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Measurements of Wood Fiber

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MEASUREMENTS OF WOOD FIBER

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Many of the properties of wood depend upon the character and arrangement of the fiber cells which enter into its composition. This is especially true of those properties which determine its strength, hardness and adaptability for the manufacture of paper pulp. With a view to throwing light on these properties, we have made measurements of the length and diameter of the fibers in forty-one species of trees. No attempt was made to segregate the various types of fiber that occur in different species. We have taken any of the slender, fusiform, non-septate, thick walled members of the xylem. The maximum and minimum figures indicate that this lack of discrimination has not introduced any serious error. Were very critical discrimination attempted, the comparison of species would prove unduly complex, if not impossible.

Our material was obtained partly from local lumber dealers, partly from the Grinnell College collection of wood specimens, and partly from fresh material cut from the College botanic garden and campus, and from neighboring groves. It was mostly heart wood, though not in every case. This should not affect the measurements.

Shreds of the wood about two millimeters in diameter were split off and placed in test tubes of strong commercial nitric acid. To each tube is added about 0.5 gm. of potassium chlorate. The maceration is carried on for about thirty hours at 35 to 40 degrees centigrade. The acid is then poured off. The wood is washed in several changes of water extending over four to six hours. The resulting fragments are usually nearly colorless, and the constituent cells are readily separated by teasing or by more or less violent shaking in water. A drop of a suspension of the separated cells is then placed on a slide, covered, and the fibers are measured with an eye-piece micrometer. Some specimens were stained in safranin, dehydrated, and mounted in balsam as permanent preparations. A few species of wood were softened in hydrofluoric acid and sectioned in the three usual planes. These served as checks on the macerated material, but were much less satisfactory for purposes of measurement, especially measurement of length. Only one genus, viz. Prunus, showed marked swelling of the fibers as a result of maceration. *Prunus Davidiana* was the most swollen species. This affected the diameter, but apparently did not affect the length.

A survey of the measurements shows first of all a striking difference between the lengths of fiber in Gymnosperms and Angiosperms. The greater length of fiber in the former group doubtless stands in relation to the demands of water conduction in these ductless plants. But when *Pinus ponderosa, Abies balsamea, Thuja occidentalis* and *Juniperus virginiana* all show lengths of fiber comparable with those of Angiosperms, one is at a loss for an explanation. It must be noted that *Pinus ponderosa* and *Juniperus virginiana* are inhabitants of dry soils, and *Abies balsamea* and *Thuja occidentalis* prosper in bog soils. All may be considered xerophytic. The remaining Gymnosperms in our list must be considered as mesophytes. But Taxodium is a bog plant, and has very long fiber. Comparing the species of Thuja, the one from the moist region of the northwest coast, *T. plicata,* shows much the longer fiber.

Among Angiosperms there is a striking uniformity in length of fiber in the apetalous series, where the measurements nearly all average above one millimeter. In the higher orders, the lengths are nearly all below one millimeter. Liriodendron, which in some respects is a relatively primitive species, and is certainly very ancient, has a fiber a little less than 1 mm. in length, i. e. intermediate between the principal groups. Platanus and Fraxinus, both very unique among their near relatives from the standpoint of floral structure, are also decidedly aberrant in fiber length. *Prunus Davidiana* is similarly aberrant. On the whole, it would seem that fiber length varies very widely within narrow taxonomic limits.

From the standpoint of the uses of wood, the length of fiber alone is not a guide to weight, strength or elasticity. Western spruce, so valuable for aeroplanes, has the longest fiber on our list. But Taxodium is a close second. Oak, ash, elm, birch and cottonwood are remarkably similar in fiber length.

