University of Pune

M. Sc. Biodiversity – Monitoring and Utilization

Revised Syllabus
(M. Sc. Part I – w. e. f July 2010)

A course sanctioned under
Innovative Programs Scheme
By
University Grants Commission
(2003)

At
Absasaheb Garware College, Pune

General Information

M. Sc. Biodiversity - Monitoring and Utilization (non-credit system) is a two year postgraduate course, comprising four semesters and is a unique program conducted at Abasaheb Garware College, Pune; since 2003. The course was sanctioned under Innovative Programs Scheme of University Grants Commission. The curriculum gives holistic coverage to the extremely valuable field of Biodiversity. Biodiversity is the largest source of potential wealth for the country, which remains grossly under explored. One of the reasons for the under utilization is the dearth of trained manpower. The current generation of biologists is largely divided into field-oriented taxonomists and ecologists on the one hand and the lab oriented functional and molecular biologists on the other. This divide has become a limiting factor in the study of Biodiversity. The present program intends to bridge the gap by inculcating excellence in field and laboratory biology simultaneously. This capacity building exercise will help generating wealth through a prudent and sustainable use of the country's bioresources.

The course consists of four semesters, each with a focal theme:

- The first year comprising two semesters is extensively field oriented and the second year is lab intensive.
- The first semester is devoted to taxonomy and diversity of various life forms and emphasizes on basic techniques of exploration of diversity.
- Second semester focuses on natural history and is supplemented adequately with quantitative techniques in biology and ecology. Human ecology component which forms the key component in shaping up of natural systems has also been included here.
- First and second semesters together emphasize on conceptual as well as empirical knowledge of the ways in which natural systems work.

- The first two semesters can make a good naturalist and ecologist.
- In the third semester, students will have an option of whether to opt for 'theory course' or undergo a 'research methodology' course. Depending on the nature of the planned work for dissertation, student will do the theory course/ dissertation in first or second half of the second year. Students who have opted for dissertation in the third semester will do course work in the fourth semester and vice-versa.
- Dissertation and understanding research methodology is a vital component. Natural systems (Biodiversity), being dynamic, possess very high seasonality component. Several of the projects are directed to field level research and need considerable time to be spent in the field.

Thus with a previous background of field knowledge and laboratory techniques complemented with scientific communication, the entire course tends to make the right kind of biologists that can translate the potential of country's Biodiversity into actual wealth.

Eligibility Criteria:

a. Bachelor in - Science / Engineering (any branch) / Agriculture / Fisheries / Pharmacy / Medicine with minimum 50% of marks
b. Clearing the entrance examination

Admission: The candidate must appear for the entrance test. The merit list will be based only on marks obtained in entrance test. Marks of qualifying graduate examination will be considered for tie-breaking.

Fee Structure: As per University of Pune guidelines for self supported post graduate courses in colleges.

Course structure:

M. Sc. Biodiversity (non-credit system) is a two year postgraduate course comprising of four semesters. Following is the outline of the course structure (with the marks in the parentheses)

Semester I: Taxonomy

Theory courses	**Marks**
BD – 101: Plant Taxonomy and Diversity	100
BD – 102: Animal Taxonomy and Diversity	100
BD – 103: Microbial Taxonomy and Diversity	100
Practical courses	
BD – 111: Taxonomy: Field Methods	100
BD – 112: Taxonomy: Lab Methods	100

Semester II: Ecology and quantitative biology

BD – 201: Ecology and Evolutionary Biology	100
BD – 202: Conservation Biology	100
BD – 203: Quantitative Biology	100
Practical courses	
BD – 211: Field Ecology Techniques	100
BD – 212: Quantitative Techniques in Ecology	100

Semester III: Bioresource exploration

BD – 301: Natural Product Chemistry and Drug Discovery	100
BD – 302: Ex-situ Conservation Methods	100
BD – 303: Molecular Techniques in Biology	100
Practical courses	
BD – 311: Bioprospecting and Bioanalytical Chemistry	100
BD – 312: Molecular Tools in Biology	100

Semester IV: Research Methodology

BD – 401: Scientific Communication and Research Methodology	100
BD – 402: Dissertation	400

Medium of instruction – English

Workload: The contact period for each semester will be 12 weeks, 4 lectures per course per week, each of 60 minutes duration. Work load for theory courses of college teacher entrusted with work of post-graduate teaching will be at the rate of one clock hour of post-graduate teaching equal to two periods of undergraduate teaching. Each laboratory course will occupy six hours / week / batch. The work-load for seminars / oral presentations of students will be 4 periods per week per class (M. Sc Part–I and M. Sc. Part–II). Dissertation will occupy equivalent workload of two laboratory courses i.e. 6 hours a week / practical course / batch.

