THE EFFECTS OF DEUTERIUM CONTENT VARIATION IN WATER ON BIOLOGICAL ACTIVITY

Lobyshev V.I., Kirkina A.A

Physics Department
M.V. Lomonosov Moscow State University
119991 Moscow, Russia

WATER IS A COMPLICATED LIQUID

- Dissociation: ions H^+, OH^- — 10^{-7} M
  hydrated ions H_3O^+, $H_3O_2^-$

- Active forms of oxygen and nitrogen
- Variable ox-red potential

- Dissolved gases, nanobubbles
- Dissolved organic and inorganic impurities

- Orto- and Para- water molecules

  ↑H H↑ ↑H H↓

  3 : 1 natural distribution

WATER IS A COMPLICATED LIQUID

- Enormous polymorphism of hydrogen – bonded structures

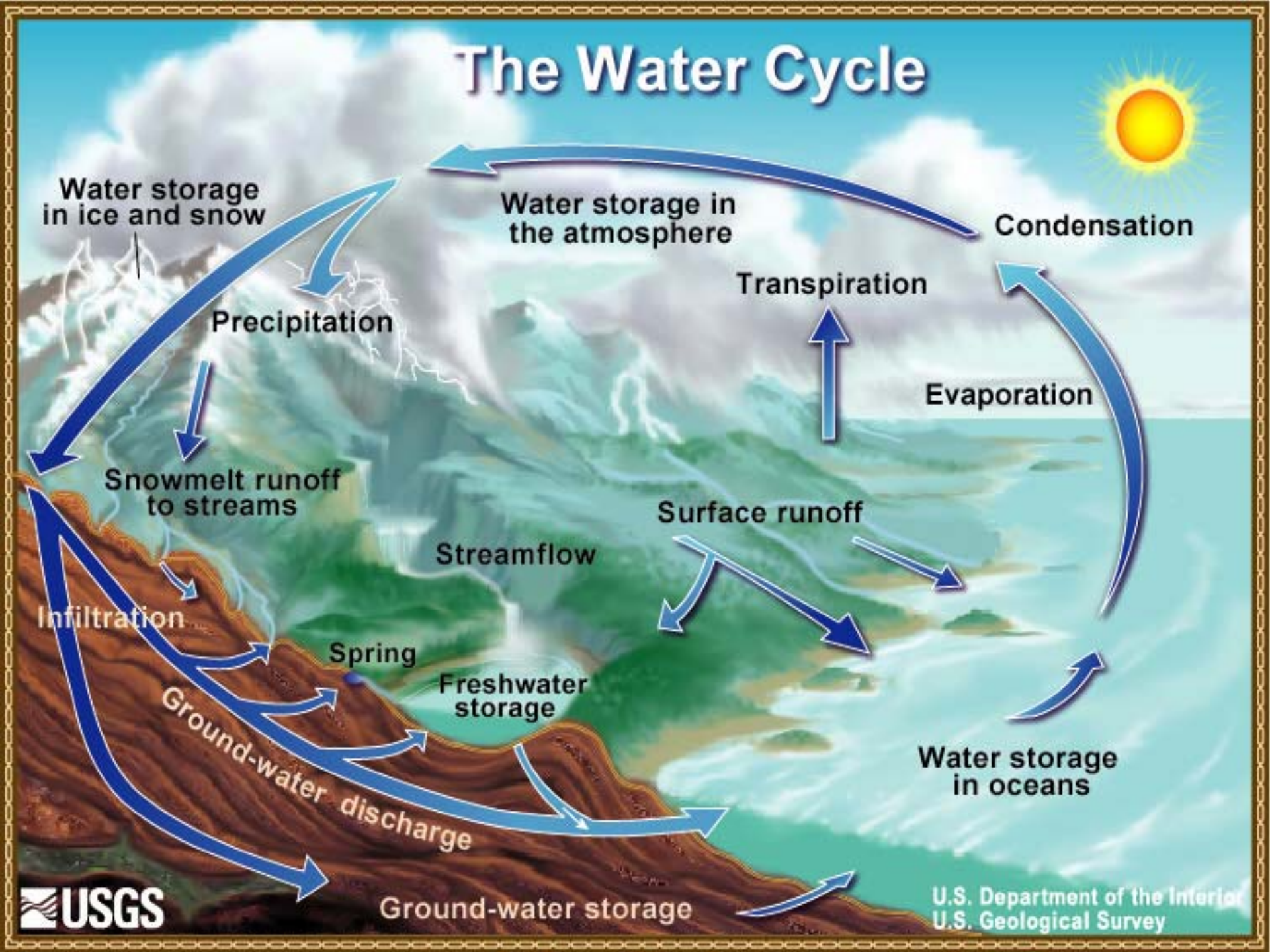
- Isotopic forms (mainly)

$H_2{}^{18}O$ $H_2{}^{17}O$ $DH^{16}O$

^{18}O — 0.20% 2000 ppm (~ 0.1M)

^{17}O — 0.04% 400 ppm (~ 0.02M)

^{2}H = (D) — 0.015% 150 ppm (~15mM)


The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Transpiration
Precipitation
Evaporation
Snowmelt runoff to streams
Surface runoff
Streamflow
Infiltration
Spring
Freshwater storage
Ground-water discharge
Water storage in oceans
Ground-water storage
USGS
U.S. Department of the Interior
U.S. Geological Survey

NATURAL VARIATION OF ISOTOPIC CONTENT

- ^{2}H (D) average 0,015%
  variation 0,0079 – 0,0195%
- ^{18}O average 0,2%
  variation 0,1887 – 0,2083%

WATER

LIGHT <——————> HEAVY

vapour liquid ice

rain, snow

THE PIONEER PAPERS

- Barnes T.C. A possible physiological effect of the heavy isotope of H in water/ // J. Amer. Chem. Soc., 1933, v.55, N10, p.4332-4333.
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- Barnes T.C., Larson E.J. Further experiments on the physiological effect of heavy water and of ice water. // J. Amer. Chem. Soc., 1933, v.55, N 12, p.5059-5060.
- Richards O.W. The growth of yeast in water containing deuterium. // Amer. J. Botany, 1933, v. 20, N 10, p.679-680.
- Mayer S.L. Deuterium oxide and Aspergillus. // Science, 1934, v.79, N2044, p.210-211
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- Curry J., Pratt R., Trelease S.F. Does dilute heavy water influence biological processes. //Science, 1935, v.81, p.275-277.

ISOTOPIC EFFECTS OF MELTED SNOW

- Родимов Б.Н. Снеговая вода – стимулятор роста и продуктивности животных и растений. // Сельское хозяйство Сибири. Омск, 1961, №7б, с.66-69.

