The data for this example are from a clinical trial with epileptic patients experiencing seizures. Patients were randomized to receive an anti-seizure drug, \( \text{treat} = 1 \), or a placebo, \( \text{treat} = 0 \). Apart from the drug, all patients were treated the same. Also recorded on each patient is the age in years, and baseline, the seizure count prior to randomization.

Responses were the number of seizures in a period around each of the visits after randomization. For this example, the response \( y \) is equal to 1 if five or more seizures occurred, and equal to 0 if fewer than five.

```r
> loc <- url("http://www.stat.umn.edu/~sandy/courses/5421/data/epileptic.txt")
> epi <- read.table(loc, header = T)
> head(epi)

individual treat age baseline y visit
1 1 0 31 11 1 V1
2 1 0 31 11 0 V2
3 1 0 31 11 0 V3
4 1 0 31 11 0 V4
5 2 0 30 11 0 V1
6 2 0 30 11 1 V2
```

For example, individual #1, of age 31 years, had baseline of 11 seizures, and on the control drug had more than five seizures around the first visit, but less than five around the other three.

Consider the following fitted model:

```r
> library(lme4)
> print(m1 <- lmer(y ~ treat + age + baseline + visit +
+   (1 | individual), data = epi, family = binomial),
+   corr = FALSE)
```

Generalized linear mixed model fit using Laplace
Formula: y ~ treat + age + baseline + visit + (1 | individual)
Data: epi
Family: binomial (logit link)
   AIC BIC logLik deviance
212.6 240.3 -98.31 196.6
Random effects:
Groups Name Variance Std.Dev.
individual (Intercept) 1.141 1.0682
number of obs: 236, groups: individual, 59

Estimated scale (compare to 1 ) 0.8767558

Fixed effects:

|            | Estimate | Std. Error | z value | Pr(>|z|) |
|------------|----------|------------|---------|----------|
| (Intercept)| -4.85871 | 1.44935    | -3.352  | 0.000801 |
| treat      | -0.94469 | 0.51423    | -1.837  | 0.066198 |
| age        | 0.06082  | 0.04227    | 1.439   | 0.150237 |
| baseline   | 0.13602  | 0.02116    | 6.429   | 1.28e-10 |
1. What is the purpose of including a random *individual* effect?

2. If $\pi_{ij}$ is the probability that $y_{ij}$ equals one at week $j$ for individual $i$, write out a model statement like:

   $$\log(\pi_{ij} / (1 - \pi_{ij})) = \text{Something}$$

   Be sure to define all the terms, and given any distributions of random effects.

3. How would the model change if the term $(1|\text{individual})$ were replaced by $(1+\text{baseline}|\text{individual})$?

4. The estimate for the *individual* (Intercept) random effect variance is 1.141. Interpret this number. Is it big, or small?

5. The following additional computations are done:

   ```r
   > m2 <- lmer(y ~ treat + age + baseline + (1 | individual),
   +             data = epi, family = binomial)
   > anova(m2, m1)
   ```

   Data: epi
   Models:
   m2: y ~ treat + age + baseline + (1 | individual)
   m1: y ~ treat + age + baseline + visit + (1 | individual)
   Df    AIC    BIC   logLik    Chisq   Chi Df Pr(>Chisq)
   m2  5 207.318 224.637 -98.659
   m1  8 212.629 240.340 -98.315 0.688 3 0.876

   What hypothesis is tested in this analysis of variance table?

6. Give the results of the Wald test for the hypothesis that the drug decreases seizures. To do a likelihood ratio test, you would need additional calculations. What are they?