ECE 4339 In-class questions

3/5/2015

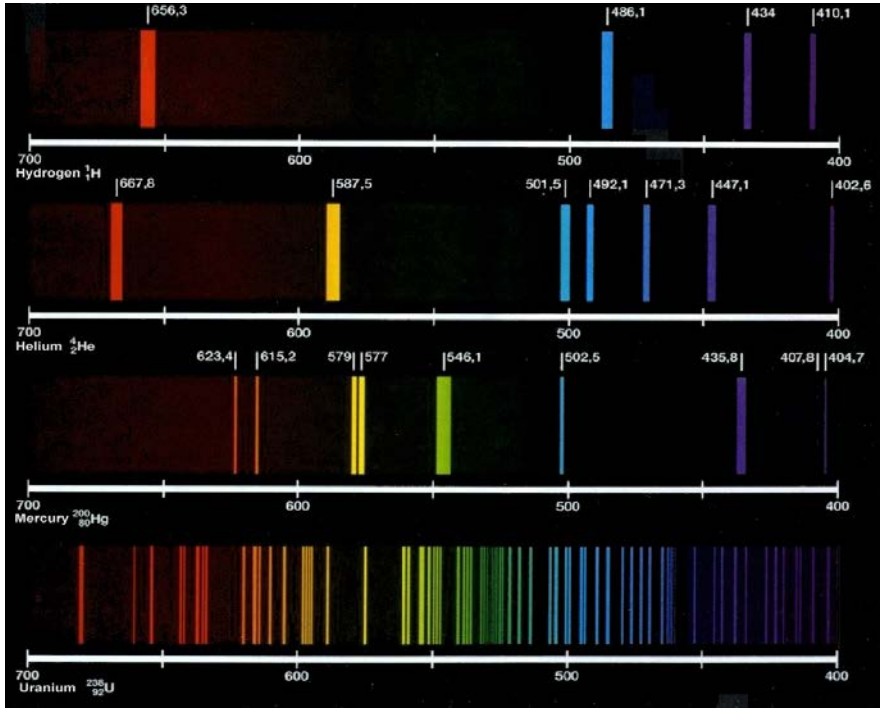
Discrete Lines in Atomic Vapor Spectra

Key concepts

- Optical spectra
- Continuous spectra vs. quantized spectra

Question 1

Is there any energy transfer (or change in energy form) in the physical process shown here, which is a key evidence in the discovery of quantum theory? If there is, what is that process? Describe or name the process

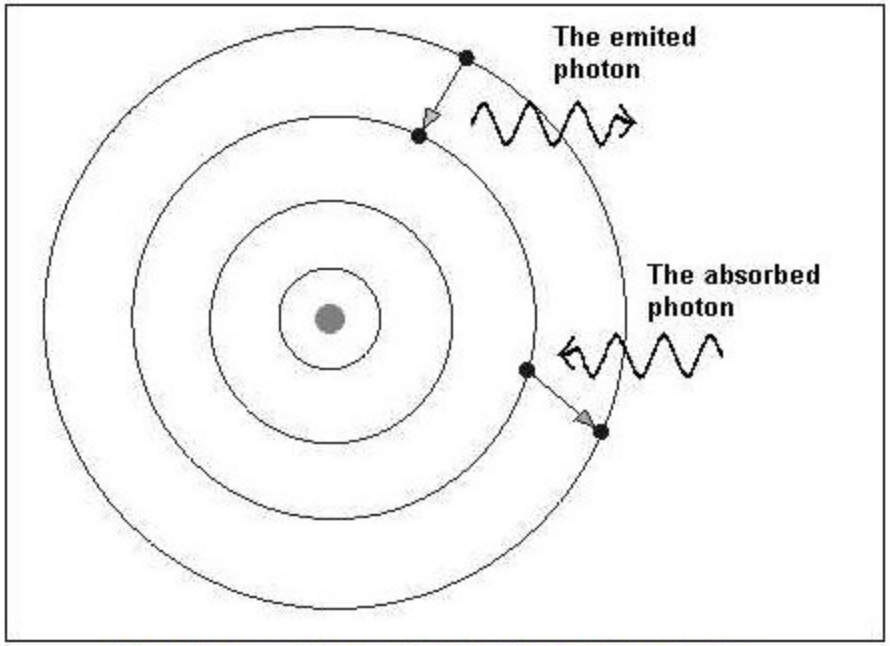


http://library.thinkquest.org

Where do the light come from? What do the spectra tell you?

Question 2

Is the reverse process of that in Question 1 possible?, and if it is, what is it called?



The electron emits or absorbs the energy changing the orbits.

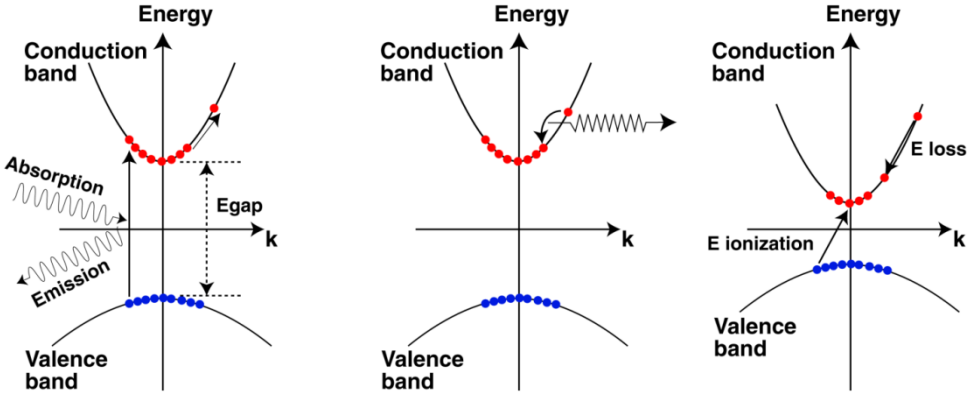
Where do the light come from? What do the spectra tell you?

Question 3

The fundamental absorption or emission interaction between a photon and an electron-hole pair in semiconductor is different from that in an atom because:

a) atom has only electrons, no holes
b) semiconductor has a balanced ratio of electron-hole population at equilibrium
c) all of the above

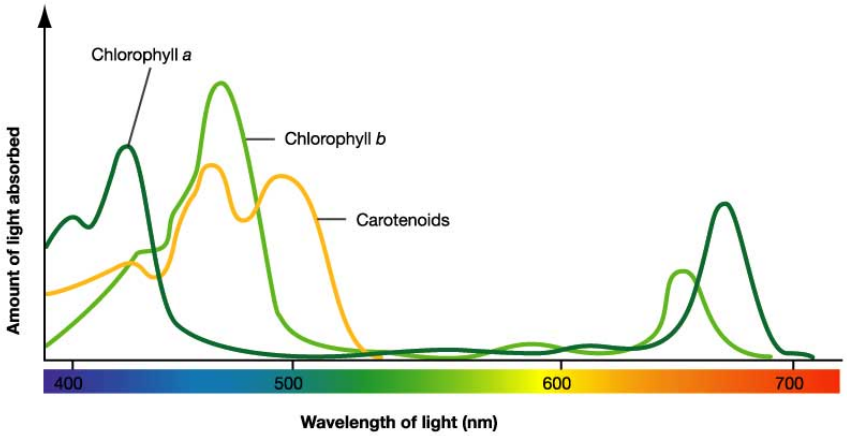
Have to explain the whole thing: the question, a, b, or c.

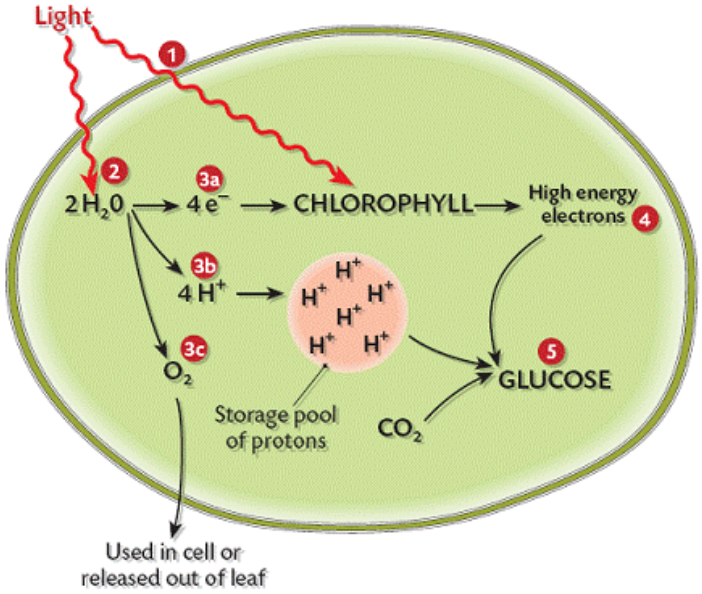


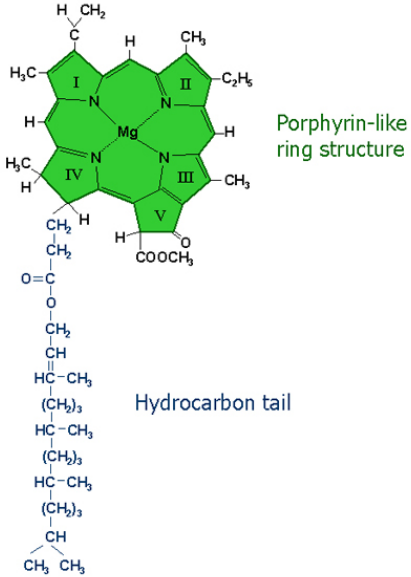
Below is an example of the answer

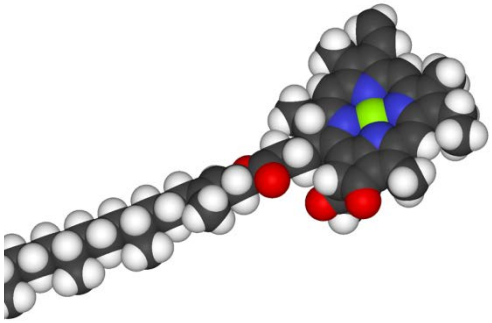
Point 1: The statement "The fundamental absorption or emission interaction between a photon and an electron-hole pair in semiconductor is different from that in an atom" is false. Semiconductor is simply a large collection of atoms bonded together by sharing electrons. The fundamental process of an electron making a transition between 2 quantum states by absorbing or emitting of a photon is governed by the same fundamental EM force (quantum electro-weak dynamics) regardless whether the electron is in an atom, molecule, or some condensed matter (semiconductors or not).

