「全学教育基礎ゼミ」

「さまざまな環境ストレス下の中で生きる生物の遺伝子」

東北大・院・生命科学　日出間　純

2009. 7. 27-29

東北大学

	文字の数	長さ
人間	約３２億	２ m
イネ	約３億	２０ cm
マウス	約２７億	1.7 m
ニワトリ	約１０億	0.7 m
チンパンジー	約28.5億	1.8 m
大腸菌	約500万	0.3 cm

TOHOKU
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人間の体にあるＤＮＡを全部つなげたら、
どのくらいの長さになるか？

人間の体の中には、いくつぐらいの細胞があるのか？

６０兆個！

2 m × 60,000,000,000,000 = 120,000,000,000,000 m

地球一周は、約４万Ｋｍ
地球と月の距離は、約３８万Ｋｍ
地球と太陽の距離は、１億５０００万Ｋｍ

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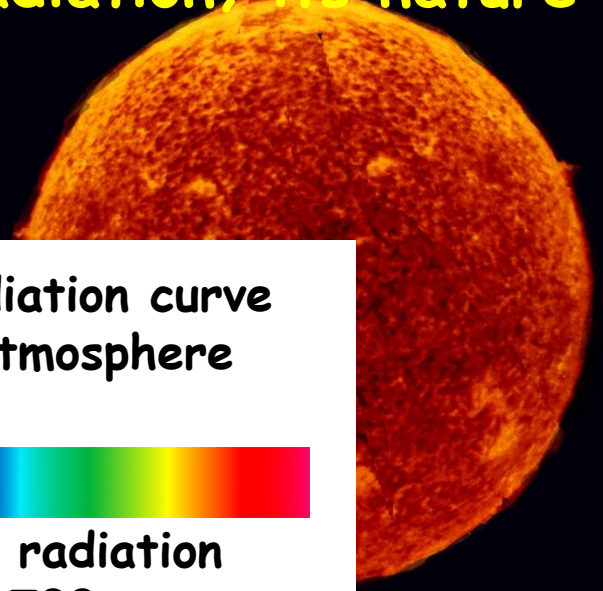
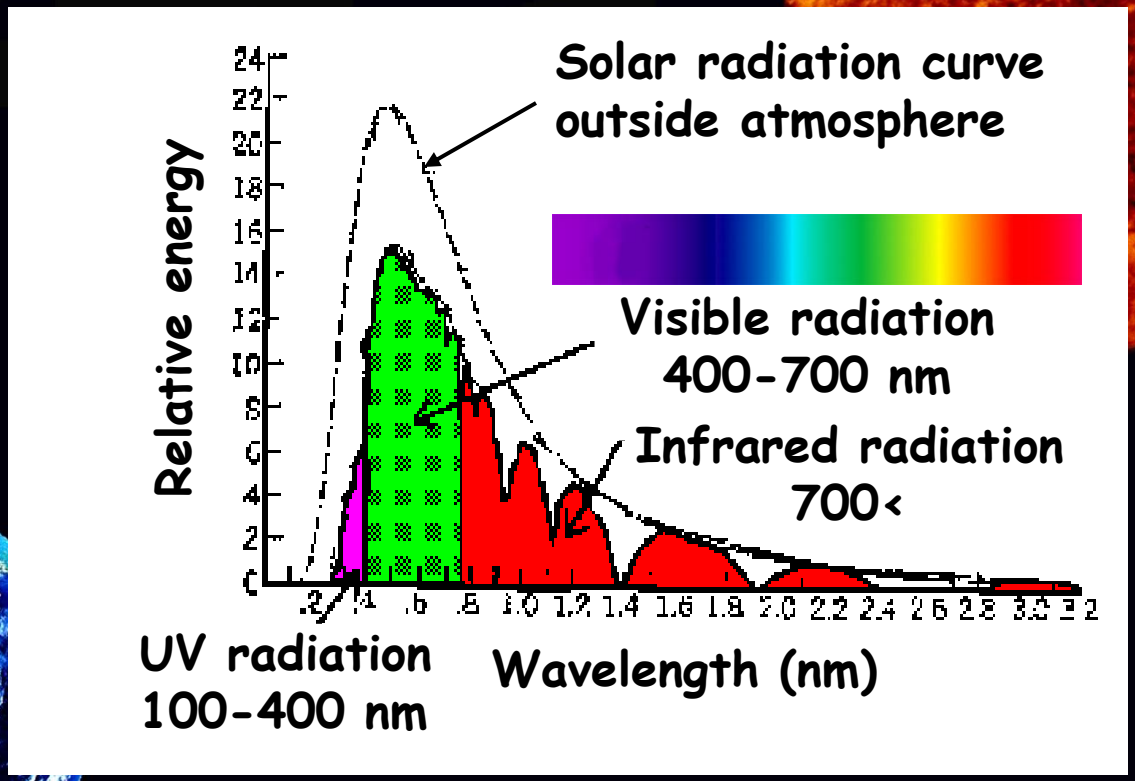
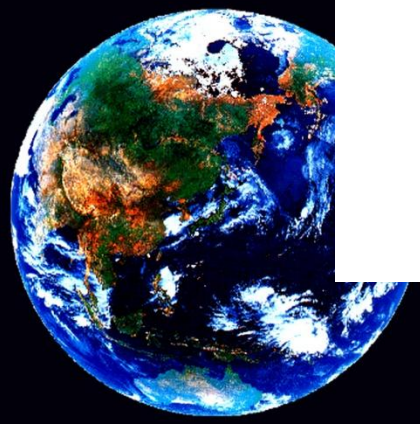
1) Solar radiation and Ultraviolet radiation; its nature

太陽光と紫外線　ー紫外線とは？ー



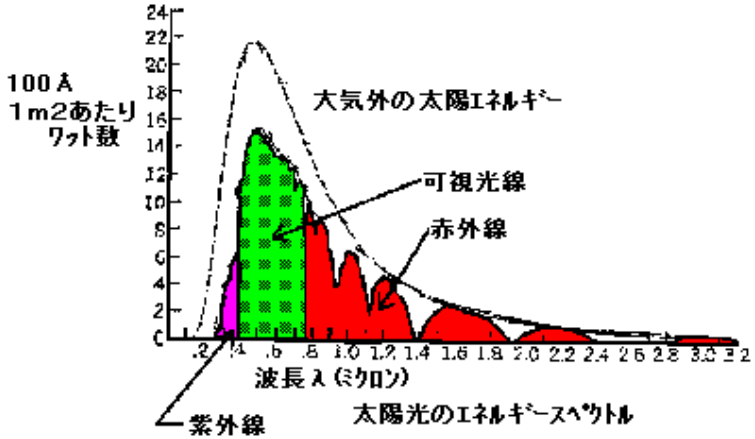
Q: What is light?





A: Light; particle with wave = photon
= an elctromagnetic wave（電磁波）

光(Light) ＝ 光子(光量子)・Photon



Energy / photon ： $h\nu$

(h: Plank's constant: 6.626×10^{-34} J s、

ν: frequency (振動数))

λ (wavelength: 波長) $= c / \nu$

(c ; light velocity (光の速度): 2.998×10^{8} m/s

$$h\nu = h \times c / \lambda$$

A photon energy at 1,240 nm ＝ 1.6×10^{-19} J = 1 eV

1モルあたりに換算すると(1.6×10^{-19} J X $6.022 * 10^{23}$)

Photon (mol) energy at 1,240 nm ＝ 23.05 Kcal

(1 cal = 4.18 J)

700 nm = 40.8 Kcal

400 nm = 71.4 Kcal

200 nm = 142.9 Kcal

Visible・UV radiation・・・photon with high energy

↓

高エネルギーの光量子は、分子中の電子を励起

Excite electron in molecules
Convert the energy of excitation into an electron transfer

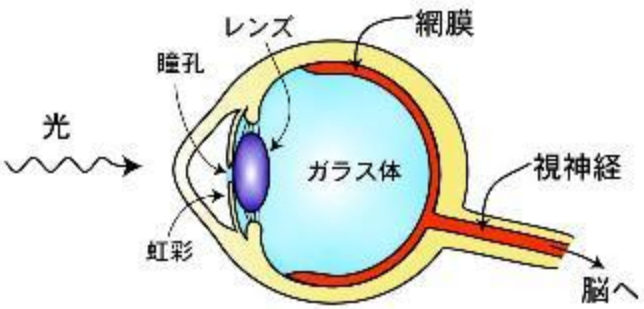
Infrared radiation・・・ photon with low energy

↓

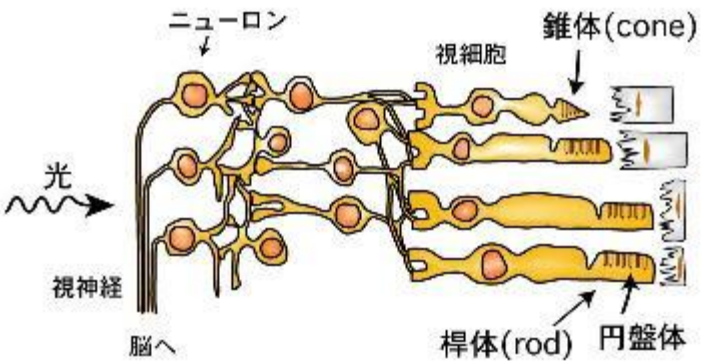
低エネルギーの光量子は、分子振動、回転状態を変えることは出来ても、
電子状態を変えることは出来ない。

Photon with low energy CAN affect vibration" or spin state"
of molecules,
BUT CAN NOT excite electron in molecules.

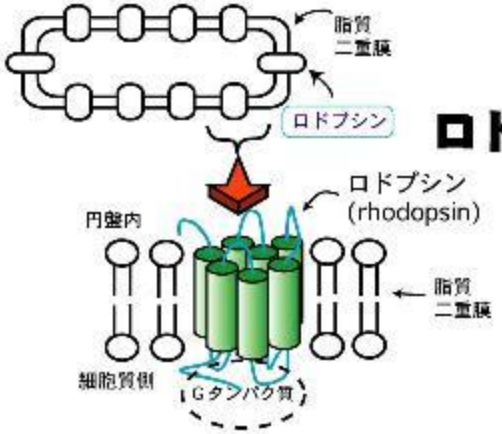
目(eye)



網膜(retina)



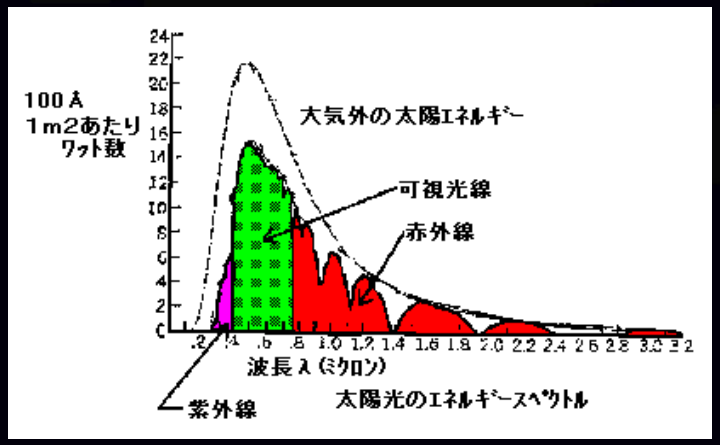
円盤体 (outer segment of rod)