Examination will be held at the end of each semester. Each course carries 100 marks, of which 80 marks for external examination and 20 marks for internal examination. All theory courses are University courses, the examination (external examination) will be for 80 marks and for duration of 3 hours. Biodiversity course being field intensive, visits to forested landscapes forms an integral part of the overall practical component. Practical examination will combine both field and lab exercises that test the knowledge and understanding of the subject. Each practical course carries 100 marks and for duration of 3 days.

Standard of Passing: The award of class / grades, ATKT and marks for passing, etc. will be as per the University of Pune rules.

Syllabus Reform Committee:

Name	Position	Expertise
Dr. Ankur Patwardhan, Abasaheb Garware College, Pune	Chairman of the committee and Head, Dept. of Biodiversity	Plant Taxonomy, Diversity and ecology
Dr. S. S. Diwanay, Abasaheb Garware College, Pune	Coordinator of the committee, Member BOS Microbiology, Faculty of Science, Univ. of Pune	Microbiology, Immunology and Immunopharmacology
Dr. M. G.Watve, IISER, Pune	Professor, Biology	Microbial Ecology, Evolutionary Biology, Quantitative biology
Dr. H. V. Ghate, Modern College, Shivajinagar	Head, Dept. of Zoology	Animal Taxonomy, Population ecology and conservation biology
Prof. S. B. Nalavade, Fergusson College	Head, Dept. of Geography	Biogeography, Physical Geography
Dr. D. G. Naik, Agharkar Research Institute	Scientist	Natural Product Chemistry, Analytical chemistry, IPR
Dr. N. M. Deshpande, Abasaheb Garware College	Associate Professor, Dept. of Microbiology	Molecular Biology, Genetics
Dr. B. D. Bhole, Abasaheb Garware College	Head, Dept. of Microbiology	Microbiology, Fermentation Technology
Prof. V. G. Kshirsagar, Abasaheb Garware College	Associate Professor, Dept. of Microbiology	Biochemistry
Dr. Milind Kothawade, RANWA	Member	Socio-economic aspects, Agrobiodiversity

Expertise availability for proposed course structure:

Following is the list of available expertise for the courses mentioned in the proposed course structure:

Semester	Courses	Available expertise	Affiliation
I	BD - 101: Plant Taxonomy and Diversity	Dr. Ankur Patwardhan	Abasaheb Garware College, Pune
	BD - 102: Animal Taxonomy and Diversity	Dr. Hemant Ghate	Modern College, Shivajinagar, Pune
		Mr. Vivek Gour-Broome	Kalpavriksh, Pune
	BD - 103: Microbial Taxonomy and Diversity	Dr. Milind Watve	IISER, Pune
		Ms. Gandhali Gharpure	Abasaheb Garware College, Pune
		Ms. Neha Shintre	Abasaheb Garware College, Pune
	BD - 111: Taxonomy : Field Methods	Dr. Ankur Patwardhan	Abasaheb Garware College, Pune
		Mr. Vivek Gour-Broome	Kalpavriksh, Pune
	BD - 112: Taxonomy : Lab methods	Ms. Gandhali Gharpure	Abasaheb Garware College, Pune
		Ms. Neha Shintre	Abasaheb Garware College, Pune
II	BD - 201: Ecology and Evolutionary Biology	Dr. Ankur Patwardhan	Abasaheb Garware College, Pune
		Dr. Milind Watve	IISER, Pune
		Dr. Neelesh Dahanukar	IISER, Pune
	BD - 202: Conservation Biology	Dr. Ankur Patwardhan	Abasaheb Garware College, Pune
		Mr. MIlind Kothawade	RANWA, Pune
		Prof. S. B. Nalavade	Fergusson College, Pune
	BD - 203: Quantitative Biology	Dr. Milind Watve	IISER, Pune
		Ms. Neha Shintre	Abasaheb Garware College, Pune
		Ms. Gandhali Gharpure	Abasaheb Garware College, Pune

