

## 0.4: Comparing Sizes and Converting Units

### Learning Objectives

- Students will be able to compare two quantities with the same units by using a ratio
- Students will be able to convert units, e.g. of distance measure

Often in astronomy, to give us a sense of scale, we compare the relative sizes of, or distances to, objects. For example, we could compare how much farther the Sun is from Earth compared to how far the Moon is from Earth. We do this by taking a ratio of the two quantities. When astronomers say things like “compare,” or “how much bigger?”, “how much smaller?”, etc., we mean find the ratio. In this case:

$$\frac{\text{Distance to Sun}}{\text{Distance to Moon}} = \frac{1.5 \times 10^8 \cancel{km}}{3.8 \times 10^5 \cancel{km}} = 395 \text{ times farther.}$$

### Play Animation

This means the Sun is 395 times farther away from Earth than the Moon is. Notice how the units cancel out: *km* on the top of the fraction cancel *km* on the bottom of the fraction. For this to happen, it is important that both quantities have the same units, for example, *km* and *km* or *miles* and *miles*; you could not mix *miles* and *km* in a comparison.

Therefore, sometimes it is necessary to convert units. By converting units, we change the way a measurement is described, even though it remains the same measurement. For instance, you can say that a ruler is 12 inches long or 1 foot long. You are using different units, but still describing the same physical length of the ruler.

There is a mathematical way to convert units, and all it entails is multiplying your original measurement by 1, expressed as a fraction. This fraction must have your original unit in the denominator (bottom part of the fraction) and the new units in the numerator (top part of the fraction).

As an example, say you have measured a bridge to be 1.4 km long, but you want to know how many meters that is. You can look up in a chart that 1,000 m = 1 km. So, you take 1.4 km and multiply it by the number 1, expressed as 1,000 m / 1 km.

$$1.4 \cancel{km} \times \left( \frac{1,000 m}{1 \cancel{km}} \right) = 1,400 m$$

### Play Animation

You can see that the kilometers cancel each other out, leaving only the new units. This works for any kind of conversion you can think of, as long as you are converting between equivalent physical measurements (length to length, temperature to temperature, etc.).

As another example, perhaps you needed to know the length of the bridge in miles. You can look up the fact that 0.62 miles = 1 kilometer. You can then calculate:

$$1.4 \cancel{km} \times \left( \frac{0.62 mi}{1 \cancel{km}} \right) = 0.87 miles$$

### Play Animation

Again, the original units are in the denominator of the conversion factor and the new desired units are in the numerator.