ロドプシン

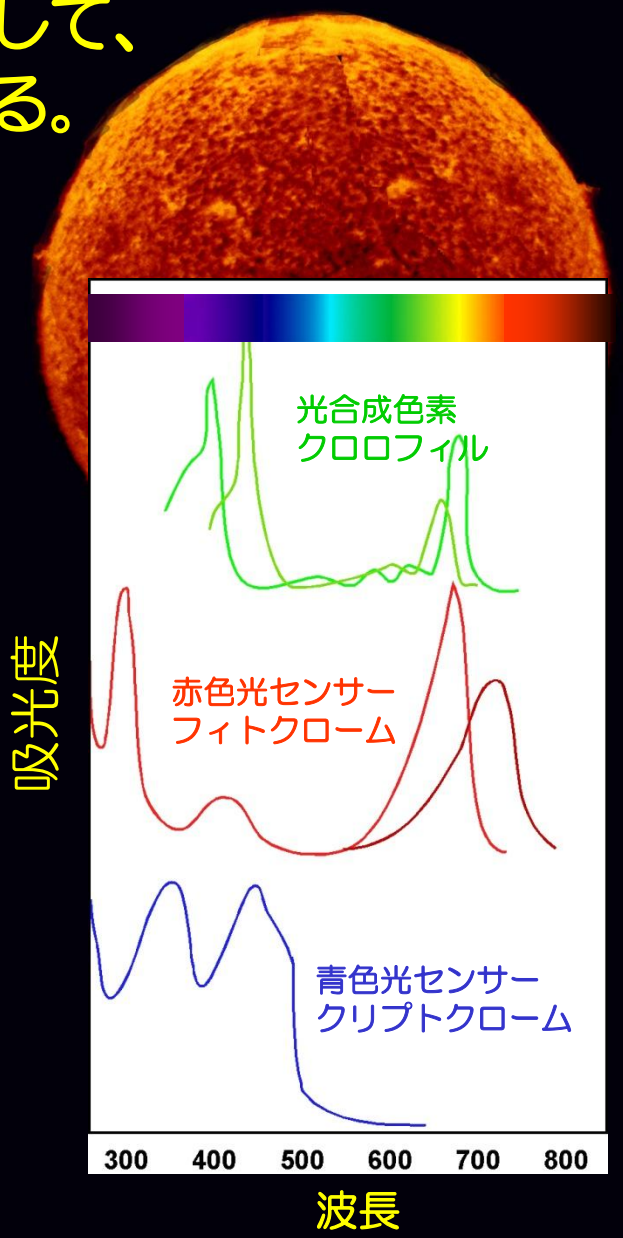
光は電気信号へと変換され、
神経細胞ニューロン内を通って、
脳へと情報として伝達される

植物は、太陽光を「エネルギー源」として、また「環境情報源」として利用している。



・光合成によって光エネルギーを化学エネルギーに変換して、エネルギー源として利用する

・光形態形成、種子発芽、伸長抑制など、遺伝子レベルで発現調節し、環境情報源として利用している

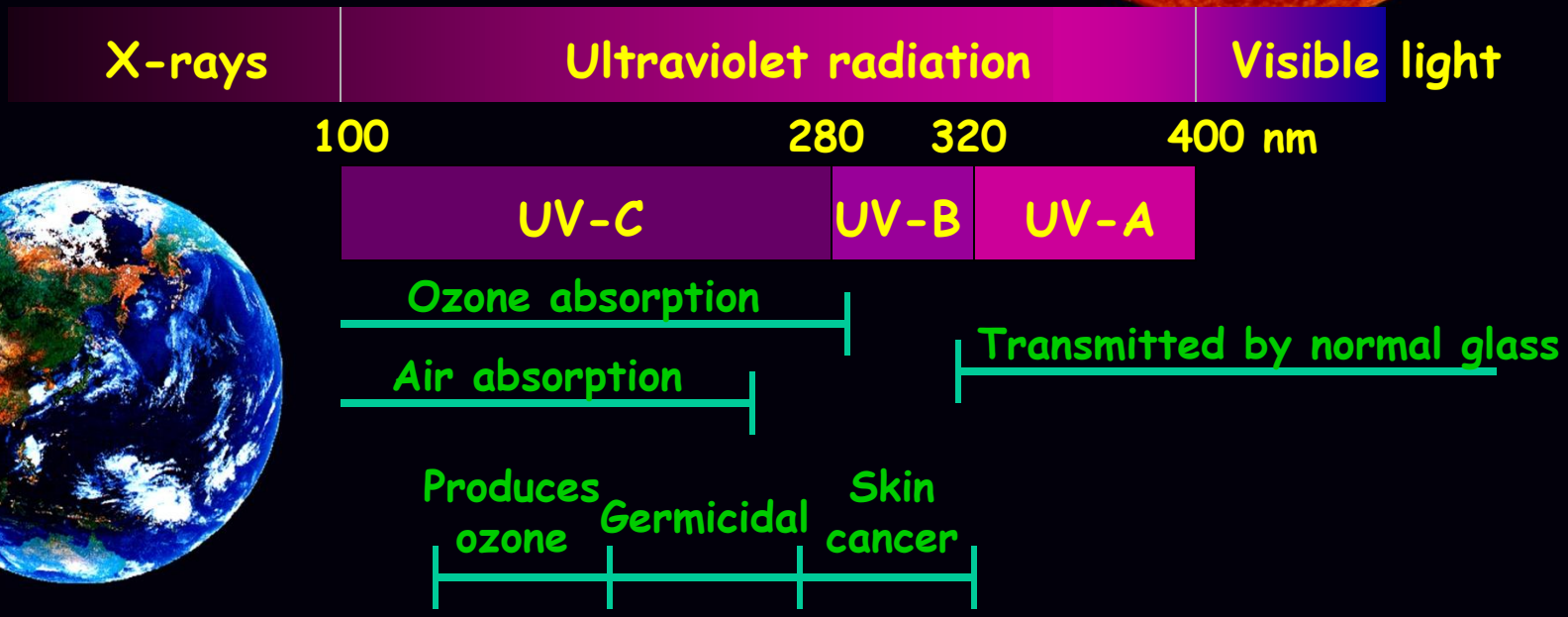


1) Solar radiation and Ultraviolet radiation; its nature

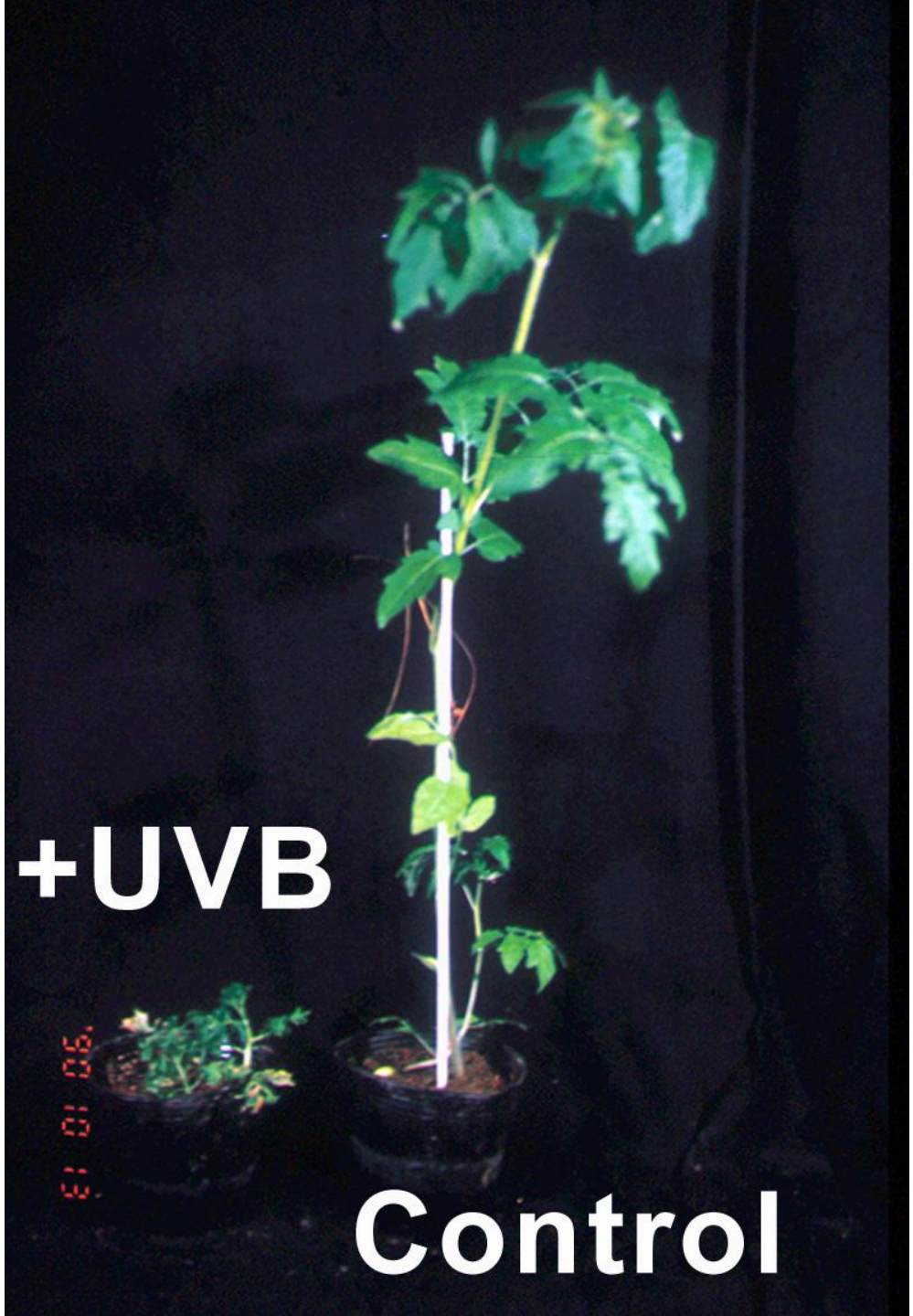
太陽光と紫外線　ー紫外線とは？ー

Q: What is UV radiation?

