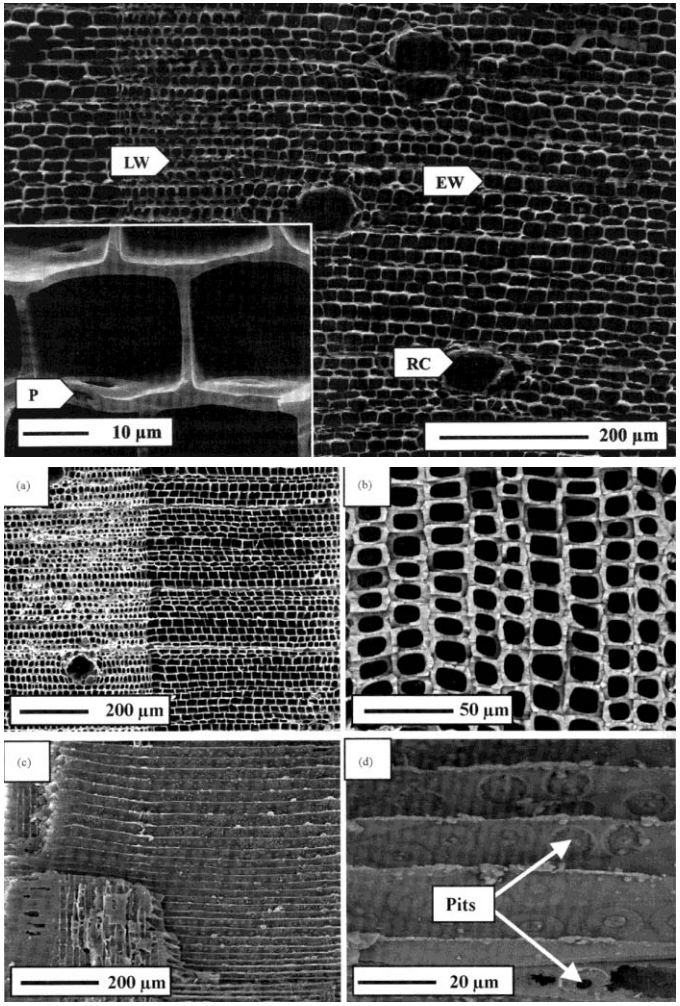
Biomimicking

Wood: Biocarbon Template



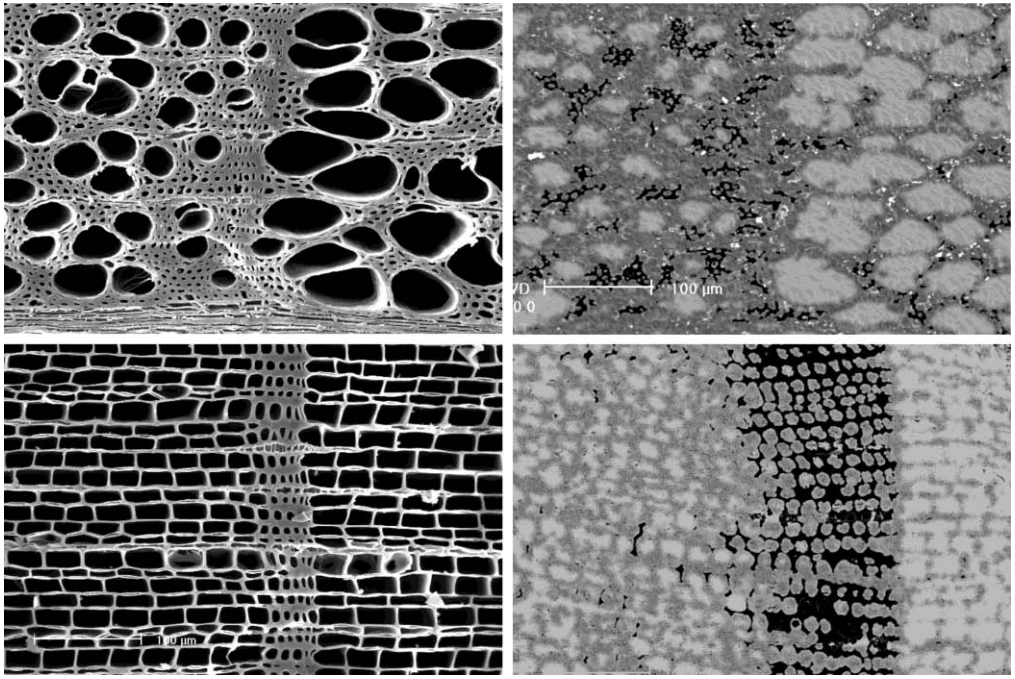
Pyrolized pine
(biocarbon template)
EW: early wood
LW: late wood
RC: sap channel
P: pit