Table 0.3 Common Distance Unit Conversations

1 inch = 2.54 cm
1,000 m = 1 km

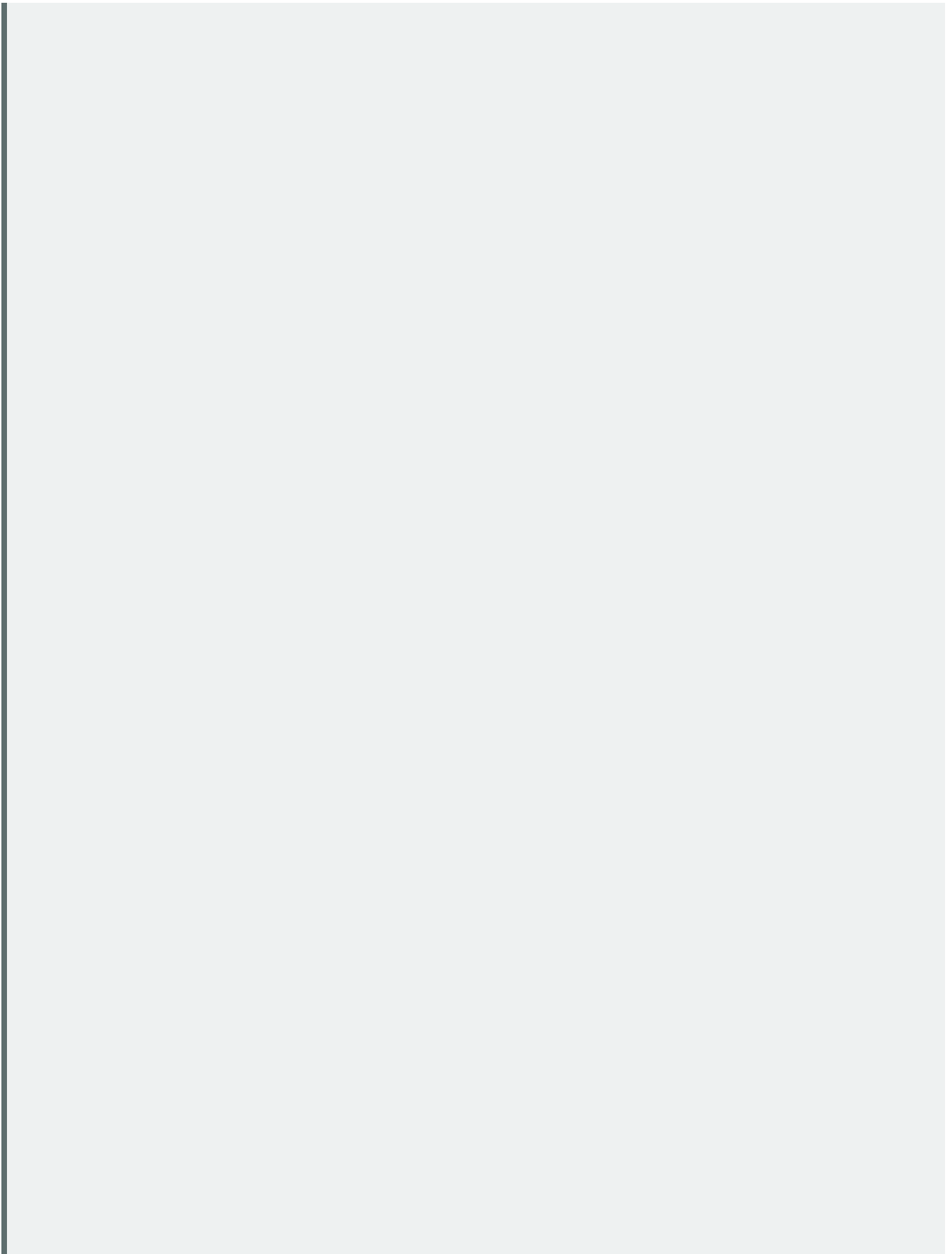
$$1 \text{ km} = 0.62 \text{ mi}$$

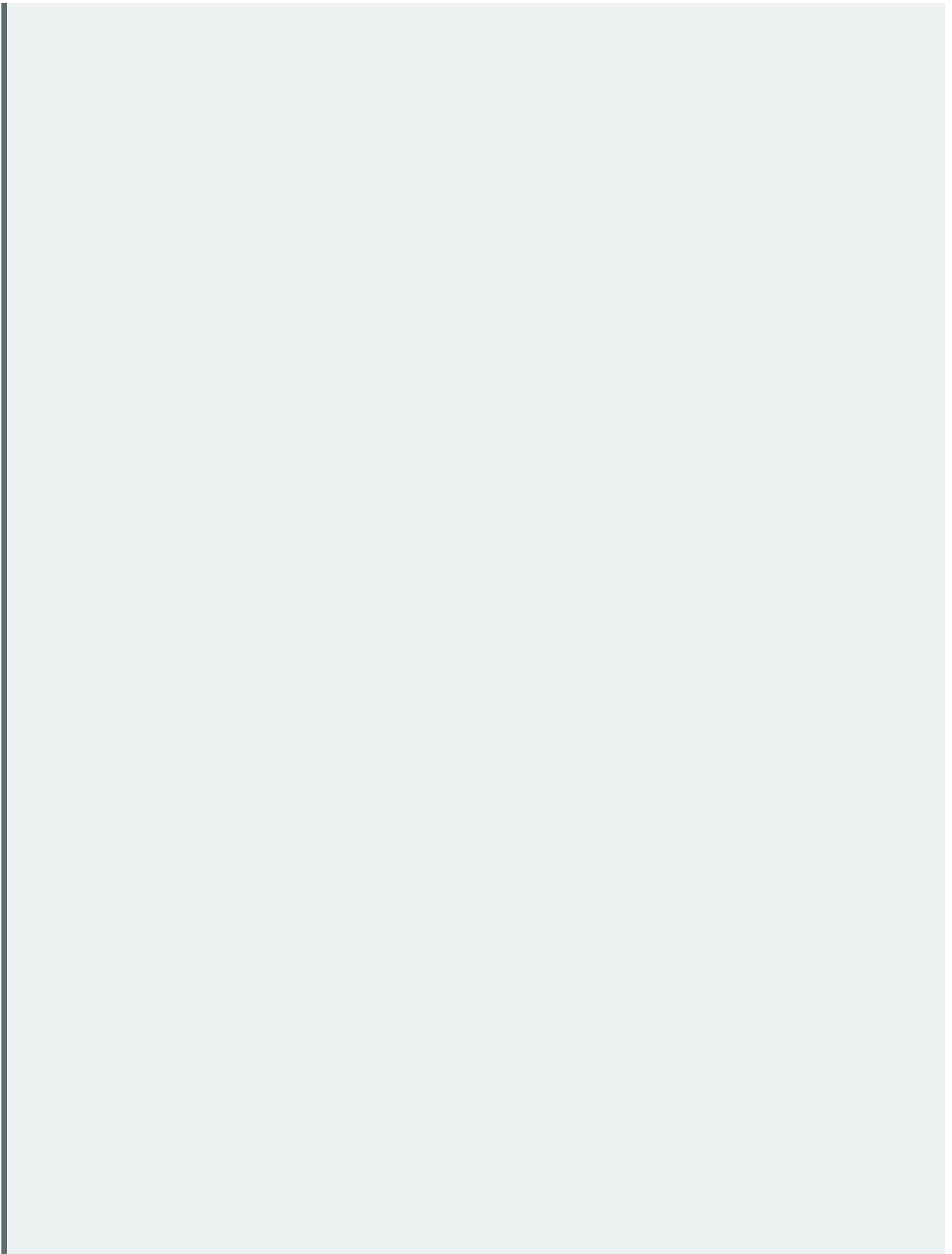
$$1 \text{ AU} = 1.5 \times 10^8 \text{ km}$$

