

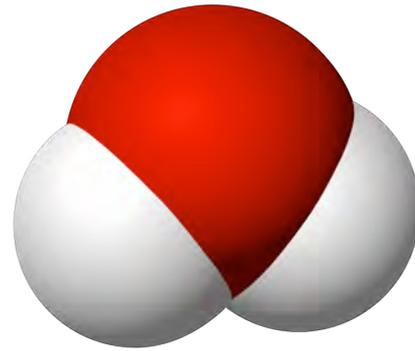


スーパーコンピュータによる  
水・氷・ハイドレートの科学

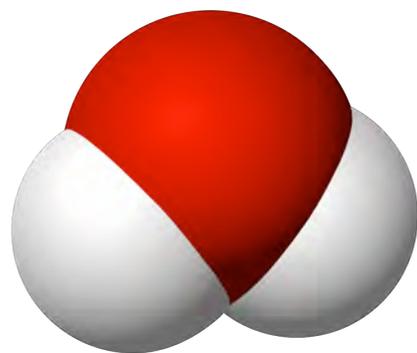
松本 正和

岡山大学 大学院自然科学研究科

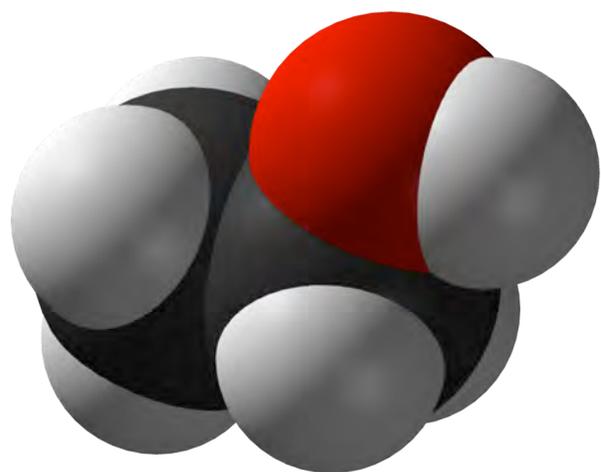
化学 = 分子の学問



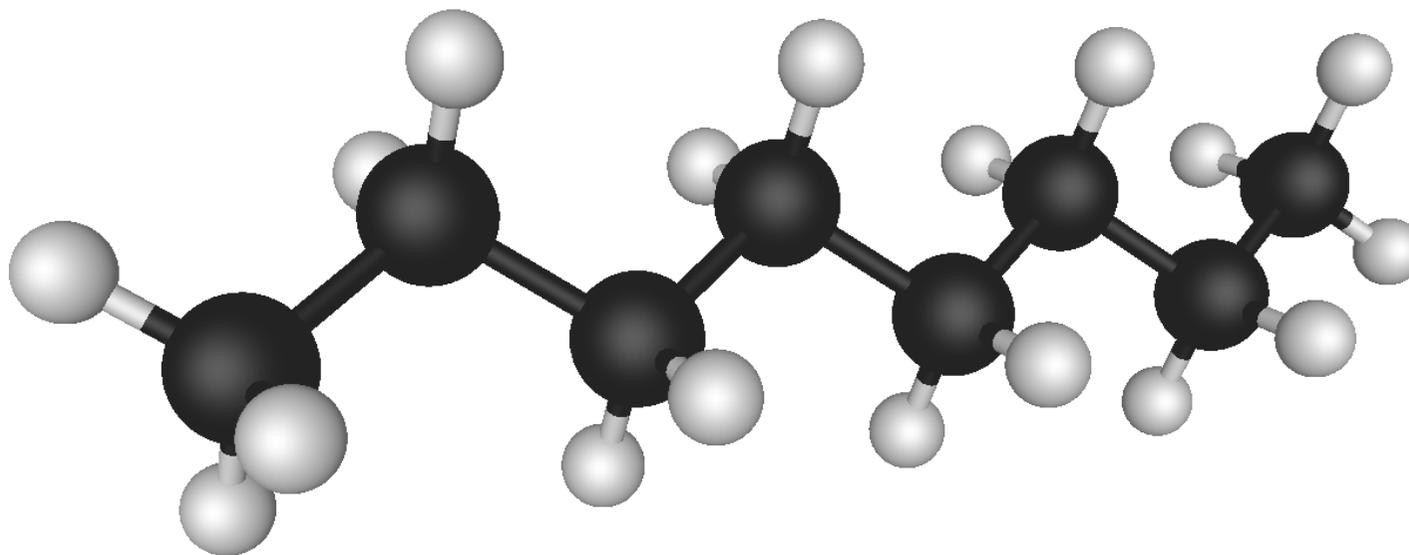
水



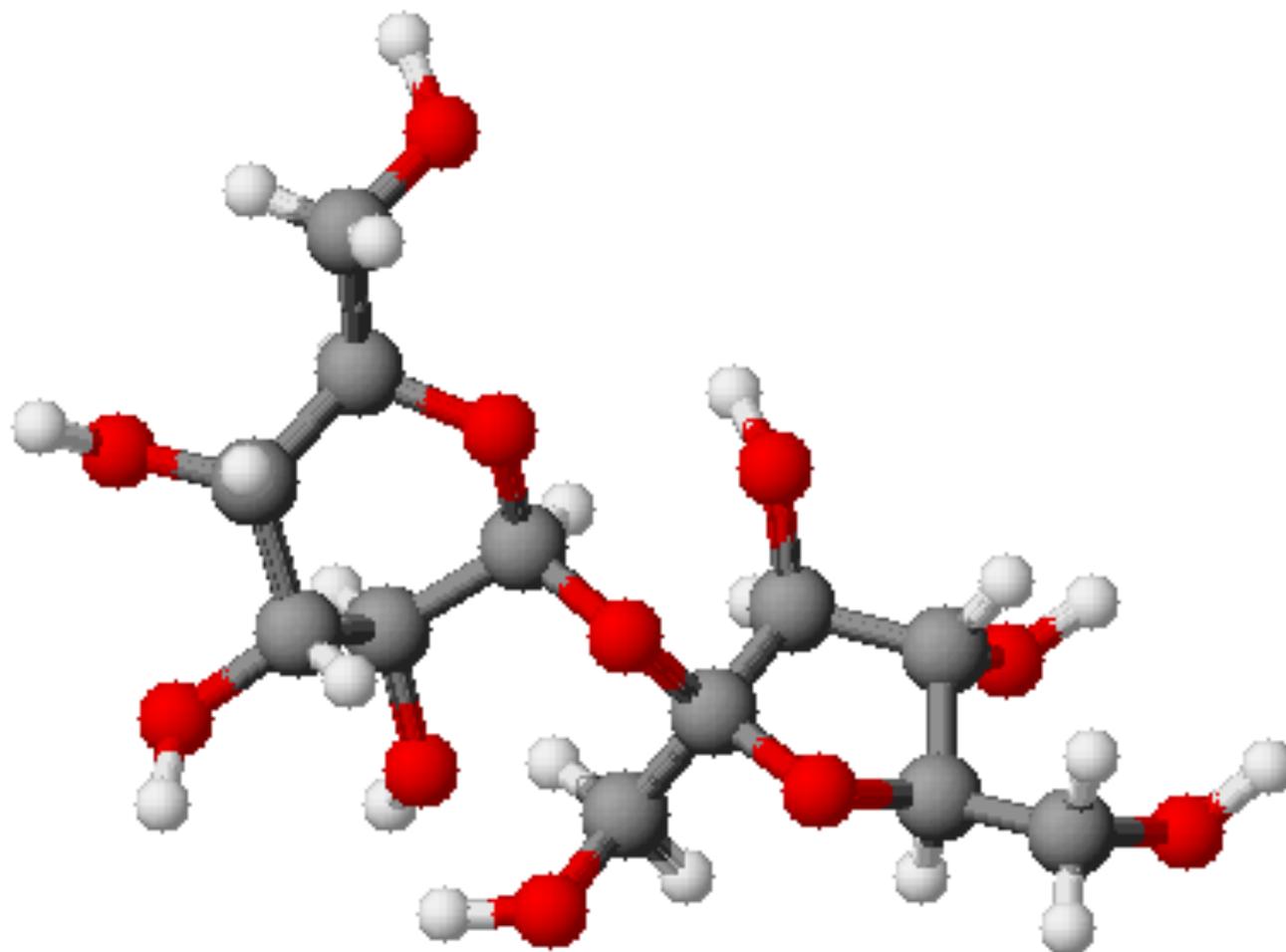
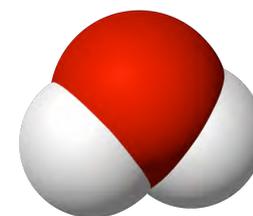
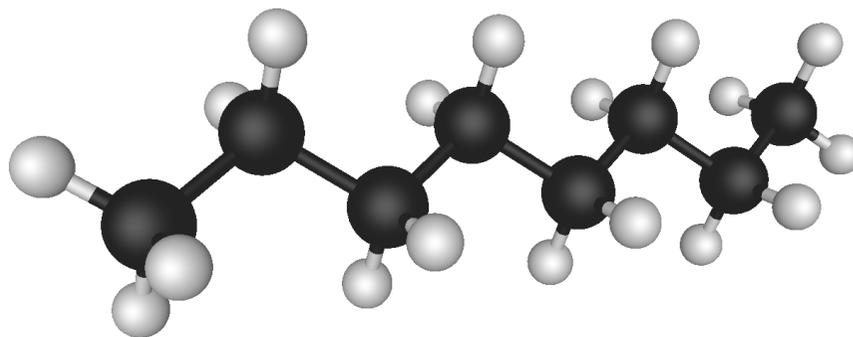
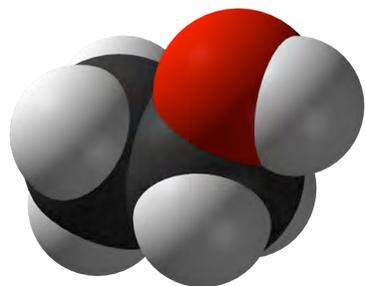
水