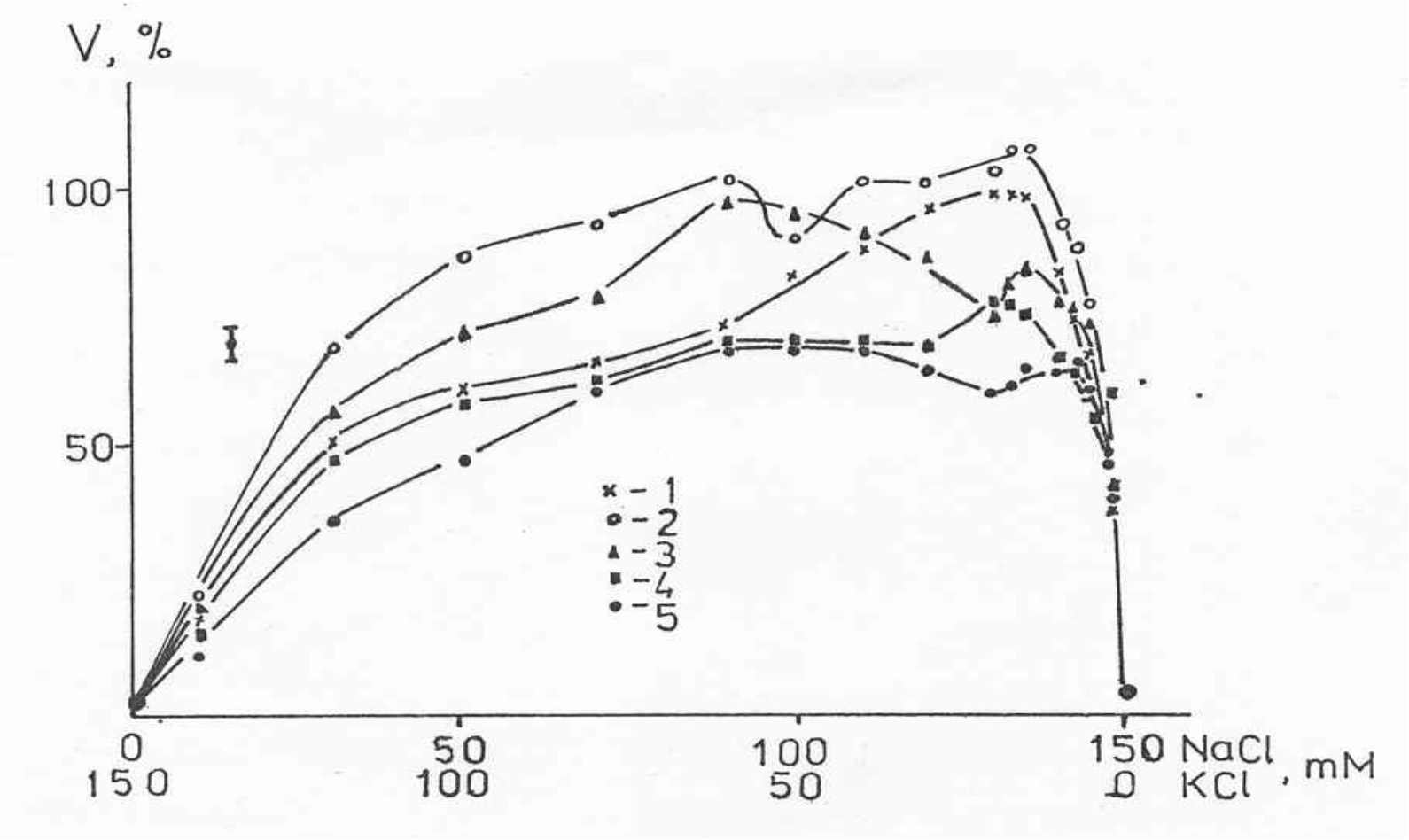
- Родимов Б.Н., Маршунина А., Яфарова И. Действие снеговой воды на живые организмы. // Сельскохозяйственное производство Сибири и Дальнего Востока. Омск, 1965, №4, с.56-57.

- Торопцев И.В., Родимов Б.Н., Маршунина А.М., Яфарова И.О., Садовникова В.И., Лобина И.Г. Биологическая роль тяжелой воды в живых организмах. // Вопросы радиобиологии и гематологии. Изд. Томского ун-та, 1966, с.118-126.

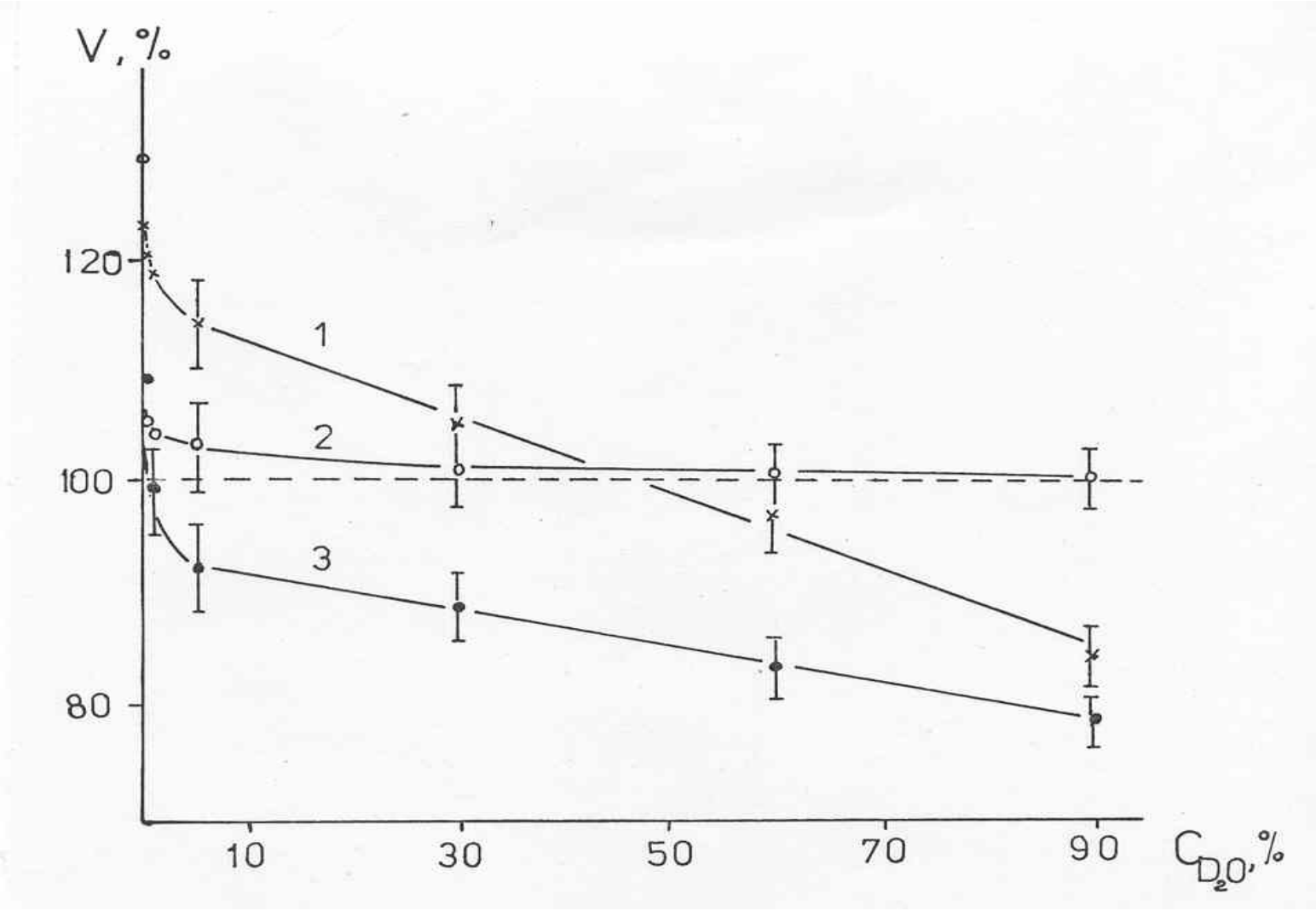
Drosophila generation	1	2	3	Control
Male,%	41.4	40.7	39.6	48.0
Female,%	58.6	59.3	60.4	52.0

- Gleason J.D., Friedman I. Oats may grow better in water depleted in oxygen−18 and deuterium. //Nature, 1975, v.256, N5505, p.305.