Probably the length of fiber in wood has more relation to its value for paper plup than for any other practical use. It is well known that coniferous woods make the best pulp, and of these spruce pulp brings the highest price. This is due to the length of the fibers. Spruce and Sequoia, however, proved to be the most difficult woods to break down by the maceration process used by us. In view of the excellent fiber produced by *Picea sitchensis,* attention should be called to the tremendous waste of the wood of this species in stumps and tops by the lumbering methods current in the northwest. Stumps six to ten feet in diameter and eight to twelve feet high cover the deforested areas. And tops less than two feet in diameter are usually left in the slashes. There remains on the ground after an ordinary lumbering operation in western Washington more cubic feet of wood than would be found in the total stand of many a profitable eastern woodland. Some way must be found to utilize this vast wastage, and convert it into paper pulp and other valuable by-products.

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FIBER LENGTHS AND WIDTHS IN WOODS.

	MINIMUM		AVERAGE		MAXIMUM	
	Length	Width	Length	Width	Length	Width
Pinus strobus	3.85mm	0.0510mm	4.04mm	0.0592mm	4.20mm	0.0731mm
P. ponderosa	1.11	.0217	1.43	.0262	1.81	.0292
P. palustris	4.40	.0425	5.28	.0462	6.50	.0510
P. sylvestris	1.40	.0212	2.00	.0277	2.20	.0340
Picea sitchensis	5.60	.0585	6.70	.0744	8.00	.0877
Tsuga heterophylla	4.00	.0425	5.64	.0526	5.40	.0595
Abies balsamea	.97	.0170	1.17	.0229	1.32	.0255
Sequoia sempervirens	4.10	.0340	5.98	.0552	7.10	.0723
Taxodium distichum	5.50	.0360	6.10	.0530	7.40	.0650
Thuja occidentalis	1.26	.0183	1.57	.0215	2.14	.0255
T. plicata	4.20	.0297	4.81	.0387	5.50	.0430
Juniperus virginiana	.84	.0170	1.00	.0198	1.15	.0212
Juglans cinerea	.63	.0170	.92	.0216	1.05	.0297
J. nigra	1.26	.0170	1.41	.0228	1.76	.0297
Hicoria ovata	1.38	.0127	1.69	.0219	1.95	.0255
Populus tremuloides	.38	.0170	.55	.0216	.65	.0233
P. deltoides	1.11	.0212	1.73	.0307	2.40	.0405
Salix nigra	.88	.0255	1.05	.0289	1.26	.0340
Betula lutea	1.13	.0212	1.67	.0262	2.00	.0297
Fagus americana	1.07	.0127	1.36	.0186	1.55	.0212
Quercus rubra	1.32	.0170	1.59	.0199	1.85	.0230
Q. alba	1.15	.0148	1.51	.0213	1.77	.0290
Ulmus americana	1.17	.0175	1.47	.0247	1.68	.0297
U. campestris	.84	.0127	1.03	.0159	1.26	.0200
Celtis occidentalis	.90	.0149	1.03	.0185	1.26	.0225
Liriodendron tulipifera	.80	.0195	.98	.0251	1.26	.0297
Platanus occidentalis	1.13	.0174	1.43	.0222	1.66	.0250
Prunus americana	.63	.0094	.71	.0124	.99	.0161
P. serotina	.59	.0128	.73	.0161	.86	.0212
P. davidiana	.86	.0098	1.02	.0134	1.57	.0157
P. persica	.48	.0127	.72	.0144	1.13	.0162
Robinia pseudacacia	.53	.0149	.67	.0174	.78	.0233
Acer saccharum	.67	.0195	.86	.0253	1.05	.0280
A. platanoides	.46	.0127	.59	.0145	.79	.0170
A. saccharinum	.63	.0170	.77	.0201	.84	.0255
A. rubrum	.59	.0132	.73	.0192	.90	.0242
A. negundo	.40	.0157	.46	.0173	.59	.0212
Tilia americana	.48	.0195	.77	.0240	1.16	.0297
Fraxinus americana	1.36	.0130	1.62	.0163	1.90	.0190
Catalpa speciosa	.52	.0195	.62	.0240	.71	.0297
C. bignonioides	.48	.0170	.59	.0198	.69	.0255