	BD - 211: Field Ecology	Dr. Ankur Patwardhan	Abasaheb Garware College, Pune
		Prof. S. B. Nalavade	Fergusson College, Pune
	BD - 212: Quantitative Techniques in Biology	Dr. Milind Watve	IISER, Pune
		Ms. Neha Shintre	Abasaheb Garware College, Pune
		Ms. Gandhali Gharpure	Abasaheb Garware College, Pune
III	BD - 301: Natural Product Chemistry and Drug Discovery	Dr. D. G. Naik	ARI, Pune
		Dr. R.N. Jukar	Deepak Nitrite, Pune
		Prof. V. G. Kshirsagar	Abasaheb Garware College, Pune
	BD - 302: *Ex situ* Conservation	Ms. Gandhali Gharpure	Abasaheb Garware College, Pune
		Ms. Neha Shintre	Abasaheb Garware College, Pune
	BD - 303: Molecular Methods in Biology	Dr. N. M. Deshpande Mr. Asim Auti	Abasaheb Garware College, Pune
	BD - 311: Bioprospecting and Bioanalytical Chemistry	Dr. S. S. Diwanay Dr. R. N. Jukar,	Abasaheb Garware College, Pune Deepak Nitrite, Pune
	BD - 312: Molecular Methods in Biology	Dr. N. M. Deshpande, Mr. Asim Auti	Abasaheb Garware College, Pune
IV	BD - Dissertation - I: Scientific Communication and research Methodology (100)		Dr. S. S. Diwanay Prof. V. G. Kshirsagar Abasaheb Garware College, Pune

Evaluation of Dissertation: Following are the guidelines for evaluation of project (Total marks - 400):

i. Understanding of the research problem and related basic concepts
ii. Extent of literature survey and comprehension of it by the student
iii. Understanding and involvement in designing the experimentation set up
iv. Novelty of work

v. Data analysis and interpretation
vi. Logical reasoning for the interpreted results
vii. Presentation Skills
viii. Report writing
ix. Viva-voce
x. Publication potential

The assessment of this course will be carried at the end of the fourth semester.

University and Departmental courses:

The dissertation course will be the departmental course and all other courses will be university courses.

SEMESTER I

BD - 101: Plant Taxonomy and Diversity

Aim and Approach:

This taxonomy course includes classroom teaching in theory of plant classification and a practical, field-based approach in identification of diverse plant groups. The course aims to generate a competent field botanist.

The approach in implementing this course is to make the student conversant with the use of taxonomic literature. We do not expect the students to learn formal taxonomy by heart. They should be able to choose and use appropriate taxonomic and identification keys efficiently for identifications. The assessment system will allow the students to use the literature in the exams.

(A) Introduction: Concept of species, variation (2)

(B) Theory of plant taxonomy: (10)

a. Introduction to major plant groups and evolutionary relationships
b. History of plant taxonomy
c. Code of nomenclature
d. Systems of classification and their application
e. Biosystematics with use of ecology, palynology

(C) Identification: (30)

a. Morphology of major plant groups (Bryophytes, Pteridophytes, Gymnosperms, Angiosperms)
b. Study of identification characters
c. Study of important plant families of flowering plants
d. Use of taxonomic literature, herbaria, cultures and databases

(D) Documentation and dissemination: (6)

Collection and preservation techniques
Recording information in field and laboratory
Photography, Illustration
Description of species, Referencing and citation
Preparation of keys, reports
Computerized database generation for dissemination

Suggested Readings :-

1. Taxonomy of Angiosperms – V. N. Naik
2. Families of Flowering plants – Heywood
3. Angiosperms : Taxonomy, Anatomy, Economic Botany & Embryology – Pandey
4. Flora of Bombay Presidency – T. Cooke
5. Flora of Maharastra - BSI
6. Flora of Bombat Presidency and Sind – Talbot
7. Taxonomy of Angiosperms – Sing & Jain
8. Key to family of Angiosperms – Dr. S. G. Date

BD - 102: Animal Taxonomy and Diversity

Aim and Approach:

Similar to paper1 the approach in implementing this course is to make the students conversant with the use of taxonomic literature. We do not expect the students to learn formal taxonomy by heart. The assessment system will allow the students to use the literature in the exams. The common organisms from the so-called "minor" phyla are generally neglected in conventional zoology curricula. They are adequately covered here.