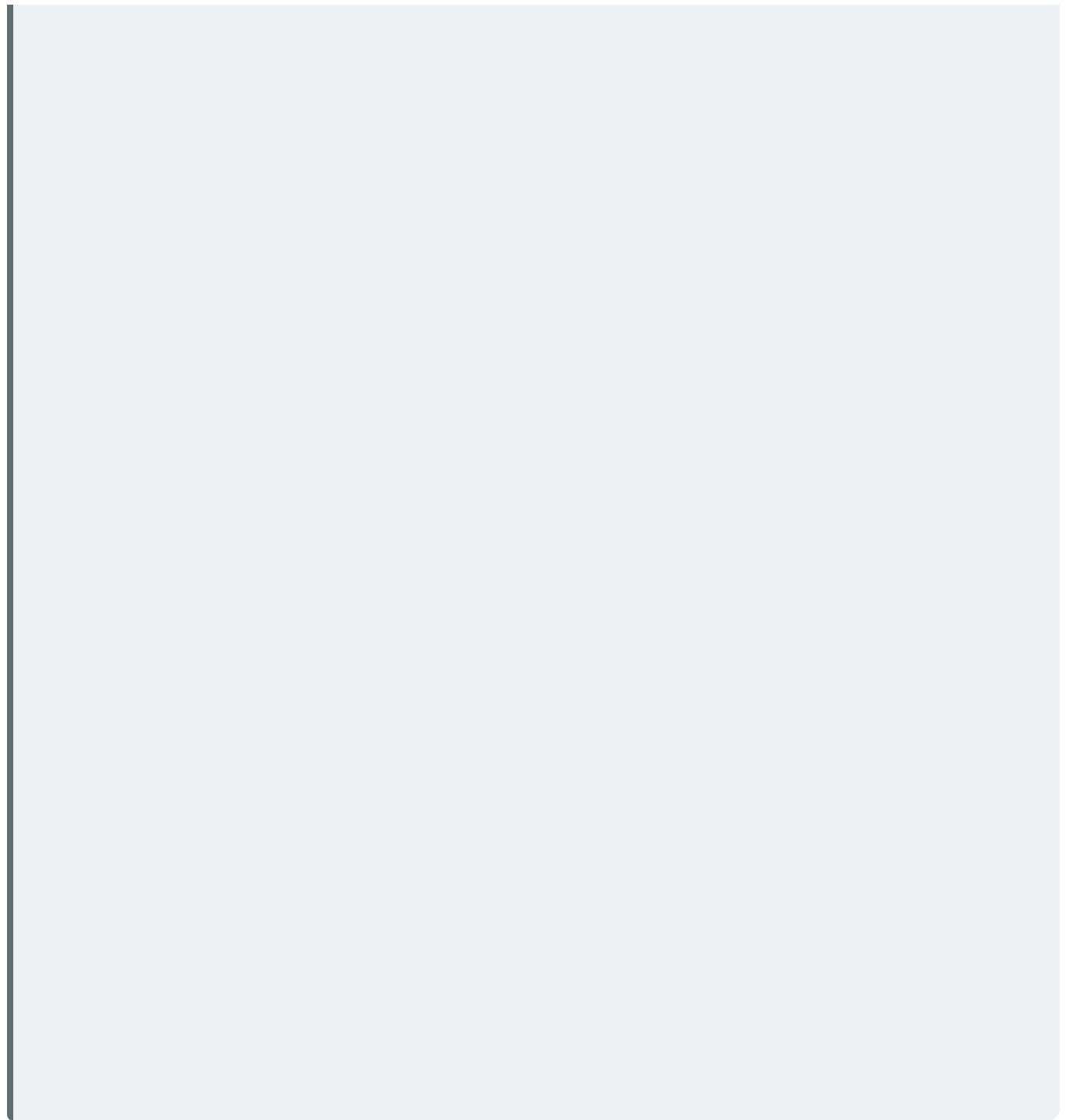
$$1 \text{ ly} = 9.5 \times 10^{12} \text{ km} = 6.3 \times 10^4 \text{ AU}$$

#### CONVERTING UNITS AND COMPARING DISTANCES

Given the conversion factors in Table 0.3 answer the questions below. Numerical answers should be given in scientific notation. The expected units will follow the answer box. For example, if you get an answer of  $6.5 \times 10^4 \text{ km}$ , you should enter 6.5e4 in a box with km next to it. When asked to show your work, you should explain your answers thoroughly.







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