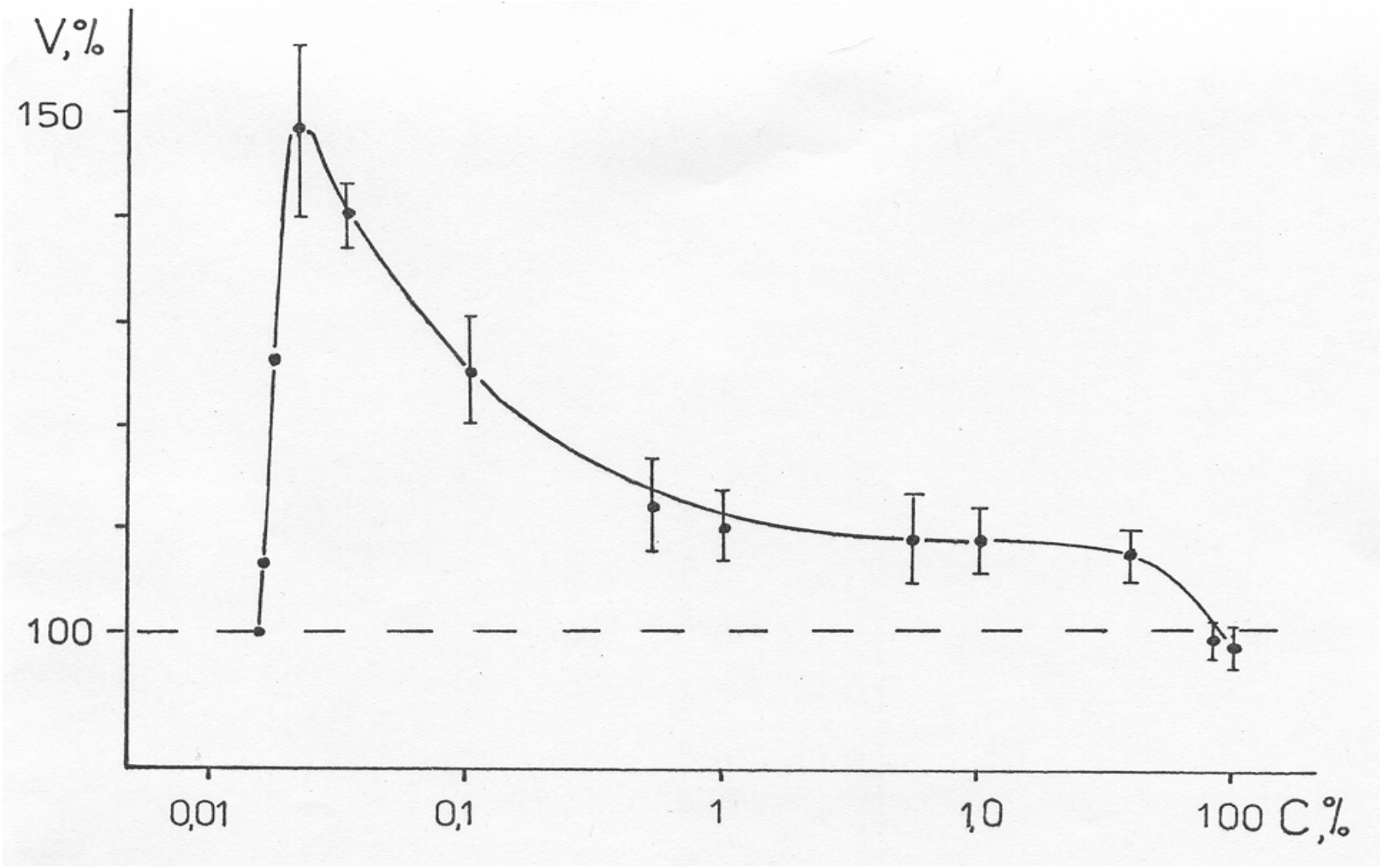
Hydrolytic activity of Na, K – ATPase at T=37^{0}C and various content of deuterium: 1-H_2O, 2-0,05%, 3-30%, 4-60%, 5-90% D_2O



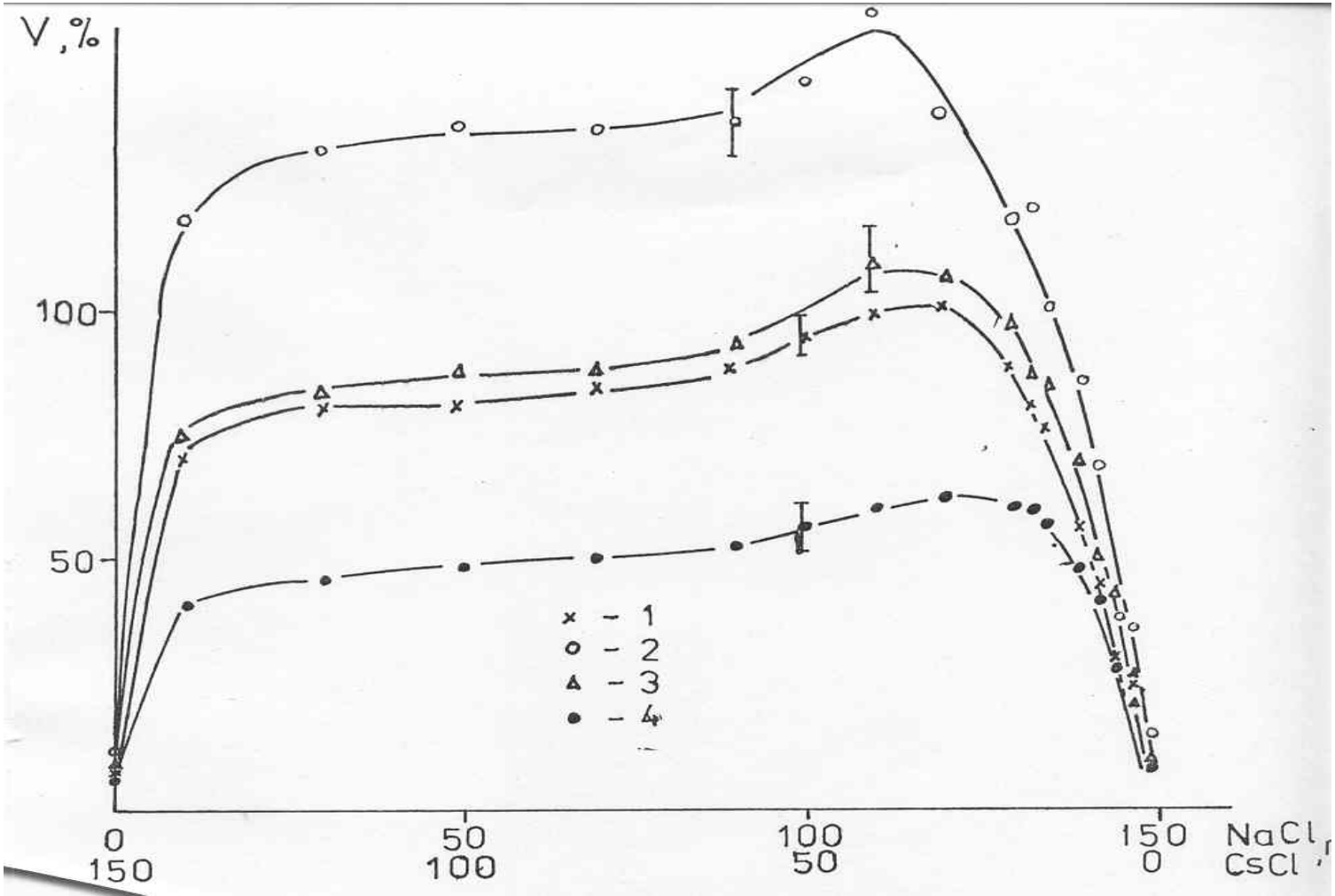
Hydrolytic activity of Na, K – ATPase at T=37^{0}C and various content of Na/K (mM): 1-50/100, 2-70/80, 3-135/15