(A) Introduction (12)

1. Principles and rules of Taxonomy, Zoological nomenclature, ICZN regulations
2. Taxonomical hierarchy (Linnean hierarchy)
3. Concepts of Taxon, holotype, paratype, topotype etc.

(B) Classification of Animal kingdom (36)

1. Brief classification of animals up to class level for invertebrates
2. Brief classification of animals up to order level for vertebrates and minor phyla.
3. Concept of phylogeny
4. Use of Taxonomic Keys for Identification of the animal specimen with emphasis on ; Amphibians,
   Reptiles,
   Fresh water mollusca,
   Insects

Suggested Readings :-

1. The fauna of British India (Reptilia and Amphibia- Vol. -III, Serpentes - Malcolm A. Smith
2. Handbook of birds of India and Pakistan (Vol. I, II, III)- Salim Ali and S. Dillon Ripley
3. The MacDonald encyclopedia of Butterflies and Moths
4. A pictoral guide to the birds of Indian subcontinent - Salim Ali, S.D.Ripley
5. The book of Indian animals - S.H Prater
6. Primates of the world - Rod and Ke Preston
7. Arthropoda – Kotpal
8. Invertebrata – Kotpal & Khetrapal
9. Principles of Animal Taxonomy - Ashlock

BD - 103: Microbial Taxonomy and Diversity

Aims and Approach:

Microbial taxonomy has taken a different route than plant and animal taxonomy, the emphasis being on cultivation and applications. The classical natural history approach of biology has been almost absent in microbiology. The course attempts to develop a new "culture" of microbiologists with a naturalistic mindset and who are equally good in the field and the lab. The teaching approach for the course should be sufficiently flexible and the teachers and the students should have enough freedom to choose any taxa/ organisms of their interest.

(A) Microbial diversity (6)

1. Magnitude, occurrence and distribution.
2. Outline classification of microorganisms.

(B) Fungi: Criteria for classification and identification (10)

Types of vegetative forms, Types of spores, fruiting bodies, life cycles

1. Outline classification
2. Taxonomic keys, Identification keys, Species databases and identification software.

(C). Bacteria: (12)

1. Concept of species
2. Criteria for classification.
3. Morphology in Actinomycetes, Cyanobacteria and Myxobacteria.
4. Biochemical characterization- enteric bacteria.
5. Serotyping, Phage typing.
6. Major classes of bacteria of ecological, agricultural and environmental importance.

(D) Viruses: Outline classification (5)

(E) Chemical and biochemical methods: (8)

1. Cell wall composition analysis
2. Lipids and Fatty acid profile analysis
3. Protein profiles and isozymes analysis

(F) Micro-organisms in extreme environments. (7)

Suggested Readings :-

1. Burgey's manual of determinative bacteriology- 8th edition
2. Burgey's manual of systematic bacteriology
3. Researches on cellular slime moulds: selected papers- J. T. Bonner
4. Microbiology: A practical approach – Dr. M. G. Watve
5. General Microbiology – Stanier
6. Microbiology – Prescott
7. Introduction to Microbiology – Pelczar

BD – 111: Taxonomy - Field Methods

1. Morphology of major groups (Bryophytes, Pteridophytes, Gymnosperms and Angiosperms)
2. Study of leaf and flower morphology
3. Study of fruits

   Expected abilities: field identification of at least 100 species and identification up to family level for all common plants in the study area)
4. Surveys, collection and preservation of different plant groups
5. Identification using reference material
6. Visits to herbaria, gardens, culture collections
7. Photography and illustration in field and laboratory conditions
8. Use of computers in analysis, documentation and dissemination of information.
9. Morphology of Insects
10. Classification of insects (all major orders using key)
11. Use of taxonomic literature and visit to local fish market for identification, morphometry
12. Methods of dry and wet preservation of animals
13. Dry preservation of insects for taxonomic studies
14. Study of traps
15. Visit to ZSI

BD - 112: Taxonomy - Lab Methods

1. Cultivation and isolation of microorganisms
2. Nutritional requirements
3. Growth media and cultivation
4. Pure culture isolation
5. Enrichment
6. Maintenance and culture collection
7. Species databases
8. Methods of cultivation and characterization of Protozoa
9. Molecular methods of taxonomy and numerical taxonomy
10. Visit to culture collection centers

SEMESTER II

BD – 201: Ecology and Evolutionary Biology

Aim and approach:
Species in nature are the part of complex community, the organization and stability of which is important in conservation. The first half of the course discusses the fundamental of community organization and the second one discusses the evolutionary concepts.

