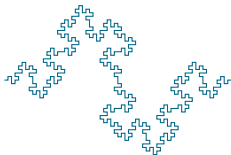


High-Throughput Sequencing Course

Time Course Hypotheses

Biostatistics and Bioinformatics



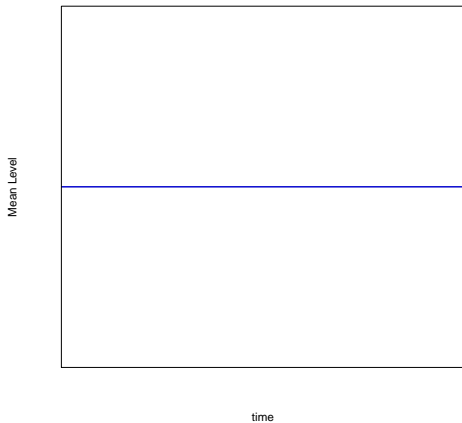
Summer 2018

TIME-COURSE HYPOTHESIS

- ▶ So far we have considered comparing mean abundance level at a single time-point
- ▶ Example: Let μ_0 and μ_1 denote the mean mRNA abundance level for the untreated and treated group
- ▶ $H_0 : \mu_0 = \mu_1$ (there is no treatment effect)
- ▶ $H_1 : \mu_0 \neq \mu_1$ (there is a treatment effect)
- ▶ What may be of interest is to identify genes for which the mRNA abundance level varies over time
- ▶ We will consider the one-sample and two-sample time-course hypotheses

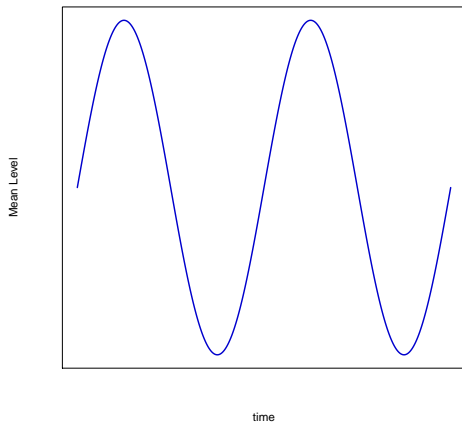
ONE-SAMPLE PROBLEM: NO TIME COURSE EFFECT

There is no time-course effect: The mean level is constant over time



ONE SAMPLE PROBLEM: TIME COURSE EFFECT

There is a time course effect: The mean level varies over time

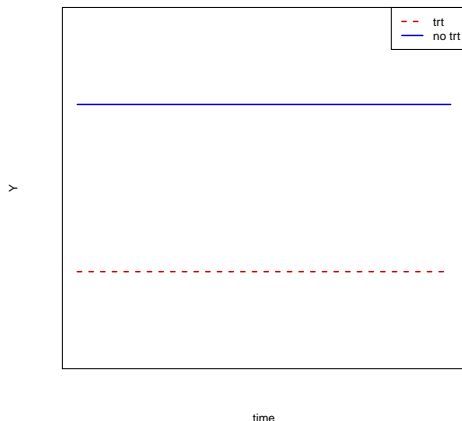


TIME-COURSE HYPOTHESIS: ONE-SAMPLE

- ▶ Let $\mu(t)$ denote the mean mRNA abundance level at time $t > 0$
- ▶ If the mean level is constant over time, there is no time effect
- ▶ $H_0 : \mu(t) = c$ for *all* t for some constant c
- ▶ $H_1 : \mu(s) \neq c$ for *some* t

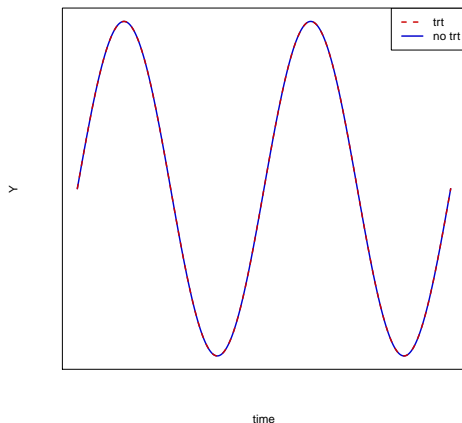
TWO-SAMPLE PROBLEM: TIME COURSE EFFECT?