A: UV is photon with high energy

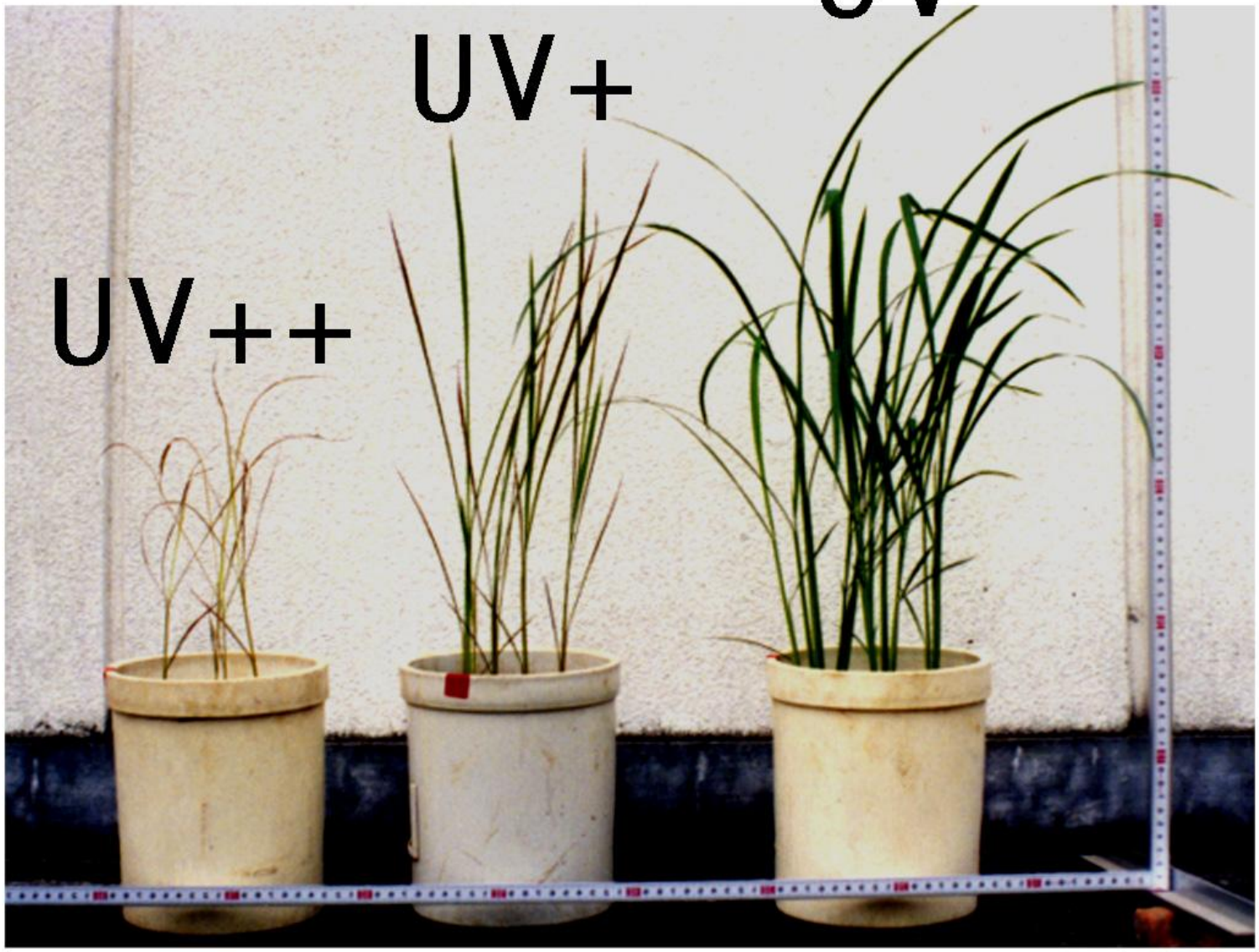


Tomato

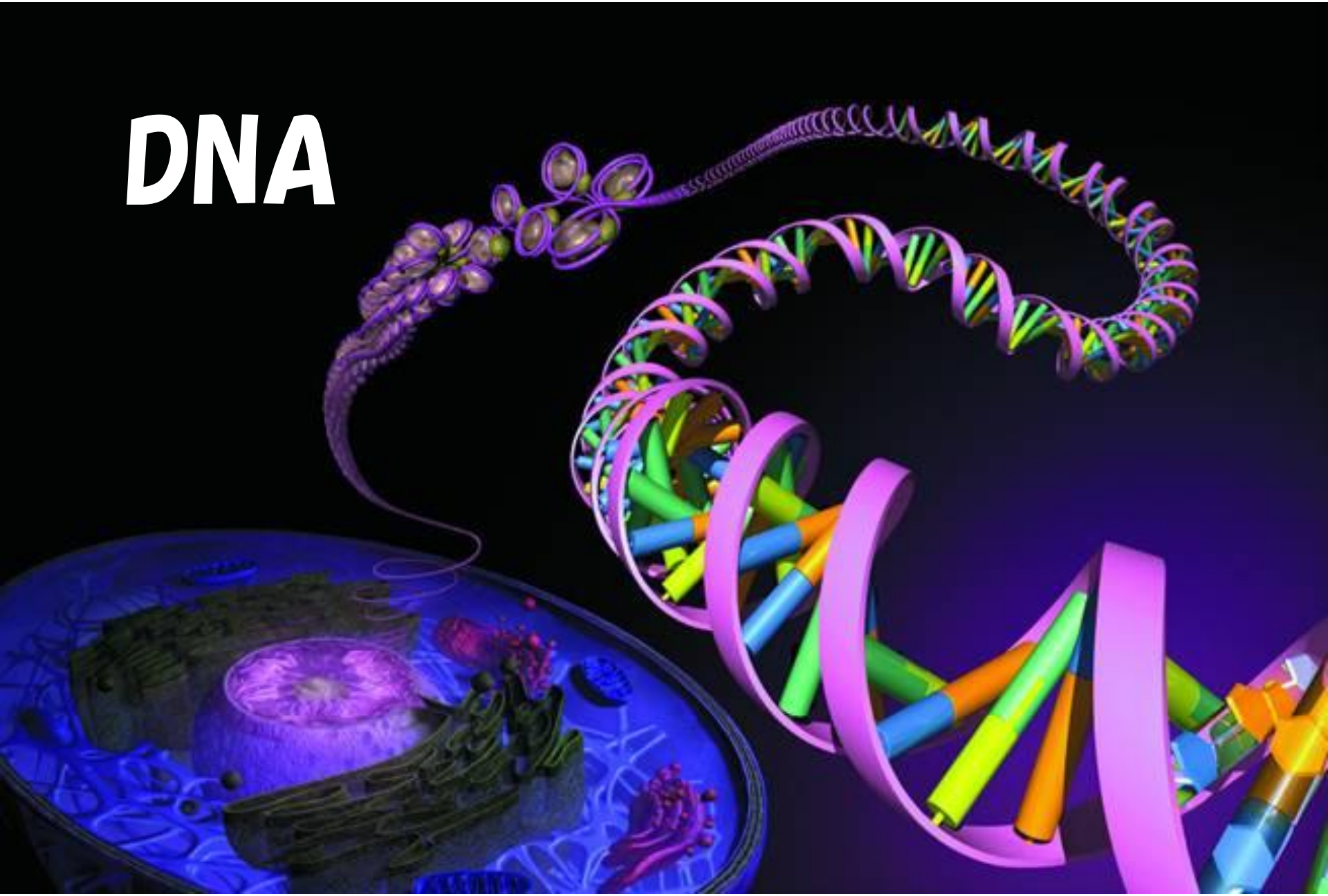


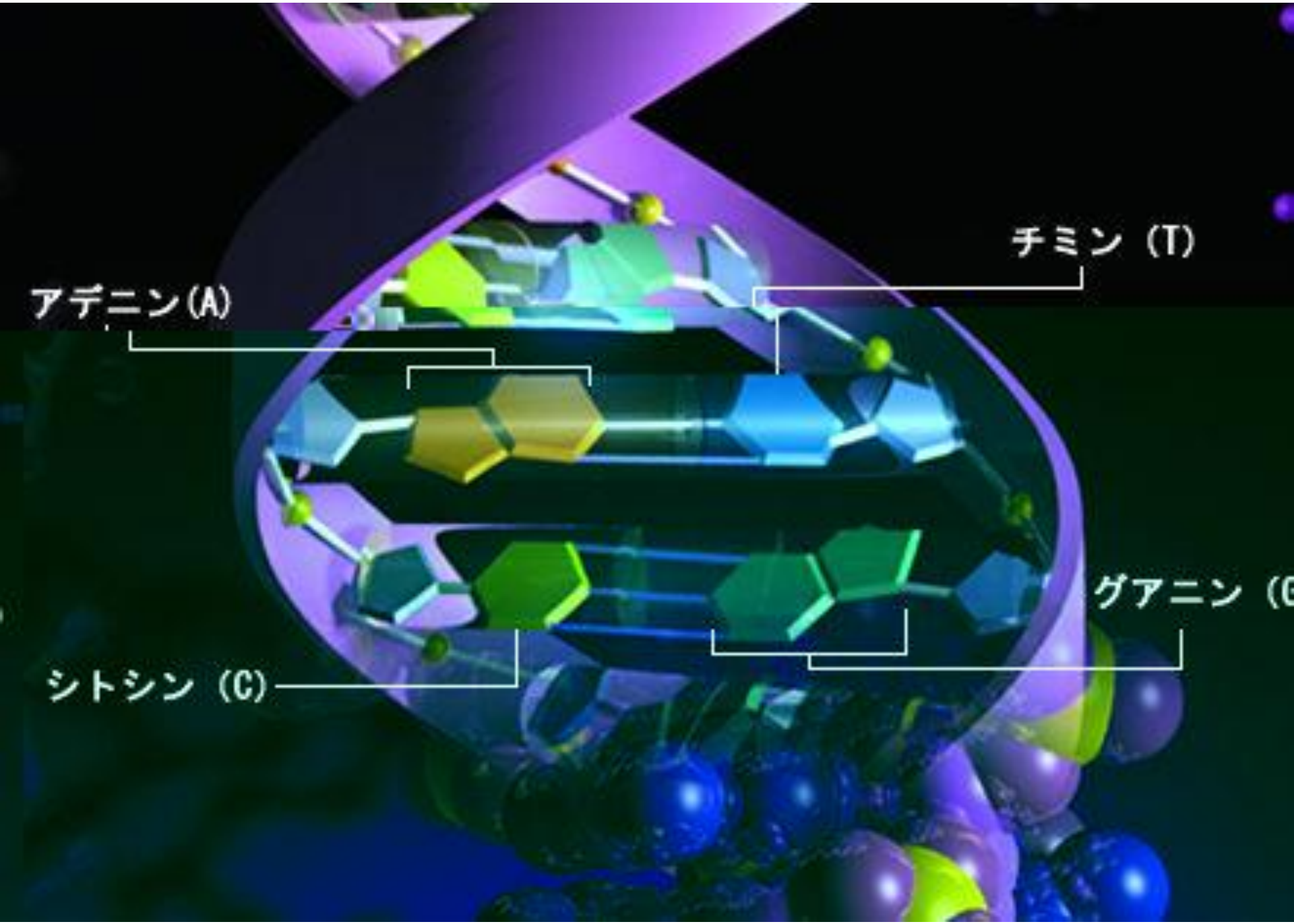
Eggplant

Rice

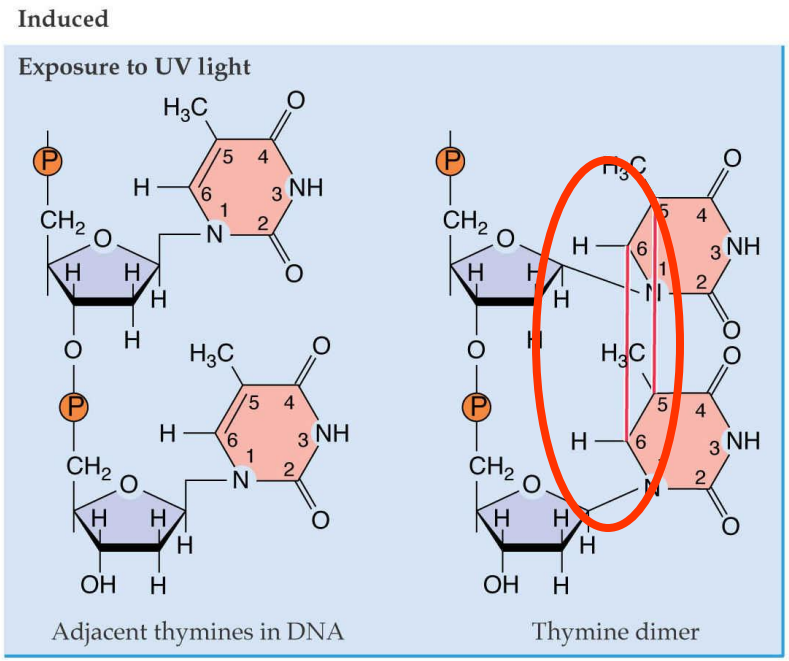


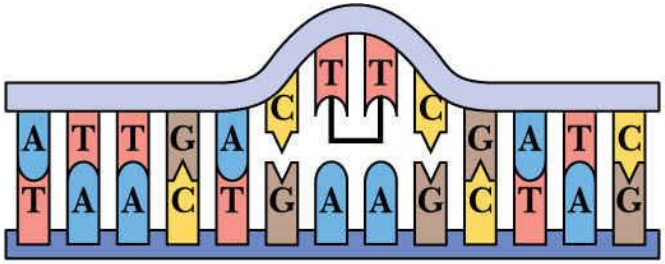
DNA



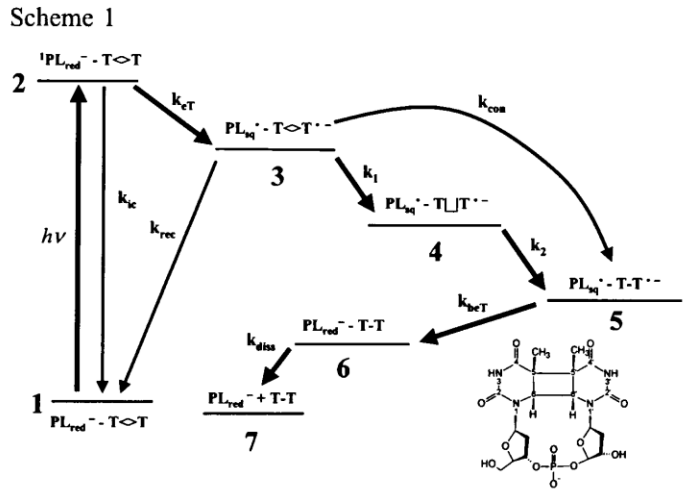

チミン（T）
アデニン(A)
グアニン（G
シトシン（C）

UVB-induced DNA damages
Cyclobutane Pyrimidine Dimer (CPD)





