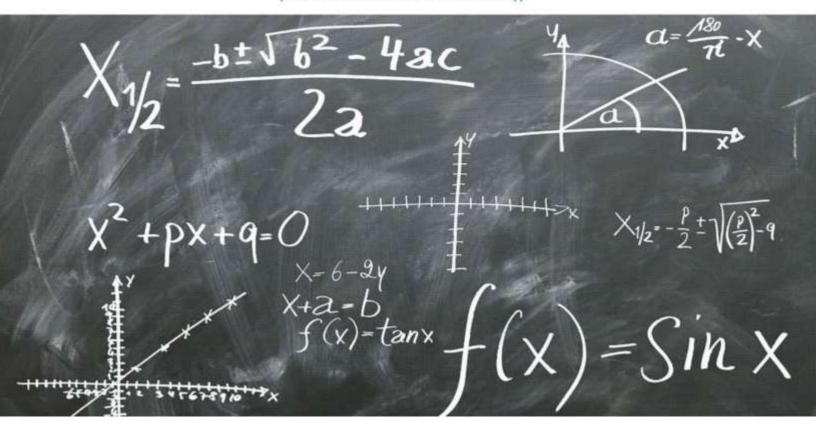
NUMERICAL PROBLEMS IN BIOLOGY

(For Standard XII -CBSE))



By R. Sridhar & Dr.S.Deepa



NUMERICAL PROBLEMS IN BIOLOGY (For Standard XII-CBSE)

Strictly based on 2017-18 CBSE Senior Secondary Curriculum NCERT, New Delhi

Mr.R.Sridhar

M.Sc.(Bot.), M.Sc.(Micro.), M.Ed., M.Phil., CLTC, CRTI, FBSS, (Ph.D), UGC-NET (Edn.)

Dr.S.Deepa

M.Sc., M.Phil.(Zoo.), M.Ed., M.Phil. (Edn.), PGDGC, Ph.D. (Biotech.)

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427, Palhar Nagar, RAPTC, VIP-Road, Indore-452005 (MP) INDIA Phone: +91-731-2616100, Mobile: +91-80570-83382 E-mail: contact@isca.co.in , Website: www.isca.co.in

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FOREWORD

Dr. V. HEMAMALINI

M.Sc (Bot.)., M.Sc(Micro)., B.Ed., M.Phil., Ph.D., FABMS, FSAB, MAMPV Assistant Professor, P.G & Research department of Plant Biology and Plant Biotechnology, Quaid-e-Milleth Government Arts College for Women (Autonomous) Chennai



It is my pleasure to write foreword about the first edition of this book entitled as "Numerical problems in biology for standard XII (CBSE)" which was written by my student Mr.R.Sridhar and his colleague Dr.S.Deepa . There are numerous private study materials available in the market. But this book is an innovative thought of the authors to present it for the students and teachers fraternities. To the best of my knowledge, this is the first book on Numerical Problems in Biology at senior secondary school level in CBSE stream.

This book presents an overview of numerical problems in biology for standard XII (CBSE) with special reference to the motivated students to understand in-depth concept in biology. An extremely brief account of key concept and wherever formulae are required are clearly mentioned in the chapters. The authors have made an attempt to gather chapter-wise numerical problems and emphasized board based solved numerical problems, NCERT text book and Exemplar based problems. Definitely this book provides detailed information particularly about the solved numerical problems.

This book is an essential for school students (biology group) who are pursuing standard XII of CBSE stream. It covers most of the important numerical problems in connection with the NCERT textbook. I hope that it will act as a suitable support material for the faculty of biology. The entire work has been presented in 10 chapters by the authors. Besides, the author Mr.R.Sridhar has published three books *via*. ESBL (enzyme), Herbal medicine and Education with ISBN internationally. I trust that the first edition of this book will fulfill the need of aspiring students and enthusiastic bio-teachers.

*******Thanking You*****

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It is our privilege and a golden opportunity to convey our heartfelt thanks to the **Prof. (Dr.). Ashish Sharma**, Editor-in-chief, Ideal International E-Publication and Founder Associate, International Science Community Association for his acceptance to allocate book publication work to the benefit of our society. Also, we convey our sincere thanks to him for his valuable suggestions and encouragement regarding book publication.

The author (Mr.R.Sridhar) would like to express a deep sense of gratitude to the Hon'ble Chairman Mr.A.S.Shanmugasundram, Mr. Ramesh Subramanian (Founder & Secretary), Mrs. Prema Subramanian (Treasurer), Mr. Babu Subramanian and Mr. Tholkappian (Managing Committee Members), Mr. Sundramoorthy (Academic Director) Mrs. Rathi Menon (Principal, ABS Vidhya Mandhir) and Mrs. R. Rathnabai (Principal, ABS Vidhyaalayaa MHSS), ABS GROUP OF INSTITUTIONS, Thiruvallur for their valuable suggestions throughout this project and also kind support forever.

The author (**Dr.S.Deepa**) would like to thank the honorary correspondent **Sri.S.Gopalakrishnan** and the Principal **Smt.S.Usharani**, **G K Shetty Vivekananda Vidyalaya Junior College, Ambattur** for their support to complete this work.

We sincerely acknowledge our special thanks to **Mrs. Mini Sebastian**, Principal, Sri Chaitanya CBSE school, Chennai & Former, Head & PGT in Biology, Velammal Vidyalaya Senior Secondary School, Mogappair, Chennai for proof reading this book and **Mrs. Vinita Sasidharan**, Vice-

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We would like to express our deep sense of gratitude to our beloved family members and friends who observed marvellous patience during our publication work and constant support forever.

Happy to calculate and feel free to get in touch with us by comments, queries and suggestions. Please do not forget to give your valuable feedback to us at edusri.tn@gmail.com & reghudeep09@gmail.com . Best wishes for your board examinations.

Thanking you !!!

By

Mr.R.Sridhar & Dr.S.Deepa

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<u>Chapter-1</u> <u>REPRODUCTION IN ORGANISMS</u>

**KEY CONCEPT/FORMULA

- ➤ **Haploid parent (n)** produces haploid gametes (n) by mitotic division. Eg. Monera, fungi, algae and bryophytes.
- ➤ **Diploid parent (2n)** produces haploid gametes(n) by meiosis division (possess only one set of chromosomes)
- ➤ **Meiocytes** (2n) or gamete mother cells are the specialized parent cells. It will be represented in diploid condition.