There is no time-course effect within each condition, while there is a treatment effect. Is this interesting?



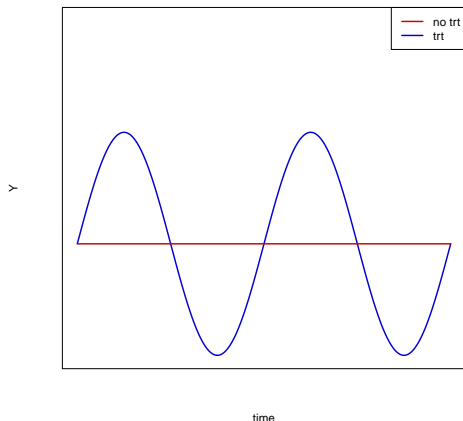
TWO-SAMPLE PROBLEM: TIME COURSE EFFECT?

There is a time-course effect within each condition but not time-course effect across conditions. Is this interesting?



TWO-SAMPLE PROBLEM: TIME COURSE EFFECT

There is a time-course effect for the treated group only. Is this interesting?

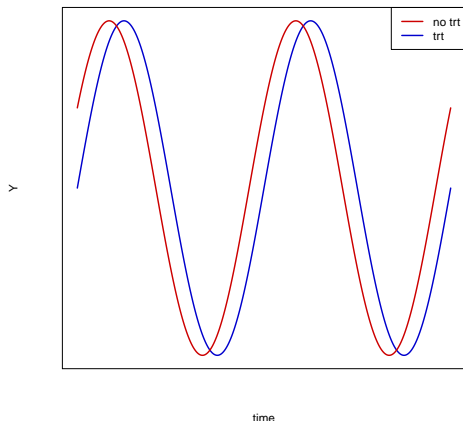


TIME-COURSE HYPOTHESIS: TWO-SAMPLE

- ▶ Let $\mu_0(t)$ denote the mean mRNA abundance level at time $t > 0$ for the *untreated* group
- ▶ Let $\mu_1(t)$ denote the mean mRNA abundance level at time $t > 0$ for the *treated* group
- ▶ $H_0 : \mu_0(t) = \mu_1(t)$ for *all* t
- ▶ $H_0 : \mu_0(t) \neq \mu_1(t)$ for *some* t

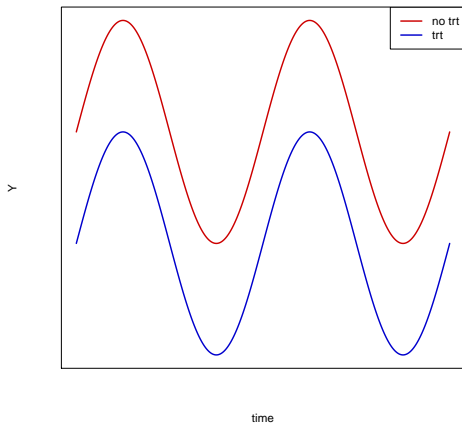
TWO-SAMPLE PROBLEM: TIME COURSE EFFECT?

There is a time-course effect within each condition and a phase shift with respect to treatment. Is this interesting?



TWO-SAMPLE PROBLEM: TIME COURSE EFFECT?

There is a time-course effect within each condition and a vertical shift with respect to treatment. Is this interesting?



STANDARD ANALYSIS (NOT RECOMMENDED)

- ▶ For each gene, do a two-sample t-test at *each* time point
- ▶ Declare a time-course if any of the P -values are "significant"
- ▶ To make things worse: Use the P -values to describe the time-course
- ▶ This approach ignores multiple testing aspect (not only due to genes but also due to multiple timepoints within each gene)
- ▶ This analysis would only be appropriate if one time-point is identified upfront
- ▶ What is the point of a time-course experiment if only one timepoint is of interest?

ANALYSIS METHODS

- ▶ Previously, we have modeled the mean abundance level at a single time point as

$$Y = \mu + \epsilon$$

- ▶ You can model the expression level at time t as

$$Y(t) = \mu(t) + \epsilon(t)$$

- ▶ The challenge here is that $\mu(t)$ is an unknown function of time
- ▶ Methods using this type of model use various approaches for estimating $\mu(t)$