出典　Biochemistry & molecular biology of plants
：ASPPより引用



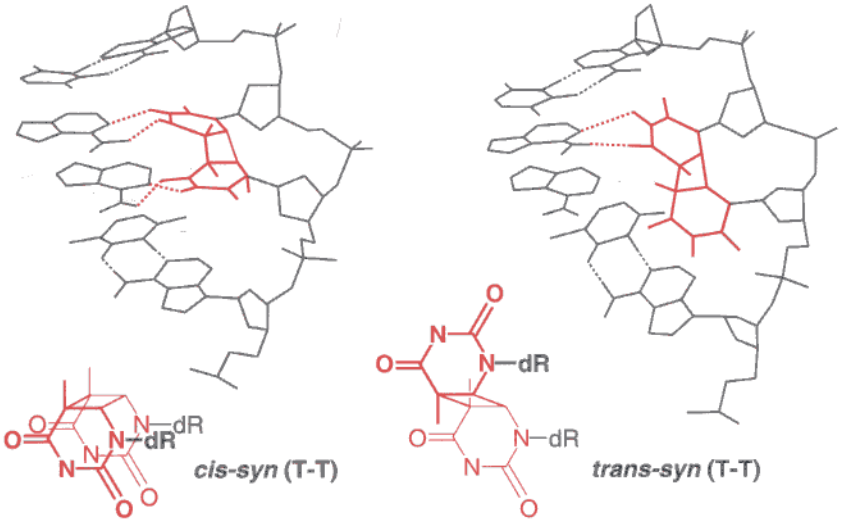


Figure 1–23 Structure of *cis-syn* and *trans-syn* cyclobutane thymine dimers and their proposed three-dimensional orientation in B-DNA. (*Adapted from Weinblum and Johns [452] and Taylor et al. [409] with permission.*)

DNA損傷の修復：ヌクレオチド除去修復
Nucleotide Excision Repair (NER)

