Bio-material sciences

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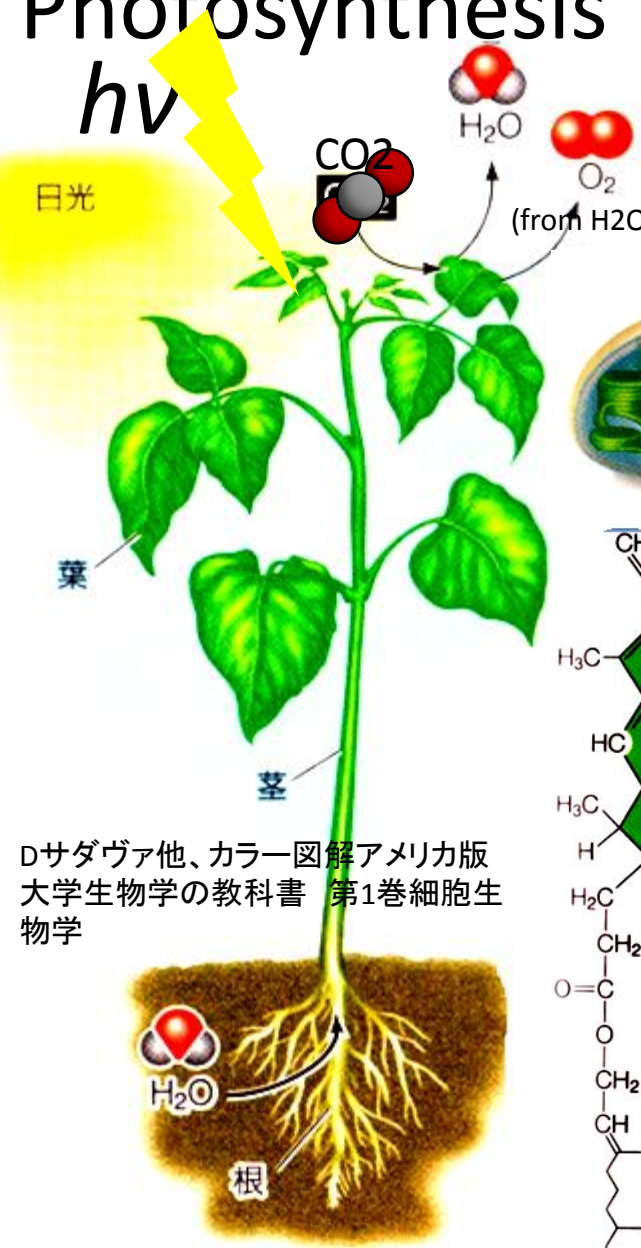
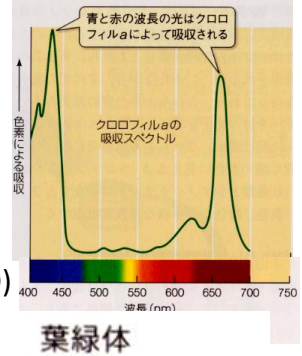
Global Plant Material Sciences Labo.

