EG60411 Bio-Material Science

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2G103, 10:10-11:25, Tuesday

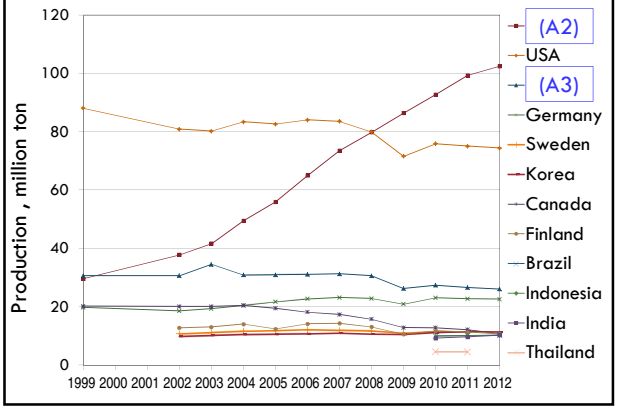
Biomaterial Science （Schedule）

#	Date	Content
1	4/15	History of papermaking
2	4/22	Pulps – Beating and fiber properties
3	5/9, Fri	Pulps – Additives and functions
4	5/13	Papermaking processes & interfiber bonding
5	5/20	Paper– Structural and absorption properties
6	5/27	Paper– Mechanical and optical properties
7	6/3	Polysaccharide chemistry by Assoc Prof Akiko Nakagawa
8-9	6/10, 17	Pulping science and technology by Professor Hiroshi Ohi
10	6/24	Recent trend of paper science and technology

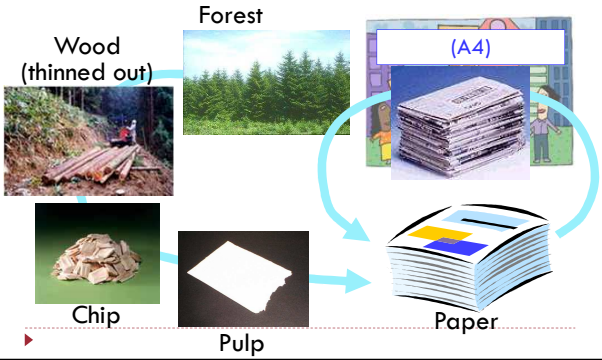
Lecture information and contact

- Homepage of “Biomaterial Science (T. Enomae)”
- http://www.enomae.com/
  → Handouts in lecture(講義資料)
- E-mail address
  → t@enomae.com
  for any questions and visit to laboratory
  (Bio-Agr. Bldg. 生農C209 or E201)

Production of paper and paperboard

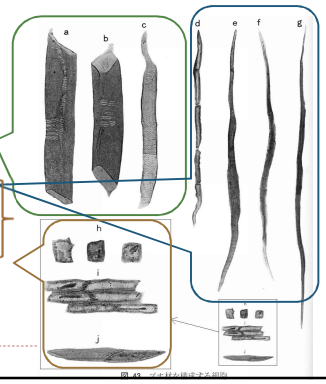


How to make paper ▸ From “wood”

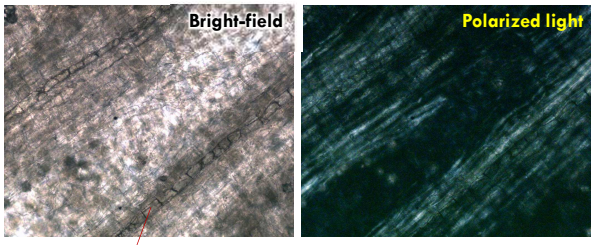


Wood tissue－cells of beech tree

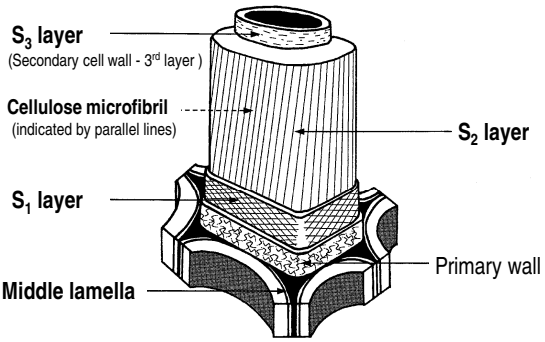
Component of hardwood tissue	
Vessel	20%
Wood fiber	60%
Axial parenchyma cell	10%
Radial parenchyma cell	10%