SOLVED PROBLEMS

1. The chromosome number in meiocyte of butterfly is 380. Find out the chromosome number in gamete?

Ans: Chromosome number in meiocyte (2n) of butterfly = 380

Chromosome number in gamete (n) of butterfly = 380/2

=190

2. In *Oryza sativa* (Rice plant), the male gamete has seven chromosomes. Find out the number of chromosomes in female gamete and in zygote?

Ans: No. of chromosomes in male gamete (n) = 7

No. of chromosomes in female gamete (n) = 7

Zygote (2n) = 7+7

= 14

The male gametes of green plant have 12 chromosomes in their nucleus. The chromosome number in the female gamete, zygote and the cells of the seedling will be, respectively.

(NCERT Exemplar)

Ans: No. of chromosomes in male gamete (n) = 12

No. of chromosomes in female gamete (n) = 12

No. of chromosomes in Zygote (2n) = 24

No. of chromosomes in the seeding cells (2n) = 24

4. The number of chromosomes in the shoot tip cells of a maize plant is 20. The number of chromosomes in the Microspore Mother Cells (MMC) of the same plant shall be:

Ans: No. of chromosomes in Shoot tips (2n) = 20

No. of chromosomes in MMC (2n) = 20

EXERCISE FOR MASTERY LEARNING

- 1. The chromosome number in meiocyte of an organism 'A' is 200. Find out the chromosome number in female and male gametes?
- 2. The female gametes of green plant have 20 chromosomes in their nucleus. The chromosome number in the male gamete, zygote and the cells of the seedling will be, respectively.
- 3. The number of chromosomes in the shoot tip cells of a plant is 26. What shall be the number of chromosomes in the Microspore Mother Cells (MMC) of the same plant?

ANSWER HINTS

- 1. Male gamete-100 chromosomes and female gamete-100 chromosomes.
- 2. 20 chromosomes in male gamete and zygote and seedling will have 40 chromosomes in each.
- 3. 26 chromosomes

<u>Chapter-2</u> SEXUAL REPRODUCTION IN FLOWERING PLANTS

❤ KEY CONCEPT/FORMULA

| SET OF CHROMOSOME | PLOIDY CONDITIONS |
|-------------------|---|
| Haploid-n | Microspore, pollen grains, male gamete, female gamete, |
| | synergids, antipodals |
| Diploid-2n | Microspore mother cell, any part of shoot system-leaf, root |
| | etc, megaspore mother cell, zygote, embryo, pollen mother |
| | cell |
| Triploid-3n | Endosperm cell, PEN (primary endosperm nucleus) |

SOLVED PROBLEMS

1. If the diploid number of chromosomes in an angiosperm plant is 16. Mention the number of Chromosomes in the endosperm and antipodal cell.

Ans: 24 Chromosomes in endosperm (3n) and 8 chromosomes in antipodal cell (n).

- A bilobed, dithecous anther has 100 microspore mother cells per microsporangium. How many male gametophytes can this anther produce? (CBSE 2010)
 Ans: 400 male gametophytes
- 3. If the chromosomes number of plant species is 42, what could be the chromosome number and the ploidy level of the cell microspore mother cell, female gamete and endosperm cells?

Ans: No. of chromosomes in of plant species (2n) = 42

No. of chromosomes in Microspore mother cell (2n) = 42

No. of chromosomes in female gamete (n) = 42/2

= 21

No. of chromosomes in the endosperm cells (3n) = 63

4. How many pollen grains and ovules are likely to be formed in the anther and the ovary of angiosperms bearing 25 microspore mother cell and 25 megaspore mother cells respectively?

Ans: 100 pollen grains and 25 ovules (75 will degenerate and 25 will function)

A flower of tomato plant following the process of sexual reproduction produces 240 viable seeds.
 (CBSE Delhi 57/1/3 2015)

Answer the following questions giving reasons:

- a) What is the minimum number of pollen grains that must have been involved in the pollination of its pistil?
- b) What would have been the minimum number of ovules present in the ovary?
- c) How many megaspore mother cells were involved?
- d) What is the minimum number of microspore mother cells involved in the above case?
- e) How many male gametes were involved in this case?

Ans:

- a) 240, one pollen grain participates in fertilisation of one ovule
- b) 240, one ovule after fertilisation forms one seed
- c) 240, each MMC forms four megaspores out of which only one remain functional
- d) 60, each microspore mother cell meiotically divides to form four pollen grains (240/4 = 60)
- e) 480 , each pollen grain carries two male gametes (which participate in double fertilisation) $(240 \times 2 = 480)$

EXERCISE FOR MASTERY LEARNING

1. A flower of tomato plant following the process of sexual reproduction produces 200 viable seeds. Answer the following questions giving reasons: (CBSE Delhi 57/1/1 2015)

- a) What would have been the minimum number of ovules present in pre-pollinated pistil?
- b) How many microspore mother cells would minimally be required to produce requisite number of pollen grain?
- c) How many pollen grains must have minimally pollinated the carpel?
- d) How many male gametes would have used to produce these 200 viable seeds?
- e) How many megaspore mother cells were required in this process?
- 2. A flower of brinjal plant following the process of sexual reproduction produces 360 viable seeds. (CBSE Delhi 57/1/2 2015)

Answer the following questions giving reasons:

- a) How many ovules are minimally involved?
- b) How many megaspore mother cells are involved?
- c) What is the minimum number of pollen grains that must land on stigma for pollination?
- d) How many male gametes are involved in the above case?
- e) How many microspore mother cells must have undergone reduction division prior to dehiscence of anther in the above case?
- 3. If the diploid number of chromosomes in an angiosperm plant is 22. Mention number of Chromosomes in the endosperm and antipodal cell.
- 4. How many pollen grains and ovules are likely to be formed in the anther and the ovary of angiosperms bearing 30 microspore mother cell and 30 megaspore mother cells respectively?

ANSWER HINTS

- 1.
- a) 200
- b) 50
- c) 200
- d) 400
- e) 200

2.

- a) 360
- b) 360
- c) 360
- d) 720
- e) 90
- 3. 33 Chromosomes in endosperm (3n) and 11 chromosomes in antipodal cell (n).
- 4. 120 pollen grains and 30 ovules (90 will degenerate and 30 will function)

Chapter-3 HUMAN REPRODUCTION

*KEY CONCEPT/FORMULA

| SET OF CHROMOSOME | PLOIDY CONDITIONS |
|-------------------|--|
| Haploid-n | secondary spermatocytes, Spermatid, Spermatozoa, |
| | Secondary oocyte, Ovum, Second Polar body |
| Diploid-2n | Germinal epithelium, Spermatogonia |
| | Primary spermatocytes, Oogonia, Primary oocyte, |
| | Zygote |

SOLVED PROBLEMS

1. How many sperms will be produced from 10 primary spermatocytes and how many eggs will be produced from 10 primary oocytes?

