Introduction to Botany. Lecture 4

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Outline

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1. Questions and answers

2. Photosynthesis
   - Chemistry of life
   - Molecules of life
   - History of photosynthesis studies

Previous final question: the answer

What is molecular weight of sulfuric acid, H_2SO_4?

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What is molecular weight of sulfuric acid, H_2SO_4?

- H_2SO_4 weight $= 2 \times 1 + 32 + 16 \times 4 = 98$
- “98” what? Dalton, 1/12 of carbon-12 isotope.

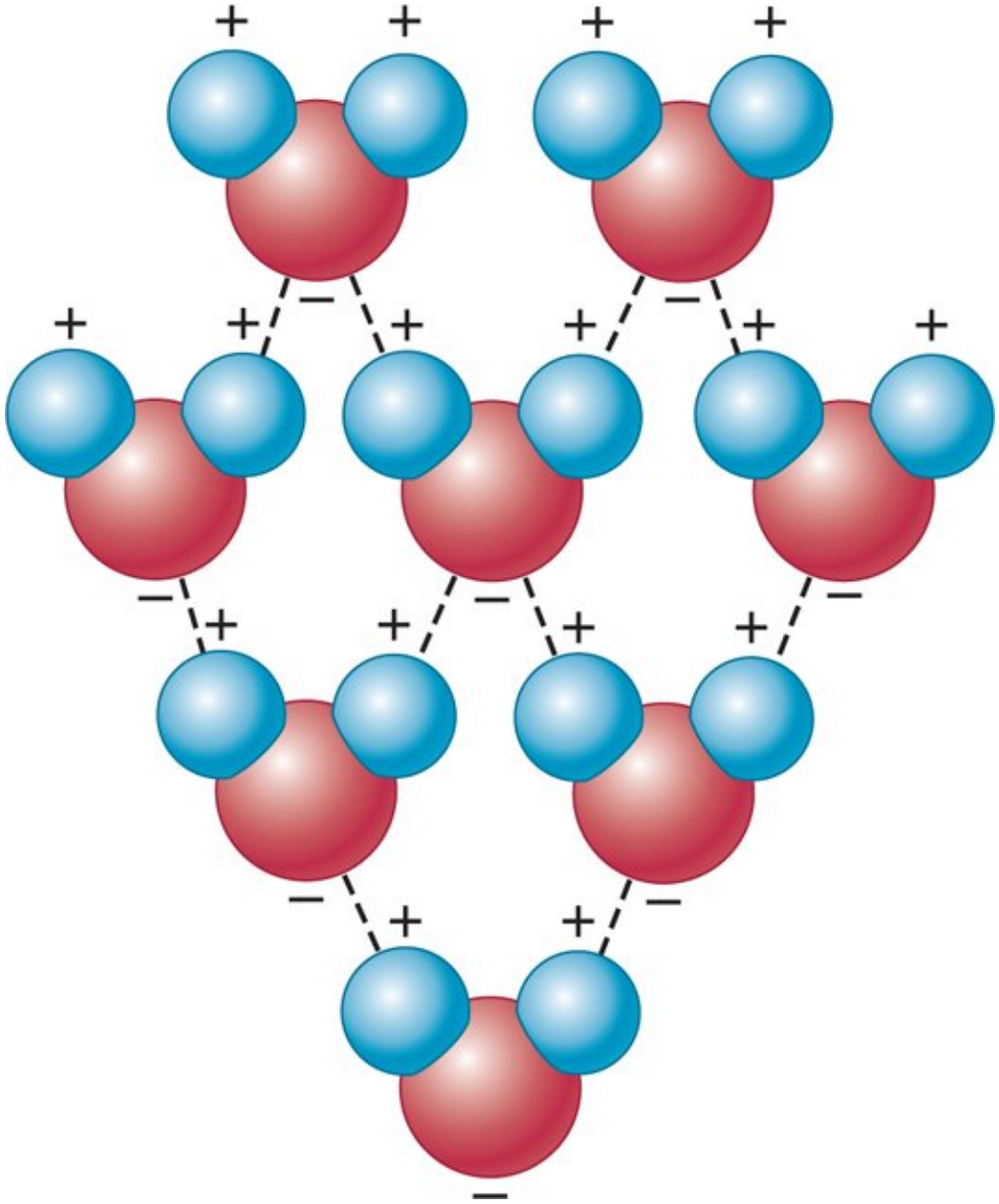
Photosynthesis

Chemistry of life

Very basics of chemistry

- Atoms
  - Protons
  - Neutrons
  - Electrons
- Atomic weight
- Isotopes
- Elements
- Periodic table: rows and columns
- Chemical bonds: ionic, covalent, hydrogen
- Valence and group
- Molecules
- Molecular weight

Water with hydrogen bonds



Acids and bases

- Acids: take out H^+ (proton), like
  $HCl \rightarrow H^+ + Cl^-$
- Bases: take out OH^- (hydroxyl)
  $NaOH \rightarrow Na^+ + OH^-$

Molar mass and molar concentration

- Molar mass is a gram equivalent of molecular mass
- For example, molecular mass of salt (NaCl) is $23 + 35$[1] $= 58$. Therefore, 1 mole of salt is 58 g
- Every mole contains $6.02214078 \times 10^{23}$ molecules (Avogadro's number)
- In water solution, 1 M (1 molar) concentration of salt means in 1 liter of distilled water 58 g of salt was diluted

[1] If we accept that atomic mass of chlorine in 35.

Concentration

- Amount of dissolved substance
- If concentration of protons is 0.1 M (1×10^{-1}, 0.1 g of protons in 1 l of water), this is an extremely acidic solution
- In distilled water, concentration of protons equal to 1×10^{-7} (0.0000001) M
- This is because water molecules can also (rarely) dissociate: $H_20 \rightarrow H^+ + OH^-$
- pH of distilled water is equal to $-\log(10^{-7}) = -(-7) = 7$
- pH of the extremely acidic solution (first example) is 1