SiC ceramic made by pyrolizing pine then Si vapor infiltration

Source: Vogli, E., H. Sieber, and P. Griel. "Biomorphic SiC-ceramic prepared by Si-vapor phaseinfiltration of wood." *Journal of the European Ceramic Society* 22 (2002): 2663. Courtesy of Elsevier. Used with permission.

Vogli et al., 2002

Wood: Si-SiC composites



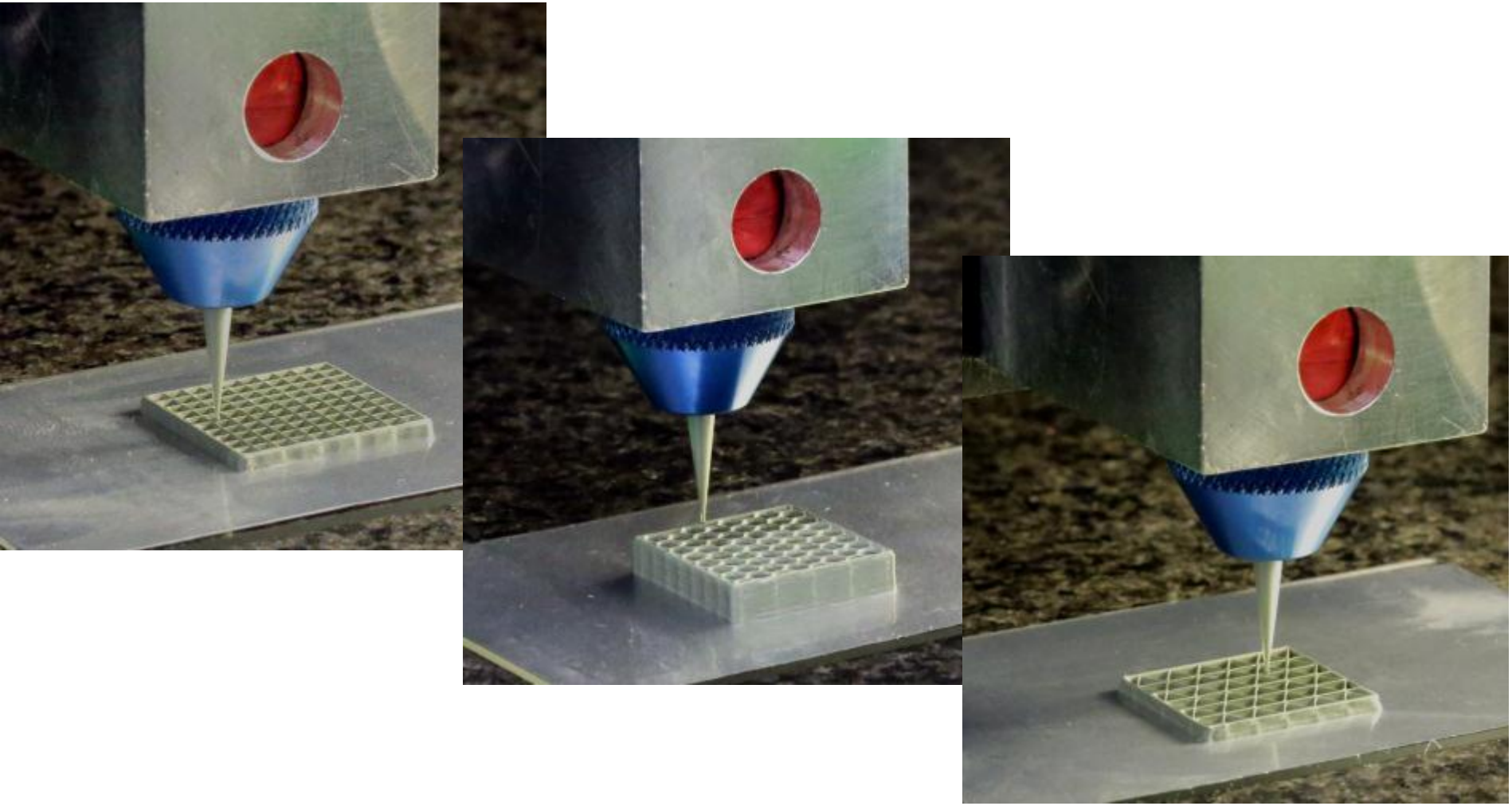
Source: Zolfrank, Cordt, and Heino Sieber. "Microstructure and phase morphology of wood derived biomorphous SiSiC-ceramics." *Journal of the European Ceramic Society* 24 (2004): 495. Courtesy of Elsevier. Used with permission.

