DEVELOPMENT OF WORKING MODELS IN BIOLOGY AT HIGHER SECONDARY LEVEL FOR ANDHRA PRADESH

Report

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[National Council of Educational Research and Training]

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Preface

The Department of Intermediate Education, A.P., expressed desire to get trained their Junior College Lecturers in Biology to undertake working models preparation at +2 level. In connection with this, a 10-day workshop was organized by Regional Institute of Education, Mysore-6 for training Andhra Pradesh Junior College Lecturers. Logistics of the programme such as financial, administrative and academic activities were planned in the Institute in consultation with DEE and the Department of Intermediate Board of Andhra Pradesh.

The programme started in the month of July 2001. We had an internal IRP meet and identified the different areas in Biology, (where working models can be prepared) and also developed two questionnaires - one for the Junior College Lecturers (or +2 teachers) of Biology and one for the Administrators Educational functionaries. A survey was conducted in Hyderabad and surrounding areas in the months of August 5.8.2001 to 10.8.2001. Using the questionnaire that was developed by the IRPs in the IRP meet. As part of the survey, Government, Aided, Junior Colleges in Andhra Pradesh were visited by Dr M.Z.Siddiqui and Dr.G.V.Gopal, Coordinators of the programme. The survey was conducted to get the first hand information from the physical laboratory/working models status in the State of Andhra Pradesh. Data gathered from the schools of urban/rural/semi-urban minority institutions formed the basis for organizing the next workshop in the month of January 2002.

The general observation was that many schools had inadequate infrastructural facilities. The laboratories, either old or outdated. In no place, working models in Biology were seen. Keeping all these things in mind, a workshop at RIE, Mysore in Phase IV during 7.1.2002 to 16.1.2002 was planned with well-defined objectives. The workshop, which was scheduled during phase IV had invited 40 teachers, out of which, 8 junior college lecturers from Andhra Pradesh participated. During this workshop, nearly 14 working models in Biology were prepared. In the last phase, coordinators and participants of the workshop had prepared a brief write-up of all the working models, their preparation and their approximate cost were given along with the design and a brief report was brought out for wider dissemination.

(M Z Siddiqui) *(G V Gopal)*

Academic Coordinators

Resource Team

Academic Coordinators and Editors

Dr G V Gopal
Reader in Botany

Dr M Z Siddiqui
Professor in Zoology

Faculty of Botany

Dr Geetha G Nair
Sr Lecturer in Botany

Faculty of Zoology

Dr L Srikantappa
Professor in Zoology

Dr A Sukumar
Reader in Zoology

Dr S P Kulkarni
Sr Lecturer in Zoology

DMS Faculty

Shri Kappanna
PGT in Biology
DMS, Mysore 6

Shri Sivakumar
Work-Experience Teacher
DMS, Mysore 6

Shri Ravi
Lab Assistant (Biology)
DMS, Mysore 6

List of Participants

1. Shri M Surya Mohan
   Junior Lecturer in Botany
   R R B H R Govt Junior College
   Pithapuram 533 450
   East Godavari Dist 533 450, A P

2. Shri P Bagiah
   Junior Lecturer in Botany
   Govt Junior College
   Miryalaguda 508 207
   Nalgonda Dist, A P

3. Dr S Hara Sriramulu
   Junior Lecturer in Botany
   Dr V S Krishna Govt Junior College
   Visakhapatnam 530 017, A P

4. Smt J Ramanujamma
   Junior Lecturer in Botany
   Govt Junior College
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   Vishakhapatnam Dist, A P

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   Junior Lecturer in Botany
   Govt Junior College
   Bangarupalem 517 429
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   Junior Lecturer in Botany
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8. Shri G P V Sekhar
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Acknowledgement

We wish to thank the National Council of Educational Research and Training (NCERT) , New Delhi for approving the programme and providing the necessary financial support. Sincere thanks to the Principal, Prof G Ravindra, Regional Institute of Education, Mysore for his encouragement and sustained interest. The Board of Intermediate Education, Andhra Pradesh evinced keen interest in the programme and extended their full support. The Commissioner, Intermediate Education, Sri B Kripanandam, IAS for his quick action at a very short notice; in deputing 25 Junior Lecturers for above workshop. Besides expressing our gratitude to him, we wish to place on record his dedication and commitment to improve the quality of education in our schools/junior colleges in Andhra Pradesh in specific. We also remain thankful to Dr N N Prahallada, Head, DEE and his staff for the quick action in conduction of the above said workshop smoothly. Last but not the least, our Head, DESM, Prof A L N Sharma, who has designed, planned, guided us for conducting the workshop smoothly as planned. Sincere thanks are also due to our colleagues in the Department of Botany and Zoology and to all the junior lecturers of Andhra Pradesh who actively participated in the workshop adding a silver line to its success. We wish to thank the staff of the Computer Processing Room for their excellent computer work and production of this report. Last but not the least, we thank the students and staff of DMS for their excellent participation and help during the workshop and DMS School staff, specially Work Experience Teachers and the technical help rendered by Mr.Ravi are highly appreciated.

(M Z Siddiqui) ***(G V Gopal)***

Academic Coordinators

Introduction

It is now almost universally acknowledged that science education must be rejuvenated to serve the needs of the society. In this regard, it is expected that the children 'Our future hope and future citizens' to work towards 'learning society' : a society which is committed to a system of education that allows all members the opportunity to stretch their minds to full capacity to *think* effectively. Teacher knows that school is a place where tests are failed and passed, where amusing things happen, where new insights are stumbled upon and skills are acquired. We also know it is a place where imagination is unleashed and misunderstanding brought to ground when teaching is viewed as encountering.

Science instruction can encourage students to be autonomous learners and independent and critical thinkers. Science teachers are aware of the fact that children learn science best when they are able to do experiments, so that they can witness 'science in action'.

Experiments help children actually see how natural world works. The sense-based real experiences help the learner to make better judgements and to apply the acquired knowledge effectively to problem solving situations in real life. Scientific explanations sometimes conflict with the way students may suppose that things happen or work. For e.g. Most students would probably think that a basket ball will fall faster than a ping-pong ball because the basket ball is larger and heavier. Unless the teacher corrects this intuitive assumptions, by having the students perform an experiment and see the results, the student will continue to trust their intuition, even though the textbooks or the teacher tells them the effect of gravity on both objects is exactly the same and both will reach the floor at the same time.

So empirical evidence are necessary for better understanding of the scientific concepts. Thus while transacting the scientific information, the selection of appropriate learning materials according to the stage and level of the learner is of greater concern to the science teacher. Teachers also know that the learning materials in the form of charts, models – working and static, will help in efficient learning. The

models have unique characteristics in teaching. The Microorganisms which are seen through electro microscope and magnified so much will be presented in the form of a model. The solar system which is so large can be presented through a 3D working model. The working model not only brings novelty but also clarifies many of the doubts. Models do have their own limitations. Basically models allow the learner to examine things often not easily seen in the real thing and model is a three-dimensional representation of a real thing, such as a replica of the human ear. It may be smaller or larger or the same thing as the real thing. It may be complete in detail or simplified for instructional purposes. Still the teaching models, if used effectively, make the learning really meaningful, easier to comprehend and provide a sense of enjoyment.

Objectives of the Programme

In our country, most of the schools have no laboratory. Science cannot be taught without demonstration to impart knowledge effectively. Buying the apparatus for laboratory is a costly affair. Therefore, the teachers have to improvise some apparatus with low cost materials available to make teaching effective and more meaningful. Keeping this objective in mind, the present workshop was planned to develop some working models at +2 level Biology. A.P. requested the Programme i.e. "*Development of Working Models at Higher Secondary Level*" (18.14 of NCERT).

General Objectives of the Workshop :

1. To facilitate enthusiastic teachers to design some simple with low-cost materials, better working models.
2. To make abstract content easier through working models and to attain concept clarity.
3. To make teachers and students involved in the process of developing working models.
4. To motivate the teachers to use these working models in classroom curricular transactions.

Specific Objectives:

(i) To identify the areas in Biological sciences where working models can be designed.

(ii) To integrate the model with the principles/concepts in teaching learning process.

(iii) Capacity building for the +2 biology teachers of A.P. in making working models and preparation of key resource persons.

APPROACH PAPER

Higher secondary or +2 stage is crucial since the students for the first time after completing ten years of school education move towards diversification channelising their interests, capabilities and aptitudes to choose their specialized academic concern or job oriented vocational courses.

Higher Secondary stage is a bridge to the tertiary academic or professional education. As such it is the secondary and higher secondary stage out of which the future leadership emerges. The quality of leadership at secondary or intermediate level in every walk of life hinges upon the quality of education imparted at secondary and higher secondary stages, since these are the stages that provide such leadership to the country.

The Knowledge, understanding, skills, attitudes and entrepreneurship abilities that are developed and promoted at the higher secondary stage determines the quality, competence, commitment and purposefulness of this leadership. To withstand the competitive and challenging global phenomenon permeating every walk of life, we are to set our national standards of education comparable to any international standards in terms of courses of study, curricular outlines, learning outcomes, variety of instructional/teaching-learning materials-Audio and Visual and multimedia packages and improved evaluation tools.

A teacher will have to play a catalytic role, entirely different from what he/she is used to be at the moment. A teacher will have to plan meaningfully and imaginatively learning opportunities, in which students are encouraged to learn individually in small groups...(National Curriculum Framework for School Education, NCERT, 2000).

Attainment of the learning skills, the ability to explore, observe and discover the unknown, facilitation in analysis, synthesis, critical thinking and decision making should be the watch words of curricular transaction that is carried out under the guidance, supervision and facilitation of the teacher. As such to provide the desirable secondary/intermediate or tertiary leadership in science and technology for the

country, the curricular transaction of science need to be re-designed and rendered dynamic, vibrant, creative and imaginative aiming at the concept clarification and concept attainment by the students, promoting productive skills of fabrication and demonstration as individuals or as a team. In this regard, to catch and stimulate the attention and arouse interest among the learners, the teacher employs certain strategies like discussions, debate, quiz, learning by doing, problem solving and discovering, etc. with the holistic presentations/enactment/portrayal of the facts and concepts. One such concept learning strategy is, facilitating design/preparation/fabrication and demonstrations of the diverse simulated working models that enact the facts and concepts.

Models can be basically static models or working models. In a static model albeit one can see the physical structure of the various components of a concept, one cannot observe the functional relateness of the components of that particular conceptual model. If we can design, prepare and assemble various component parts of a concept centered model demonstrating the individual component alignment, component actions, co-actions and interactions, driving at the understanding of the concept and working with it, the curriculum transaction fulfils its commitments to the society. The working models will be more effective in a classroom transaction. Teaching of concepts related to solar system and plant movements, air as a mixture of many gases enzyme action, cyclic and non-cyclic photophosphorylation and the energy transfer could be better understood and appreciated by the learners through the working models.

In this direction we have analysed the content areas of the +2 Biology textbooks of Andhra Pradesh and identified the different concepts that could be better transacted through the design and development and demonstration of working models.

The selected list of concepts for developing the working models is enclosed herewith separately.

To ascertain the existing status of Biology concept transaction/teaching through the activity/aids/models, questionnaires for the educational administrators, and practicing +2 teachers in Biology working in urban, rural and semi-urban and

minority institutions located in and around Hyderabad were prepared and administered on them. The data thus collected has been considered as a basis to ascertain the need for development of the working models based on various Biology concepts. There appears a distinct transactional deficiency in Biology in the +2 schools in the state. The labs are poorly equipped, and teaching-learning materials are seldom used.

The analysis of administered questionnaires indicate that both the +2 teachers and administrators are very much appreciative of need for developing concept centered working models/experiments/ activities to develop productive skills of science and technology among the learners that can go a long way in equipping them with the necessary life skills. With this backdrop of need survey/assessment and the preliminary analysis of the +2 Biology concepts that need simulated working models for concept clarification and attainment the present workshop to develop working models is planned to develop professional creative teaching competencies and commitment in Biology teachers at +2 level of Andhra Pradesh by involving them in the process of preparation of working models. This is the first attempt in this direction wherein +2 teachers/junior college lecturers are trained and involved in the design, development and fabrication of working models in Biology for concept clarification and attainment. These trained +2 teachers could serve as key resource persons for the state and train further the teaching fraternity in Biology empowering them with the effective skills of preparing the concept based working models and employ in curricular transaction. Hope our endeavours with the +2 faculty in Biology would meet with success and the expected objectives/goal attainments would be realized.

Prof. M.Z. Siddiqui **Dr. G.V. Gopal**

Programme Coordinators

Phase – I

Time-Schedule

11.6.2001 (Monday) Time: 3.00pm
Venue : Zoology Department (Methods Lab)

11.6.2001 (Monday) Time : 3 .00 to 5.30 pm

Identification of Areas for Making Models and Procurement of Books from A.P. and Textbook Analysis

Phase – II

Time Schedule

18.7.2001 Time: 3.00 to 5.30 pm

To discuss the modalities and prepare the format of the Questionnaire in connection with the preparation of Working Models in Biology at +2 level from Andhra Pradesh

Phase III

A Survey of Selected Junior Colleges in Andhra Pradesh
For assessing the availability of working models, their use, etc.

Duration: Five days duration at Hyderabad, Andhra Pradesh
05-08-2001 to 10-08-2001

Title of the programme: **Preparation of working Models Biology at +2 level (Code No. 18.14)**

REPORT

We visited in and around Hyderabad city, some Government aided Junior Colleges for the purpose of survey to assess the availability of working models in Biology, Physical Laboratory facilities and how often they are used by the teachers in the lab. The Junior Colleges have been categorized in Urban/Rural/Minority/Backward/SC/ST institutions.

We visited the following colleges the addresses and code numbers of which are mentioned below:

Sl.No.	College Code No.	Name of the College	Date of Visit	Remarks
1	4530	The Principal/Superintendent Govt. Jr. College, Aliya Gun Foundry, Hyderabad-500001	7-8-01	
2	4535	The Principal/Chief Superintendent, Gautami Jr.College, Sanjeev Reddy Nagar, Hyderabad-500 038	9-8-01	
3	4547	The Principal/Chief Superintendent, Sri Gauthami Jr.College for Girls, S.R.Nagar, Hyderabad.	9-8-01	
4	4548	The Principal/Chief Superintendent, Sri Gauthami Jr.College for Girls, S.R.Nagar, Hyderabad	9-8-01	
5	4550(A)	The Principal/Chief Superintendent, Anwar-UI-Uloom (Evening) College, New Mallepally, Hyderabad	8-8-01	
6	4580(A)	The Principal/Chief Superintendent, Anwar-UI-Uloom (Evening) College, New Mallepally, Hyderabad Girls Wing	8-8-01	
7	4582(A)	The Principal/Chief Superintendent, Anwar-UI-Uloom (Day) College, New Mallepally, Hyderabad-500 001	8-8-01	
8	4600	The Principal/Chief Superintendent, New Government/Jr.College, Nampally, Hyderabad-500 001	9-8-01	

9	4694	The Principal/Chief Superintendent, Gowthami Jr. College, Ameerpet, Hyderabad.	9-8-01	
10	4750(A)	The Principal, V.V.College (Day) Jambagh, Hyderabad	7-8-01	
11	4751(A)	The Principal, V.V.College (Evening), Hyderabad	7-8-01	
12	4842	The Principal, B.J.R.Government Junior College, Chirag Ail Lane, Hyderabade-500 001	7-8-01	
13	4870	The Principal, Government Mahaboobia Jr.College, Gunfoundry, Hyderabad	8-8-01	
14	4900	The Principal, New Science College, Ameerpet, Hyderabad	9-8-01	
15	4600	The Principal, New Government Jr.College, Nampally (changed to Kukkatpally), Hyderabad	9-8-01	

As part of the survey, Government, Private, Aided Junior Colleges in Andhra Pradesh have been visited by us from 5-8-2001 to 10-8-2001 and the physical/laboratory facilities and working model status was done in respect of the above said schools.

The general observation is that many schools lack one or the other infrastructural facilities, i.e. even if some of them are having labs, either they are old or outdated labs and in no place we have seen working models in Biology. We explained the objectives of the work at RIE, Mysore, during which the working models will be prepared with the help of the teachers. Henceforth, the present workshop will be of great help and benefit teachers from this area and teachers interviewed and the schedule responses giving us feedback information that most of the teachers show willingness to come and participate in the workshop.

We also contacted the Board of Intermediate Education, and the concerned Joint Director, Positive response is given and the teachers will be deputed. The endeavour made by the RIE, Mysore was appreciated. As it is a PAC approved state request programme, they are shared keeping interest in this programme.

(Dr. M.Z. Siddiqui)
Programme Coordinator

(Dr. G.V. Gopal)
Programme Coordinator

REGIONAL INSTITUTE OF EDUCATION, MYSORE-570 006
(National Council of Educational Research and Training, New Delhi)

Programme Proposal: Preparation of Working Models in Biological Science +2 Level for Andhra Pradesh

QUESIONNAIRE FOR TEACHERS

1.	Name of the school/junior college	:
2.	Medium of instruction	:
3.	Rural/Urban	:
4.	Government/Private/Aided	:
5.	Co-education/Gender specific/Ashram school/Tribal schools	:
6.	Name of the place where Jr.College/school is located	:
7.	Number of Biology faculty/with their qualifications	:
8.	How many PGTs/TGTs are there?	:
9.	They are trained/untrained	:
10.	What is the total strength of students in Biology?	:
11.	Whether there is any Botany /Zoology laboratory?	:
12.	Whether there is any museum in Botany/Zoology department?	:
13.	Whether any teaching aid/chart/static model/working models are available in the school/junior college?	:
14.	Whether the school/junior college conducts any exhibition/participated in inter-collegiate exhibitions?	:

15.	Number of Biology students	:	Boys	Girls
16.	Number of sections in	:	XI	XII
17.	Whether teaching aids/models/charts/static modes/working models are used in class/practical lab?	:		
18.	What teaching strategies are adopted? Lecture method/Demonstration method/Activity Based Discussion Method	:		
19.	Number of theory hours per week Number of practical hours per week	:		
20.	What are the topics/lessons for which the models are used and how often they are used?	:		
21.	The topics for which the teaching aids were not available.	:		
22.	Does your school/junior college have a computer? If yes, do you use computer-assisted models for teaching?	:		
23.	Name the topics for which computer assisted models were used.	:		
24.	Whether the teaching aids/models are prepared by students/teachers/purchased from the market?	:		
25.	Do you like to have more computer assisted teaching models?	:		
26.	Do you have any workshops/work experienced teachers/technical assistant in preparation of biological working models?	:		
27.	Do you think working models have an advantage over static models in concept attainment? If so, would you like to develop more of these working models in your Institute?	:		
28.	Do you wish to be trained with hands on experiences on preparation of working models at RIE, Mysore?	:		

29. If the charts/models are developed in school/college, do you have resources to develop multiple copies? :

30. Whether teachers had any previous training in developing working models? :

Signature

REGIONAL INSTITUTE OF EDUCATION, MYSORE-570 006
(National Council of Educational Research and Training, New Delhi)

Programme Proposal: Preparation of Working Models in Biological Science +2 Level for Andhra Pradesh

QUESIONNAIRE FOR ADMINSTRATORS, BOARD OF SECONDARY EDUCATION

1. Do you provide budgetary provision for acquiring/repairing models/charts?

2. Do you conduct school exhibitions at school/district/state level?

3. Do you depute the teachers/students to participate in such exhibitions?

4. Whether training/orientation/workshops are conducted at +2 teachers to develop teaching aids/models/working models?

5. What follow-up action would you suggest for the models developed by us to provide them to schools/junior colleges?

6. Do you purchase the teaching aids/models/working models from any authorized dealers?

7. Will you get the multiple copies of the prototype model developed at RIEM for the distribution and use in the school/junior colleges in your state?

8. Would you like to conduct similar workshops at state level using key persons trained at RIEM?

9. Would you like to collaborate with RIEM in conducting similar workshop?

10. Do you plan to develop "State Resource Centre" for conducting training programmes to train teachers/students in preparation of teaching aids (including a mobile service centre)?

Signature of the Officer

Name :

Designation :

Address :

Phase IV

Identified areas of Biological Science
Where Working Models can be prepared

INTERMEDIATE FIRST YEAR

Botany

1. Cell Biology – Mitosis/Meiosis (Three dimensional cell – *Cell* as a dynamic unit) / working models (GN).
2. Organisation of Plasma-membrane (GGN).
3. Phyllotaxy – Angle of divergence (GVG).
4. Microscope working mode (GVG).

INTERMEDIATE SECOND YEAR

5. Flow-chart of plant tissue-culture.
6. Bacterial cell – virus cell – working model (GVG).
7. Photosynthesis – Non-cyclic photophospiration (GVG).
8. Lock and key enzymes working model (GVG).
9. Osmosis (GGN).
10. Transpiration (GGN).
11. Munchi Hypothesis.
12. Geotrapisum/Phototropisum/Working Model
13. Opening and closing of stomato, progression of Biotic Components of the ecosystem.
14. Working model hydrophytes/xerophytes
    Spirogyra Reproduction (GVG)

Zoology Working Models

1. Electrical model of evolutionary tree for taxonomy of animals (AS).
2. Working of heart using computer. (SPK and MZS).
3. Low-cost working models using Pepsi bottle for respiratory system (AS).
4. Model of Nephron to show the ultra filtration (SPK and AS).
5. Female reproductive system to show the uterus movement of sperms, fertilization, implantation, etc. (electrical model) (MZS).
6. Propagation of nerve impulse using bamboo pieces (SPK).
7. Autonomous nerve system (MZS).
8. Endocrine glands with diseases (electrical model) (MZS).
9. Blood groups (LS and MZS).
10. DNA model and structure and replication (electrical model) (MZS).
11. Protein synthesis (LS).
12. Trachea respiration in insects (AS and SPK).
13. Life cycle of plasmodium (AS).

REGIONAL INSTITUT OF EDUCATION, MYSORE 570 006

WORKSHOP FOR PLANNING AND PREPARATION OF PROTOTYPE WORKING MODELS IN BIOLOGY

Date/Day	9.00 am to 11.15 am	11.30 am to 1.00 pm	1.30 pm to 3.30 pm	3.45 pm to 5.30 pm
19.11.2001 Monday	Inauguration by Principal. Plan of Action – ALNS	Preparation of list of models to be prepared.	Cost estimation, items required for preparation of models.	Dividing into groups and start working in the preparation models.
20.11.2001 Tuesday	Group work – Preparing of prototype models and write-ups.	Expert/s to be called for preparation of models from Hyderabad/local resources.	Group work	Group work.
21.11.2001 Wednesday	Group work prototype, model preparation and write-ups.	- do -	- do -	- do -
22.11.2001 Thursday	-do-	-do-	Presenting the models, prepared and demonstrate.	-do-
23.11.2001 Friday	Presentation of working models.	Presentation of working models.	Valedictory function and address by ALNS	

PHASE - V

TITLE OF THE PROGRAMME

DEVELOPMENT OF WORKING MODELS IN BIOLOGY AT +2 LEVEL FOR ANDHRA PRADESH

INAUGURAL ADDRESS

1. **Welcome by Dr. N.N. Parahallada**
2. **Self-Introduction by Participants**
3. **About the Programme by Dr. M.Z.Siddiqui and Dr. G.V. Gopal**
4. **Inaugural remarks by Principal, Dr.G. Ravindra**

List of working models prepared in Biological Science during the workshop

Botany:

1. Cell Biology-Mithosis (Three dimensional cell Cell as a dynamic unit)/working models (GVG)
2. Organisation of cell-organelle
3. Phyllotaxy-Angle of divergence (GVG)
4. Microscope working model (GVG)
5. Flow-chart of plant tissue-culture (GVG)
6. Bacterial Cell-virus cell-working model (GVG)
7. Photo-synthesis-Non-cyclic photophospiration (GVG)
8. Lock and Key enzymes working model (GVG)
9. Oxygen is evolved during photosynthesis.

10. Transpiration (GGN)

11. Munchi Hypothesis working model (GVG)

12. Working model

13. Opening and closing of stomata, (GVG)

14. a) Spirogyra Reproduction (GVG)
    b) Spirogyra lateral conjugation (GVG)

Zoology:

1. Female reproductive system to show the uterus movement of sperms, fertilization, implantation, etc. (electrical model). (MZS)
2. Propagation of nerve impulse using bamboo pieces (SPK)
3. Autonomous nerve system. (MZS) & SPK
4. Endocrine glands with diseases (electrical model.). (MZS)
5. DNA model and structure (electrical model). (MZS) & (LS)
6. Protein synthesis (LS)

SCHEDULE OF WORKSHOP ON

WORKING MODELS IN BIOLOGY AT +2 LEVEL FOR ANDHRA PARDESH

Duration: 07-01-2002 **Venue: Regional Institute of Education, Mysore-570 006**

Day/Date	9am to 11.30 am		11.45 am to 12.45 pm		2.00 pm to 3.30 pm		3.45 pm to 5.30 pm
07-01-2002 Monday	Registration/Inauguration by principal	Tea Break	Approach paper Presentation/objective of the workshop to be specified by the programme co-ordinator	Lunch Break	Discussion on the identified concepts and the working models prepared in the previous workshop	Tea Break	Group formation for selecting the themes/concepts for preparation of working models and related group work
08-01-2002 Tuesday	Allocation of preparation of working models to groups assisted with resource persons		Group work on the preparation of working models with the resource persons		Group work 1 GVG/GGN(IRPS) +DMS Teachers (IRPS)		Group work II MZS/SPK/LS/AS (IRPS) +DMS Teachers (IRPS)
09-01-2002 Wednesday	Group work GVG/GGN (IRPS) +DMS Teachers (IRPS)		MZS/SPK/LS/AS (IRPS) +DMS Group work Teachers (IRPS)		Group work GVG/GGN (IRPS) +DMS Teachers (IRPS)		MZS/SPK/LS/AS (IRPS) +DMS Group work Teachers (IRPS)
10-01-2002 Thursday	Discussion on each of the working model under preparation Group work MZS/SPK/LS/AS/IRPS) +DMS Teachers (IRPS)		Discussion on each of the working model under preparation Group work GVG/GGN (IRPS)		Discussion on each of the working model under preparation Group work MZS/SPK/LS/AS/IRPS) +DMS Teachers (IRPS)		Discussion on each of the working model under preparation Group work MZS/SPK/LS/AS/IRPS) +DMS Teachers (IRPS)

11-01-2002 Friday	Preparation of working models and discussion for improvement of the model	Tea Break	Preparation of working models and discussion for improvement of the model	Lunch Break	Presentation of the working models	Tea Break	Presentation of the working models
12-01-2002 Saturday	Group work for improvement and finalisation of the working model		Group work for improvement and finalisation of the working model		Group work		Group work
13-01-2002 Sunday	Group work MZS/GVG/LS/SPK/ AS/GGN		Group work MZS/GVG/LS/SPK/ AS/GGN		Group work MZS/LS/SPK/AS		Group work GVG/GGN
14-01-2002 Monday	Group work GVG/GGN		Group work MZS/LS/SPK/AS		Discussion and finalisation of the working model by each group Group work for the refinement		Discussion and finalisation of the working model by each group Group work for the refinement
15-01-2002 Tuesday	Group work to refine the working model and presentation of the working model		Group work to refine the working model and presentation of the working model		Group work to refine the working model and presentation of the working model		Group work to refine the working model and presentation of the working model
16-01-2002 Wednesday	Finalisation and vetting of the model, presentation of the working models by all groups		Finalisation and vetting of the model, presentation of the working models by all groups		Finalisation and vetting of all the working models in Botany/Zoology		Valedictory Function TA/DA disbursement

IRPS –Internal Resource Persons; DMS-Demonstration and Multipurpose School; GVG- Dr.G.V.Gopal; GGN-Dr.Geetha G.Nair, SPK-Dr. S.P.Kulkarni; MZS-Dr. M.Z.Siddiqui; LS: Dr.L.Srikantappa; AS: Dr.A.Sukumar

WORKING MODELS

Photosynthesis

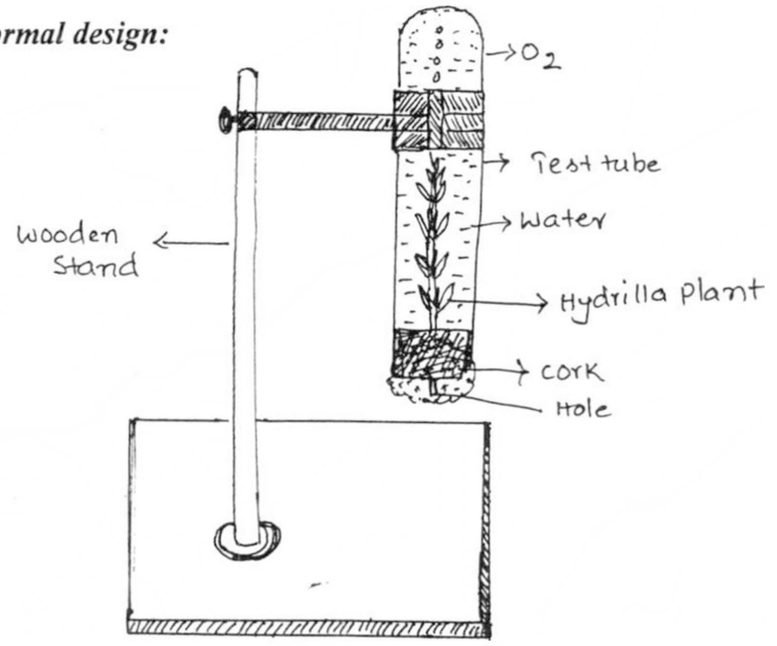
Aim of the model:
To demonstrate that oxygen is evolved during the process of "Photosynthesis".