Plant

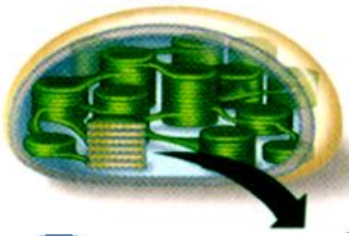
Photosynthesis

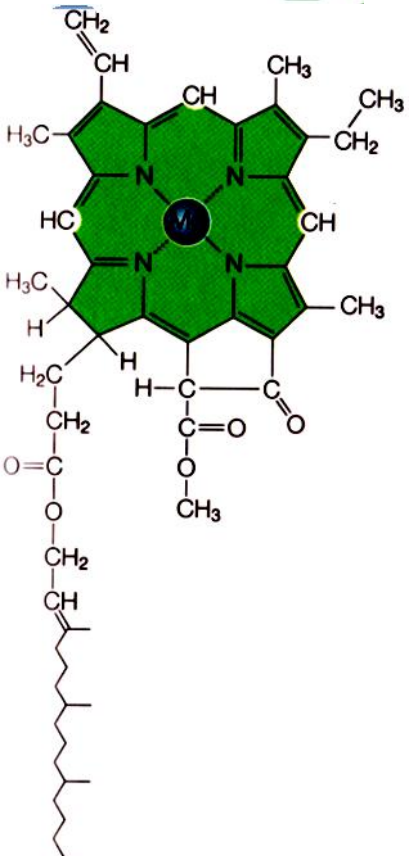
hv

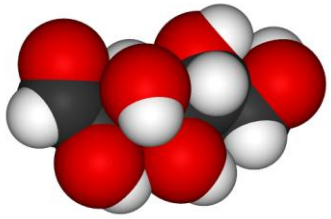


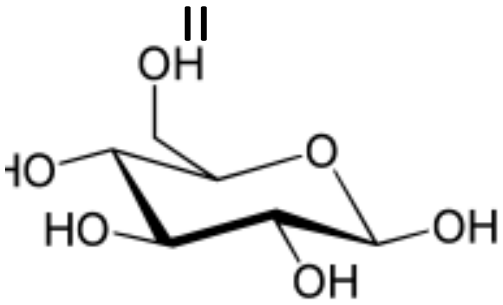


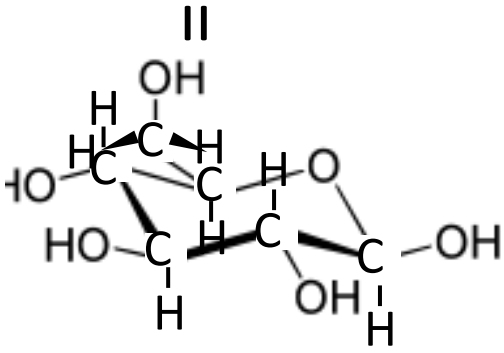
葉緑体





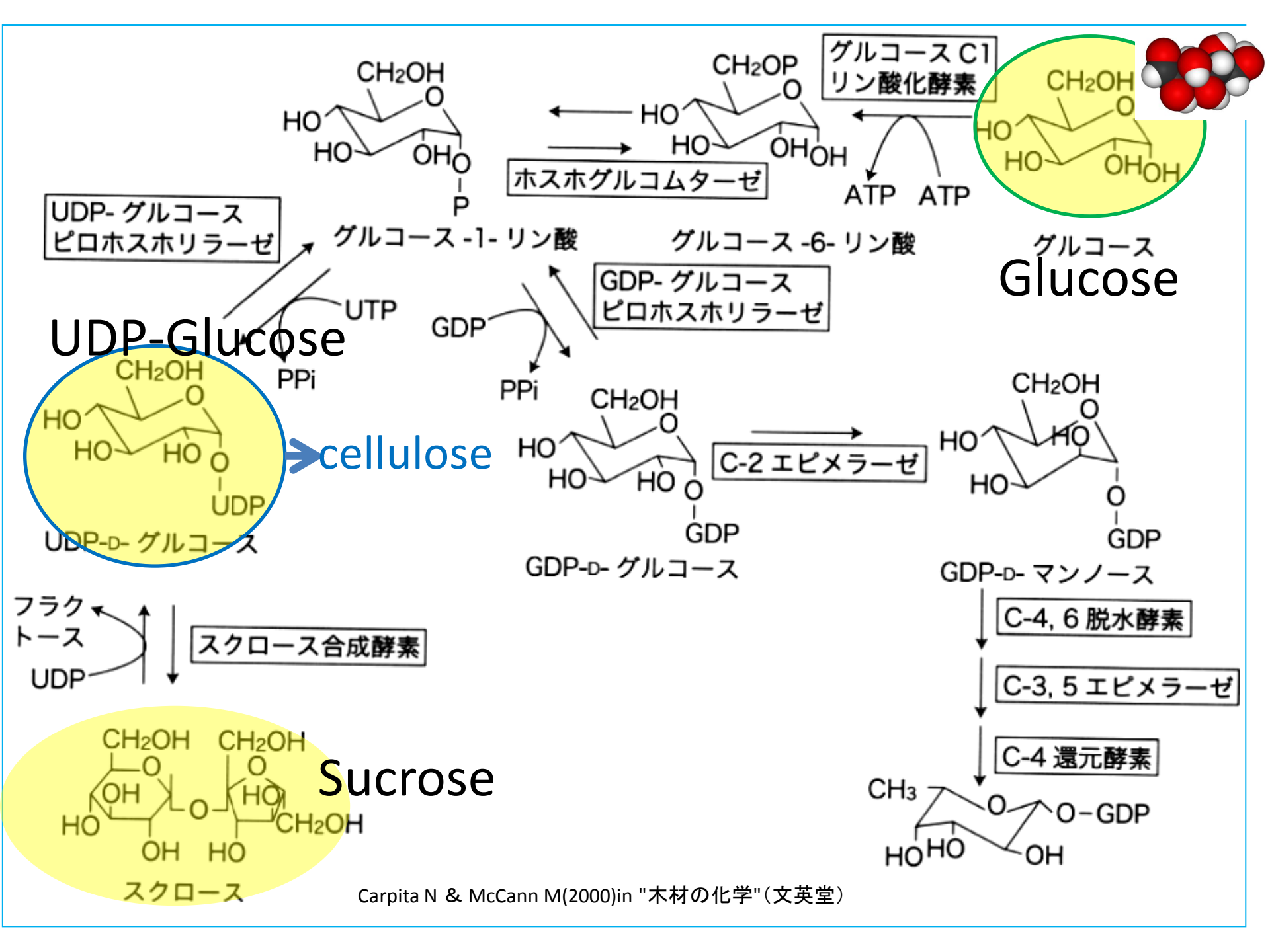






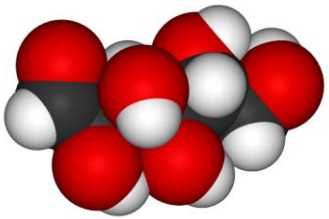
$C_6H_{12}O_6$

Dサダヴァ他、カラー図解アメリカ版大学生物学の教科書　第1巻細胞生物学

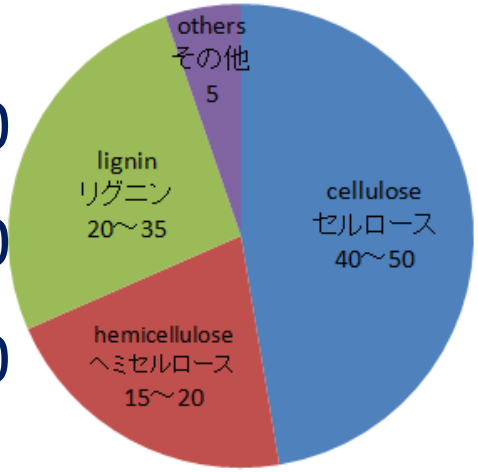


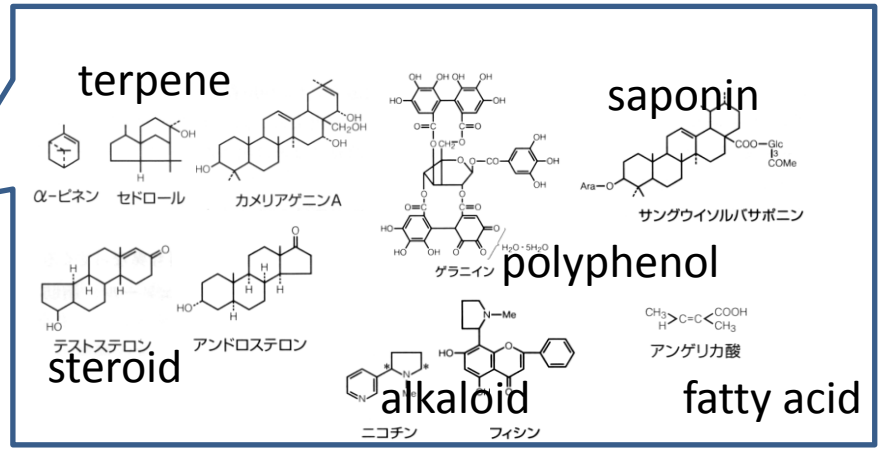
Carpita N & McCann M(2000)in "木材の化学"（文英堂）

Glucose: precursor for everything from large to small molecules

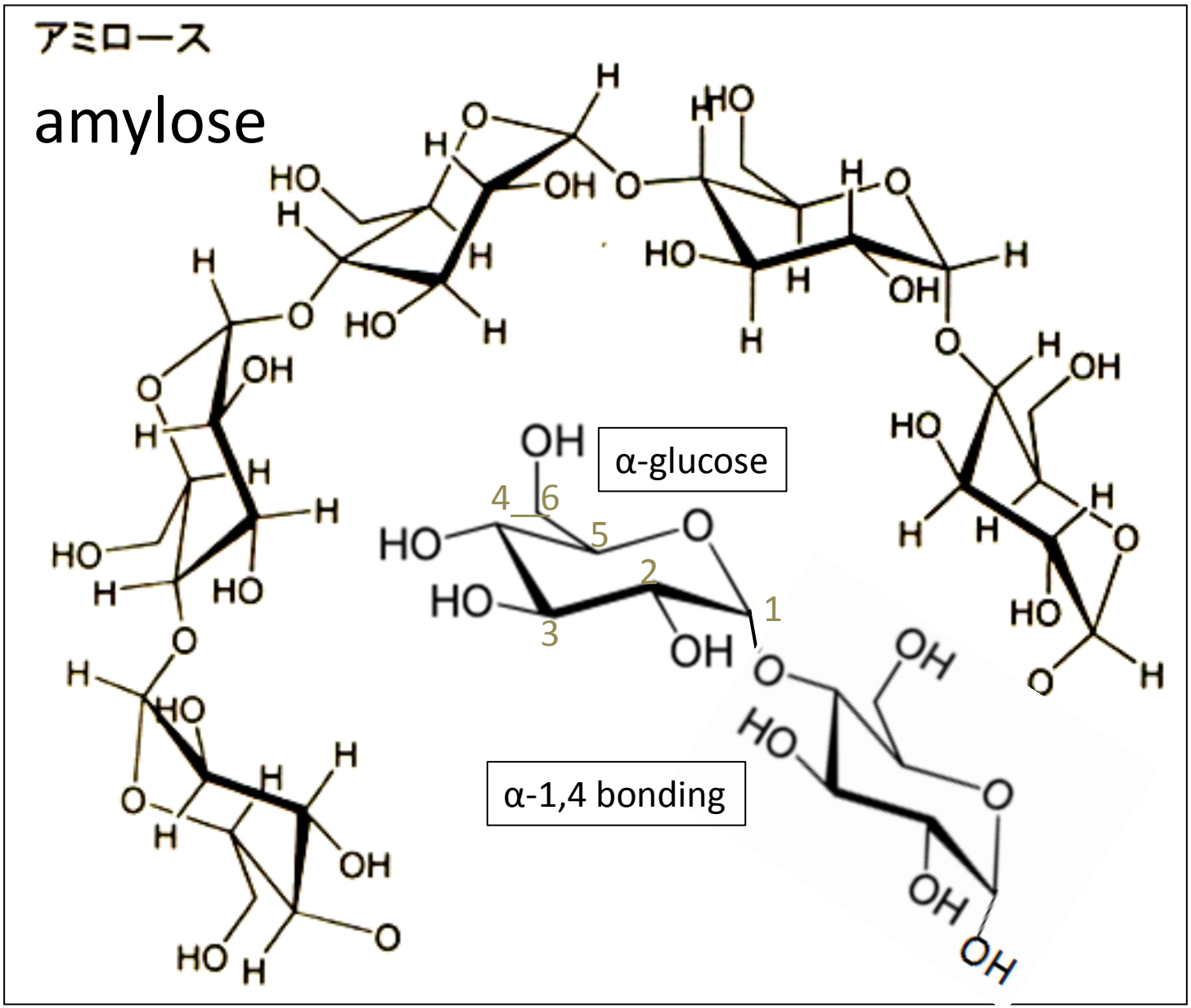


- Cellulose MW1620000
- Hemicellulose 30000
- Lignin >20000
- Starch
- Pectin （＜1000）
- Amino acid
- Protein
- Sugar
- Others

