Introduction

Biological Processes in Environmental Eng.

- **Instructor: Prof. Yongju Choi**

  Associate professor, Civil and Environmental Eng., SNU

  Office: 35-307

  Email: ychoi81@snu.ac.kr

- **Office hour**

  via Zoom (https://snu-ac-kr.zoom.us/j/8675573197,
  meeting ID 867 557 3197)

  Tue 5:00 – 5:30 pm & Fri 9:00 – 9:30 am

Course material / textbook

- **Main references**

  1. Lecture notes
  2. Rittmann & McCarty; Environmental Biotechnology: Principles and Applications; McGraw-Hill

- **Supplementary readings**
  - Maier, Pepper, & Gerba; Environmental Microbiology; Academic Press
  - Sawyer, McCarty, & Parkin; Chemistry for Environmental Engineering and Science; McGraw-Hill; Ch. 6
  - Davis & Masten; Principles of Environmental Engineering and Science, 4th ed.; McGraw-Hill

    (Kor) 박제량, 최용주(감수); 환경공학 및 과학, 청문각

Student presentation & paper discussion

- Only one exam for this class? But…
- One of the student leads the class
- Topic & paper selection & posting
  - Select a topic & a paper (relevant to the class!) and submit a brief presentation plan to me at least **3 business days prior to the class assigned** (Mon class → Wed; Wed class → Fri)
  - Post the paper link to eTL at least **2 business days prior to the class assigned**

    (Mon class → Thu; Wed class → Mon)

Student presentation & paper discussion

- Contents
  - General introduction on the selected topic
  - Not a simple summary but a critical review of the selected paper
  - Consider how to facilitate discussion among students!
    - e.g., provide ≥3 points you would like to discuss
  - Presentation (15 min) + Discussion (10+ min)

Class objectives

- Understand the scientific principles related to the application of biological approaches for the management of water, soil, and solid waste.
- Obtain in-depth knowledge on the biological approaches applied for environmental engineering (with a focus on wastewater management), study current issues of research, and discuss the future direction of research and applications.

New updates this year

2020

* 4.Lecture Plan	W01: Introduction to biological processes in environmental engineering / Basics of microbiology W02: Enzyme reactivity and inhibition / Stoichiometry of biochemical reactions I W03: Stoichiometry of biochemical reactions II & III W04: Microbial energetics / Microbial kinetics W05: Reactor analysis I & II W06: Microbial kinetics in reactors I & II W07: Microbial kinetics in reactors III / Bioreactor analysis – numerical solution W08: Wastewater treatment overview / Biological wastewater treatment I W09: Biological wastewater treatment II & III W10: Anaerobic processes / Microbial fuel cells W11: Recalcitrant compound biotransformation mechanisms / Discussion & review W12: Final exam W13-15: Student presentation & discussion

2023

**3. Course Schedule	W01: Introduction to biological processes in environmental engineering / Basics of microbiology W02: Biomolecules / Biochemical reactions W03: Stoichiometry of biochemical reactions I & II W04: Stoichiometry of biochemical reactions III / Microbial energetics W05: Microbial kinetics / Reactor analysis I W06: Reactor analysis II / Microbial kinetics in reactors I W07: Microbial kinetics in reactors II & III W08: Bioreactor analysis – numerical solution / Wastewater treatment overview W09: Biological wastewater treatment I & II W10: Practices of biological wastewater treatment / Anaerobic processes W11: Innovative biological wastewater treatment processes / Recalcitrant compound biotransformation mechanisms W12: Bioinformatics using metagenomics / Final review W13: Final exam W14-15: Student presentation & discussion

3. 생물분자와 효소반응

3.1. 생물분자

대표적인 생물분자(biomolecule) 물질에는 탄수화물(carbohydrates), 지방을 포함한 지질류(lipids), 단백질(protein), 핵산(nucleic acid)이 있다. 핵산, 즉 DNA와 RNA에 대해서는 2.2절에서 상세히 소개했으므로 여기에서는 탄수화물, 지질류, 단백질에 대해 소개한다.

3.1.1. 탄수화물

생화학에서 탄수화물은 당류(saccharides)와 동의어이며, 이들은 단당류(monosaccharides)를 모노머로 한다. 탄수화물 또는 당류는 분자에 존재하는 모노머의 개수에 따라 단당류, 이당류(disaccharides), 올리고당류(oligosaccharides), 다당류(polysaccharides)로 나뉜다. 이당류는 단당류 2개가 결합된 물질을, 올리고당류는 일반적으로 단당류가 2개 또는 3개에서 10개까지 결합된 물질을, 다당류는 10개가 넘는 단당류가 결합된 물질을 가리킨다. 다당류에는 녹말(starch), 셀룰로오스(cellulose), 글리코겐(glycogen) 등이 있다. 키틴(chitin)은 포도당의 파생물질인 *N*-acetylglucosamine을 모노머로 하는 폴리머로, 탄수화물 유사체이다(그림 3-1).