Objective of the model:

To find out

- during Photosynthesis, O_2 is evolved.
- To find out the gas evolved during photosynthesis is O_2.
- To find out, light is essential for photosynthesis.
- To illustrate the role that $CaCO_3$ initiate photosynthesis process.
- To find out O_2 is absorbed by pyrogallol solution.

Normal design:



Materials required:
Test tube, wooden stand (wood), *Hydrilla* plant, cork, cotton.

Approximate cost:

Item	**Rs.**
Test tube	10.00
Wooden stand to be fabricated	50.00
Cork	10.00
Cotton	
Pyrogallol solution	
Total	

Most of them are available in chemistry lab of a school.

Preparation of Working Model:

Procedure:

Place a green *Hydrilla* plant in large/small test tube filled with water. Invert the test tube, plug the cotton and cork, which is having a hole. Carefully invert the test tube with *Hydrilla* plant is inserted, so that there is no leaking of water. Small O_2 bubble will start coming. We place this set up in sunlight. If bubbles are not coming, add a pinch of sodium bicarbonate to initiate the process of photosynthesis.

Observation:

When exposed to bright light, a stream of small gas bubbles is seen to rise upwards through the cut ends of stems and collect at the upper end of the test tube displacing the water. If the apparatus/working model is taken to dark/semi-dark room covered with black paper, no bubbles will be seen coming out of the *Hydrilla* plant.

Inference:

That the gas is oxygen can be proved in the following way. Close the test tube with thumb and add 5% pyrogallic acid to it. Oxygen absorbed by pyrogallol solution is formed. Pyrogallol solution absorbs oxygen. The gas in the tube therefore is oxygen.

Mitotic cell division

Aim of the Model:
To demonstrate mitosis in the classroom situation.

Objectives:

(i) To find out different stages of cell-division.
(ii) During cell division at different stages the nucleus and cytoplasm will undergo certain changes.
(iii) To find out/observe the changes in interphase, prophase, metaphase, anaphase and telophase.
(iv) To find out chromosomal behaviour at each stage.
(v) To find out the cell wall formation during Telophase.

Working principle:
The magnetic pieces will represent the centromeres of chromosomes with the chromatids of chromosomes being represented by loop of wires. The different stages of mitosis are manifest on a single template of cardboard or asbestos by moving the magnetic pieces and the wires coming into alignment as chromatids. Two magnetic pieces at either end of cell stand for spindle poles (of plant cell) and spindle itself is made up of fuse wires.

Materials required:
Magnetic pieces (small ones) – 25 nos; Metal wires (thick)- 1 packet; Cardboard base : Thermocol – 1 sheet; fuse wire – 1 packet.

Cost estimate:

Item	Rs.
Magnets – 25 approx	
Metal wire – 1 packet	
Fuse wire – 1 roll	
Cardboard (good quality thick and hard)	
Thermocol	
Total	

Small bulbs, metal wires, 6 connections, thermocol, battery.

- Chromosomes (12) can be formed with the help of coloured bulbs in plastic tubes.
- All stages to be arranged on the template.
- At different stages of mitosis, the correct positioning/location of chromosomes to be lighted up.

Description/ Preparation of the Working Model:

Mitosis is a type of cell division which results in the formation f 2 daughter cells. These cells are identical to the parent cells and have the same number of chromosomes. Mitosis occurs in vegetative cells. It can be best observed in onion root tip.

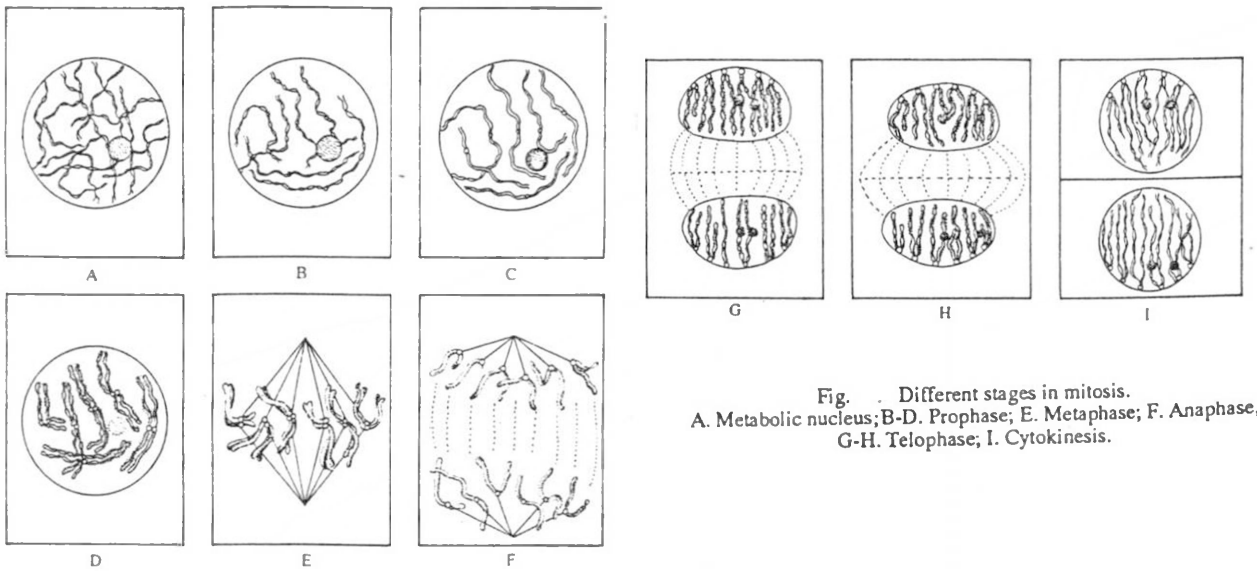


Fig. . Different stages in mitosis.
A. Metabolic nucleus; B-D. Prophase; E. Metaphase; F. Anaphase, G-H. Telophase; I. Cytokinesis.

Different stages in mitosis.
A. Metabolic nucleus: B-D Prophase; E-Metaphase; F. Anaphase, G-H Telophase, I. Cytokinesis

Interphase:

The following characteristics are seen:

1. Cell is metabolically most active, DNA replication occurs during this period.
2. Nuclear membrane and nucleolus are very distinct.
3. Chromosomes are in the form of chromatic network and individual chromosomes cannot be seen separately.
4. The chromosome appears double-stranded i.e. made of two chromatids.

Prophase:

1. NM and nucleolus disappear.
2. Chromosomes coiled and shortened and more distinct – chromosome shows chromatids, primary and secondary constriction and centromeres.
3. Specific fibres appeared.

Metaphase:

1. NM and nucleolus disappeared.
2. Chromosomes move and gather near the equatorial plate and they are attached to the spindle fibres.
3. mitosis is anastral mitosis as centriole is absent and aster is not found in plant cells.
4. Each chromosome shows two chromatids, centromere, primary constriction, enchromatic and heterochromatic regions, chromomeres, etc.

Anaphase:

1. The centromere of each chromosome gets split into two.
2. Chromosome of each chromosome gets split into two. Each chromatid now bears one centromere each.
3. The chromosome becomes shorter and thicker.
4. Separated chromatids are now pulled towards the opposite poles due to contraction of spindle fibres.
5. During movement, each chromosome shows characteristic shape which is dependent on the position of centromere.

Telophase:

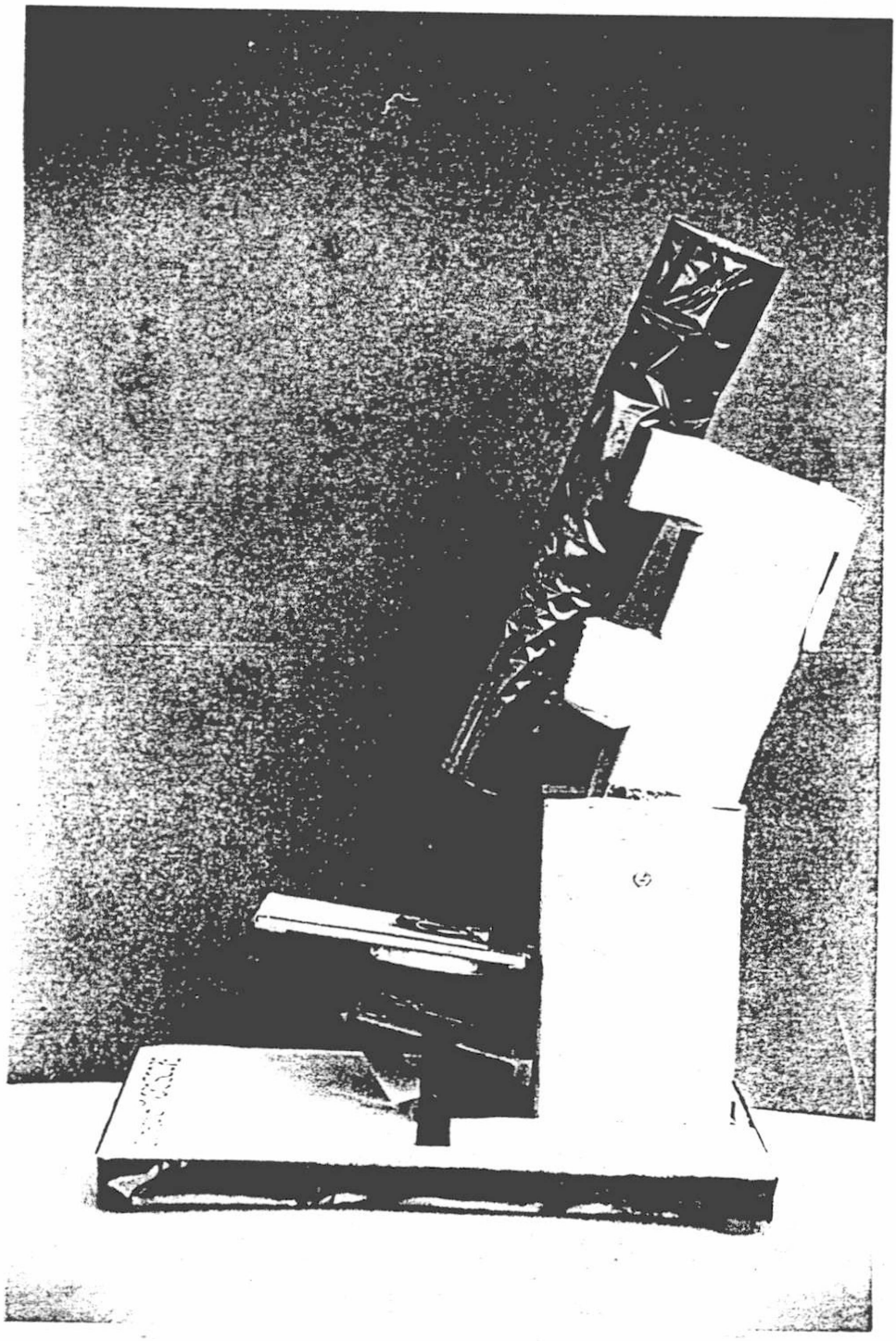
The following characteristics are seen :

1. Chromosomes are present at both the poles of a parent cell.
2. Chromosomes become thread-like, form chromatic network and lose their individuality.
3. Groups of chromatic network are surrounded by nuclear membrane. Nucleolus is also present.
4. Thus two fully formed nuclei, one at each pole are present in the parent cell.
5. Spindle fibres are absent.

Cytokinesis:

The following characters are seen :

1. In this stage, cytoplasm divides into two. It results in the formation of two daughter cells.
2. Formation of a cell plate in the equatorial region.
3. Cell plate formation starts in the center of the cells and progresses towards the periphery.
4. Through daughter cells with organelles formed.
5. Number of chromosomes in each daughter cell is equal to the number present in the parent cell.



Microscope

Aim of the model:
Microscope (compound and dissection microscope).

Objectives:
(i) To understand the structure of compound microscope.
(ii) To make the students aware of resolving power and observation of magnified objects which are not visible to nacked eye.
(iii) To understand the working principle of a compound microscope.
(iv) The operational skills in handling a compound microscope.

Materials required :
Wooden planks – size 2½ × 10 cm length, concave lens – 2 nos, convex lens – 2 nos, mirror – 1 no, wooden strips/screw, cardboard, wrapping paper – colour paper, cotton.

Unit of measurements:
The resolving power of our naked (unaided) eye is 0.1 mm (=100 microns; one micron (μ) is equal to (1/1000 mm). It means objects smaller than 0.1 mm will not be visible to us and objects or points separated by a distance of less than 0.1 mm will appear as one to the human unaided eye. Majority of cells measure from 1 mm to 0.1 micron and cell organelles are still smaller. Therefore, these are measured in *micron*(μ), *millimicron*(mμ), *nanometer* (mm), *Angstrom* (Å). Their values are represented in the table.

Table : Linear units of measurement used in cytology

Unit	Symbol	Value
1 Centimeter	cm	10 mm or 1/100 meter = 10^{-2} meter
1 Millimeter	mm	1000 μ or 1/10 cm = 10^{-3} meter
1 Micron or micrometer	μ or μm	1000mμ or 1/1000 mm = 10^{-6} meter
1 Millimicron or 1 Nanometer	mμ nm	10□ or 1/1000 μ = 1×10^{-9} meter
1 Angstrom	Å	0.1 mμ or 0.1 nm or 1×10^{-10} metres

Resolving power:
The problem of magnification is considered in terms of resolving power. The ability to distinguish neighbouring points or objects as distinct and separate entities is called *resolving power*. The microscope is the instrument that magnifies as well as resolves the objects seen through it. If the resolving power of a microscope is low, the images of two closely placed points will overlap and only a blurred single point will be visible. However, with microscope of high resolving power, these two points will appear sharply distinct.

The resolving power of a microscope depends upon the wavelength of illumination λ and light gathering capacity of objective lens (called numerical aperture – NA). This is represented by the formula $R = \frac{0.61\,\lambda}{NA}$. By using illuminating agents of different wavelengths, the resolving powers of microscopes have been increased and it is now possible to see cell structure as small as one billionth of a meter (□). Depending upon the source of illumination, the microscopes are – ***light microscope, electric microscope, X-ray microscope, ultraviolet and fluorescent microscopes.***

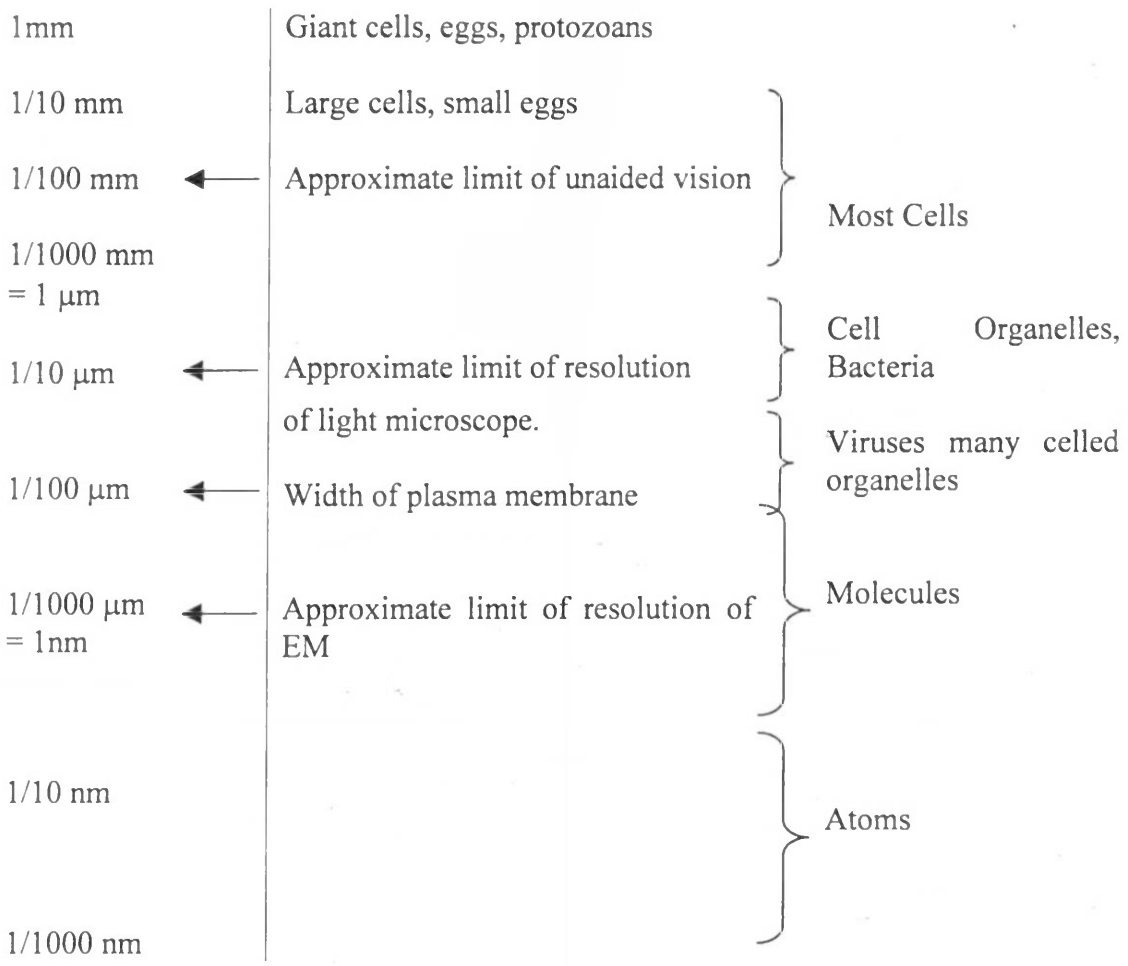


Diagram to show various units of measurements and the Measurements of various biological structures

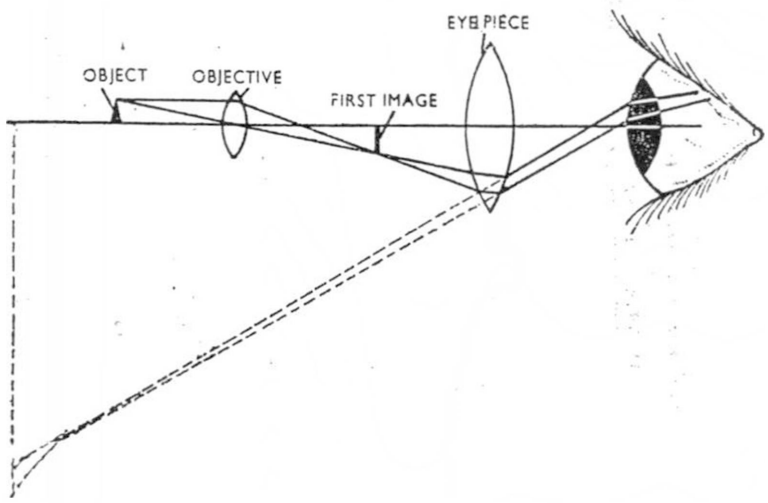
Description and design of the light microscope:

Until 1940, most of our knowledge concerning the structure was obtained by the compound light microscope. Till now, it is the popularly used classroom microscope. The operational light microscope was constructed by Janssen Hans in 1590. The essential parts of present-day light microscope are (i) an *objective lens system* that forms the initial image of the object and enlarges it, (ii) an *ocular lens system or eye piece* that forms image of the image and thus further magnifies the image, (iii) the *condenser* that focuses light rays on the specimen.

The source of illumination in compound light microscope is visible light. The wavelength of visible spectrum of light ranges from 4000 Å – 8000 Å. Taking the average as 6000 Å, the resolving power of a light microscope will be 3000 Å or 0.3 micron. It means if visible spectrum of light is used for illumination, even the best objective lens cannot resolve structures smaller than 0.3 μ.

The structures are visualized as a result of differences in light absorption by different portions of the object. In untreated cells, the differences in light absorption are less. Therefore, fixation and staining are employed to improve differentiation of structural components.

An Angstrom (Å) is equal to 1/10,000 of a micron (μ) or 1/254,000,000 of an inch.



Formation of image by light microscope

Description of the subject:

Cytological studies present two main problems, the exceedingly small size and the transparent nature of cell and its components. Majority of cells are too small to be seen with the naked eye. It was only after the invention of microscope that the existence of cell was noticed. Since then the search continues for new instruments and techniques that can provide more and more details of the cell and its organelles. Microscopy (the advent of different types of microscopes) has opened a new microworld ordinarily invisible to us.

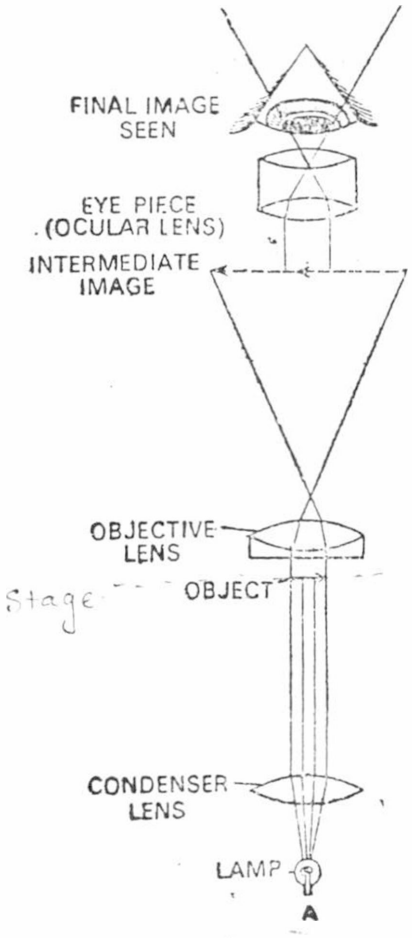
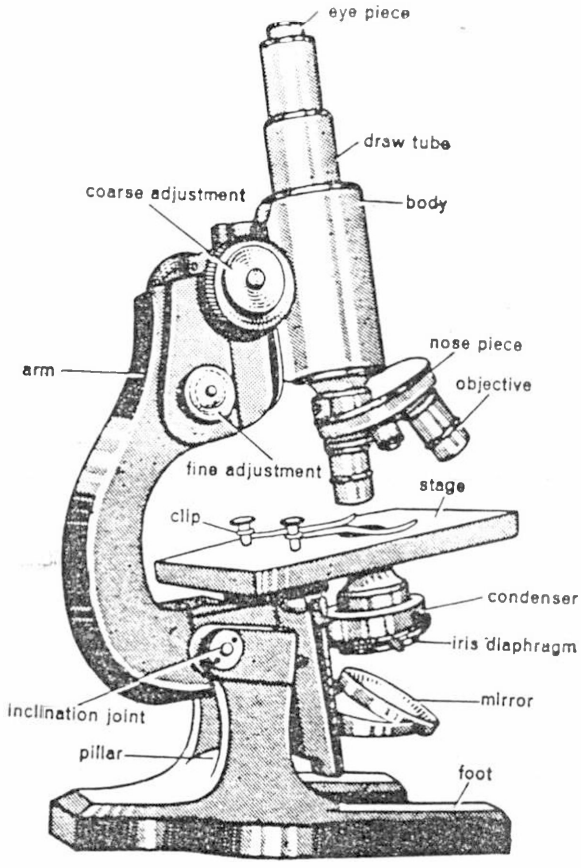
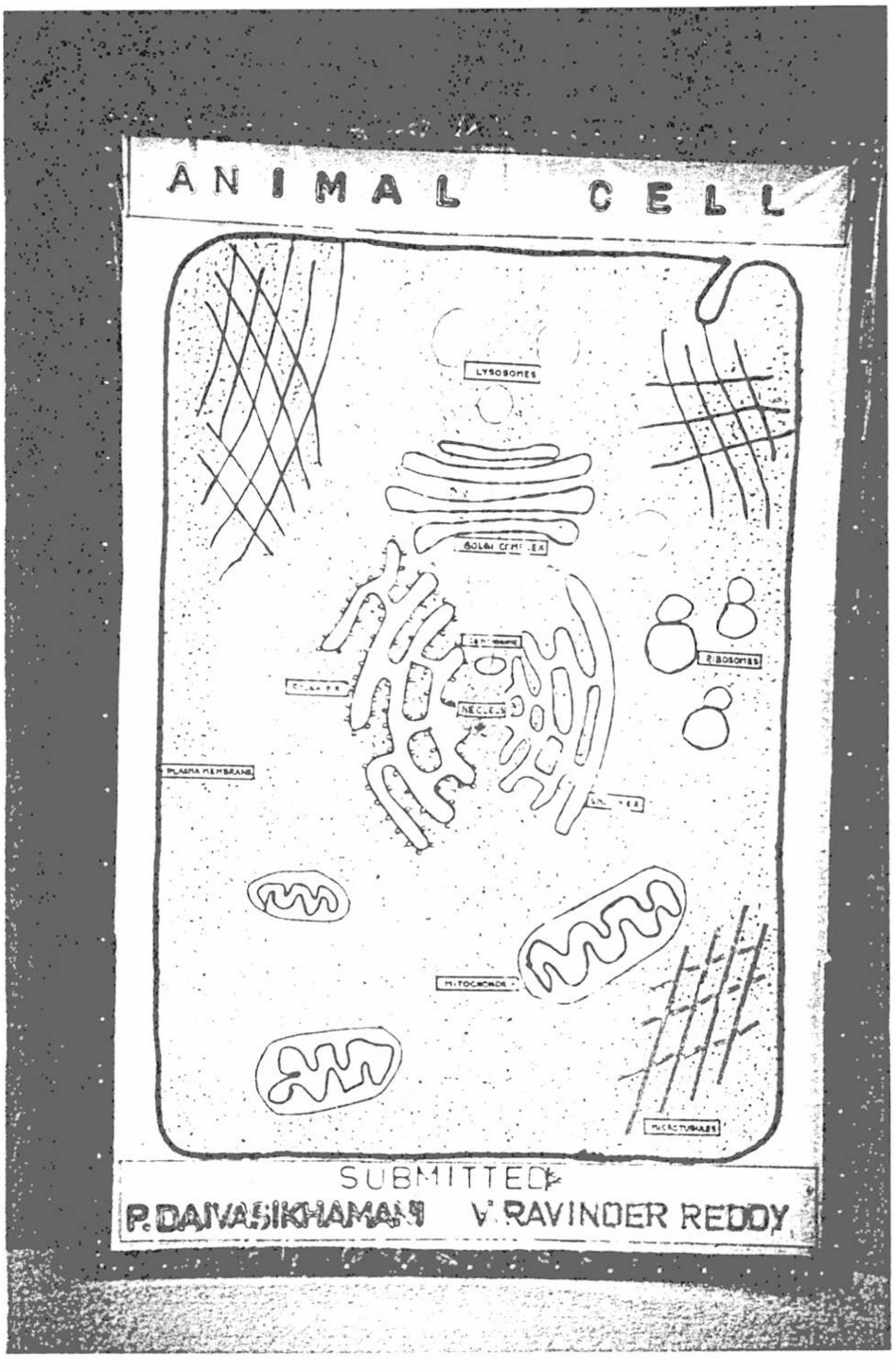


Fig. Diagram to compare the formation of image in (A) light microscope

Diagram to compare the formation of image in (A) light microscope



Compound Microscope


ANIMAL CELL
LYSOSOMES
RIBOSOMES
NUCLEUS
PLASMA MEMBRANE
MITOCHONDRIA
SUBMITTED
P. DAIVASIKHAMANI
V. RAVINDER REDDY

Cell and Cell Organelle

Aim of the Model: **Cell and cell-organelle**

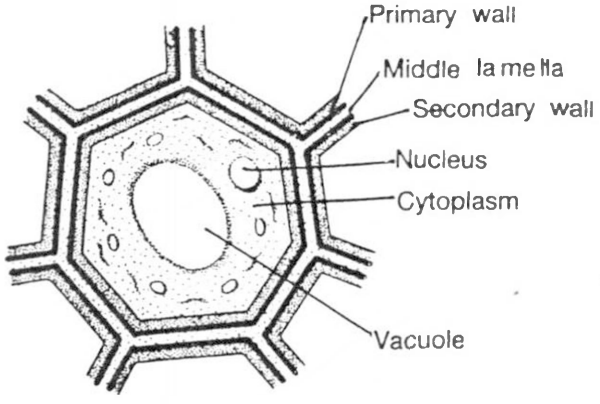
Objectives of the Model:

(i) Students acquire knowledge about the cell in general and its different organelle.
(ii) Students also learn about different functions of cell-organelles.
(iii) Understanding the cell and its functions and its activities in general.
(iv) Understand the cell structure, chemistry and functions of cells.