(A) Population growth: (6)
Growth types and growth models, exponential, logistic and chemostat models and their variants, Populations with age structure, age class distributions, Effect of environment on population growth. Stochasticity in growth, Growth efficiency and growth yield: Laws of thermodynamics, energetics of growth, biomass conversion rates. r and K selection strategies.

(B) Population interactions: (4)
types of interactions, models of competition, predator-prey dynamics. Empirical and experimental studies on population interactions

(C) Community ecology: (10)
Definition of population and community, ecological succession, characteristics of community, composition of community, structure/ stratification of community, habitat, niche and guild
Biodiversity hot-spots, diversity distribution, factors affecting diversity, impact of exotic species & disturbance on diversity, dispersal, diversity-stability relationship.

(D) History and development of evolutionary theory (10)
Neodarwinism: spontaneous mutation controversy, effects of natural selection on populations, stabilizing and dispersing selections, Levels of selection, group selection controversy, selfish gene theory.

(E) Kin selection and sociobiology, evolution of cooperation, sociality, game theory. (4)

(F) Evolution and stability of sex, sexual selection, evolution of secondary sexual characters. (4)

(G) Problem of speciation, origins and stability of diversity, relationship between ecosystem stability and diversity, genetic diversity and infectious diseases. (4)

(H) Neutral evolution and molecular clocks, origins of molecular diversity, phylogeny and molecular distances, reconstructing evolutionary origins from molecular studies. (6)

Suggested Readings :-

1. Genes and Evolution - A. P. Jha
2. Darwin's dangerous idea - Daniel .C. Dennett
3. The meaning of evolution - George Gaylord Simpson
4. The evolution of life : its origin history and future - Sol Tasc
5. Charles Darwin – Richard Milner
6. Ecological diversity and its measurements – Magguran
7. A methodology mannual for scientific inventorying, monitoring and conservation of Biodiversity – Madhav Gadgil
8. Planet Earth: The view from space
9. The private life of plants – David Attenborough
10. Ecological census technique – W. Sutherland
11. Principles of ecology – Chapman and Reiss
12. Biodiversity - Myres

BD - 202: Conservation Biology

Aim and approach:

Field biological data make sense only in the light of its underlying geography. Species in nature are the part of complex community, the organization and stability of which is important in distribution and conservation. The first half of the course discusses the fundamental of biogeography and the second one the possible conservation strategies and policies. Management of bioresources is more about management of people. Understanding the human angle is perhaps the most importance aspect of conservation. The course aims at giving conceptual understanding of the human factors involved.

(A) Geological time scale: (2)

(B) Dispersal Dynamics: (4)

Manners & Means of Dispersal, Barriers, Dispersal of Young, Rate of Dispersal, Causes of Dispersal

(C) Dispersal Pathways: (5)

Continental Drift Theory, Land Bridges, Centers of Origin, Island Dispersal, Theory of Island Biogeography, Origin of Indian Fauna (Satpuda Hypothesis etc).

(D) Migration: (4)

Meaning & Definition, Theory of Migration (Annual – Summer, Monsoonal, Winter, Local, Altitudinal; Daily – Commuting; Metamorphic), Concept of Ecesis

(E) Patterns of Distribution (with example of each type): (4)

Cosmopolitan, Circum – Boreal, Circum – Austral, Pan – Tropical, Linear, Restricted / endemism (bathymetric, altitudinal, latitudinal), Zoogeographical Realms

(F) Biomes, Phytogeography (habitat types), (4)

Overview of India: Flora & Fauna with respect to western ghats

(G) Applied Biogeography: (3)

Conservation, Human Animal Conflict, Human impact on distribution, consequences

(J) Human Ecology : (4)

History of man – nature interactions, Role bioresources in shaping human culture.
Agriculture – Origin, Spread, Changes, Challenges
Animal Husbandry - Origin, Spread, Changes, Challenges

Resource Use Patterns – Diversity, Specificity, Sustainable utilization of bioresources

(K) Economics: (4)
Four types of economic units – Development, role in economic interactions viz. Household, Firm, Financial Intermediaries, Government;
Earlier economic activities - Banker
Need for currency
Local Market, National, International trades in Biodiversity
Participatory Rural Appraisal (P.R.A.), R.R.A.

