**Course: Advance Bio Informatics**

**Module Title: Phylogenetic Bayesian Method**

**Module No: 59**

Since probability theory and statistics are important in genomics because evolution itself is stochastic in nature and availability of large amounts of data make statistical approaches powerful.

**Significance:** unlikely things do happen in large genomes

There are two schools of thoughts when it comes to explaining some inference from data.

**Frequentists & Bayesians**

In both cases, concept of "probability" is used. Both of them are based on mathematical formalism in same way, but have a (slightly) different Interpretation. With lots of data, the prior does not influence result, and the two approaches give the same answers.

Bayesian inference is a method of statistical inference in which Bayes' theorem is used to update the probability for a hypothesis as evidence is acquired. Bayesian inference is an important technique in statistics, and especially in mathematical statistics. Bayesian updating is particularly important in the dynamic analysis of a sequence of data. Bayesian inference has found application in a wide range of activities, including science, engineering, philosophy, medicine, and law. In the philosophy of decision theory, Bayesian inference is closely related to subjective probability, often called "Bayesian probability"

Bayesianism contends that mathematical probability theory pertains to degree of plausibility / belief a parameter has a distribution, not a single value.

Bayesian inference derives the posterior probability as a consequence of two antecedents, a prior probability and a "likelihood function" derived from a statistical model for the observed data. Bayesian inference computes the posterior probability according to Bayes' theorem:

P(H\mid E) = \frac{P(E\mid H) \cdot P(H)}{P(E)}

* *\textstyle \mid  denotes a conditional probability; more specifically, it means given.*
* *\textstyle H stands for any hypothesis whose probability may be affected by*[*data*](https://en.wikipedia.org/wiki/Experimental_data)*(called evidence below). Often there are competing hypotheses, from which one chooses the most probable.*
* *the evidence \textstyle E corresponds to new data that were not used in computing the prior probability.*
* *\textstyle P(H), the*[*prior probability*](https://en.wikipedia.org/wiki/Prior_probability)*, is the probability of \textstyle H before \textstyle E is observed. This indicates one's previous estimate of the probability that a hypothesis is true, before gaining the current evidence.*
* *\textstyle P(H\mid E), the*[*posterior probability*](https://en.wikipedia.org/wiki/Posterior_probability)*, is the probability of \textstyle H given \textstyle E, i.e., after \textstyle E is observed. This tells us what we want to know: the probability of a hypothesis given the observed evidence.*
* *\textstyle P(E\mid H) is the probability of observing \textstyle E given \textstyle H. As a function of \textstyle H with \textstyle E fixed, this is the*[*likelihood*](https://en.wikipedia.org/wiki/Likelihood_function)*. The likelihood function should not be confused with \textstyle P(H\mid E) as a function of \textstyle H rather than of \textstyle E. It indicates the compatibility of the evidence with the given hypothesis.*
* *\textstyle P(E) is sometimes termed the*[*marginal likelihood*](https://en.wikipedia.org/wiki/Marginal_likelihood)*or "model evidence". This factor is the same for all possible hypotheses being considered. (This can be seen by the fact that the hypothesis \textstyle H does not appear anywhere in the symbol, unlike for all the other factors.) This means that this factor does not enter into determining the relative probabilities of different hypotheses.*

Note that, for different values of \textstyle H, only the factors \textstyle P(H) and \textstyle P(E\mid H) affect the value of \textstyle P(H\mid E). As both of these factors appear in the numerator, the posterior probability is proportional to both. In words:

* *(more precisely) The posterior probability of a hypothesis is determined by a combination of the inherent likeliness of a hypothesis (the prior) and the compatibility of the observed evidence with the hypothesis (the likelihood).*
* *(more concisely) Posterior is proportional to likelihood times prior.*
* *Note that Bayes' rule can also be written as follows:*
* *P(H\mid E) = \frac{P(E\mid H)}{P(E)} \cdot P(H)*
* *where the factor \textstyle \frac{P(E\mid H)}{P(E)} represents the impact of E on the probability of H.*