Materials Requried:

1. Iron rods – thin gauge – 20 cm pieces.
2. Perchsheets plastic – hexagonal pieces (transparent) - 50 sheets
3. Iron wire - 30 cms.
4. Iron pieces with diagram of cell organelle – 10
5. Bulbs, bulb holders – 20 numbers.
6. Wire – 20 metres
7. Batteries – 5 numbers
8. AC/DC adaptor, plug pin.

Approximate Cost: **Rs.2000/- only.**



A diagram of a typical cell showing position of cell wall and different components.

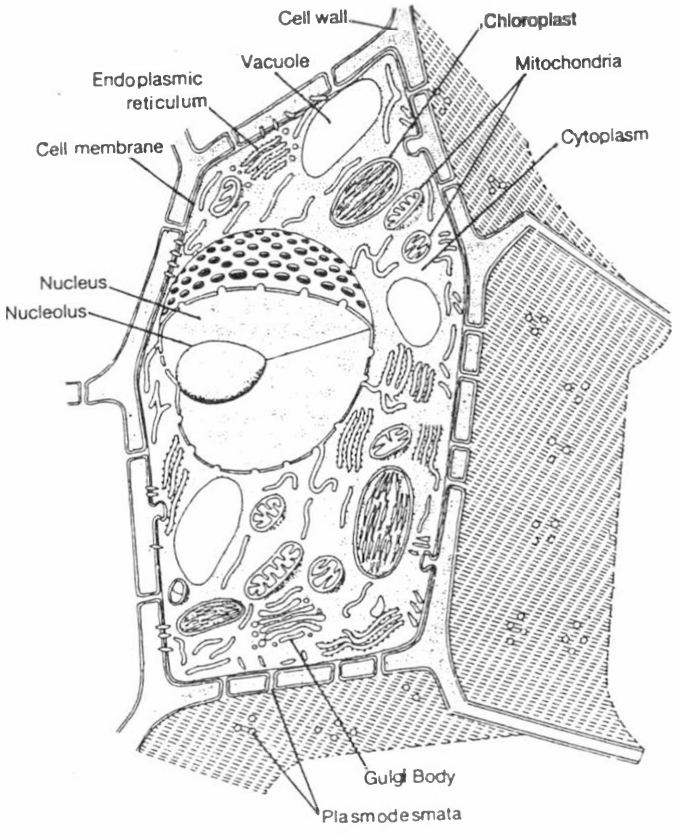


Fig. A generalised diagram of a plant cell based on electron microscopic studies. The perforations on the wall indicate the sites of plasmodesmata.

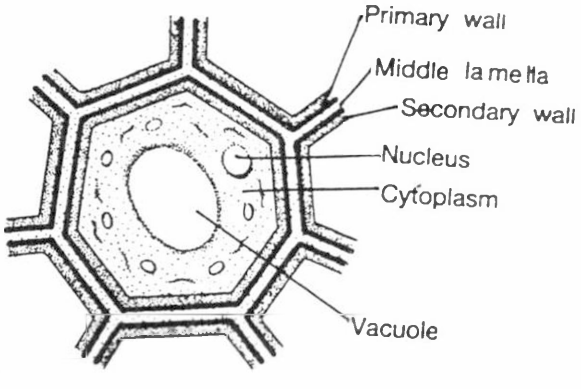


Fig. . . A diagram of a typical cell showing position of cell wall and different components.

Eukaryotic cell structures and their functions

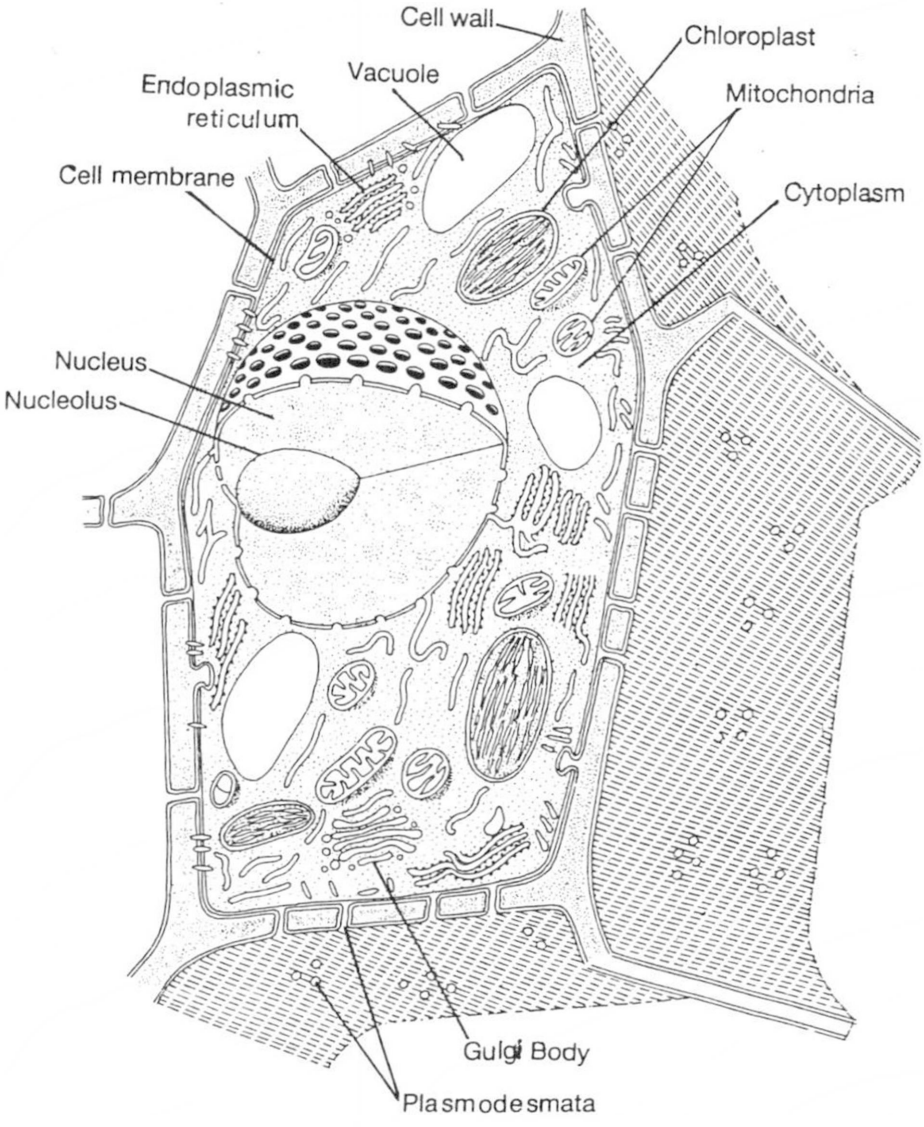
	Cell Organelle	Structure	Functions
I. Cell Membrane System			
1.	Plasma membrane	Formed of lipid bilayer sand-witched between two protein layers.	(i) Regulates passage of materials in and out of cell; (ii) Exocytosis and endocytosis; (iii) pro-tection; (iv) main-tenance of cell shape; (v) cell communication.
2.	Cell wall (only in plant cells)	Thick, rigid, non living; Formed of cellulose	Protection
3.	Cell coat	Glycoproteins	(i) Cell interacti on (ii) Cell recognit ion
II. Cytoplasm			
1.	Cytosol	Colloidal substance with soluble enzyme.	Glycolysis
2.	Cytoskeleton	(a) Microfilaments dispersed in cytosol. (b) Microtubules – membranous, hollow, spirally arranged tubules, formed of protein-tubulin.	Cell motility Cell motility and cell shape (rigidity); components of centrioles, cilia and flagella.

III. Endomembrane System (Double membrane organelle)			
1.	Endoplasmic reticulum (ER)	Network of internal membranes, traversing the cytoplasm; a system of tubules and versicles.	Intracellular transport.
	a) Smooth (SER)	Without ribosomes	Transport
	b) Rough (RER)	Studded with ribosomes	Manufacture and transport of proteins.
2.	Golgi Complex	Stacks of flattened sacs or cisternae, small vesicles and secretory vacuoles.	Package secretions; Forms lysosomes.
3.	Nuclear membrane	Structure similar to plasma membrane.	Nuclear permeability; protection; and isolation of nucleoplasm from cytoplasm.
IV. Double Membrane Organelle			
1.	Mitochondria (Power House)	Sac bounded by two membranes, inner membranes folded into cristae; contain respiratory enzymes.	Cell respiration and release of energy.
2.	Plastids	Double membrane structures.	
	a) Chloroplasts	Contain disc like thylakoides with chlorophyll.	Photosynthesis (Trap solar energy).
	b) Chromoplasts	Contain pigment	Gives colouration.
3.	Vacuoles	Membranous sacs	Store ingested materials, cellular secretions or wastes.

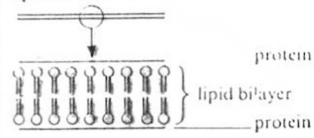
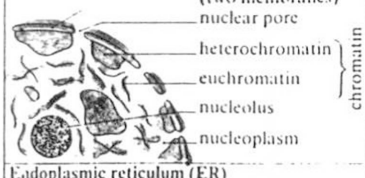
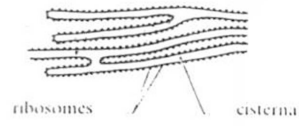
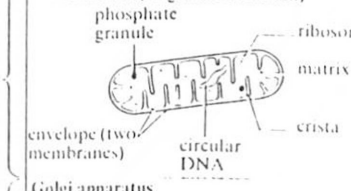
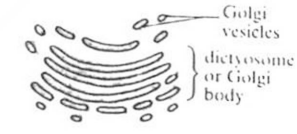
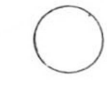
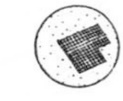
V. Single Membrane Organelle			
1.	(suicide bags)	Membranous sacs containing hydrolytic enzymes.	Carry out intracellular digestion of food, digestion of ingested bacteria and auto dissolution of cell contents.
2.	Peroxisomes	Membranous sacs containing oxidative enzymes.	Carry on metabolic reactions and split of H_2O_2.
3.	Glyoxisomes.	Membranous sacs containing oxidative enzymes.	Site of glycoxylate cycle.
VI. Nonmembranous Organelle			
1.	(Factories of cells)	Granules of RNA and protein, attached to ER membranes or in the cytosol.	Protein synthesis.

VII. **Microtubular Organalle (Non membranous)**			
1.		A pair of hollow cylinders located in the region – centrosome; formed of nine triple microtubules.	Formation of spindle during cell-division; Give rise to basal bodies.
2.	Cilia	Hollow tubular structures with 2 central and 9 peripheral microtubules, present on the cell surface.	Movement of material outside the cell and cell movement.
3.	Flagella	Same as cilia but longer.	Cellular locomotion.
4.	Basal bodies	Same as cilia and flagella, present at their bases.	Co-ordinate movement of cilia and flagella.

VIII. Nucleus (control room of cell)			
1.		Network of long thread like structures composed of DNA and protein.	(i) Controls cell metabolism; (ii) transmits characters from parents to offsprings.
2.	Nucleolus	Rounded granular body inside the nucleus; contains RNA and protein.	Synthesis of subunits of ribosomes.



A generalised diagram of a plant cell based on electron microscopic studies. The perforations on the wall indicate the sites of plasmodesmata.

	Diagram	*Structure*	*Functions*
cell surface membrane	**Cell surface membrane (plasmalemma)**  	Two layers of lipid (bilayer) sandwiched between two protein layers	A partially permeable barrier controlling exchange between the cell and its environment
nucleus	**Nucleus**  	Largest cell organelle, enclosed by an envelope of two membranes that is perforated by nuclear pores. It contains chromatin which is the extended form taken by chromosomes during interphase. It also contains a nucleolus.	Chromosomes contain DNA, the molecule of inheritance. DNA is organised into genes which control all the activities of the cell. Nuclear division is the basis of cell replication, and hence reproduction. The nucleolus manufactures ribosomes.
endoplasmic reticulum	**Endoplasmic reticulum (ER)**  	A system of flattened, membrane-bounded sacs called cisternae, forming tubes and sheets. It is continuous with the outer membrane of the nuclear envelope.	If ribosomes are found on its surface it is called **rough ER**, and transports proteins made by the ribosomes through the cisternae. **Smooth ER**, (no ribosomes) is a site of lipid and steroid synthesis.
ribosomes	**Ribosomes**  	Very small organelles consisting of a large and a small subunit. They are made of roughly equal parts of protein and RNA. Slightly smaller ribosomes are found in mitochondria (and chloroplasts in plants).	Sites of protein synthesis, holding in place the various interacting molecules involved. They are either bound to the ER or lie free in the cytoplasm. They may form **polysomes** (polyribosomes), collections of ribosomes string along messenger RNA.
mitochondria	**Mitochondria** (sing. mitochondrion)  	Surrounded by an envelope of two membranes, the inner being folded to form cristae. Contains a matrix with a few ribosomes, a circular DNA molecule and phosphate granules.	In aerobic respiration cristae are the sites of oxidative phosphorylation and electron transport, and the matrix is the site of Krebs cycle enzymes and fatty acid oxidation.
Golgi apparatus	**Golgi apparatus**  	A stack of flattened, membrane-bounded sacs, called cisternae, continuously being formed at one end of the stack and budded off as vesicles at the other. Stacks may form discrete dictyosomes as in plant cells, or an extensive network as in many animal cells.	Processing in cisternae and transport in vesicles of many cell materials, such as enzymes from the ER. Often involved in secretion and lysosome formation.
lysosome	**Lysosomes** 	A simple spherical sac bounded by a single membrane and containing digestive (hydrolytic) enzymes. Contents appear homogeneous.	Many functions, all concerned with breakdown of structures or molecules. See text for role in autophagy, autolysis, endocytosis and exocytosis.
microbodies	**Microbodies** 	A roughly spherical organelle bounded by a single membrane. Its contents appear finely granular except for occasional striking crystalloid or filamentous deposits.	All contain catalase, an enzyme that breaks down hydrogen peroxide. All are associated with oxidation reactions. In plants, are the site of the glyoxylate cycle.

Plant and Animal Cells

Both plant and animal cells are eucaryotic cells having a well-organized nucleus and cytoplasmic organelles. These have many features in common but differ in the following characteristics:

Diagram showing differences between an animal and a plant cell

Structure of a typical animal cell as seen under electron microscope

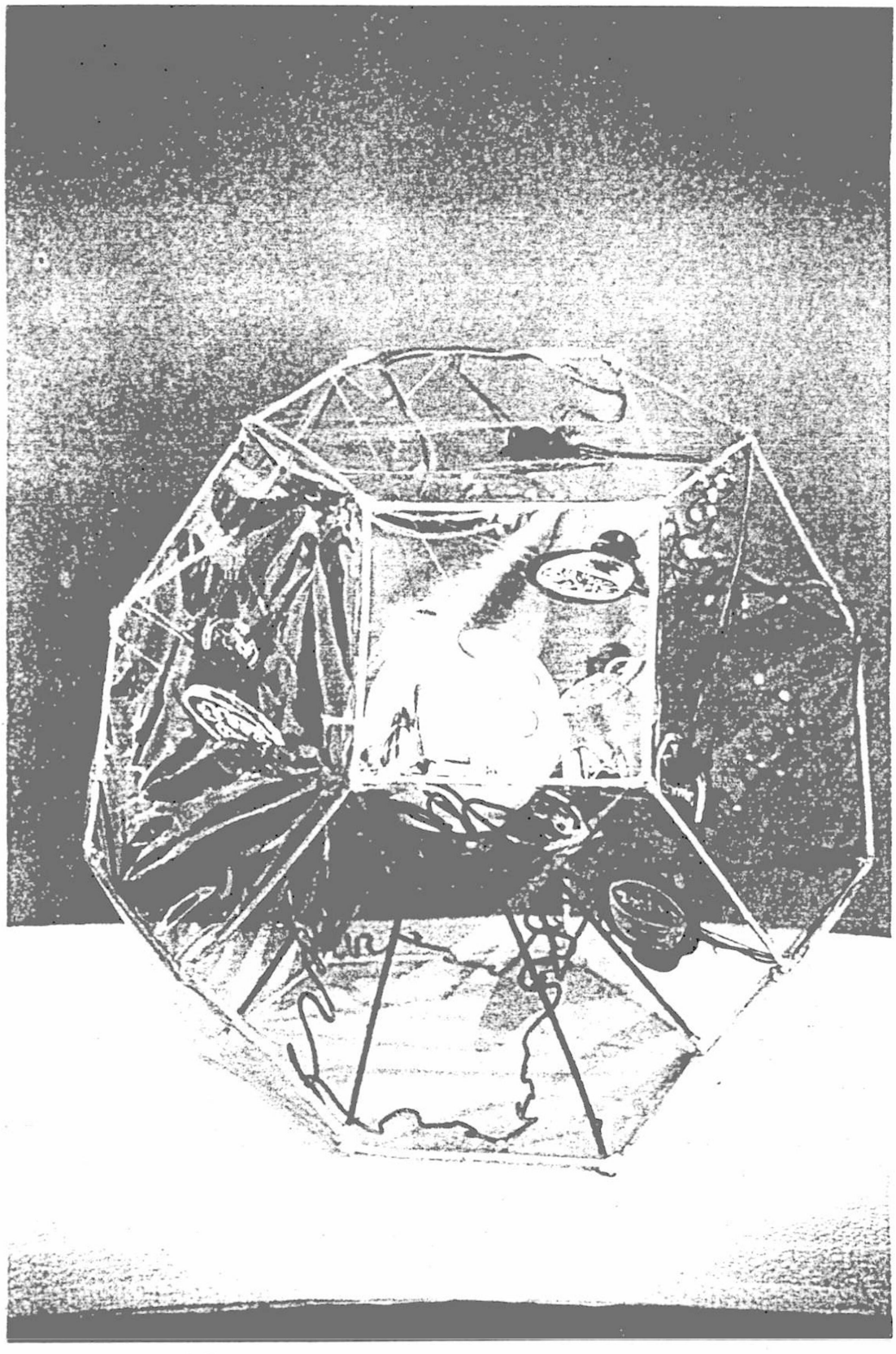
Organisation of Cells: A cell has three distinct regions (i) cell wall, (ii) protoplasm and (iii) vacuole. Cell wall and vacuoles have been considered as non-living components. The protoplasm consists of two important components, the cytoplasm and the nucleus. It remains externally bounded by cell membrane or plasma membrane. The cytoplasm contains several cell organelles such as plastids, mitochondria, endoplasmic reticulum, ribosomes, lysosomes, cilia, flagella, etc. A plant cell is distinguished from an animal cell in presence of (i) cell wall, (ii) plastids and (iii) vacuoles. An animal cell has centrosome which is not found in plants, except in few micro-organisms.

Cell Wall

Cell wall is the non-living component of the cell and is secreted and maintained by the living portion of the cell, called protoplasm. The synthesis of cell wall is controlled by Golgi bodies. A typical cell wall is composed of three different regions – (i) middle lamella, (ii) primary wall (1-3 μm thick and elastic) and (iii) secondary wall μm thick and rigid).

Middle Lamella

The formation of this layer starts in the telophase stage of cell division and is formed by deposition. It works as a cementing layer between the two daughter cells and is called middle lamella. It consists of Ca and Mg pectates (composed of chains of hexuronic acids). Pectic substances are a mixture of polygalacturons (D-galacturonic acid) and (D-Galacturonic Acid) and polysaccharides (neutral sugars). This common layer between the two cells may be dissolved with the help of pectolytic enzymes and the two cells are separated. This is evident during the loosening of mature ripe fruits, which is the result of the dissolution of middle lamella.



Cell

Aim of the model:
The working model of cell electrical model. All the cell-organelle or seen in a three-dimensional model.

Objectives :

- To acquire knowledge of different cell components.
- To explain the functions of different cell-organellae.
- To explain the position and structure of different cell organellae.
- To explain the three-dimensional model of cell.
- The make the students understand the formation of ES.
- It will also tell the surface of enzyme is specific.
- To know enzymes have different molecular shapes and isozymes inhibitors; Non-competitive and allosteric modulation.

Materials required:
Cardboard, bulbs, wire, board with structure and function of different cell organelle.

Cost of the materials:

Item	Rs.
Cardboard	2,000.00
Bulbs (20 Nos.)	200.00
Wire – 1	100.00
Batteries – 6	100.00
Soldering iron	120.00
Transparent perch sheets	200.0
Cellophane tape – 1 roll	40.00
Thread - 1 roll	20.00
Cardboard – 3mm × 7 feet long	250.00
Total	3,030.00

Preparation and design of principle of the working model :

Whenever a teacher wants to explain a cell-organelle, the bulbs will glow there, thus teacher can effectively explain about that particular part giving a 3-dimensional view and its position in cell. The whole cell frame was made with transparent perch sheets and iron rods and cell organelles were kept inside the bulbs to give a real feel of the situation .

Enzyme Action

Aim of the model: Enzyme Action

Objectives :

1. The teachers are able to understand the mode of enzyme action.
2. They will understand Lock-and key hypothesis.
3. They will understand relationship between substrace and enzyme molecules.

Materials Required:

Electrical wire/bulbs (small) – 4 Nos, wooden board/wood pieces.
Thermocol sheets – 5 lay sheets 4" × 6" size.
Colour papers 4" × 6 ½ " size 10 sheets (green, orange, green, red or any other colour).
Fevicol, Fevistic – 2 tubes.

Approximate cost: Rs.2000/-

Description of the model/design:
The bulb will glow only when specific site of the substrate and enzyme are placed in proper position /orientation. Then only enzyme and substrate complex from bulb glows, otherwise the bulb will not glow.
Electronic model.

Enzyme action:

In order to explain the mode of action of enzyme, Fischer (1898) proposed a Key-Lock Theory or Lock-Key hypothesis. It was later advanced by Paul Fildes and D.D. Woods. They proposed that as a particular lock can be opened by a particular key, in the same way a particular enzyme acts on a particular substrate. *The substrate molecules get fitted* upon enzyme molecule and decomposes into products, i.e. this theory depends upon physical contact between substrate and enzyme molecules.

The theory is supported from the study of competitive inhibition.

Nature of Enzymes

Enzymes are biocatalysts produced in the protoplasm. They are supposed to act withint he cell where they have been formed but may diffuse out of the cell to act upon some outside substrates. The enzmes which act within the cell are referred to as intra-cellular enzymes or *endoenzymes* and the other one is called *extra-cellular enzymes* or *exoenzymes.* Majority of enzymes are endoenzymes. Enzymes can be isolated in pure state without affecting their catalytic properties. Some of the enzyme properties are described below:

1. **Enzymes are colloidal in nature:** Because of being colloidal in nature enzymes provide large surface area for reaction to take place. The system

of enzymes in water affords surface area for catalytic reaction. Being colloidal, enzymes are hydrophilic in nature and form hydrosols in the free state.

2. **Enzymes can react with both acidic and alkaline substances.** The presence of protein (being amphoteric in nature) as major parts of enzymes enable them to react with both acidic and alkaline substances (cations and anions).
3. **Enzymes show sensitivity.** They are inactivated by all those factors and substances which can precipitate or denature the protein. The degree of denaturation will depend upon degree of hydration.
4. **enzymes are thermolabile.** They are heat sensitive (See 'Factors affecting enzymatic activity').
5. **Enzyme activity can be inhibited.**
6. **Enzyme activity can be accelerated.** Such substances which accelerate enzyme activity are called activators. Most of them are inorganic salt or ions such as Mn, Ni, Mg, Cl etc. and are required in a low concentration. Some of these ions make enzymes specific and may help in maintaining optimum condition necessary for the maximum enzyme activity. Occasionally these activators function as protectors or anti-inhibitors.
7. **Enzymes are organic catalysts.** Enzymes are organic catalysts very much similar to inorganic catalyst. They only speed up the rate of reaction and never change the equilibrium of reaction. They are required in very small quantity yet they are capable of bringing about a change in large amount of substrate.
8. **Enzyme molecules are too much greater.** Enzyme molecules are too much greater in size than the substrate molecule.
9. **Enzymes are specific.** Nearly 700 different types of enzymes have been isolated so far and it has been found that they are specific in nature.

Enzymes are specific in their action, i.e. they react with only particular substrate. This type of nature of enzymes is called the specificity of enzymes. This important feature of enzyme can be divided as follows :

(i) ***Group specificity***. An enzyme may be active for a general group of compound e.g. hexoses may be phosphorylated by kinase and ATP. It is called ***absolute specificity.***

(ii) ***Stereo specificity.*** Enzymes have specificity to a D or L optical or structural isomers.

$$\text{Amino Acid} \xrightarrow[\text{L-amino acid}]{O_3} \alpha\text{m- keto acides} + NH_3 + H_2O$$

Kinase

(Here D-amino acid kinase is not used).

Some enzymes also show specificity to cis-trans isomers, e.g. fumaric acid cis and trans isomers.

10. **To a great extent enzyme activity is controlled by pH.** (For details see 'Factors affecting enzyme activity').

11. Enzymes lower down the energy of activation.
Mode of Enzyme Action

Michaelis and Menton (1913) while studying the hydrolysis of sugar by invertase evolved a theory on mode of enzyme action. They considered that enzymes have certain active sites for the attachment of substrate molecule where an enzyme can form an intimate relationship with the substrate. According to the theory they proposed, an enzyme forms a weakly bound compound with substrate which on hydrolysis decomposes into the reaction products.

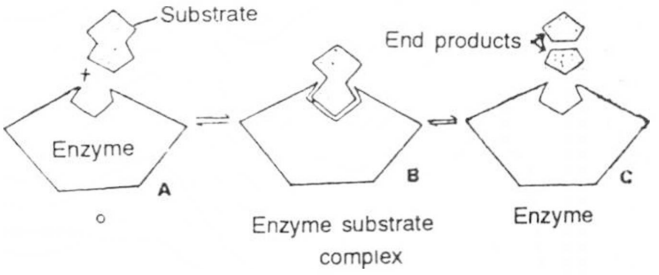


Fig. Diagrammatic representation of enzyme substrate complex theory. A-enzyme going to combine with substrate, B-enzyme substrate complex is formed and C-end products are formed and released from enzyme.

In simple form theory can be represented as follows :

Enzyme + substrate → Enzyme-substrate → End products + enzyme complex.

They applied equation kinetics of enzyme while discussing about mode of action. It can be explained as follows:

$$E + S \underset{K_2}{\overset{K_1}{\rightleftharpoons}} ES$$

(where E = enzyme; S = substrate; ES = enzyme substrate complex; K_1 = velocity constant of the formation of ES and K_2 = velocity constant of dissociation of ES).

$$E + S \underset{}{\overset{K_1}{\rightleftharpoons}} ES \xrightarrow{K_3} P + E$$

(where K_3 = velocity constant for decomposition of the complex ; P = end products).

Considering these facts Michaelis and Menton derived the following formula.

$$Km = \frac{K_2 - K_3}{K_1}$$

This Km is known as *Michaelis Constant*. Km value is characteristic for each enzyme substrate system and if the same enzyme attacks more than one substrate, its value gives a useful comparison of the relative affinities for the different substrates. Lower the Km value more the affinity. When velocity of reaction is half of the maximum velocity, Km is equal to the concentration of the substrate. Substrate concentration is expressed in moles per litre.

Michaelis and Menton theory has not been found universally true, though recently intermediate enzyme-substrate compound from the reaction mixture has been isolated (acetyl coenzyme A in the citric acid respiration cycle).