Photosynthesis

Molecules of life

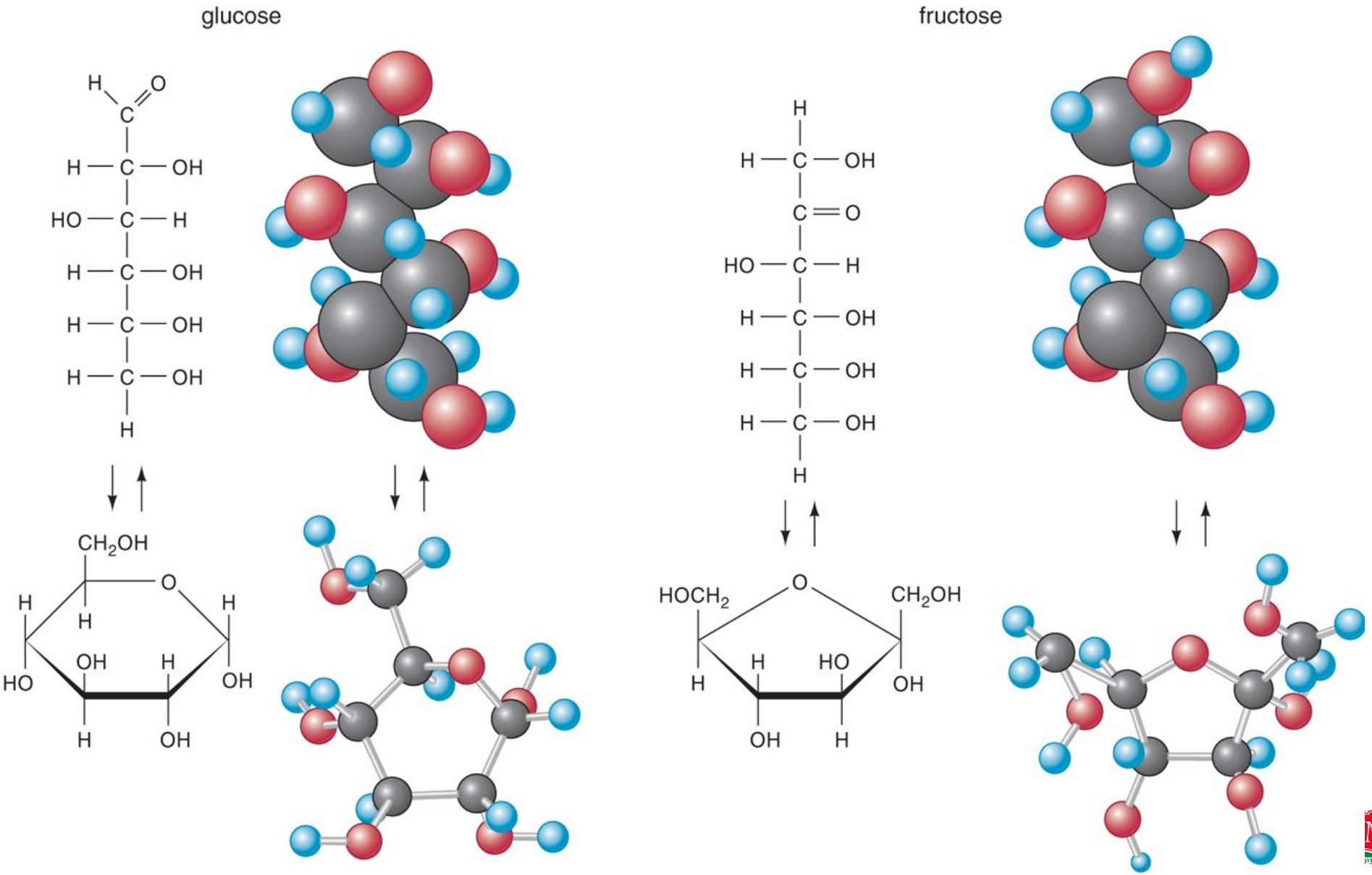
Organic chemistry: chemistry of carbon

- Carbon skeleton
- And H, O, N, P, S

Four types of biomolecules

- Lipids: hydrophobic
- Carbohydrates (sugars): multiple $-$OH groups
- Amino acids: N + C + O and hydrogen
- Nucleotides: cycle with nitrogen (heterocycle), sugar and phosphoric acid

