

# R Lab #8b - Probability under a normal curve

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## Probability under a normal curve : NASA example

Chapter 10 introduces the normal distribution. There are an infinite number of normal distributions, each with a mean and standard deviation parameter. If you know the population mean and standard deviation then you know the shape of the curve, and can thus calculate probabilities for different areas under the curve.

Chapter 10 does this in the NASA example, in which the population mean and standard deviation of mean male heights aged 20-29 years is known. Then the question is asked what proportion of this population is excluded from being a NASA astronaut based on height.

$\mu$  (parameter mean) = 177.6 cm  $\sigma$  (parameter standard deviation) = 9.7 cm

### What proportion of males are too tall

The maximum height for an astronaut is 190.5 cm, and the minimum is 157.5 cm.

You can use the standard normal deviate to calculate the area under the curve above 190.5.

The command for this is `pnorm()`. It takes three arguments: the Y value,  $\mu$ , and  $\sigma$

Additionally, the default for the command is `lower.tail=T`. In this case we want the upper (right) tail so we need to change this to `lower.tail=F`.

```
pnorm(190.5, 177.6, 9.7, lower.tail = F)
## [1] 0.09177612
```

This calculates the proportion of the area under this normal curve above 190.5 to be 0.09177612.

### Proportion of males that are too short

Now we can get the proportion of males that are below the minimum height cutoff of 157.5 cm. Note that now we want the lower/left tail, so you can use the default `lower.tail=T`. Here I add that argument to be explicit.

```
pnorm(157.5, 177.6, 9.7, lower.tail = T)
## [1] 0.01912503
```

### Total proportion excluded

If you want the probability of being too tall OR too short then you use the addition rule. Since you can't be both too tall and too short the probability is  $\text{Pr}[\text{too tall OR too short}] = \text{Pr}[\text{too tall}] + \text{Pr}[\text{too short}]$ .

```
pnorm(190.5, 177.6, 9.7, lower.tail = F) + pnorm(157.5, 177.6,  
  9.7, lower.tail = T)  
## [1] 0.1109012
```

Under these height restrictions, and with a known normal curve for height for this population, the proportion of males excluded from being a NASA astronaut is ~0.111.

## R commands summary

- Probability under a normal distribution (lower (TRUE) or upper (FALSE) tail of value q)
  - `pnorm(q,mean,sd,lower.tail)`