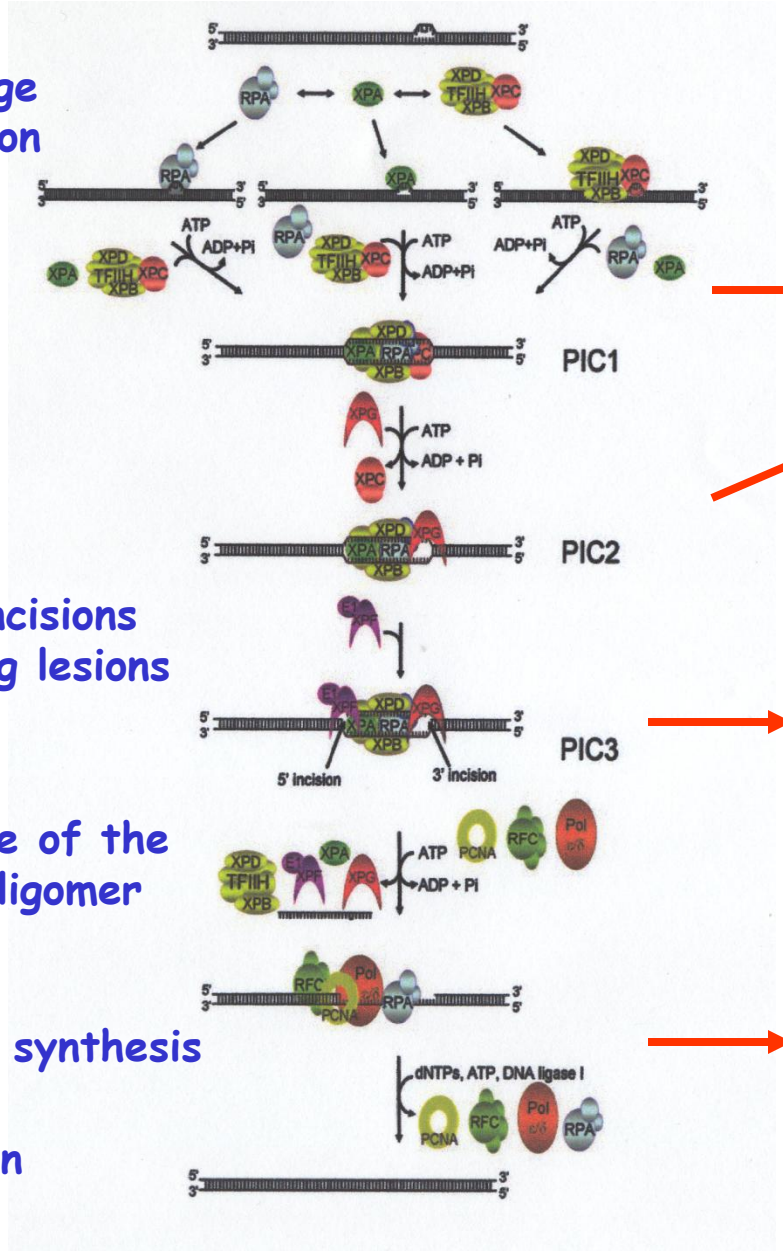
① Damage recognition

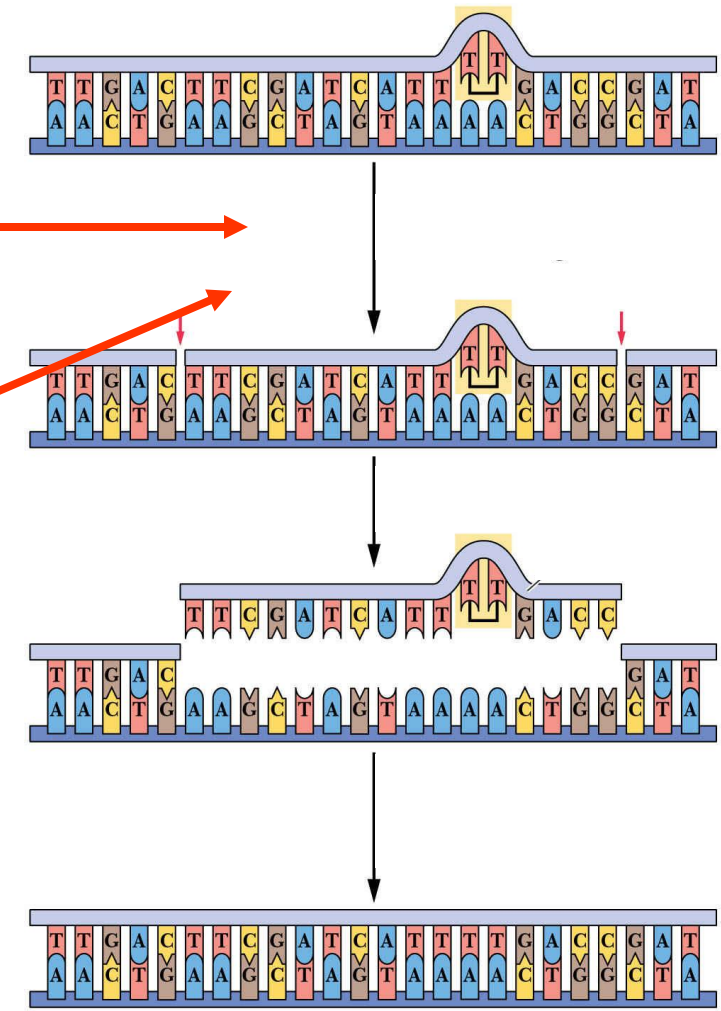
② Dual incisions bracketing lesions

③ Release of the excised oligomer

④ Repair synthesis

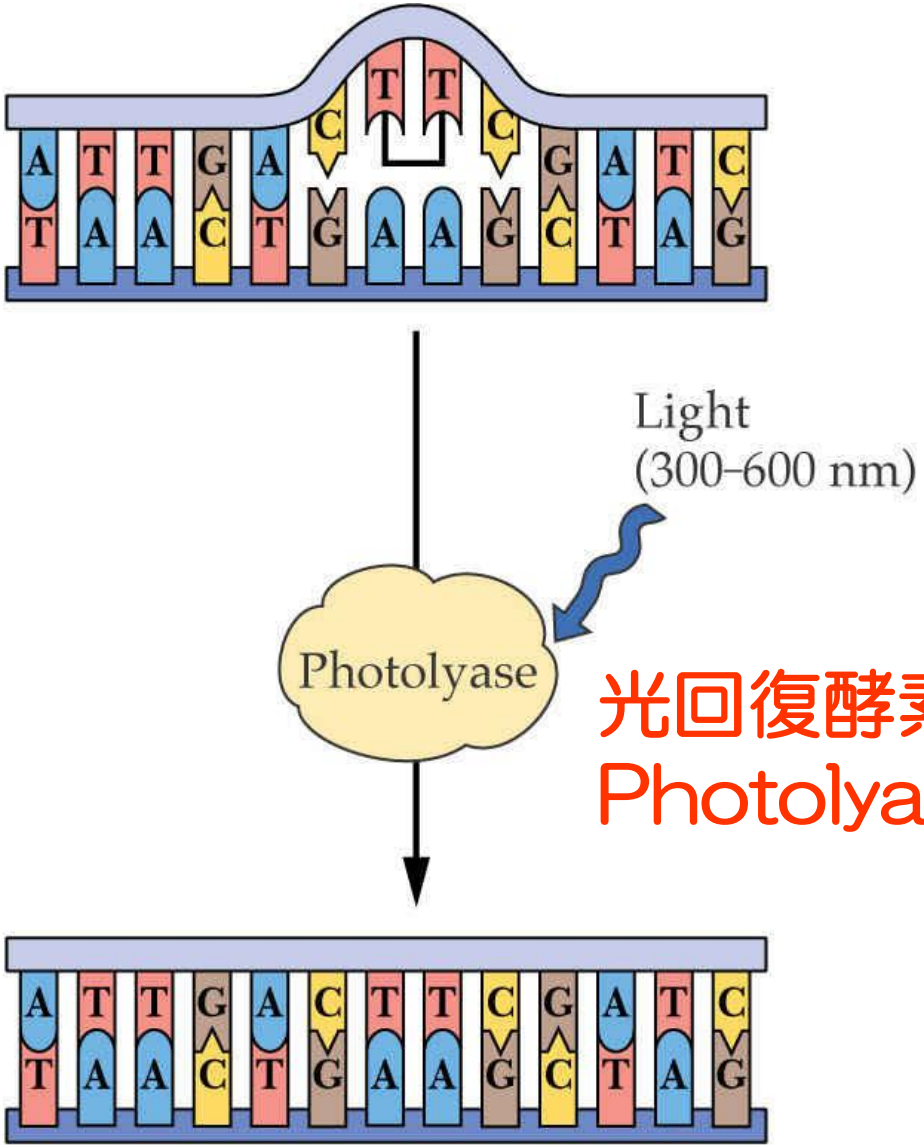
⑤ Ligation



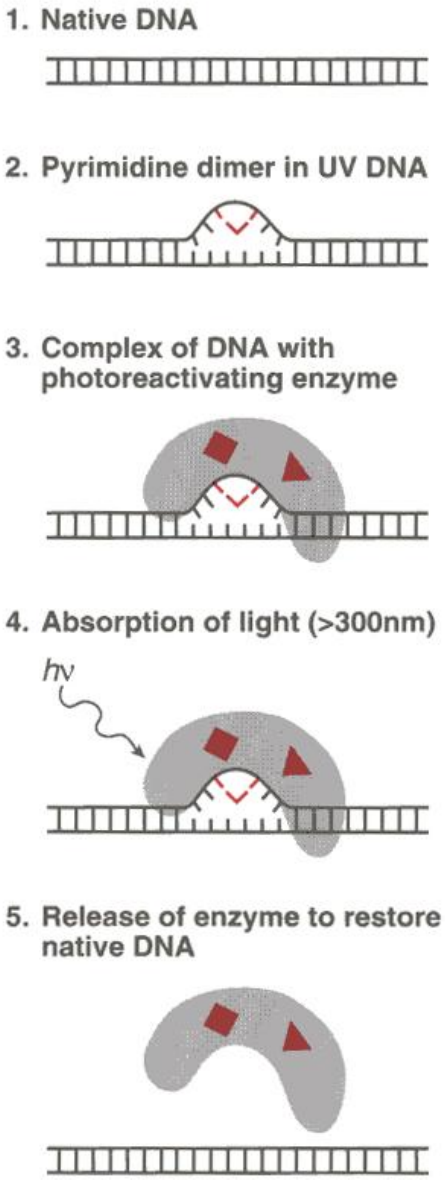


出典　Biochemistry & molecular biology of plants: ASPPより引用

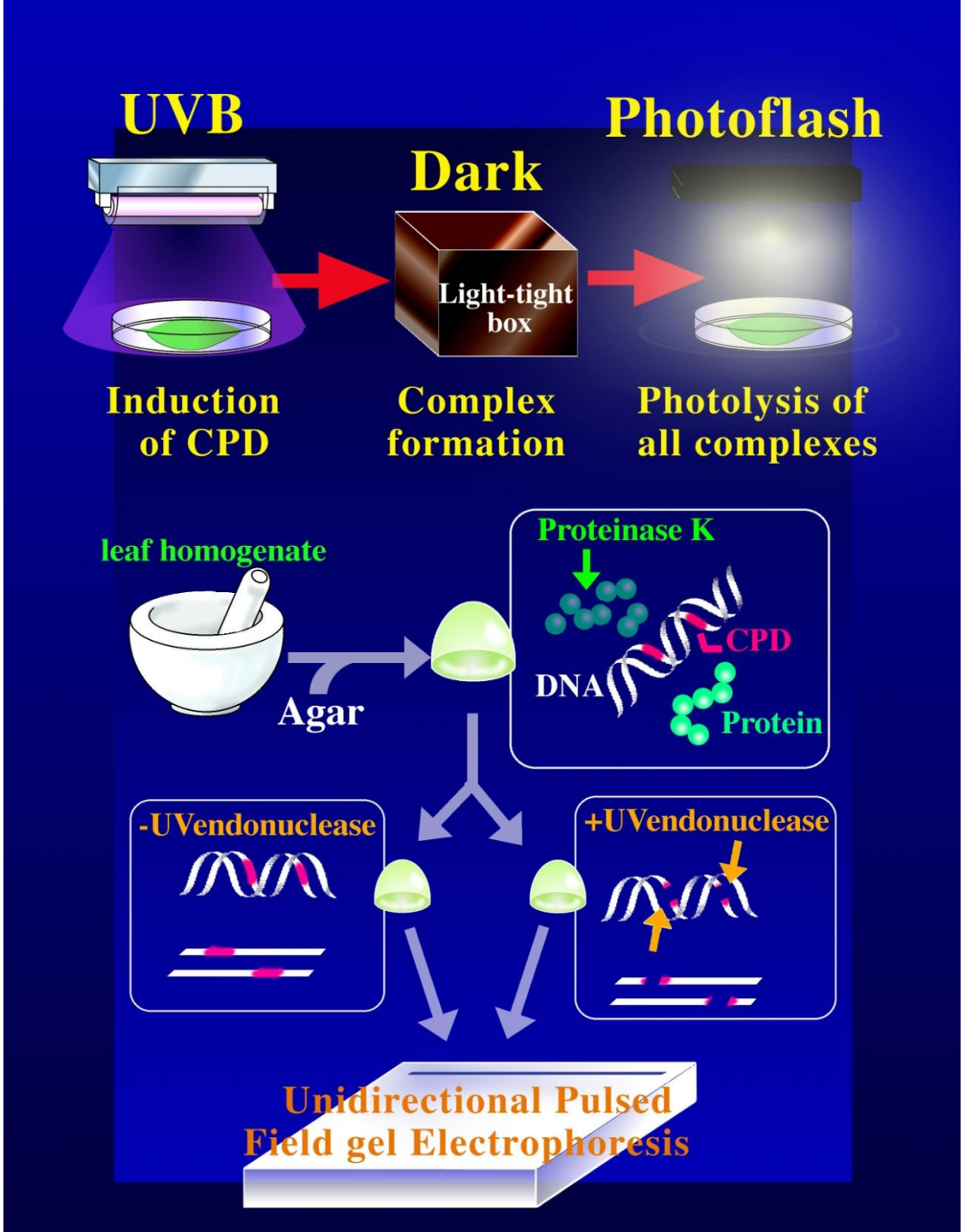
DNA損傷の修復：光回復酵素による光修復
Photorepair (Photoreactivation)