Biocarbon template of beech, pine

Si-SiC composites made by liquid infiltration of Si into the SiC replicas

Zollfrank and Sieber, 2004

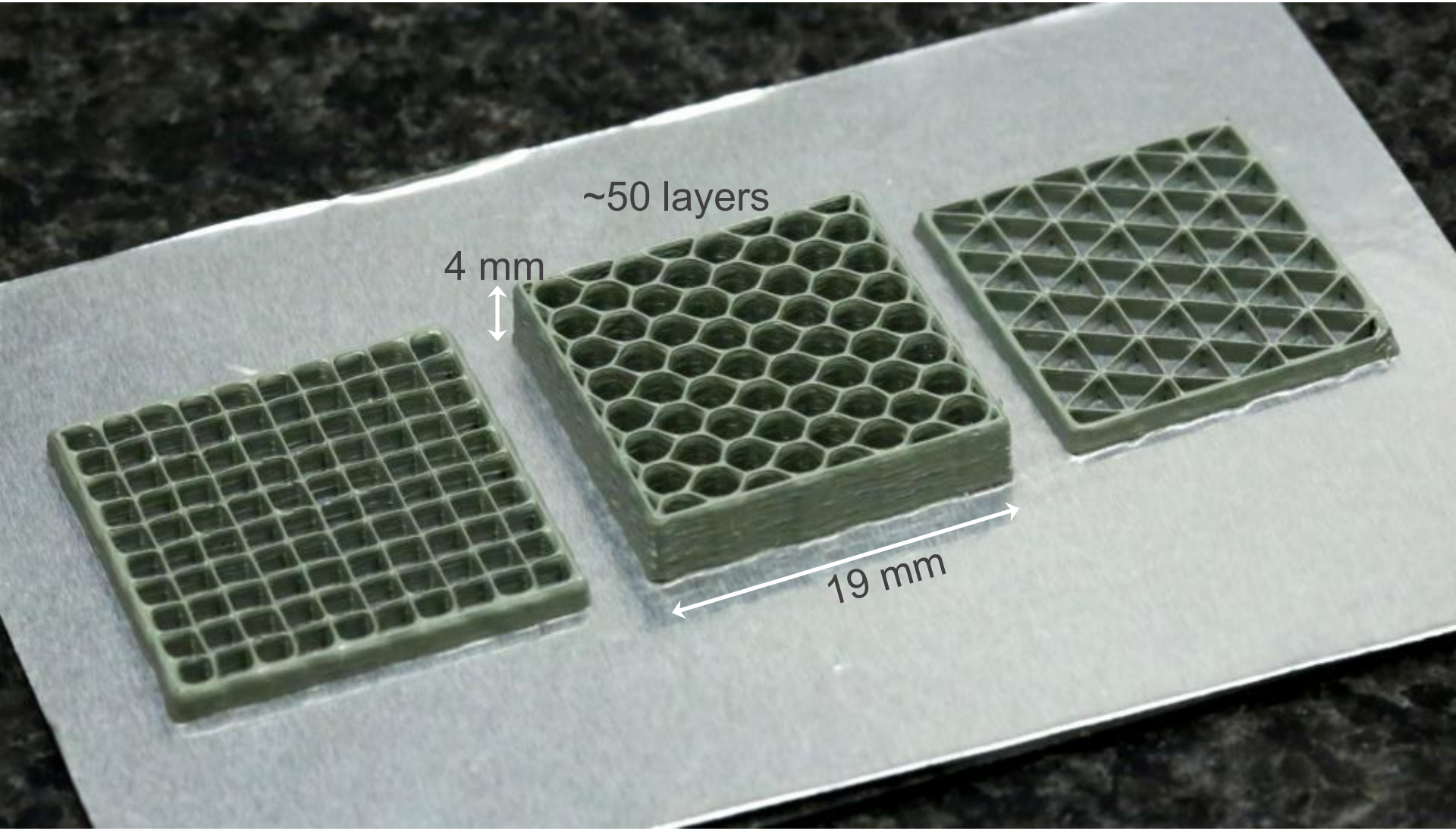
Printing honeycomb specimens



Courtesy of Brett Compton and Jennifer Lewis. Used with permission.

Brett Compton, Jennifer Lewis

Honeycomb specimens



Courtesy of Brett Compton and Jennifer Lewis. Used with permission.

Brett Compton, Jennifer Lewis

Fiber reinforced walls

Trabecular Bone: Metal Foam