In order to explain the mode of action of enzyme, Fischer (1898) proposed a 'Key-lock theory' which was later advanced by Paul Fildes and D.D.Woods. They proposed that as a particular lock can be opened by a particular key in the same way, particular enzyme acts on particular substrate. The substrate molecule gets fitted upon an enzyme molecule and decomposes into products, i.e. this theory depends upon physical contact between substrate and enzyme molecules.

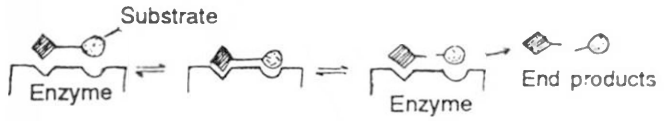


Fig. Diagrammatic representation of key-lock theory.

Diagrammatic representation of key-lock theory

The theory is supported from the study of competitive inhibition. In this case, the active site of the enzyme is blocked by another substance which has near about the same structure as that of substrate as a result of which activity of enzyme is lost.

The other most important role which enzymes play during reaction is that *"they lower down the energy of activation"*. Suppose A is spontaneously getting converted into B, firstly in absence of an enzyme and secondly in presence of an enzyme. In given number of molecules of A at a specific temperture, they have certain kinetic energy. Some are poor in energy and others are rich. Before converting A ⟶ B, the molecules of substrate A must surmount a required kinetic energy. The kinetic energy of A is higher than B. So only few energy-rich molecules can get converted into product B. *The energy that is required for A to react and get converted into B is called the activation energy of reaction.*

An enzyme will lower the activation energy of reaction. The enzyme reacts with the energy-rich and energy-poor molecules and forms an intermediate complex. This complex again breaks into product and enzyme. If the activation energy of the formulation of this complex is low, many molecules can react and participate in reaction. In this way, activation energy is lowered by the enzyme but in this action equilibrium is never altered. It remains the same.

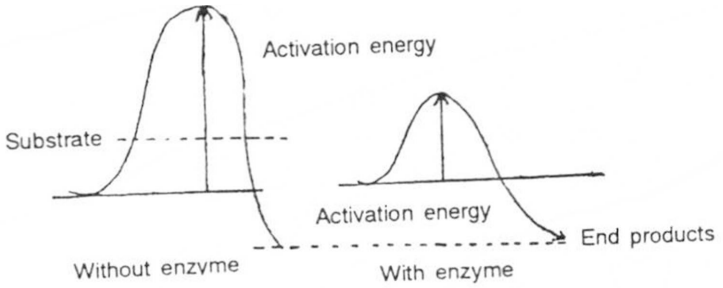
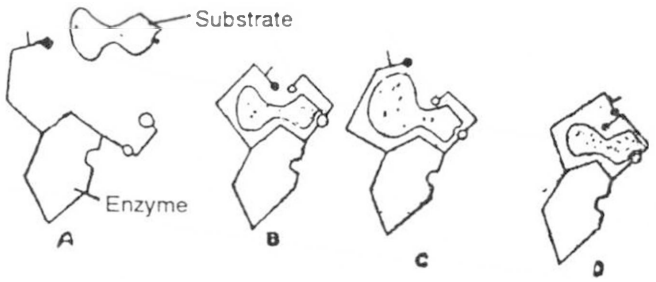


Fig. Diagram showing lowering of energy of activation in presence of enzyme.

Diagram showing lowering of energy of activation in presence of enzyme

However, modern methods such as isotope method, enzymatic hydrolysis, paper chromatography, electrophoresis, X-ray diffractions etc. have revealed certain phenomena which cannot be correctly explained on the basis of Key lock theory. It is presumed by certain scientists that the enzyme protein does not retain its original shape and structure in minute details. Not only this, but Koshaland reported certain fine geometrical alterations of the active centers of enzyme protein so that perfect fitting with substrate may be achieved. At this point, Michaelis-Menton theory of loose complex of substrate-enzyme suits well which makes catalysis possible. From this comes a name "induced fit-theory" which agrees with modern concept of induction. According to this theory, the active centers of the substrate and of the enzyme fit into each other and they may combine to form an active complex.



Specificity of enzyme and substrate : A, B – show good fit condition between Substrate and reactive groups of the enzyme; C, D - conditions show poor Fit between substrate and reactive groups of enzyme and hence no reaction. Spheres represent cofactors and reactive groups (active sites) of the protein molecule (after Koshaland 1963).

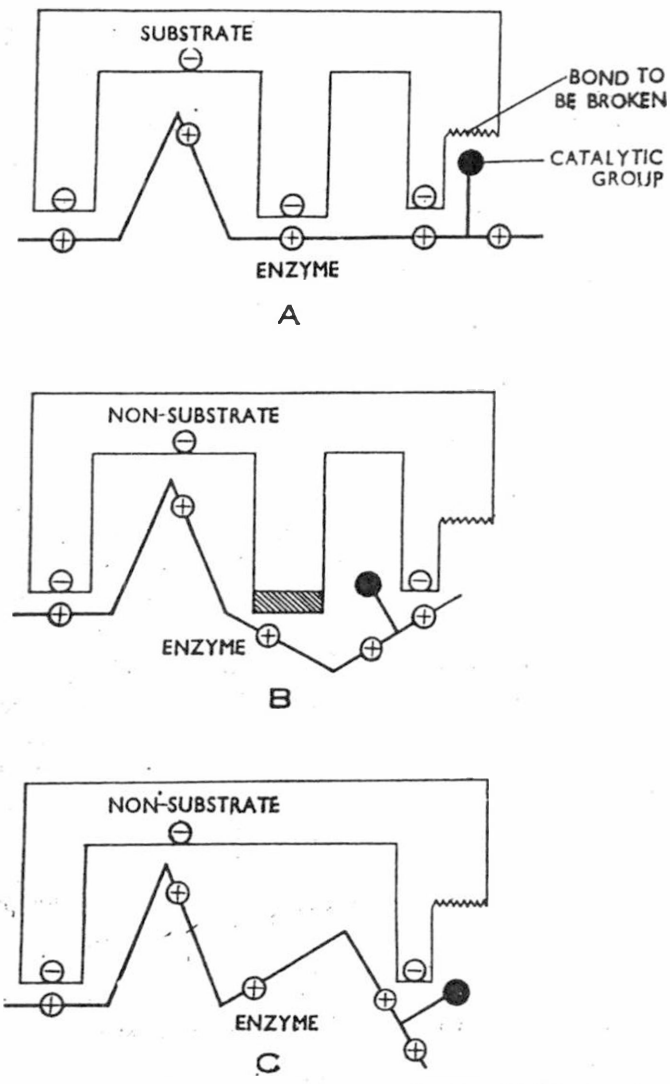
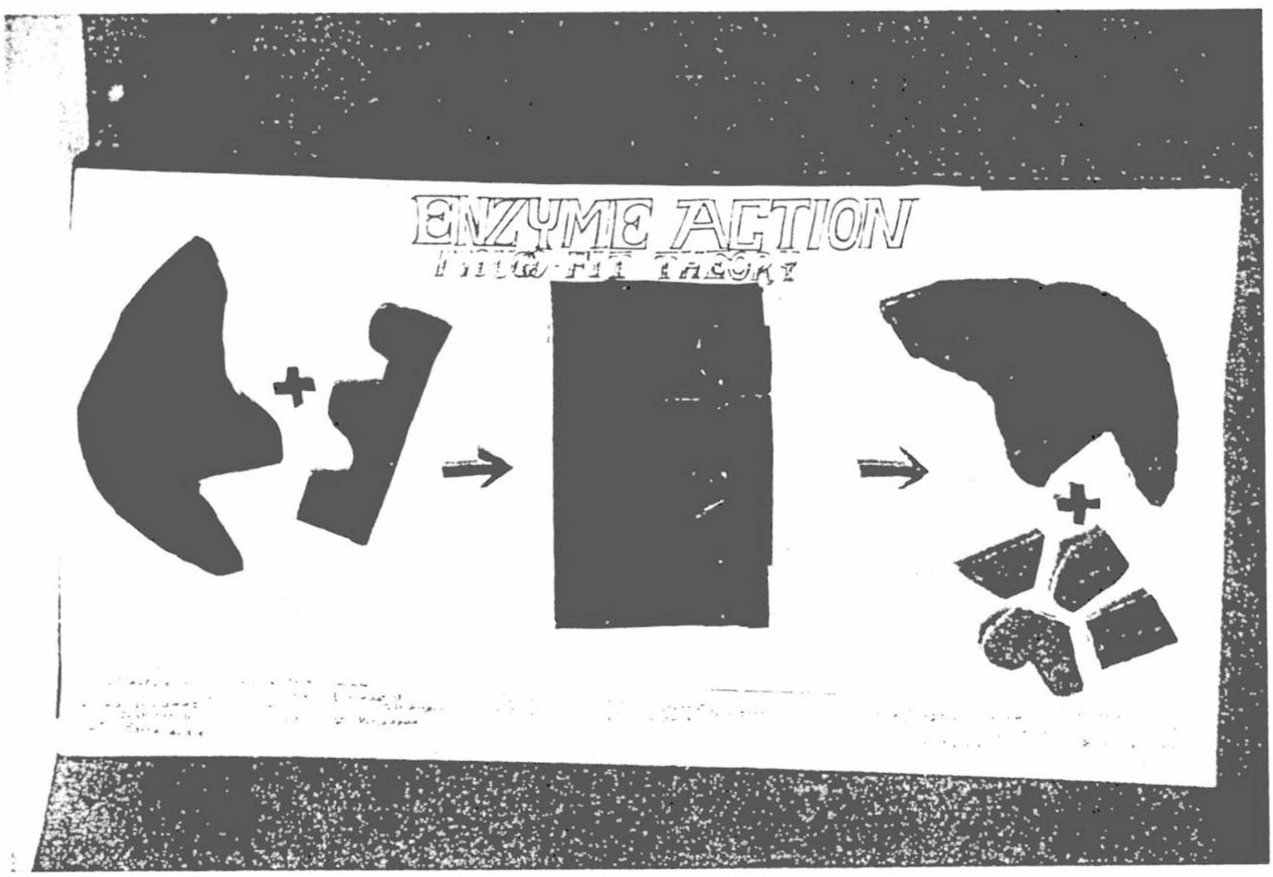


Fig.

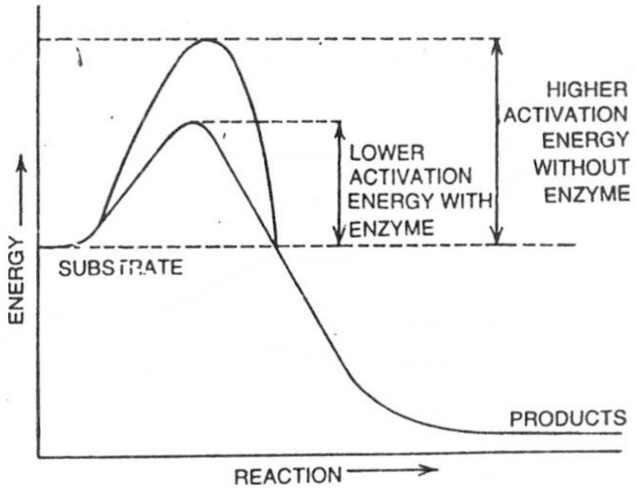
Diagrammatic representation of Koshland's induced-fit theory


ENZYME ACTION

Mechanism of the Enzyme Action

Arrhenius first pointed out that all the molecules in a given population do not have the same *kinetic energy*. Some molecules due to collisions have more energy and are *energy-rich molecules* which others are *energy-poor molecules*.

In an ordinary chemical reaction, only energy-rich molecules can take part at normal temperature due to an *energy barrier* to reaction and the rate of reaction is lower. The higher is the energy barrier for a molecule, the greater is its stability (or inactiveness to take part in reaction). The energy required to hurdle molecules over this energy barrier is called as the *energy of activation*.



Activation energy of an enzyme catalysed reaction is Lower than that of an uncatalysed reaction

At higher temperature, the rate of chemical reaction becomes faster because increased temperature bring about an increase in the number of *activated molecules* by increasing their movement and number of collisions due to *thermal agitation*.

But, in case of *enzyme catalysed reactions*, the rate of reaction is *optimum* at normal body temperatures. It is because all the molecules (energy-rich and energy-poor) can combine with the active sites of enzyme to form *enzyme substrate complex* which later on breaks into enzyme and the product. In other words, the enzymes act by *lowering the energy of activation of the reactions* .

Properties of Enzymes

1. Catalytic property

Like inorganic catalysts the enzymes are active in very small or catalytic amounts and remain unchanged after the reaction. Only a small amount of enzyme is enough to convert large quantity of the substrate into products.

Isozymes

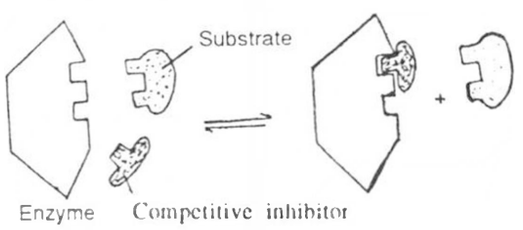
Market and Moller (1959) proposed the term isozyme for multiple molecular forms of an enzyme participating in a catalytic activity derived from a tissue of a single organism. The term isoenzyme is a synonym of it. Isoenzymes have common catalytic activity though these are synthesized by different genes and have different molecular properties. Isoenzyme analyses have been made in several plant enzymes, e.g. peroxidase, catalase, amylase, esterase, acid phosphatase, phosphorylase, cytochrome oxidase, etc. The molecular forms of an isoenzymes can be separated by sedimentation, electrophoresis, chromatography, gel filtration, etc.

Inhibitors

There are certain products which inhibit the enzyme activity, e.g. presence of malonate (in Krebs cycle) inhibits the activity of succinate dehydrogenase. These substances are called inhibitors and are of following types :

a) **Competitive Inhibitors:** Competitive inhibitors usually have structure sufficiently similar to the substrate that they are able to compete for the active site of enzyme.

The active site of enzyme is fitted with molecules of other substances which are similar to those of substrate. So the activity of enzyme is lost. Examples are observed in case of succinic acid and malonic acid, either one can fit with enzyme-FAD. Similarly, sulpha drugs are competitive inhibitors of folic acid synthesis in bacteria as they substitute for p-aminobenzoic acid and thus preventing the next step in the synthesis.

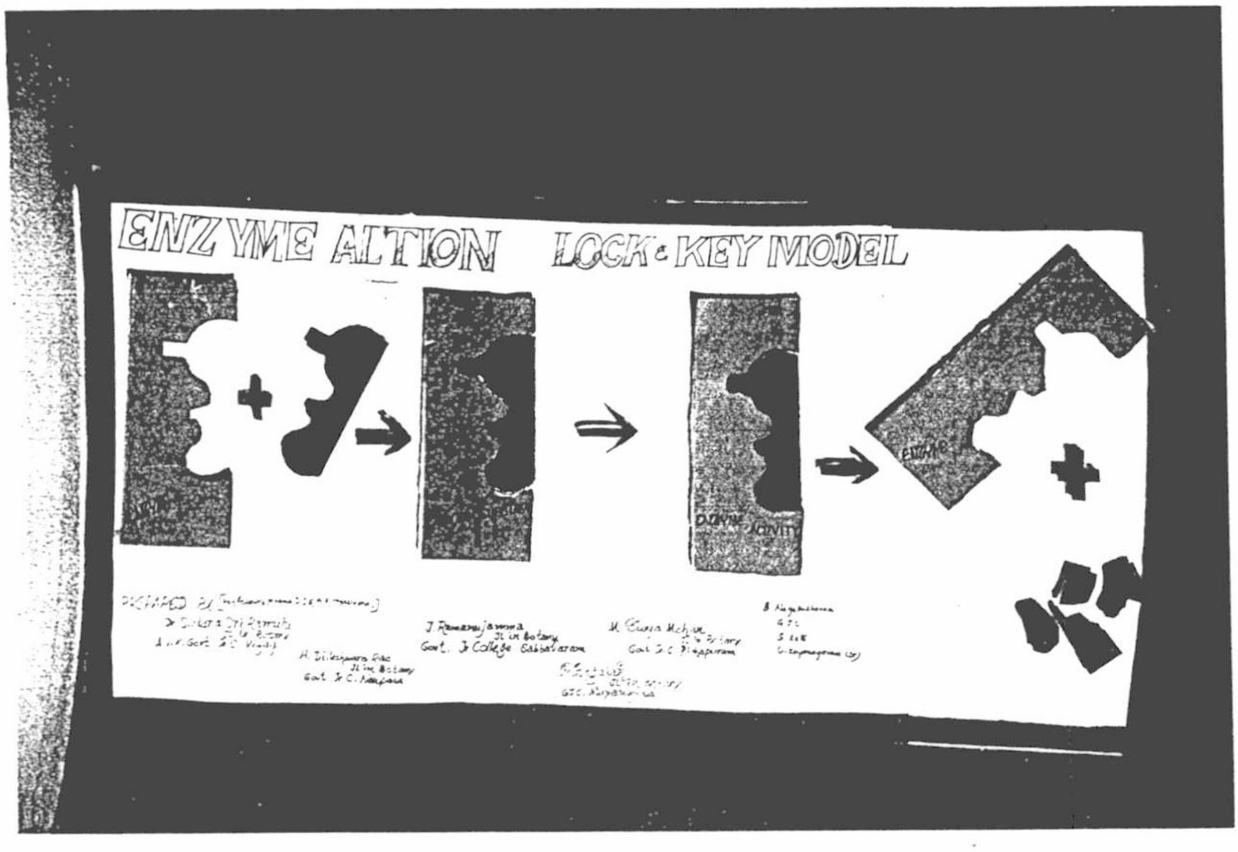


Diagrammatic representation to illustrate how inhibitors check the activity of enzyme (Inh = Inhibitor)

b) **Non-competitive inhibitors:** In contrast to first, these never compete with the active sites of enzyme. In this case, inhibitors react with either parts of enzyme not involved in catalytic activity or active site. These inhibitors do not show structural resemblances with the substrates. Toxic metal ions and compounds that destroy essential sulfhydryl groups (e.g. excess oxygen) are examples of non-competitive inhibitors. Cyanide which inhibits cytochrome oxidase is another example.

c) **Allosteric modulation:** The activities of some enzymes are regulated internally. Some specific low molecular weight substances, such as products of another enzyme of the same metabolic pathway, acts as inhibitor. Such substances bind with a specific site of the enzyme different from its substrate binding site, and thus alter the shape of the enzyme and decrease the enzyme action. Such enzymes are called **allosteric enzymes** e.g. hexokinase which changes glucose to glucose-6-phosphate. Glucose-6-phosphate inhibits the hexokinase activity. It may also be called **allosteric inhibition** or Feedback Inhibition.

Lowering of energy of activation energy in presence of enzyme.

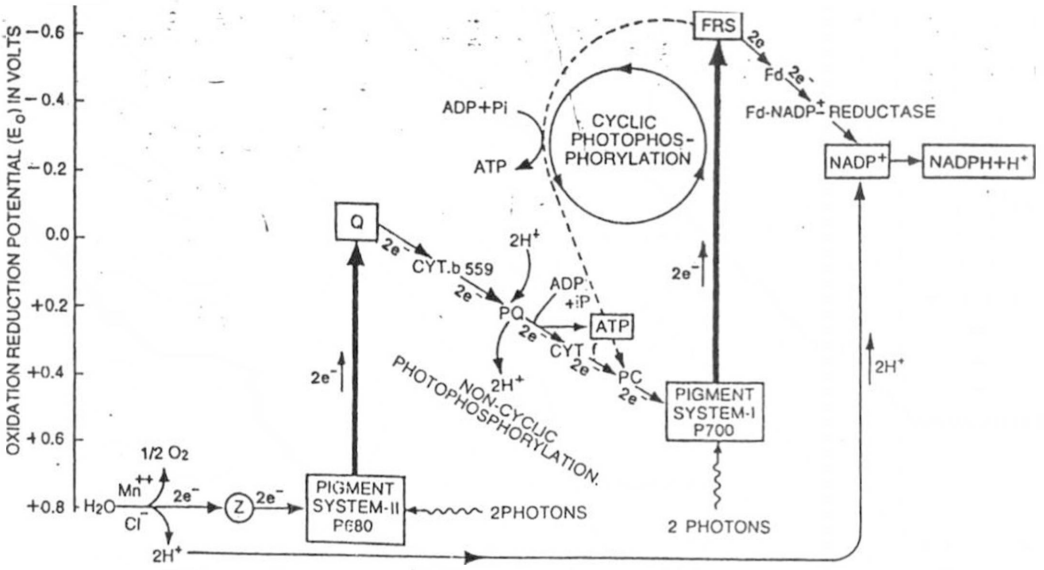

ENZYME ALTION
LOCK & KEY MODEL
ENZYME
SUBSTRATE

Aim of the Model : Non-cyclic photophospheralation

It occurs among green plants and involves both PS I and PS II. The most important difference from cyclic phosphyralation is utilization of water molecule and the electron which helps the chlorophyll molecule coming to ground state comes from hydroxyl group of water molecule.

Non-cyclic photophosphoralation of electron transport in photosynthesis.

Fig. Schematic representation of the electron transport and photophosphorylation in photosynthesis.



Schematic representation for the working model (Z scheme)

Oxidation reduction potential in (E_o) in volts.

(i) Absorption of Light energy by chloroplast pigments:

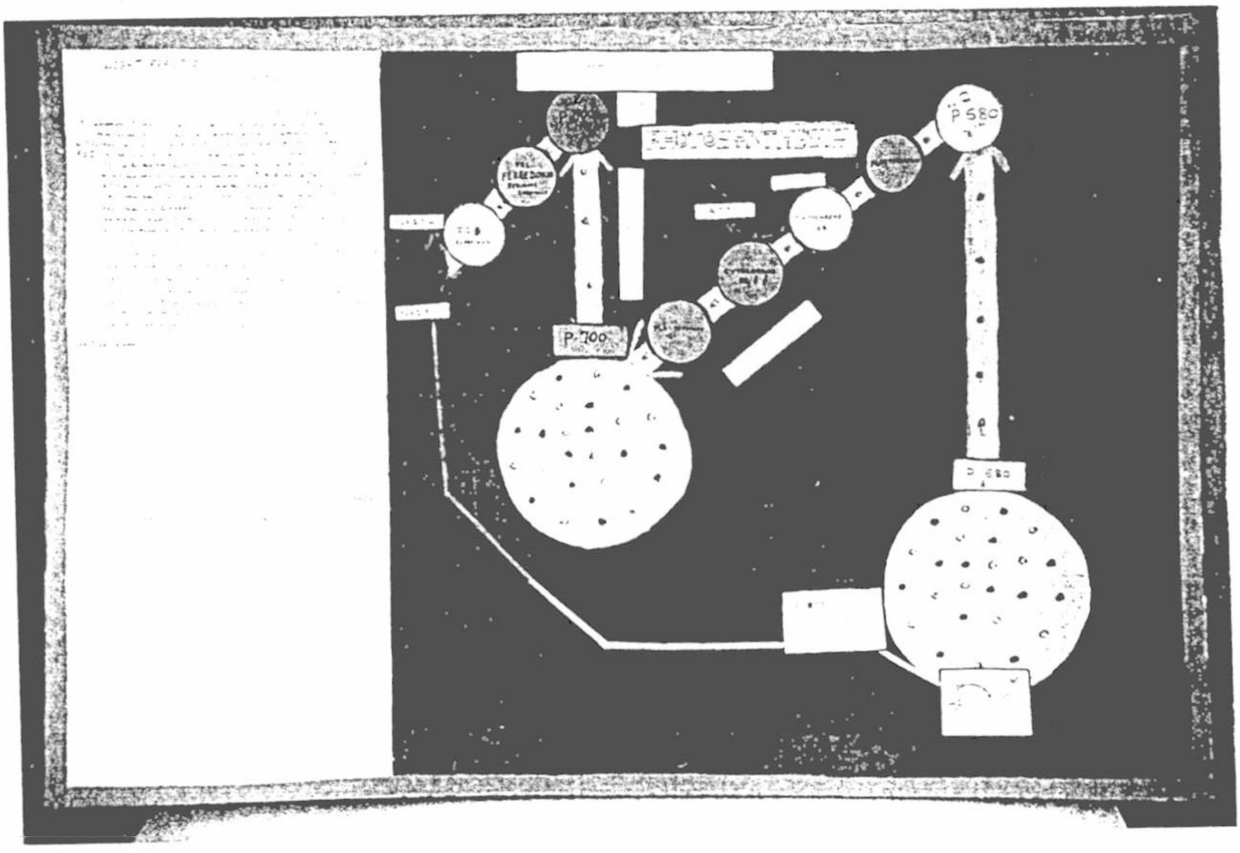
Different chloroplast pigments absorb light in different regions of the visible part of the spectrum.

(ii) Transfer of Light Energy from Accessory Pigments to Chlorophyll-a

All the photosynthetic pigments except chlorophyll-a are called as accessory or antenna pigments. The light energy absorbed by them is transferred by resonance to chlorophyll-a which alone can take part in primary photochemical reaction. Chrlorophyll-a molecule can also absorb the light energy directly. In pigment system II the photoreaction center is P 680 (or in some plants P 690) while in pigment system I, it is P 700.

(iii) Activation of Chlorophyll-a Molecule by Photons of Light

When P 680 or P 700 forms a chlorophyll – a molecule in two pigment systems receives a photon (quantum) of light, it becomes an excited molecule having more energy than the ground state energy. After passing through the unstable *second singlet state*, and first singlet state the chlorophyll molecule comes to the metastable triplet state. It is this latter excited form of chlorophyll-a which in fact takes part


P-580
P-700

further in primary photochemical reaction. It expels its energy along with an electron and a positive charge comes on the chlorophyll-a molecule which now becomes oxidized :

$$\text{Chlorophyll-a} \xrightarrow{\text{Light}} \text{Excited Triplet State of Chlorophyll-a}$$

$$\text{Excited Triplet State of Chlorophyll-a} \longrightarrow (\text{Chlorophyll-a})^{+} + e^{-}$$

(iv) Photolysis of Water and O_2 Evolution (Oxidation of Water)

These are associated with pigment system II and are catalysed by presence of MN++ and Cl^- ions. When pigment system II is active, i.e. it receives light, the water molecules split into OH^- and H^+ ions (photolysis of water). Its mechanism is least understood. The OH^- ions unite to form some water molecules again and release O_2 and electrons. It is believed that photolysis of water involves a strong oxidant which is yet unknown and is designated as Z.

$$4H_2O \rightarrow 4H^+ + 4\,(OH^-)$$
$$4(OH^-) \rightarrow 2H_2O + O_2 + 4e^-$$

$$2H_2O \rightarrow 4H^+ + O_2 + 4e^-$$

There are now strong evidences to suggest that liberation of one O_2 molecule from $2H_2O$ molecules is a four-step process. The unknown strong oxidant 'Z' is supposed to form a redox-system between H_2O and P 680^+ which must accumulate four positive charges before a molecule of O_2 is evolved. Each step requires one extremely short flash of light or a photon (hv) in which one positive charge is added on 'Z'.

$$2H_2O \quad \underset{}{Z} \quad \underset{hv}{Z^+} \quad \underset{hv}{Z^{2+}} \quad \underset{hv}{Z^{3+}} \quad Z^{4+} \quad O_2 + 4H^+ + Z$$

(v) Electron Transport and the Production of Assimilatory Power (i.e. NADPH + H^+ + ATP)*

It has already been said that when chlorophyll-a molecule receives a photon of light it becomes excited and expels the extra energy along with an electron in both the pigment systems. This electron after traveling through a number of electrons carriers is either cycled back or is consumed in reducing $NADP^+$ (Nicotinamide Adenine Dinucleotide Phosphate) to NADPH + H^+ . The extra light energy carried by the electron is utilized in the formation of ATP molecules at certain places during its transport. This process of the formation of ATP from ADP and inorganic phosphate (iP) in photosynthesis is called as *Photosynthetic phosphorylation* or *Photophosphorylation.*

Arnon has contributed a lot in our understanding of electron transport and photophosphorylation in chloroplasts. These are of two types :

a) Non-cyclic Electron Transport and Non-cyclic Photophosphorylation (Z-Scheme). This process of electron transport is initiated by the absorption of a photon (quantum) of light by P700 form of chlorophyll-a molecule in pigment system Iwhich gets excited. An electron is ejected from it so that an electron deficiency or a 'hole' is left in the P700 molecule (or in other words a positive charge comes on chlorophyll-a-molecule). This ejected electron is trapped by FRS (Ferredoxin reducing substances) which is an unknown oxidation-reduction system with a redox potential (E_0') of –0.6 volts and may be a pteridene. The electron is now transferred to a non-heme iron protein called **ferredoxin (Fd)** with E'_0 of –0.432 V. From ferrodoxin the electron is transferred to $NADP^+$ (E'_0 = -0.32 V) via intermediate protein electron carrier ferredoxin-NADP reductase so that $NADP^+$ is reduced to NADPH + H^+.