Axial parenchyma cell



Wood tissue – structure of cell wall

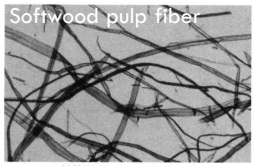


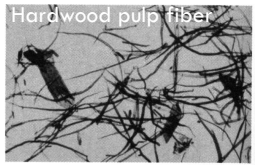
Structure of plant cell wall and axial direction of cellulose microfibrils

Kind of pulp

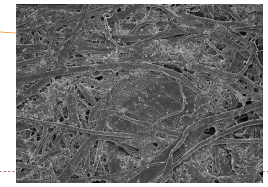
- **Pulp**
  - **Fibers mainly consisting of cellulose extracted from plant such as wood by mechanical or chemical treatment**
- Mechanical pulp [MP]
  - Fibers extracted from wood by crushing
- Chemical pulp [CP]
  - Fibers extracted from wood by dissolving lignin
- Deinked pulp [DIP] (recycled pulp)
  - Fibers extracted from waste paper by removing ink

Chemical pulp – Fiber geometry



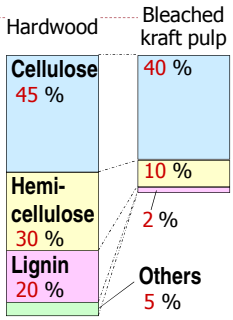


- Copy paper consists of (B) wood pulp fibers
- Observe pulps



Wood composition – Major 3 components

Chemical component	Approx. ratio (%) Softwood	Hardwood
Cellulose	45	45
Hemicellulose	25	30
Lignin	25	20
Others Terpenoid Resin acid Fatty acid etc.	2 - 8	



Change of Composition by kraft pulping

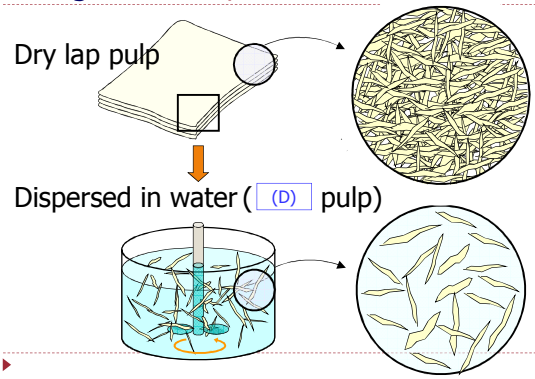
Form of pulp

Dry lap pulp

- **Slush pulp**
  Pulp suspension with concentrations of approx. 1-4%
- **Lap pulp**
  Pulp Formed and folded by wet machine. Called "**Dry lap**" when dried
- **Bale pulp**
  A bunch of pulp sheets compressed and bound with a wire

Transported (C) pulp

Disintegration - Separation into individual fibers



Standard disintegrator (defibrator)

- Pulp is put in water in steel container with ca. 3.4 L capacity
- Stirred with a propeller mixer at 3000 min^{-1} (rpm)
- Latency of MP should be removed at high temperature (Latent=hidden)

Pulp	Dry mass	Water volume	Revol-utions
Chemical	30 g	2.0 L	30,000
Mechanical	60 g	2.7 L	60,000