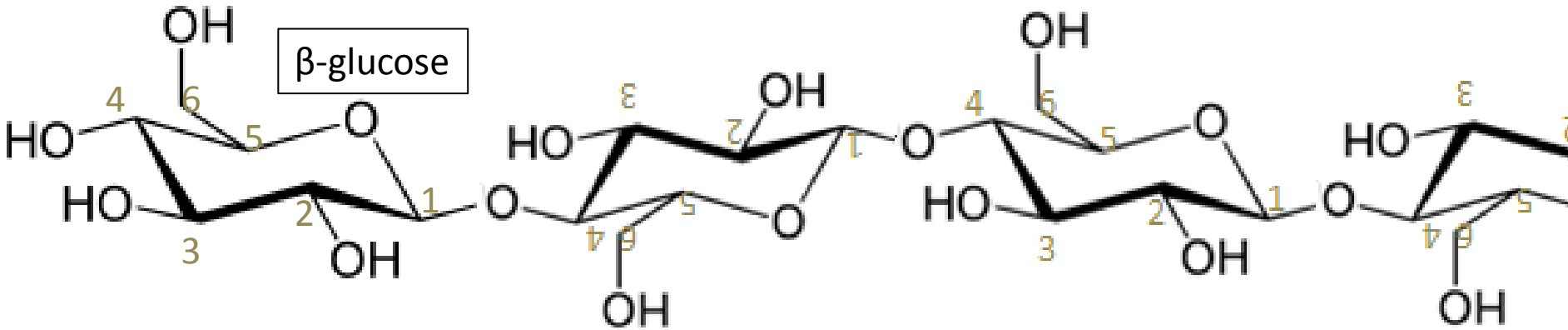


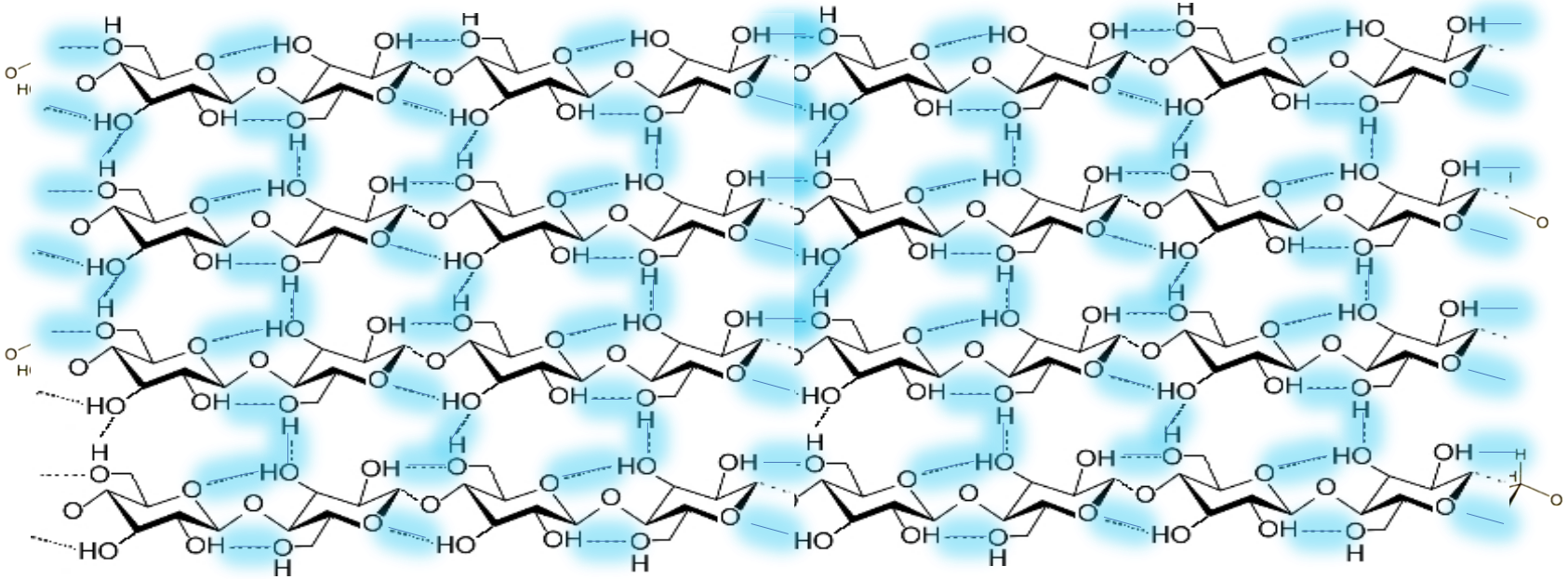


Storage starch 貯蔵多糖



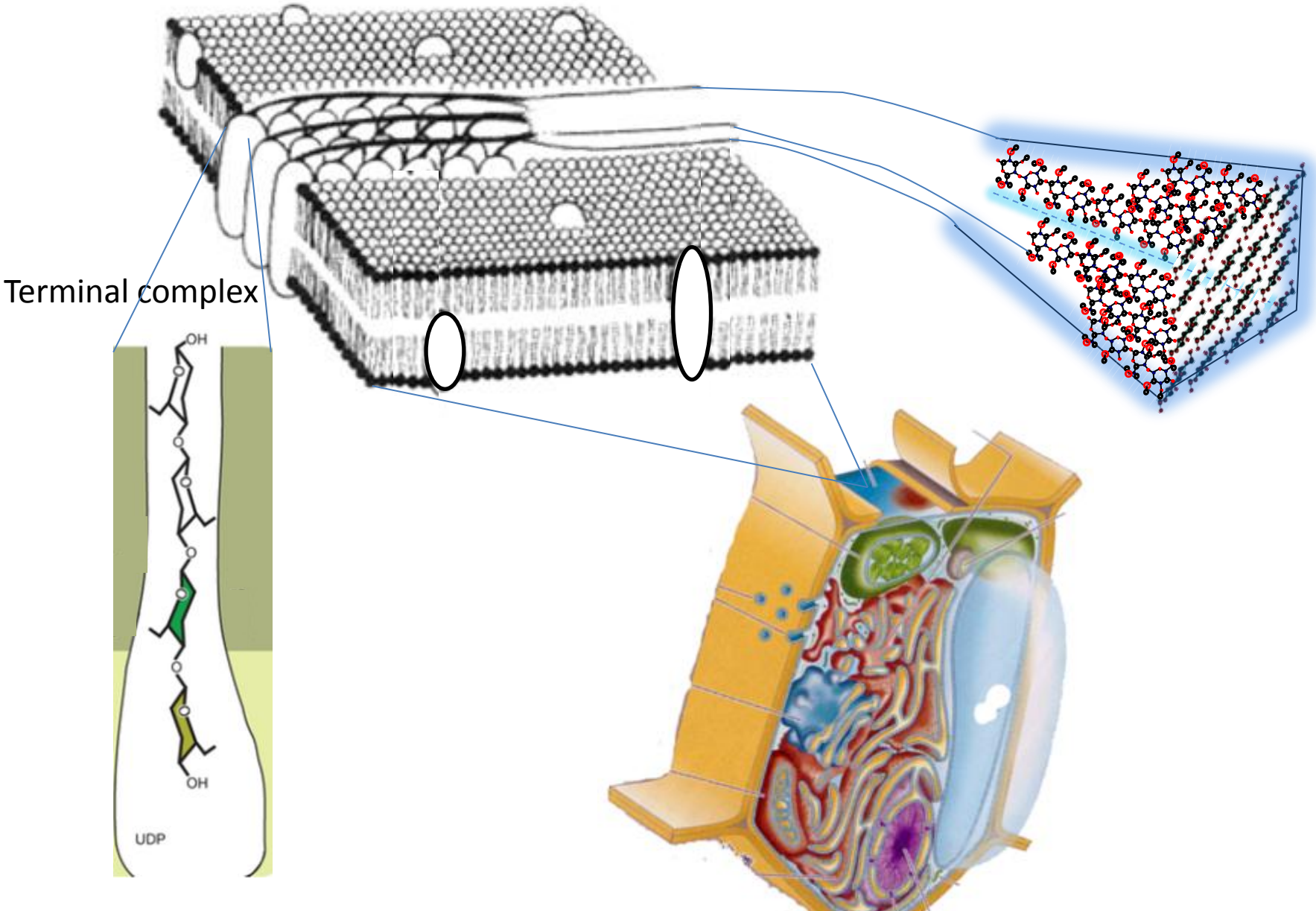
Structural polysaccharide 構造多糖- Cellulose



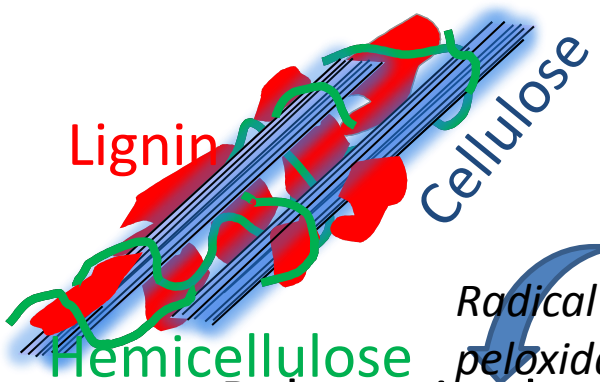


- “β1,4-” bonding enables chain straight and structure crystalline.
- → high mechanical strength of 5-15 times of iron (per weight).

Bio-synthesis of Cellulose



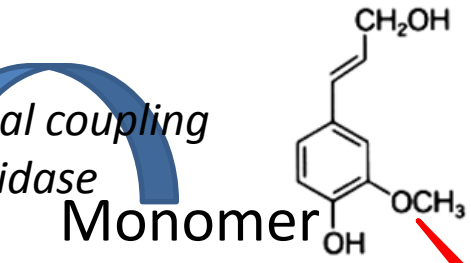
Completion of plant cell wall

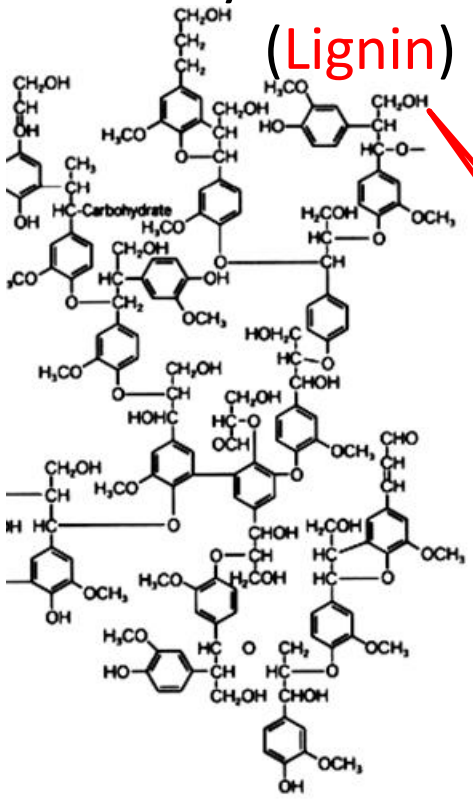


Radical coupling
peloxidase

Polymerized (Lignin)

