

## Two-Sample Comparisons:

**Background:** Charles Darwin, the father of evolutionary theory, was the first person to document the operation of *natural selection*. Simply stated, natural selection is a process by which organisms best suited to their environment become the ones most likely to survive and leave descendants.

The central argument of this theory starts from the existence of variations among animals and Darwin's observation of these variations. Experience with animal and plant breeding demonstrates that variations can be developed that are "useful to man," such as developing new breeds of dogs or domesticating farm animals. So, reasoned Darwin, variations must occur in nature that are favorable or useful in some way to the organism itself in its own struggle for existence. Favorable variations are ones that increase chances for survival and procreation. Those advantageous variations are preserved and multiplied from generation to generation at the expense of less advantageous ones. This is the process known as natural selection. The outcome of the process is an organism that is well adapted to its environment.

**Scenario:** In February of 1898, there was a severe winter storm with rain, sleet and snow near Providence, RI. Fifty-nine English sparrows were found freezing and brought to the laboratory of Dr. Herman Bumpus at Brown University. Of those 59 sparrows, 35 survived and 24 died. Bumpus analyzed 9 characteristics of the birds to see if the surviving sparrows were markedly different from the birds that died (which would support natural selection). We will analyze one particular characteristic of the sparrows – the humerus length (length of the arm bone).

1) The following table describes the observed humerus lengths of each group of sparrows. Sketch boxplots of this data.

Group	n	$\bar{X}$	s	Min	Q25	Median	Q75	Max
Survivors	35	738.00	19.839	687.00	728.00	736.00	752.00	780.00
Dead	24	727.92	23.543	659.00	714.75	733.50	743.75	765.00

2) Formulate the competing hypotheses:

3) Make an educated guess as to what the pooled standard deviation will be. Calculate the pooled standard deviation,  $s$ :

4) Calculate a one-sided 95% confidence interval for the difference in means. How many degrees of freedom are there?

5) Based on this confidence interval, do the surviving sparrows have greater humerus lengths than the sparrows that died?

6) Now let's calculate a one-sided significance test with  $\alpha=0.05$ . Find the critical regions (in terms of  $t$ ) and then compare your test statistic to that critical value. State your conclusion.