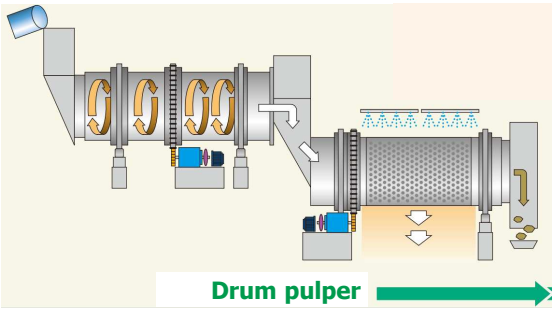
Waste paper in yard

Waste paper and pulp

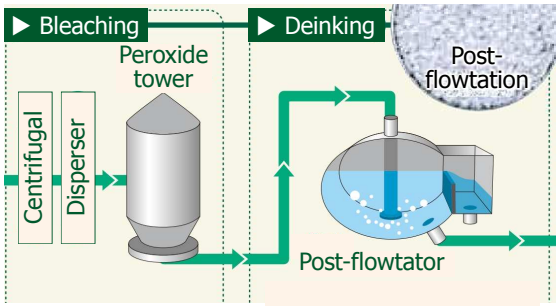
Belt conveyer

Disintegration in industry (pulper)

Disintegration in industry (Drum pulper)



Floatation



Floatation (flowtator)

Beating (refining)

- Post-disintegration process
- Process where shear stress is applied to water-containing fibers resulting in **fibrillation** (formation of small filaments or fibers) on the surface and **concentrically loose structure**

Beating (refining)

- Beating achieves large bonded area between fibers and thus higher paper strength.

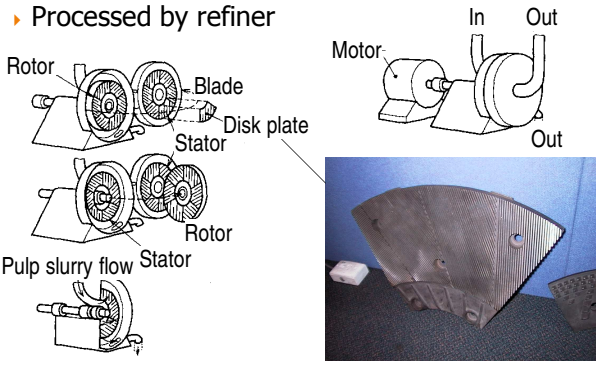
Q. Why can this breaking process increase paper strength?

Difference between disintegration and beating

- **Disintegration** is a process to separate fibers bonded or entangled, keeping fiber characteristics
- **Beating** is a process to treat mechanically individual fibers, changing fiber characteristics

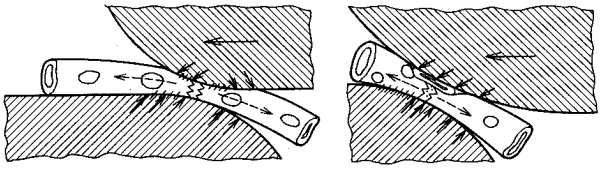
Beater – Refiner(refining)

- Processed by refiner



Beater – PFI mill (beating)

Beating – mechanism

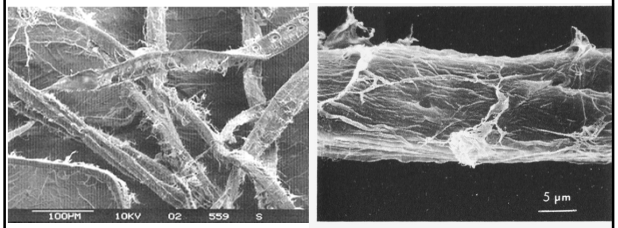


Effect of blades on pulp fibers during beating

Refining – movie – refiner

Beating – change of fibers – **external** fibrillation

{ External fibrillation
Internal fibrillation



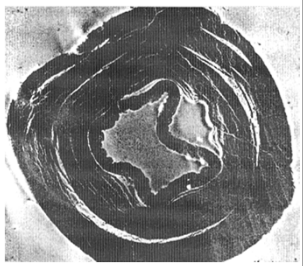
Scanning Electron Micrographs of freeze-dried softwood pulp fibers after beating

Beating – change of fibers – **internal** fibrillation

{ External fibrillation
Internal fibrillation

=Concentric loosening (Lamellar separation)

Connection of small pores formed by lignin removal



Lamellar separation of fiber cell wall by beating