Monomer





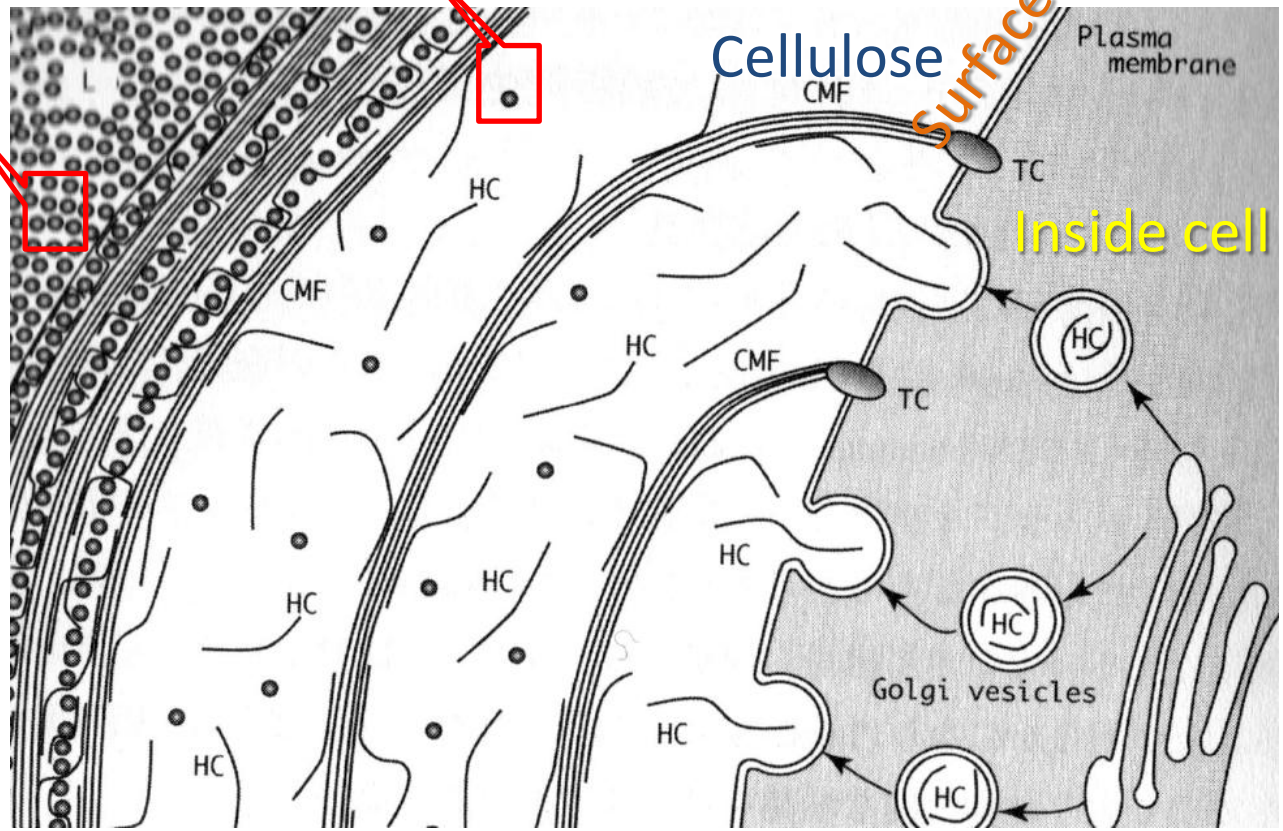
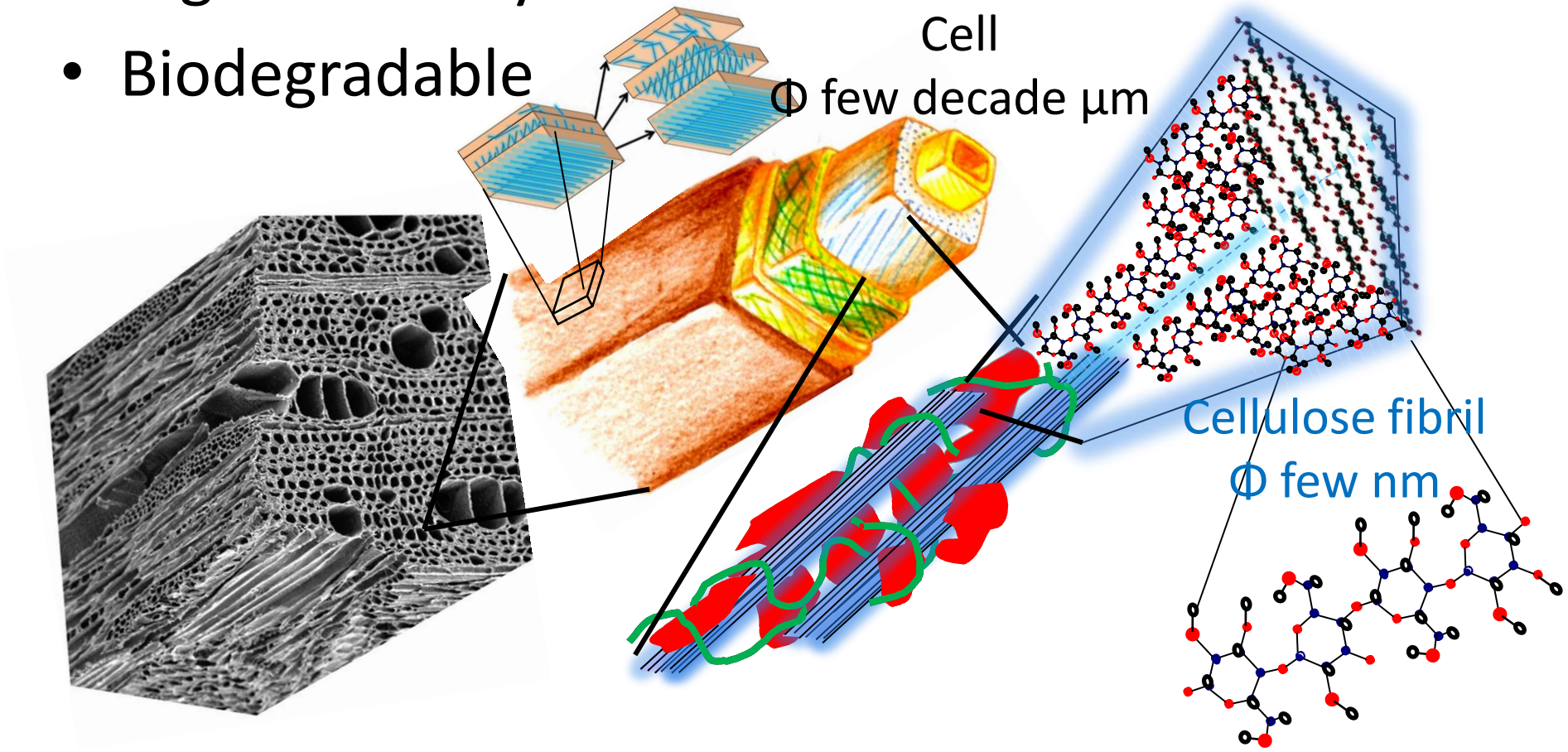


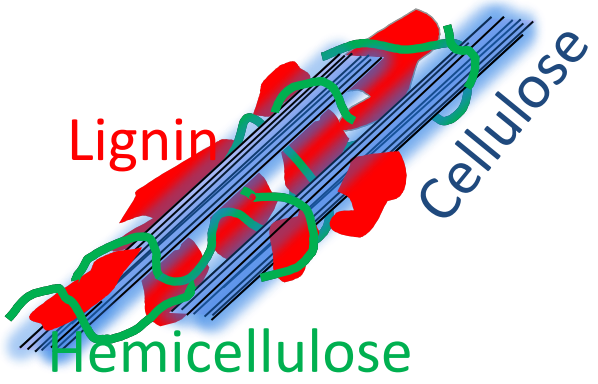
図　粟野達也（寺島の図を改変）木材の形成

Plant cell wall

- Micro-sized Multi-layered structure
- High durability
- Biodegradable



Utilization of plant body (cell wall)