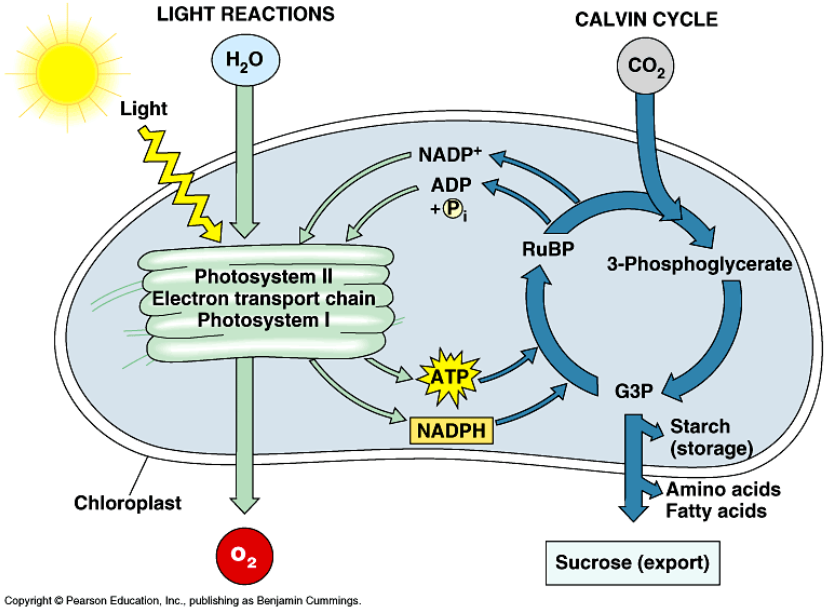
In fact, a most basic and important process for most life on Earth involves the absorption of a photon by an electron in chlorophyll. The absorbed photon energy is then used to synthesize ATP from ADP, a molecule with higher energy than ADP, which serves as the "currency of energy" in all life forms. Photosynthesis life forms synthesize all complex molecules with higher energy content than CO2 and H2O by using this photon absorbed energy.











About a: To argue that "atom has only electrons, no holes" as the reason for the false premise: "The fundamental absorption or emission interaction between a photon and an electron-hole pair in semiconductor is different from that in an atom" is a type of "semantics" fallacy. It illustrates how language and semantics can be misused to construe something that sounds logical but actually is utterly non-sense.

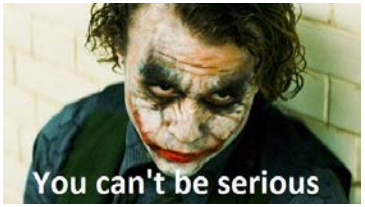
Imagine this argument: US cavalry regiments and Germany Nazi panzer divisions were different during WW II because cavalry means using war horses while panzer means using tanks for battle.

About b: The argument "semiconductor has a balanced ratio of electron-hole population at equilibrium" as the reason for "The fundamental absorption or emission interaction between a photon and an electron-hole pair in semiconductor is different from that in an atom" is a type of "non-sequitur" argument due to misunderstanding or the lack of clarity in concept.

This type of fallacy is the hardest to handle but also most popular, and is the origin for the "facepalm" emoticon invention. It is akin to a case that someone who is accused of murdering someone during a spring break, argues with the alibi: "I couldn't be the murderer because it happened during the spring break and everyone was away on the spring break."

It is mixed up of individual behavior concepts (electron-photon interaction in atom and electron-hole pair-photon interaction in semiconductor) with statistical collective behavior concepts (electron-hole pair population distribution), that are also totally irrelevant with respect to each other. Consider this: a baby born found with sexual development disorder (hermaphroditism). Since human population is 50% male and 50% female, the baby is declared to be statistically normal to be half-male/half-female.

About c:



Question 4

It is possible for light to be absorbed in a sunglasses without the involvement of any electrons or atoms or semiconductors because sunglasses “work” that way.
Agree or disagree, explain.

Question 5

In a semiconductor, it is possible for an electron to lose its energy completely without the involvement of a photon. What is a generic name for this?

Question 6

When an electron excited to conduction band of a semiconductor (without any holes in the deep bands beneath valence band) loses all of its energy, it will end up in the valence band. True or False.

Question 7

The difference between the optical transition of an electron from valence band to conduction band and the creation of an electron-hole pair by the absorption of a photon is:

a) There is no hole in the 1^{st} process
b) Creation of electron-hole pair in the 2^{nd} process maintains a ratio of electron-hole population at equilibrium whereas the 1^{st} process is independent of hole density
c) Both the above

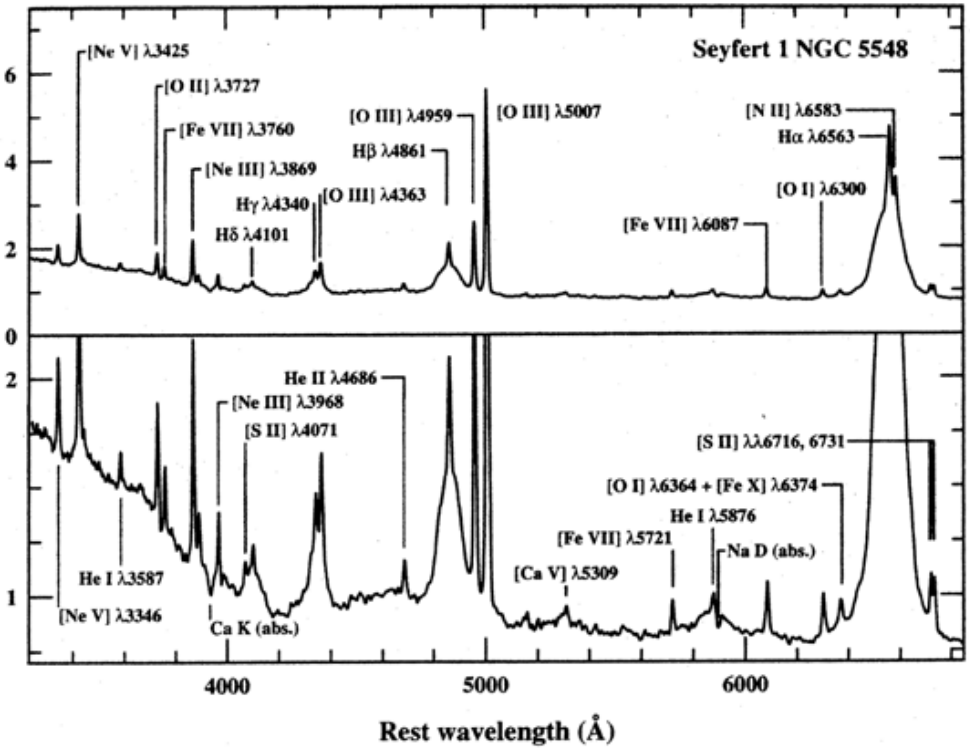
Question 8

Radiative recombination between e-h pair is fundamentally different from optical transition from conduction to valence band because the latter involves only energy relaxation but no recombination. Agree or disagree. Explain.

Question 9 - bonus

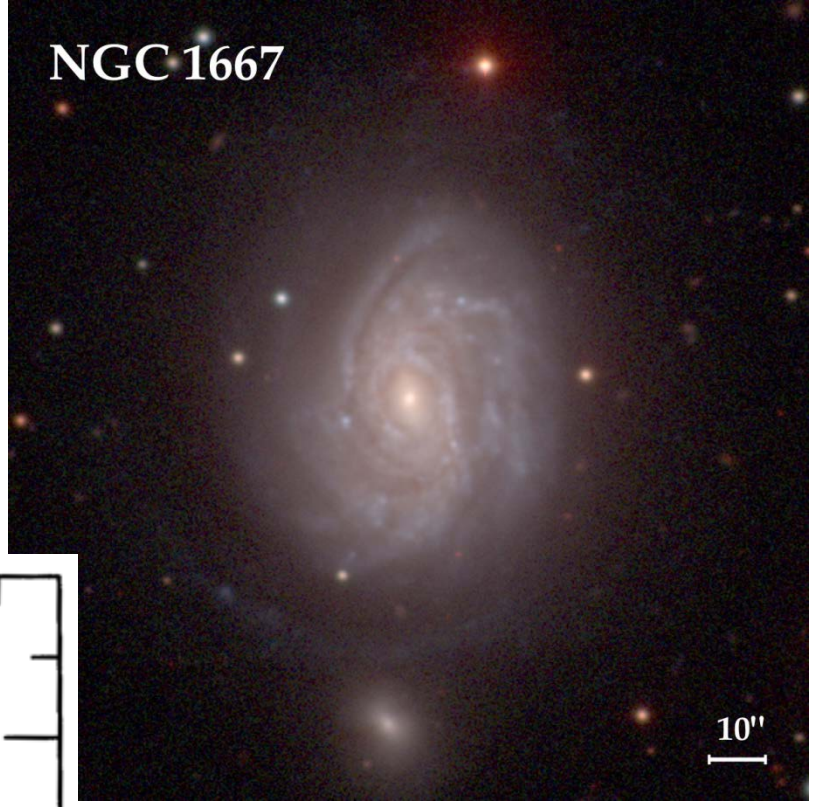
How do people know certain atoms or molecules exist in other planets, stars or galaxies?

