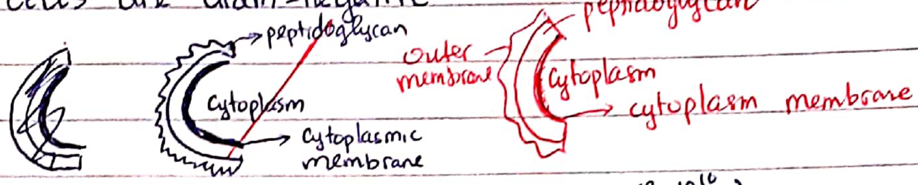
Memo No. PYP 15-16
Date / /

Hoang Thu Minh

1.
(i) d ✓ (ii) a ✓ (iii) c ✓ (iv) b ✓ (v) c ✓ (vi) d ✓ (vii) c ✓ (viii) d (ix) a ✓ (x) a ✓

2.
(a) (i) phenotypic description (ii) chemically defined
(b) EN2002 cells are Gram-negative



(c) Specific growth rate $\mu = \frac{\ln(x_2/x_1)}{t_2 - t_1} = \frac{\ln\left(\frac{3\times10^{10}}{3\times10^{7}}\right)}{9-4} = 1.38\ h^{-1}$

Doubling time $t_d = \frac{\ln 2}{\mu} = \frac{0.693}{1.38} = 0.502\ h$

(d) Genus: Pseudomonas, species: Pseudomonas putida
(e) Concentration of C_6H_6 = 20 mg/L = $\frac{20\ mg/L}{78\ g/mol}$ = 0.2564 mmol/L

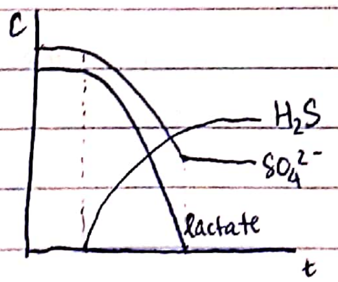
Concentration of Fe^{3+} = 1 mg/L = $\frac{1\ mg/L}{56\ g/mol}$ = 0.01786 mmol/L

$C_6H_6 + 18\,H_2O + 30\,Fe^{3+} \rightarrow 6\,HCO_3^- + 30\,Fe^{2+} + 36\,H^+$

	C_6H_6	Fe^{3+}
Initial (mmol/L)	0.2564	0.01786
React	$\frac{0.01786}{30}$	0.01786
Remain	$0.2564 - \frac{0.01786}{30} = 0.2558$	0

∴ Minimum concentration of benzene remaining = 0.2558 mmol/L
= 19.95 mg/L

3.
(a)



(b) - Isolate bacteria from the sample by ~~streak~~ plate method: Spread sample on the plate and incubate so that the bacteria cells will grow and form colonies.
- Phylogenetic analysis: Extract DNA from the colonies to perform PCR. After getting the DNA sequences, analyse the sequences to generate phylogenetic tree

(c) Limitations of the method used in (b) is that it depends on cultivation. Hence, there could be viable but non-culturable cells that are missed → GPCA
To avoid cultivation, we can use metagenomics.

Memo No.

Date / /

4.

(a) ~~Techono~~ Technology advances allow humans to produce chemical fertilisers by synthesizing NH_3 from N_2 and H_2. When excessive N fertilisers are applied to soils, there could be nutrient run off to water bodies, which causes eutrophication. Long term application of N fertiliser also results in soil acidification.

(b) Coliforms, Fecal streptococci.

(c) (i) Biogeochemical cycle of mercury:
- Mercury is released from natural or anthropogenic sources
- Deposition of Hg to waters
- Conversion of Hg^0 to Hg (II) (soluble)
- Microbial conversion of Hg (II) into methyl mercury
- Mercury enters the atmosphere as gaseous Hg or bioaccumulates in the ecosystem.

(ii) Human activities increase the amount of mercury released into the ecosystem.

(iii) Methylation is a bio-mediated microbial process in the biogeochemical cycle of mercury ($Hg^{2+} \rightarrow [CH_3Hg]^+$). It is important because it converts ~~Hg into~~ inorganic Hg into organic Hg which can be easily uptaken by aquatic microorganisms and hard to remove from ecosystem. Subsequently, Hg bioaccumulates in the ecosystem.

5.

(a) (i) Biofilms are prevalent in hospitals. Since free chlorine is very reactive with organic matter, it will react with organic compounds in the biofilms and deplete before reaching the microorganics. On the other hand, monochloramine has low reactivity with organic matter, therefore, it can easily penetrate into biofilms to deactivate bacteria.

(ii) Chloramine

(b) $\overset{-3}{N}H_4^+ + 2O_2 \rightarrow \overset{+5}{N}O_3^- + H_2O + 2H^+$

10mM → 10mM

$6NO_3^- + 5CH_3OH \rightarrow 3N_2 + 5CO_2 + 7H_2O + 6OH^-$

10mM → $\frac{5 \times 10}{6} = 8.33$ mM

⇒ Concentration of CH_3OH = 8.33 × 32 = 266.56 mg/L

(c) - High loading rate to keep a high substrate concentration
- Anoxic condition (as used in N removal) to select floc-forming bacteria

8.

(a) Maximum efficiency $E = 100\%$ ⇒ one DNA has 2 copies after 1 cycle
⇒ After N cycles: $X_0(1+1)^N \geq X$ ⇒ $X_0(2^N) \geq X$
⇒ $2^N \geq \frac{X}{X_0}$ ⇒ $N \ln 2 \geq \ln\left(\frac{X}{X_0}\right)$ ⇒ $N \geq 1.44 \ln\left(\frac{X}{X_0}\right)$

(b) Richness: $S = 6$ for all 3 profiles
Community evenness:
- No exposure: $H = 1.306$; $E_H = \frac{1.306}{\ln 6} = 0.729$
- Exposure to X: $H = 1.135$; $E_H = \frac{1.135}{\ln 6} = 0.634$
- Exposure to Y: $H = 1.274$; $E_H = \frac{1.274}{\ln 6} = 0.711$

Both contaminants reduce evenness
X has more impacts on community evenness than Y

6.

(a) Complex organic matter is hydrolized into soluble organic molecules by hydrolytic bacteria. These molecules are then converted into volatile fatty acids by acidogens (fermentative bacteria) and are further converted into acetic acid and CO_2. The last step is methanogenesis, which is the final conversion to methane.

(b) - Mineralization: Complete conversion of organic compounds into simpler inorganic compounds
- Immobilization: Removal of contaminants, typically metals, by means of biosorption, bioaccumulation, or biotransformation, to insoluble forms
- Cometabolism: contaminants is taken up by microorganisms but is metabolized alongside the organism's food into a less hazardous chemical

Memo No.
Date / /

7.

(a) - Entering dormant state
- Producing carotenoidal dyes or special protective layers
- Spores of fungi
- Viruses with envelopes

(b) - Microbes degrade contaminants into CO_2, H_2O, mineral salts, etc. during metabolism.
- Contaminants can also be trapped on the media surface and/or absorbed into the moist biofilm.

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