Ans: 40 sperms, 10 eggs

- 2. The spermatogonial cell has 46 chromosomes in human male. Give the number of chromosomes in the following,
 - (a) Primary spermatocyte
 - (b) Spermatid

Ans

- (i) 46 in Primary spermatocyte
- (ii) 23 in spermatid.
- 3. How many eggs do you think were released by the ovary of a female dog which gave birth to 6 puppies?

Ans: six eggs are released by the ovary of a female dog if it gave birth to six puppies (actually dog is a polyovulatory animal)

EXERCISE FOR MASTERY LEARNING

- 1. The spermatogonial cell has 46 chromosomes in human male. Give the number of chromosomes in
 - (a) Spermatogonia
 - (b) Germinal epithelium
 - (c) Spermatid
- 2. How many eggs do you think were released by the ovary of a female dog which gave birth to 8 puppies?

ANSWER HINTS

- 1. (a) & (b) 46 chromosomes and (c) 23 chromosomes.
- 2. 8 eggs

<u>Chapter-5</u> PRINCIPLES OF INHERITANCE AND VARIATION

*KEY CONCEPT/FORMULA

- ➤ **Genotype:** Genetic constituent of an organism
- **Phenotype:** Physical appearance of an organism
- **Karyotype:** The number and appearance of chromosomes in the nucleus
- **Locus:** Location of a gene in a chromosome
- ➤ **Punnet's square:** Graphical representation to calculate the probability of all possible genotype.
- ➤ **Allele**: Alternative form of a gene
- ➤ Body chromosomes are called **autosomes**
- > Sex chromosomes are called **allosomes**
- ➤ **Linkage group**: Number of chromosomes in one set or haploid condition

| Frequency of recombination = | No. of recombinants |
|------------------------------|----------------------|
| rrequency of recombination = | Total no. of progeny |

- ➤ **Higher Recombination %:** If two genes are located relatively far apart on a chromosome (loosely linked) there are more chances of crossing over.
- ➤ Lower Recombination %: If two genes are located relatively close together on a chromosomes (tightly linked), the chances of crossing over are less
- All the genes that are present on the same chromosomes are **linked genes**
- \triangleright Test cross: A crossing of a F_1 hybrid with recessive parent.
- \triangleright Back cross: A crossing of a F_1 hybrid with one of its parents

Glimpses of genetic crosses

| Cross | Result of F2 generation | | |
|----------------------|----------------------------------|-------------------|--|
| | Phenotypic ratio Genotypic ratio | | |
| Monohybrid | 1:3 | 1:2:1 | |
| Dihybrid | 9: 3:3:1 | 1:2:1:2:4:2:1:2:1 | |
| Incomplete dominance | 1:2:1 | 1:2:1 | |

Figure out the gamete produced by each parent using 2ⁿ

Eg.

Monohybrid cross-Rr-(heterozygous parent)- 2^1 = 2 gametes Dihybrid cross-RrYy-(heterozygous parent)- 2^2 = 4 gametes Trihybrid cross-RrYyAa-(heterozygous parent)- 2^3 = 8 gametes Tetrahybrid cross-RrYyAaIi-(heterozygous parent)- 2^4 = 16 gametes

SOLVED PROBLEMS

1. The 'egg' of an animal contains 10 chromosomes, of which one is X chromosome. How many autosomes would there be in the Karyotype of this animal?

Ans: It will have 18 (9 pairs) autosomes.

2. A diploid organism is heterozygous for 4 loci, how many types of gametes can be produced?

Ans: $2^n=2^4$ (16 types of gametes can be produced)

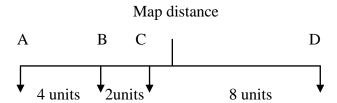
- 3. The egg of an animal contains 12 chromosomes, of which one is x-chromosome. How many body chromosomes (autosomes) would be in the Karyotype of this animal?
 - Ans: 11 pairs (22 chromosomes) of body chromosomes in the Karyotype of this animal.
- 4. Write the percentage of F₂ homozygous and heterozygous conditions in a typical monohybrid cross? (CBSE Foreign 2010)

Ans: The ratio of a typical monohybrid cross is 1 (25% of homozygous dominant): 2 (50% of heterozygous dominant): 1(25% of homozygous recessive). Hence, the percentage of F_2 homozygous and heterozygous conditions is 50%: 50%

5. What could be the percentage of phenotypes in a typical dihybrid cross?

Ans: the ratio of a typical dihybrid cross in 9: 3: 3: 1 (56.25%: 18.75%: 18.75%: 6.25%) or (56%: 19%: 6%).

6. The map distance between in certain organism between gene A and B is 4 units, B and C is 2 units and between C and D is 8 units. Which one of these gene pairs will show more recombination frequency? Give reasons in support of your answer.
Ans:

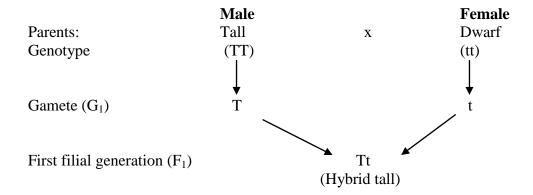


Recombination frequency is directly proportional to the distance between the genes, the distance between C and D is more. i.e., 8 units in above condition, so recombination frequency will be more between them.

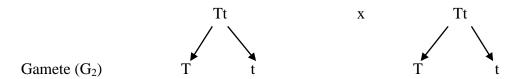
- 7. In Drosophila 2n = 8, how many linkage groups are present?
 - Ans: Linkage groups are groups of genes that are so close together on a chromosome that they tend not to assort independently (i.e., recombination rarely occurs between them). Therefore, there are 4 linkage groups present.
- 8. With the help of a Punnett square, find the percentage of homozygous tall in a F_2 population involving a true breeding tall and a true breeding dwarf pea plant.

Ans.:

Ans. Trait: size of the plant [Tall (TT) Vs Dwarf (tt)]



Selfing of F₁ generation/F1 hybrids are self crossed.....