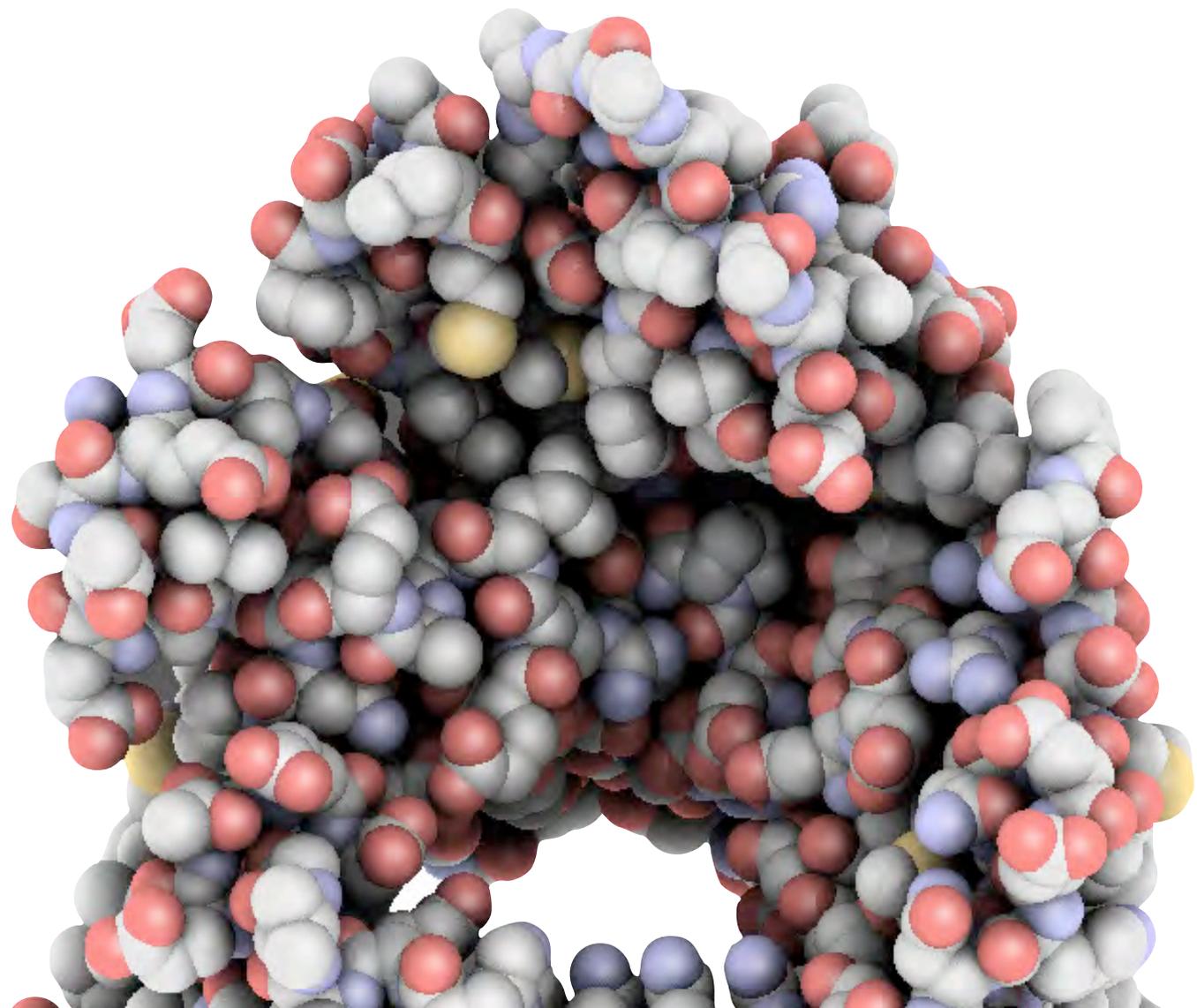
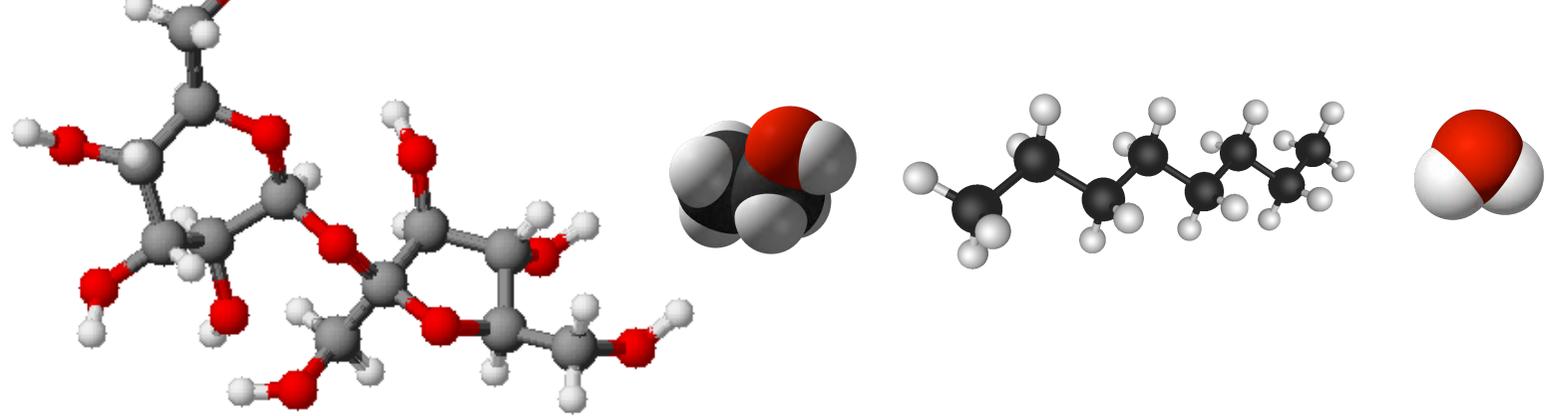


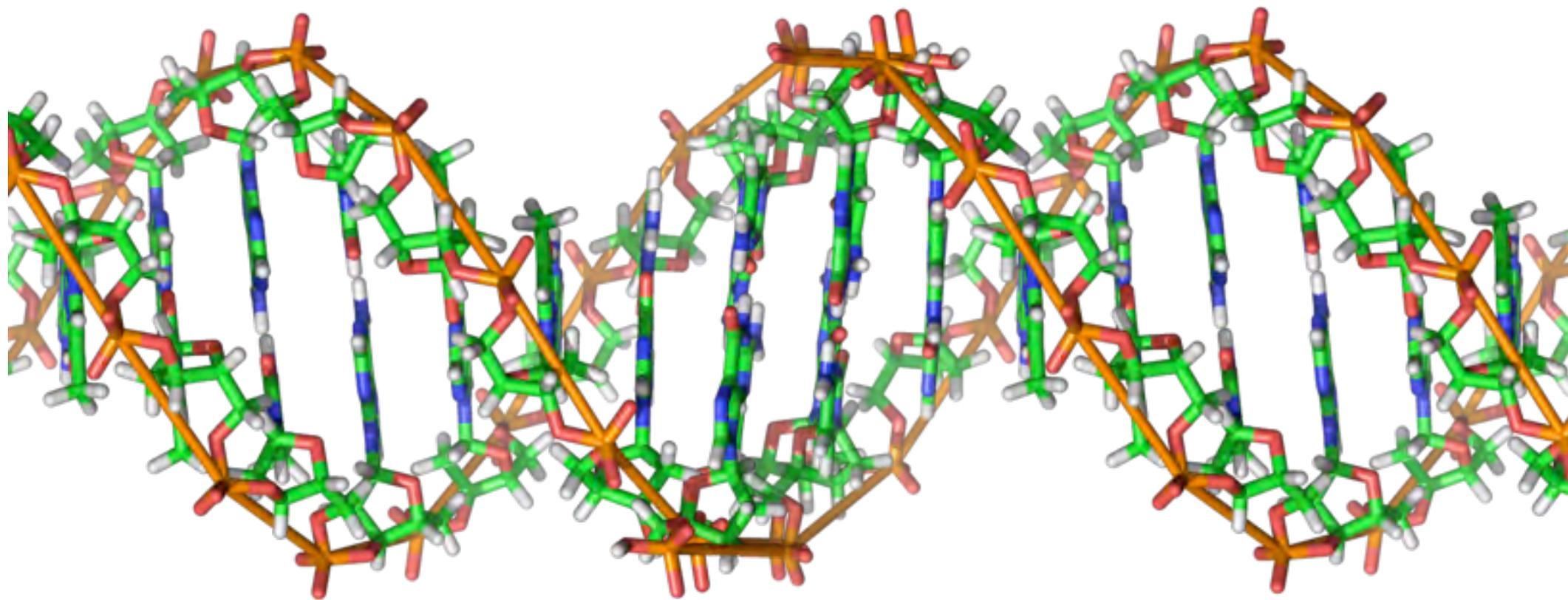
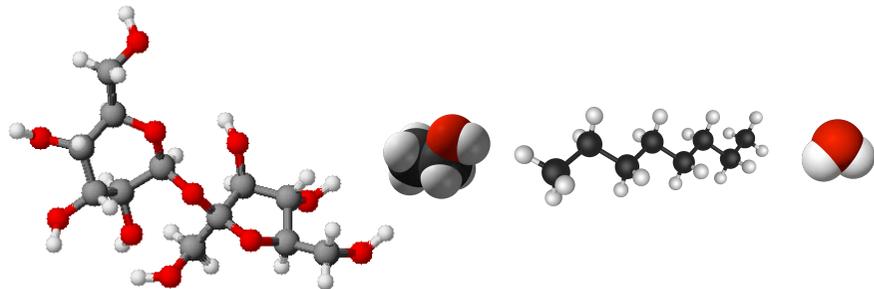
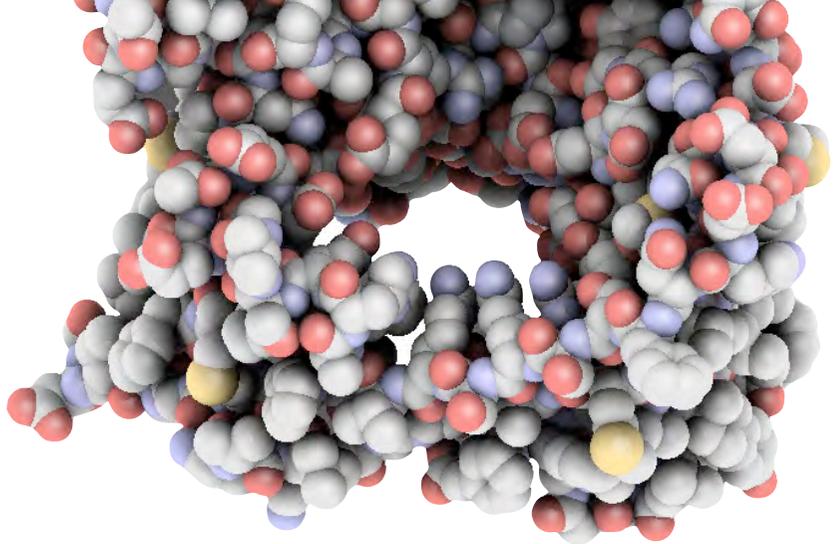
エタノール



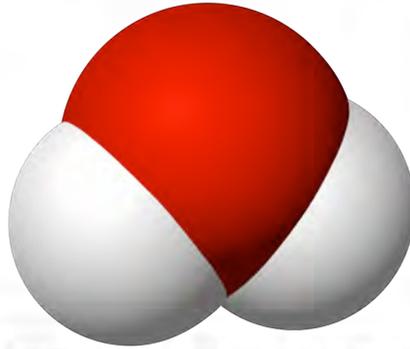
オクタン (ガソリン)



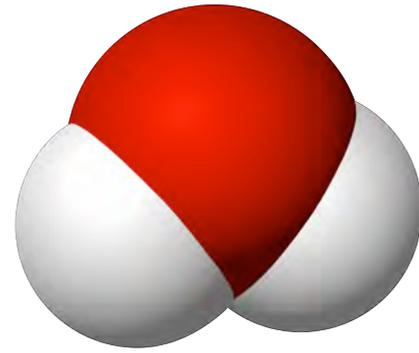




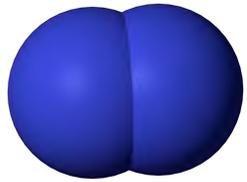
# Periodic Table of the Elements



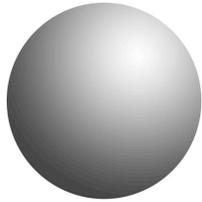
1 <b>H</b>																	2 <b>He</b>
3 <b>Li</b>	4 <b>Be</b>											5 <b>B</b>	6 <b>C</b>	7 <b>N</b>	8 <b>O</b>	9 <b>F</b>	10 <b>Ne</b>
11 <b>Na</b>	12 <b>Mg</b>											13 <b>Al</b>	14 <b>Si</b>	15 <b>P</b>	16 <b>S</b>	17 <b>Cl</b>	18 <b>Ar</b>
19 <b>K</b>	20 <b>Ca</b>	21 <b>Sc</b>	22 <b>Ti</b>	23 <b>V</b>	24 <b>Cr</b>	25 <b>Mn</b>	26 <b>Fe</b>	27 <b>Co</b>	28 <b>Ni</b>	29 <b>Cu</b>	30 <b>Zn</b>	31 <b>Ga</b>	32 <b>Ge</b>	33 <b>As</b>	34 <b>Se</b>	35 <b>Br</b>	36 <b>Kr</b>
37 <b>Rb</b>	38 <b>Sr</b>	39 <b>Y</b>	40 <b>Zr</b>	41 <b>Nb</b>	42 <b>Mo</b>	43 <b>Tc</b>	44 <b>Ru</b>	45 <b>Rh</b>	46 <b>Pd</b>	47 <b>Ag</b>	48 <b>Cd</b>	49 <b>In</b>	50 <b>Sn</b>	51 <b>Sb</b>	52 <b>Te</b>	53 <b>I</b>	54 <b>Xe</b>
55 <b>Cs</b>	56 <b>Ba</b>	57~71 <b>La-Lu</b>	72 <b>Hf</b>	73 <b>Ta</b>	74 <b>W</b>	75 <b>Re</b>	76 <b>Os</b>	77 <b>Ir</b>	78 <b>Pt</b>	79 <b>Au</b>	80 <b>Hg</b>	81 <b>Tl</b>	82 <b>Pb</b>	83 <b>Bi</b>	84 <b>Po</b>	85 <b>At</b>	86 <b>Rn</b>
87 <b>Fr</b>	88 <b>Ra</b>	89~103 <b>Ac-Lr</b>	104 <b>Rf</b>	105 <b>Db</b>	106 <b>Sg</b>	107 <b>Bh</b>	108 <b>Hs</b>	109 <b>Mt</b>	110 <b>Ds</b>	111 <b>Rg</b>	112 <b>Cn</b>						
			57 <b>La</b>	58 <b>Ce</b>	59 <b>Pr</b>	60 <b>Nd</b>	61 <b>Pm</b>	62 <b>Sm</b>	63 <b>Eu</b>	64 <b>Gd</b>	65 <b>Tb</b>	66 <b>Dy</b>	67 <b>Ho</b>	68 <b>Er</b>	69 <b>Tm</b>	70 <b>Yb</b>	71 <b>Lu</b>
			89 <b>Ac</b>	90 <b>Th</b>	91 <b>Pa</b>	92 <b>U</b>	93 <b>Np</b>	94 <b>Pu</b>	95 <b>Am</b>	96 <b>Cm</b>	97 <b>Bk</b>	98 <b>Cf</b>	99 <b>Es</b>	100 <b>Fm</b>	101 <b>Md</b>	102 <b>No</b>	103 <b>Lr</b>



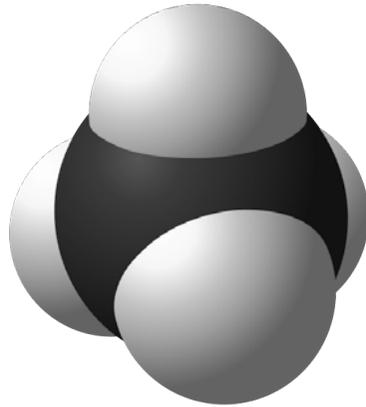
水



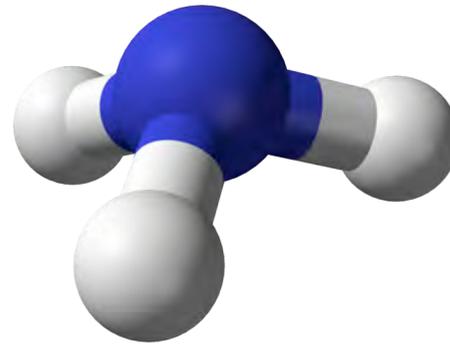
水素



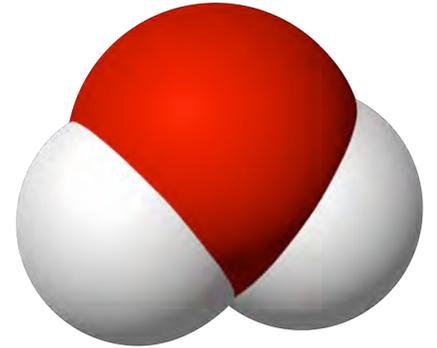
ヘリウム



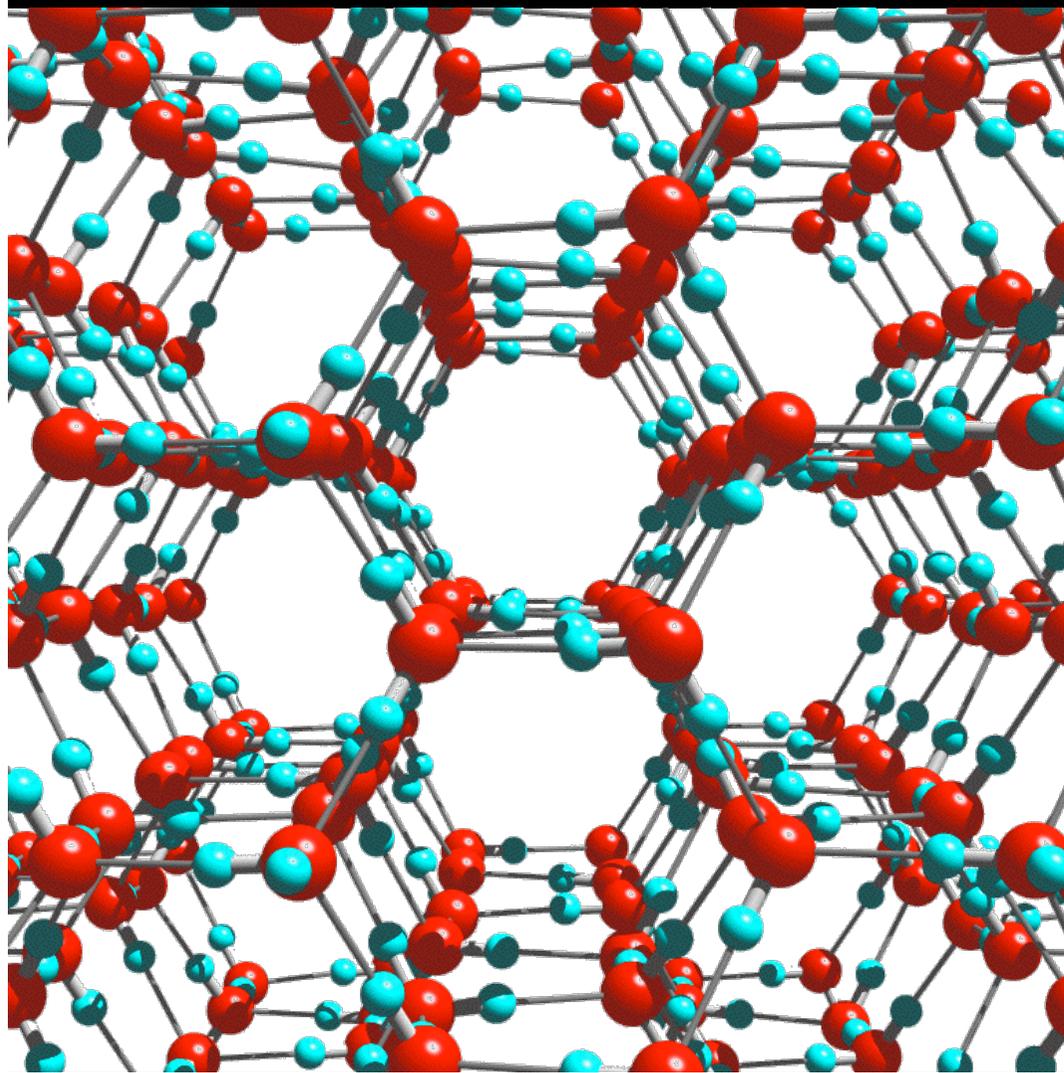
メタン



アンモニウム



水





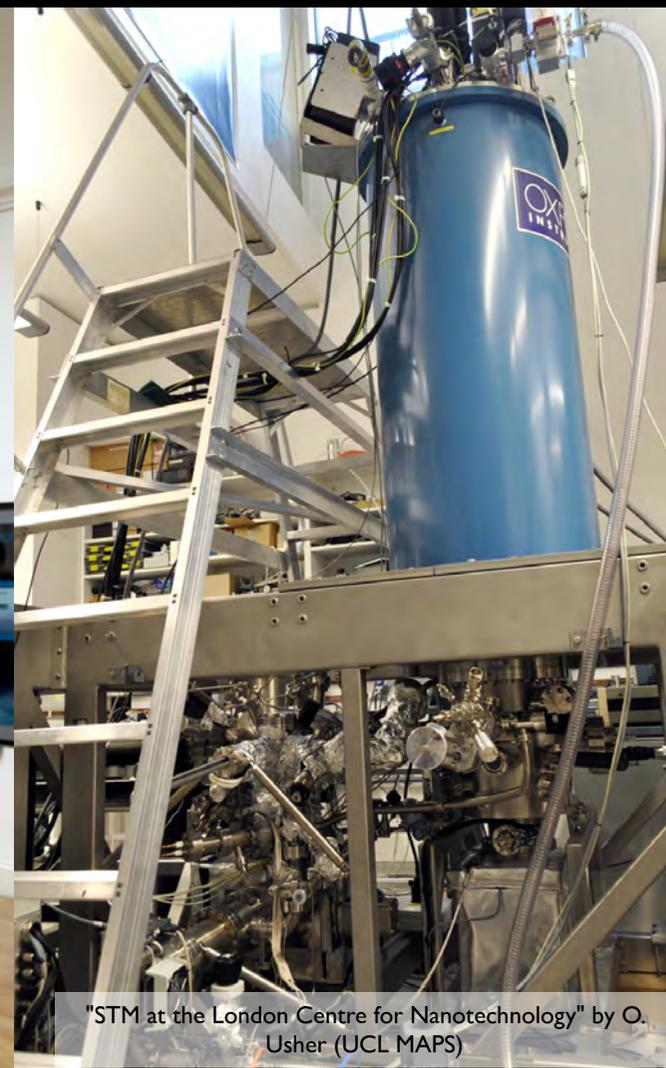
?



"Microscope" by Original uploader was Zephyris

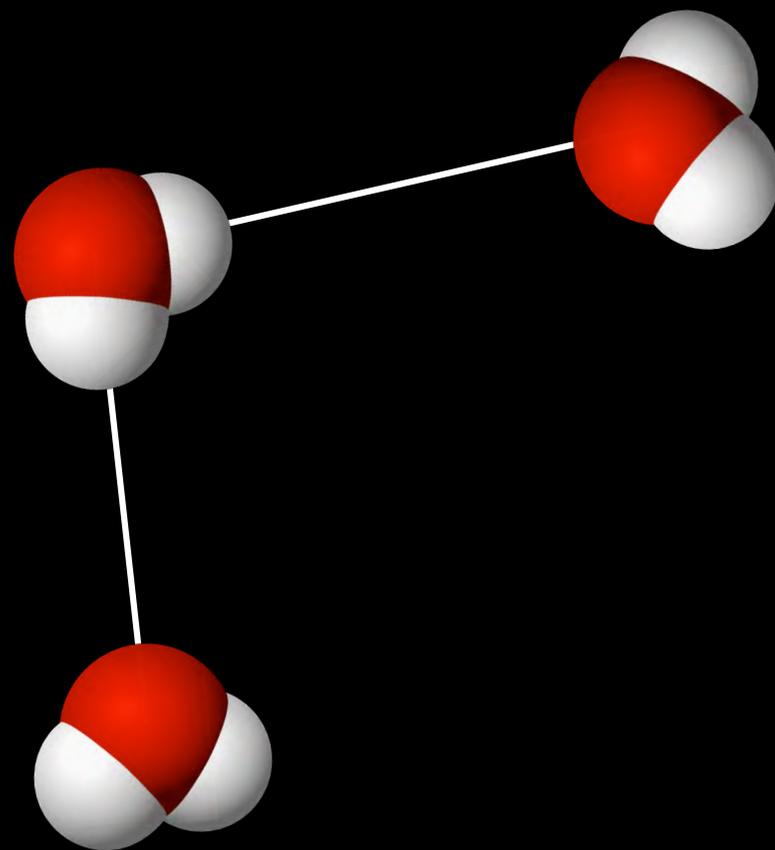


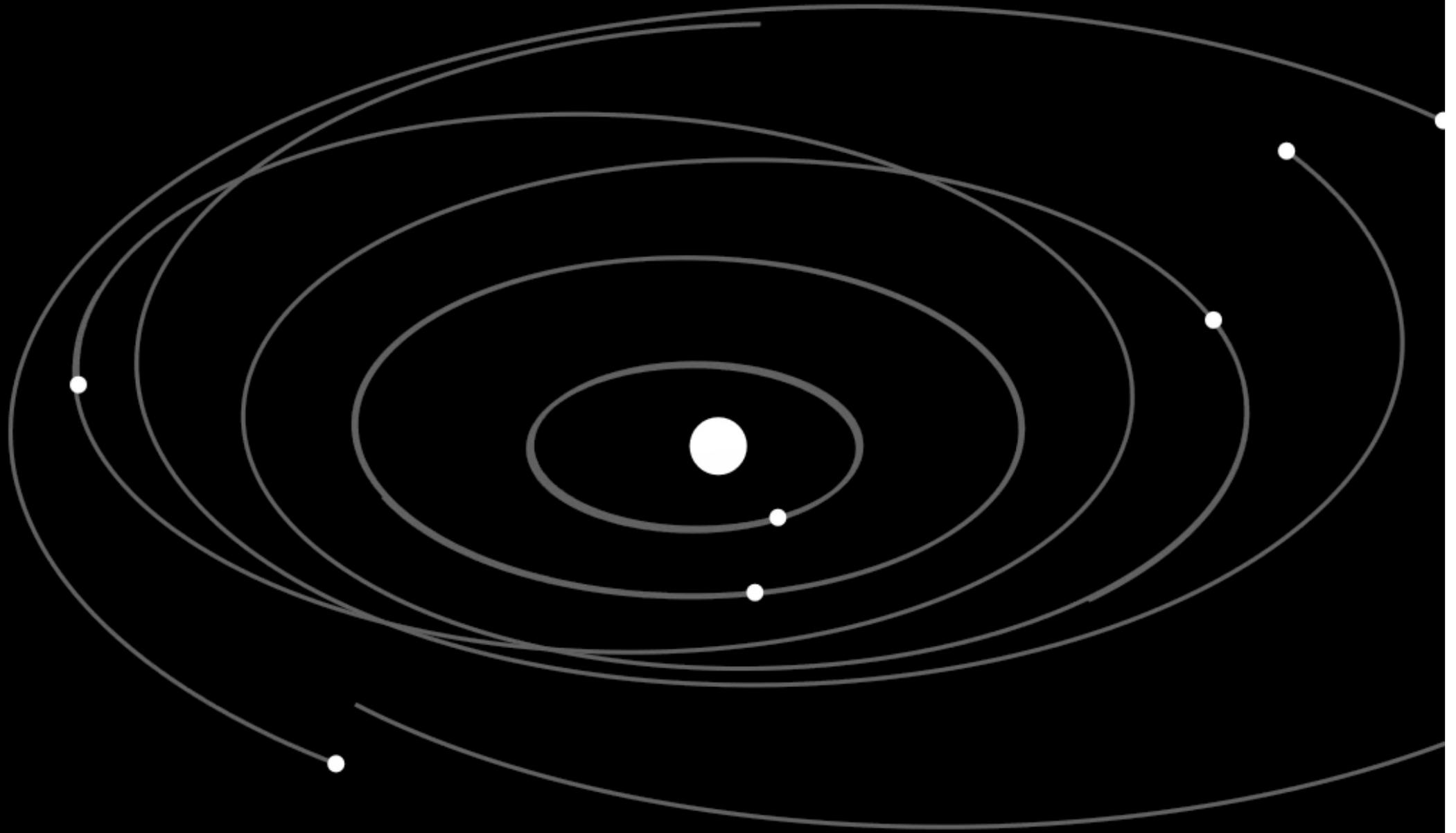
"Microscope-IMG 0518" by Work by Rama

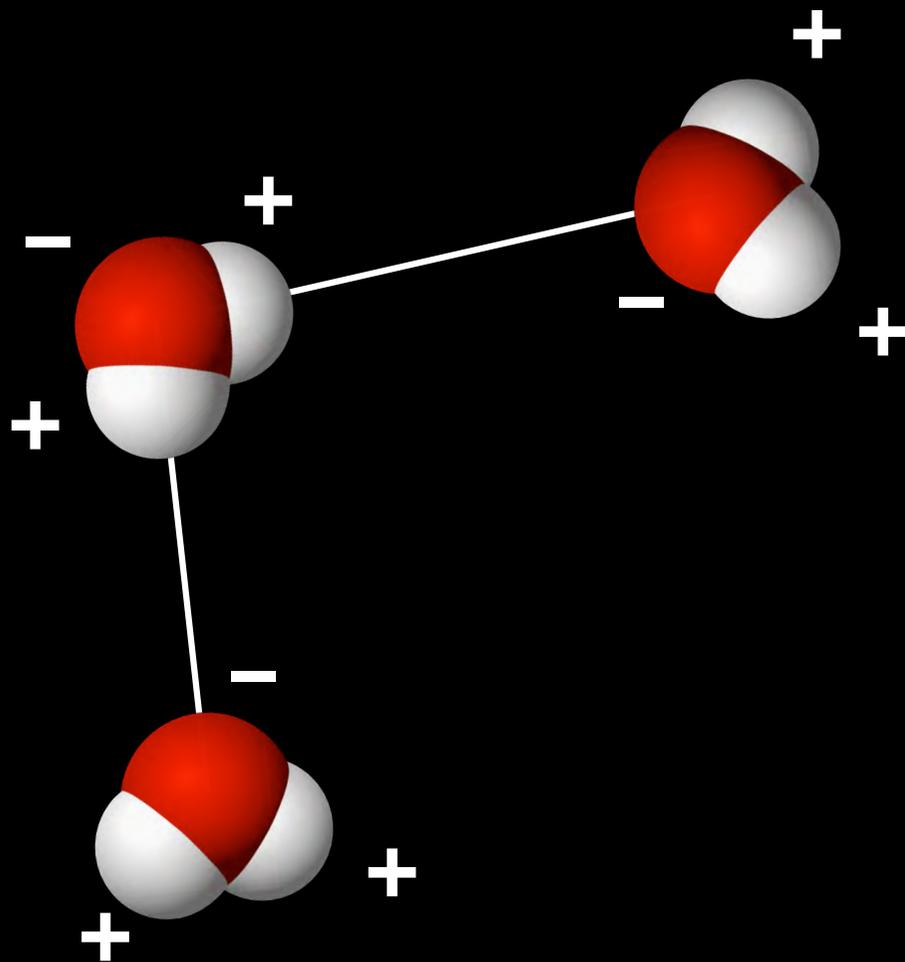
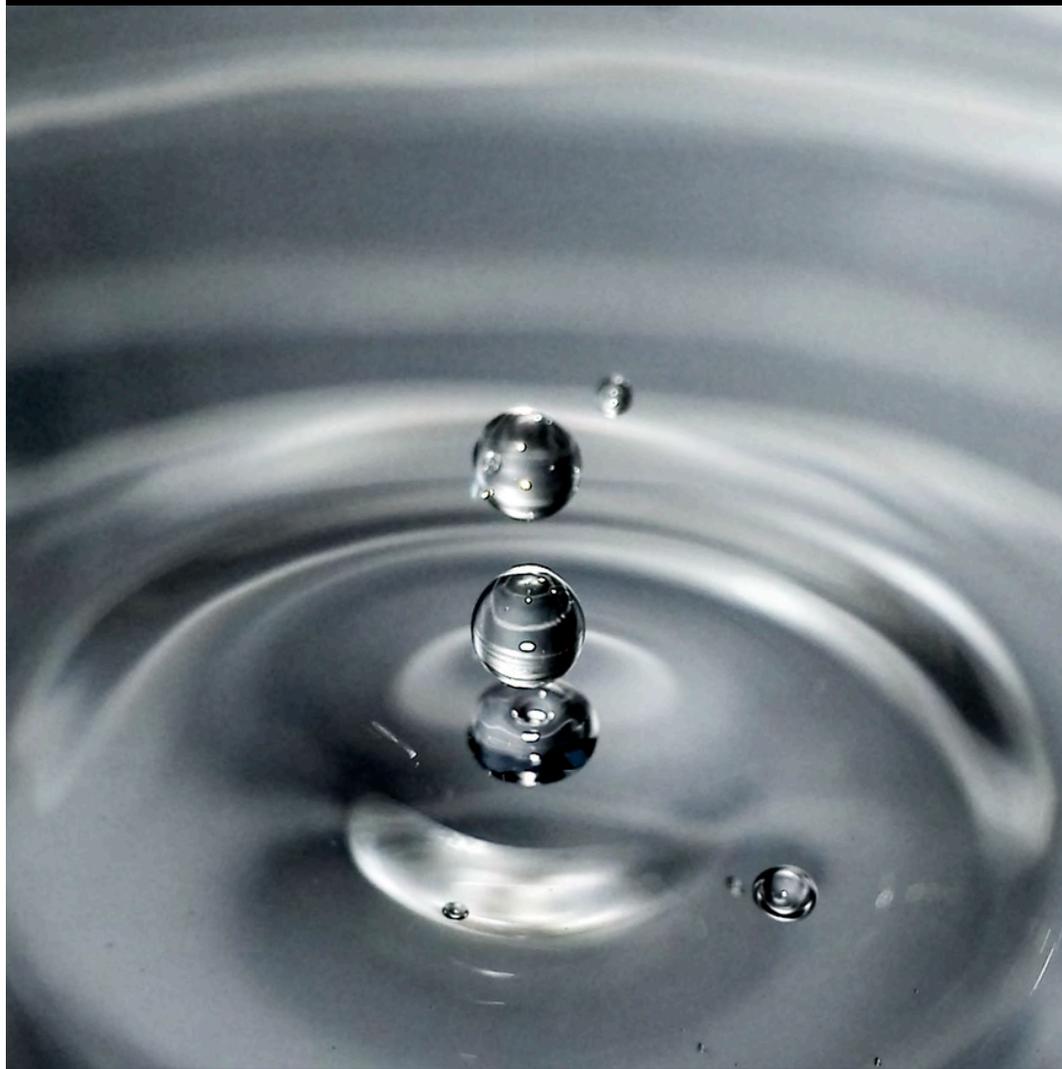


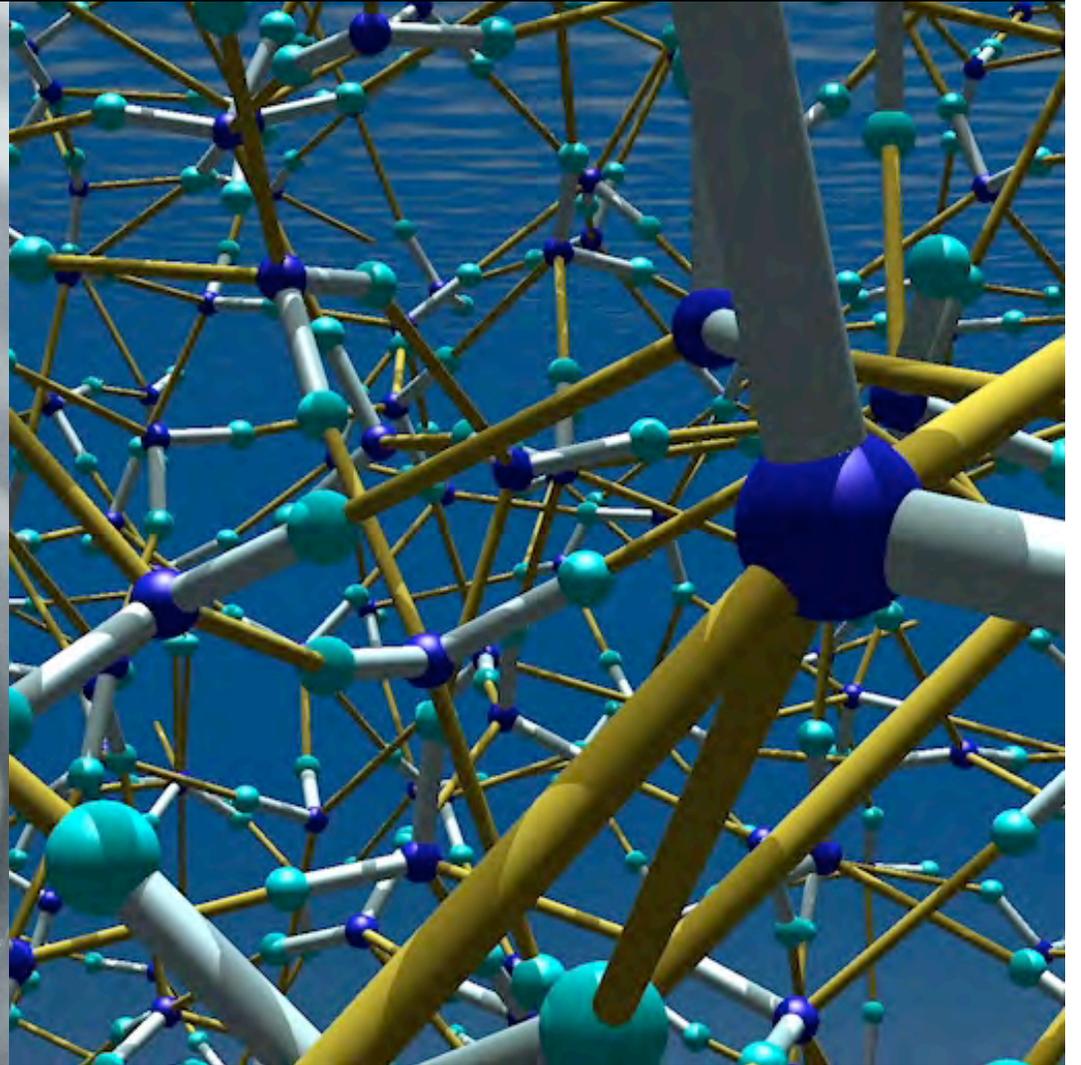
"STM at the London Centre for Nanotechnology" by O. Usher (UCL MAPS)

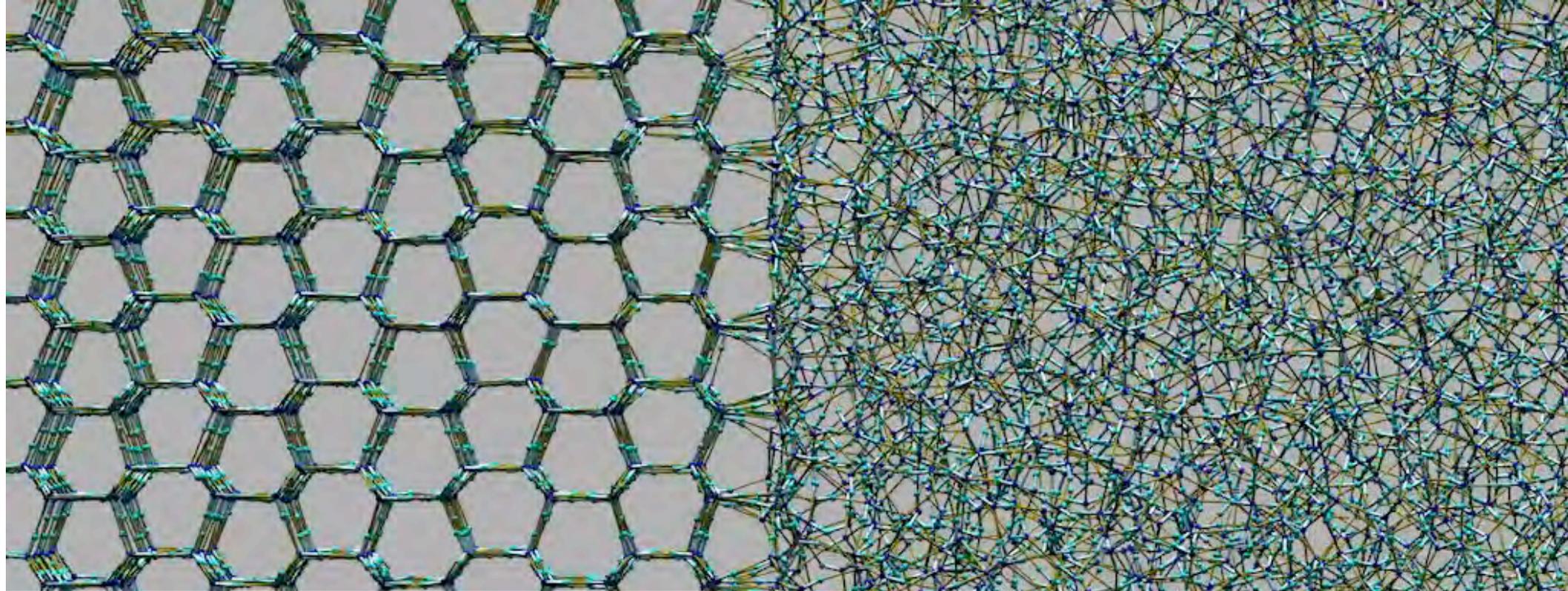
動く水分子を直接観察できる顕微鏡はない

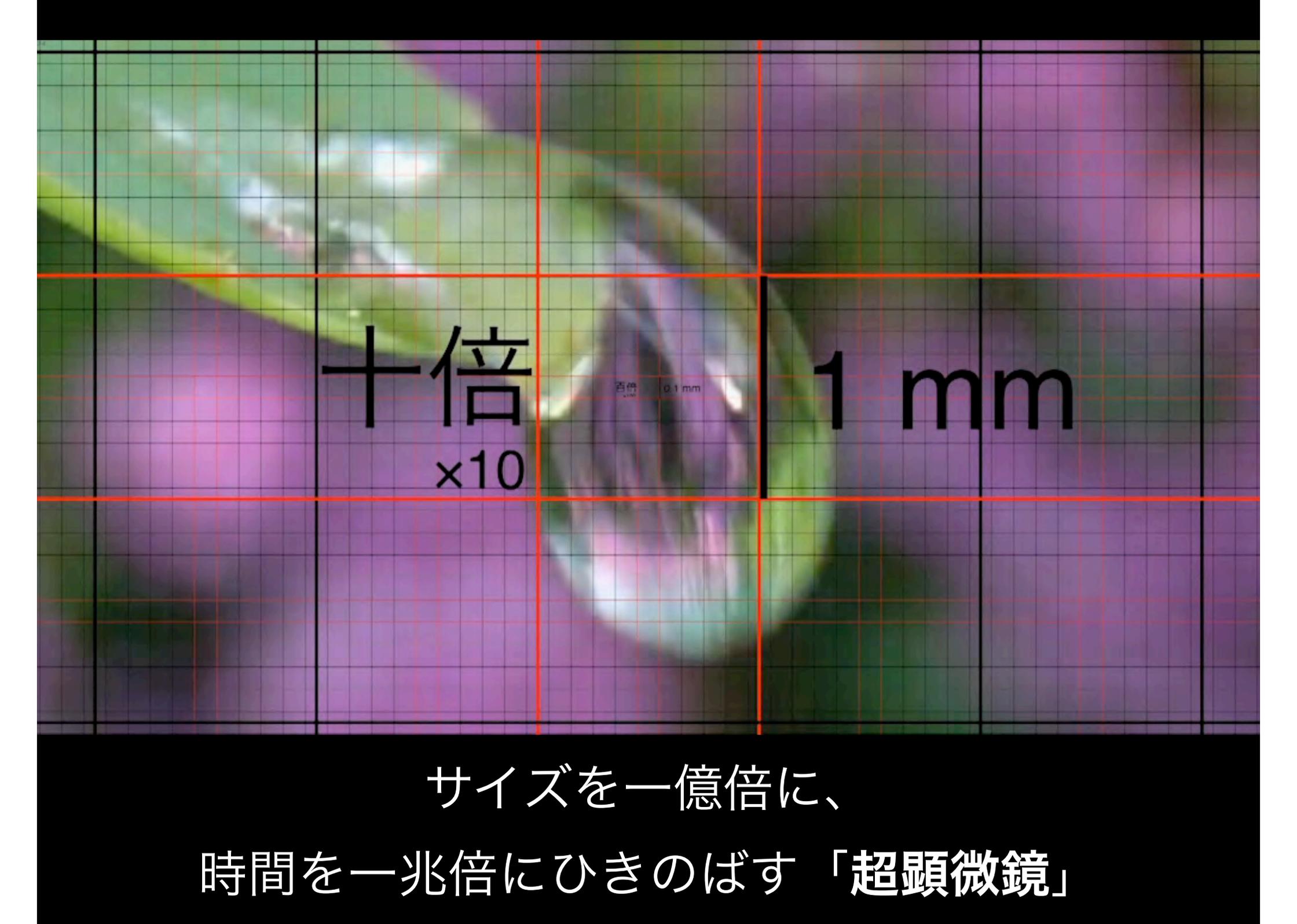










A microscopic image of a biological specimen, possibly a cell or tissue, showing various internal structures. The image is overlaid with a grid of red lines. A vertical red line is positioned to the left of the specimen, and a horizontal red line is positioned above it. The text '十倍 x10' is overlaid on the left side of the image, and '1 mm' is overlaid on the right side. A small label '百倍 0.1 mm' is visible near the center of the specimen.