Image removed due to copyright restrictions. See Figure 8.1: Gibson, L. J., M. Ashby,et al. *Cellular Materials in Nature and Medicine*. Cambridge University Press, 2010. http://books.google.com/books?id=AKxiS4AKpyEC&pg=PA228

Image removed due to copyright restrictions.

Trabecular bone
Muller

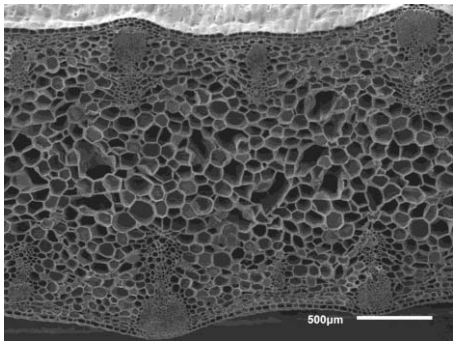
Tantalum foam
Bobyn et al, 1999

Extracellular matrix: Tissue engineering scaffolds

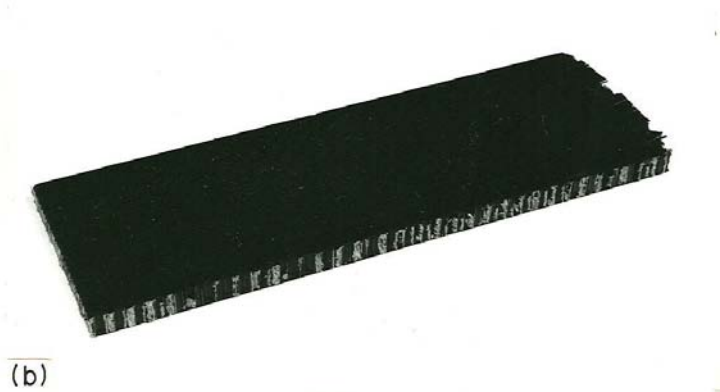
Images removed due to copyright restrictions. See Figure 8.6: Gibson, L. J., M. Ashby, et al. *Cellular Materials in Nature and Medicine*. Cambridge University Press, 2010.