- Wood construction
- Chemical refinery

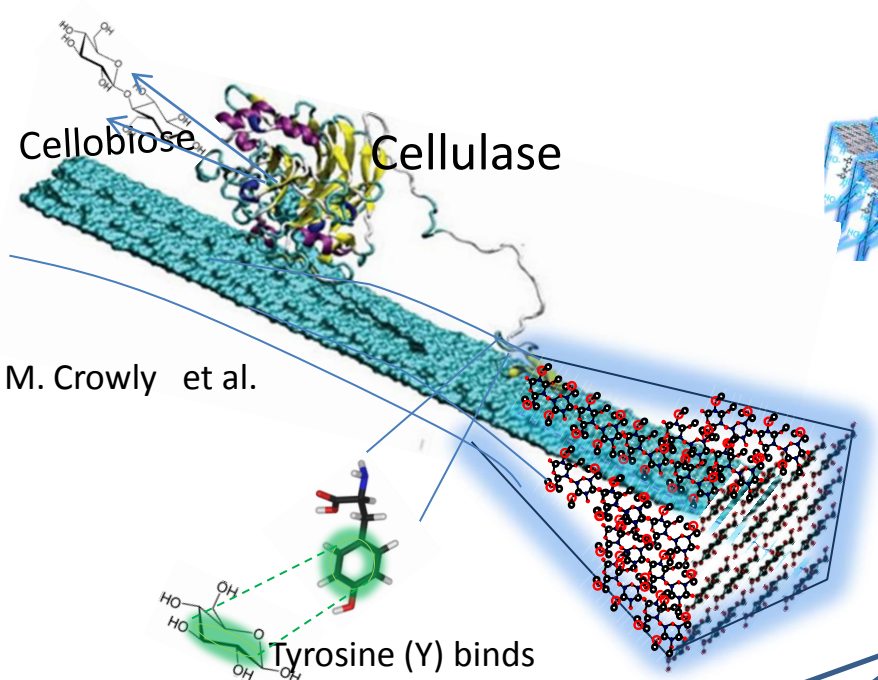
→ Cellulose : paper, nanofiber, viscose rayon…

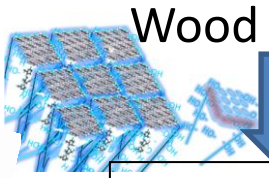
$[Cu(NH_3)_4](OH)_2$

→ glucose: precursor as monomer (lactic acid)

as energy (ethanol)

How to make ethanol





Wood cellulose Corn starch Mollases

Delignification

saccharification

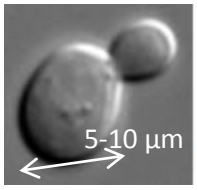
fermentation

distillation

Bio-ethanol

$C_6H_{12}O_6 \longrightarrow 2CH_3CH_2OH + 2CO_2$

100 g 51.4 g 48.8 g



Yeast 酵母

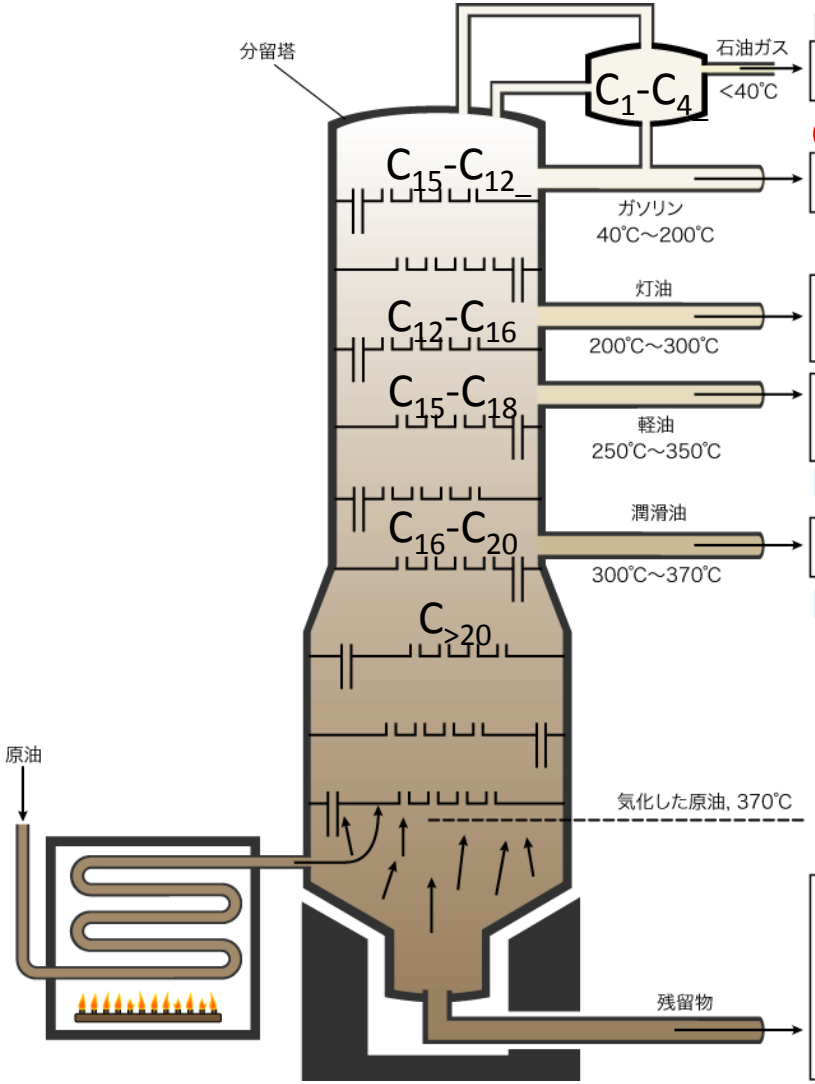
Saccharomyces spp.

Fossil resources

Oil refinery industry

(1) Polymer

Petroleum: precursor for everything from large to small molecules



LRG (Liquefied refinery gas)

炭素数1～4の炭化水素
用途:燃料、化学合成の原料

(Raw materials for chemical)

Gasoline

炭素数5～12の炭化水素
用途:燃料、溶媒

Jet fuel

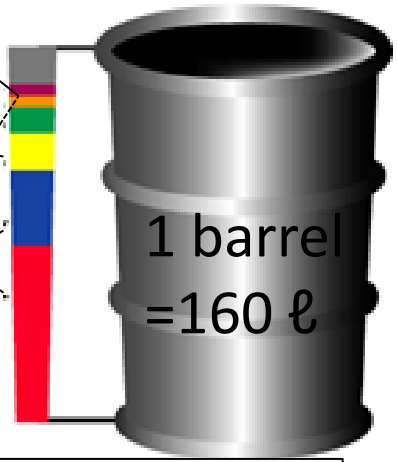
炭素数12～16の炭化水素
用途:クラッキングの原料、燃料

炭素数15～18の炭化水素
用途:クラッキングの原料、ディーゼル燃料

Diesel/ Raw material for LRG

炭素数16～20の炭化水素
用途:潤滑油

Diesel/Industrial fuel



134 ℓ : fuels for transportation

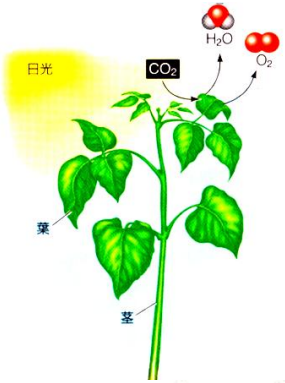
5 ℓ : Materials, Medicines

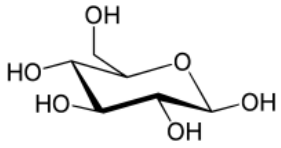
Asphalt

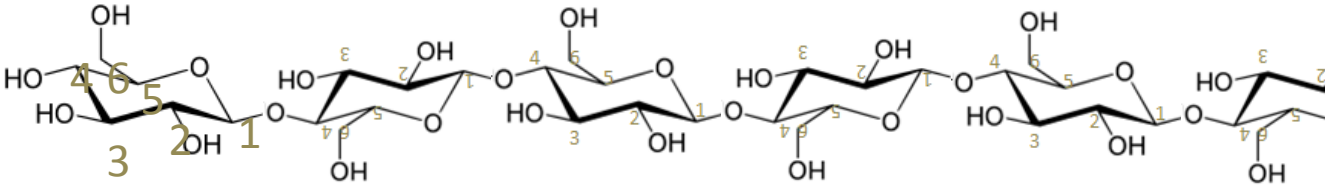
炭素数20以上の残留炭化水素類には、370℃でも気化しないパラフィン、ワックス、アスファルト、コークスが含まれている。
用途:さらに分別して別の製品にすることができる。

