

$$\pi(p | \text{data}) \propto_p \pi(\text{data} | p) \pi(p)$$

$$= \prod_{i=1}^n \text{Binomial}(y_i; N, p) \cdot \text{Beta}(p; \alpha, \beta)$$

$$= \left[\prod_{i=1}^n \binom{N}{y_i} p^{y_i} (1-p)^{N-y_i} \right] \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} p^{\alpha-1} (1-p)^{\beta-1}$$

$$\propto_p p^{\alpha + \sum_{i=1}^n y_i - 1} (1-p)^{\beta + nN - \sum_{i=1}^n y_i - 1}$$

$$\propto_p \text{Beta}(p; \alpha + \sum_{i=1}^n y_i, \beta + nN - \sum_{i=1}^n y_i)$$