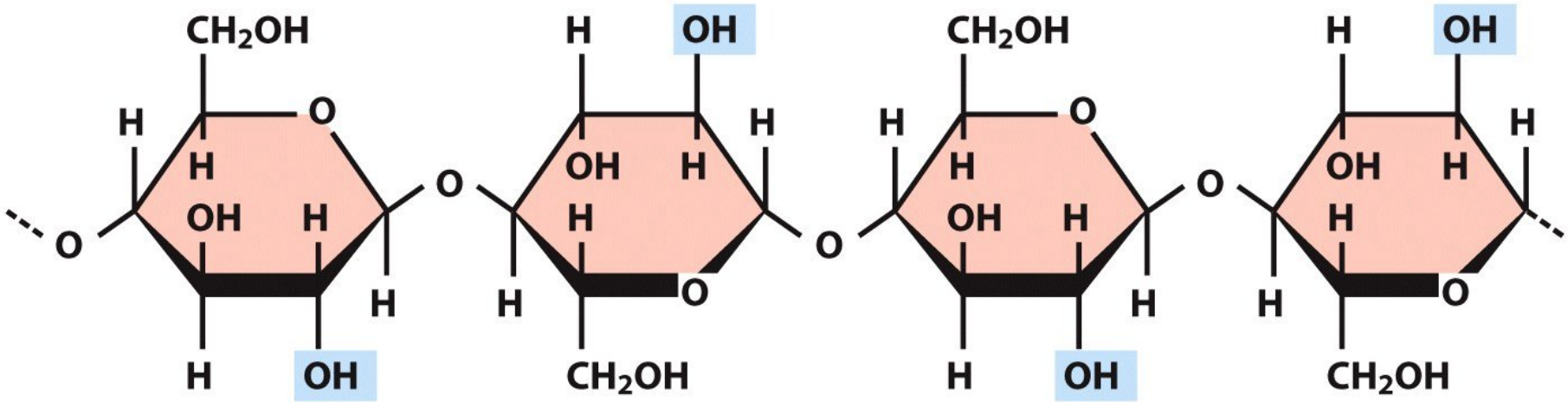
Carbohydrates

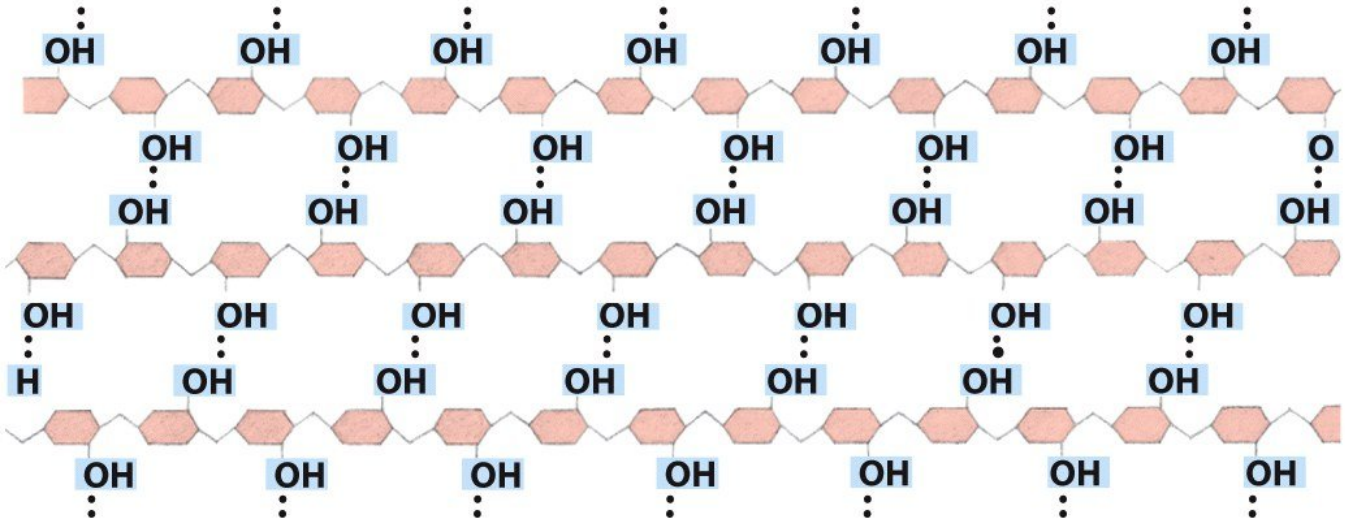


Organic polymers

- Polymeric carbohydrates: polysaccharides (like cellulose and starch)
- Polymeric amino acids: proteins
- Polymeric nucleotides: nucleic acids (DNA and RNA)

Cellulose





Photosynthesis

History of photosynthesis studies

van Helmont

- Johannes van Helmont (17th century) rejected the idea that plans take most of their biomass from soil
- Willow (*Salix* sp.) tree of 2.27 kg grew to 67.7 kg in five years, but weight of soil decreased only by 57 g
- van Helmont concluded that plants take most of their weight from water

Pristley

- Famous Joseph Pristley in 1772, made series of experiments with mouse, candle and sprig of mint (*Mentha* sp.)
- Mouse behave similar to candle, they both “spent” air
- Plant revives the air for both candle and mouse