(L) Knowledge Systems: (4)
Traditional Knowledge Systems – Folk Biology, Traditional healthcare (medicinal plants)
SWOT Analysis of traditional systems and modern knowledge systems

(M) Policies / Acts: (6)
Various policies – Brandies
Various treaties – Rio- to – till date
Protected Areas, Community Conserved Areas, Environmental Impact Assessment (EIA)

(M) Intellectual Property Rights (4)
Concept of IPR, Interventions and Discoveries, Patentable and non – patentable Interventions, Pct and its Significance, Opposition of patent application, Significance of Holding a Patent, Infringements, Licensing of Patents

Suggested readings :-

1. Biogeography of India – Mani
2. Systematics, the fossil record and biogeography - Lawrence G. Abele
3. Shrusti vigyan manual for conservation – M. Gadgil
4. A walk on the wild side (an information guide to National Parks and Wildlife Sanctuaries of Karnataka) – Karnataka forest Dept
5. Cultural and ecological dimension of sacred grove in India – Kailash Malhotra
6. Whose Eden? Wildlife management – Institute of environment and development
7. Biological conservation
8. Conserving western ghats biodiversity – CES Bangalore
9. Gearing up for Patents: The Indian Scenario – Prabuddha Ganguli
10. Principles of ecology – Chapman and Reiss
11. The wildlife protection act
12. The management of intellectual property

BD - 203: Quantitative Biology

Aim and approach:

Quantitative techniques are essential in Life sciences. The course introduces the student to the statistical tools and their applications. The student should able to choose right kind of tool for answering a given question in a given situation. The tests can be carried out using available software.

(A) Descriptive statistics (5)

Classification of data, tabulation, graphical representation, Measures of central tendencies and variability/dispersion, Probability distributions and frequency distributions, Normal distribution, central limit theorem, confidence interval.

(B) Hypothesis testing and statistical inference, concept of Null hypothesis, significance level, Type I & II errors (3)

(C) Comparison of means, t - test family, nonparametric tests (4)

(D) Regression and correlation (7)

Linear regression, Pearson's correlation, Non-parametric correlation, Multiple regression.

(E) Factorial experiments and ANOVA (4)

(F) Experimental and Sampling design (3)

Sampling strategies and selection of sampling strategies, Optimization of sample size.

(G) Multivariate analysis (12)

Measuring and testing multivariate distances,

Ordination and Principle Component Analysis

Cluster analysis- strategies of clustering– merits & demerits. Construction of Dendograms, rooted and unrooted trees, interpreting phylogenetic relationships.

(H) Introduction to mathematical models- (10)

a. Population genetic models-

Population genetics: Mutations and Rates of mutations.

Diploid populations: Mendelian genetics, Hardy-Winberg equilibrium, Genetic drift and allelic fixation

b. Epidemiological models

Suggested readings :-

1. Probability and statistics – Indian academy of Sciences
2. Descriptive statistics - Churchill Livingstone
3. Introduction to Statistics - Wardlaw
4. Biometry: Principles and practice of statistics in biological research: Robert Sokal and F. James Rohlf.
5. A primer of mathematical writing- Steven G. Krantz
6. Statistical methods – Cochran & Snedeco

BD – 211: Field Ecology Techniques

Sampling techniques of plants/animals (quadrats / transects)

1. Species area curve, species abundance distribution, species association, girth class distribution, Biomass estimation
2. Indices of diversity, species rarefaction
3. Introduction to Maps (SOI Toposheets – Detailed Study)
4. Use of Compass & GPS for making rough field maps
5. Study of RS Images
6. Introduction to GIS
7. Exercise - Making of territory map , land use / land cover maps
8. Square – Grid Pattern of Species
9. Diversity Gradient Technique (Contoured Diversity Pattern)
10. Procedures for filling applications in India, Patent Search, various databases

BD - 212: Quantitative Techniques in Ecology

1. Introduction to computers
2. Use of spreadsheets and statistical packages for performing statistical tests
3. Use of clustering algorithms.
4. Determining allelic frequencies in a population: e.g. blood groups.
5. Growth curve
6. Simulation models of growth and population interactions
7. Methods of estimating population densities and population growth rates in plants, animals and microorganisms, optimum harvesting and sustainability