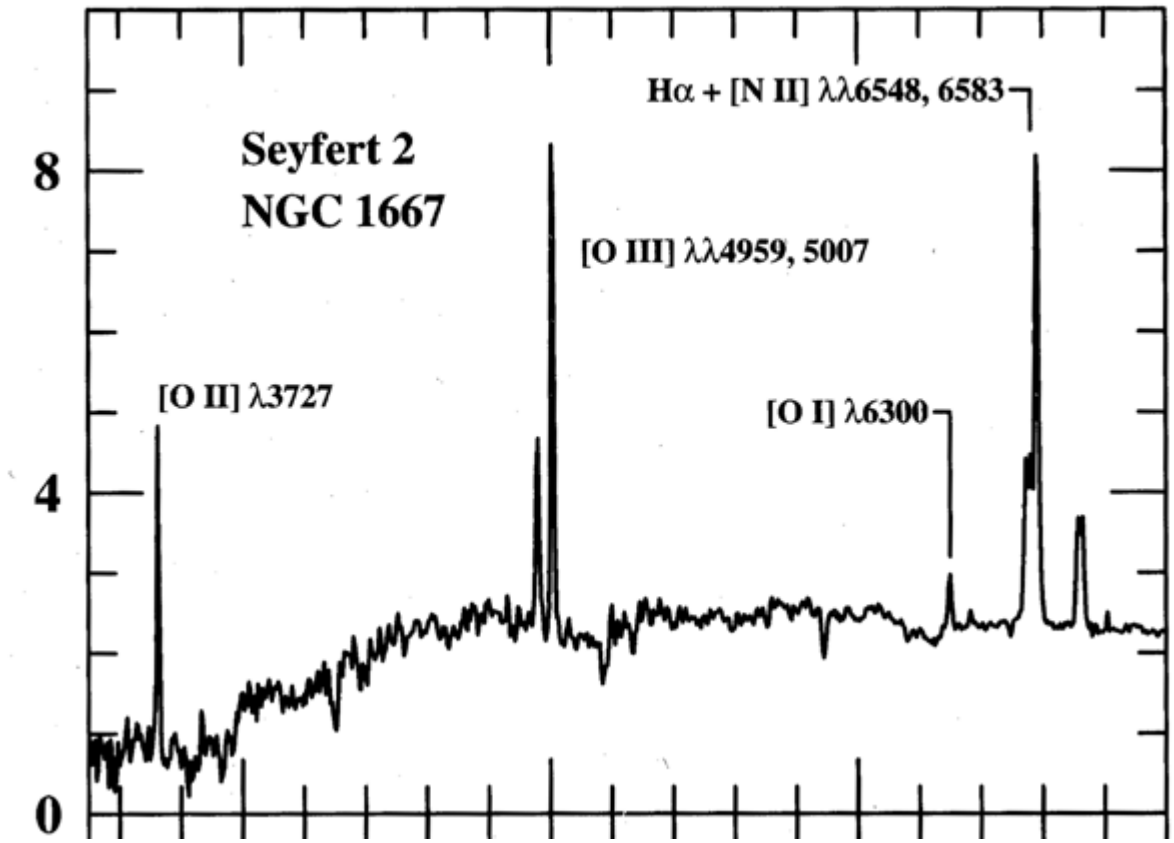
What atomic species can be inferred to be in galaxy NGC 5548?



Source: http://ned.ipac.caltech.edu/level5/Glossary/Essay_seyfert.html

Source: http://www.astronomy.ohio-state.edu/~bentz/images.html


NGC 1667
10''


Seyfert 2
NGC 1667
Hα + [N II] λλ6548, 6583
[O III] λλ4959, 5007
[O II] λ3727
[O I] λ6300
8
4
0

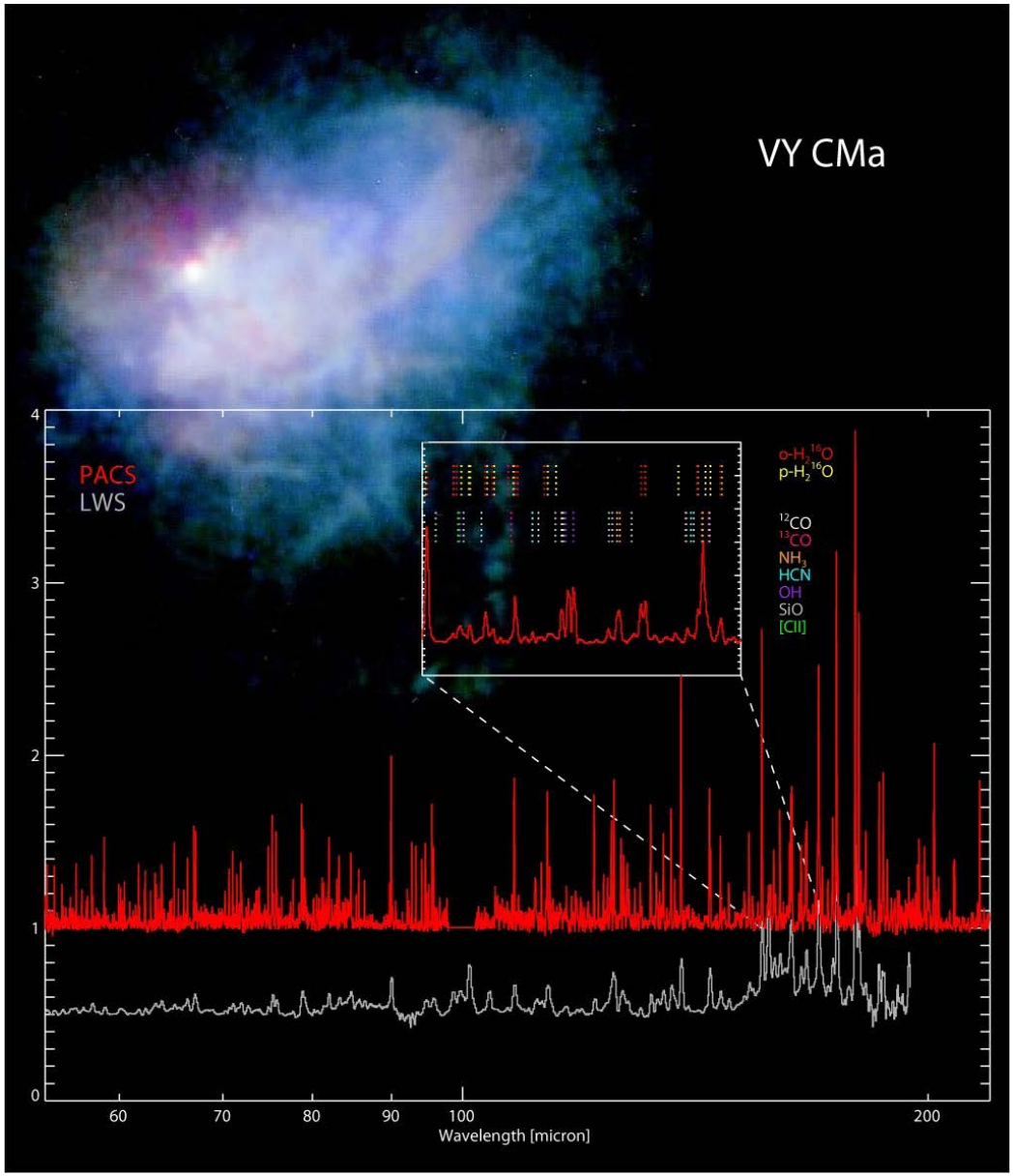
Herschel project: Far IR and mm-wave spectroscopy

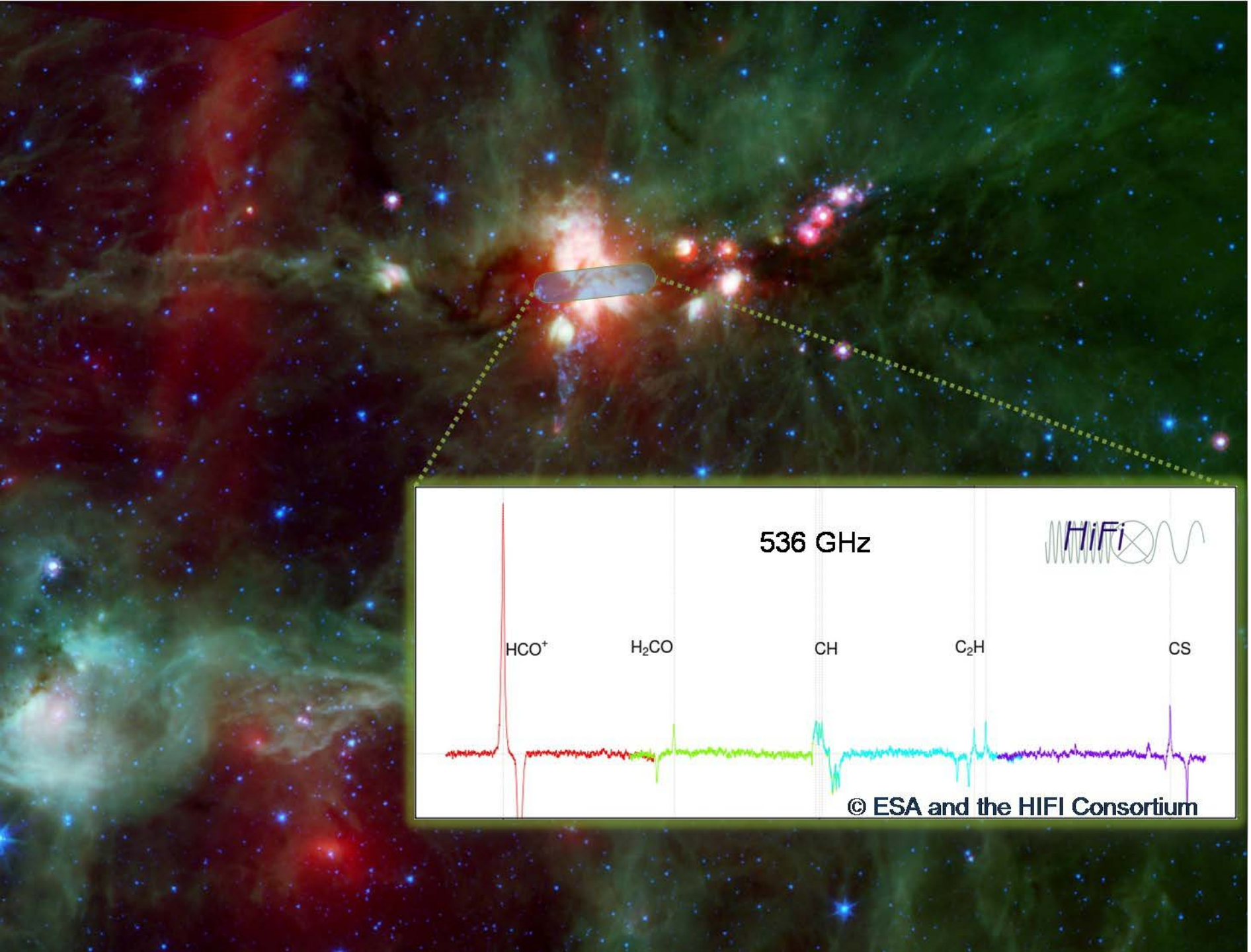
Are spectra of atoms (usually in the visible spectral range) that interesting?

