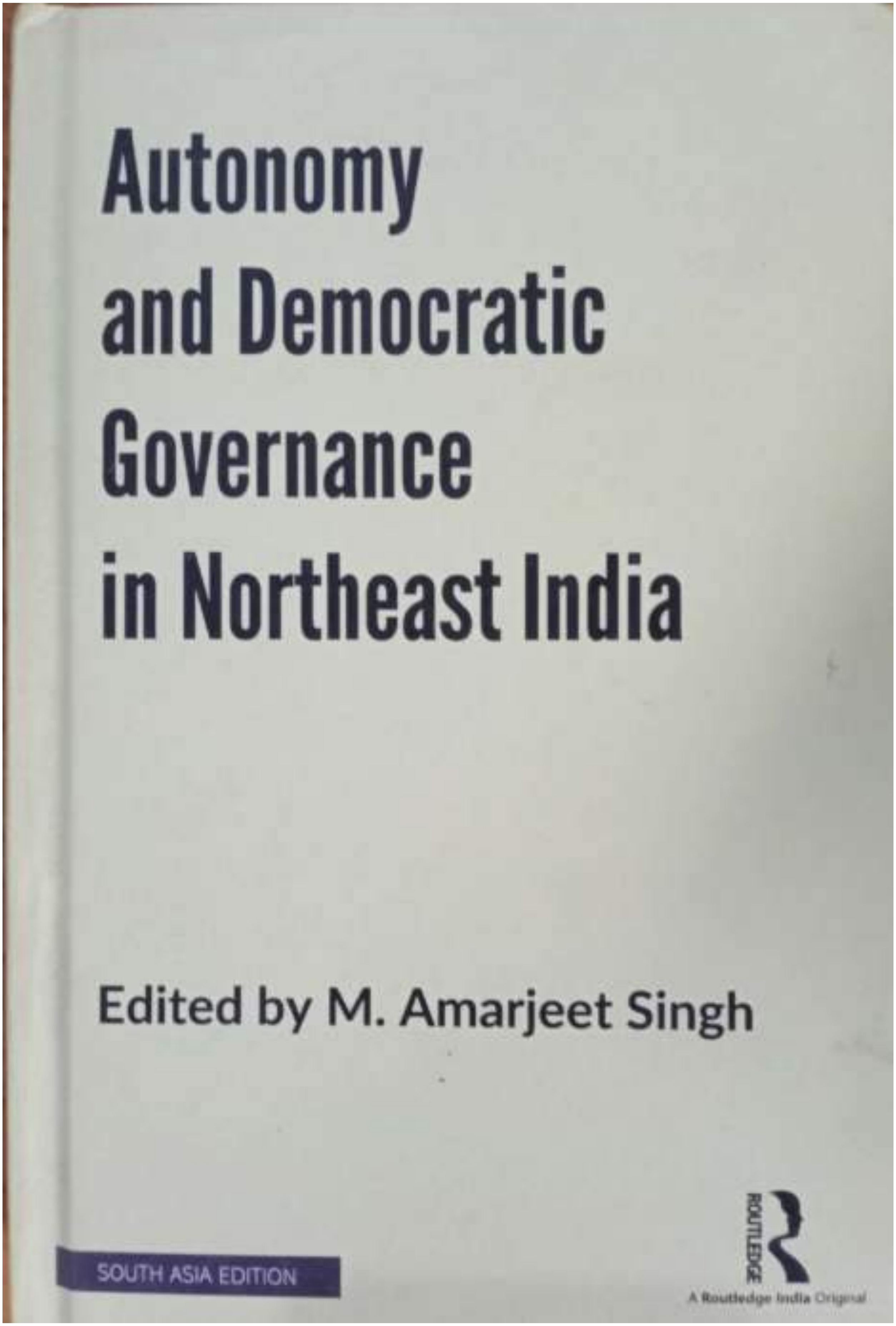

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Chapter 12

Understanding the autonomy movement of the Misings in Assam

Bhasker Pegu

Introduction

The political mobilisation of ethnic groups has been a recurrent feature in the studies of ethnic politics in Northeast India. The Misings, who are the second-largest Schedule Tribe in Assam, are also engaged in the mobilisation for autonomy since the 1980s. They are one of the few tribes who have not lifted arms in order to achieve their stated objective. The absence of armed militia and the adoption of the democratic method of struggle to exert political demand has been one of the significant features of the Mising autonomy movement which is least studied in the context of ethno-political mobilisation. While the abstinence from armed violence might have been one of the main reasons for failure to realise their demand for autonomy to safeguard their socio-cultural identity, land and resources when compared to the Nagas, Mizos or Bodos in so far as the responses of the state and central government are concerned. This essay argues that the Mising movement has its own relevance in understanding ethnic politics in India. The essay is drawn with a qualitative approach from secondary sources such as articles, leaflets, pamphlets and newspapers, periodicals magazines as well as primary sources such as interviews and field visits.

Historical background

The autonomy movement of the Misings can be traced back to the days of pre-Independent India. As early as May 1947, the North East Frontier Miri Abor Sanmila, a community organisation, expressed its desire for separate politico-administrative arrangement for the Misings, the Adis and the Nyishis. The sanmila also demanded the creation of an autonomous administrative unit with specific boundaries for all Tani tribes (such as Adi, Mising, Nyishi, Galo, Apatani and Tagin) inhabited areas of Brahmaputra valley to the border of Tibet (Pegu 1998). In successive years of post-colonial India, like many other indigenous people of Assam, the Misings also joined the echoes of deprivation and injustice against the hegemonic project. The formation of the Mising Agom Kebang, a literary body, in 1972, became

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