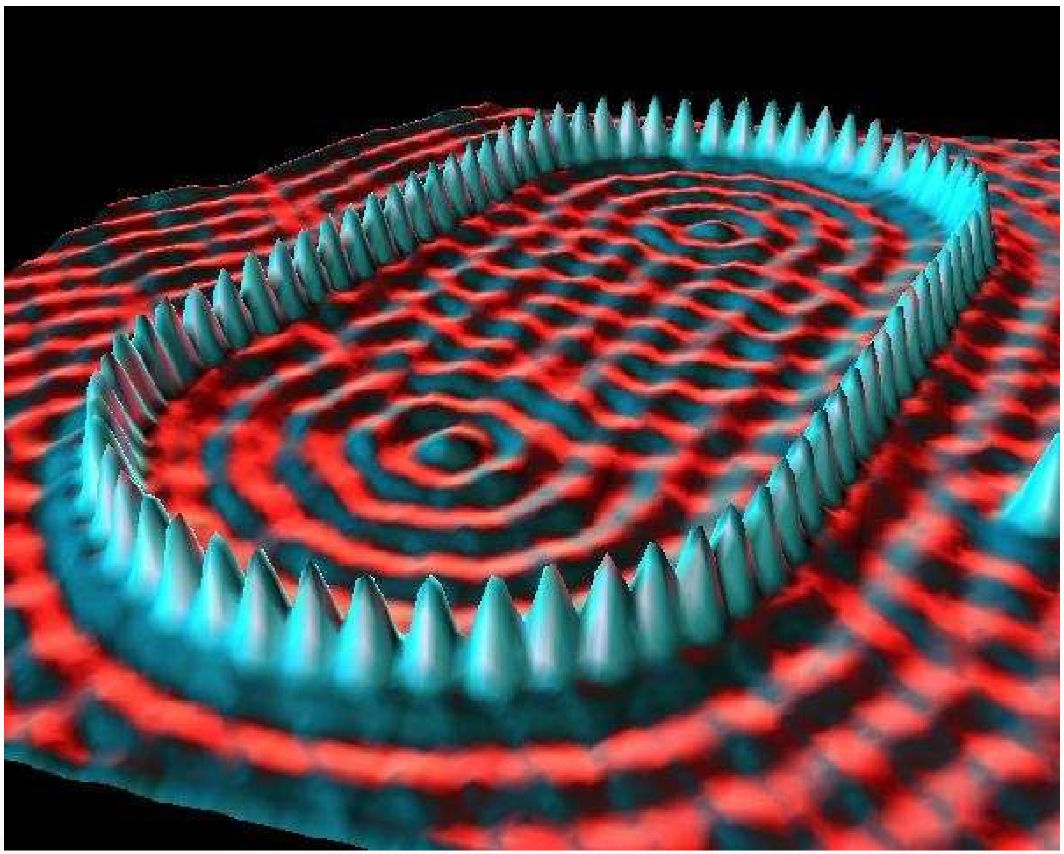
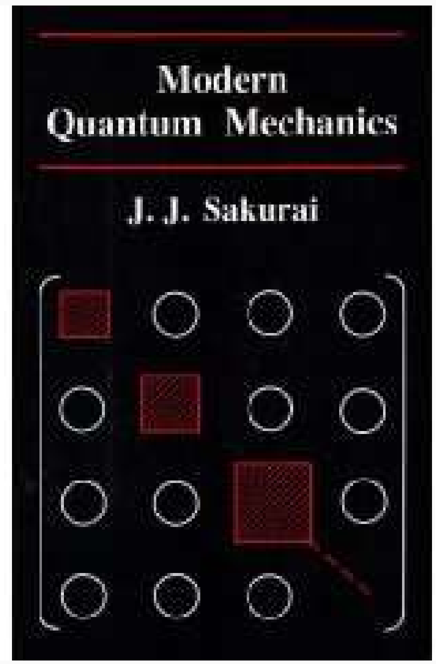
بسم الله الرحمن الرحیم