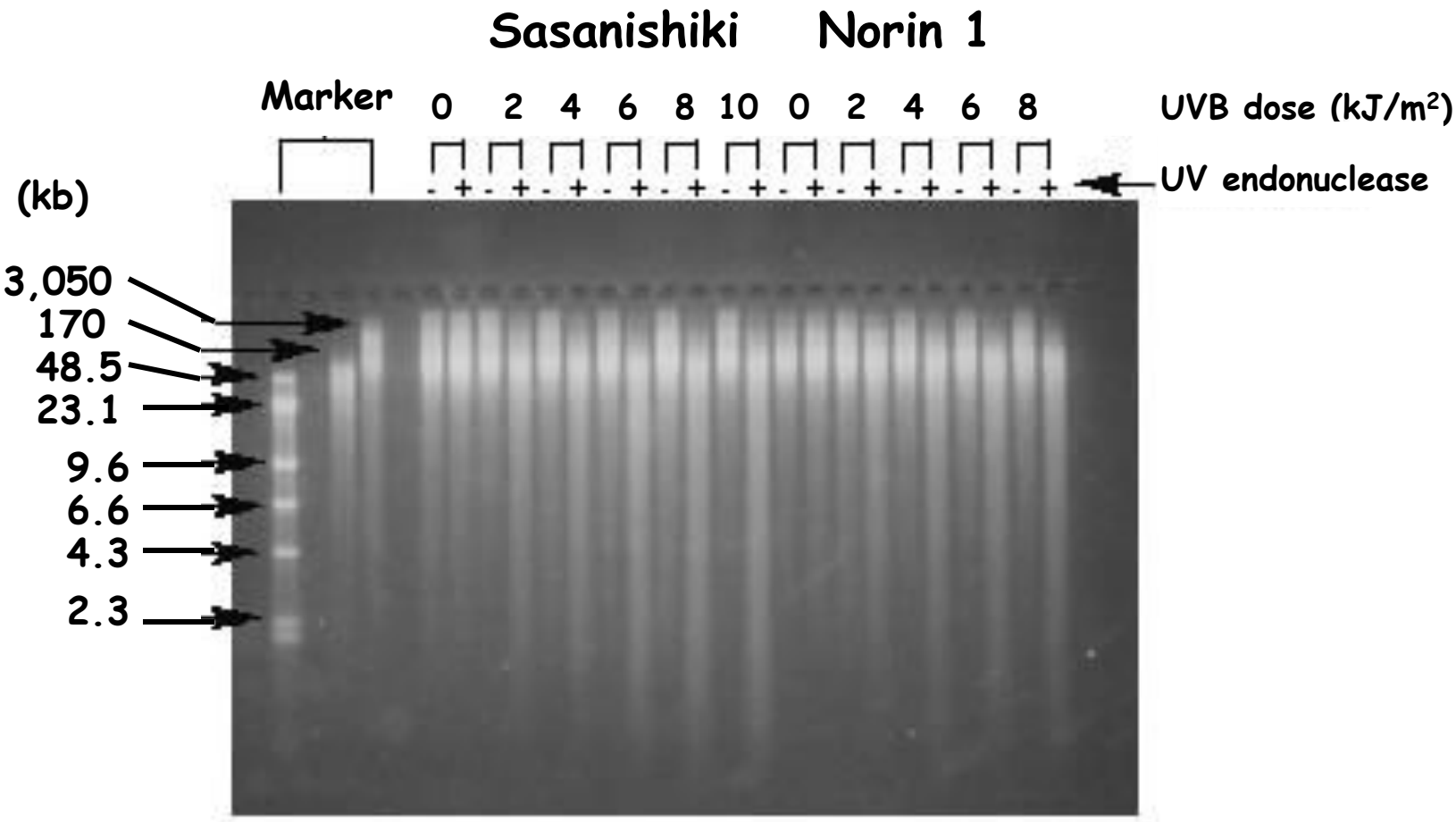


光回復酵素
Photolyase



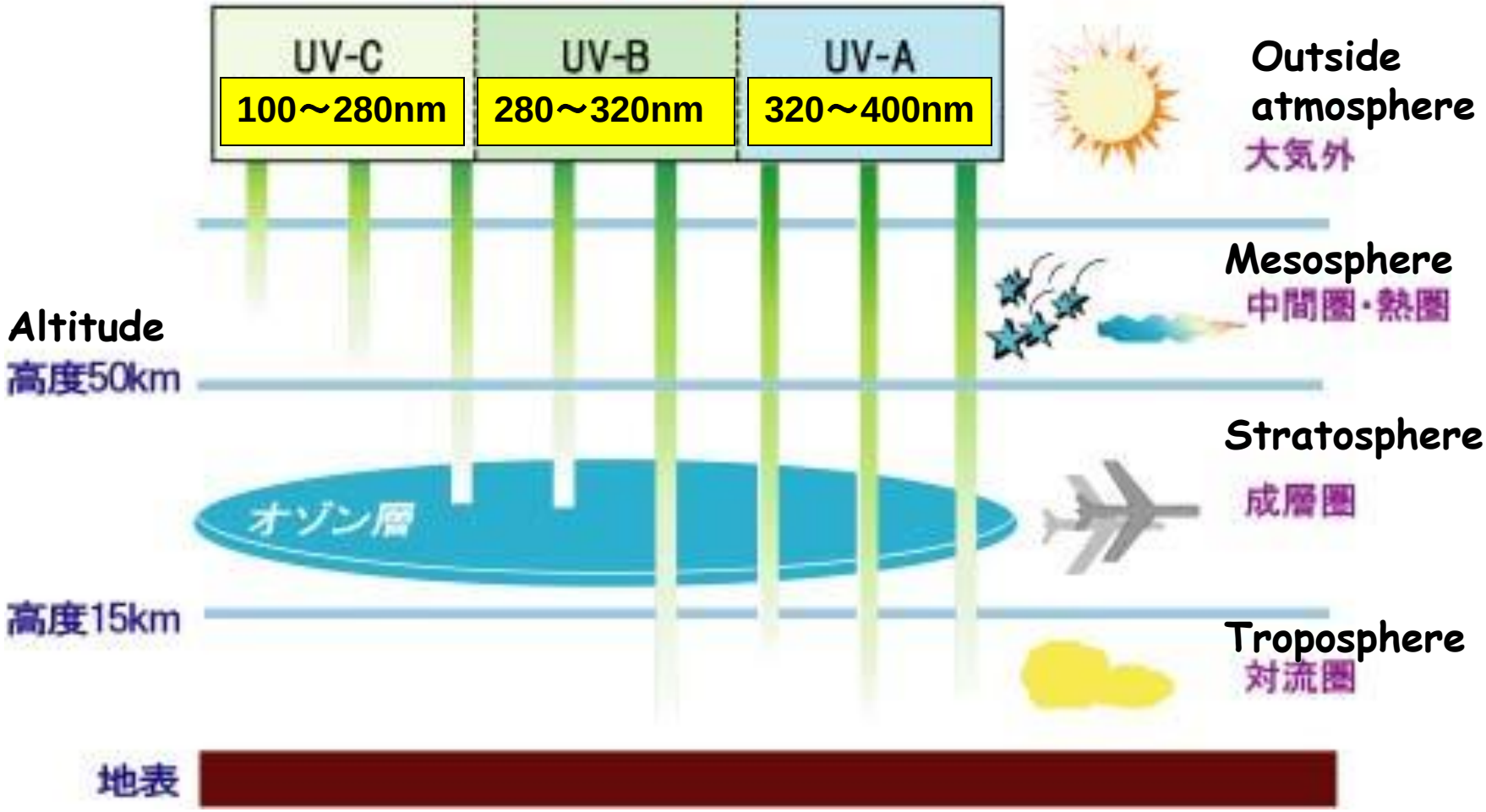
出典　Biochemistry & molecular biology of plants: ASPPより引用


UVB
Dark
Photoflash
Light-tight box
Induction of CPD
Complex formation
Photolysis of all complexes
leaf homogenate
Agar
Proteinase K
CPD
DNA
Protein
-UVendonuclease
+UVendonuclease
Unidirectional Pulsed Field gel Electrophoresis


Sasanishiki
Norin 1
Marker
0 2 4 6 8 10 0 2 4 6 8
UVB dose (kJ/m2)
- + - + - + - + - + - + - + - + - + - + - +
UV endonuclease
(kb)
3,050
170
48.5
23.1
9.6
6.6
4.3
2.3

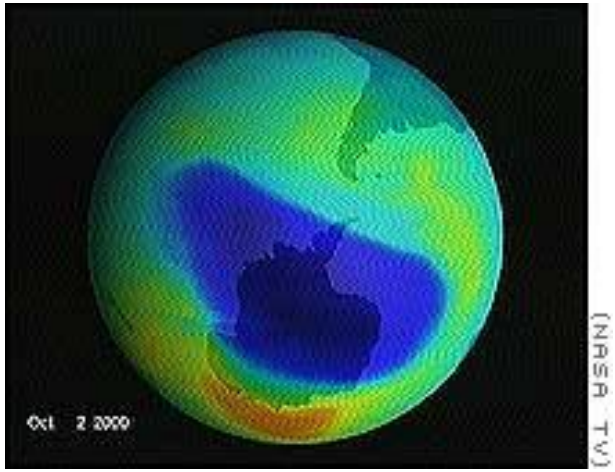
UV radiation

（紫　外　線）

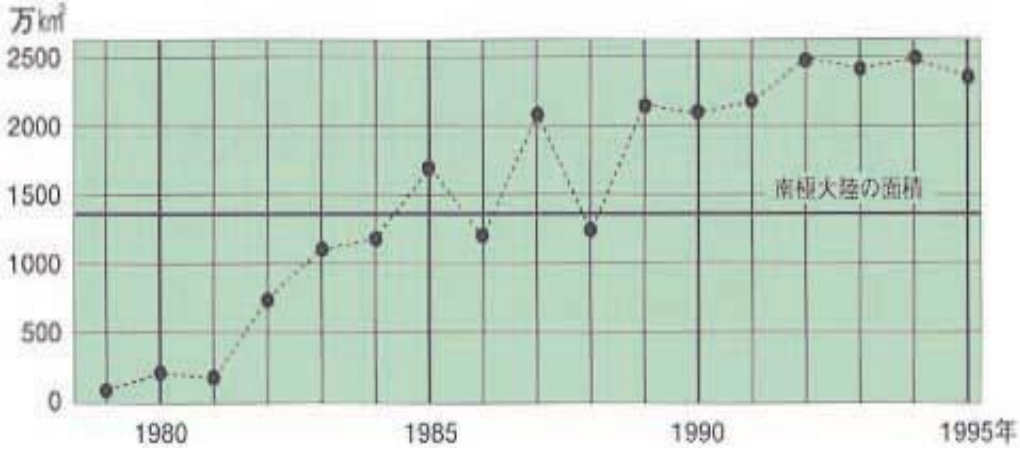


Surface of earth

オゾンホールの現状



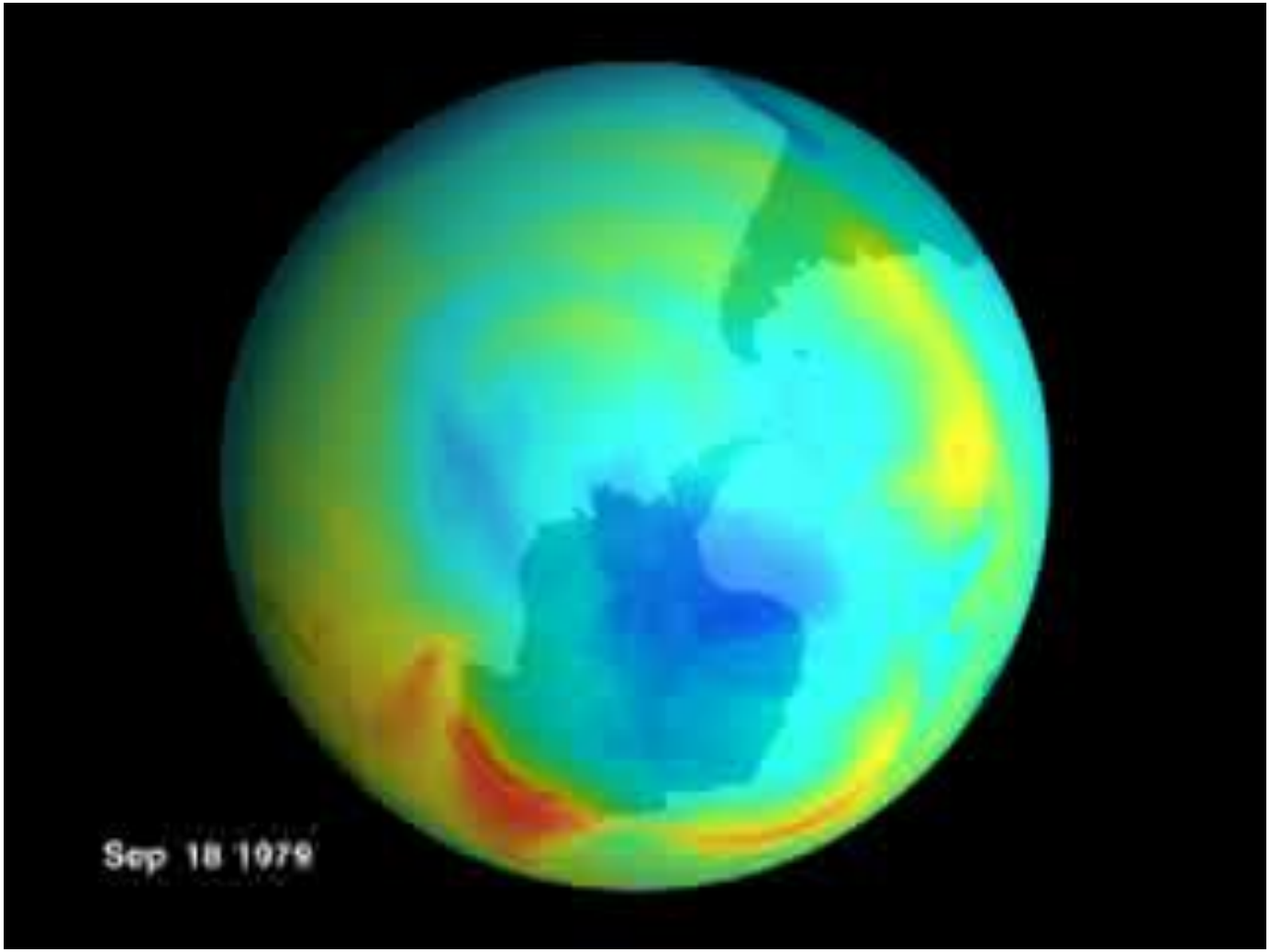
NASAの画像　2000, 10. 4



気象庁のデータ

- メリーランド・グリーンベルト（CNN）　アメリカ航空宇宙局（NASA）は4日、南極大陸上空で米国の3倍もの大きさがあるこれまでで最大規模のオゾン層の穴が見つかったとする報告書を出した。フロンガスの一種、クロロフルオロカーボン（CFCs）や他のオゾン層破壊物質の使用と、極地特有の高層での旋風が原因としている。

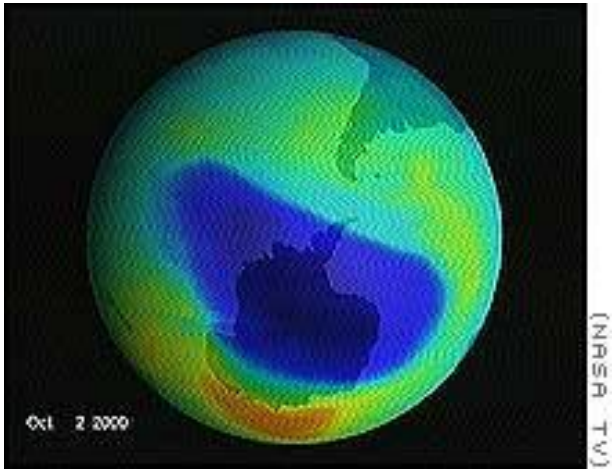
- フロンの排出量は、オゾン層破壊物質の削減を決めたモントリオール議定書が採択された1987年以降、ほぼ同じレベルで推移しているという。しかし、オゾン層破壊物質は何十年も大気圏にとどまるため、長い時間を経てから成層圏でオゾン層の破壊を始めるという。

