

Part A: 名詞解釋，請從以下 15 個名詞選擇 8 個回答，用簡單句子說明名詞定義或概念。(每個 5 分，共 40 分)

1. Metapopulation.
2. Maximum sustainable yield.
3. Eutrophication.
4. Ecotype.
5. Biological pump.
6. The Keeling Curve.
7. Spillover effect.
8. Redfield ratio.
9. eDNA.
10. Alpha diversity.
11. Bycatch.
12. Hypoxia.
13. Southern Oscillation Index.
14. Symbiont.
15. Secondary production.

Part B: 問答題。(共 60 分)

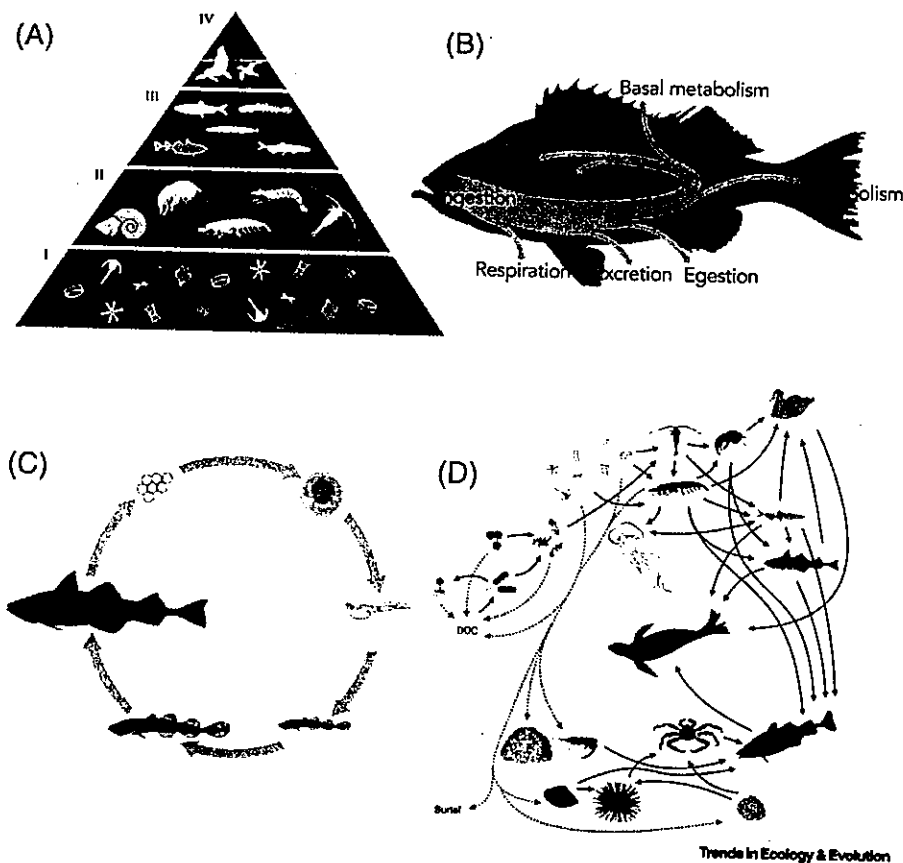
1. Autotrophy is a lifestyle in which inorganic compounds provide for all nutritional needs of an organism. The energy source other than organic molecules is used to fix inorganic compounds into organic matter. Autotrophs are described as photosynthetic or chemosynthetic organisms.

(1) Please link the following equations to either photosynthesis or chemosynthesis. All should be done. (5 points).

- a.  $SO_4^{2-} + H^+ \rightarrow H_2S + H_2O + energy$
- b.  $H_2S + O_2 \rightarrow SO_4^{2-} + H^+ + energy$
- c.  $CO_2 + H_2O + solar\ energy \rightarrow O_2 + organic\ matter$
- d.  $CO_2 + H_2S + light\ energy \rightarrow S(or\ SO_4^{2-}) + organic\ matter$
- e.  $NO_2^- + O_2 \rightarrow NO_3^- + energy$

(2) Please indicate in which marine ecosystems the photosynthesis and chemosynthesis dominate, respectively. Maximum 300 words. (5 points)

2.



“(A) A trophic pyramid depicts the classic view of production flowing from primary producers to secondary consumers. Roman numerals indicate trophic level. A 10% transfer efficiency of production is indicated by lighter grey in the pyramid, highlighting how little primary production gets transferred to the top of the food web. (B) At the individual scale, metabolic processes determine growth efficiency. (C) At the species population scale, maturation, reproduction, and survival of individual life cycles influence transfer efficiency. (D) At the ecosystem scale, complex energy pathways, including the microbial loop [depicted middle left, which includes dissolved organic carbon (DOC)] and differing paths through benthic and pelagic communities influence transfer efficiency.”