탄수화물은 생물체의 주요 에너지원으로 사용된다. 탄수화물은 에너지 저장물질로 기능하기도 하는데, 식물은 주로 녹말을, 동물은 주로 글리코겐을 생체 내에 저장했다가 포도당으로 분해하여 추후 호흡 반응에 사용한다. 또한, 탄수화물은 세포나 생물에 구조적 강도를 부여하는 역할을 하기도 하는데, 대표적인 예로는 식물의 세포벽을 구성하는 주요 물질인 셀룰로오스와 절지동물의 외골격, 연체동물의 껍질, 균류의 세포벽 등을 구성하는 주요 물질인 키틴이 있다.

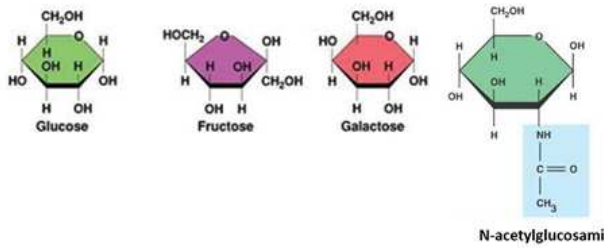


그림 3-1. 단당류인 포도당(glucose), 과당(fructose), 갈락토오스(galactose)와 키틴의 모노머인 *N*-acetylglucosamine의 구조

3.1.2. 지질류

지질류는 탄수화물, 단백질, 핵산 등 다른 생물분자와는 달리 중합체 구조가 아니며 다양한 소수성(hydrophobic) 또는 양쪽 친매성(amphiphilic) 물질의 총칭이다. 양쪽 친매성 물질이란 친수성과 친유성을 동시에 갖는 계면 활성 물질을 가리킨다. 지질류에 속하는 물질로는 지방, 왁스류(waxes), 콜레스테롤을 포함한 스테롤류(sterols), 지용성 비타민(비타민 A, D, E, K 등), 모노글리세라이드류(monoglycerides), 디글리세라이드류(diglycerides), 인지질류(phopholipids) 등이 있다. 생물에서 지질류는 에너지 저장물질(예: 지방), 세포막 구성성분(예: 인지질), 신호전달 물질(예: 스테로이드계 호르몬) 등으로 사용된다. 지방은 글리세롤에 세 개의 지방산[fatty acid; 지방족 사슬(aliphatic chain)에 카르복시산 작용기가 있는 물질]이 결합된 구조로, 세 개의 지방산 모두가 단일결합만으로 이루어진 포화 지방산일 경우 포화 지방(saturated fat)으로, 이중결합이 최소한 하나 존재할 경우 불포화 지방(unsaturated fat)으로 불린다(그림 3-2).

Application of biological processes

- Usually to exploit microorganisms' capability of enzymatic transformation of chemicals

- Natural systems vs. engineered systems
  - (natural) self-purification of rivers, natural attenuation of soil contaminants, etc.
  - (engineered) bioreactors
  - (nature-based solutions) constructed wetlands

Bioreactors

- A controlled environment provided for the growth and maintenance of complex, self-assembled microbial communities that perform ecologically critical functions

"Do what microorganisms want such that we can get what we want"

Application of biological processes

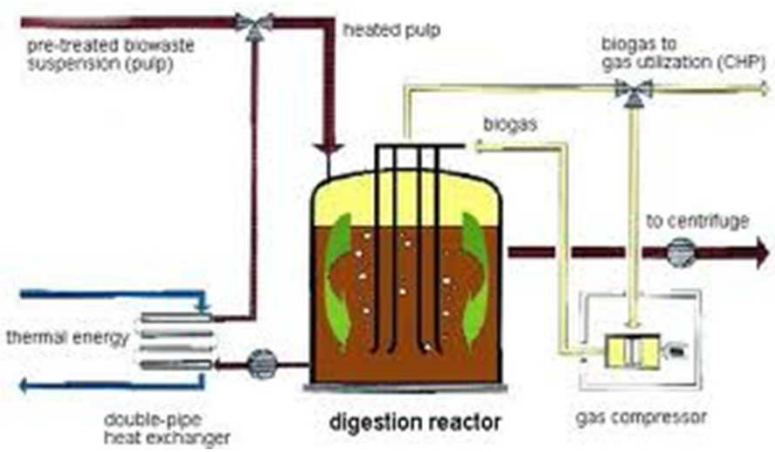
- Wastewater treatment – secondary treatment