با نام و یاد خداوند متعال و با

تقدم شما دانشجویان محترم گرامی و شروع سال تحصیل

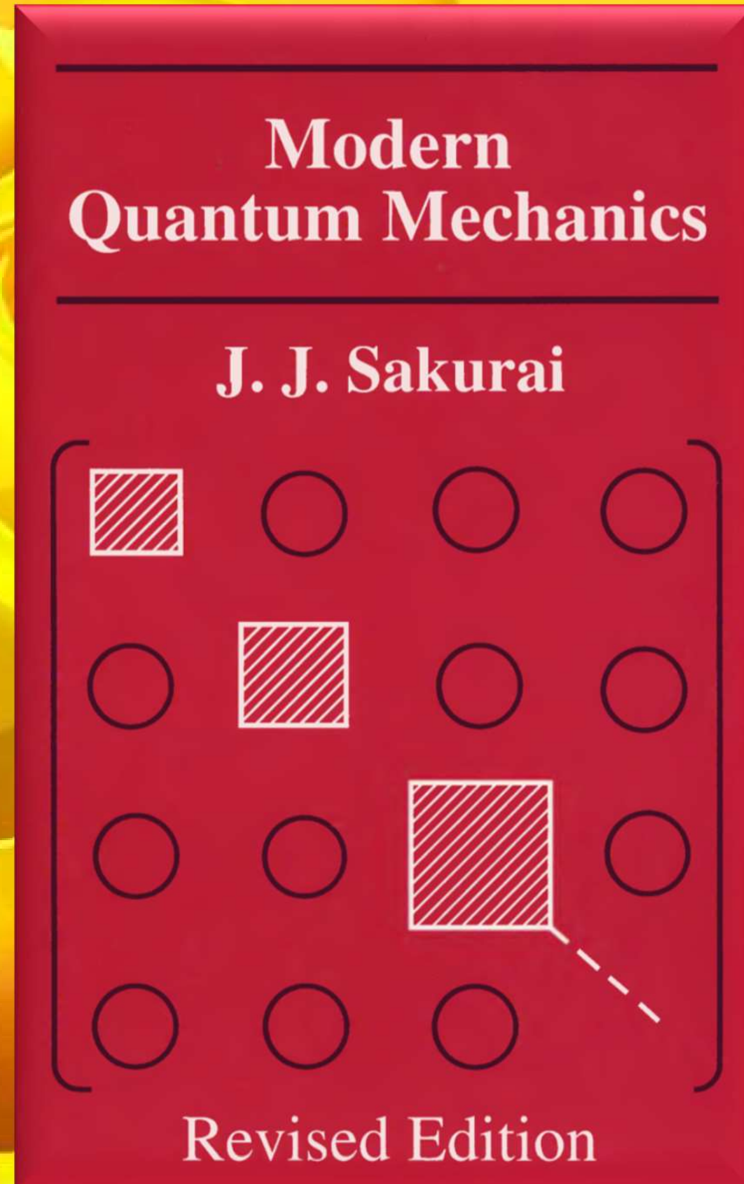


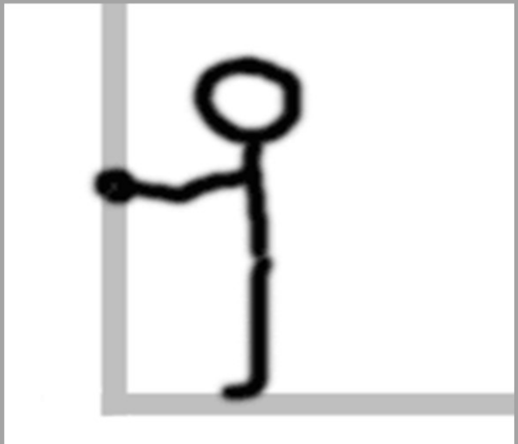


References:

1) J. J. Sakurai, Modern Quantum Mechanics, (1994).
2) Leslie E. Ballentine , Quantum Mechanics A Modern Development, (2000).
3) P. W. Atkins and R. S. Friedman, Molecular Quantum Mechanics, (2000).
4) Quantum Mechanics (2 vol. set) , Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe , (1977) .
5) L. I. Schiff, Quantum Mechanics, (1968).
6) E. Merzbacher, Quantum Mechanics, (1968).
7) Consistent Quantum Theory, Robert B. Griffiths, (2003).
8) Stephen Gasiorowicz, Quantum Physics, first (1974) and third editions (2003).
9) J. L. Powell and B. Crasemann, Quantum Mechanics, (1961).
10) R. Shankar, Quantum Mechanics, (1980).

Main Reference





Homework

You would give me your homework per week at my office
not in class or under my door.

You can work with others on homework (I encourage you to do so!),
but write it yourself.

Evaluation Procedure:

Midterm (40% or 45%) + Final (50% or 45%) + Homework (10%)