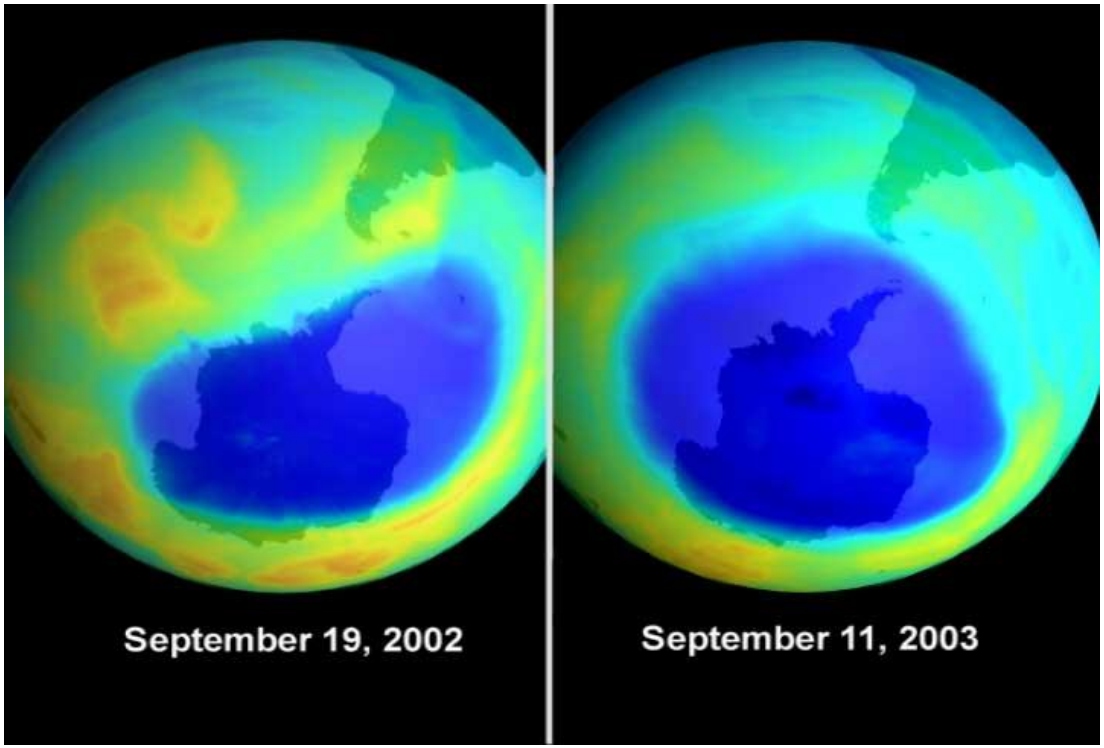


Changes in ozone hole around Antarctica over 30 taers

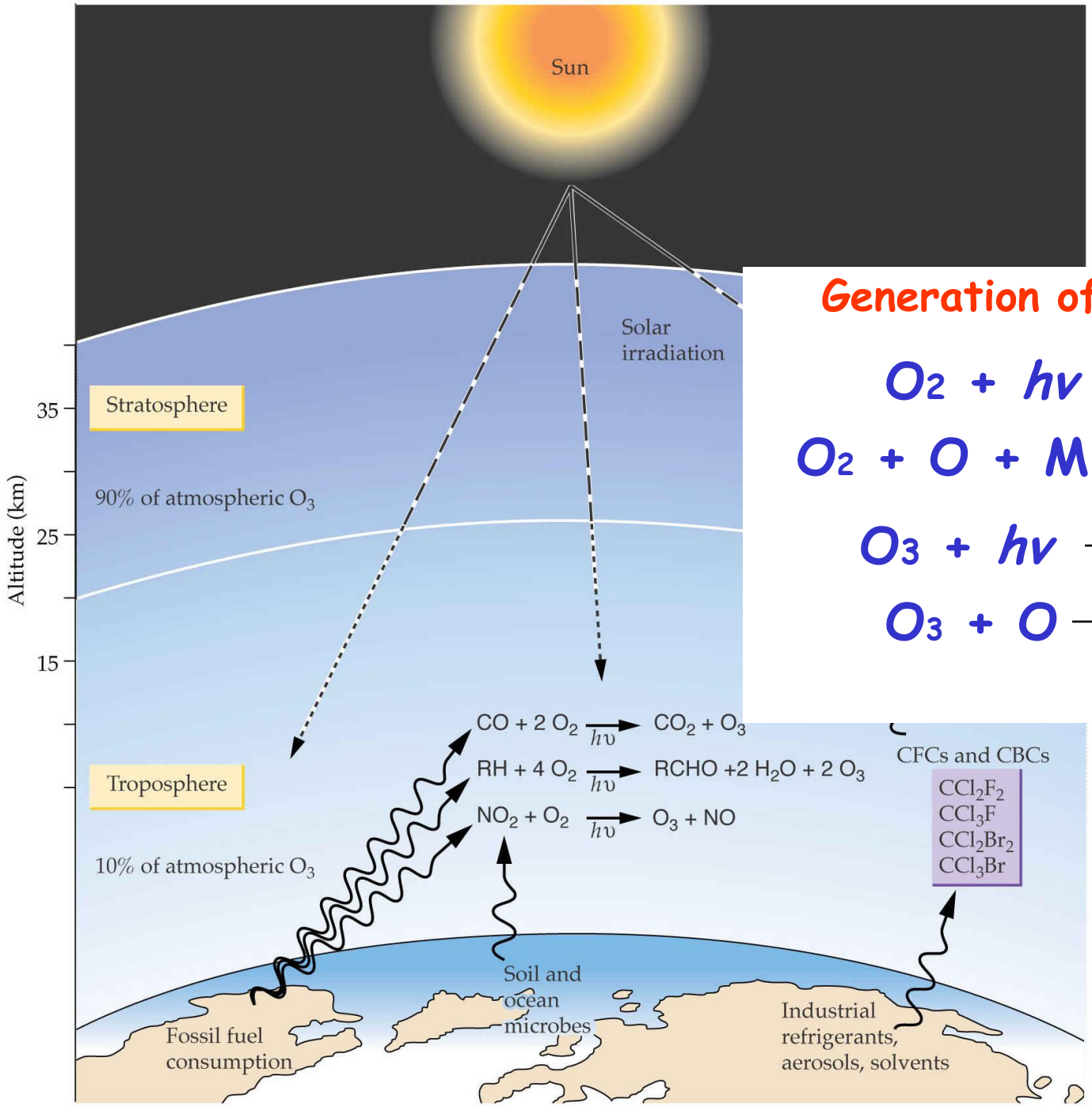
過去３０年間における南極付近のオゾンホールの変化

NASAホームページより　http://www.gsfc.nasa.gov/topstory/2003/0925ozonehole.html





NASA ホームページより



Generation of ozone layer

$$O_2 + h\nu \longrightarrow 2O$$

$$O_2 + O + M \longrightarrow O_3 + M$$

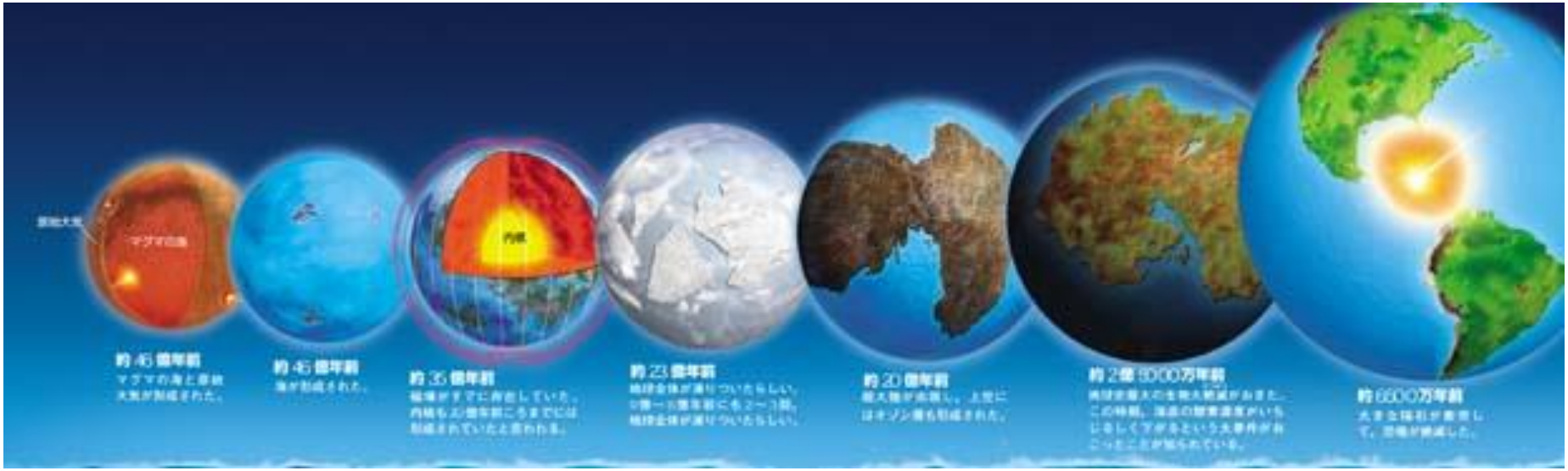
$$O_3 + h\nu \longrightarrow O_2 + O$$

$$O_3 + O \longrightarrow 2O_2$$

O_3 : ozone

O_2 : oxygen

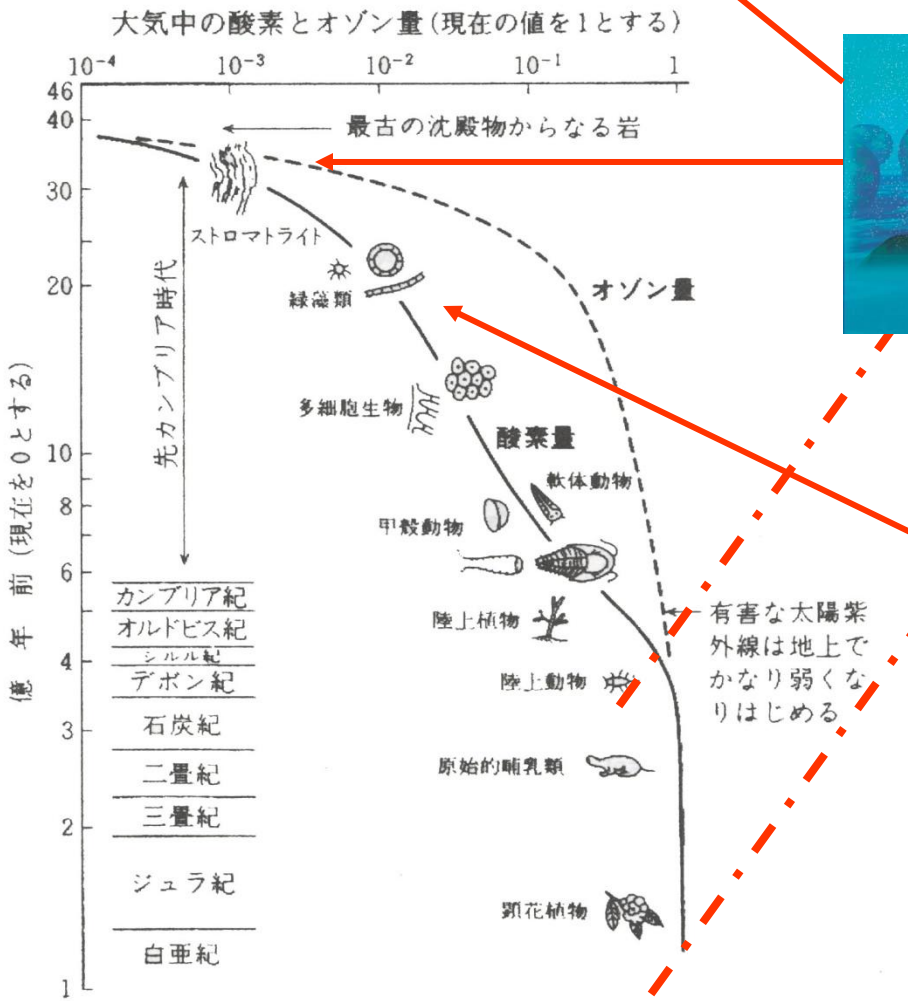
Evolution of earth and organisms
地球と生物の進化

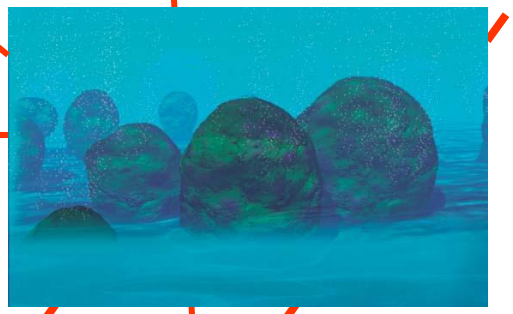


4,600 million years ago, the earth was bone!