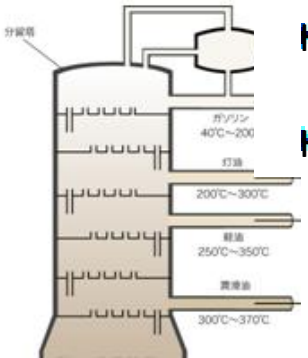
Monomer

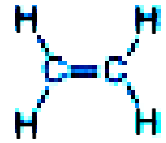
Polymer

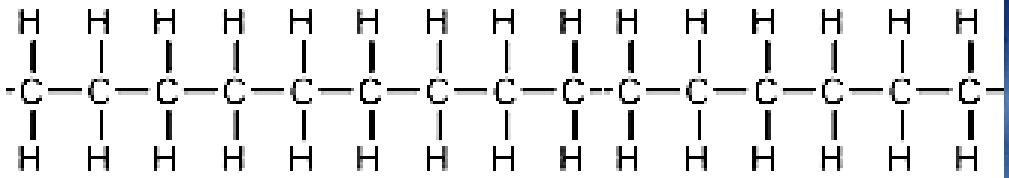


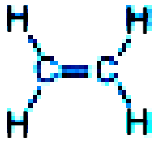




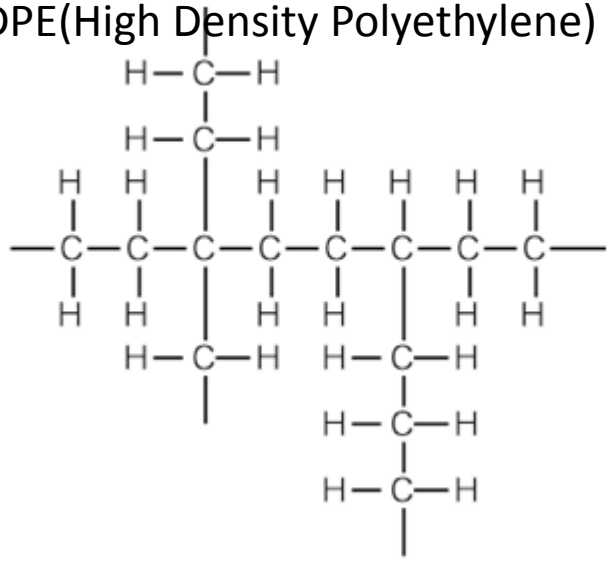




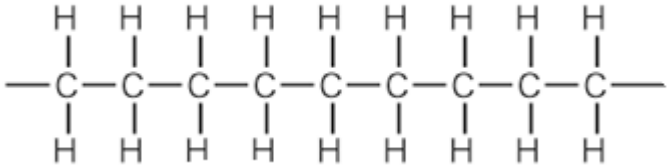


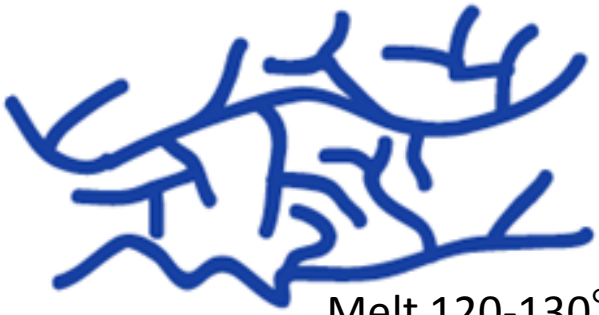


LDPE(High Density Polyethylene)

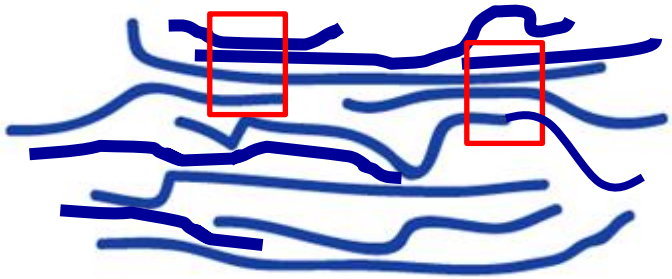


HDPE(High Density Polyethylene)





Melt 120-130℃



Melt 160-170℃

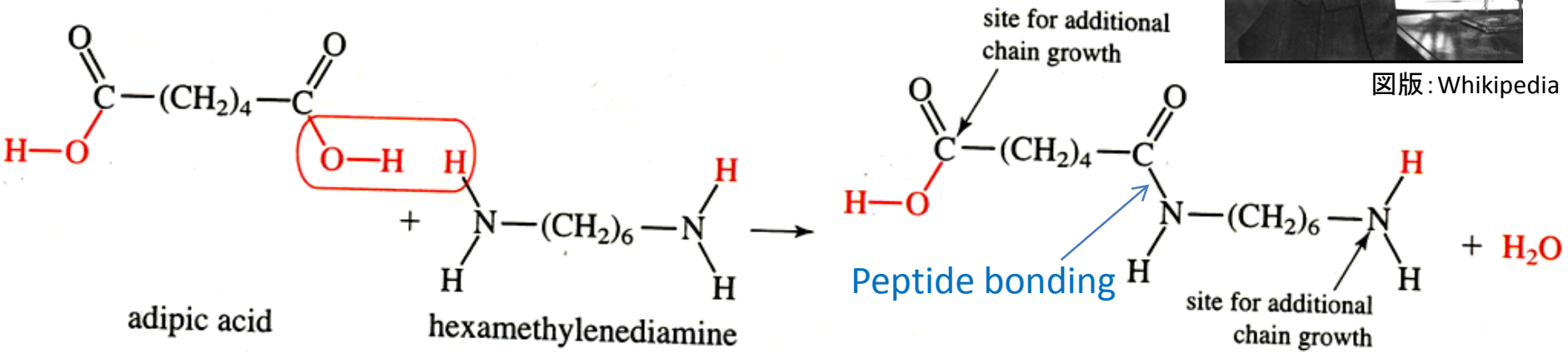
Soft
flexible
transparent

Hard
opaque
more heat-resistant

Nylon inventor:
Wallace Hume Carothers
(1896-1937)

図版：Whikipedia

- Nylon
  Bio-mimetically designed polymer



Polymer- “Big 6”

Polyethylene (LDPE)

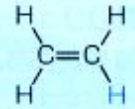
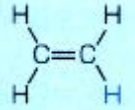
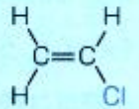
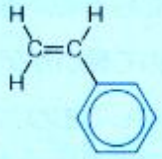
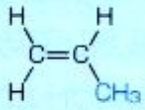
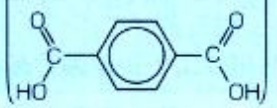
Polyethylene (HDPE)