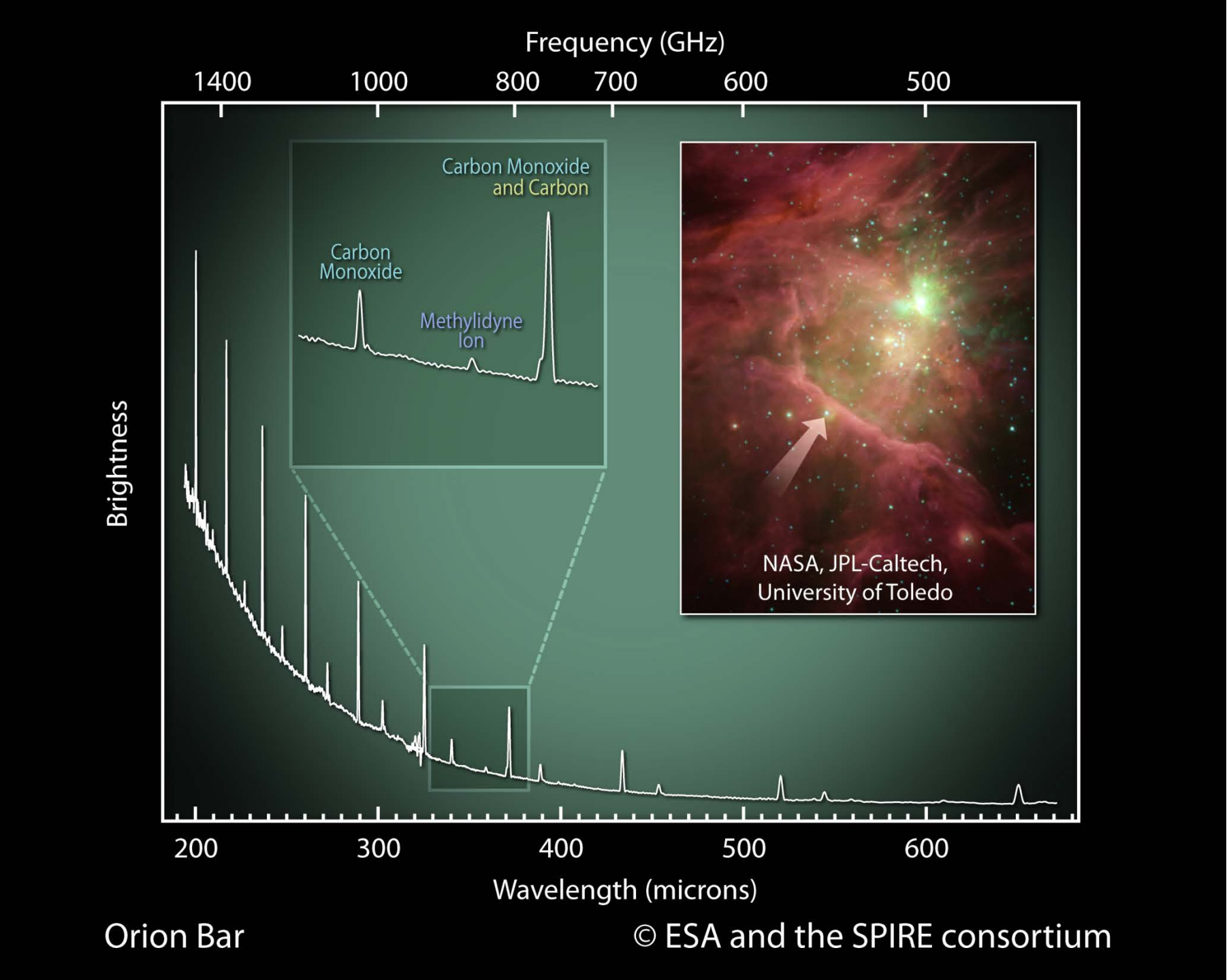
Not really. It would be silly to think that other galaxies don't have the full periodic table like what we have here on Earth.

More interesting are molecules, especially organic that may suggest the possibility of life similarly on Earth.

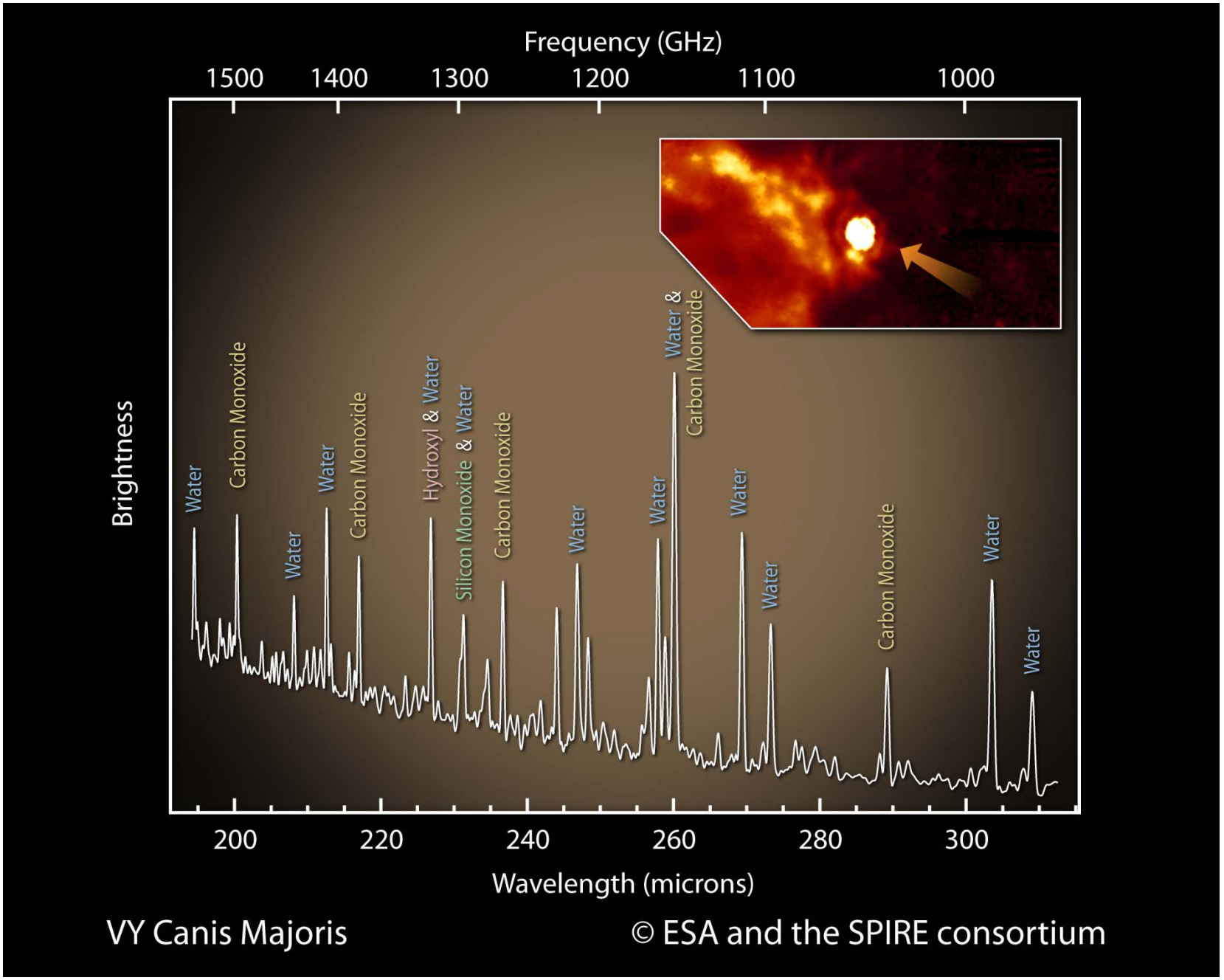
A different spectral range: IR-mm-wave is much better for observing complex molecular species than the visible spectral range.