(Ferrredoxin reducing substance FRS, is also called as X by some workers. Other mention it as A (Fe.S) meaning thereby an iron-sulphur protein. Still according to some others, A (Fe-S) exists in two forms called A_1 (Fe-S) and A_2 (Fe-S).

Now, when a photon (quantum) of light is absorbed by P 680 form of chlorophyll-a molecule in **pigment system II,** it gets excited and an electron is ejected from it so that an electron deficiency or a 'hole' is left behind in the P 680 molecule. The ejected electron is trapped by a compound of unknown identity usually designated Y (compound Y is sometimes called as Q because it also causes quenching of the characteristic fluorescence of chlorophyll-a in pigment system II). This unknown compound forms oxidation-reduction system with a redox-potential (E'_0) value more negative than 0.0 V. From Q, the electron passes downhill along a series of conpounds or intermediate electron carriers and is ultimately received by pigment system I where it 'fills the hole'. Redox potential of P 700 in pigment system is + 0.043 V. The series of compounds consists of (i) *cytochrome b-559 (E'_0 = +0.055V),* (ii) Plastoquinone (PQ) whose chemical structure shows similarity with vitamins of K series. It has a redox potential (E'_0) of +0.113 V, (iii) *Cytochrome f* (E'_0 = + 0.36V) and (iv) plastocyanin (PC) which is copper containing protein (E'_0 = +0.39 V). At one place during the electron transport i.e. between plastoquinone and *cytochrome f* there is enough change in free energy which allows phosphorylation of one molecule of ADP to form one ATP molecule (photophosphorylation).

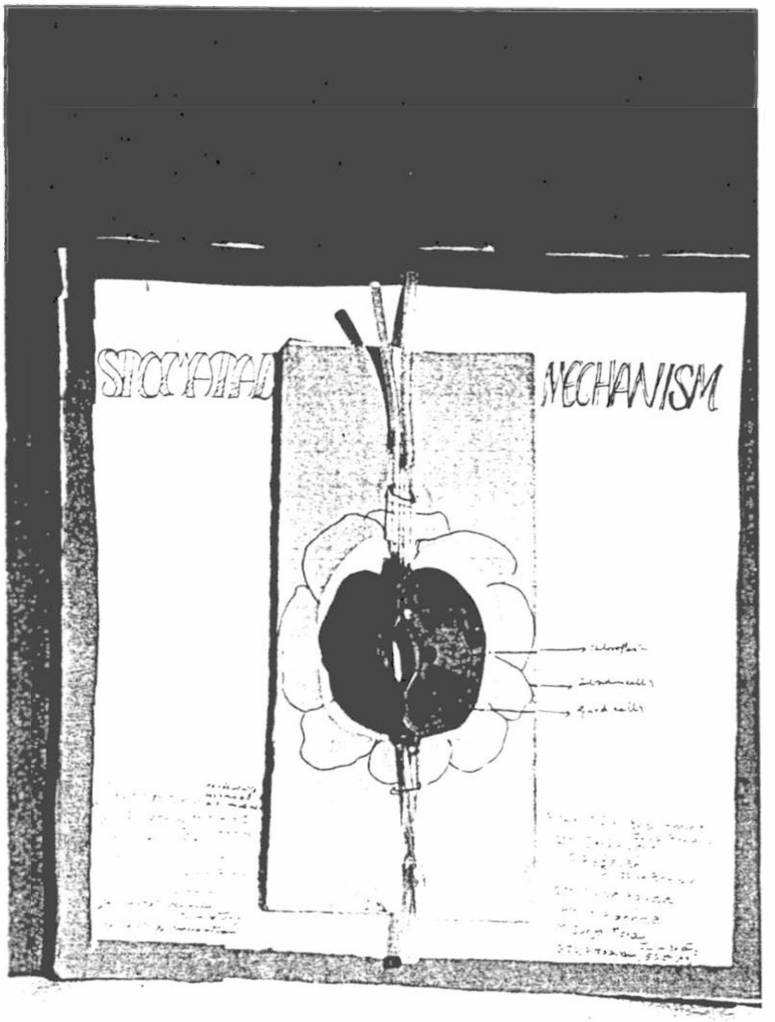
More recent researches have shown that from P 680 the electron is transferred to unknown compound 'Q' via 'phaeophytin. The later is special form of chlorophyll which lacks magnesium atom. The unknown compound Q exists in two forms QA and QB. QB is sometimes only called as B.

(*Cytochrome f* is a typical c type of cytochrome, 'f' is abbreviated from 'frons' which in Latin means leaf).

The 'hole' in pigment system I has been filled by the electron coming from pigment system II. But the 'hole' or an electron deficiency is still there in pigment system II. This is fulfilled by the electron coming from photolysis of water. Water here acts as electron donor. It has redox-potential (E'_0) of +0.82 V. This transfer of

electron from water probably involves a strong oxidant which is yet unknown and is designated as Z.

In the above scheme of electron transport the electron ejected from pigment system II did not return to its place of origin, instead it was taken by pigment system I. Similarly, the electron ejected from pigment system I did not cycle back and was consumed in reducing $NADP^+$.


MECHANISM

Mechanism of stomatal opening and closing

Aim of the model:

To show stomatal opening and closing.

Objectives:

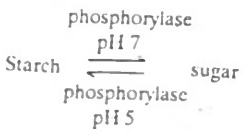
1. To acquaint the students about transpiration.
2. Students will understand working principle of transpiration i.e. through plant surface water loss.
3. To observe the rate of transpiration in different conditions.
4. It explains transpiration pull, and Cohesion and Tension Theory.

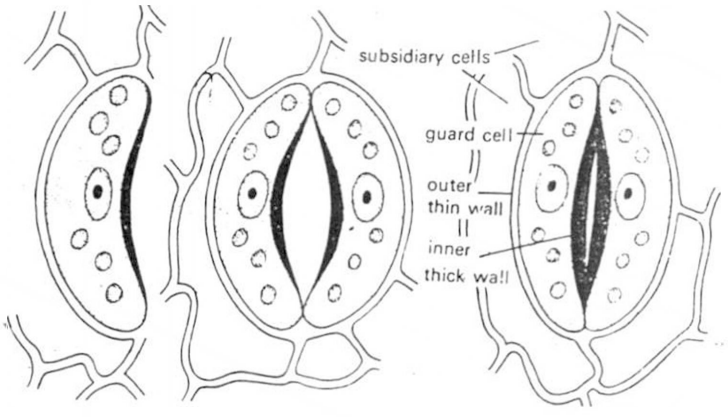
Materials ***required:***

Cycle rubber inner, Rubber tubes, Pinch cocks & glass stubs.

Procedure/working principle of the model:

The opening and closing of stomata are controlled by the size and shape of the guard cells. In dicots when the turgor of the guard cells increases due to entry of water into guard cells the outer wall becomes more convex drawing the inner walls of guard cells apart opening the pore. Due to loss of water from the guard cells the inner walls return to their original position resulting the closing of the pore. Stomatal movements are closely associated with metabolic changes and solute levels of guard cells.





The stomata during transpiration.

Model : Transpiration

Aim:
To show that transpiration has the power to lift a column of water.

Objectives:

1. To acquaint the students about Transpiration.
2. Students will understand working principle of Transpiration (i.e) through plant surface water loss.
3. To observe the rate of Transpiration in different conditions.
4. It explain transpiration pull, and Cohesion and Tension theory.

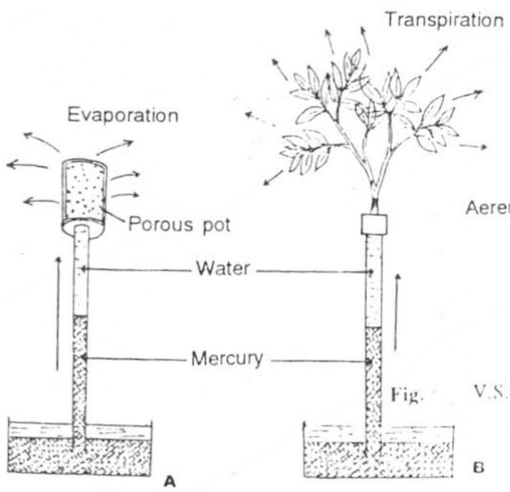
Materials required:
Stand, Beaker, A glass tube/capillary tube with a wide mouth, cork, oil cloth, plant twig, water, mercury, Beaker.

Cost estimate:

Stand	-1-
Beaker	-1 (250 ml)
Capillary tube	-1-
Cork	-1-
Oil cloth	-1-
Hg	-1 bottle

Working principle:
A beaked or petridish is filled with mercury and a capillary tube filled with water is invested over the mercury. The twig is inserted through a hole into the cork in a way that the cut end of the plant is dipped in the water. Make the cork and hole airtight by applying Vaseline or tie oil cloth around it,. Initial level of Hg is noted. The expt is allowed to stand in open and sunny place. Note the level of Hg at the end of the experiment. The level of Hg rises showing transpiration pull.

Diagram:



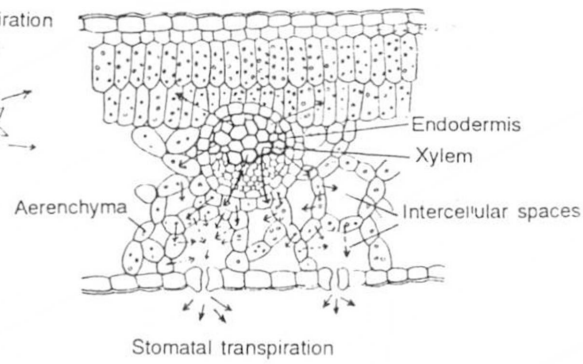


Fig. V.S. of leaf showing stomatal transpiration generating a transpiration pull.

Fig. . *A*—Demonstration of cohesion-tension theory by physical system (Evaporation of water from porous pot pulls up the column of mercury due to tension.). *B*—demonstration of the same using plant instead of porous pot (mercury column rises).

Description:
The plant transpires and absorbs water to make up the loss of water happened during transpiration.

a) Evidences in support of the theory (Osmotic Pressure): This theory has several experimental supports. Some of them are as follows :

(i) The osmotic pressure of mesophyll cells has been recoded upto 20 atms, which is quite sufficient for ascent of sap. It has been calculated that 1atm osmotic pressure can result in water rise upto 10 metres.

(ii) It is purely a physical process which does not require metabolic energy and even if it requires, it is negligible because for 200-metre rise of 1 ml. Water 0.5 cal. energy would be needed.

(iii) The tensile strength of xylem sap is in between 25-30 atms, which is sufficient enough to maintain a continuous water column.

(iv) The theory gets further support when it is compared with the porous pot experiment i.e. if at the top of continuous water column a porous pot is placed and its water is subjected to evaporation, the water column is put under tension. This column is not broken de to cohesive property of water molecules while evapoaration continues. Thus, it is believed that a similar kind of mechanism may operate in plants. A comparative figure fo two identical conditions is given in the figure.

(v) The cohesion- tension theory is further strengthened by certain calculations based on various experiments. Zimmermann (1965) explained that a pressure of 0.15 atm. Per metre is required for fastest movement of water in plants which would mean that a water potential difference of 45 atms. will be sufficient for the rise of water in any tallest tree. The cohesive property or tensile strength of water is quite high (1000 atms) and about 1300 atms is necessary to break a stretched water column. This amazing figure is quite high against 45 atms.

The capillarity theory faces following objections:

(i) Water can rise only to height of little more than one metre in the vessels of 0.03 mm diameter. This diameter is considered average and standard among the plants.

(ii) In the plants where vessels are absent and only tracheids are present capillarity cannot operate or capillarity theory cannot be applicable due to presence of end walls in tracheids. Vessels are not found among gymnosperms whereas trees of this group are enormously long.

(iii) The soil water is not directly connected with the vessels, hence this theory cannot be functional in vessel bearing fruits.

(iv) A free surface must be present in the xylem vessels to maintain capillarity.

(v) The capillarity operates easily in plants having narrower vessels but tall plants have rarely such vessels.

b) Imbibitional theory

Propounded by Unger (1868) and advanced by Sachs (1878, 1879) imbibitional theory assumed that water moves upward in the stem entirely through the wall of the xylem elements due to process of imbibition. Though the movement of water through imbibition by colloids is extremely slow but the imbibitional pressure (100 to 1000 atms) is quite adequate to carry water to any distance. The imbibitional theory was, however, discarded as soon as it became evident that walls do not carry water, it moved through the lumen of the xylem.

Moreover, the imbibitional movement of water has been found not only slow but also negligible.

c) Atmospheric Pressure Theory

This theory considers that atmospheric pressure is responsible for ascent of sap. Water rises upward to fill up the gap in fall of atmospheric pressure at the transpiring surface due to loss of water during transpiration.

There are two main objections to this theory:

(i) For the operation of atmospheric pressure, the presence of free surface at the lower end of the plant is essential which cannot be found in plants.

(ii) It is not applicable because even if complete vacuum is created at the transpiring surface, the maximum rise of water can be 10 metres. Whereas no vacuum is observed in the plants and certain plants are far more taller.

d) Transpiration Pull or Cohesion-tension Theory

This theory was propounded by Dixon and Jolly (1894) and has been supported by Curtis and Clark (1951), Milburn and Johnson (1966). This theory is now popularly known by various names such as Cohesion hypothesis, Theory of cohesive force, Dixon and Jolly's theory of cohesion, Cohesion-tension theory or Transpiration pull theory. It is by far the most accepted theory which could be better explained as follows:

(A) What **is cohesion?** Attraction between the similar molecules is called cohesion. The water molecules have strong mutual attraction (cohesion) due to which they cannot be easily separated from one another. The magnitude of cohesive force of water, which has been measured up to 350 atms. is much in excess of the minimum required for the ascent of sap in the tallest trees.

(B) Cohesion-**tension theory.** Water forms a continuous column from base of the plant to its top and remains under cohesive tension due to transpiration pull. And according to the need water is being pulled up to the top of the tree.

(C) Characteristics **of cohesion-tension theory.** This important and widely accepted theory has following essential features.

Water forms a continuous column from the base of the plant to its top.

(i) Water is lost from mesophyll cells due stods transpiration because of which a pulling force develops. It puts these cells under tension.

(ii) The tension may cause a break in water column but due to tensile strength or cohesive property of water molecules, the continuous column is not broken.

(iii) The tension or transpiration pull is transmitted to the root region to regulate absorption.

(D) **Mechanism of ascent of sap.** The loss of water from the surface of leaf mesophyll cells due to transpiration reduces the water amount and causes an increase in the osmotic pressure of these cells. Thus a reduced water potential is developed in mesophyll cells, i.e., DPD increases. Water from the adjacent cells and ultimately from the conducting

tissue is pulled to meet this loss of water and as a result a pull is developed in mesophyll cells and xylem cells of the leaf. Now water present in the xylem cells is placed under tension, which is ultimately transmitted to the root through the stem tracheids.

This downward transmission of tension is because of cohesive properties of continuous water column in the vessels and tracheids from leaves to roots through stem. The water column moves upward by mass flow due to transpiration pull and simultaneously the process of ascent of sap is accomplished

However, earlier workers Loomis and Santamaria (1960) reported that tensile strength of xylem sap is in between 25 and 300 atms. comparatively lower than that of water but still quite sufficient to maintain the continuity of water column.

Kramer and Kozlowski (1960) while using dendrographic measurements of the tree trunk diameter variations found that diameter of the xylem elements decreased during excessive transpiration period due to strain exercised on the water column by tension. This further supports the theory.

In a pressure-bomb technique adopted by Scholander and coworkers (1965), a shoot was cut and enclosed in the vessel placing the cut surface in the bomb. A tension was exercised in the vessel in order to pull the liquid back. They then measured the counter pressure that must be exerted on the shoot to force the liquid back to the cut surface. This was found to be as high as 80 atms. These results support cohesion-tension theory.

The movement of water under tension is quite rapid which can be shown by cutting the stem of a wilted plant under water. It recovers soon when tension is exercised as compared to intact plant when watered. It also illustrated the involvement of few living cells in the root, which offer a greater resistance to movement than do the vessels.

(F) Objection to cohesion-tension theory.

There is only one relevant but refutable objection to this theory. Due to variation of temperature during day and night and in vessels of larger diameter, there are fair chances of gas bubbles entering in water column from soil with water which may break the continuity of water column. It is true that such bubbles are not rare among the plants but this objection has been successfully explained.

Explanation. The vessels are found gas filled during excessive tension. This phenomenon is known as cavitation and has been demonstrated by Milburn and Johnson (1966). This difficulty is overcome due to presence of many parallel columns of vessels side by side and the injurious effects of temporary cavitation are eliminated (Fig. 4.3). When the tension is relieved (by rain or simply at night) the gases are dissolved in solution and the column becomes continuous.

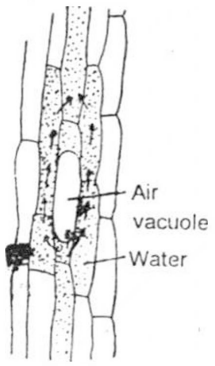


Fig. 4.3. L.S. Of a portion of stem showing the pathway of water when disturbed due to air vacuole.

Aim of the Model:

DOUBLE FERTILIZATION

In plants:

2. Objectives:

1. The Teachers are able to explain the process of fertilization through, working model of (power point presentation)
2. They will under stand the details of Double Fertilization.
3. Importance double fertilization to fruit formation will be understood by the teachers.
4. They will understand double fertilization product is a result of triple fussion.

3. Materials required:

Computer software, 3 ½floppy, 6, CD's and scanner for diagram & pictures.

4. Working Principle:

Fertilization is the process of fusion of male and female gametes in the embryosac.

Stamens are the male reproductive organs in the ovules are the female reproductive organs in the flower.

Stamens produce pollengrains(haploid cells). The pollengrains structurally gets modified into male gametophyte. The male gametophyte produces male gametes. Pollengrains germinates on the stigma several changes takesplace. During germination the outerwall of the pollengrains and the inner wall (in tine) develops into pollen tube. The nucleus in the pollen grain divide mitotically to form two nuclei, out of which one is vegetative and the other is generative nucleus. The generative nucleus divides to produce two male gamets. The vegetative nucleus which is useful for the growth of the degeneration latter.

The ovary contains ovules. The ovule(mega sporangium) in turn produces embryo sac, the megaspore mother cell in the nucellus (2n) divides mitotically and produces 4 haploid cells, out of which 3 degenerate and one is functional. The functional megaspore nucleus divides thrice and forms 8 nuclei. The 8 nuclei are in the embryo sac Out of 8, 3nuclei develops into egg apparatus(one egg + 2 synergids) and 3 develops into antipodals and the remaining two which are at the each pole move into center and form Secondary nucleus.

During the process of fertilization the pollen tube enters into the embryo sac, poro gamy ,chalazo gamy and mesogamy. After entry into the embryo sac the Pollentube bursts and releases the two male gametes.

One male gamet fuses with egg cell which is known as syngamy discovered by Strasburger in 1884. As a result the zygote (diploid-2n). From the zygote embryo develops .

Male gamete(n) + egg(n) ----→ Syngamy---→Zygote(2n)

The second male gamete fuses with secondary nucleus(2n) which is known as Triple fusion discovered by S .G. Nawaschin in 1898, As a result of triple fusion Primary endosperm nucleus(PEN) is formed which later develops into endosperm.

Second male gamete (n) + Secondary nucleus(2n)-→triple fusion-→ PEN(3n).

The zygote forms the embryo which in turn develops into a seed. The PEN Which form the endosperm used for the development of embryo.

Thus the double fertilization and triple fusion takes place in all angiosperms.

5. ***Cost estimation*** *:Approximately 3000/-*

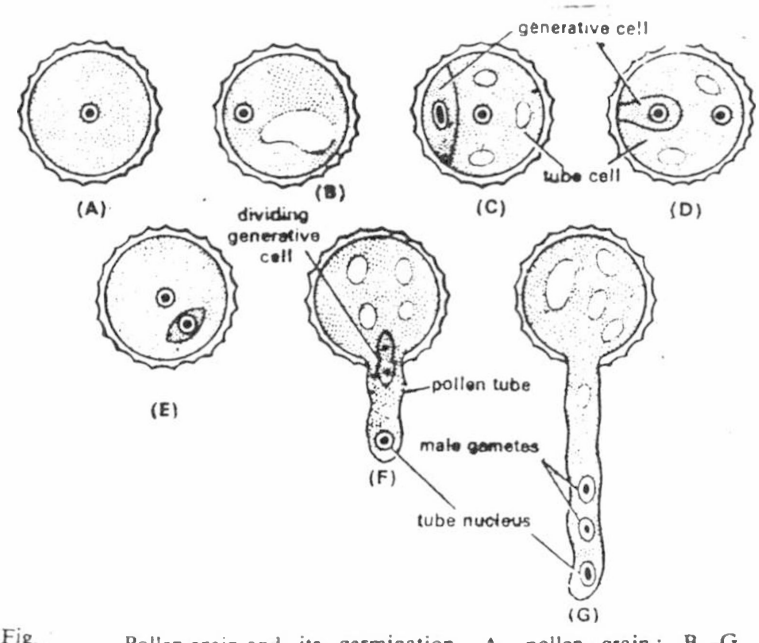


Fig. Pollen grain and its germination. A, pollen grain; B—G different stages in the development of male gametophyte.

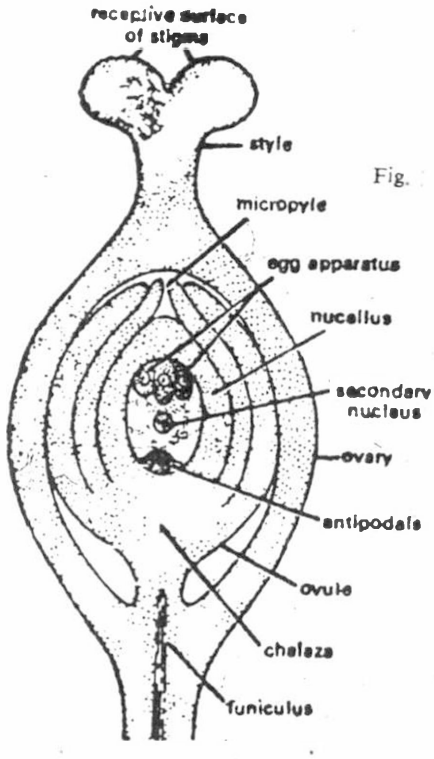


Fig. 21·18. Pistil in longitudinal section showing different parts of mature ovule attached to a basal placenta.

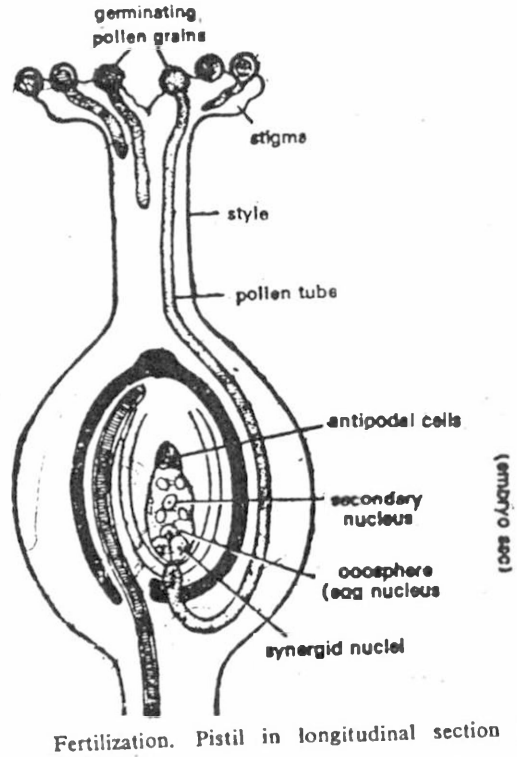


Fig. Fertilization. Pistil in longitudinal section showing porogamy.

1. Aim of the model: ANTHER CULTURE

2. Objectives:

a. The Teacher is able to explain the process of tissue-culture.
b. Teacher is able to explain Anther Culture and Medium Preparation.
c. Teacher is able to explain the precautions necessary for Anther Culture.
d. The Students will understand the power point presentation of tissue culture in short the Anther Culture.

3. *Materials required:*

3 ½ floppy , Computer, Scanner, Pictures ,Printer & CDs.

4. Working Principal:

Tissue Culture or Micropropagation is a technique involving the culture of a cell, tissue, or organ on a suitable nutrient medium resulting in the production of new plants.

The part of the plant used for this purpose is called *explant*.

The explant used in Anther Culture is excised Anther.
A Japanese Cytologist SHIMAKURA in 1934 undertook this Culture with a view to understand the physiology of meiosis in anthers of Datura innoxia.

While undertaking the similar type of study Guha and Maheswari (1964-1966) have successfully raised for the first time haploid plants using invitro technique.

This enabled other scientists in raising haploid plants of nearly 20 plants eg.Maize, Potato, Mustard etc. using Anther culture.
High rate of success can be achieved in the production of haploid plants, when the Anthers contain uninucleate microspores.
Production of haploid plants, through the culture of Anthers involving invitro technique is known as *Androgenesis*.
The explant Anther excised from the flower is surface sterilized using disinfectants like Calcium hypochlorate, or Hydrogen peroxide or chlorine solution.

After inoculating the anthers in the suitable medium the culture vessels are incubated at 25^0C -- 28^0C for 3 – 4 weeks , which results in the production of haploid plants.

The haploid plants grow normally till they flower , similar in nature to that of diploid plants.

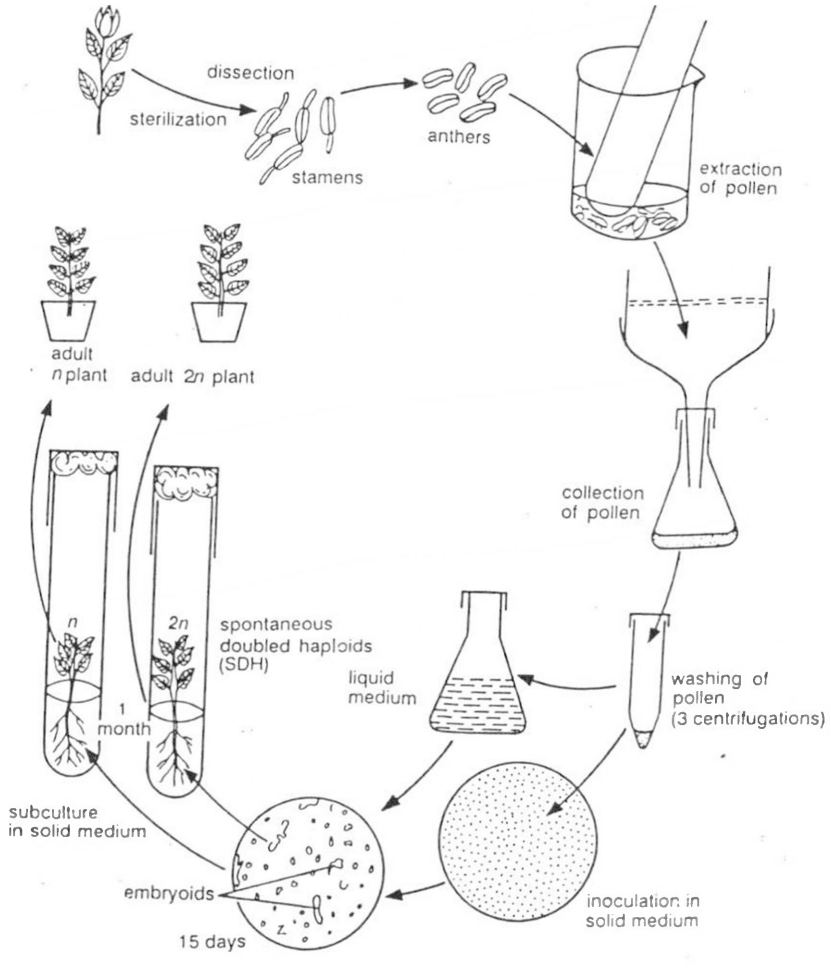
No gametes are produced as they are haploid in nature. Using colchicine, the haploid plants can be transformed into homozygous diploid plants.