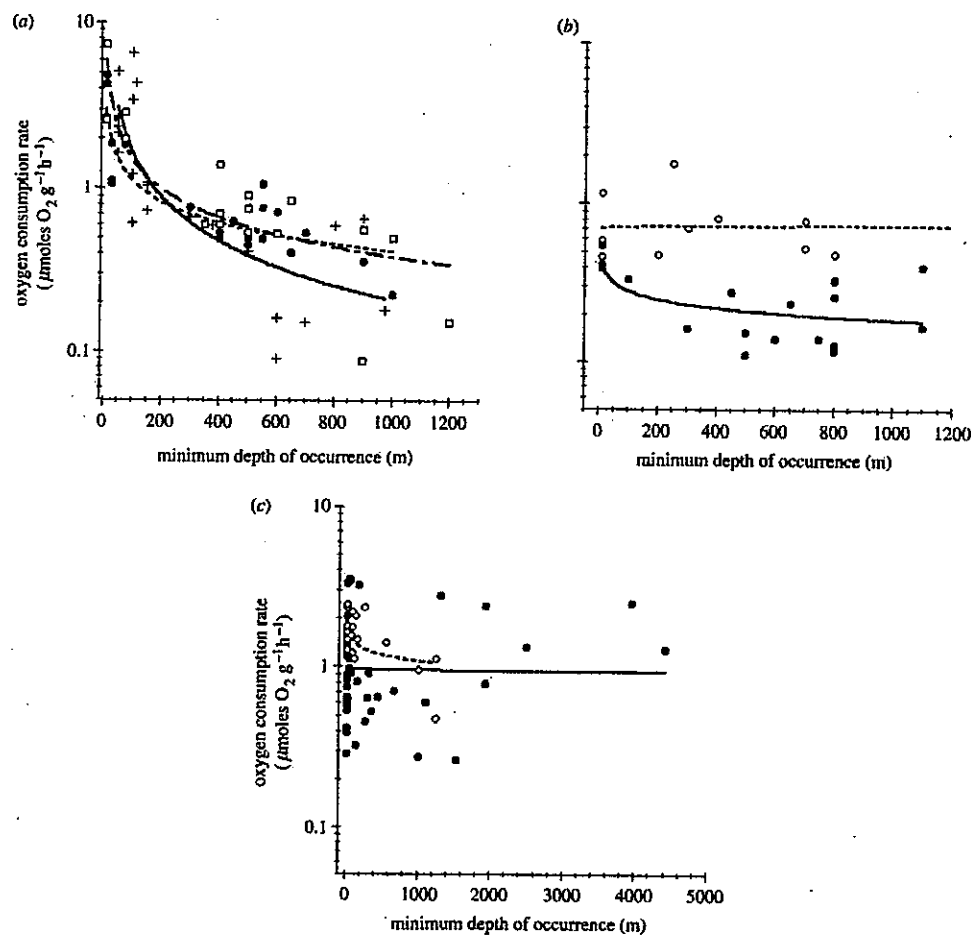
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Reference: Eddy et al. "Energy flow through marine ecosystems: confronting transfer efficiency." Trends in Ecology & Evolution 36.1 (2021): 76-86.

Energy flows and transfer efficiency shape the marine ecosystem. Based on these figures, please answer the following questions:

- (1) What is the general estimated percentage of energy transfer efficiency between trophic levels. (3 points)
- (2) Based on Figure B, please establish the energy budget equation in an individual organism. (5 points)
- (3) During the life cycle, benthic fishes may have a pelagic larval stage and then turn to benthic feeding as mature, but pelagic fishes may keep pelagic lifestyles in a whole life. Based on Figure C and D, what do you expect that differences of ontogenetic trophic increases between pelagic and benthic fishes? (5 points)
- (4) Please describe the concept of Figure D and do include the part of the microbial loop. Maximum 300 words. (6 points)

3.