536 GHz
HiFi
HCO+
H2CO
CH
C2H
CS
© ESA and the HIFI Consortium



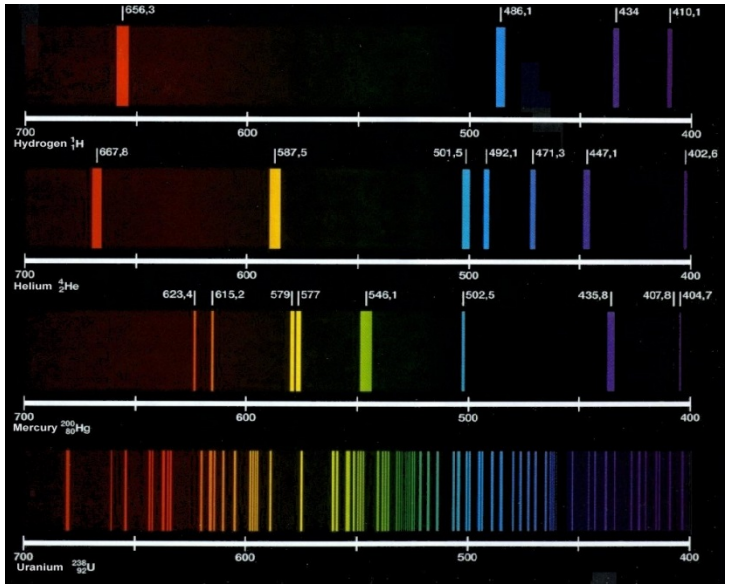
Orion Bar

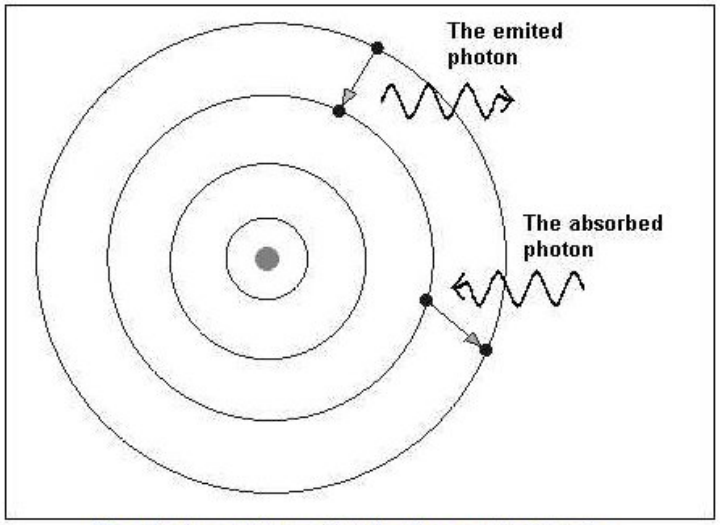

Frequency (GHz)
1500
1400
1300
1200
1100
1000
Brightness
Water
Carbon Monoxide
Water
Water
Carbon Monoxide
Hydroxyl & Water
Silicon Monoxide & Water
Carbon Monoxide
Water
Water
Water & Carbon Monoxide
Water
Water
Carbon Monoxide
Water
Water
200
220
240
260
280
300
Wavelength (microns)
VY Canis Majoris
© ESA and the SPIRE consortium

Question 10 – research topic

What happens in the leaves of deciduous trees between summer and fall?
How do you see any similarity to semiconductors that have different colors?

Electronic quantum transition





The electron emits or absorbs the energy changing the orbits.

Question 11 – research topic

Someone writes: "*Electronic quantum transition by absorbing a light photon in atoms or molecules is important in the quantum theory and is also important in solid state electronics. However, it has nothing to do with the human body and I don't really care.*"

What would you write in response? (hint, see the next few slides).

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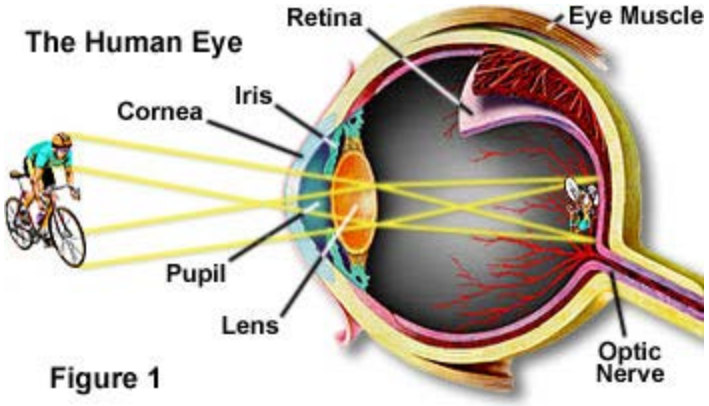


Figure 1

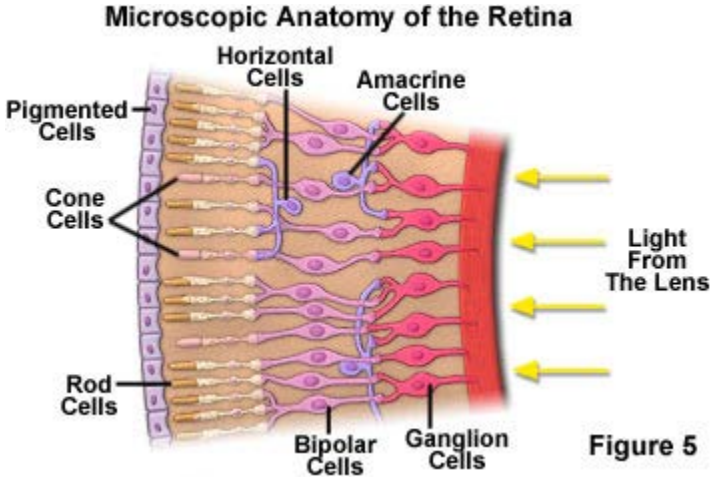


Figure 5

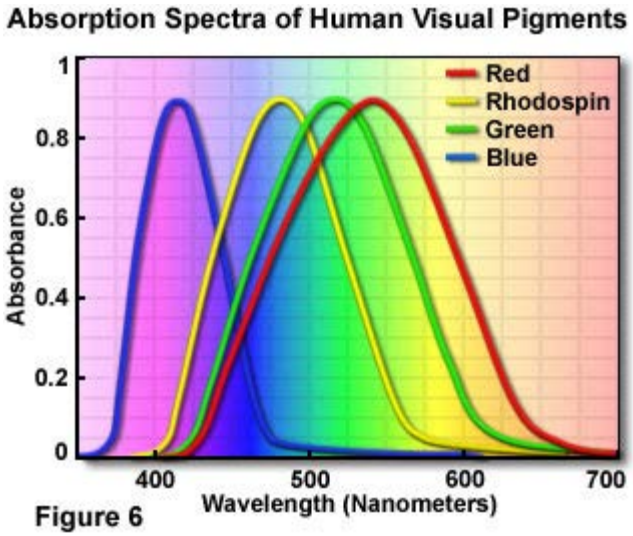
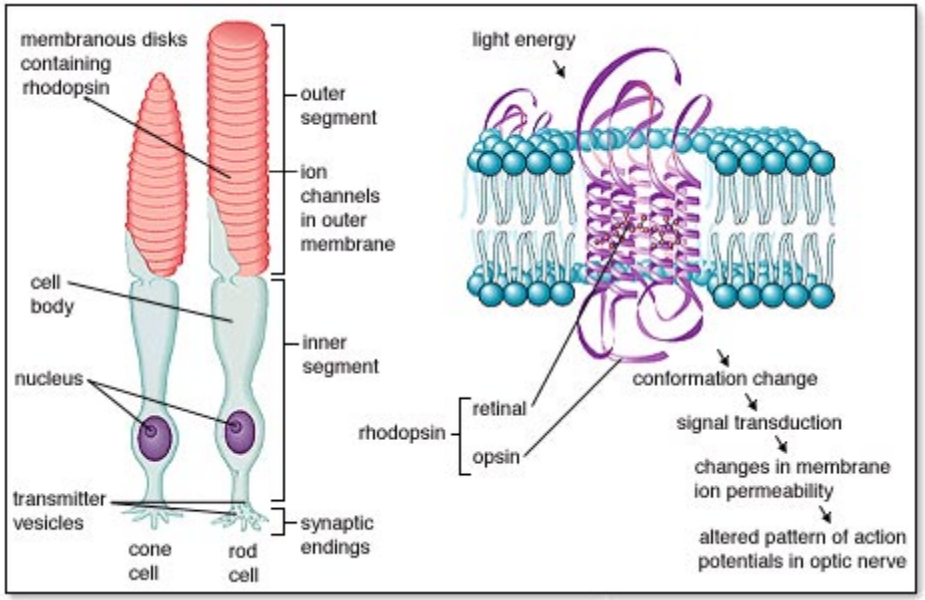
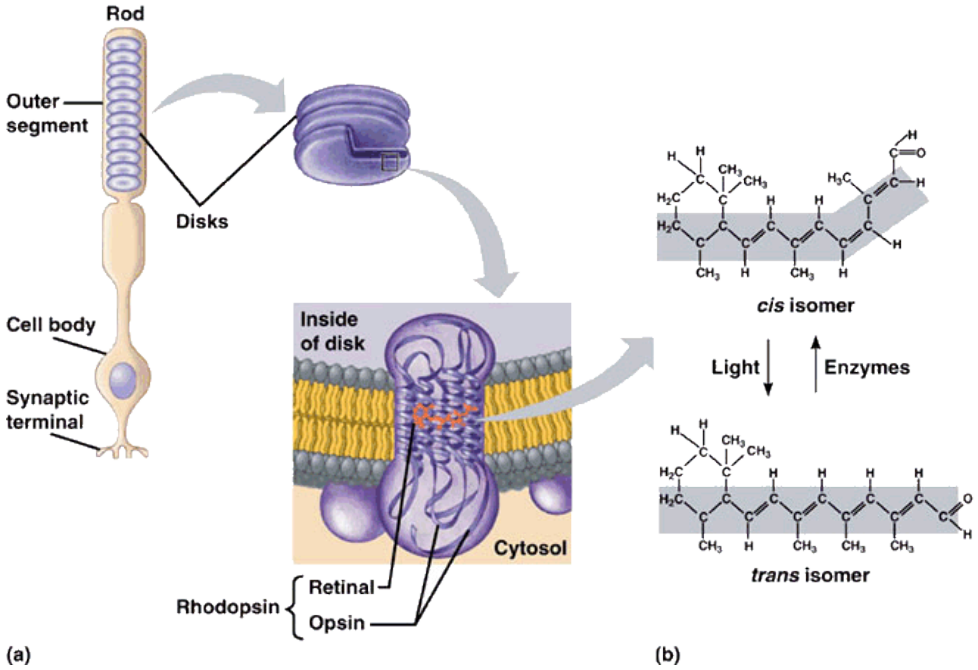