Second filial generation (F₂)

Punnett's square

| Male Female | T | t |
|----------------|----------------------------|----------------------------|
| T | TT Homozygous tall | Tt Heterozygous tall |
| t | Tt Heterozygous tall | tt Homozygous dwarf |

Percentage of homozygous tall=1/4 x100 =25%

9. How many types of gametes are produced by the individual with genotype AABBCCDD and AaBbCcDd?

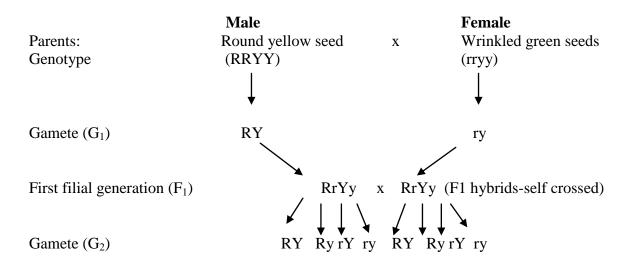
Ans: One type of gamete by individual (AABBCCDD) and sixteen types of gametes by individual AaBbCcDd.

10. How many linkage groups are present in an organism with a diploid number of 18 chromosomes?

Ans: Nine (9) linkage groups

11. Make a cross between round yellow seeds and wrinkled green seeds and find out F_2 ratios.

Ans. Trait: Round yellow seed vs wrinkled green seeds [RRYY x rryy]



Second filial generation (F₂)

Punnet's square

| Female | | | | |
|--------|---------------|---------------|---------------|---------------|
| Male | RY | Ry | (rY) | ry |
| | RRYY | RRYy | RrYY | RrYy |
| (RY) | Pure Round | Pure Round | Hybrid Round | Hybrid Round |
| | pure yellow | hybrid yellow | pure yellow | hybrid yellow |
| Ry | RRYy | RRyy | RrYy | Rryy |
| | Pure Round | Pure Round | Hybrid Round | Hybrid Round |
| | hybrid yellow | pure green | hybrid yellow | pure green |
| rY | RrYY | RrYy | rrYY | rrYy |
| | Hybrid Round | Hybrid Round | pure wrinkled | pure wrinkled |
| | pure yellow | hybrid yellow | pure yellow | hybrid yellow |
| | RrYy | Rryy | rrYy | rryy |
| (ry) | Hybrid Round | Hybrid Round | pure wrinkled | pure wrinkled |
| | hybrid yellow | pure green | hybrid yellow | pure green |

Phenotypic ratio

Round yellow: Round green: Wrinkled yellow: wrinkled green

9 : 3 : 3 : 1

Genotypic ratio

Pure round pure yellow : 1
Pure round hybrid yellow : 2

Pure round pure green : 1

Hybrid round pure green : 2

Hybrid round hybrid yellow : 4

Pure wrinkled hybrid yellow : 2
Pure wrinkled pure yellow : 1
Hybrid Round pure yellow : 2
Pure wrinkled pure green : 1

12. In a flowering plant, tallness is dominant over dwarfness, and red colour of flowers is dominant over the white colour. When a tall plant bearing red flowers was pollinated with a dwarf plant bearing white flowers, the different phenotypic groups were obtained in the progeny in numbers mentioned against them:

Tall, Red = 138

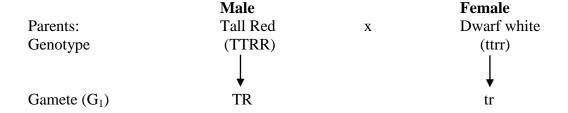
Tall, White = 132

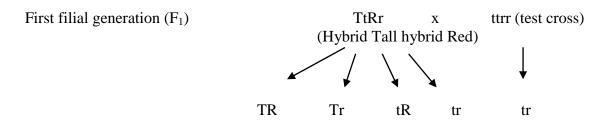
Dwarf, Red = 136

Dwarf, White = 128

Mention the genotypes of the two parents and of the four offspring types Ans: From the given data, the cross can be represented as,

Trait: Size of the plant and colour of the flower [Tall red (TTRR) Vs Dwarf white (ttrr)]





Punnett's square

| Female Male | TR | Tr | tR | tr |
|----------------|----------|------------|-----------|-------------|
| | TrRr | Ttrr | ttRr | ttrr |
| tr | Tall red | Tall white | Dwarf red | Dwarf white |

Therefore, the result that the four types of offspring are in a ratio of 1: 1: 1: 1. This type of result is observed in a test-cross of a dihybrid cross to determine if the individual is homozygous dominant or heterozygous.

EXERCISE FOR MASTERY LEARNING

- 1. Workout out a monohybrid cross upto F₂ generation between two pea plants and two Antirrhinum plants both having contrasting traits with respect to the colour of flower. Comment on the pattern of inheritance in the crosses carried above.
- 2. A homozygous tall pea plant with green seeds is crossed with a dwarf pea plant with yellow seeds.
 - a. What would be the phenotype and genotype of F_1 generations?
 - b. Work out the phenotypic ratio of F₂ generation with the help of a Punnett square.
 - c. Mention the genotypic ratio of F_2 generation of the same traits.
- 3. With the help of a Punnett square work out the distribution of phenotypic features in the first filial generation after a cross between a homozygous female and a heterozygous male for a single locus.
- 4. In a monohybrid cross of plants with red and white flowered plants, scientist got only red flowered plants. On self-pollinating these F1 plants got both red and white flowered plants in 3:1 ratio. Explain the basis of using RR and rr symbols to represent the genotype of plants of parental generation. (NCERT Exemplar)
- 5. A plant with red flowers was crossed with another plant with yellow flowers. If F1 showed all flowers orange in colour, explain the inheritance. (NCERT Exemplar)
- 6. Two genes 'A' and 'B' are linked. In a dihybrid cross involving these two genes, the F₁ heterozygote is crossed with homozygous recessive parental type (aabb). What would be the ratio of offspring in the next generation?
- 7. A, B and C are three genes lying in a sequence on a chromosome. Between A & C, there is 11% recombination and between B & C there is 5% recombination. How many map units are found between A and B?

ANSWER HINTS/SOLUTION

- 1. 3:1 & 1:2:1
- 2. a). Hybrid tall and hybrid yellow plant (TtYy)
 - b). Workout the cross using Punnett's square
 - c). 9:3:3:1 & 1:2:1:2:4:2:1:2:1
- 3. 1:1
- 4. Workout the detailed cross of monohybrid experiment to get the ratios 3:1 & 1:2:1 and explain Mendal's laws i.e., Law of dominance and Law of segregation.
- 5. 1:2:1 (Incomplete Dominance)
- 6. 1:1:1:1
- 7. 6 units

<u>Chapter-6</u> MOLECULAR BASIS OF INHERITANCE

FKEY CONCEPT/FORMULA

 \triangleright The distance between two adjacent base pair (bp) = 0.34×10^{-9} m

> Base pair values

The number of base pairs is characteristics of every organism/species. e.g., bacteriophage ϕ 174 has 5386 bp., Lambda phage has 48502 bp., *E. coli* has 4.6×10^6 bp. and human has 3.3×10^9 bp. (haploid number).