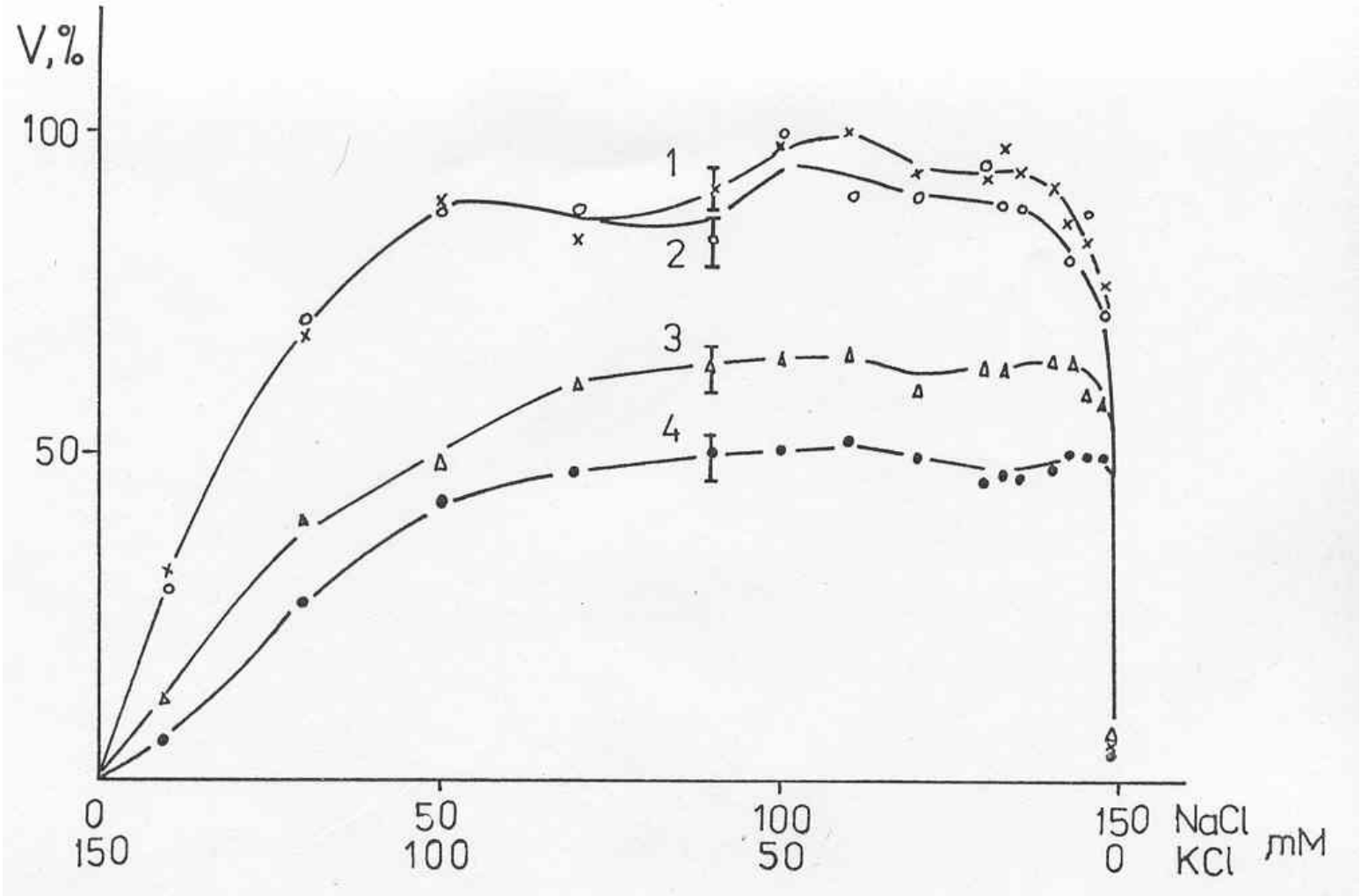
Hydrolytic activity of Na,K – ATPase at various amount of deuterium in water Na/K = 70/80 mM



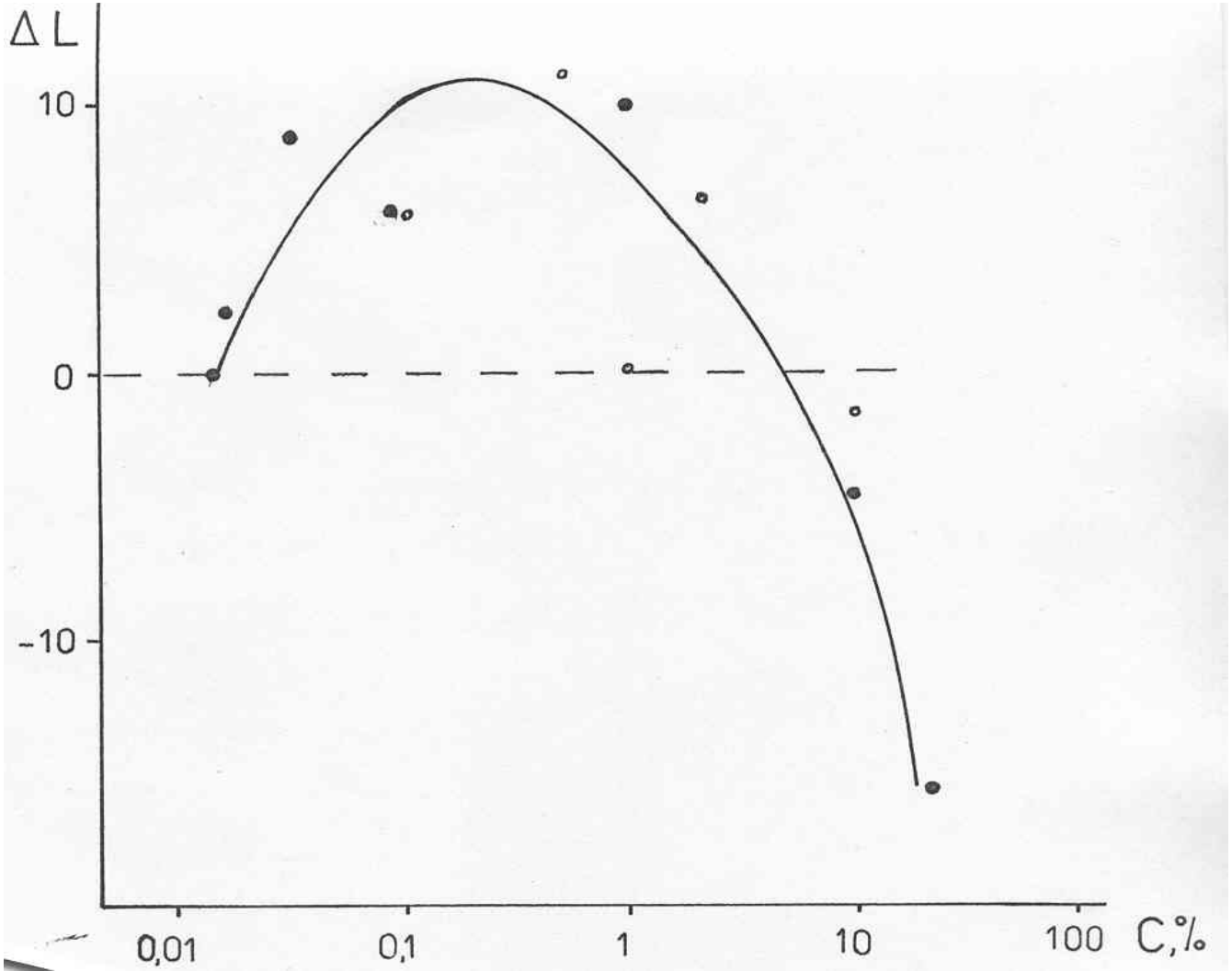
Hydrolytic activity of Na, K – ATPase in Na/Cs media T=37^{0}C and various content of deuterium: 1-H_2O, 2-0,05%, 3-30%, 4-90% D_2O



Hydrolytic activity of Na, K – ATPase at T=13^{0}C and various content of deuterium: 1-H_2O, 2-0,05%, 3-30%, 4-90% D_2O