Advantages of Anther Culture

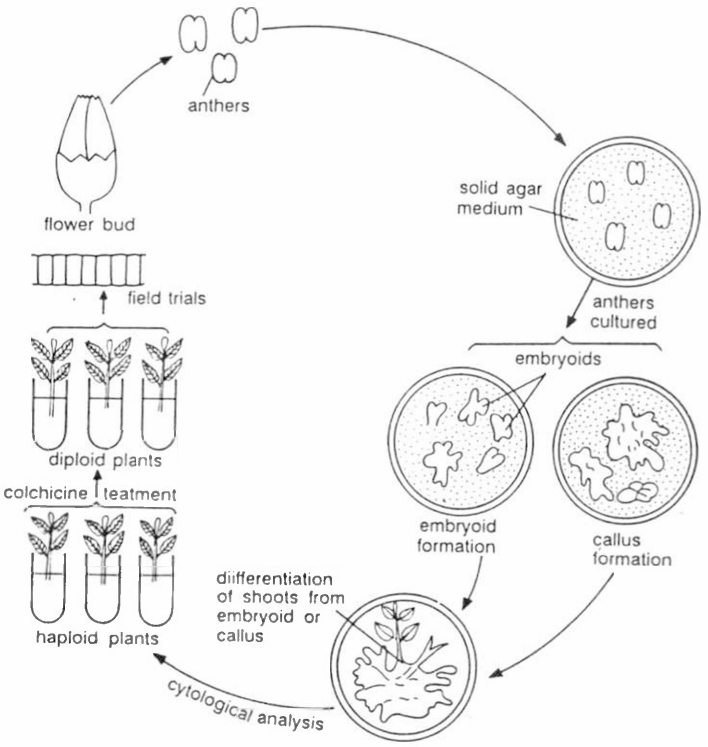
1. Homozygous Diploid Plants can be produced from haploid plants which are useful in plant breeding.
2. Since the haploid plants contain one set of chromosomes, the recessive genes with mutant characters can be identified easily.
3. Haploid plants are also useful in Genetic Engineering.

5. ***Approximate cost**: 2500/-*

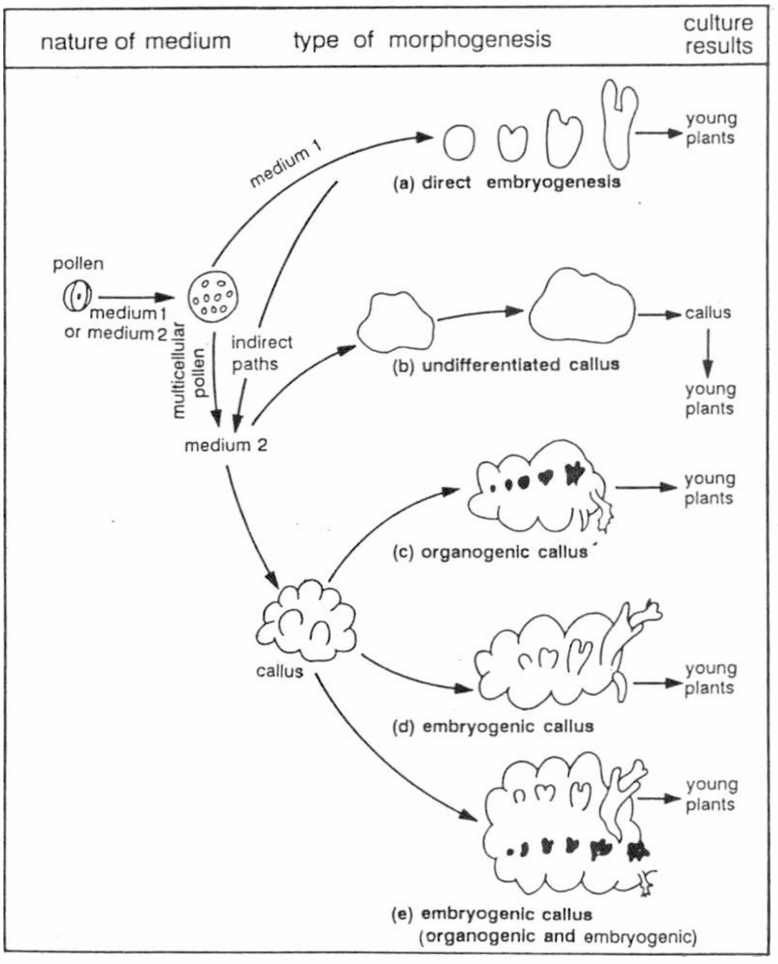
Various Developmental Stages involved in Anther Culture.



Different steps involved in the production of haploid plants using isolated pollen grains.



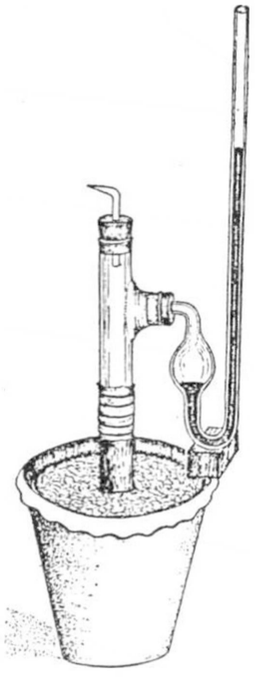
Different steps involved in the production of haploid plants using anther culture.



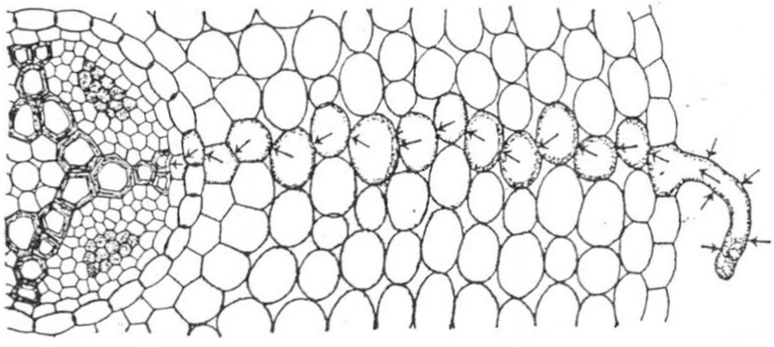
A direct and several indirect paths leading to production of haploid plants from isolated pollen grains.

EXPERIMENTS ON ROOT PRESSURE

Experiment 1. To demonstrate root pressure in plants.
A well-watered plant, a tube attached with manometer, a stand, a piece of rubber tube, knife and thread are required for the experiment.
The stem of the plant is cut a few inches above from the base with a sharp knife and Rubber tube and glass tube are attached. We can observe water level changes in the tube.



Experiment on root-pressure.



A root in transverse section showing the course of water from the root-hair to the xylem.

Model : Munch Hypothesis

Aim of the Model:
To demonstrate mass flow using an analogans situation in plants.

Objectives:
1. The Mass flew-hypothesis can be understood by this model.
2. The Phloem Transport can be understood by this model.
3. Translocation from source (heat) to sink (Roof) is proportional to the concentration gradient in phloem is also understood.

Materials required:
Cloth bags which can be pasted on to rubber tubings on the outer side 2; Bracket shaped glass tube with stand; sugar water; colour (to notice flow of water). Large glass trough; plastic/poli stop-cock can be provided in the tubing above water for addition of sugar.

Cost estimate:

Cloth bags (sized)	-2 nos.
Rubber tubings	-2 nos.
Bracket shaped glass tube	-1 no.
Stand (wooden/,metal)	-1no.
Sugar	-1
Colour ( )	-1 bottle
Glass trough	- 1 bottle

Model proposed:
The diagram shows a closed set up where 2 bulbs with membranes permeable only to water are dipped in a trough containing water and joined by a tube with stop-clock arrangement.

Working principle:
Hence one bulb is visualized as the leaf end of the plant and the receiving end as the root end. Tube represents the conducting tissues (Xyloem, phloem). As leaves (X) have a high osmotic potential (through replenishment of soluble carbohydrate by photosynthesis), the products of photosynthesis are pushed downward through the phloem cells tube and as they reach the receiving end(Y) they are rendered osomatically ineffective by either chemical transformation or consumption by the cells in the region. ∴ this ensures further movement of foods from the leaves towards the consuming end.

Description:
Living cells are absolutely essential for the purpose of translocation and translocation of foods through the phloem ceases when the cells are killed. Though the movement of solutes bi-directional i.e., both upward and downward, it does not involve a simultaneous two-way movement through the same phloem elements. The rate of flow of foods is quite high. Food movement exhibits a periodicity. Food flow occurs in some species at night and in some species during day.
Mass flow hypothesis was first advocated by munch is 1927, or 1930 and later modifies by others.

X and Y are membranous bulbs, water enters membrane X and this exerts a pressure that would push the water along the tube and then into the other bulb. This pressure would also cause water to flow out of membrane Y. ∴ *in a set-up such as this, there has to be a continuous mass flow of water from the bulb containing stronger solution and the flow would continue until the concentrations in both become equal.* The process would go on indefinitely if we can arrange for removal of sugar from the weaker solution as soon as it reaches and replace the sugar lost by the stronger solution, the process should continue indefinitely.

Diagram:

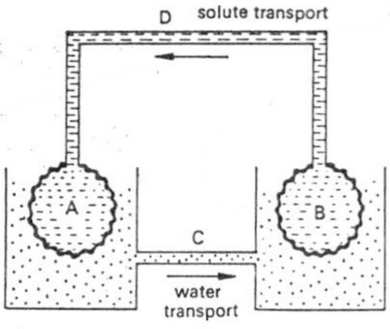


Fig. Model to illustrate mass flow hypothesis.

Munch flow when applied to plants.

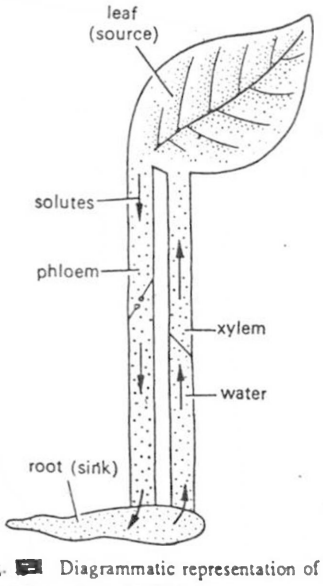
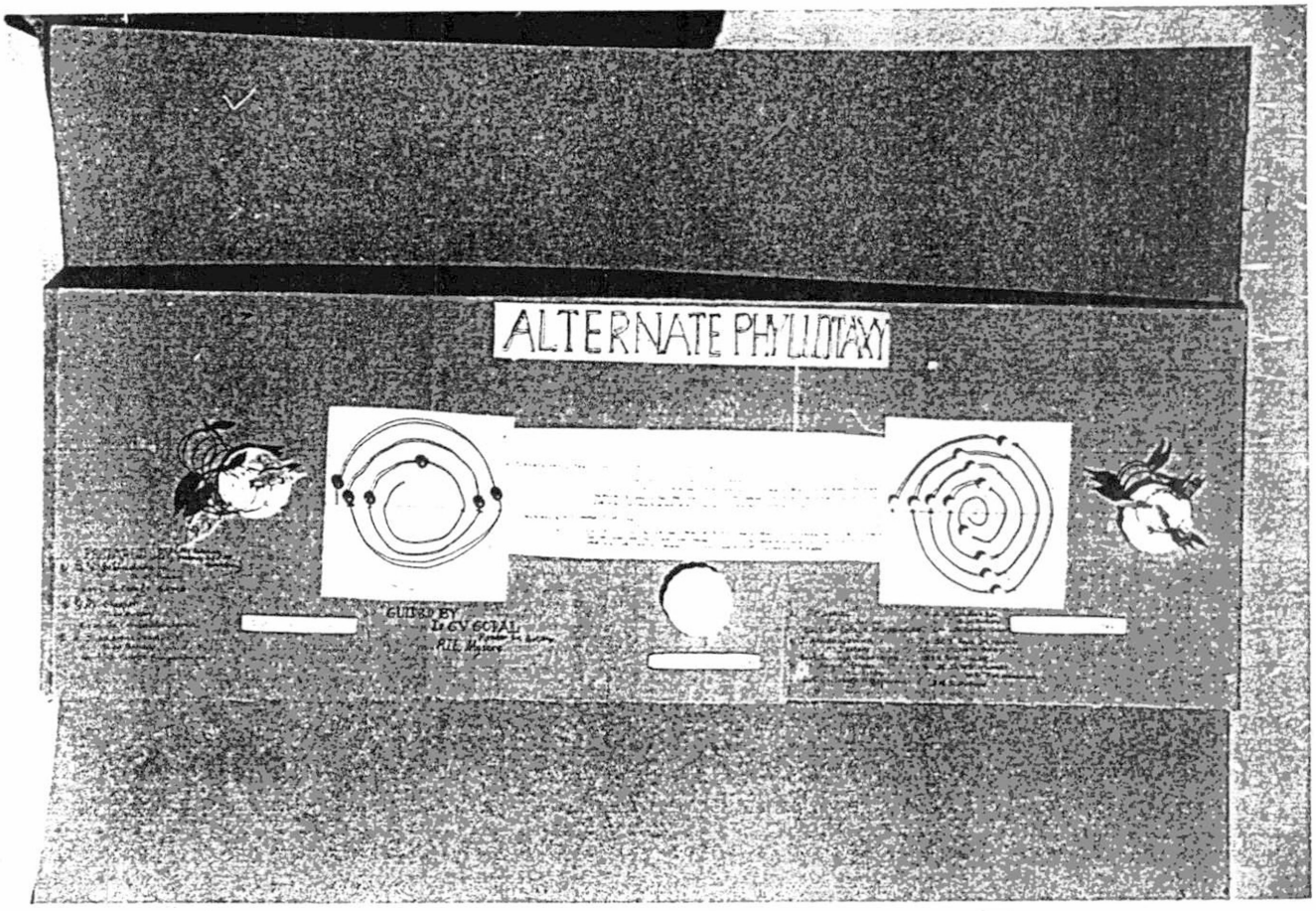


Fig. Diagrammatic representation of mass flow through phloem.


ALTERNATE PHYLLOTAXY

Aim and objective of the working model: Phyllotaxy in plants, a working model:

Objectives:

1. To make students aware about different types of leaf arrangements of phyllotaxy.
2. To bring in awarness all plants do not have same phyllotaxy.
3. To bring the understating and knowledge about different types of genetic spirals.
4. To apply this knowledge and measure the different plants with reference to2/5 , ½ ,1/3, angular divergence in plants.

Materials required:

Thread (twine) Quality, cello tape, Thermocal board, Iron spril, wire, cardboard, colour papers, green and white and pink, orange, Favicol.

Approximate cost: Rs. 1000/- (Approximately)

PHYLLOTAXY

Aim of the Model: Phyllotaxy in Plants, a working model.

The term phyllotaxy (phyla,leaves; taxis, arrangement) means the various modes in which the leaves are arranged on the stem or the branch. The object of this arrangement is to avoid shading one another so that the leaves may get the maximum amount of sunlight to carry on their function of the manufacture of fool. Three principal types of phyllotaxy are noticed in plants.

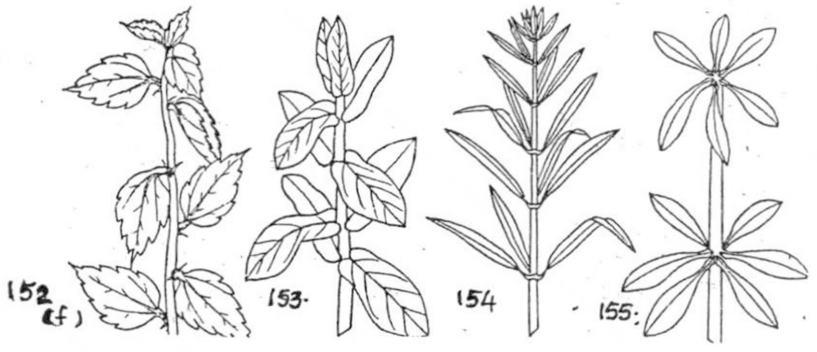
Objectives:

1. To make students aware of different types of leaf arrangements of Phyllotaxy.
2. To bring in awareness that all plants do not have same phyllotaxy.
3. To bring the understanding and knowledge about different types of genetic spirals.
4. to apply this knowledge and measure the different plants with reference to 2/5, ½, 1/3, Angular divergence in plants.

Materials Required :

Thread (twine quality), cellotape, thermocol board, Iron spring, wire, cardboard, colour papers - green, white, pink and orange, Fevicol.

Approximate Cost : Rs.1000/- (approximately).



Description and Working Principle of the Model :

1. **Alternate or Scattered** (fig. 152), when a single leaf arises at each node, as in tobacco, China rose, mustard, sunflower, etc.

2. **Opposite** (fig. 153), when two leaves arise at each node standing opposite each other. In opposite phyllotaxy one pair of leaves is most commonly seen to stand at a right angle to the next upper or lower pair. Such an arrangement of leaves is said to be opposite **decussate** or simply decussate. This is seen in basil (Ocimum), . (Ixora). or madar, or & guava, etc. Sometimes, however, a pair of leaves is seen to stand directly upon the lower pair in the same plane. Such an arrangement of leaves is said to be **superposed**, as in Rangoon creeper (Quisqualis). Branches growing in the horizontal direction, as in guava, B. (Ixora). Etc., commonly bear superposed leaves Not infrequently the same plant shows both alternate and opposite phyllotaxes.

3. **Whorled** (fig.154-5), when there are more than two leaves at each node and these are arranged in a circle or whorl, as in devil tree (Alstonia), or oleander (Nerium), Allamanda, (Vangueria), *etc.*

Alternate Phyllotaxy. The leaves in this case are seen to be spirally arranged round the stem. Now, if an imaginary spiral line be drawn from the base of one particular leaf, and this line be passed round the stem through the bases of the successive leaves, it is seen that the spiral line finally reaches a leaf which stands vertically over the starting leaf. The imaginary spiral line, thus drawn, is known as the **genetic spiral**, and the vertical line, i.e., the vertical row of leaves, known as the **orthostichy** (orthos, straight; stichos, line).

(1) **Phyllotaxy** ½ or 2- ranked or distichous(fig.157). In grasses, bulrush, traveller's tree (fig (Bellamcanda), or butterfly lily, ginger, turmeric, (Vanda), etc. the third leaf stands above the first, and the genetic spiral makes one complete revolution to come to that leaf, and it involves two leaves (leaving out of consideration the first or the third leaf). The fourth leaf stands on the second, the fifth on the first and the third, and so on. Thus there are only two orthostichies, i.e. leaves are arranged in two rows or ranks. Phyllotaxy is, therefore, 2-ranked or distichous(di,two;stichos, line). If now the position of the leaves be marked out on a circle or helix, these are seen to be placed at half the distance of the circle, leaves being equidistant from each other. The phyllotaxy is said to be half and represented by the fraction ½ , the numerator indicating the number of turns of the genetic spiral, and the denominator the number of intervening leaves.

The genetic spiral makes one complete turn in this case, subtending an angle of 360^0 in the center of the circle, and it involves two leaves; so the **angular divergence**, that is, the angular distance between any two consecutive leaves, is ½ of 360^0, i.e. 180^0.

(2) **Phyllotaxy** 1/3 or 3-rankeed, or tristichous (fig.158). In sedges the fourth leaf stands vertically overt the first one, and the genetic spiral makes one complete turn to reach that leaf, and it involves three leaves. The fifth leaf stands on the second, the sixth on the third, and the seventh on the fourth and the first. Thus there are three orthostichies, i.e. leaves are arranged in three rows or ranks. If now their position be marked out on a circle or helix, these are seen to be placed at one-third the distance of the circle; so the phyllotaxy is 1/3 or 3-ranked or tristichous. The angular divergence is 1/3 of 360^0 , i.e. 120^0.

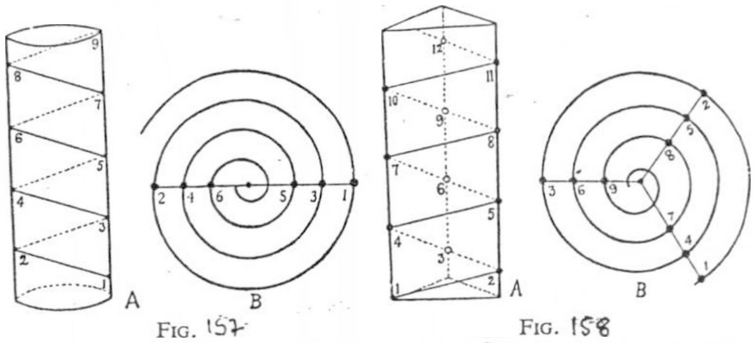


FIG. 157 FIG. 158

Phyllotaxy and Angular Divergence. Fig. 157 *A*, phyllotaxy ½; *B*, angular divergence 180°. Fig. 158. *A*, phyllotaxy ⅓; *B*, angular divergence 120°.

(3) **Phyllotaxy** $\frac{2}{5}$ or 5-ranked or pentastichous (fig 159). In China rose the sixth leaf stands over the first, and the genetic spiral completed two circles to come to that particular leaf. The seventh leaf stands on the second, the eighth on the third, the ninth on the fourth,

the tenth on the fifth, and the eleventh on the sixth and the first. Thus there are five orthostichies, i.e. leaves are arranged in five rows, and because two turns of the genetic spiral involve five leaves, the latter are seen to be placed at two-fifths the distance of the circle. Phyllotaxy is, therefore, $\frac{2}{5}$ or 5-ranked or pentastichous. This is the commonest type of alternate phyllotaxy found in plants. The angular divergence in this case is $\frac{2}{5}$ of 360^0, i.e. 144^0.

(the same fraction can also be arrived at by adding separately the numerators and the denominators of the two previous cases, e.g. $\frac{1+1}{2+3}=\frac{2}{5}$. The next case will, therefore, be $\frac{1+2}{3+5}=\frac{3}{8}$, and so on. Fractions higher than $\frac{3}{8}$ are not commonly met with.)

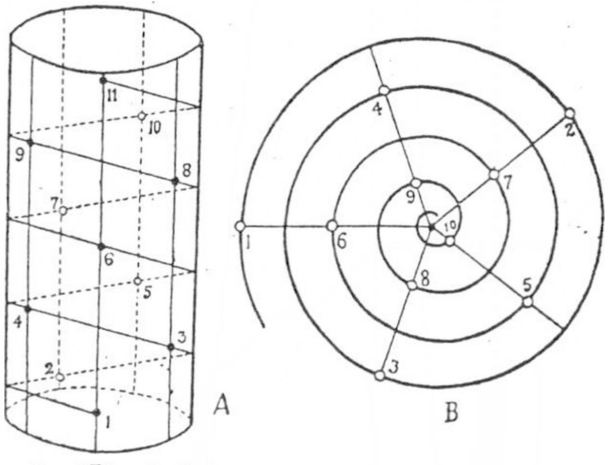


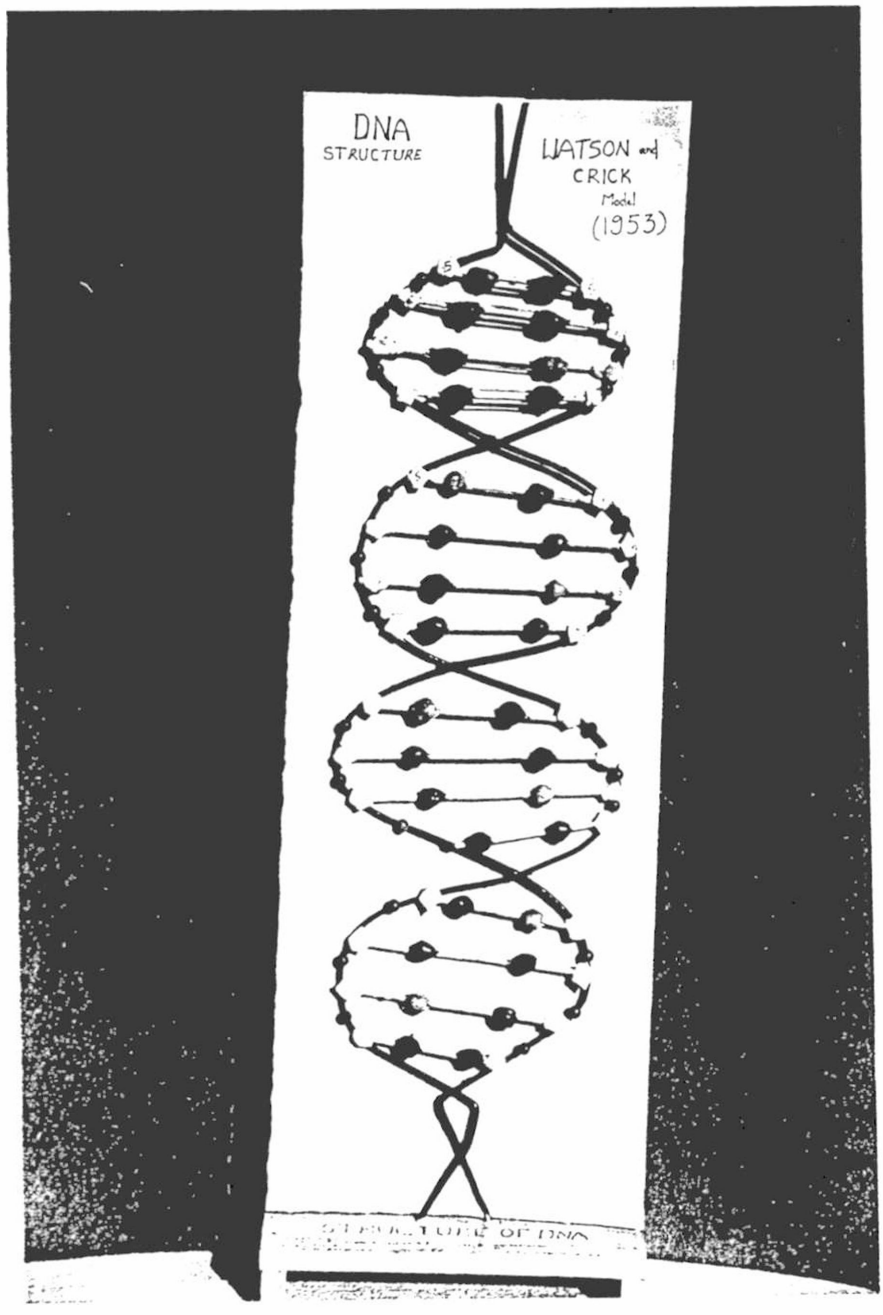
FIG. 159. *A*, phyllotaxy $\frac{2}{5}$; *B*, angular divergence 144°.

Leaf Mosaic

In the floors, walls and ceilings of many temples and decorated buildings we find setting of stones and glass pieces of variegated colours and sizes into a particular pattern. This pattern is known as mosaic. Similarly, in plants wer find setting or distribution of leaves in a peculiar pattern. This pattern of leaf-distrucution is known as leaf mosaic. ·Leaves are in special need of sunlight for the manufacture of food material, and this being so, they tend to fit together and adjust themselves in such a way that they shade the neighbouring leaves as little as possible. IT is thus seen that there is a minimum of overlapping; an inspection of garden nasturtium, or (Acalypha), Begonia and climbers bearing a dense mass of leaves, show that these leaves are disposed very much like the tiles of a tile-house. In plants with a rosette of radical leaves, in those having short internodes and broad leaves, and in whorled phyllotaxy upper leaves are seen to alternate with the lower ones. When the leaves are much crowded they become distributed like the glass pieces fitting into a mosaic, with the smaller leaves fitting into the interspaces of the broader ones. Leaves of prostrate plants, like or wood-sorrel(Oxalis), also form a more or less perfect mosaic. In horizontally growing branches, as

often seen in (Artabotrys), the leaves become distichous, i.e. they twist and orientate themselves in such a way as to exposed their flat upper surface to the sun.

FIG. Leaf mosaic of *Acalypha*.


DNA
STRUCTURE
WATSON and
CRICK
Model
(1953)

Model: Structure of DNA (Deaxyribo nucleic acid)

Aim of the Model:
To explain to the students the structure of DNA proposed by Watson and circk in 1953.