Length of DNA = Total No. of base pairs x Distance between two consecutive base pairs

> Base pair/ Chargaff's rule

- o Adenine-Thymine (A=T) pair has two hydrogen bond
- o Guanine-Cytosine ($G\equiv C$) pair has three hydrogen bonds.
- ➤ **DNA** contains four different bases called Adenine (A), Guanine (G) Cytosine (C), and Thymine (T).
- ➤ RNA contains four different bases called Adenine (A), Guanine (G) Cytosine (C), and Uracil (U).

SOLVED PROBLEMS

1. If the length of *E.coli* DNA is 1.36 mm, calculate the number of base pairs it contains. Ans: The distance between two adjacent bp = 0.34×10^{-9} m

Length = Total no. of bp \times distance between two bp.

Therefore, Total no. of bp =length of the DNA/ distance between two adjacent bp

No. of bp. =
$$1.36 \times 10^{-3}/0.34 \times 10^{-9}$$

= 4×10^{6} bp

2. Calculate the length of the DNA of bacteriophage lambda that has 48502 base pairs.

Ans:

Given data: base pairs of bacteriophage lambda =48502

In general, the distance between two consecutive base pairs = 0.34×10^{-9} m

Length of DNA in bacteriophage lambda = $48502 \times 0.34 \times 10^{-9} \text{ m}$ = $16.49 \times 10^{-6} \text{ m}$

3. If a double stranded DNA has 30 percent of cytosine, calculate the percentage of adenine in DNA.

Ans:

Given data, percent of cytosine = 30

As per base pair rule $A=T \& C \equiv G$, therefore Guanine = 30

The percent of Thymine + Adenine will be 100-(30+30) = 40

Therefore, the percent of Adenine will be 40/2 = 20%

4. If *Escherichia coli* is allowed to grow for 80 minutes, what would be the proportions of light and hybrid densities of DNA molecules.

Ans. 2ⁿ=2⁴ (16 types of DNA strands can be produced)

In the first generation, one DNA strand with N^{15} and the other hybrid DNA strand would be N^{14} will be formed

In the second generation, two light DNA and two hybrid DNA would be formed (50%: 50%)

In the third generation, two hybrid DNA and six light DNA would be formed (25%: 75%) In the fourth generation, two hybrid DNA and 14 light DNA would be formed (12.5%: 87.5%)

5. A DNA segment has a total of 1000 nucleotides, out of which 240 of them are adenine containing nucleotides. How many pyrimidine bases does this DNA segment possess? (CBSE Delhi 2015)

According to Base pair/Chargaff's rule, ratio of purines to pyrimidines is equal, i.e. A +

$$G = C + T$$

Since, the number of adenine (A) is equal to the number of thymine (T) and A = 240 (given)

Therefore, T = 240

Also, the number of guanine (G) is equal to cytosine (C).

Thus,
$$G + C = 1000 - (A + T)$$

$$G + C = 1000-480 = 520$$

Hence,
$$G = 260$$
, $C = 260$

therefore, the number of pyrimidine bases, i.e. C + T(2)

$$= 240 + 260 = 500$$

6. Write a transcription unit/sequence of mRNA of the given sequence of nitrogen bases of the coding strand of DNA.

7. Given below is a single stranded DNA molecule. Frame and label its sense and antisense RNA molecule.

5' ATGGGGCTC 3'

Ans.:

Sense strand 5' ATGGGGCTC 3'
Antisense strand 3' TACCCCGAG 5'
RNA sense strand 5' AUGGGGCUC 3'
RNA antisense strand 3' UACCCCGAG 5'

8. The haploid content of human DNA is 3.3×10^9 bp and the distance between two consecutive base pair is 0.34×10^{-9} . What is the length of the DNA molecule?

Ans.:

Haploid content is 3.3 x 10⁹

Therefore, diploid content is 6.6 x 10⁹

Distance between consecutive base pair is 0.34 x10⁻⁹

Therefore, length is diploid content x distance between base pair= $6.6 \times 10^9 \times 0.34 \times 10^{-9}$

=2.24 m

9. Given below is a part of the template strand of a structural gene:

TAC CAT TAG GAT

Write its transcribed mRNA strand with its polarity.

(CBSE Delhi 2008)

Ans: 5'-AUG GUA AUC CUA-3'

- 10. AUG GAC CUG AUA UUU UGA is the base sequence in a strand of mRNA.
 - i. Write the base sequence of the DNA strand from which it has been transcribed.
 - ii. Upon translation, how many amino acids will the resulting peptide have?

Ans:

- i. TAC CTG GAC TAT AAA ACT
- ii. Five amino acids (since last is a stop codon)
- 11. A template strand is given below. Write down the corresponding coding strand and the mRNA strand that can be formed, along with their polarity.

3'-ATGCATGCATGCATGCATGC-5'

Ans:

Coding strand: 5'-TACGTACGTACGTACGTACGTACG-3'

mRNA : 5'-UACGUACGUACGUACGUACGUACG-3'

EXERCISE FOR MASTERY LEARNING

1. A DNA segment has a total of 1,500 nucleotides, out of which 410 are Guanine containing nucleotides. How many pyrimidine bases does this segment possess?

- A DNA segment has a total of 2,000 nucleotides, out of which 520 are adenine containing nucleotides. How many purine bases does this DNA segment possess? (CBSE Delhi 57/1/3 2015).
- 3. If the length of *E.coli* DNA is 2.01 mm, calculate the number of base pairs it contains.
- 4. If *Escherichia coli* is allowed to grow for 100 minutes, what would be the proportions of light and hybrid densities of DNA molecules?

d ANSWER HINTS

- 1. 750
- 2. 1000 purines
- 3. $5.9 \times 10^6 \text{bp}$
- 4. 2 hybrid DNA and 30 light DNA (6.25%: 93.75%)



☞ KEY CONCEPT/FORMULA

HARDY-WEINBERG EQUILIBRIUM/POPULATION GENETICS PRINCIPLE

- The sum of frequency of allele 'A' and allele 'a' is 1 (by Hardy-Weinberg's definition)
- \triangleright i.e., A + a = 1 or p + q = 1

Hardy-Weinberg equilibrium state that in a population, the total sum of all the allelic frequencies is equal to 1

- Frequency of AA individuals in the population = p^2
- \triangleright Frequency of an individuals in the population = q^2
- \triangleright Frequency of Aa individuals in the population = 2pq
- Then, the sum of AA, aa and Aa individuals will represent the gene pool of the alleles:- $p^2 + q^2 + 2pq = 1$ or $(p + q)^2 = 1$
- In a diploid organism, p and q are the frequencies of alleles A and a respectively.