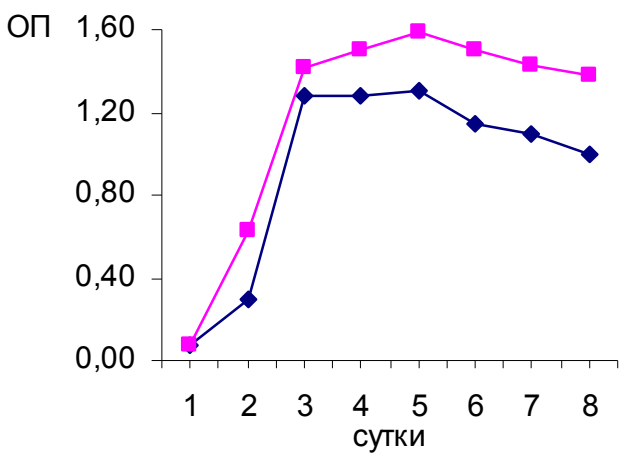


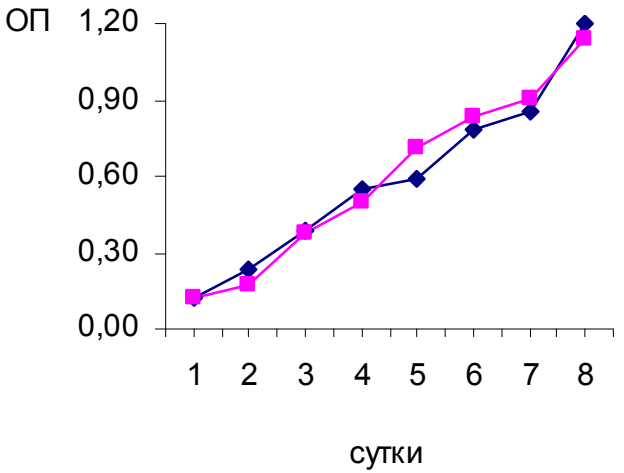
Regeneration of hydroids *Obelia geniculata* in sea water with various content of D_2O . $\Delta L = L_D - L_H$ (arb. units)

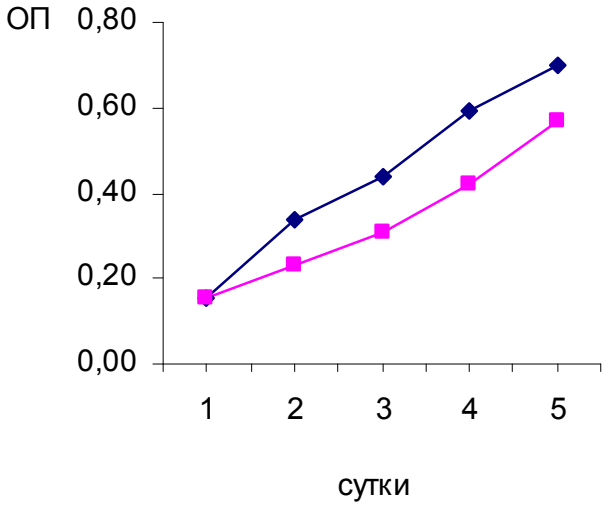
- 

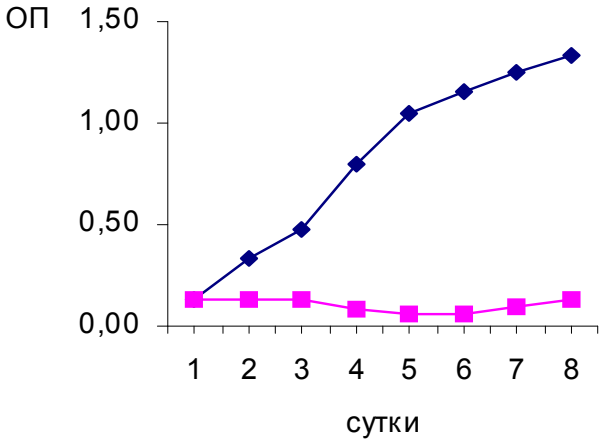
Growth of *Methylobacterium organophilum* in water (blue) with various content of deuterium (red):

A-0,01, B-1, C-50, D-88%.



