Practice: Worksheet: Estimation of Toothless' wing area using three reference flyers: a large bat, a pterosaur, and a small glider.

How Big Should Toothless' Wings Be?: Use the **scaling law** to estimate how big Toothless' wings must be.



Reference Animal #1: Large Bat

- **Mass of reference animal**: 1.5 kg
- **Wing area**: 0.2 m²
- **Toothless' mass**: 1,000 kg

1. Fill in the scaling law:

$$\text{Toothless Wing Area} = 0.2 \times \left(\frac{1000}{1.5}\right)^{2/3}$$

2. Calculate the ratio inside the parentheses:

$$\frac{1000}{1.5} = _____$$

3. Raise the ratio to the power of 2/3 (use calculator):

$$\left(\frac{1000}{1.5}\right)^{2/3} = _____$$

4. Multiply by 0.2: Toothless Wing Area= _____m²

Reference Animal #2: Pterosaur



- **Mass**: 250 kg

- **Wing area**: 20 m²
- **Toothless' mass**: 1,000 kg

1. Fill in the scaling law:

$$\text{Toothless Wing Area} = 20 \times \left(\frac{1000}{250}\right)^{2/3}$$

2. Ratio:

$$\frac{1000}{250} = _____$$

3. Raise to the power of 2/3:

$$\left(\frac{1000}{250}\right)^{2/3} = _____$$

4. Final wing area estimate: Toothless Wing Area _____m²

Reference Model #3: Small Glider



- **Mass**: 150 kg
- **Wing area**: 15 m²
- **Toothless' mass**: 1,000 kg

1. Scaling law:

$$\text{Toothless Wing Area} = 15 \times \left(\frac{1000}{150}\right)^{2/3}$$

2. Ratio: $\frac{1000}{150} = _____$

3. Raise to power:

$$\left(\frac{1000}{150}\right)^{2/3} = _____$$

5. Final area: Toothless Wing Area _____m²

Reflection Questions:

1. Which reference animal gave the **largest estimate** for Toothless' wings? How did you know?

2. Which gave the **smallest**? Why do you think that is?

3. If you were Hiccup, which model would you trust most to design Toothless' wings? Why?

4. How do these calculations help you understand **why real flying animals are limited in size**?