

When Size Changes, What Changes With It?

SCALING LAWS — *what changes when a figure is scaled by k*

Measurement	Dimensions	Scale factor	Scales by	Why — write here
Length / Perimeter	1D	k	$k^1 = k$	
Area / Surface area	2D	k	k^2	
Volume	3D	k	k^3	

MY SHAPE FROM CLASS

My Shape from Class — Worked Example	
	My shape: _____ Scale factor $k =$ _____
	Side length: original = _____ scaled = _____ ratio = _____
	Perimeter: original = _____ scaled = _____ ratio = _____
	Area: original = _____ scaled = _____ ratio = _____
	Volume (if 3D): original = _____ scaled = _____ ratio = _____
	What I noticed:

The key idea:

The number of _____ is the _____.

This is not a coincidence — it is what the word ‘dimension’ means in measurement.

THE SQUARE–CUBE LAW IN THE REAL WORLD

The Square–Cube Law — Why nature cannot just scale things up

Heat problem (elephants):

Heat is produced by _____
(scales as k^3).

Heat is lost through _____
(scales as k^2).

So as animals grow, heat
_____ outpaces heat

_____.

What elephants did about it:

Oxygen problem (insects):

Oxygen enters through _____
(scales as k^2).

Oxygen must supply _____
(scales as k^3).

So as insects grow, oxygen demand
_____.

Why Carboniferous insects were larger:

When mathematical prediction and empirical observation differ...

Geometric prediction: metabolism $\propto \text{mass}^{2/3}$. Empirical result: metabolism $\propto \text{mass}^{3/4}$
(Kleiber's Law).

This is not a failure of geometry. It means: