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# Lecture No. 4

# Probability, Chi

# Square & Dominance

# relationship



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# Lecture – 4

## Probability, Chi square & Dominance relationship

by

**Dr. Praveen Kumar**

*Asst. Prof. **GPB***

MSSSoA, CUTM, Odisha



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**Probability:** can be defined as the proportion of times in which that event occurs in a very large number of trials.

If there are  $x$  trials and the event occurs on the average  $y$  times during the  $x$  trials then, probability is expressed as  $y/x$ .

Range - between zero and one.

The closer the probability is to zero, the less chance is there for the event to occur.

When probability is one, the event is certain to occur.



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# Rules of probability:

**The multiplication rule:** when the probability of an event is independent of that of another event, and the occurrence of one does not influence the occurrence of the other, probability that both events will occur together is the product of their individual probabilities.



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**The Addition Rule:** The probability that *one* of several mutually exclusive events will occur is the *sum* of their individual probabilities.

This law is applicable when different types of events cannot occur together.

If one occurs the other is *excluded*

When a coin is tossed



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# Chi- Square test

To measure discontinuous categorical/binning data in which a number of subjects fall into categories

We want to compare our observed data to what we expect to see. Due to chance? Due to association?

When can we use the Chi-Square Test?

Testing outcome of Mendelian Crosses, Testing Independence  
Is one factor associated with another?, Testing a population for expected proportions



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# Assumptions:

- 1 or more categories
- Independent observations
- A sample size of at least 10
- Random sampling
- All observations must be used
- For the test to be accurate, the expected frequency should be at least 5



# The null hypothesis

The assumption that the observed data are in agreement with expected ratio, such as 3:1 ratio of tall and dwarf plant is the null hypothesis.

It assumes that there is no real difference between the measured values and the predicted values.

Use statistical analysis to evaluate the validity of the null hypothesis.

- If rejected, the deviation from the expected is NOT due to chance alone and you must reexamine your assumptions.
- If failed to be rejected, then observed deviations can be attributed to chance.





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# Chi-square formula

$$X^2 = \sum \frac{(o - e)^2}{e}$$

where  $o$  = observed value for a given category,  
 $e$  = expected value for a given category, and  
sigma is the sum of the calculated values for each  
category of the ratio



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# Conducting Chi-Square Analysis

- 1) Make a null hypothesis based on your basic biological question
- 2) Determine the expected frequencies
- 3) Create a table with observed frequencies, expected frequencies, and chi-square values using the  $X^2$  formula
- 4) Find the degrees of freedom:  $(n-1)$
- 5) Find the chi-square statistic in the Chi-Square Distribution table
- 6) Determine if null hypothesis is either (a) rejected or (b) not rejected



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- ❖ Table value of  $X^2$  – depends on **degree of freedom and probability**
- ❖ In most biological experiments, **0.05 probability** as the standard probability level for decision-making.
- ❖ Once  $X^2$  is determined, it is converted to a probability value ( $p$ ) using the degrees of freedom ( $df$ ) =  $n - 1$  where  $n$  = the number of different categories for the outcome.



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# Arriving at a conclusion

Conclusion may validate the null hypothesis

Value of  $X^2$  at 0.05 probability against the appropriate  $df$  is obtained from  $X^2$  table

- if calculated value of  $X^2 < \text{table value}$  = null hypothesis accepted
- if calculated value of  $X^2 > \text{table value}$  = null hypothesis rejected



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# DOMINANCE RELATIONSHIPS

- **Complete dominance:** The phenotype produced by heterozygotes is identical with that produced by homozygotes for the concerned dominant allele.
- The dominant allele in such a situation is known as completely or fully dominant.
- Characters showing complete dominance yield the typical 3:1 monohybrid ratio in F<sub>2</sub>.



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- **Incomplete dominance:** Neither allele is dominant and heterozygous individuals have an intermediate phenotype
- For example, in Japanese “Four o’clock”, plants with one red allele and one white allele have pink flowers:
- Modified ratio of 1 red: 2 pink: 1 white was observed in F<sub>2</sub>.



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- **Co-dominance:** Neither allele is dominant and both alleles are expressed in heterozygous individuals
- Example ABO blood types
- In case of co- dominance, both alleles are active
- while in case of incomplete dominance only one allele (dominant) is active.



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**Over dominance:** Intensity of character expression is greater in the heterozygotes than in the two concerned homozygotes

Many cases of presumed overdominance may actually be cases of repulsion phase linkage and/or epistasis.

The white eye ( $w$ ) gene of *Drosophila* exhibits overdominance for some of the pigments, e.g., sepiapteridine and himmelblaus.





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**THANK YOU**