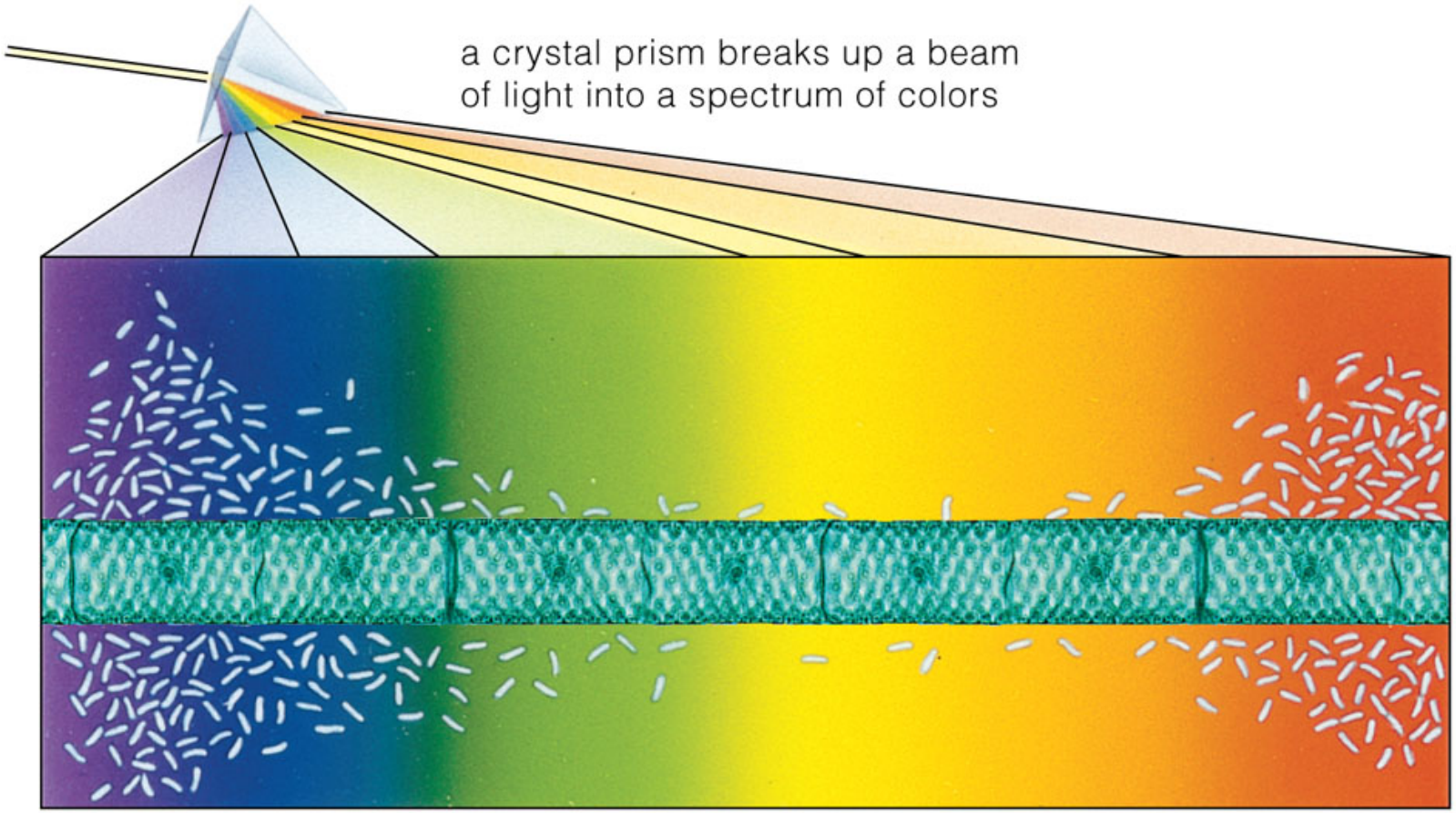
Further history

- Jan Ingenhousz (1779–1796) and Jean Senebier (1780) found that:
  - Only in day time the air is reviving
  - CO_2 is assembled
- Antoin-Laurent Lavoiser (1783) found that the “revived air” is a separate gas, **oxygen**

Engelmann

- Thomas Engelmann in 1884 found that *Spirogyra* alga produce oxygen mostly in blue and red parts of spectrum
- Therefore, the key photosynthetic pigment should accept blue and red rays and reflect green rays
- Chlorophyll fits best to this description

Experiment of Engelmann



Final question (2 points)

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Which conclusions can be drawn from Pristley's experiments? Please list more than one.

Summary

- Main biogenic elements: C, H, O, N, P
- Most important bonds: covalent and hydrogen
- Most important monomers: lipids, carbohydrates, amino acids, nucleotides
- Most important polymers: polysaccarides, proteins, nucleic acids
- From 17th century, in constantly become clear that plants make their biomass from light, water and carbon dioxide

For Further Reading

A. Shipunov.
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