Sources in Cellular Materials in Nature and Medicine

Leaves, skulls: Sandwich panels



Buhler 1972



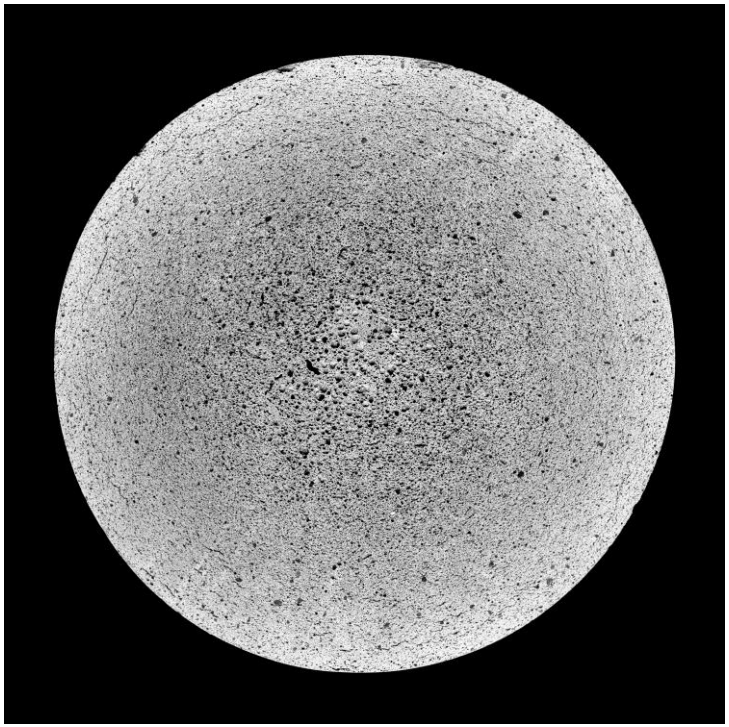
Gibson, L. J., and M. F. Ashby. *Cellular Solids: Structure and Properties*. 2nd ed. Cambridge University Press. © 1997. Figure courtesy of Lorna Gibson and Cambridge University Press.

Images of bird skulls removed due to copyright restrictions. See Figure 6.7: Gibson, L. J., M. Ashby, et al. *Cellular Materials in Nature and Medicine*. Cambridge University Press, 2010. http://books.google.com/books?id=AKxiS4AKpyEC&pg=PA176

Palm: Density Gradients

- Can replicate structure of plant materials with density gradients using same methods as for woods
- Projects at MIT on density gradients in foamed cements, using either gravity or centrifugal force to produce density gradient

Density Gradients: Concrete

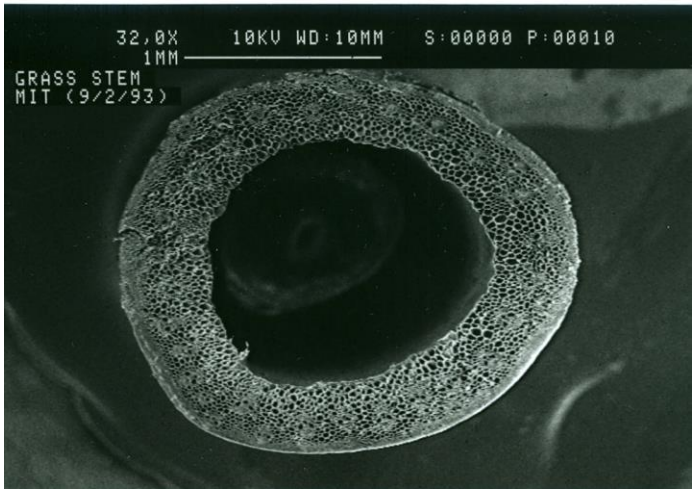


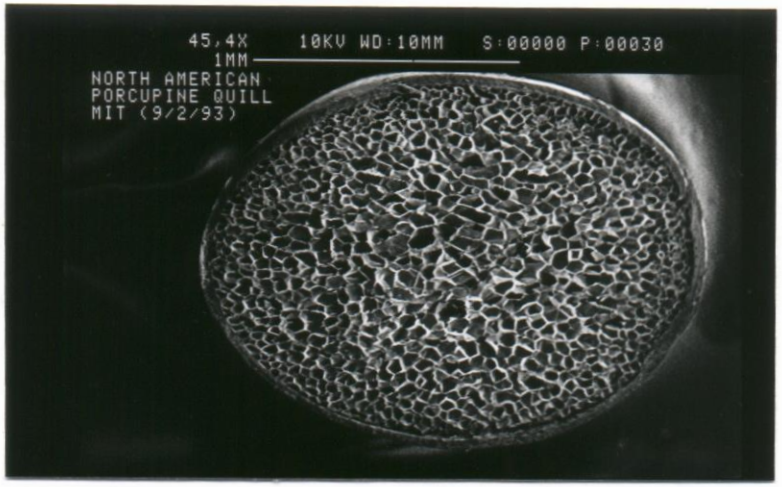
Source: Cooke, T. G. "Lightweight Concrete: Investigations into the Production of Variable Density Cellular Materials." Ph.D. Thesis. MIT Department of Architecture, 2012.