Figure 6





Source: http://www.fukui.kyoto-u.ac.jp/users/hasegawa/hase_files/Retinal.html

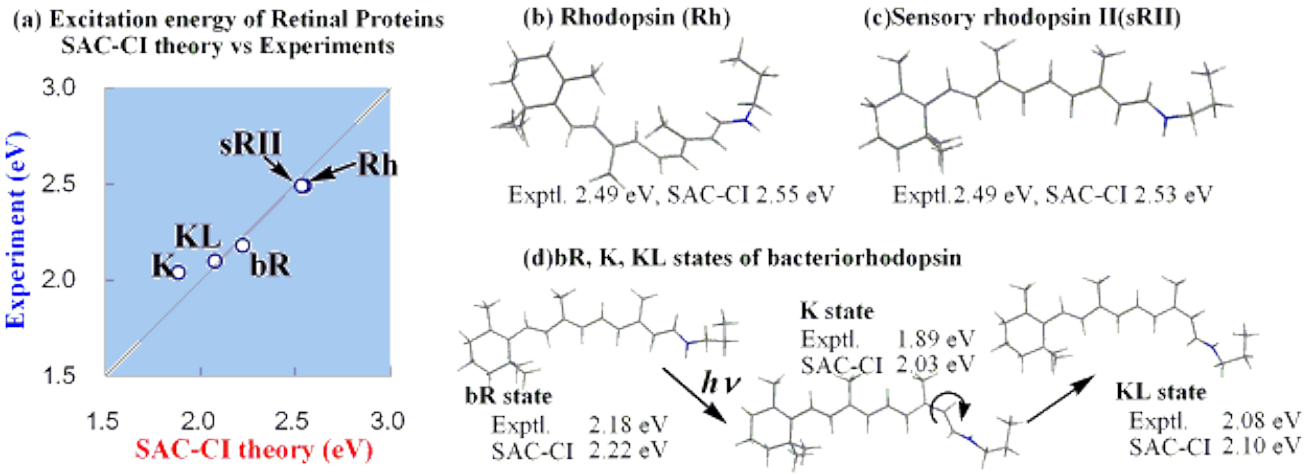
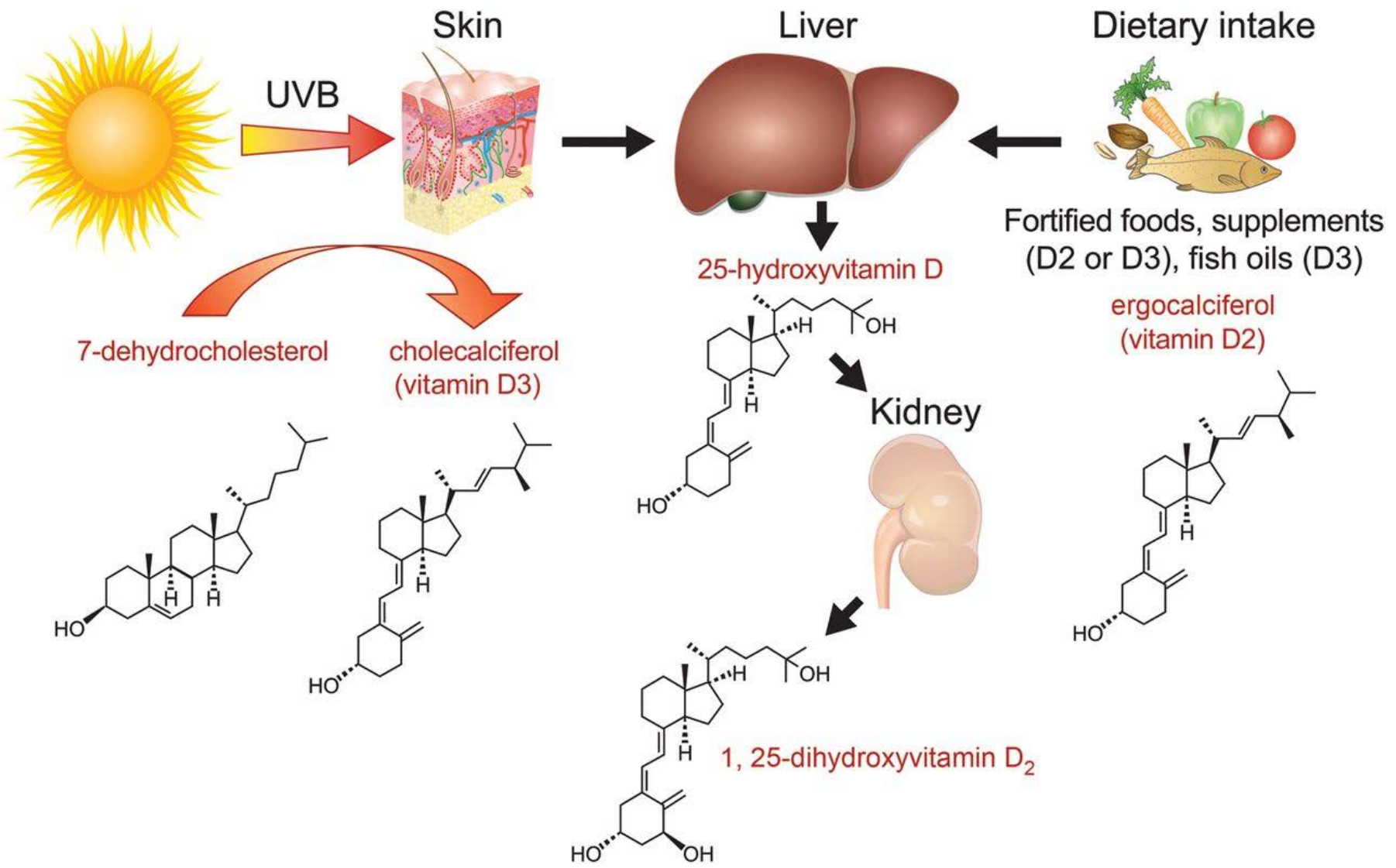
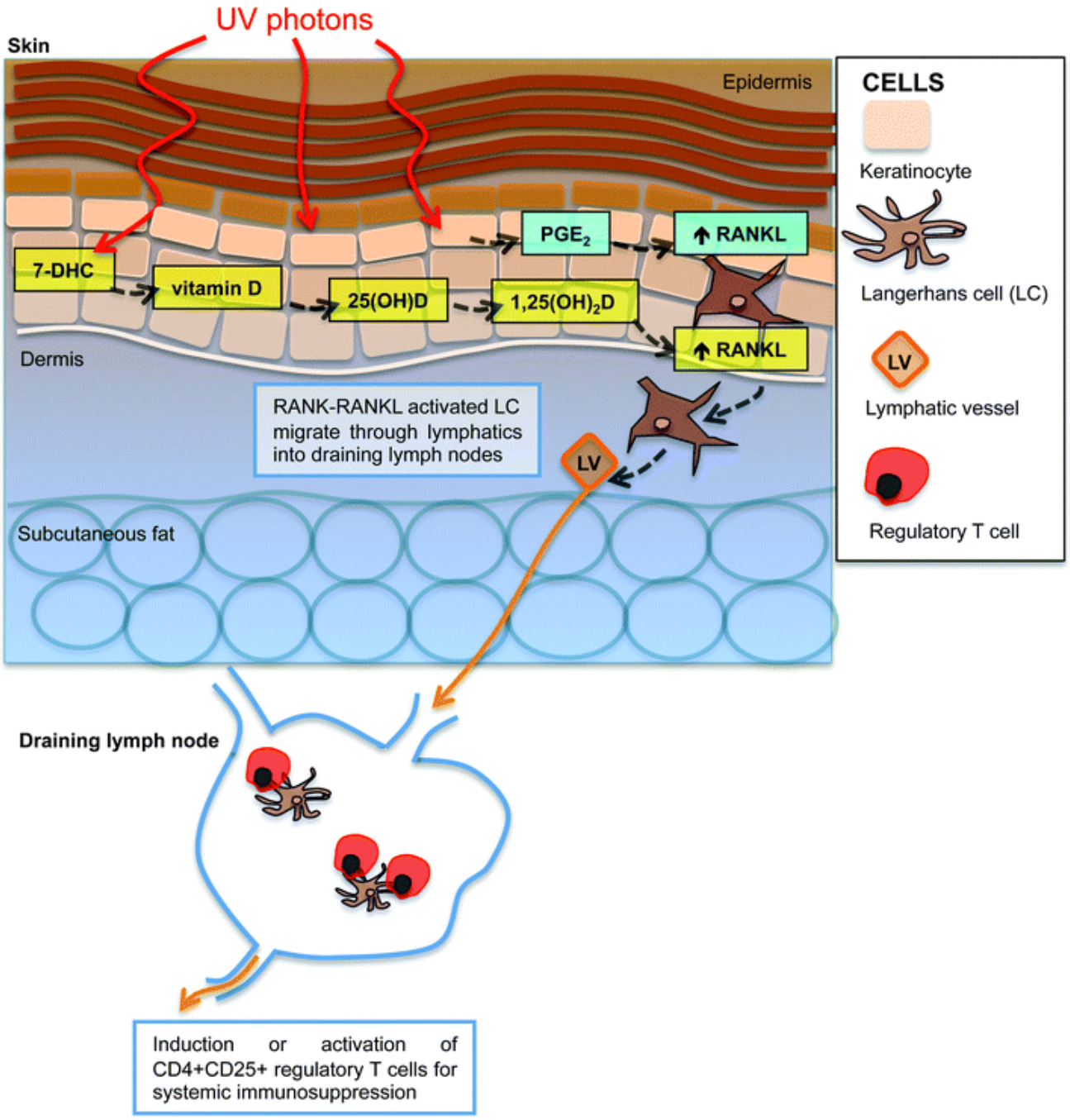