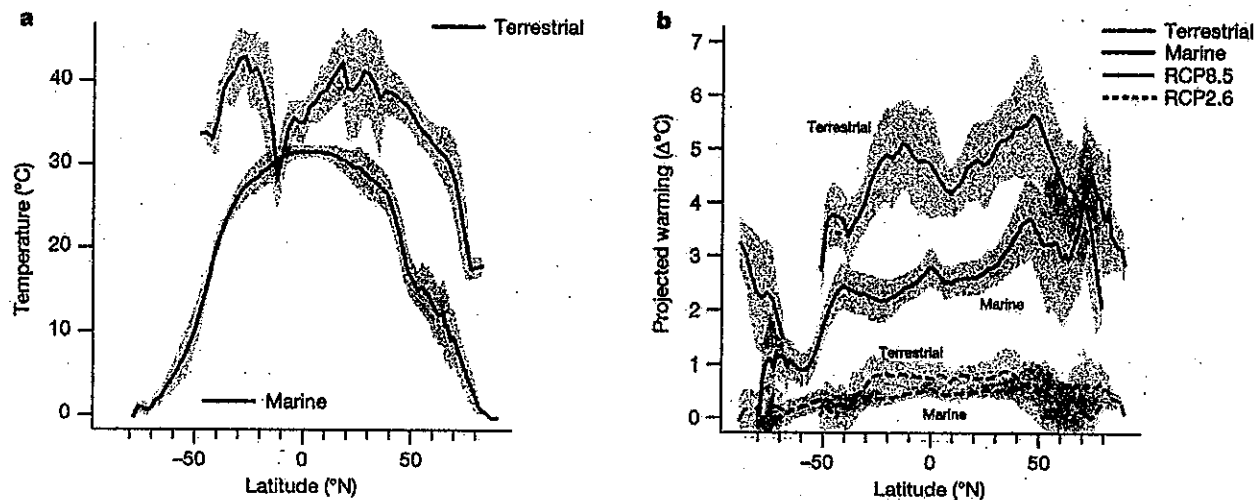


"Metabolic rates of diverse marine species as a function of minimum habitat depth. (a) Pelagic groups with image-forming eyes, including fish (closed circles,  $8.08 \text{ MDO}^{-0.43}$ ), cephalopods (plus signs,  $105.16 \text{ MDO}^{-0.90}$ ) and crustaceans (open squares,  $23.02 \text{ MDO}^{-0.59}$ ) show significant ( $p < 0.05$ ) declines in oxygen consumption rates with increasing depth. (b) Pelagic taxa lacking image-forming eyes, including chaetognaths (open circles, no significance) and medusae (closed circles,  $0.64 \text{ MDO}^{-0.18}$ ;  $p < 0.05$ ), show only subtle declines with depth where significant. (c) Benthic carridean decapod crustaceans (open circles,  $2.6 \text{ MDO}^{-0.13}$ ) show a modest decline with depth, while most benthic crustaceans (closed circles, no significance), including crabs, non-carridean decapods and aphipods, do not."

Reference: Brad and Drazen. "The rate of metabolism in marine animals: environmental constraints, ecological demands and energetic opportunities." Philosophical Transactions of the Royal Society B: Biological Sciences 362.1487 (2007): 2061-2078.

1. Please summarise the trends shown in figures and compare the trends between pelagic and benthic taxa. (5 points)
2. According to the core equation of the metabolic theory of ecology (Brown et al, 2004), which two are the main factors determining the metabolic rate of organisms? (a) body length, (b) body mass, (c) temperature, (d) age, or (e) gender. (4 points)
3. Please try to explain why oxygen consumption rate (metabolic rate) changes with habitat depths based on your answers in the previous question. Apart from those two factors, what factors may also influence the depth-related trends varied between pelagic and benthic taxa. Maximum 300 words. (7 points)

4.



"Data for terrestrial environments are shown in green; data for marine environments are shown in blue. a, The hottest hourly air or water-surface temperatures reveal that the warmest extremes are at mid-latitudes on land and in the tropics in the ocean.  $n = 1,454$  (land) or  $691,150$  (ocean) grid cells. b, Projected warming of the hottest hour across latitudes under RCP8.5 and RCP2.6 scenarios, comparing the change in temperatures from the 1986–2005 period to the 2081–2100 period.  $n = 3,106$  (land, both scenarios),  $28,925$  (ocean RCP2.6), or  $28,965$  (ocean RCP8.5) grid cells. In both plots, the line shows the mean and shaded areas show the s.d. across grid cells within each latitudinal band."

Reference: Pinsky et al. "Greater vulnerability to warming of marine versus terrestrial ectotherms." *Nature* 569.7754 (2019): 108-111.

1. RCP is an abbreviation of Representative Concentration Pathway. Currently scientists use RCP scenarios based on how future \_\_\_\_\_ concentrations will change. Please fill the blank. (3 points)
2. Please describe patterns that you observe in these two figures. (5 points)
3. Are terrestrial or marine ectotherms more sensitive to warming? Provide your point of views (please consider warming rate, thermal refugia, moving ability and any possible factors). Maximum 300 words. (7 points)