Sreekumar-Nirmalan model of the total surface area of an Indian elephant

## Winner of the [2002 Ig Nobel Prize](#) for Mathematics

- This model provides an estimate for the total surface area (S) of an adult Indian elephant, irrespective of sex.
- It is useful for zoologists who study metabolic rates in elephants, which are often expressed in relation to the elephant's total body surface area.

Model Aspects

- Static
- Empirical
- Deterministic
- Single-scale

Salient Features

- Divides the elephant's body into **13 anatomical regions**.
- Uses simple geometric relations to combine **41 different parameters** related to lengths and circumferences into a single mathematical equation to estimate the total surface area of the elephant.
- The trunk, neck, body (torso), forelimbs, hindlimbs, and tail are modelled as **cylinders**. The frontonasal region and shoulders are modelled as **rectangles**. The face, ears, jowl region, and perineal region are modelled as **triangles**. The hip is modelled as a **trapezium**.
- The modellers also provided an approximation for their equation using the height (H) and the forefoot pad circumference (FFC) as $S = -8.245 + 6.807H + 7.073FFC$.
- Sreekumar was [reportedly](#) attacked by an elephant during model development!
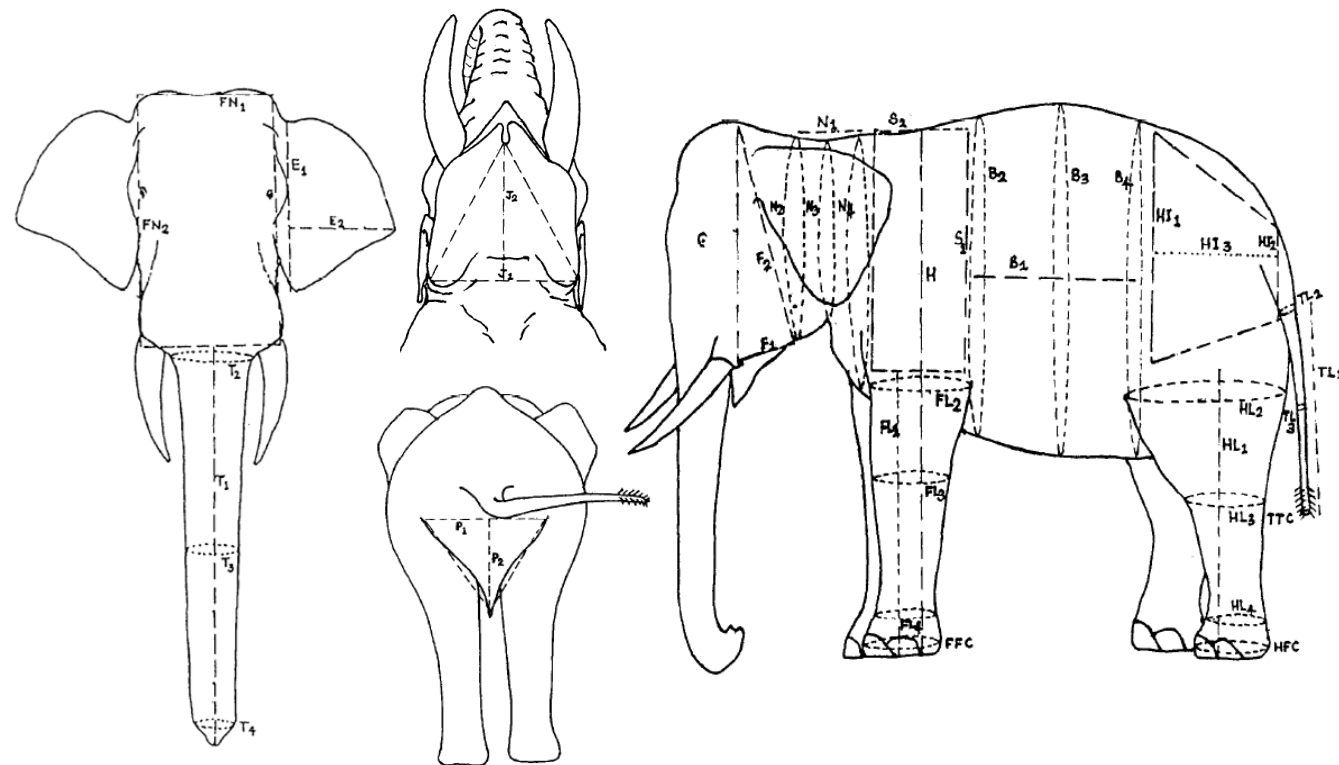
$$S = T_1 \frac{(T_2 + T_3 + T_4)}{3} + (FN_1 \times FN_2) + (F_1 \times F_2) + 2(E_1 \times E_2) + \frac{(J_1 \times J_2)}{2}$$

$$+ N_1 \frac{(N_2 + N_3 + N_4)}{3} + 2(S_1 \times S_2) + \frac{FFC^2}{2\pi} + 2FL_1 \frac{(FL_2 + FL_3 + FL_4)}{3}$$

$$+ B_1 \frac{(B_2 + B_3 + B_4)}{3} + HI_3(HI_1 + HI_2) + \frac{HFC^2}{2\pi}$$

$$+ 2HL_1 \frac{(HL_2 + HL_3 + HL_4)}{3} + \frac{TTC^2}{4\pi} + TL_1 \frac{(TL_2 + TL_3)}{2} + \frac{(P_1 \times P_2)}{2}$$

Reference – Sreekumar, K. P., & Nirmalan, G. (1990). Estimation of the total surface area in Indian elephants (*Elephas maximus indicus*). Veterinary Research Communications, 14(1), 5–17. https://doi.org/10.1007/bf00346377