Objective of the model:
The model enable

- Student to acquire knowledge about the structure of DNA molecule.
- Students will learn different aspects in valued in the structure of DNA.
- Students will understand the influence commanded by DNA new different processes.
- Students will be in a position to utilize the knowledge DNA structure in future understanding of the Genetic engineering of transgenic plants.
- To explain students the structure of DNA
- To acquire the different components of DNA
- To know about the structural adjustment Nitrogen bases (purines and pyrimidines)
- To acquire the knowledge of bonds between Nitrogen bases. Weak Hydorgen bonds.
- To make students understand the complementary base pairing affinity.

Materials Required:

1.	Iron Rods. Small gaze	- 6 metre
2.	Wooden frame	- 1
3.	Thermoed	- 1 sheet
4.	Gum (Synthetic)	- 1 bottle
5.	Electrical bulb set	- 1
6.	Paints Red,Blue,White, Yellow	
7.	Small iron wire	- 5 cm.

Composition of the model:

1) Wooden frame which helps to fix the DNA threads.
2) 4 mm iron rods twisted spirally anti parallel to each other.
3) The twisted iron strands gives an appearance of a ladder.
4) To show the nitrogen, bases, parallel iron rods are fixed connecting the opposite linear strands.
5) Prepare Adenine(A), Gaunine (G), Thymine (T) and Cytosine (C) bases, Deorxynibosose sugar units and phosphaste radicals (made up of Lappam).
6) Shown double bonds between 'A' and 'T' and triple bond between 'G' and 'C'
7) Deoxyribose and phosphate radical are arranged in such a manner as both will form the back bone.

Working principle of the model:
In 1953 watson and circk proposed a double helix model for the DNA molecule.

The DNA is the most complex and the heaviest molecule of the cell, having a molecular weight of 10^8 to 10^{11} in one molecule of DNA about 4,00,000 nucleotides are present.

DNA is composed of two backbones intervined in a clockwise direction. The Diameter of the DNA molecule is about 20 A^0. The base pair in about 3.4 A^0 thick and the distance for a complete turn is 34 A^0.

A DNA molecule is a polymer consisting of several thousand pairs of deoxynucleotide monomers. Each monomer is composed of a base(A-T,or C- G) + a deoxtribose sugar + phosphase.

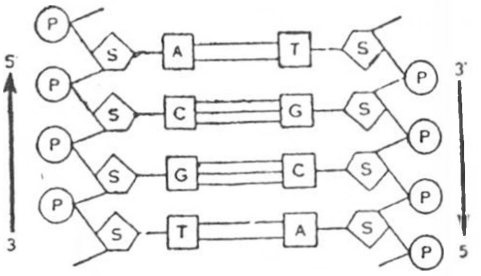
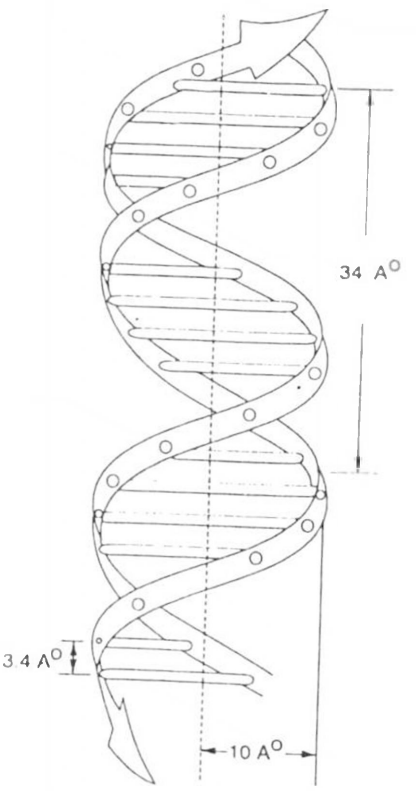


Fig. Diagrammatic representation of a part of DNA molecule to show complementary base pairing.

DEOXYRIBOSE NUCLEIC ACID (DNA)

Watson and Crick (1953) have proposed a model for the structure of DNA molecule which is now usually accepted by all. According to this model called as **Watson Crick Model, the DNA** molecule is a double helix structure consisting of two long polynucleotide Chains coiled round each other around an imaginary axis and running opposite to each other. (Fig



Each polynucleotide chain consists of thousands of nucleotide units.

The back-bone of the two helices of polynucleotide chain consists of deoxyribose phosphates while the bases are present on the inner sides.

The bases of the one polynucleotide chain are complementary to the bases of the other polynucleotide chain and are joined together by

Fig. A double helical model of DNA (Watson and Crick, 1953)

hydrogen bonds. (Fig. ' ;.

The base pairing is very specific (Fig 9.15), The complementary bases are:-

Adenine and Thymine

Guanine and Cytosine

The ratio of purine and pyrimidine basis is 1:1.

The distance between two subsequent base pairs in the polynucleotide chain is 3.4 A.

Each turn of the two polynucleotide chains is completed after 10 base pairs i.e., a distance of 34 A.

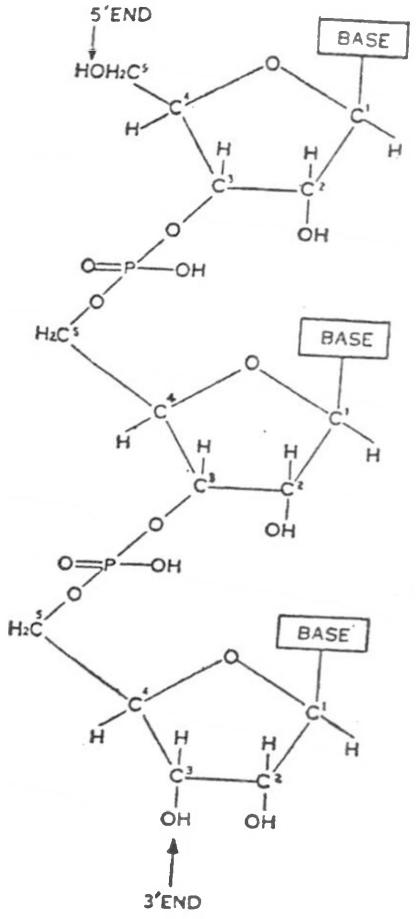


Fig. Polynucleotide chain showing phosphorous ester links.

The distance between the axis and the sugar phosphate region is about 10 A.

The helical coiling is right handed.

(1. D.N.A. molecules are gigantic. Their molecular weights are in the region of several millions.

2. In some bacteriophages i.e., the viruses that attack bacteria, the DNA is single stranded.)

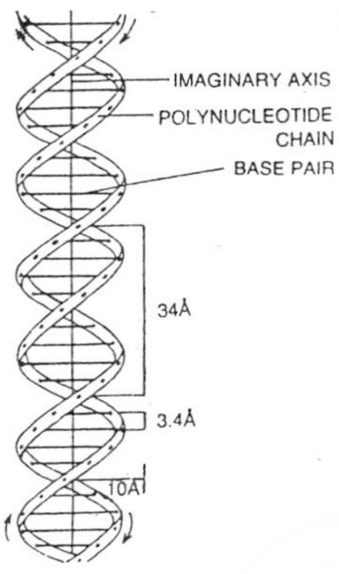
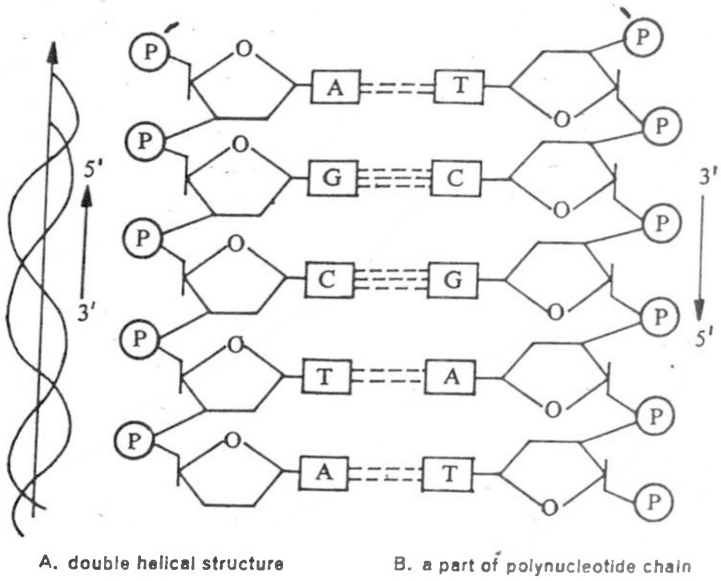
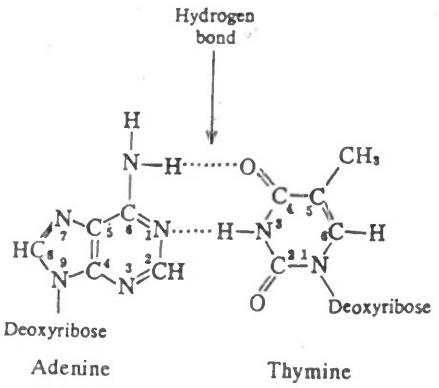


Fig. The Watson-Crick model of DNA.



A. double helical structure B. a part of polynucleotide chain

Fig. Diagrammatic representation of the structure of DNA (A) Double helical structure (B) A part of polynucleotide chain.



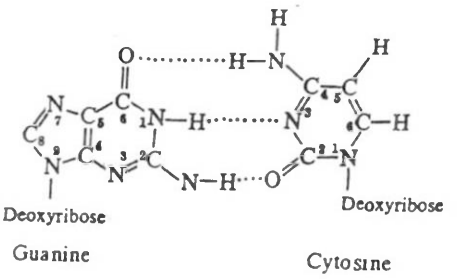


Fig. Base pairing of adenine and thymine and guanine and cytosine.

Various findings from analytical, electron microscopy and X-ray diffraction studies and with the consideration of contribution of earlier workers such as Wilkins, Franklin, Stokes, Stahl, Meselson etc., J.D. Watson and F.H.C. Crick were able to construct a model of DNA which successfully solved the several problems in the field of nucleic acid chemistry.

DOUBLE HELICAL MODEL OF DNA

Watson and Crick (1953a) published double helical model of DNA in Nature (London). The model of DNA has following characteristics.

1. A DNA molecule consists of two polynucleotide chains.
2. The two chains coil in an inverted way around the assumed same axis.
3. The chains follow right handed helices, with ten base pairs in one turn of the spiral.
4. The one chain runs inverted relative to the other. i.e. the sequence of atoms in two chains runs in opposite directions. Thus, the two-helix show anitparallel arrangement.
5. The bases are present inside and phosphates on the outside of the double helix, with their planes set at right angles to the axis of helix and spaced at intervals of 0.34 m μ along it.

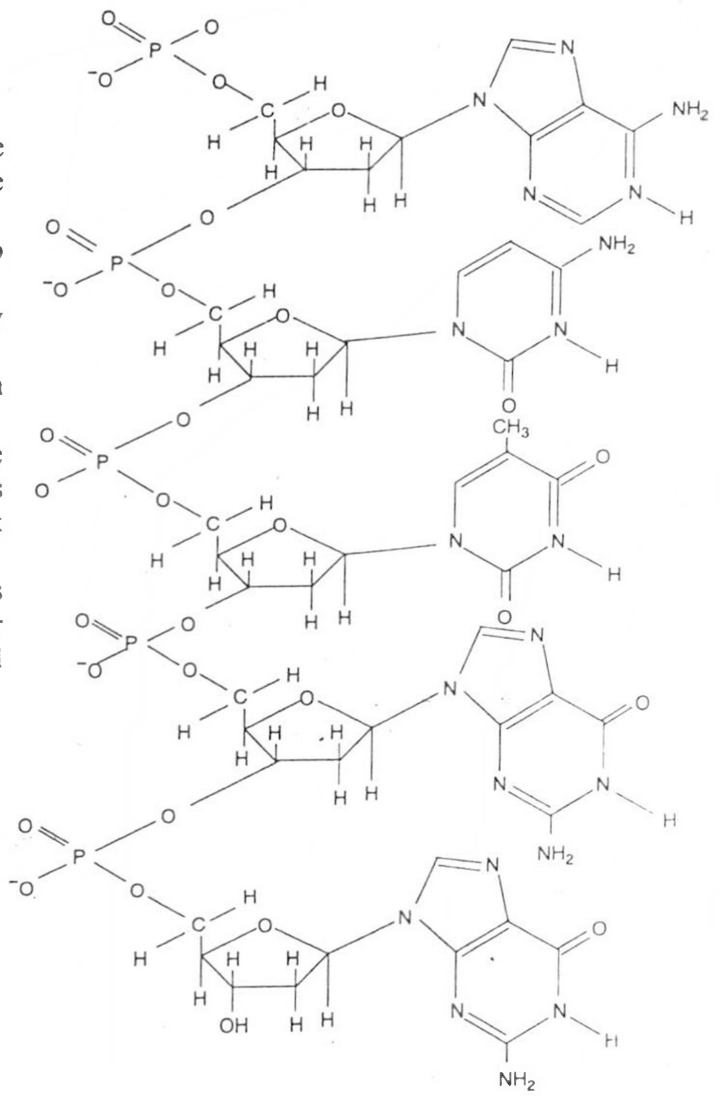
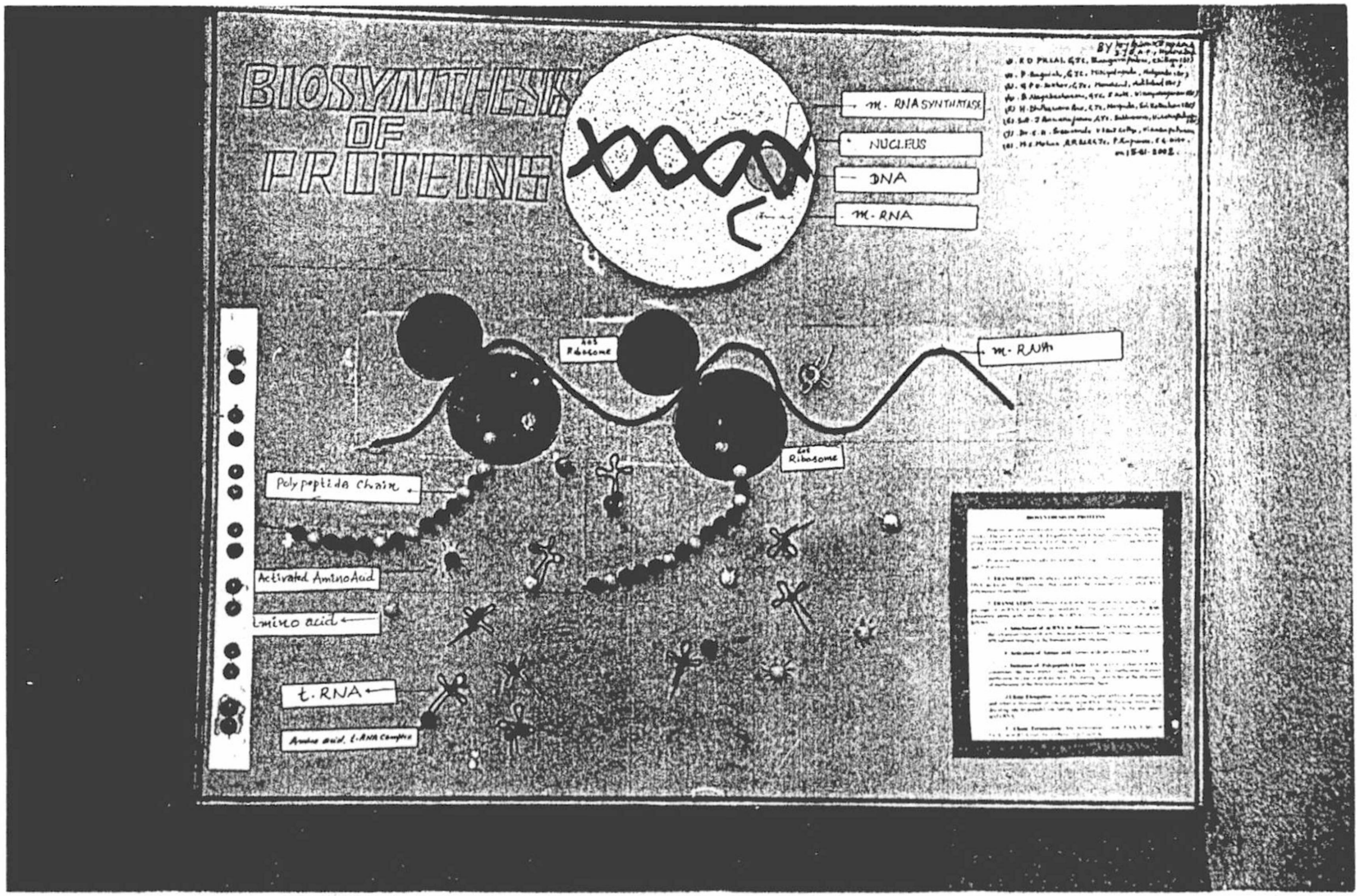


Fig. A long polynucleotide chain. See carefully position of attachment of different nucleotides.


BIOSYNTHESIS
OF
PROTEINS
m-RNA SYNTHATASE
NUCLEUS
DNA
m-RNA
Ribosome
m-RNA
Ribosome
Polypeptide chain
Activated AminoAcid
Amino acid
t-RNA
Amino acid t-RNA Complex

Aim of the Model : **Synthesis of proteins**

Protein synthesis in plants is under the direct control of DNA. A brief account of the various steps involved in protein synthesis is as follows :

(i) DNA in the nucleus which directs the synthesis of m-RNA and provides it with necessary genetic information in the form of codons for the formation of specific proteins. This process is called as **transcription.** **M-RNA** is synthesized in the presence of the enzyme RNA-polymerase.

(ii) **M-RNA** molecule moves into the cytoplasm where it associates with specific **t-RNA** molecules having specific anticodons complementary to its codons.

(iii) **M-RNA** becomes associated with the ribosome which acts as template for protein synthesis. At this template, energy is supplied by GTP (Guanosine triphosphate). Mg^{++} ions are also required.

(iv) t-RNA molecule picks up a specific amino acid by its C-C-A end (according to its anticodon) after the amino acid has been activated by ATP in the presence of a specific enzyme.

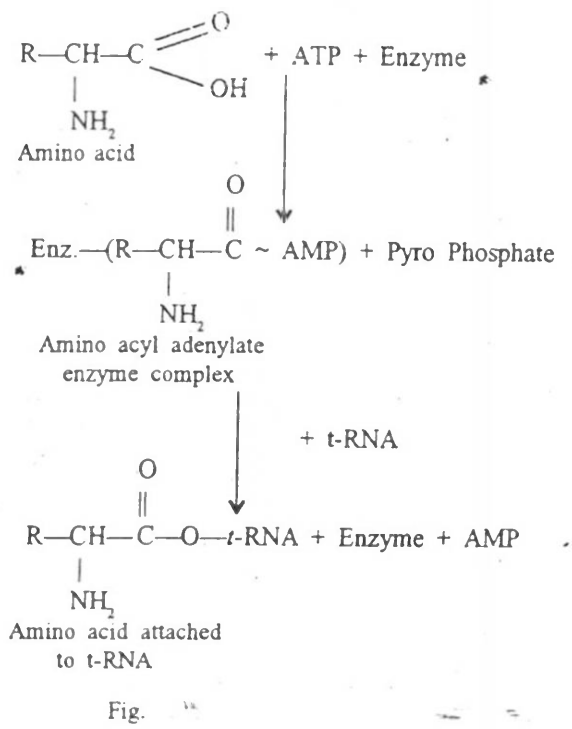


Fig.

Activation of the amino acid

Initiation of polypeptide chain

(v) In bacteria *Escherichia coli* the 70 S ribosome dissociates into 30 s and 50 S subunits when Mg^{++} conc. is low. In higher plants, the 80 S ribosome breaks into 40 S and 60 S subunits.

Initiation factor called IF3 is also required for dissociation of 70 S ribosome into 30 S and 50 S subunits.

(vi) 30 S subunits of the ribosome recognizes the 5' terminal end of the m-RNA from where the protein synthesis i. e. the formation of polypeptide chain starts.

Factor IF3 is also required for binding of 30 S subunit with 5' end of m-RNA.

(vii) 30 S subunit also recognizes t-RNA – amino acid complex which is then transferred to 50 S subunit. The first amino acid to be incorporated into the polypeptide chain is N-Formlymethionine for which the codons are UUG, AUG, GUG. Thus, t-RNA-N-Formly-methionine-complex is the initiator of the polypeptide chain.

Factor IF2 is required for binding of formyl-methionine-t-RNA with 30 S – m-RNA complex.

(viii) 30 S and 50 S subunits of the ribosome unite in the presence of Mg++ ions and become associated with m-RNA. GTP provides energy.

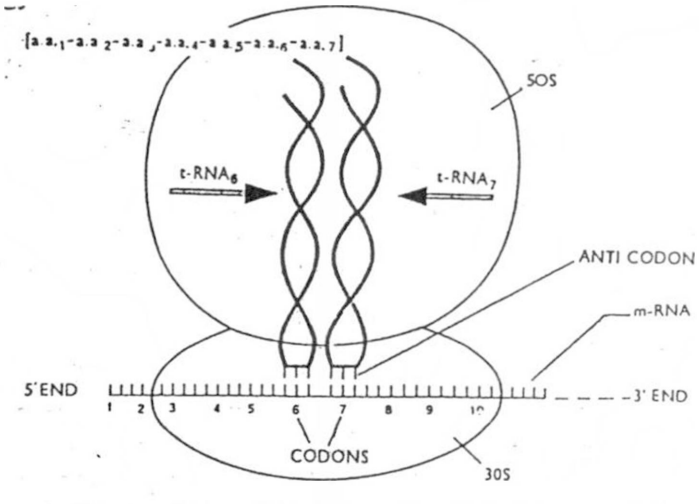
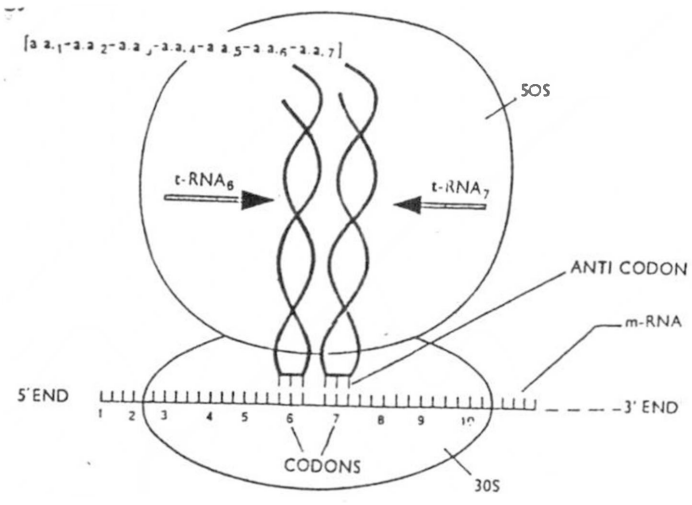


Fig. The translation of the information carried by m-RNA into protein structure.

The translation of the information carried by m-RNA into Protein structure

(ix) t-RNA-amino acid complex attached to the ribosome is placed opposite the specific codon on m-RNA molecule due to the presence of its complementary anticodon in t-RNA molecule.



Elongation of polypeptide chain :

(x) Ribosome and the m-RNA move relative to each other. When ribosome reaches a second codon, another specific t-RNA- amino acid-complex is attached to the ribosome so that its anticodon is placed opposite its complementary codon.

Each ribosome has two sites for the attachment of aminoacyl – t-RNA complex. These are 'P' site (Peptidyl site, facing towards '5' end of m-RNA) and 'A' site (aminoacyl-site, facing towards, 3' end of m-RNA). It is not clear whether the first aminoacyl –t-RNA (i.e. formyl – methionine – t-RNA) comes to A site or P site, but ultimately it has to be shifted to P site before a second aminoacyl-t-RNA attaches itself to A site.

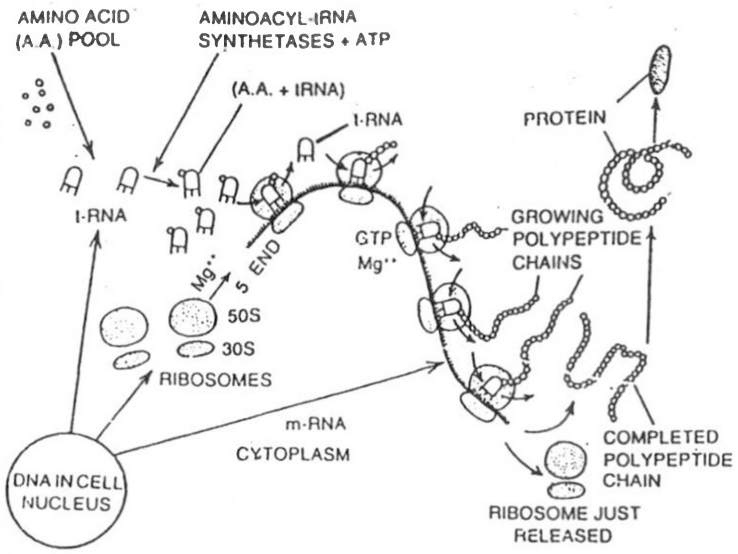
T-factor(T) or transfer factor (TFI) also called as elongation factor (EF) which consists of two components EF-Tu (unstable on heating) and EF-Ts (stable on heating) is required for proper binding of aminoacyl-t-RNA to 'A' site of the ribosome.

(xi) A peptide bond is established between the carboxylic and amino group of the two amino acids in the presence of the enzyme peptide synthetase. The preceding t-RNA-amino acid complex breaks so that t-RNA molecule is released into the cytoplasm to become charged again with amino acid.

The 'P' site of ribosome now becomes free and 'A' site of ribosome carries the growing polypeptide chain.

The peptidyl-t-RNA (i.e. the t-RNA carrying the growing poypeptide chain at site 'A' is now translocated or shifted to 'P' site of ribosome so that its 'A' site becomes free paving way for next aminoacyl-t-RNA complex to be attached to 'A' site.

This transfer of peptidyl-t-RNA from A to P site requires GTP and elongation factor called EF-G (earlier known as transfer factor II i.e. TF-II or translocase).



Diagrammatic representation of the complete process Of protein synthesis

(xii) In the same way, during the movement of the m-RNA and ribosome, a number of specific amino acids are added one after another into the growing polypeptide chain.

(xiii) Polypeptide chain remains attached to the 50 S subunit till it is complete.

Termination of polypeptide chain

(xiv) Termination of the polypeptide chain takes place when ribosome (to which the polypeptide chain is attached) comes over the non-sense codon in m-RNA molecule during its movement against m-RNA. Non-sense or chain termination codons are UAA, UAG, UGA.

The sequence of 3 nucleotides in polynucleotide chains of the DNA molecule is called as **triplet code.**

In messenger RNA molecule (m-RNA) this sequence of 3 nucleotides is **Complementary** to the sequence of nucleotides in DNA and is called as **codon.** (A will be complementary to U and G to C and vice versa).

There are different codons for different amino acids. The latter are incorporated in a particular protein through specific t-RNA molecules with specific **anticodons.** Anticodon is complementary to codon.