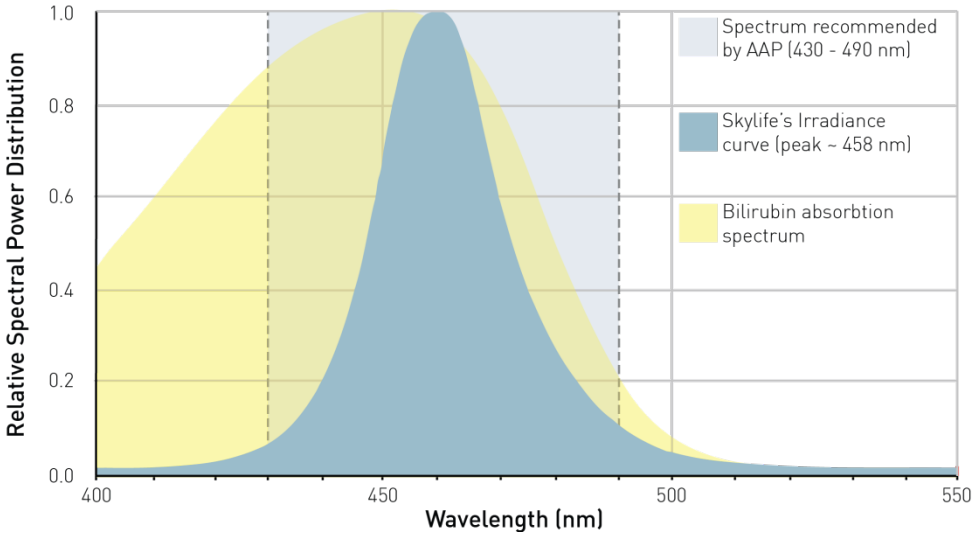
Fig. Excitation energy of retinal proteins.(a) The SAC-CI theoretical excitation energies are compared with the experimental values. Structures and excitation energies of (b)rhodopsin, (c)sensory rhodopsin II, and (d) bR, K, and KL states of bacteriorhodopsin.

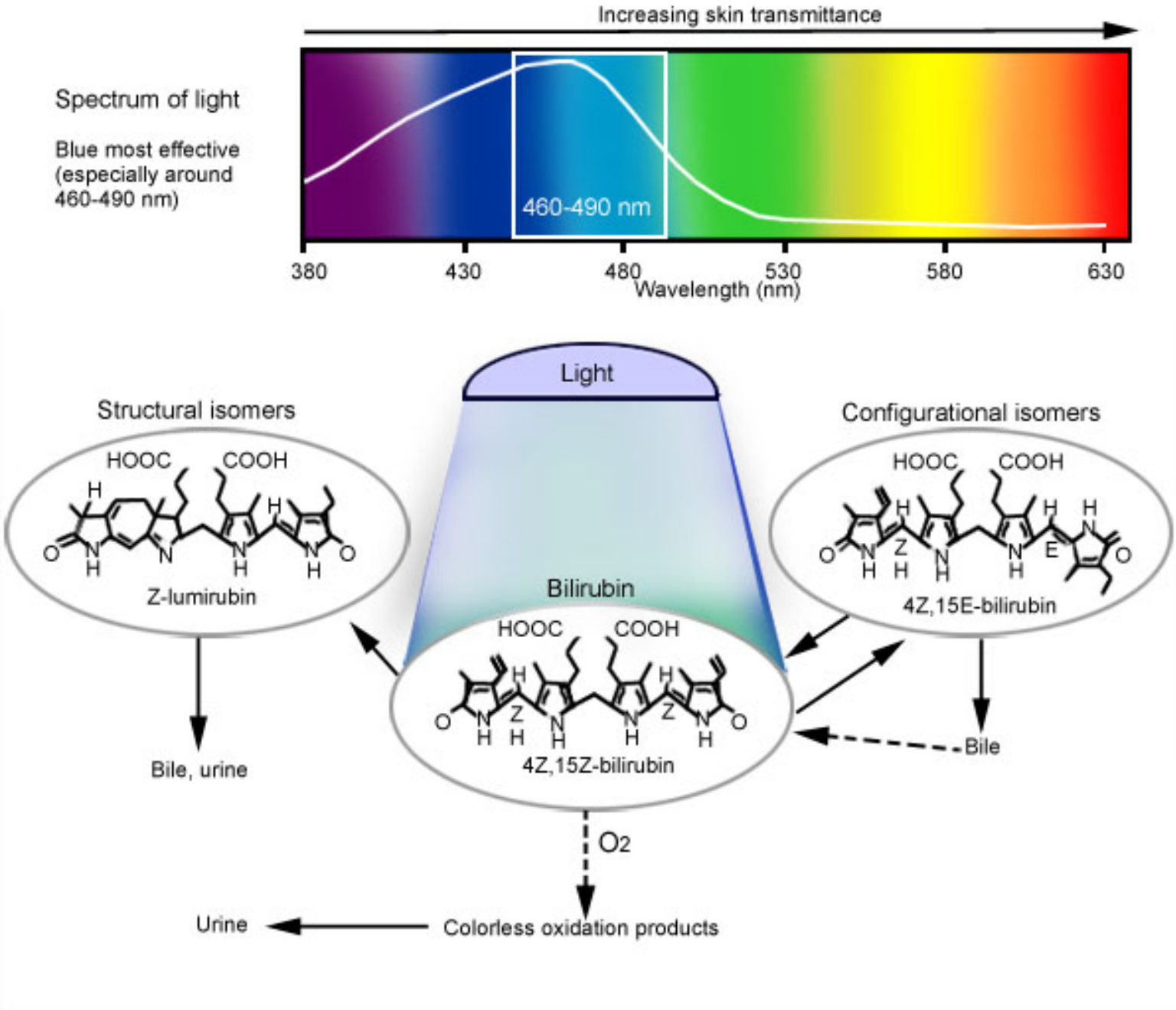

Skin
Liver
Dietary intake
UVB
Fortified foods, supplements
(D2 or D3), fish oils (D3)
25-hydroxyvitamin D
ergocalciferol
(vitamin D2)
7-dehydrocholesterol
cholecalciferol
(vitamin D3)
Kidney
1, 25-dihydroxyvitamin D2


UV photons
Skin
Epidermis
7-DHC
vitamin D
25(OH)D
1,25(OH)2D
PGE2
RANKL
RANKL
Dermis
RANK-RANKL activated LC migrate through lymphatics into draining lymph nodes
LV
Subcutaneous fat
Draining lymph node
Induction or activation of CD4+CD25+ regulatory T cells for systemic immunosuppression
CELLS
Keratinocyte
Langerhans cell (LC)
LV
Lymphatic vessel
Regulatory T cell

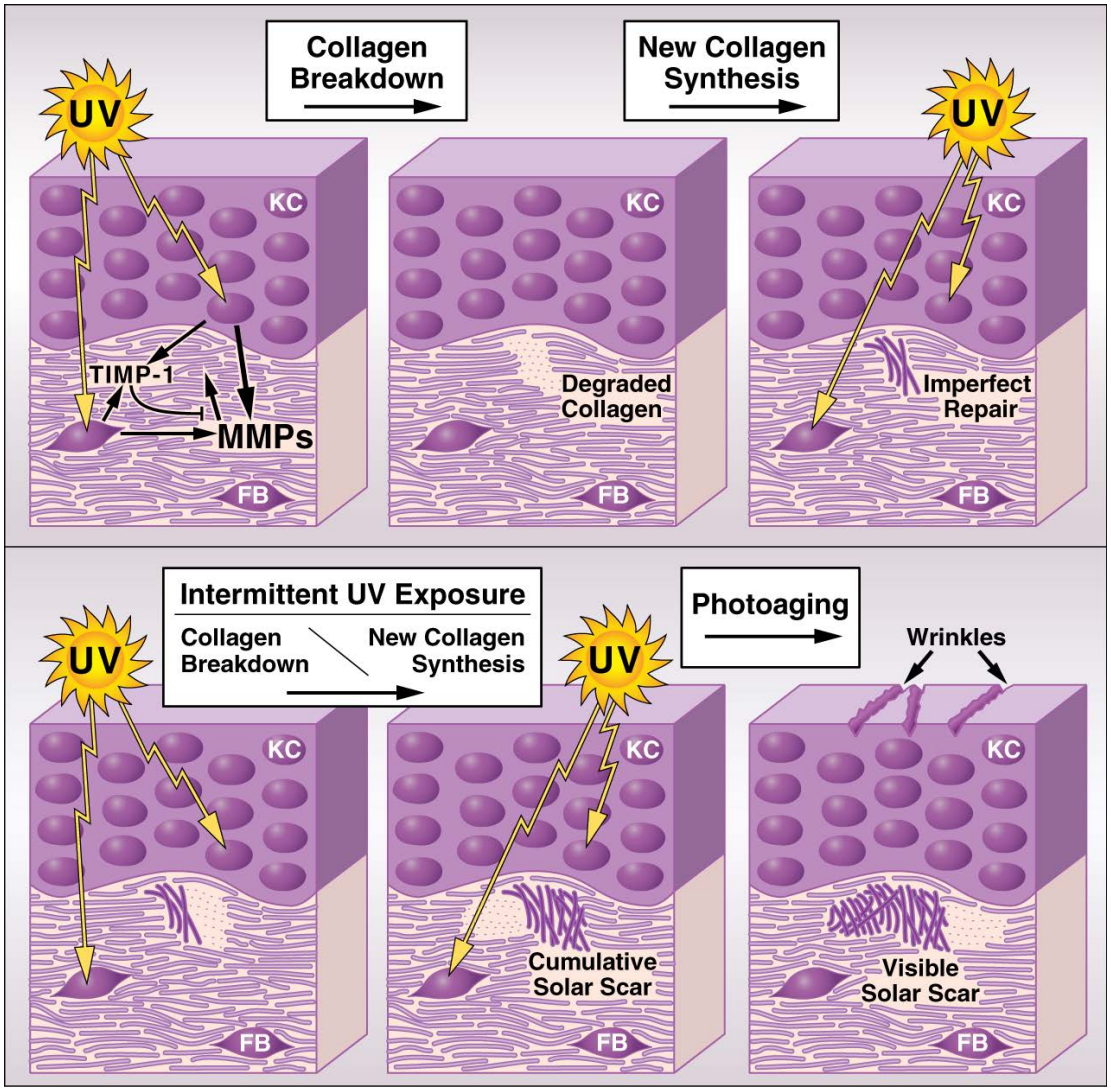
Do you think green light (550 nm) or yellow or red light can be used to treat jaundice babies?

