## Bayesian Overview

* Bayes’ Theorem:
* **Evidence –** P(B) likelihood, averaged over the prior.
* **Prior –** P(A) probability distribution of the parameter before the evidence is taken into account.
  + Is updated based on the data.
* **Likelihood –** P(B|A) relative number of ways that the data can occur within the bounds of the prior.
* **Posterior distribution –** P(A|B) probability distribution of the parameter, given the prior and the data.
* **Parameter –** unknown. Estimated from the data.

## Priors

* **Informative –** specific, definite information about a variable.
* **Regularizing –** keeps inferences within a reasonable range, but he data does most of the informing.
  + Use this kind for myctophids.
  + We have some idea about what the parameters might be from previous studies, so can keep within a range, but we want the data do most of the informing.
* **Diffuse prior –** equal probabilities to all outcomes.

## Multilevel Models

1. Adjust for repeated sampling.
   * Many individuals per species.
2. Adjust for imbalance in sampling.
   * Different number of individuals per species.
3. Avoids averaging.
   * Individuals per species rather than species averages.

## MCMC

* **Monte Carlo simulations** - approximates a parameter by repeatedly generating random numbers.
* **Markov Chains** – sequence of event, where the next event is predicted by the current event.
* Basic method:

1. Pick a random potential parameter value.
2. Test how likely the parameter value is to explain the data, given the prior.
3. The parameter then informs the next parameter to be picked.

* Samples directly from posterior without assuming a shape.
  + I.E. doesn’t assume normality.
* **Gibbs Sampling –** adjusts the distribution of a proposed parameter value, depending on the current parameter values.
  + Used in BUGS and JAGS (and therefore MixSIAR).
  + Uses **conjugate priors** (prior and posterior distributions are from the same family, e.g. both Gaussian).
* **Hamiltonian Monte Carlo –** sends a frictionless particle to glide over the posterior, turning when the gradient of the posterior specifies.
  + Used in Stan.
  + Doesn’t require conjugate priors.
  + More efficient than Gibbs sampling.

## MixSIAR

* Uses JAGS (Just Another Gibbs Sampler).
* Mixing models that estimate proportion of sources to an isotopic mixture.
* Advantages of Bayesian:
  + Takes uncertainty into account for source values and discrimination.
  + Incorporates prior information.

### Priors

* Use the uninformative priors.

### MCMC Parameters

* **“Long”**
  + Chain length = 300,000
  + Burn in = 200,000
    - Proportion of the chain that may not converge on the target distribution yet (discarded).
  + Thinning parameter = 100
  + Number of chains = 3

### Error Structure

* Error structure is “**process only**” because we only have one mixture data point.
  + Error comes from consumers sampling in different areas of the diet and DIC distribution.

### Diagnostics

* **Gelman-Rubin diagnostic** is the same as R-hat.
  + Needs to be a close to 1 to ensure convergence.
* **Geweke diagnostic** is a z-score.
  + MixSIAR tells you how many variables were outside +/- 1.96 in each chain.

### Outputs

* Posterior plot of contributions of each source.