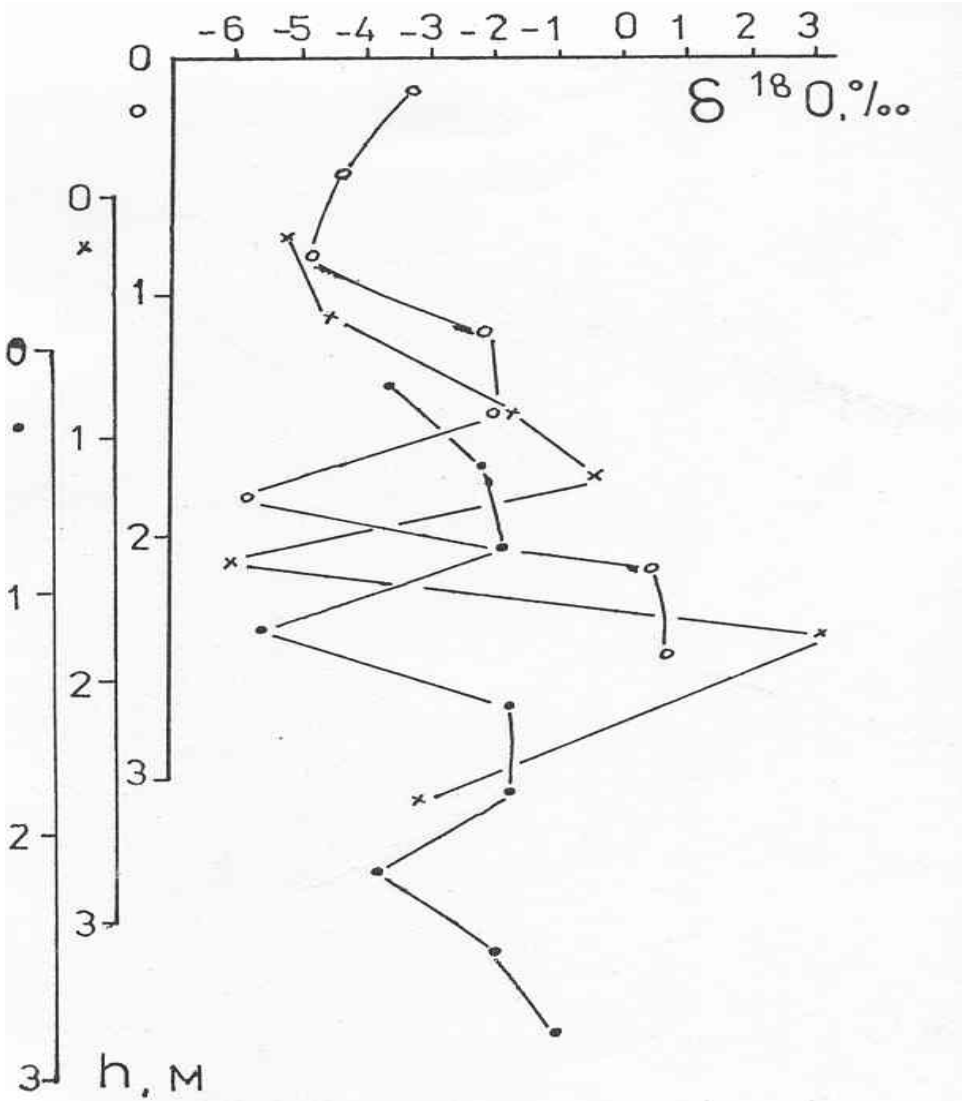




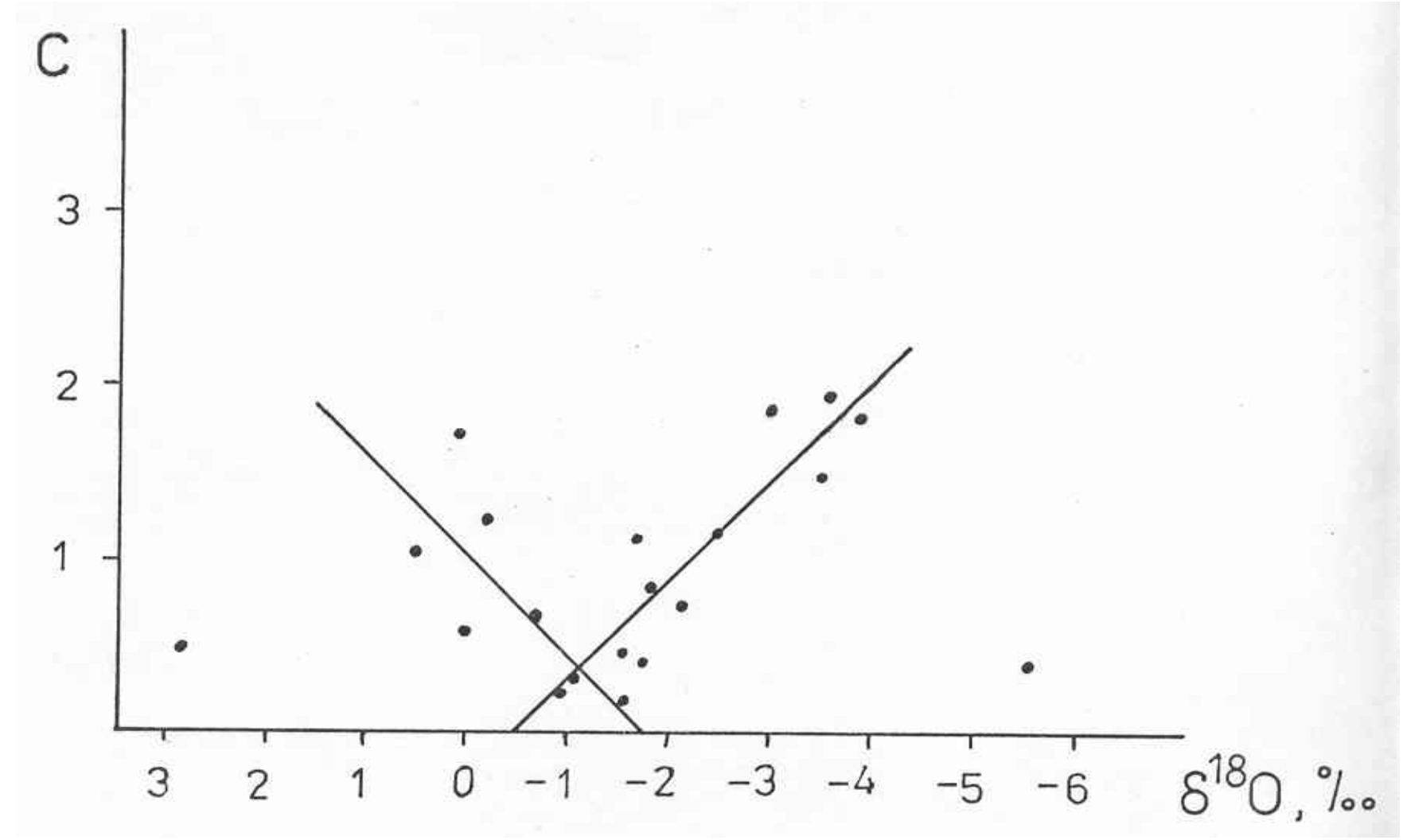


Vertical variation of isotopic content of water oxygen in arctic drifting ice SP-23 Craig line $\delta D = 8\delta^{18}O - 10$

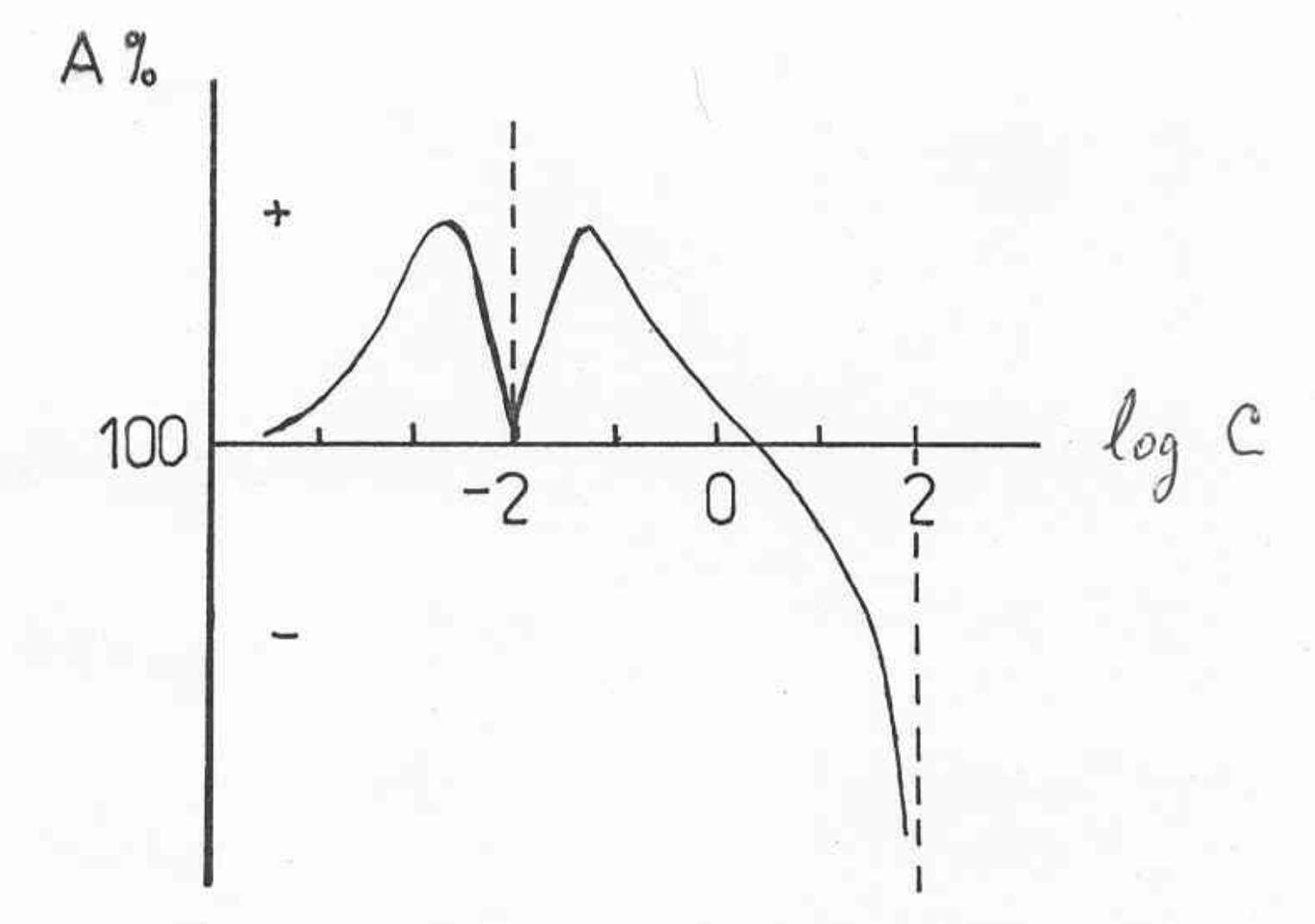
"0" corresponds to the surface of ice in june, july and april 1977-78



The amount of blue-green algae (carotinoids) against ^{18}O content in arctic drifting ice. The cross point corresponds to the isotopic content of ancient ocean (-1,3 $\delta^{18}O$).