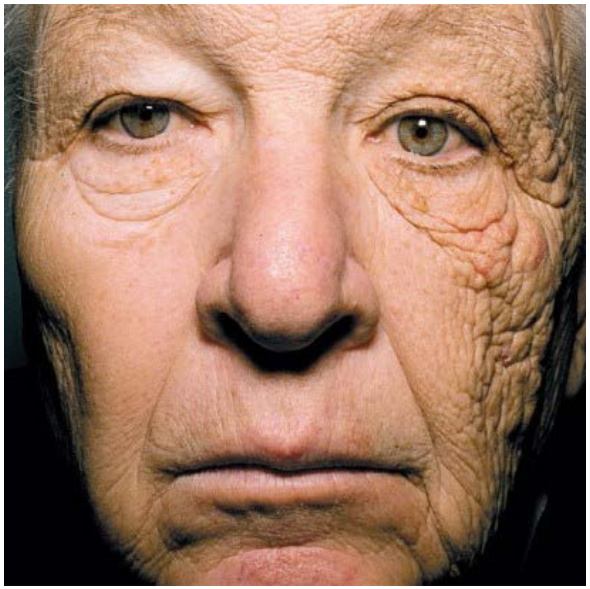
Why or why not?




Increasing skin transmittance
Spectrum of light
Blue most effective (especially around 460-490 nm)
460-490 nm
380
430
480
530
580
630
Wavelength (nm)
Light
Structural isomers
HOOC
COOH
Z-lumirubin
Bile, urine
Bilirubin
4Z,15Z-bilirubin
Configurational isomers
4Z,15E-bilirubin
Bile
O2
Urine
Colorless oxidation products

Trucker accumulates skin damage on left side of his face after 28 years on the road

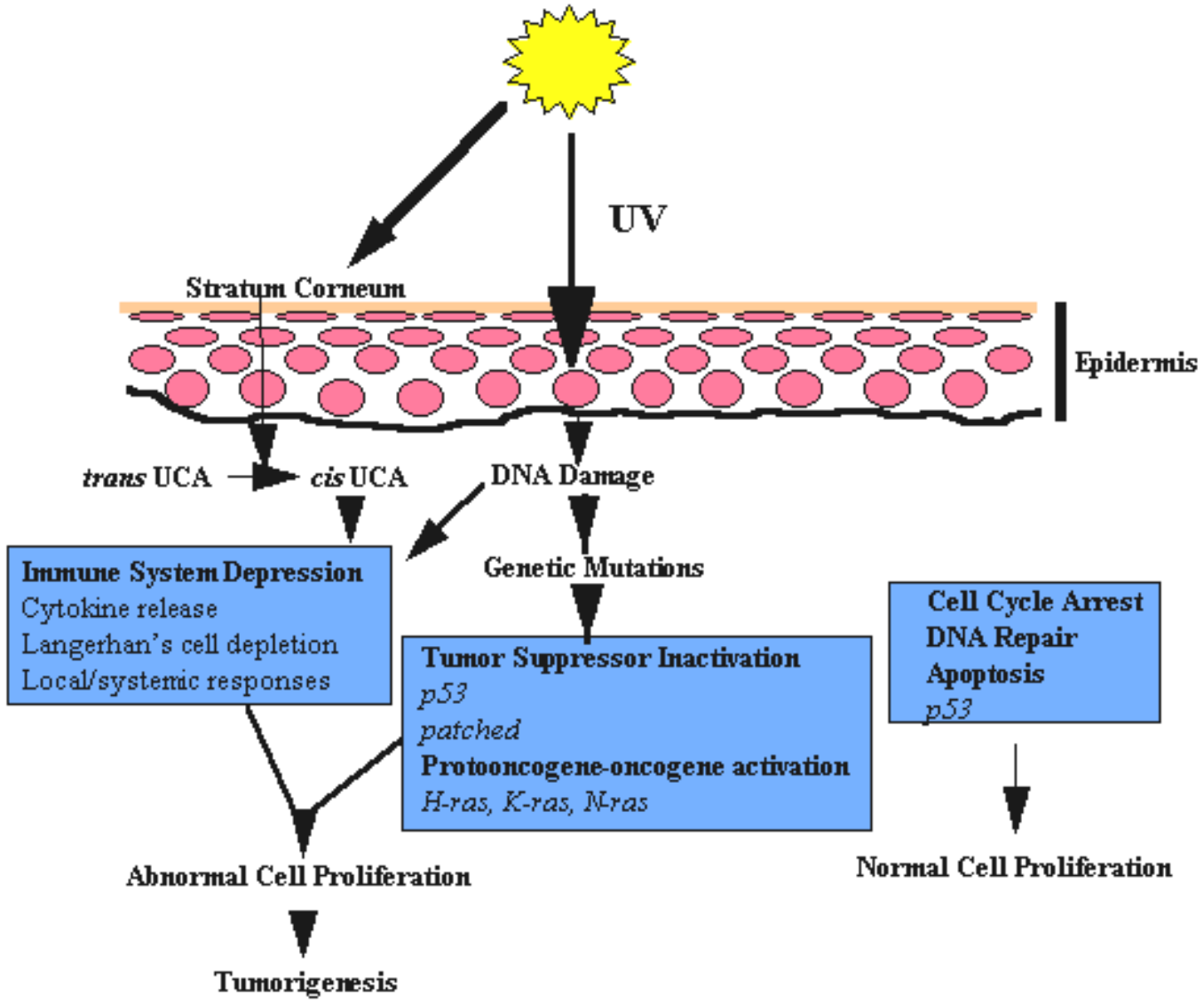




Unilateral Dermatoheliosis

Jennifer R.S. Gordon, M.D., and Joaquin C. Brieva, M.D.

N Engl J Med 2012; 366:e25April 19, 2012DOI: 10.1056/NEJMicm1104059

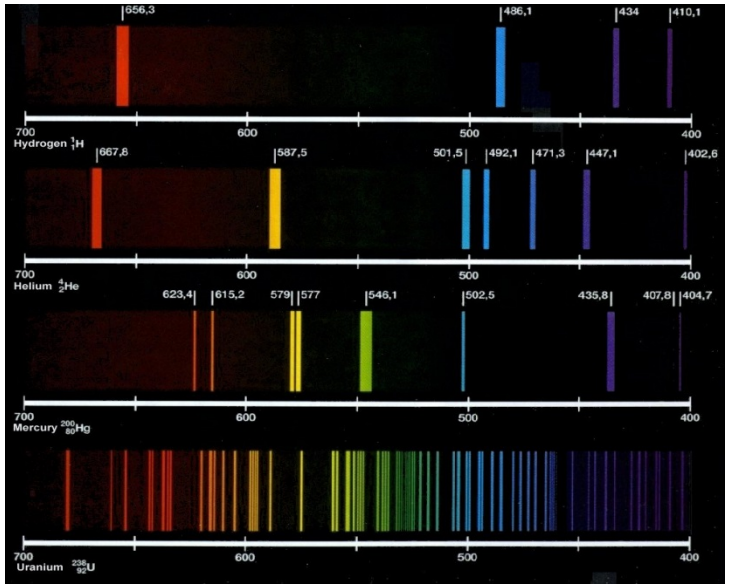


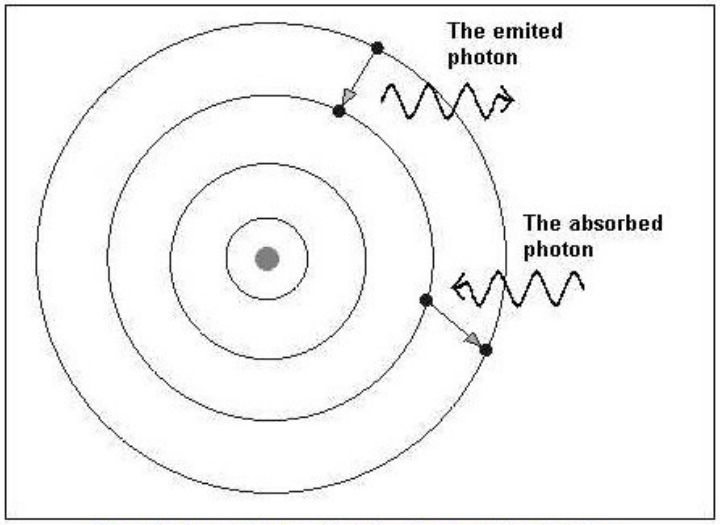
A MODEL FOR UV-INDUCTION OF SKIN CANCER

Holly Soehnge, Allal Ouhtit and Honnavara N. Ananthaswamy

Department of Immunology, The University of Texas M D Anderson Cancer Center, 1515 Holcombe Blvd., Box 178, Houston, TX 77030

Electronic quantum transition





The electron emits or absorbs the energy changing the orbits.

Question 12 – research topic

Someone writes: *"OK, may be the absorption of a photon with electronic quantum transition has some roles on photosynthesis, or human vision, or skin cancer etc. .. But I don't see how the reverse process, the emission of a photon by electronic transition is relevant to living things?"*

What would you write in response? (hint, see the next few slides).

And I mean organic living things, not cyborg!


0:30 / 0:53