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Physical evidence for a glue holding mineralized collagen fibrils together in bone* P. HANSMA, G.E. FANTNER, J.K. KINDT, P. THURNER, M.M. FINCH, P. TURNER, G. SCHITTER, B. ERICKSON, Z. SCHRIOCK, L.S. GOLDE, E. STRONG, S.F. UDWIN, Dept. of Physics, University of California, Santa Barbara — Evidence from Atomic Force Microscope indentation, pulling and imaging, and macroscopic testing and enzymatic digestion, suggests that collagen fibrils and mineral plates are not the only components of bone with mechanical roles. A "glue" appears to bind mineralized collagen fibrils together. Order of magnitude calculations show that less than 1% by weight of this "glue" profoundly affects bone fracture resistance, as it involves a remarkable natural toughening and strengthening system: sacrificial bonds and hidden length. This system dissipates large amounts of work against entropic forces while stretching out the hidden length that is exposed when sacrificial bonds break. This appears to occur when mineralized collagen fibrils are torn apart or slid against each other during bone fracture. In bone, this system depends on multivalent positive ions such as calcium ions, which allows us to follow its influence up to macroscopic fracture testing levels. Many bone matrix proteoglycans and glycoproteins have negatively charged groups at physiological pHs that could be bound together into sacrificial bonds by multivalent positive ions, and are thus natural candidates for this "glue." We cannot rule out a possible involvement of nonfibrillar collagen. Precisely which candidates are involved is yet to be determined. *NSF MRL DMR00-80034, NIH GM65354, NASA BiMAT URETI NCC-1-02037 (00000532), Veeco, USARL ARO DAAD19-03-D-0004

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