Timothy Graham Cooke, MArch Thesis, MIT 2012

Animal Quills, Plant Stems

Cylindrical shells with
foam/honeycomb core

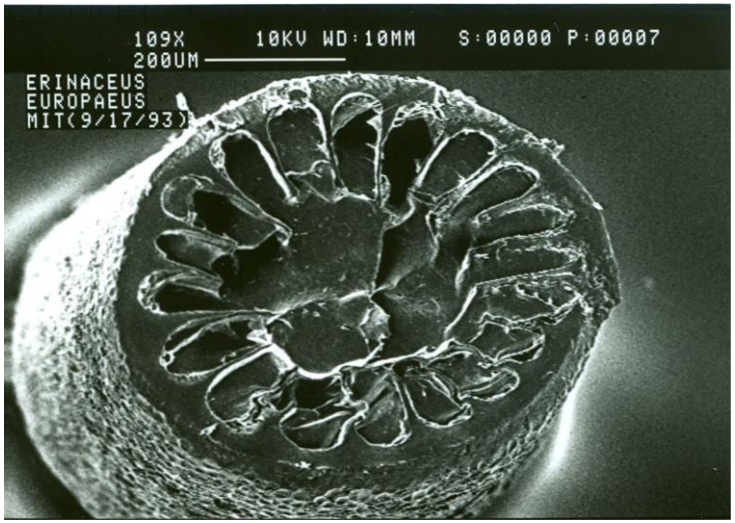


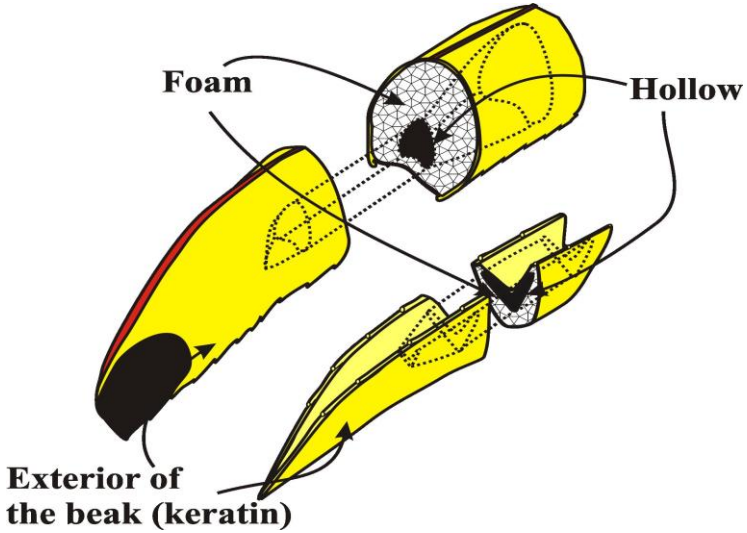


Grass

Karam and Gibson 1995

Porcupine quill





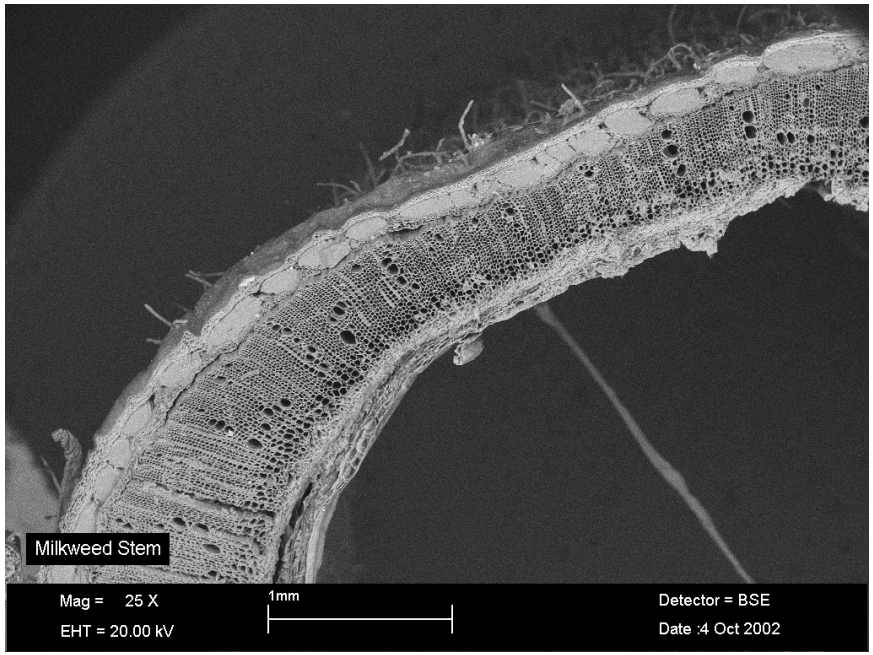
Hedgehog spine

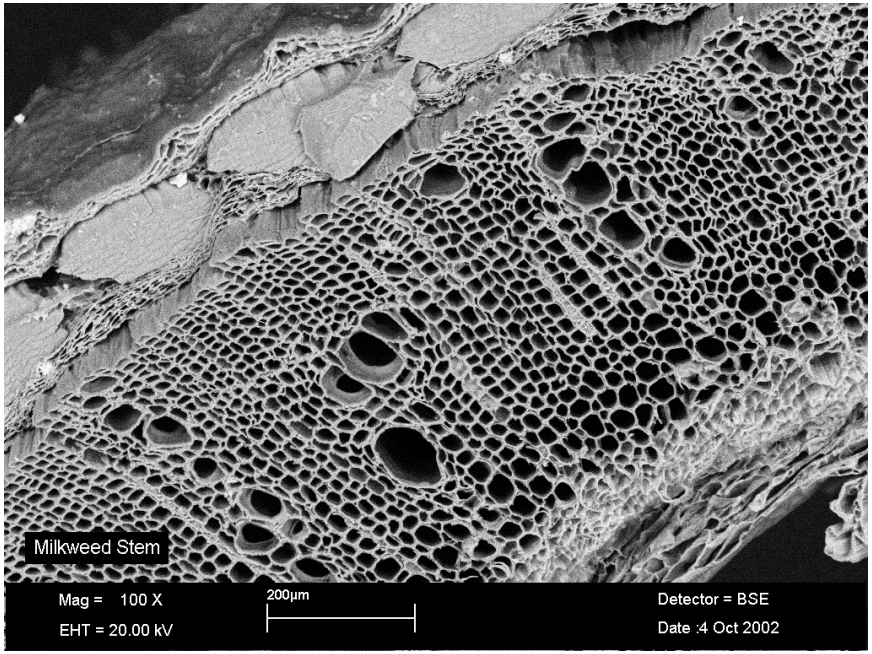
Meyers, M. A., P. -Y. Chen, et al. *Progress in Materials Science* 53 (2008): 1–206. Courtesy of Elsevier. Used with permission.
http://www.sciencedirect.com/science/article/pii/S0079642507000254

Source: Karam, G. N., and L. J. Gibson. *Int. Journal Solids and Structures* 32 (1995): 1259-83. Courtesy of Elsevier. Used with permission.
http://www.sciencedirect.com/science/article/pii/002076839400147O

