# 05: MAXIMUM LIKELIHOOD ESTIMATION

Stat250-S25

#### 1 WARM UP

**Example:** You are testing seeds from a new plant variety. You plant 10 seeds (n=10) and observe that 3 of them successfully germinate (k=3). Consider two hypotheses about the true germination probability (p) for this variety:

Hypothesis A:

Hypothesis B:

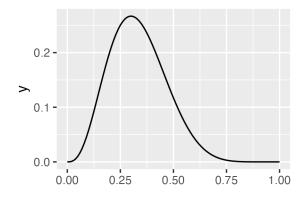
Given you observed 3 germinations out of 10 seeds, which hypothesis (A or B) is more supported by the data?

In general, the *likelihood* of seeing X = 3 given p is:

3 ways of finding the maximum:

1. Approximate solution graphically

```
germ_function <- function(p) {choose(10,3) * p^3 * (1-p)^7} # define function
ggplot() +
   geom_function(fun = germ_function) +
   xlim(c(0,1))
```



2. Find a numerical approximation

optimize(germ\_function, interval = c(0,1), maximum = TRUE)

\$maximum

[1] 0.3000157

\$objective

[1] 0.2668279

3. Use calculus to find an exact maximum

Can we generalize to any dat	ta?		
2 Definitions			

#### Likelihood function

Let  $f(x;\theta)$  denote the probability mass function for a discrete distribution with associated parameter  $\theta$ . Suppose  $X_1, X_2, ..., X_n$  are a random sample from this distribution and  $x_1, x_2, ..., x_n$  are the actual observed values. Then, the *likelihood function* of  $\theta$  is:

#### Maximum likelihood estimate

A maximum likelihood estimate (MLE),  $\hat{\theta}_{MLE}$  is the value of  $\theta$  that maximizes the likelihood function, or equivalently, that maximizes the log-likelihood  $l(\theta) = \ln L(\theta)$ 

### Bernoulli Data Example

Estimator		
Fetimata		
Estimate		

## 3 Exercise

Let  $X_1,...,X_n$  be an iid random sample from a distribution with PDF

$$f(x|\theta) = (\theta + 1)x^{\theta}, 0 \le x \le 1$$

- 1. Find the maximum likelihood estimator for a random sample of size n using calculus.
- 2. Suppose we observe a sample of size 5: {.83, .49, .72, .57, .66}. Find the maximum likelihood estimate and verify with a graph or numerical approximation