SOLVED PROBLEMS

1. In a population 49% are homozygous with genotype tt, find out the gene frequency of alleles T and t.

Ans:

Given data, Recessive homozygous 'tt' = 49%

Assume that total individual in the given population = 100

Frequency of recessive homozygous 'tt' = 49/100

= 0.49

By Hardy-Weinberg principle,

Let us assume the frequency of homozygous 'tt' = $q^2 = (0.49)$

Therefore $q = \sqrt{0.49} = 0.7$

Again by definition,

$$p + q = 1$$

$$p = 1-q$$

$$= 1-0.7$$

Therefore, p = 0.3

Hence, the frequency of 'T' is 0.3 and frequency of 't' is 0.7 respectively.

2. If the frequency of allele 'a' is 0.4, what about the percentage of individuals homozygous for allele 'a'?

Ans:

Given data,

Frequency of allele 'a' = 0.4

By Hardy-Weinberg principle,

Frequency of an individuals in the population $= q^2$ = $(0.4)^2$

$$=0.16$$

Hence, the percentage of individuals homozygous for allele 'a' = 16%

3. In a sampled population the frequency of the recessive trait is 16%. Find out the frequency of homozygous dominant and heterozygous dominant individuals.

Ans:

Given data: The frequency of the recessive trait (aa) =16% ('aa' is an assumed trait)

The frequency of the 'a' allele as per Hardy-Weinberg's principle (by definition)

$$q^2 = 0.16$$

Then, q = 0.4 (taking square root on both the sides)

Again by definition,

$$p+q=1$$

$$p=1-q$$

The frequency of AA is equal to p²

= 0.36

Therefore, the percentage frequency of homozygous dominant (AA) = 36%

The frequency of Aa is equal to 2pq

 $= 2 \times 0.4 \times 0.6$

=48%

Therefore, the percentage frequency of heterozygous dominant (Aa) = 48%

4. In a certain population, the frequency of three genotypes is as follows:

| Genotypes | BB | Bb | bb |
|-----------|-----|-----|-----|
| Frequency | 22% | 62% | 16% |

What is the likely frequency of B and b alleles?

Ans:

Method-I (direct method)

The parent generation-100 individuals

Given data

| Genotype | BB | Bb | bb |
|--|------|----------------------|------------------------------|
| | 22 | 62 | 16 |
| Frequency of each Genotype in the population | 0.22 | 0.62 | 0.16 |
| Frequency of each Allele in the Population | | 0.22 + 0.31 0.53 B | 0.16 + 0.31 0.47 b |

Therefore the percentage frequency of allele 'B' is 53% and the percentage frequency of allele 'b' is 47%.

or

Method-II (Indirect method)

Frequency of B allele = all of BB + 1/2 of Bb = 22+31= 53%Frequency of b allele = all of bb + 1/2 of Bb = 16 + 31= 47%

EXERCISE FOR MASTERY LEARNING

- 1. In a population 36% are homozygous with genotype tt. Find out the gene frequency of alleles T and t.
- 2. If the frequency of allele 'a' is 0.6, what about the percentage of individuals homozygous for allele 'a'?
- 3. In a certain population, the frequency of three genotypes is as follows:

| Genotypes | YY | Yy | уу |
|-----------|-----|-----|-----|
| Frequency | 24% | 58% | 18% |

What is the likely frequency of 'Y' and 'y' alleles?

ANSWER HINTS

- 1. Frequency of 'T' is 0.4 and frequency of 't' is 0.6
- 2. 36%
- 3. The percentage frequency of allele 'Y' 53% and the percentage frequency of allele 'y' is 47%.

<u>Chapter-10</u> <u>MICROBES IN HUMAN WELFARE</u>

S KEY CONCEPT/FORMULA

- ➤ **Biological Oxygen Demand (BOD):** Total amount of oxygen consumed by bacteria for oxidation of organic matter present in one litre of water.
- ➤ High value of BOD represent more polluted water

| | | 60 minutes x hours |
|-----------------------|---|--------------------|
| No. of generation for | = | |
| Bacterial population | | Generation time |
| | | |

SOLVED PROBLEMS

1. The generation time of microbacterium cells present in activated sludge is 30 minutes. If these bacteria are allowed to grow for 15 hours, how many generation would have taken place

Ans.:

Number of Generations =15x60 minutes/30 minutes

= 30

2. BOD level of three samples of water labeled as A, B and C are 30 mg/L, 10mg/L and 500 mg/L respectively. Which sample of water is most polluted?

Ans.:

Sample 'c' is most polluted because it has highest BOD level among the three samples of water

EXERCISE FOR MASTERY LEARNING

- 1. BOD level of three samples of water labeled as X, Y and Z are 31mg/L, 12 mg/L and 500 mg/L. Which sample of water is most polluted?
- 2. The generation time of bacterial population present in activated sludge is 30 minutes. If these bacteria are allowed to grow for 20 hours, how many generations would have taken place?

ANSWER HINTS

- 1. Sample Z(due to high BOD value)
- 2. 40

<u>Chapter-11</u> BIOTECHNOLOGY: PRINCIPLES AND PROCESSES

**KEY CONCEPT/FORMULA

- ➤ In general, Molarity/Molar concentration is defined as the number of moles of solute dissolved per liter of solution (mol/L = M).
- > Haploid set of chromosome is denoted by 'n'
- > Diploid set of chromosome is denoted by '2n'
- The average molecular weight of a nucleotide pair is 330 dalton
- \triangleright Genome size of a diploid human cell is around 6.6 x 10^9 bp
- ➤ The concentration of DNA will be 330 x 6 x 10⁹ g/mol

Molarity =
$$\frac{\text{Sample of DNA (diploid) concentration (in g)}}{330 \times 6.6 \times 10^9 \text{ g/mol}}$$

SOLVED PROBLEMS

1. If DNA concentration is 2 grams, what would be the molar concentration of human DNA in a human cell?

Ans:

Given data: DNA concentration = 2 g

Molarity =
$$\frac{\text{Sample of DNA (diploid) concentration (in g)}}{330 \times 6.6 \times 10^{9} \text{ g/mol}}$$
=
$$\frac{2 \text{ g}}{330 \times 6.6 \times 10^{9} \text{ g/mol}}$$
=
$$9.1827 \times 10^{-13} \text{ mol}$$
=
$$9.2 \times 10^{-13} \text{ mol}$$

