Advances in Biology Laboratory Education
Publication of the Association for Biology Laboratory Education
Volume 41, Article 81, 2020

Engineering Analysis of Design of Mammalian and Avian Femurs

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Natural selection can change structures over time by differential survival and reproduction of individuals with heritable phenotypic variation, increasing adaptation of organisms to their environment. We can seek insight into organismal structures by applying engineering principles of good design, by (1) identifying the purpose of the structure, (2) determining the physical constraints acting on it, and (3) calculating costs and benefits if the structure was changed. Mammalian and avian femurs are hollow tubes not solid rods. A tube is an excellent shape for a structure that must resist bending and breaking, yet be as light as possible. A tube is stronger than a solid rod of the same mass. A tubular bone of external diameter d has an internal cavity with internal diameter k x d. The factor k is 0 if a bone is solid, or close to 1 if a bone is very thin-walled. Note that avian or mammalian bones do not actually range across these k-values. The mass per unit length of a series of bones of identical strength but differing values of k can be calculated. Students determine whether k values of various avian and mammalian femurs are optimized to minimize mass for femurs of a given strength.

Keywords: femur analysis, comparative femur designs, comparative bone analysis, mass per unit length, *k* values

Link to Original Poster File: **https://doi.org/10.37590/able.v41.poster81**

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Citing This Article

Sharp J. 2020. Engineering analysis of design of mammalian and avian femurs. Article 81 In: McMahon K, editor. Advances in biology laboratory education. Volume 41. Publication of the 41st Conference of the Association for Biology Laboratory Education (ABLE).