Polyvinyl chloride

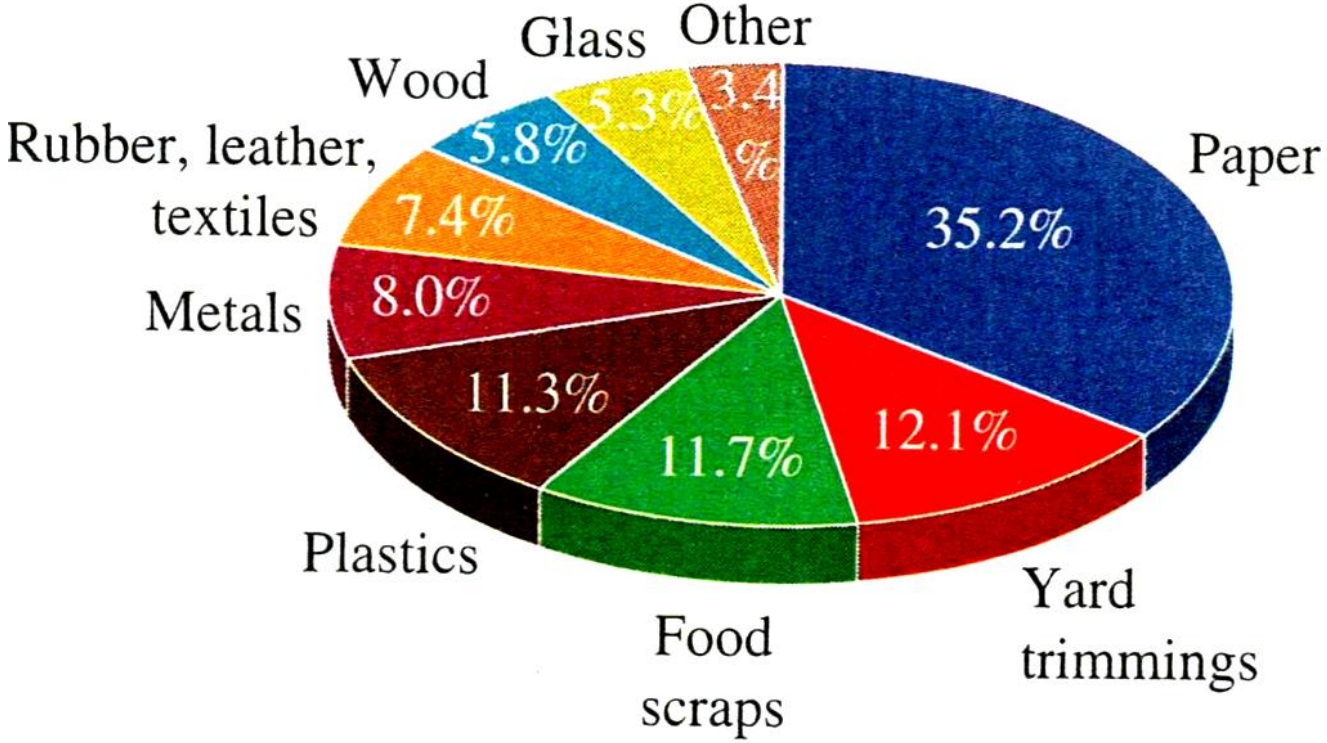
Polystyrene

Polypropylene

Polyethylene terephthalate

ポリマー	モノマー	ポリマーの特性	ポリマーの用途
ポリエチレン(LDPE) 4 LDPE	エチレン  $H_2C=CH_2$	乳白色、柔軟性、屈曲性、水蒸気を不透過、酸・塩基に不活性、油を吸収して、膨潤・軟化、100～120℃で融解、－100℃まで脆化しない、太陽光で酸化、亀裂	プラスチック袋、オモチャ、電気製品の絶縁、発泡ビニールシート(バブルラップ)
ポリエチレン(HDPE) 2 HDPE	エチレン  $H_2C=CH_2$	LDPEに類似、より不透明、高密度、機械強度大、結晶性大、剛性大	牛乳、ジュース、水さし、硬いプラスチックバッグや容器
ポリ塩化ビニル 3 PVC	塩化ビニル  $H_2C=CHCl$	硬い、熱可塑性、油および大部分の有機物を不透過、透明、耐衝撃性が高い	配管用パイプ、ガーデンホース、シャワーカーテン、透明包装
ポリスチレン 6 PS	スチレン  $H_2C=CHPh$	ガラス状、高透明度、硬い、脆性、加工性、90℃まで耐用、多くの有機溶媒に可溶	発泡スチロール断熱材、安価な家具、飲用カップ
ポリプロピレン 5 PP	プロピレン  $H_2C=CHCH_3$	不透明、高融点（160～170℃）、高引っ張り強度と硬さ、汎用プラスチックで最小密度、液体及び気体を不透過、高輝度で滑らかな表面	電池のケース、室内外のカーペット、ボトルのキャップ、自動車の内装
ポリエチレンテレフタレート 1 PET	エチレングリコール $HOCH_2-CH_2OH$ テレフタル酸 $HOOC-Ph-COOH$ 	透明、高耐衝撃性、酸及び大気ガスを不透過、伸長性なし、6種類のうちで最も高価	衣類、ソフトドリンク用ボトル、オーディオ・ビデオテープ、フィルム裏張

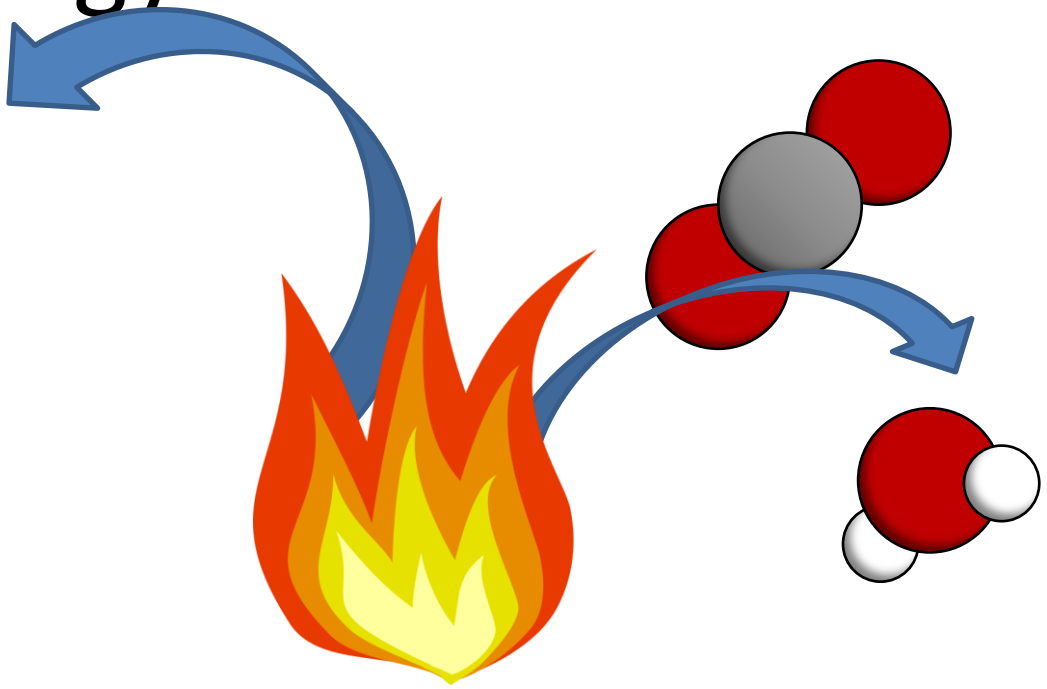
出典:「実感する化学」



Composition by weight of municipal solid waste before recycling in 2003.

Source: U.S. Environmental Protection Agency, EPA 530 F-05-003, April 2005, USA.

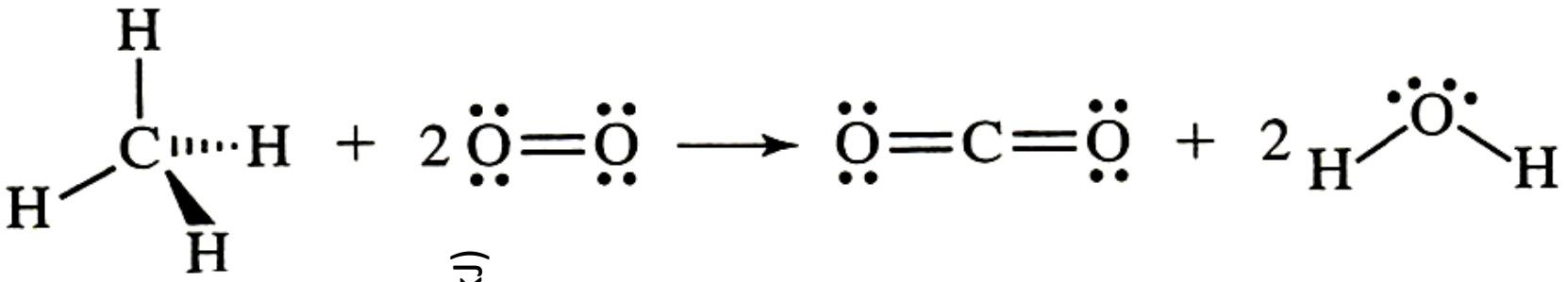
(2) Energy

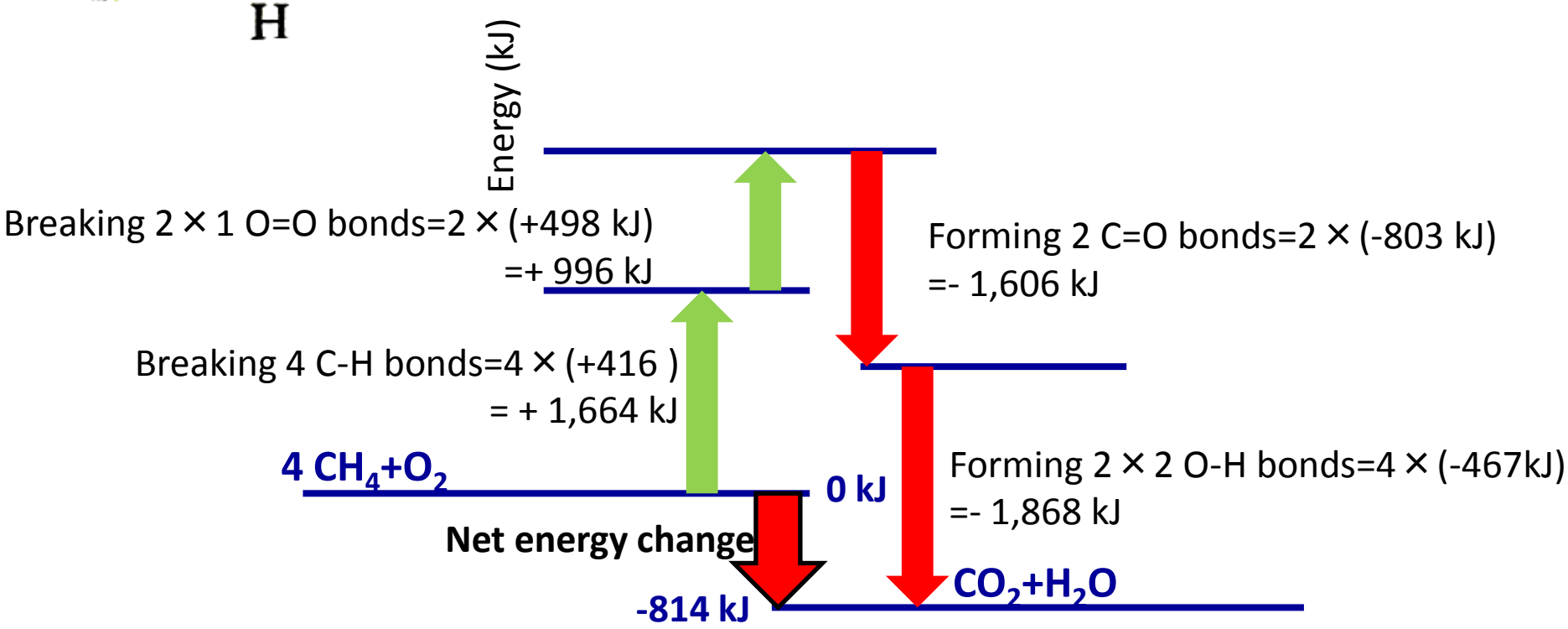


Energy calculation

- Chemical bonds convey energy

$$CH_4(g) + 2\,O_2(g) \longrightarrow CO_2(g) + 2\,H_2O(g) + \text{energy}$$





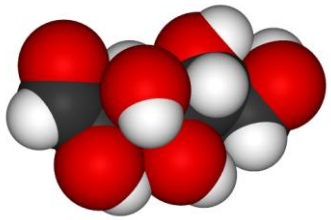
Bond Energies (in kJ/mol)

	H	C	N	O	S	F	Cl	Br	I
Single bond									
H	436								
C	416	356							
N	391	285	160						
O	467	336	201	146					
S	347	272	—	—	226				
F	566	485	272	190	326	158			
Cl	431	327	193	205	255	255	242		
Br	366	285	—	234	213	—	217	193	
I	299	213	—	201	—	—	209	180	151

Multiple bond		
C=C 598	C=N 616	C=O 803 (CO_2)
C≡C 813	C≡N 866	C≡O 1073
N=N 418	O=O 498	
N≡N 946		

出典：Darrell D. Ebbing, General Chemistry, Fourth Edition, Copyright © 1993 by Houghton Mifflin Co.