Therefore the molarity of the given DNA sample is 9.2×10^{-13} mol

EXERCISE FOR MASTERY LEARNING

1. If DNA concentration is 15 grams, what would be the molar concentration of human DNA in a human sex cell?

ANSWER HINTS

1. Calculate by using the following formula,

Molarity =
$$\frac{\text{Sample of DNA (haploid) concentration (in g)}}{330 \times 3.3 \times 10^{9} \text{ g/mol}}$$
$$= 1.37 \times 10^{-11} \text{ mol}$$

Chapter-13 ORGANISMS AND POPULATIONS

*KEY CONCEPT/FORMULA

- > Sex ratio expressed as the number of females and males per given individual of a population in a given time
- ➤ Interrelation of Productivity, Gross Primary Productivity (GPP), Net Primary Productivity(NPP) and secondary productivity (CBSE SQP 2015-16)

 Productivity is rate of biomass production

$$GPP - R = NPP$$

R-Respiration loss

NPP - biomass available to consumers for secondary productivity

Population density
$$=\frac{\text{No. of individuals in a region (N)}}{\text{Size of unit area in a region (S)}}$$

> Verhulst-Pearl Logistic Growth equation

$$dN/dt = rN (K-N/N)$$

Where, N = Population density at time t

r = Intrinsic rate of natural increase

K = Carrying capacity

The above equation can also be equated as,

$$P(t) = \frac{K}{1 + Ae^{-\alpha t}}$$

Whereas,

P(t) = population at time't'

K= carrying capacity

 α = constant proportionality

t = time

A= population at t=0 or population at initial

 \triangleright If N is the population density at time t, then its density at time t +1 is

$$N_{t+1} = N_t + [(B+I) - (D+E)]$$

Where,

N = Population density

t = Time

t+1 = population density at time't'

E = emigration

D = mortality

B =Natality

I = Immigration

SOLVED PROBLEMS

1. If 8 individual in a laboratory population of 80 fruit flies died in a week, then what would be the death rate of population for that said period? (CBSE Delhi 2010)

Ans:

Death rate = No. of individuals dead

Total no. of individuals

= 8/80

= 0.1

Hence, the death rate will be 0.1 individuals per week

2. In a pond there were 20 *Hydrilla* plants. Through reproduction 10 new *Hydrilla* plants were added in a year. Calculate the birth rate of the population. (CBSE Delhi 2010)

Ans:

Birth rate $= \frac{\text{No. of individuals added}}{\text{Total no. of individuals}}$ = 10/20= 0.5

Hence, the birth rate will be 0.5 plants per year.

3. In a pond there were 200 frogs. 40 more were born in a year. Calculate the birth rate of the population. (CBSE Delhi 2010)

Ans:

Birth rate = No. of individuals added

Total no. of individuals

= 40/200

= 0.2

Hence, the birth rate will be 0.2 frogs per year.

4. Calculate the death rate if 6 individuals in a laboratory population of 60 fruit flies died during a particular week

Ans:

Death rate = $\frac{\text{No. of individuals dead}}{\text{Total no. of individuals}}$ = $\frac{6/60}{}$

= 0.1 individuals per fruit fly per week

5. Calculate the birth rate if 16 new plants are added through reproduction in the existing 40 lily plants in a pond during a particular month.

Ans:

Birth rate $= \frac{\text{No. of individuals added}}{\text{Total no. of individuals}}$ $= \frac{16/40}{\text{No. of individuals}}$ $= \frac{16/40}{\text{No. of individuals}}$

6. If a population is growing exponentially double in size in 3 years, what is the intrinsic rate of increase (r) of the population?

Ans.

$$N_{\rm t} = N_{\rm o} {\rm e}^{\rm rt} \quad \dots \qquad (1)$$

Whereas,

 $N_{\rm t}$ = population density after time t

 N_0 = population density at time zero

e = base of natural logarithms (2.71828)

r = intrinsic rate of the population

Given data,

Present population density = x

Then, population density after 3 years = 2x

t=3 years

Substituting values in (1)

$$\Rightarrow 2x = xe^{3r}$$

$$\Rightarrow$$
 2 = e^{3r}

Applying log on both sides

$$\log 2 = 3r \log e \dots (Power rule: \log a^b = b \log a)$$

 \Rightarrow r = log 2/3 log e

 $= 0.3010/3 \times \log 2.71828$

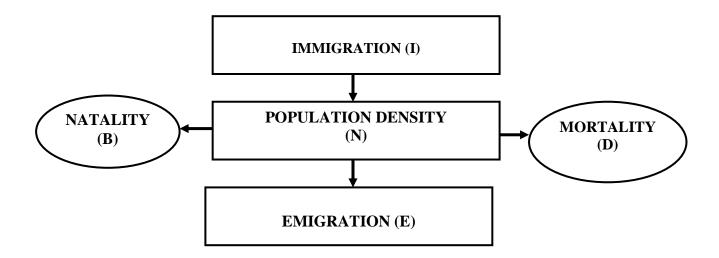
 $= 0.3010/3 \times 0.434$

= 0.3010/1.302

=0.2311

Therefore, the intrinsic rate of increase (r) of the population is 0.2311

7. Carefully observe the given illustration and answer the following (CBSE SQP 2015-16)



- a) Which of the above represents the increase and decrease of population?
- b) If N is the population density at time t, then what would be its density at time (t+1)? Give the formula.
- c) In a barn there were 30 rats. 5 more rats enter the barn and 6 out of the total rats were eaten by the cats. If 8 rats were born during the time period under consideration and 7 rats left the barn, find out the resultant population at time (t+1)
- d) If a new habitat is just being colonized, out of the four factors affecting the population growth which factor contributes the most?

Ans:

- a) B and I represents increase of population and D and E represent decrease of population
- b) $N_{t+1} = N_t + [(B+I) (D+E)]$
- c) Here $N_t=30$; I=5; E=7; D=6; B=8

Putting the value in N t+1 = N t + [(B+I) - (D+E)]

$$N_{t+1}$$
 = 30+ [(8+5)-(6+7)]
=30+[13-13]
= 30+0
=30 rats

d). Immigration contributes the most.