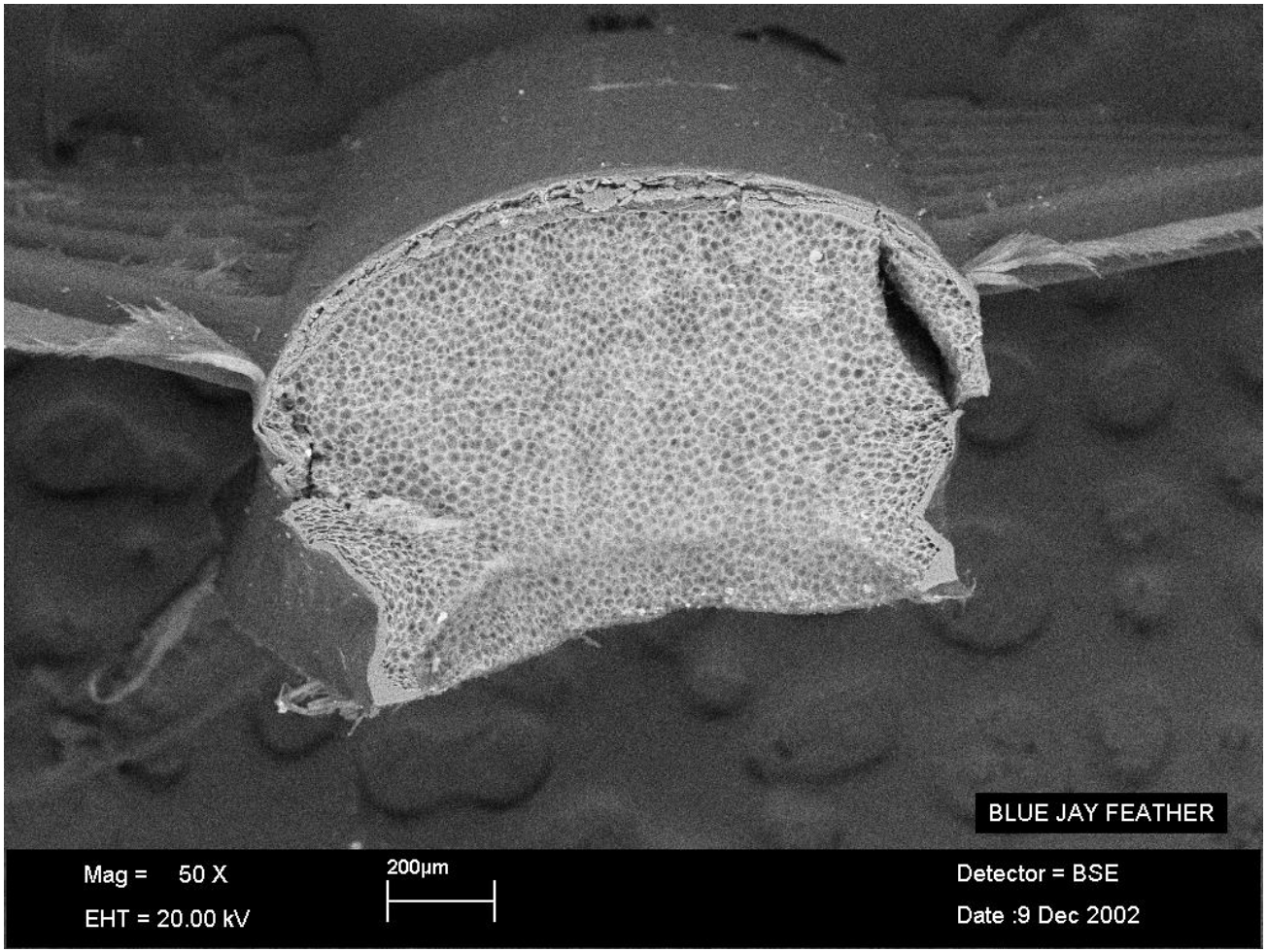
Toucan beak
(Meyers et al., 2008)

Milkweed stem





Blue jay feather



Gibson Ashby and Harley, 2010

Gibson, L. J., M. Ashby, and B. A. Harley. *Cellular Materials in Nature and Medicine*. © 2010 Cambridge University Press. Figure courtesy of Lorna Gibson and Cambridge University Press.

Cylindrical shells with compliant cores

Images removed due to copyright restrictions.
See Figures 6 and 19: Milwich, M., et al. *American Journal of Botany* 93 (2006): 1455-65.
http://www.amjbot.org/content/93/10/1455.abstract

Milwich et al., 2006

Cylindrical shells with compliant cores

Images removed due to copyright restrictions. See Figures 1 (No. 1c) and 3 (No. 7c) and Utsunomiya, H., H., et al. *Advanced Engineering Matererials* 10 (2008): 826-29. http://onlinelibrary.wiley.com/doi/10.1002/adem.200800084/abstract

Utsunomiya et al, 2008

3.054 / 3.36 Cellular Solids: Structure, Properties and Applications
Spring 2014