Some of the codons like UAA, UAG, UGA cannot select any amino acid and are called as **non-sense codons** or **Chain termination codons.**

A list of all the codons which specific amino acids constitutes the **coding dictionary or genetic code.**

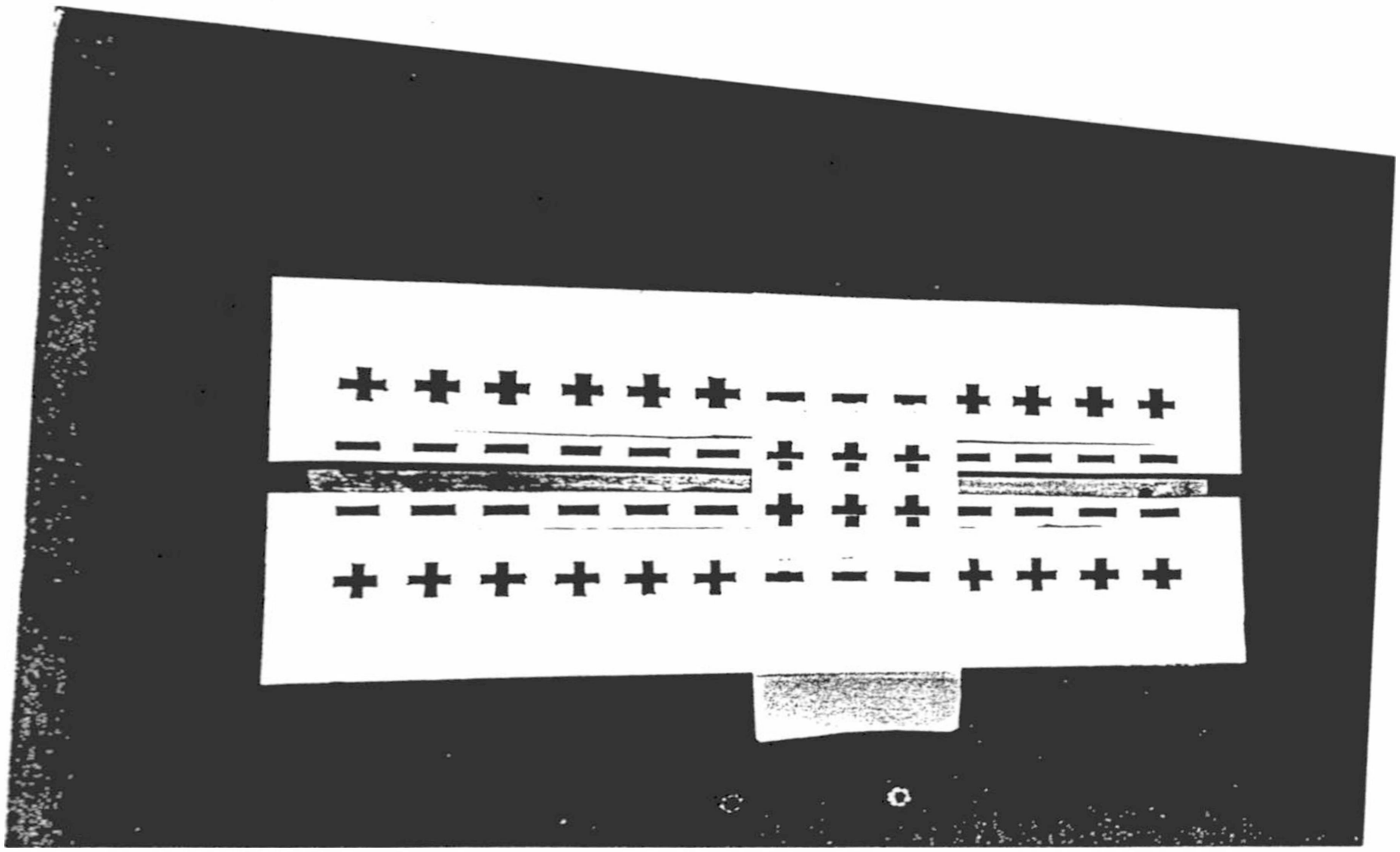
Some of the important features of the genetic code are :

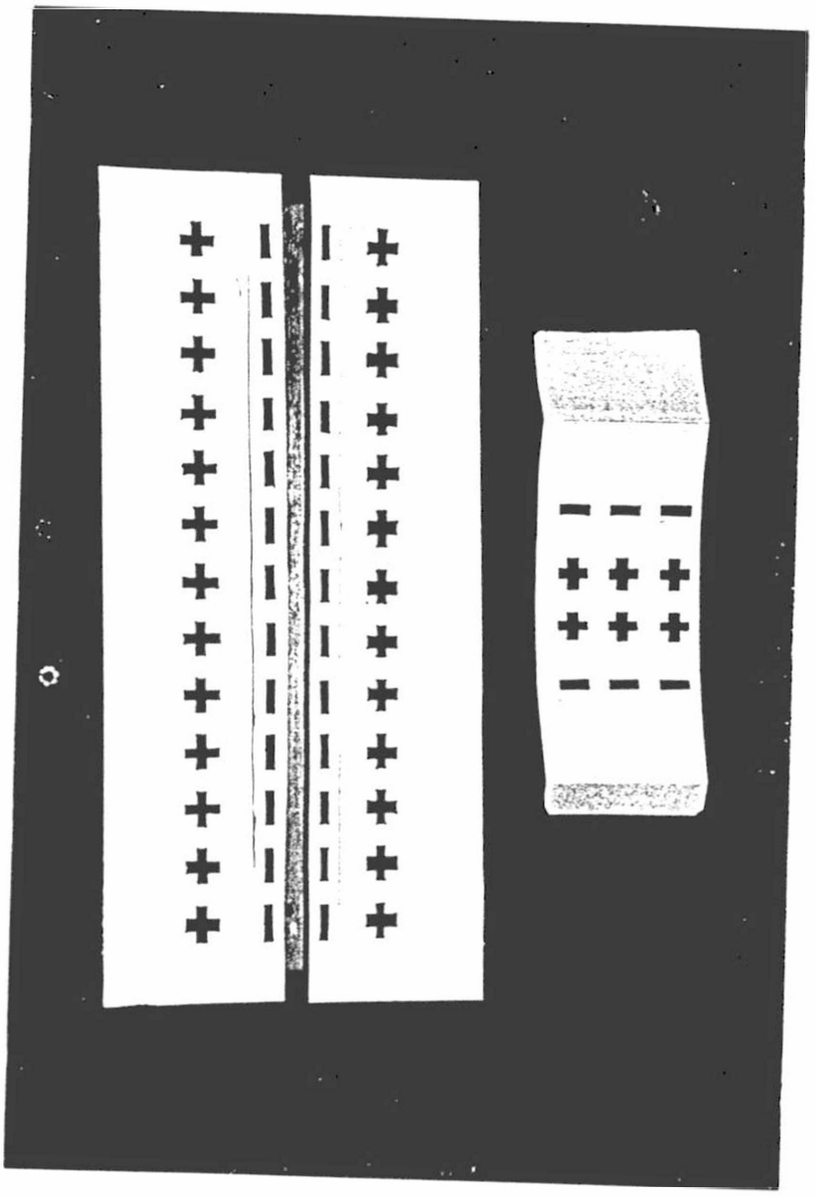
(i) It is degenerate i.e. there may be more than one codon for a particular amino acid e.g. UUU, UUC = phenyl alanine.

(ii) It is non-overlapping i.e. only as many amino acids are coded as there are codons in end to end sequence e.g. UUUCCC = Phenylalanine (UUU) + proline(CCC).

(iii) It is commaless ie. there are no intermediary nucleotides (or commas) between the codons.

(iv) The first and the second letters of a codon are more important than the third in specifying an amino acid.





Aim of the Model: To show propagation of nerve impulse.

Objectives:

1. To show structure of a nerve fibre is in section.
2. To show arrangement Sodium and Potassium ions in the membrane system of nerve fibre.
3. To describe the nature of Resting potential.
4. To explain the 'action potential' during propagation of nerve impulse.
5. To explain saltatory conduction of nerve impulse.

Materials required:

Half split bamboo piece, drawing sheets, black ink, fevicol, pins, card board,etc.

Working Principle: (Preparation)

On a split bamboo piece hard card board pieces are fixed like wings as shown in diagram. Over the card board pieces white drawing sheet pieces are pasted with fevicol to cover from all sides. On drawing sheets positive (+) and negative (-) markings are written in such a way that all positive marking remain outside the bamboo piece and all negative markings on the inner side as shown in diagram. Such two pieces are pasted on to the sides of bamboo piece. Another strip of drawing sheet is inserted in to the long slits made between positive and negative marking. This sheet is made to run from one end of bamboo pieces to another end in the slit, and this sheet should cover 3 positive and 3 negative markings on both the sides. On this piece small windows in the form of negative markings are cut in such a way that each window covers positive marking exposing only negative sign. Similarly on inner side windows with black markings are also made. When this strip is slided in the long slits, it appears as if there is change in signs, i.e., positive outside look like negative and negative inside like positive. This change is brought about by moving paper from one end to the other end.

Materials required for preparation of working models in Biology

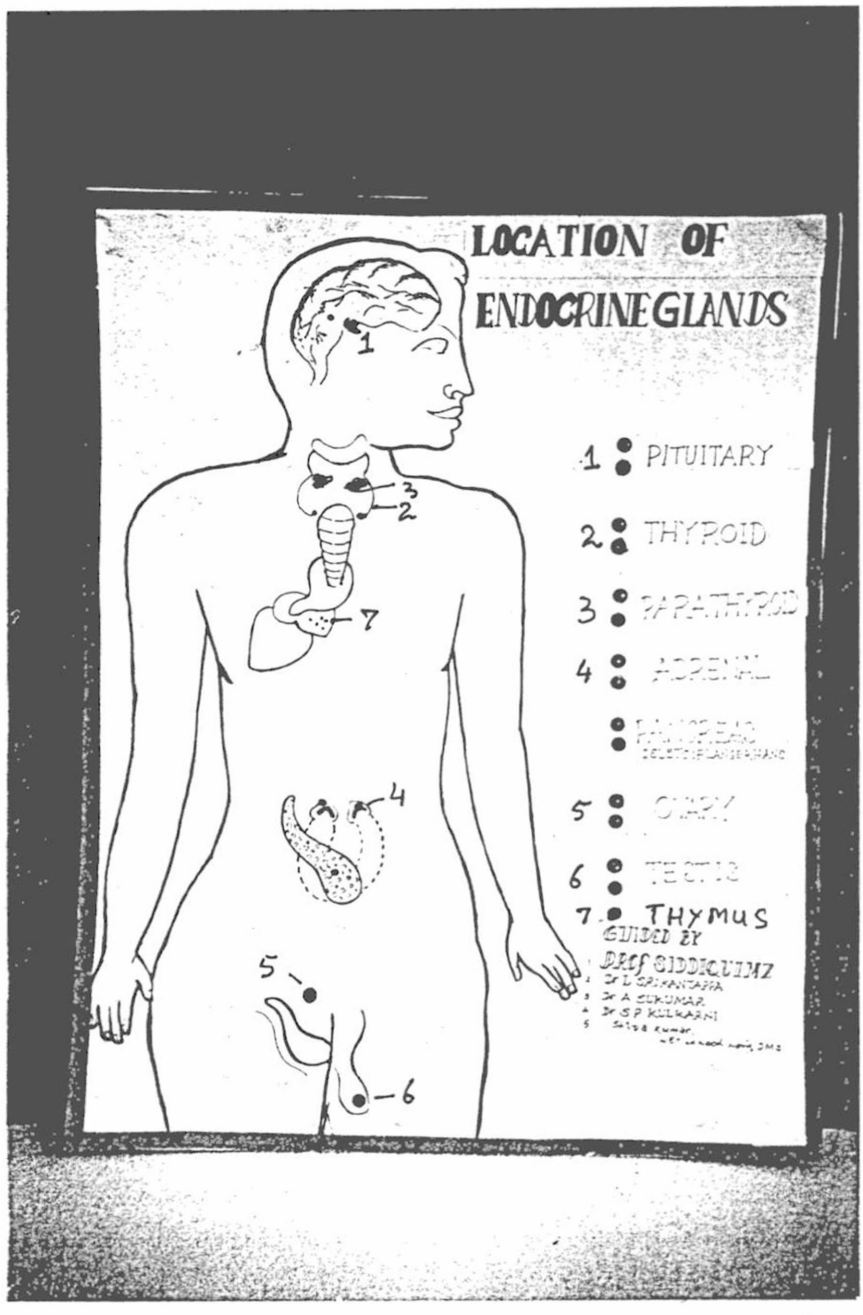
I. Propagation of nerve impulse.

1. Bamboo pieces – 12 Nos. (Splits into two).
2. K G Cardboard - 4 Nos
3. Hardboard - 4 Nos.
4. Fevicol - ½ Kg.
5. Sketch Pens - One Set
6. Sharp cutting Knives – 6 Nos.

7. Electrical bulbs in the Form of Circuit - 4 meters (Two different colours-Red & Green)
8. Plug Pins - 6 Nos.
9. Wire - 6 meters.

II. ***Ultrafiltration in nephron***

1. Plast bottles (Empty peps) - 6 Nos.
2. Plastic tube 1" dimension - 6 meters.
3. Plastic tube ¼'' dimension - 6 meters
4. Wooden Board 3' x 4' - 4 pieces
5. Enamel colours white & black - 250 ml x 2


LOCATION OF
ENDOCRINE GLANDS
1 PITUITARY
2 THYROID
3 PARATHYROID
4 ADRENAL
5 OVARY
6 TESTIS
7 THYMUS
GUIDED BY
Prof SIDDIQUIMZ

Aim of the Model : To show the positions of endocrine glands and their functions in Human body.

Objectives:

1. To know different endocrine glands of human beings.
2. To identify their location in body.
3. To understand importance of endocrine glands.

Materials required:

Wooden board 3' x 2' , Thermocol sheet 3' x 2' Oil paints, drawing sheets, LED bulbs, wires, dry cells, poly thene sheet, Fevicol/Fevibond,(Approximate cost Rs.200/-) Drawing pins, etc.

Preparation:

Wooden board of 3' x 2' is painted with a suitable oil paint colour for background. Cut the thermocol and drawing sheets to a suitable sized diagram of human body as shown in diagram. Fix the thermocol cutting on board by fevicol. On drawing sheet cutting draw positions of endocrine glands like pituitary, thyroid, pancreas, adrenals, testes and ovaries etc with pencil and colour them suitably. Fix the paper cutting on thermocol on the wooden board. Drill small holes through each endocrine gland and fix LED bulbs. On backside of wooden board connect all LEDs by wire in series. On the front side to one corner fix pairs of drawing pins and a piece of wire which act as switches. In turn these pins are connected to LED Circuit. All LED are connected to dry cells. Each pair of drawing pins and switch are linked to one endocrine gland, next to which name of that endocrine gland is labelled. On pressing any switch the bulb of that endocrine gland grows.

Concepts explained:

1. All human activities are regulated by neuro endocrine system.
2. Pituitary gland produces trophic hormones that regulate other endocrine glands.
3. There exists a feed back mechanism to regulate pituitary secretion also.
4. All endocrine glands produce specific hormones that regulate physiological functions of the body.
5. Any malfunctioning of these glands lead to diseases (Hypo and hyper actions).

Principle: _The main properties of nerve fibre are exicitability and conductivity which enable the nerve fibre to transmit nerve impulses. Nerve impulse is a physico – chemical change observed in the nerve fibres leading to propagation of impulse.

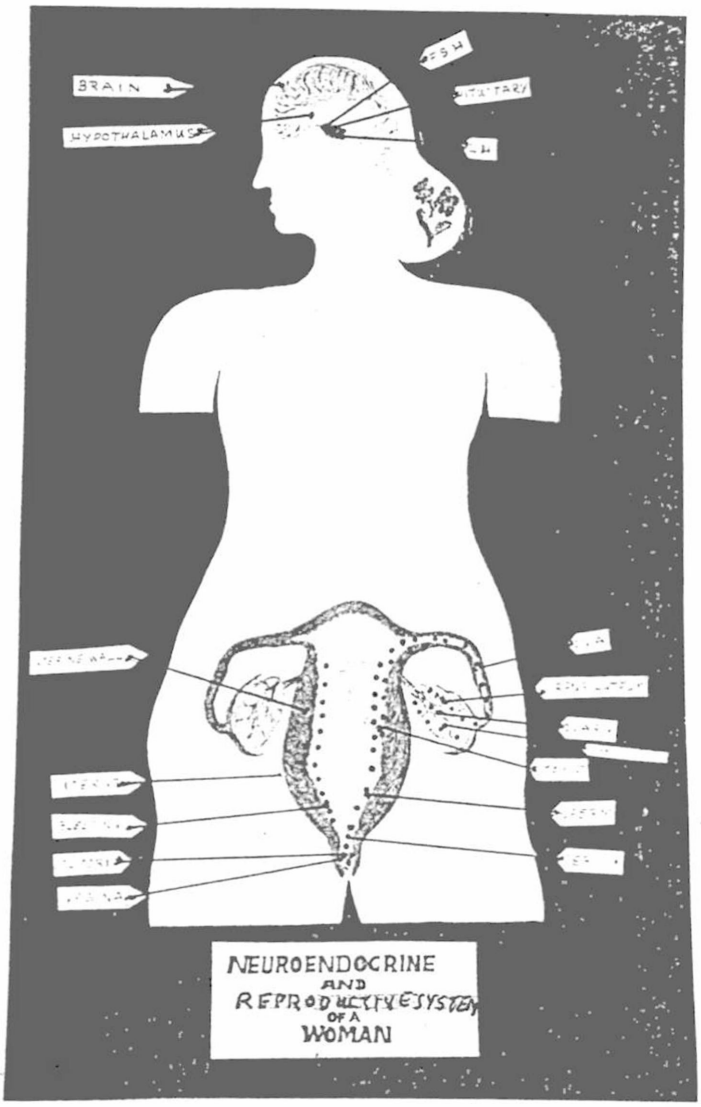
A nerve fibre is a cylindrical structure with axoplasm inside and axon membrane outside. The axon membrane exhibits bioelectrical potential or membrane potential. Due to semipermiable nature of membrane to certain ions the distribution of sodium and potassium vary all along the length the fibre. At rest a nerve impulse is electropositive outside because of high concentration of Na ions, and electronegative inside. Small amount of K ions are found inside the membrane.

Nerve signals are transmitted by action protentials, which are rapid changes in the membrane potential. Action potential moves from one end of nerve fibre to another end. This happens within fractions of seconds. During nerve impulse membrane becomes permeable to sodium ions and lots of sodium ions get into membrane resulting into change in polarity. This is known as depolarization. Now membrane is -vely changed outside and +vely inside. So also with Potassium ions, causing flow of potassium exterior when the impulse passes forwards bring back the norm al membrane potential.

In saltatary nerve impulse the signal jumps from node to node making the impulse travel extremely past.

Concepts developed:

1. Every nerve fibre has membrane potential of –vely inner side and +ve outer side at rest.
2. Impulse causes disturbance in arrangement of Sodium and Potassium ions by change in permeability in membrane.
3. Action potential is due to inflow of sodium ion inside and potassium ions outside.
4. Depolarization is the change in membrane and repolarisation is regaining normal potential.
5. Saltatary nerve impulses travel much faster than normal impulses.


BRAIN
HYPOTHALAMUS
NEUROENDOCRINE
AND
REPRODUCTIVE SYSTEM
OF A
WOMAN

Aim of the Model:
Neuro-endocrine and reproductive system of a woman.

Objectives:

1. To illustrate the hypothalamic control of the pituitary gland.
2. To illustrate the role of Trophin hormones from pituitary to effect the ovary and uterus.
3. To illustrate the role of FSH in development of ova (graffian follicle).
4. To illustrate the role of Estrogen for the ovulation.
5. To illustrate the role of corpus luteum (Progesteron) to maintain the uterine wall for the implantation.
6. To illustrate the pituitary trophin (L H) to maintain the secretion of progesterone.
7. To illustrate the phenomenon of fertilization and implantation of fertilized egg (zyote) in the uterus.
8. To illustrate the phenomenon of menstrual cycle in a woman.
9. To illustrate the tubectomy (family planning)

Materials required:

The following materials are required to prepare the working model which can be assembled in a practical lab.

A wooden cardboard 3 ' x 2 ' , thermocol sheet 3 ' x 2 ' ; Fevicol, white paper sheet, colour paints, LED bulbs, wire and dry cells/current converter AC to DC.

Preparation of the working model:

A low-cost working model can be made in the lab for which cardboard of 3'x2' can be cut for the base of the model. After making a sketch, the cut out can be made and drawing the hypothalamic area with pituitary and a diagram of female reproductive system on the thermocol can be pasted on the cardboard (as shown in the photo). Two LED bulbs of different colours are fixed in the pituitary area and series of bulbs are fixed in the ovary as a growing follicles and corpus luteum. Number of bulbs are arranged from the vaginal area to oviduct to represent the sperms and different coloured bulbs to indicate the movement of fertilized ova (zygote) to get attached in the uterus. The other half of the uterus is shown with series of two different coloured bulbs representing the healthy uterine wall and its bleeding part. The electrical circuits with wire are made and fixed on the back side of the cardboard. The circuit is made in such a way that once the switch is on and current is provided first one bulb (FSH) in the pituitary glows which follows the lighting of bulbs in the ovary (Follicles) then a bulb for estrogen glows which follows the ovulation represented by a series of bulbs in the oviduct. At the same time the bulbs representing the sperms show movement towards the oviduct. This is followed by the downward movement of zygote and implantation in the uterus.

The second phase of the circuit which shows the glow of a bulb in the pituitary (LH) which also glow the corpus luteum and the bulbs in the other half of the uterus presenting the growth of healthy endometrium of uterus. In the end of the series, the red bulbs, show the bleeding, completing the menstrual cycle of the system.

Principles of the model:

It is a well established fact that the hypothalamus controls the hypophysis(Pituitary) through the Releasing Factor (neurosecretory materials) secreted by the hypothalamic centers and in turn the pituitary controls the other endocrine glands through its tophic hormones.

In the female reproductive system the Follicle Stimulating Hormone (a trophin) enhances the growth of folicular cells in the ovary for the maturation of graffian follicle (ovum). The estrogen produced by the ovary (in the stroma of ovary) causes the ovulation and then the ovum moves in the oviduct where it gets fertilized by a sperm. The fertilized ovum (zyote) gets attached to the healthy endometrium of the uterine wall. The implantation of the zygote (embryo) is maintained by the functional corpus luteum through the secretion of progesteron hormone till the full period of pregnancy (can be shown by lighted bulbs)

If the tubectomy is done (cutting of oviduct and legated separately) of both the oviducts, there will be no fertilization, hence no pregnancy, which is a process of family planning and this can be explained in this model.

The second aspect of the model which shows the menstrual cycle in female can be explained with illuminated bulbs in the uterus. In principle the Lutenizing Hormone (LH) a trophin which controls the secretion of progesteron from corpus luteum to keep the healthy growth of the endometric the wall of the uterus. If the implantation of embryo has not taken place or otherwise after 14 days, the endometrial wall gets dissolved and caused bleeding for about 2-3 days but again the next cycle is maintained and it gets repeated.

Media Coverage

The news item figured about the programme in local daily "Star of Mysore" dated 22.1.2001 (Tuesday) in page - 7.

An extract of the Xerox copy is pasted here. In many dailies like Deccan Herald, Indian Express, the news item has figured about the workshop. Thus the workshop is a great success.

Workshop on preparing models

Mysore, Jan. 22- Classroom teaching can be made more effective and interesting through the use of appropriate teaching aids, opined Prof. G. Ravindra, Principal, Regional Institute of Education (RIE) here, while delivering the valedictory address of the 10-day workshop on the preparation of working models in Biological Science at Pre-University level here on Jan. 16.

Learning is more important than mere teaching. Teaching becomes effective if the appropriate teaching aids are used and explained to the students, he said.

Teachers should know how to use and when to use the teaching aids. Teaching aids for the sake of teaching aids will not help the teacher rather they should know what type of teaching aids fit in well to the concept to be taught, he added.

Prof. K. Dorasami, Dean of Instruction, RIE emphasised the use of teaching aids to make classroom transaction interesting.

Prof. M.Z. Siddiqui and Dr. G.V. Gopal, Programme Co-ordinator explained the achievements of the 10-day workshop and lauded the efforts of participants in preparing 13 working models in Biological Science.

As many as eight junior college lecturers from Andhra Padesh representing different regions of Andhra participated in the workshop, according to a press release from Dr. N.N. Prahallada, Head, DEE.-MA

RIE workshop

Times News Network

MYSORE: The 10-day workshop on preparation of working models in biological sciences at the pre-university level was conducted by the Regional Institute of Education here recently. Eight junior college lecturers from different parts of Andhra Pradesh prepared 13 working models in biological sciences during the workshop.

'Use teaching aids to improve teaching'

DH News Service

MYSORE, Jan 17

Classroom teaching can be made more effective and interesting through the use of appropriate teaching aids, said Prof G Ravindra, principal, Regional Institute of Education (RIE), Mysore.

Delivering the valedictory address of the 10-day workshop on "Preparation of working models in biological science at pre-university level" at RIE here, he said learning is more important than mere teaching.

Teaching becomes effective if appropriate teaching aids are used and explained to the students, he said, adding that use of working models will enthuse the students' interest thereby motivating them to learn the concepts better.

Prof Ravindra stated that teachers should know how to use and when to use the teaching aids. Prof Ravindra pointed out that science is doing, experimenting and demonstrating, therefore no science classes should be taught without appropriate teaching aids.

"Simplified models" if used, will go a long way in helping children understand the concepts better. Teachers can also improvise certain teaching aids, he opined here.

Prof K Dorasami, dean of Instruction, RIE, Mysore, who spoke on the occasion, emphasised the use of teaching aids to make classroom transaction interesting.

Programme co-ordinators, Prof M Z Siddiqui and Dr G V Gopal explained the achievements of the 10-day workshop and appreciated the efforts of participants in preparing 13 working models in biological science.

As many as eight junior college lecturers from Andhra Pradesh took part in the workshop. Dr N N Prahalada, head, DEE, RIEM was present.

INTEGRATED EDUCATION: Mr Ravindra, after inaugurating a 15-day masters' trainers training programme on Integrated Education of Disabled (IED) at RIE today, said through IED, disabled children will get all the benefits just like any other normal student.

DH photo

Teaching aids emphasised for effective classroom teaching

Times News Network

MYSORE: Classroom teaching can be made more effective and interesting through the use of appropriate teaching aids, said Prof G. Ravindra, principal, Regional Institute of Education, here on Wednesday.

Delivering the valedictory address of the I0-day workshop on the preparation of working models in biological science at the pre-university level here at RIE, Ravindra said "Learning is more important than mere teaching. Teaching becomes effective if the appropriate teaching aids are used and explained to the students. Use of working models will enthuse the students interest thereby they will be motivated to learn the concepts better."

Therefore, he said teachers should know how to use and when to use the teaching aids.

Prof K. Dorasami, dean of instruction, RIE, Mysore also spoke on the occasion and emphasised the use of teaching aids to make classroom transaction interesting.

As many as eight junior college lecturers from Andhra Pradedh representing different regions of Andhra participated in the workshop and contributed richly to the preparation of working models.

On Thursday, Prof G. Ravindra, inaugurated a 15-day Masters Trainers training programme on IED at Regional Institute of Education.

Speaking on the occassion, he stressed the need for identifying the disability of children and accordingly plan the effective educational interventions to help the disabled children.

The 15-day training programme is being organised jointly by the DSERT, Government of Karnataka and RIE, Mysore. As many as 20 DIET personnel representing different parts of Karnataka are participating in the training programme.

SUMMARY OF THE WORKSHOP REPORT

	Planned for Biology group working models preparation	Achieved/prepared working models during the workshop
Botany	**14**	**13**
Zoology	**13**	**06**
Total	**27**	**19**

70% of the targeted work was achieved.

This was due to the limited number of participants. Out of the planned 35 teachers for the programme only 8 Junior College Teachers/Lecturers have attended from Andhra Pradesh and added to this, all of them have only Botany M.Sc.Background. So models in Zoology were prepared with the help of faculty of RIE, Mysore. The remaining 30% of activities were selected by the RIEM faculty and completed the task. With constraint of participants, we could achieve more than 70% of the targeted work. Thus the workshop was successful.

क्षेत्रीय शिक्षा संस्थान
(राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद)
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Dr.G.Ravindra
Principal

No.F.18.14/DEE/RIEM/2001
20th December, 2001

Dr.D.Ravindranatham
Director, S.C.E.R.T
Government of Andhra Pradesh
Fateh Maidan Road
Hyderabad-540 001

Sir,

The Regional Institute of Education, Mysore will be organizing a 10 day programme on the preparation of working model in Biological Science at +2 level from 7 – 16th January, 2002.

The main objective of this workshop is to prepare working models in Biological Science at + 2 level.

In this connection, we request you to kindly depute twenty five Biology Teachers at + 2 stage who have the knowledge of preparing working models to this ten day workshop at RIE, Mysore from 7 – 16 January, 2002.

TA/DA will be paid to the deputed + 2 Biology Teachers as per NCERT norms and they will be accommodated in the Narmada Hostel of our Institute during the programme period.

I request you to kindly send the list of twenty five Biology Teachers at + 2 stage to this workshop at the earliest. You may give due weightage to SC/ST categories of teachers while deputing the + 2 Biology Teachers.

A line in reply confirming the deputation of + Biology Teachers to this programme is highly appreciated.

Thanking you,

Yours faithfully,

(G.Ravindra)

Copy to: Dr.B.Atchamamba, Joint Director,
Board of Intermediate Education, Hyderabad with a request to do the needful in the matter.

2) Dr.M.Z.Siddiqui/Dr.G.V.Gopal, Coordinator, RIEM for information.

3) File