EXERCISE FOR MASTERY LEARNING

- 1. In a pond there were 300 frogs. 40 more were born in a year. Calculate the birth rate of the population.
- 2. Calculate the birth rate if 18 new plants are added through reproduction in the existing 60 lily plants in a pond during a particular month.
- 3. Recently the Zoological Survey of India (ZSI) had studied (2017) the crane population and expressed as following,

$$N_{t+1} = 1200 + [(600+700) - (200+800)]$$

On the basis of the above, answer the following,

- a) Natality rate
- b) Morality rate
- c) No. of cranes immigrated
- d) No. of cranes emigrated
- e) Population cranes in India in 2017

ANSWER HINTS

1. 0.13 frogs per year.

- 2. 0.3 individuals per lily per month
- 3. By applying the Population Density formula
 - a. 600
 - b. 200
 - c. 700
 - d. 800
 - e. 1500

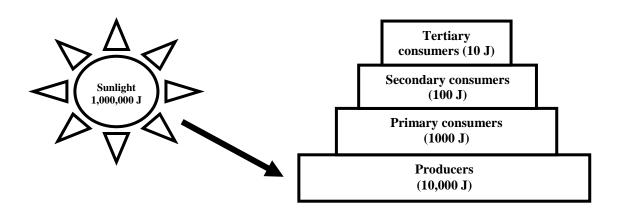
Chapter-14 ECOSYSTEM

FKEY CONCEPT/FORMULA

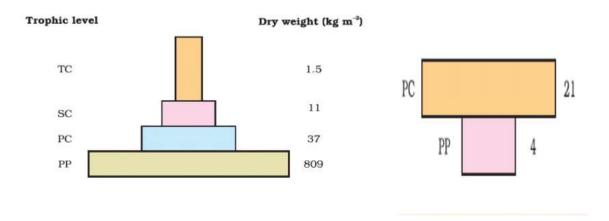
- ➤ Net Primary Productivity (NPP) = Gross Productivity (GPP) Respiration (R)
- ➤ 1% Law: The transfer of energy from sunlight to the producer.
- ➤ 10% Law: The transfer of energy from one trophic level to the next.

SOLVED PROBLEMS

Construct an ideal pyramid of energy when 1,000,000 joules of sunlight is available.
 Label all its trophic levels. (CBSE Delhi 2009)

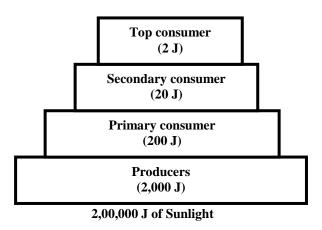


Compare the two ecological pyramids of biomass given below and explain the situations in which this is possible. Also construct an ideal pyramid of energy if 200,000 joules of sunlight is available. (CBSE SQP 2015-16)



Ans:

The first pyramid of biomass corresponds to a terrestrial ecosystem. Second pyramid refers to a small standing crop of phytoplankton supporting a large standing crop of zooplankton/aquatic ecosystem.



3. What will be the amount of energy available to the organism of the 2nd trophic level of a food chain, if the energy available at the first trophic level is 10,000 Joules?

Ans:

According to 10% law, only 10% of energy entering a particular trophic level of organism is available for transfer to the next higher trophic level.

Energy in 2^{nd} trophic level = 10,000 Joules

As per 10% law = 10% of 10000 Joules

=10/100 x 10000 Joules = 1000 Joules

Hence, the energy available in the 2nd trophic level is 1000 joules

EXERCISE FOR MASTERY LEARNING

1. In the given food chain, suppose the amount of energy at fourth trophic level is 6 J. what will be the energy available at the producer level and sunlight?

Grass → Grasshopper → Frog → Snake

- 2. Construct an ideal pyramid of energy if 200,000 joules of sunlight is available.
- 3. What will be the amount of energy available to the organism of the 3rd trophic level of a food chain, if the energy available at the first trophic level is 5,000 Joules?
- 4. What will be the amount of energy available in the sunlight, when the 4th trophic level of a food chain is 4 joules?

ANSWER HINTS

- 1. 6000 J and 600000 J
- 2. Refer q.no.1 and construct
- 3. 50 joules
- 4. 400000 joules

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ABOUT AUTHORS



Mr. R. Sridhar has qualified UGC-NET Lectureship in Education (2011), a University rank holder, has had higher education from Madras, Tamilnadu Teacher Education and PRIST Universities. Currently he is working as a Vice-Principal (Admin) & Post Graduate trained teacher (Biology) in ABS Vidhya Mandhir Senior Secondary School (affiliated to CBSE, New Delhi), Thiruvallur. He has a decade of teaching experience in the field of education. He had contributed more than 25 scientific research articles to reputed National and International peer reviewed and referred Journals including pubmed and ISI indexed journals. He had Gene Accession Numbers (GU479040 and JX444058) from NCBI, USA. He has authored two

books (ESBL and Handbook on Herbal Medicine) with international ISBN and edited many chapters in educational books and proceedings

He is serving as an editorial committee member in an ISI indexing journal-Indian Journal of Natural Science and Thomson Reuters and crossref indexing journal-International Journal of Scientific and Engineering Research, USA and also serving as an advisory board member in Weekly Science and Review of Progress journals. He is associated with national (BSS, TNSRO, SRUA) and international (IAMPV, ISID, APCBEES, IAENG) professional societies to disseminate his research knowledge. He has received very prestigious Fellowship title award from the Boss Scientific Society which is affiliated to Tamilnadu Scientific Research organisation (TNSRO), India. He is currently pursuing his doctoral degree in Tamil Nadu Open University, Chennai and he was honored with Har Gobind Khorana Best Young Investigator Award-2014 for Biological Science by TNSRO. He is awaiting his novel antiviral invention (Patent Filed Ref No.5246/CHE/2015) to be patented by Intellectual Property Rights, India.

Dr.S.Deepa has received her doctoral degree from St. Peter's university. Her doctoral degree was highly commended and she had researched on "The Biodiversity of Fungi from Tannery Effluent and Their Chromium and Dye Reduction Efficiency" and she was a recipient of the university rank at Post graduate level. She has been working in G K Shetty Vivekananda Vidyalaya Junior College for more than 13 years. She has good teaching experience for CBSE students at the senior secondary level. She has published scientific research articles in peer-reviewed, international and national journals.



She is an eminent resourceful person and efficiently conducted many orientation programs for teachers, enrichment programme for students, board of member in textbook, curriculum framing etc. She has adorable organising ability when she had conducted workshops for the biology teachers at the secondary and senior secondary levels. She has been enthusiastic in publication of work in national and international conferences. She is associated with many reputed scientific organisations and associations. Recently, she had conducted an effective biology teaching workshop for senior secondary teachers (for around 100 teachers) at Thrissur, Kerala, India which was organised by CBSE Sahodaya School Complex...

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