The hypothesis for deuterium action on biological systems



Hydrolytic activity of Na,K-ATPase from nasal salt glands of a duck in depleted deuterium water

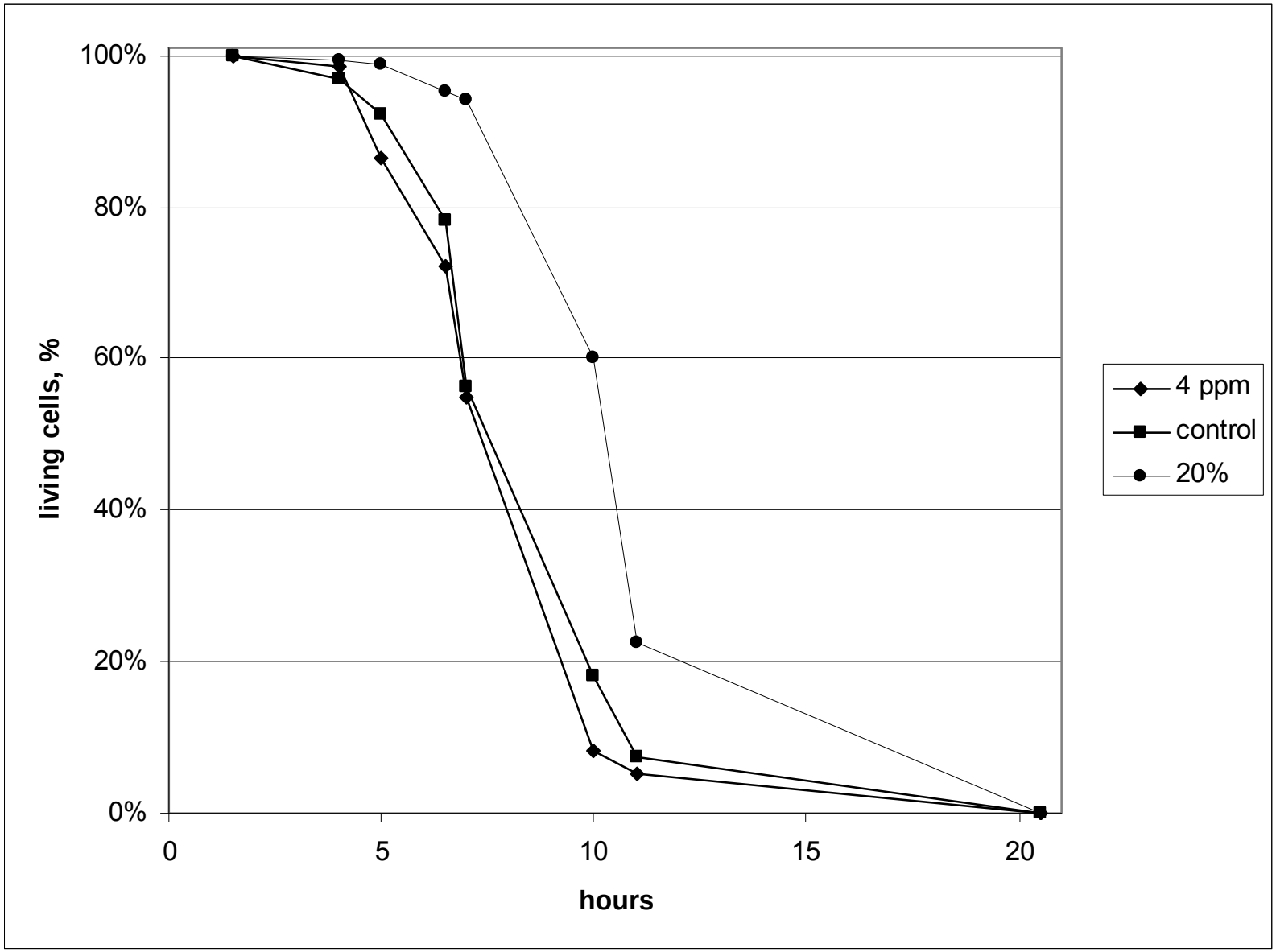
Deuterium content	Hydrolytic activity
9.9%	169 ± 8 arb.units
4.95%	174 ± 4 arb. units
150 ppm	179 ±10 arb. units
24 ppm	158 ±12 arb. units
4 ppm	181 ± 9 arb. units

- Confidence interval 95%

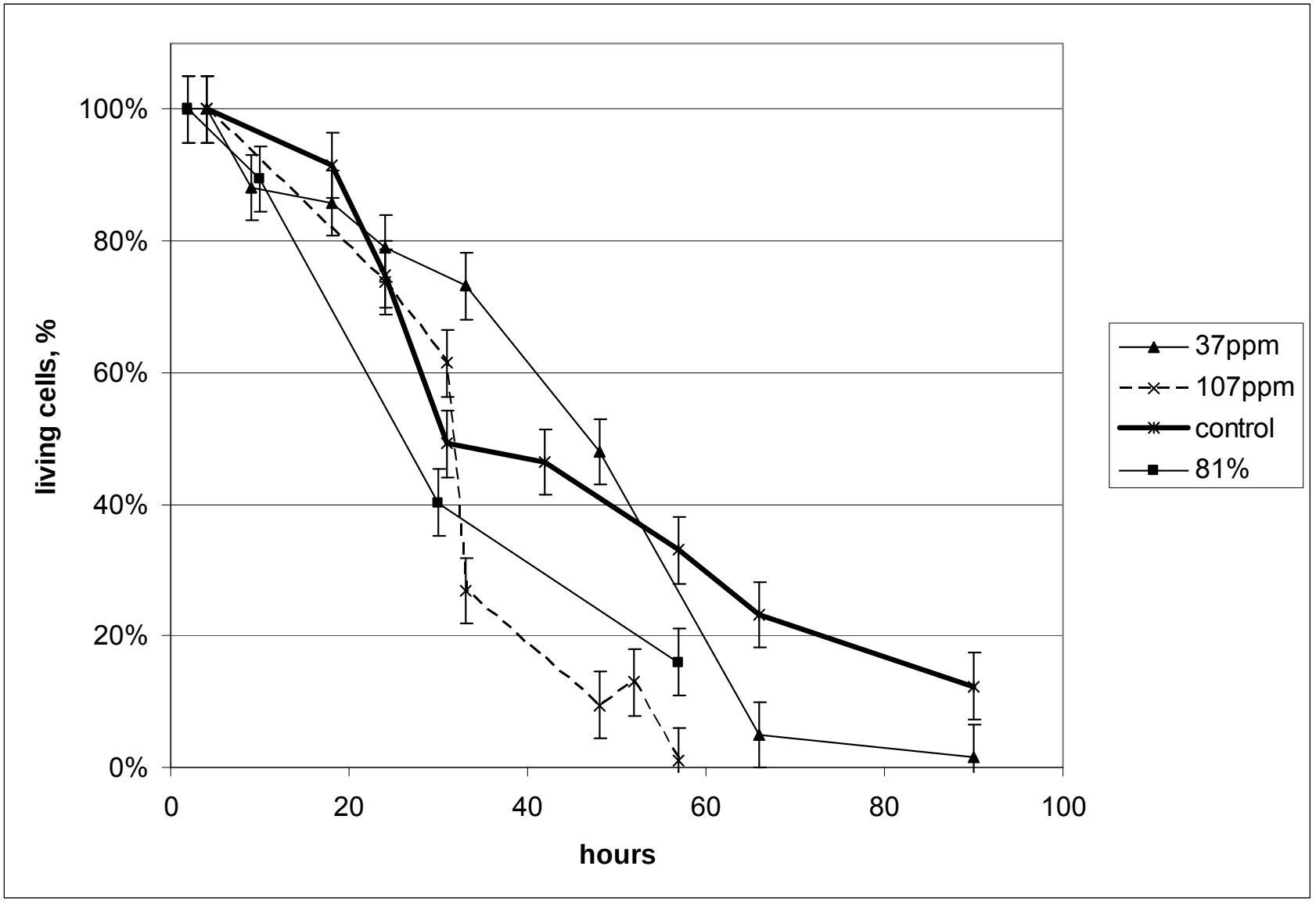
Development of fertilized loach roe *(Misgurnus fossils)* during six days of incubation

	Initial number of roe	Number of living roes (number of anomalous)	Living roes, %	Anomalous roes/living roes, %
Control	166	25 (6)	15	24
14 ppm	165	53 (16)	32	30
D_2O, 20%	40	0	0	0