activated sludge

trickling filter

Application of biological processes

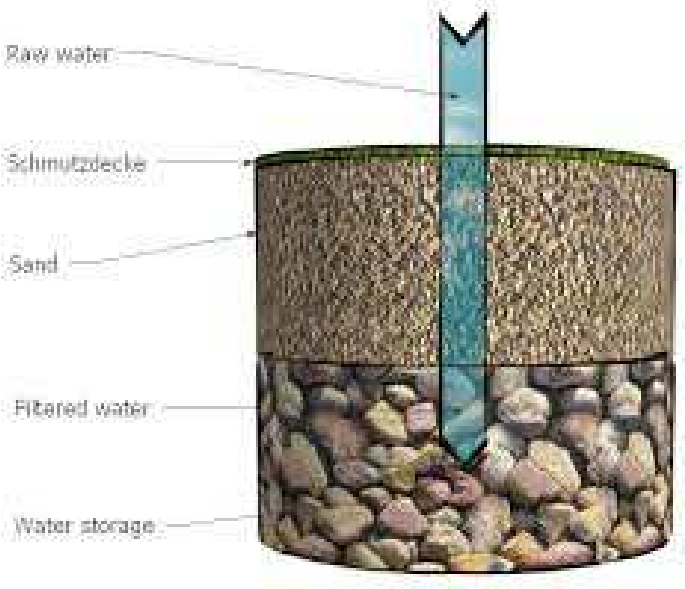
- Wastewater treatment – sludge treatment



anaerobic digestion

Application of biological processes

- Drinking water treatment



slow sand filtration

biological AC treatment

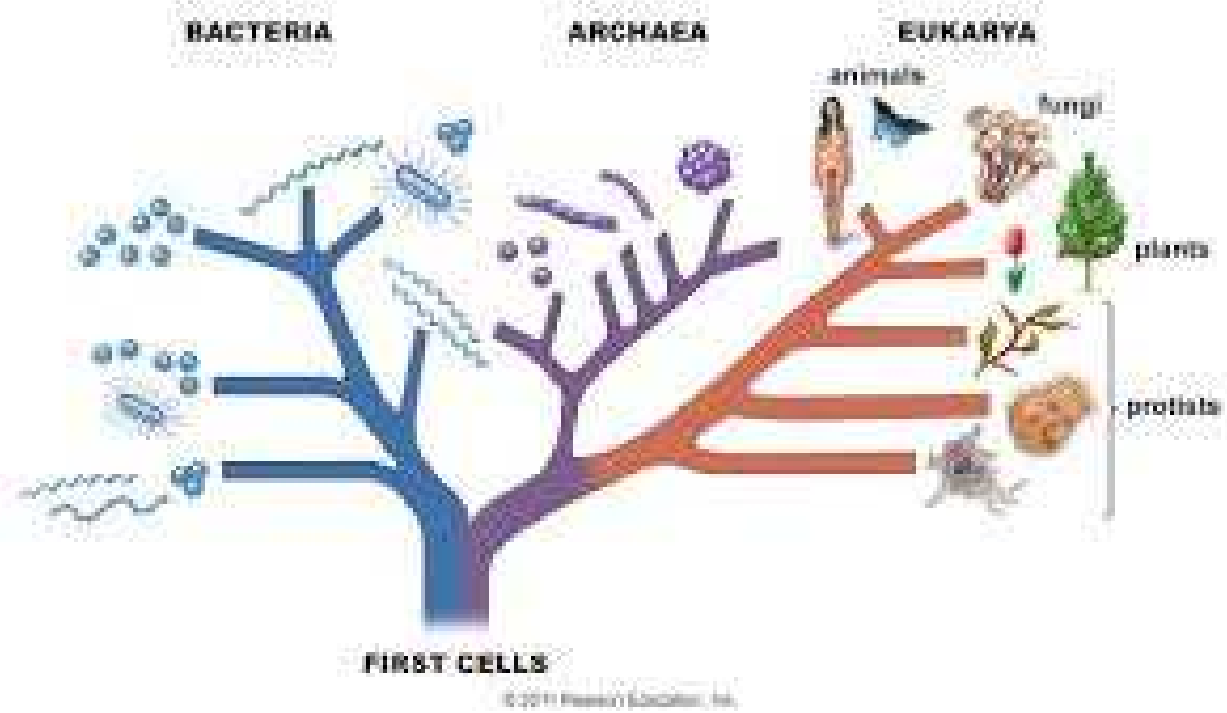
Application of biological processes

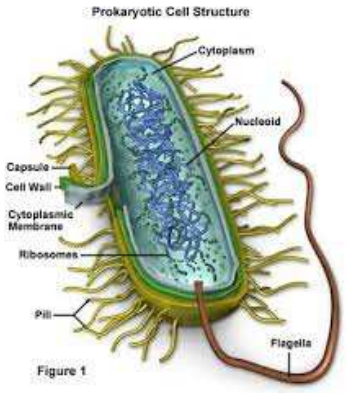
- Soil and groundwater treatment

landfarming

biostimulation

The main player





bacteria