Graphic science Magazine “Newton”より

(X 100 million years ago)

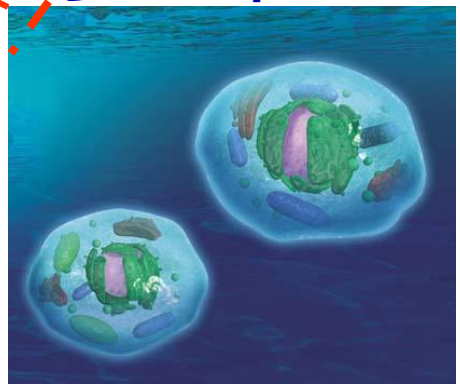




およそ35億年前に太陽エネルギーを利用して光合成を行う原核生物（らん藻）が海底に出現する

Cyanobacteria appears on the earth, 3,500 million years ago.

CO2 consumption and O2 evolution



Eukaryote

Graphic science Magazine “Newton”より

Ozone and UVB Monitoring Station in the World

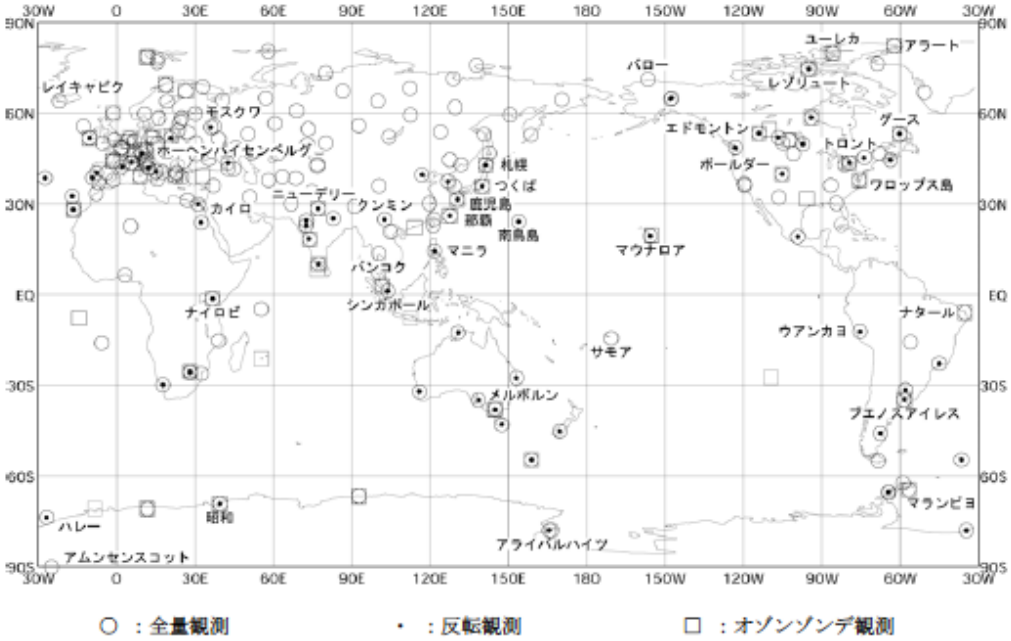
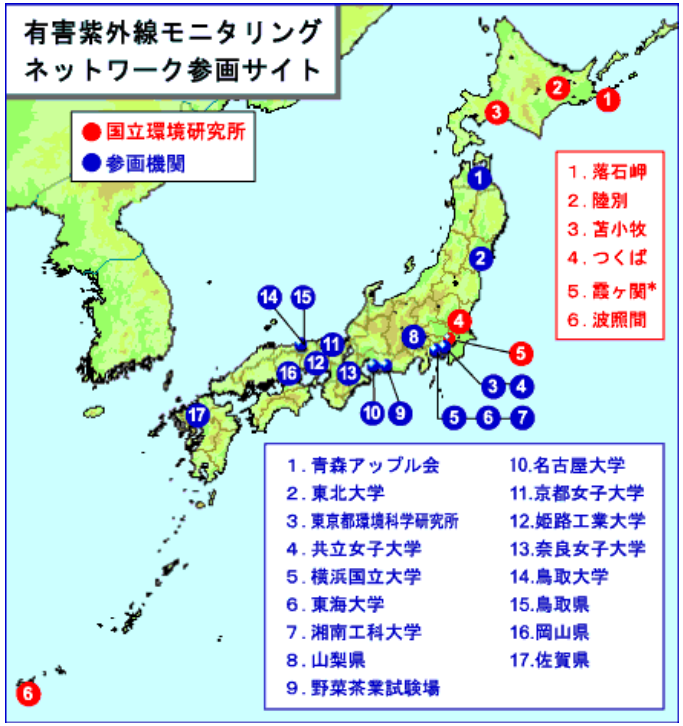


図 50　世界のオゾン観測所の分布（2002 年現在）

全量観測は 229 地点、反転観測は 72 地点、オゾンゾンデ観測は 63 地点。

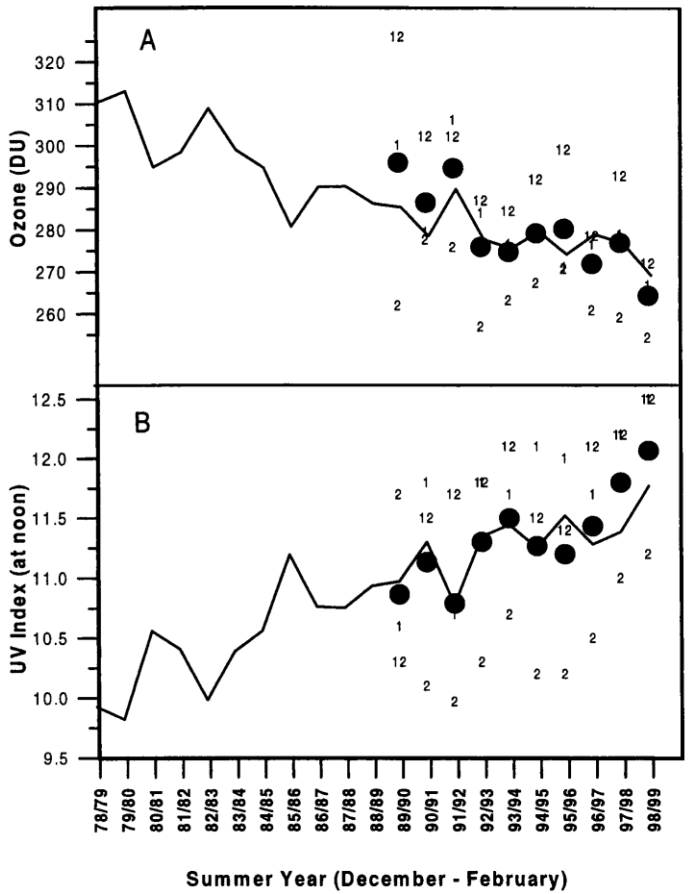
（出典）気象庁 オゾン層観測報告 2002



UVB Monitoring Network in Japan

Relationship between reduction in stratospheric ozone layer and increasing in the amount of UVB radiation.

Fig. 1. Mean ozone (Dobson units, 1 DU = 2.69×10^{16} molecules cm^{-2}) (**A**) and estimated UV Index (**B**) at Lauder, New Zealand, for the summer of 1978–79 through the summer of 1998–99. Summer is defined as the period from December through February. The solid line in (A) shows the changes in summertime ozone that have occurred since the 1970s. The solid line in (B) shows the deduced changes in clear-sky UV radiation expected from these changes in ozone (*14*). The symbols (from 1989–90 on) show measured values of ozone and the summertime peak UV Index (*13*), as discussed in the text, both derived from the UV spectroradiometer. The plot also shows the values from each contributing month, labeled by the month number.



In New Zealand

McKenzie R. et al. 1999. Science

Relationship between reduction in stratospheric ozone layer and increasing in the amount of UVB radiation.

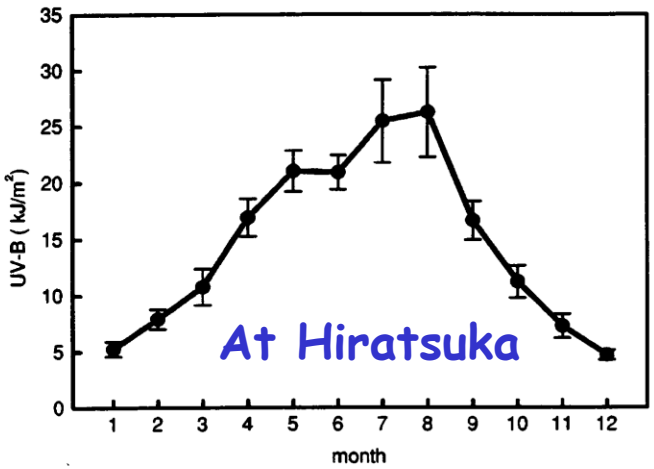


Fig. 4 Seasonal variation of the monthly mean values of global solar UV-B irradiance accumulated daily from October 1990 to September 2000 (at Hiratsuka). The standard deviation is given by a ve

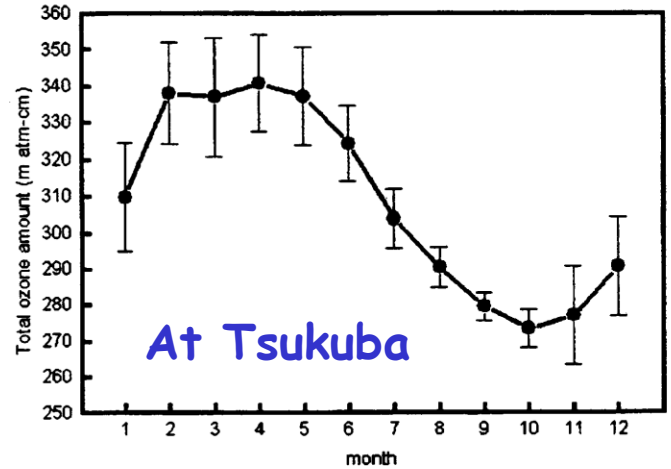


Fig. 5 Seasonal variation of the monthly mean values of daily representative "total" ozone amount from October 1990 to September 2000 (at Tsukuba). The standard deviation is given by a vertical bar.

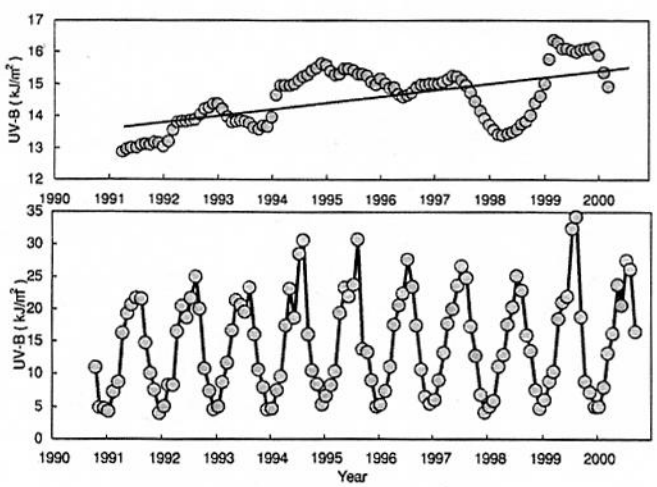


Fig. 8 Increasing trend of 12-month moving averages of monthly mean values of the global UV-B irradiance from October 1990 to September 2000 (upper chart) and the original UV-B data (lower chart).

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