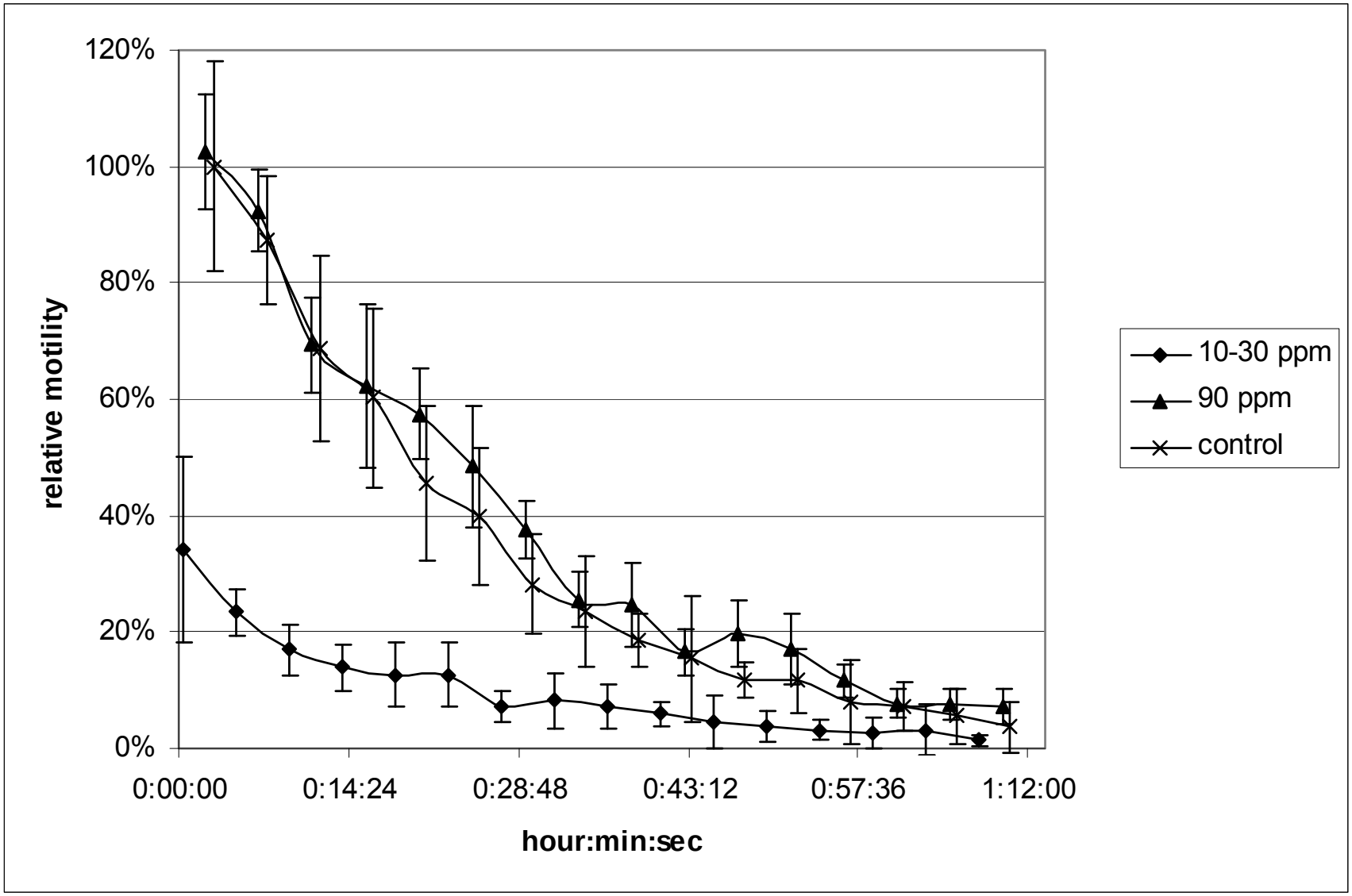
Dying dynamics of non-fertilized roe



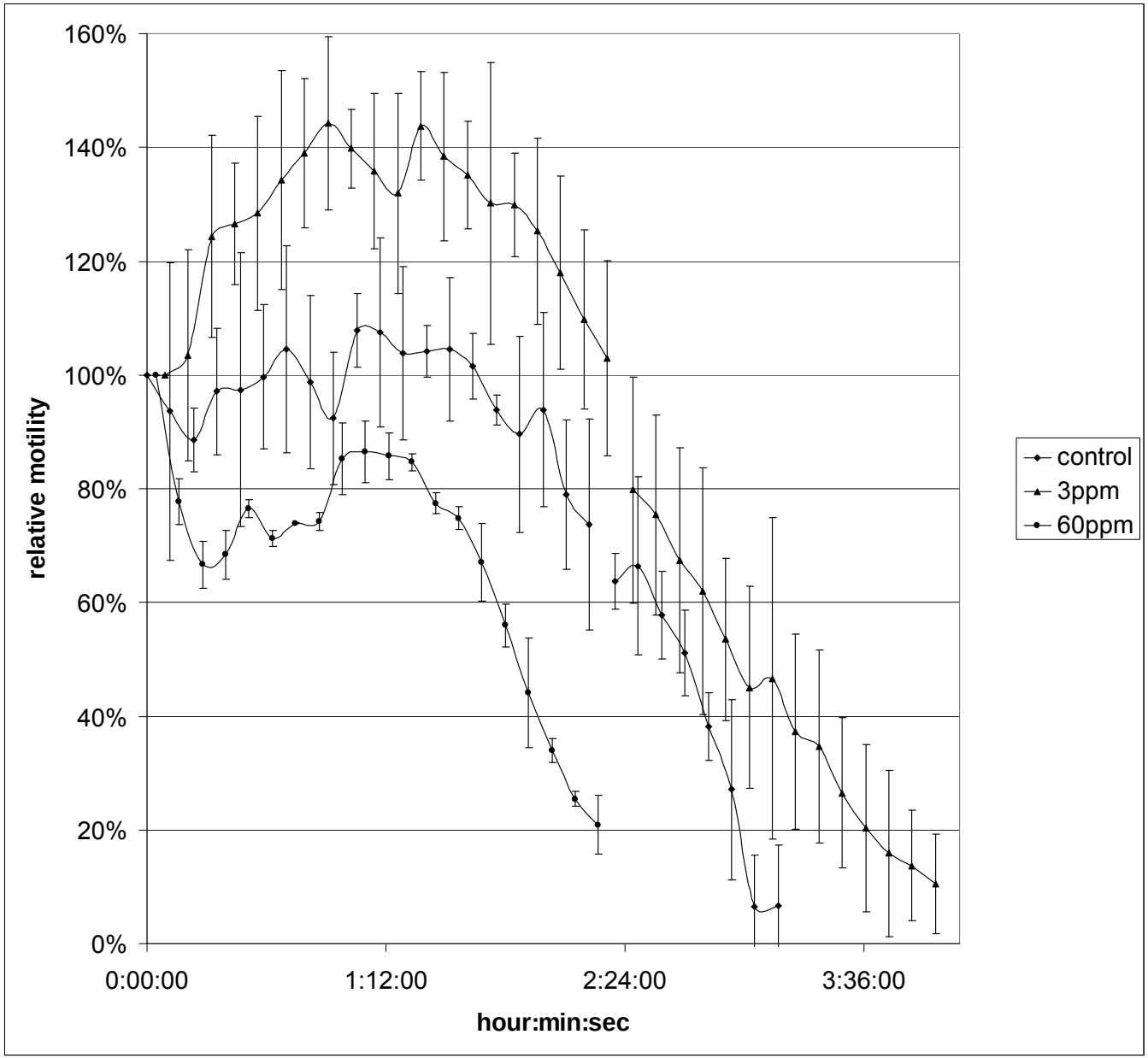
Survival curve for human spermatozoa



Motility of bovine sperm cells after unfreezing



Motility of human sperm cells



Acknowledgments

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- THANK YOU FOR ATTENTION