十倍  
x10

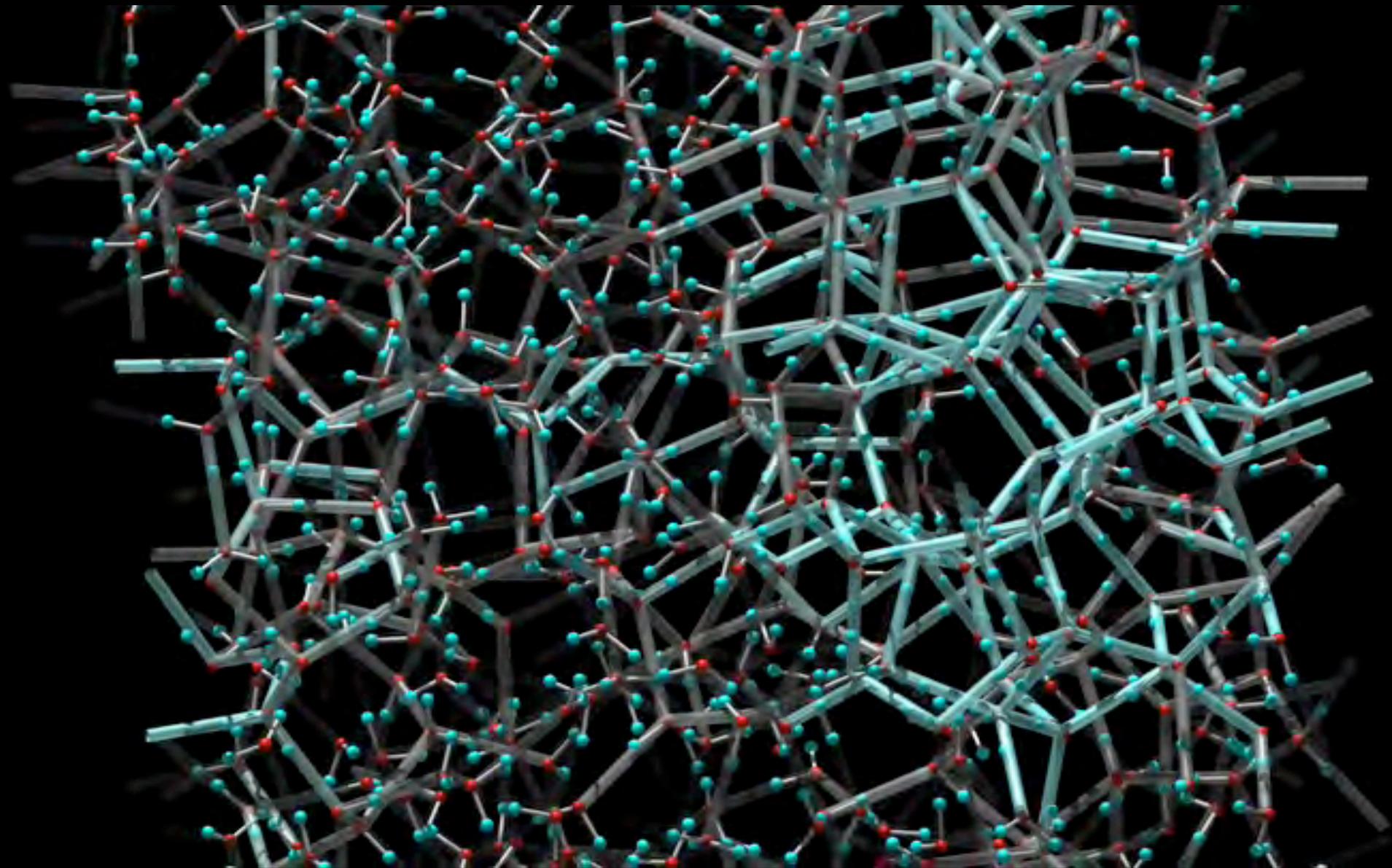
1 mm

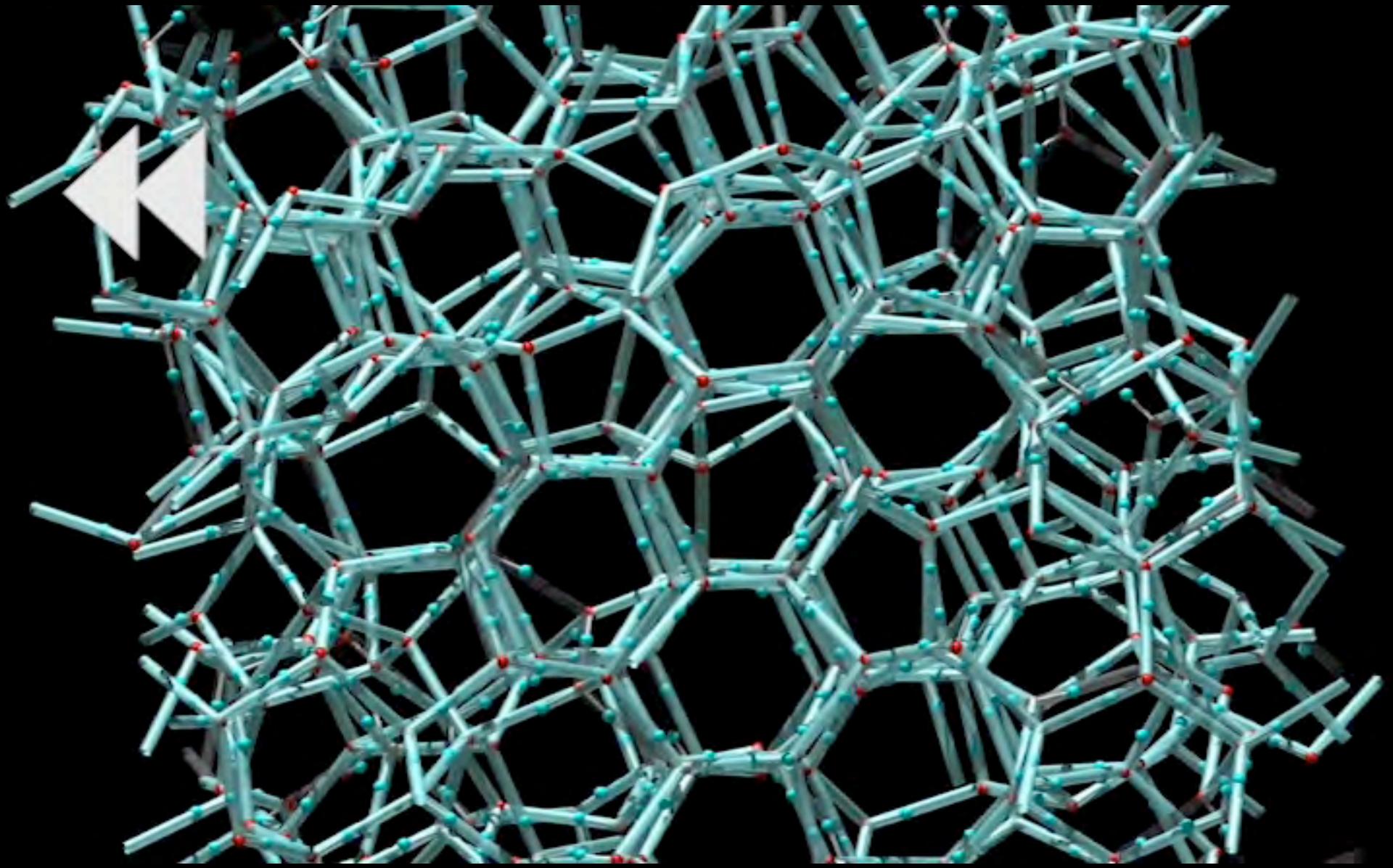
サイズを一億倍に、  
時間を一兆倍にひきのばす「超顕微鏡」



real time

“Supercooled Water Instantly Freezing”  
by Seattle Food Geek Videos  
<https://www.youtube.com/watch?v=zOt53yKB6ZI>



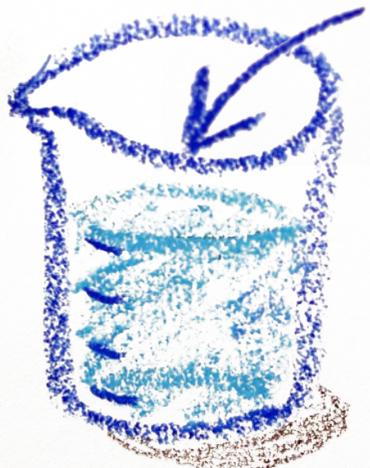
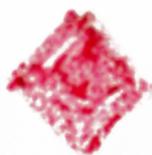


# メタンハイドレート(MH)

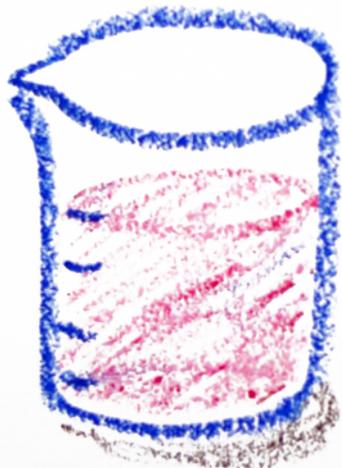


# メタンハイドレートのふしぎ

しお

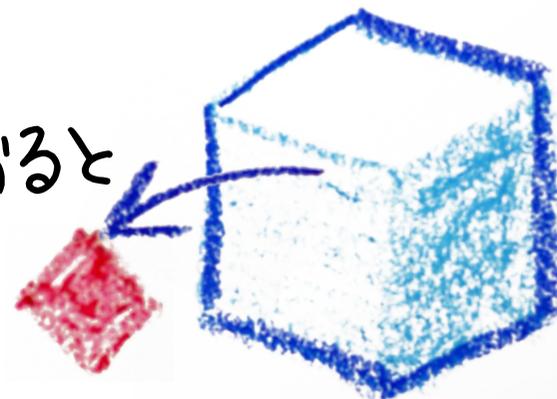


とかすと



しお水

こおると

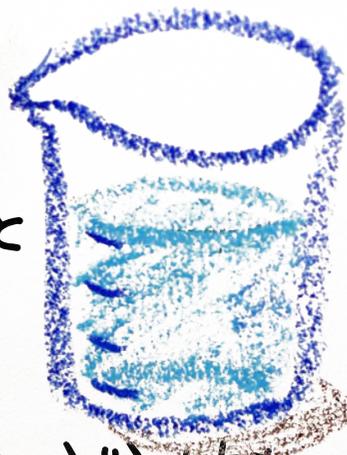


水だけがこおる

メタンガス

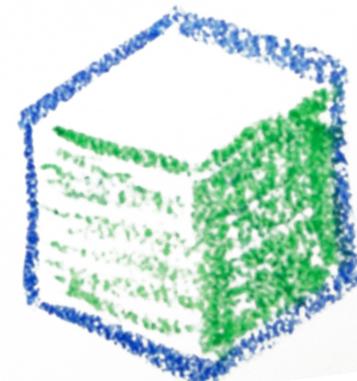


とかすと



ほとんどとけない

こおると



1万ばいとけて  
いっしょにこおる!

10 ナノメートル = 0.000 01 mm



水中のメタンハイドレートの分解

数百万個の分子を、一つ一つ見分けつつ、  
時間を自在に巻き戻して現象を観察できる

## 「超顕微鏡」

超顕微鏡の性能を決めるのは、  
コンピュータの**速さ**

目に  
見える  
大きさ

サイズ

分子の  
大きさ

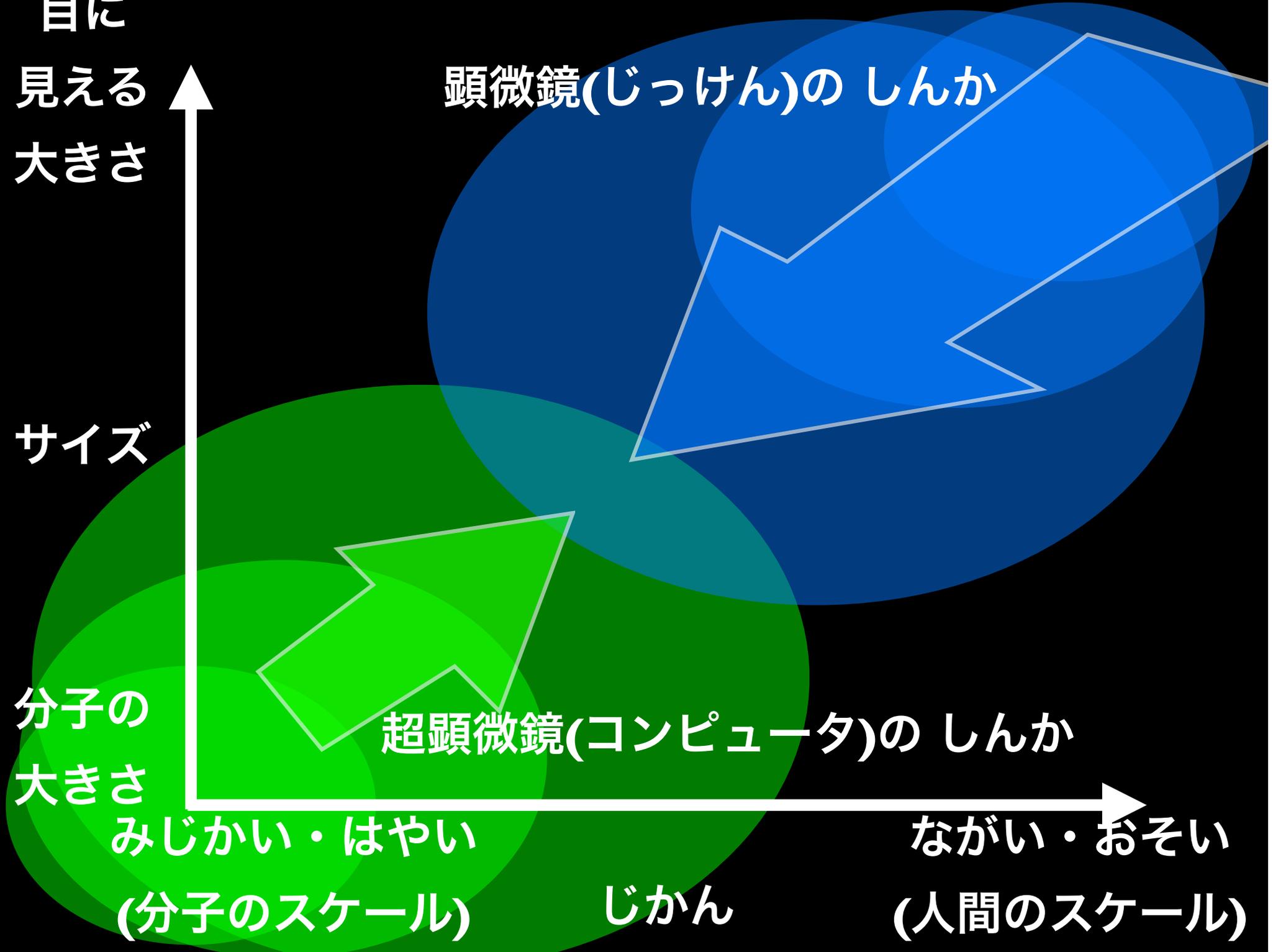
みじかい・はやい  
(分子のスケール)

顕微鏡(じっけん)の しんか

超顕微鏡(コンピュータ)の しんか

じかん

ながい・おそい  
(人間のスケール)



さいごに

「コンピュータは科学全体に資する」