Q. Compute the amount of energy (in kilojoules) released by burning one mole glucose.



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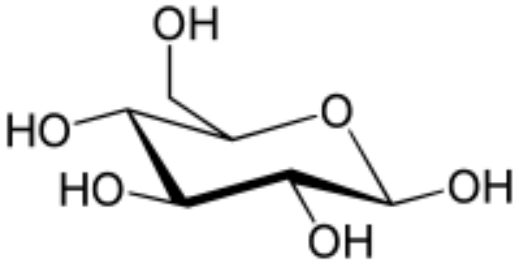

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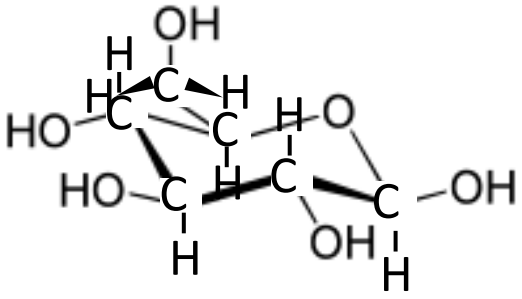
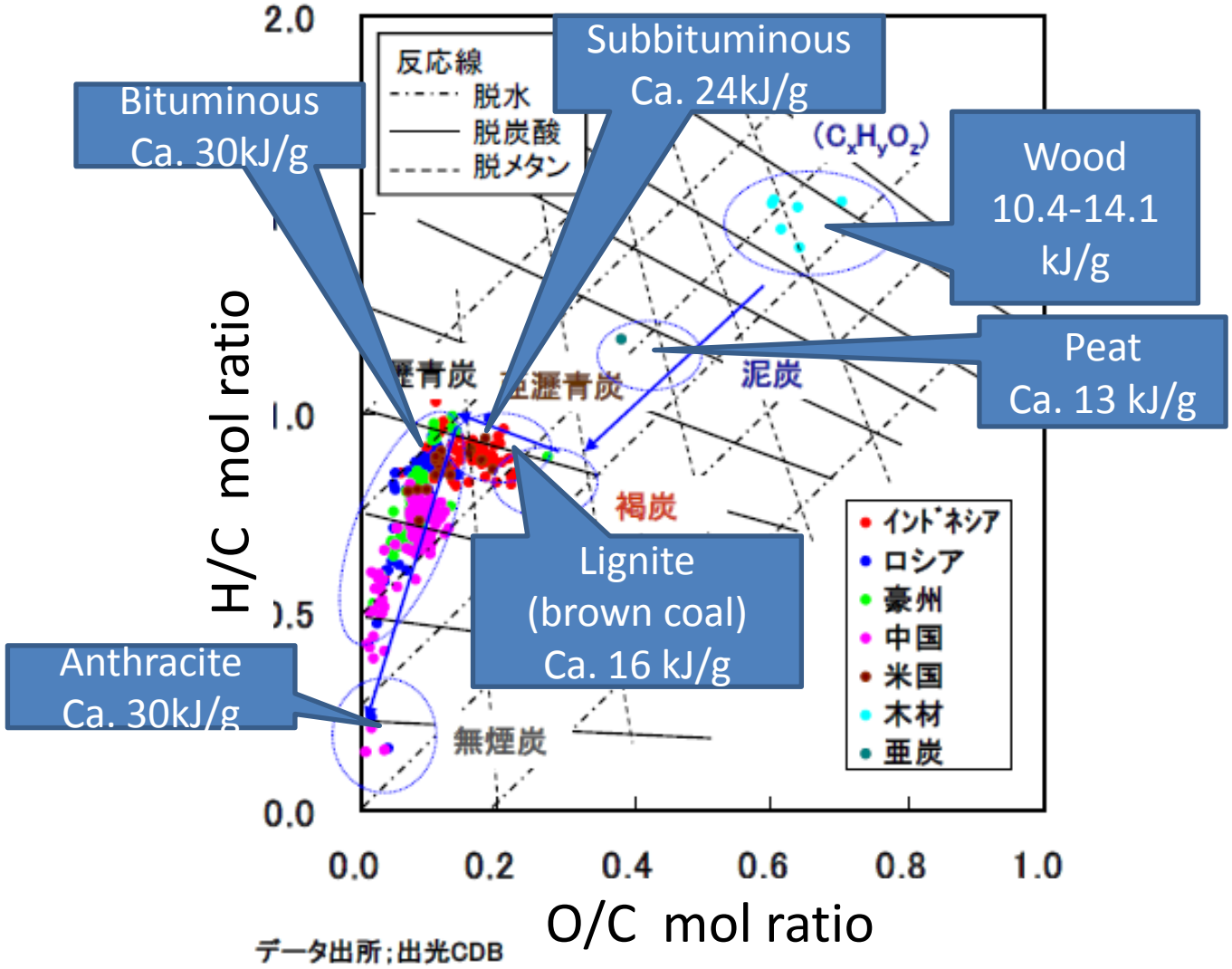


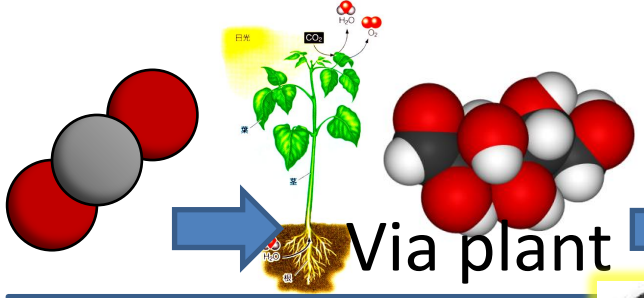
$C_6H_{12}O_6$

Assume glucose as “gas” phase in this case in order to use the table for the practice. (glucose is solid normally)

Q. Generally speaking, the less oxygen a compound contains, the more energy per gram it will release on combustion. Explain the reason.



Carbon materials



Char Coal

Carbon Black

Tire

Glassy Carbon

C/C Composite

Fullerene

Graphite Electrode

Isotropic Graphite

Graphene

2010ノーベル賞

Coke

製鉄

Carbon Fiber

CVD products

Cathode

Carbon Nano Tube

Pencil Lead

Activated Carbon

活性炭

Fuel Cell

Lithium Ion Battery

Capacitor

Carbon Alloy

Carbon Brush

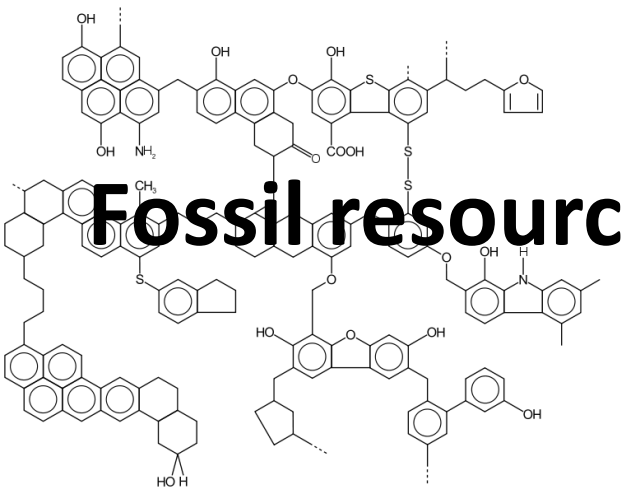
炭素材料の市場構造　室伏信幸、2011炭素

Ancient Carbon (1st generation)

Conventional Carbon (2nd generation)

New Carbon (3rd generation)

Nano Carbon (4th generation)



Fossil resources

40 million years

Fuel
Polymers
Carbon materials

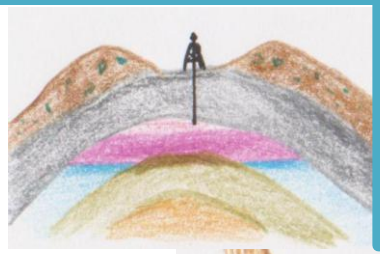
Challenge

hv

H_2O

O_2

Only the system of carbon-fixing



Conversion
High pressure
High temperature

Partial degradation

H_2O

Homework

Why synthesized polymers from petroleum is more popular in modern living than natural polymers?

Discuss quantitatively and qualitatively, standing in the view points of natural science, engineering, and social science.