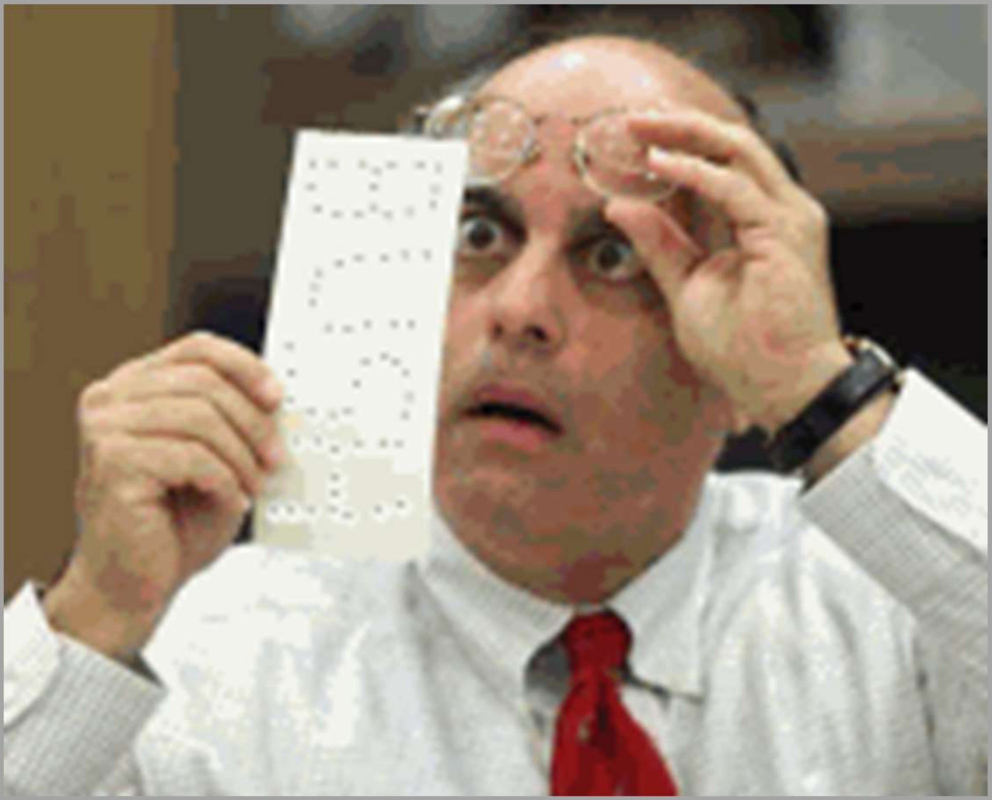
The Importance of Having Class

You should come to class because there's a lot that I'll say that won't be in the Power Point files. And which will be on the quizzes.

In the past, people who have skipped a lot of classes have received very bad grades. Conversely, people who've come to most or all of the classes nearly always receive godd scores.

Understanding the ideas of each lecture requires the knowledge of the previous lectures.

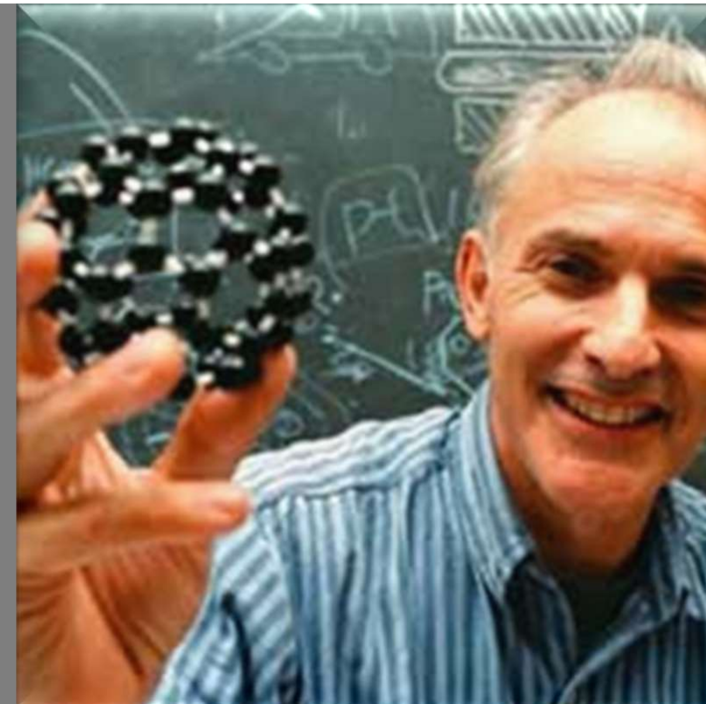
If you keep up,
you won't end up
looking like this
the night before
the exams!



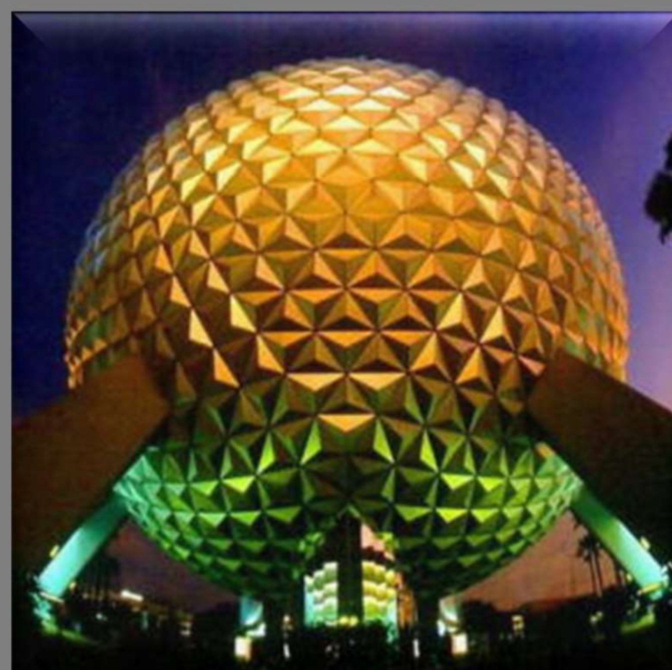
Leonardo da Vinci
1452 (Italy)-1519 (France)

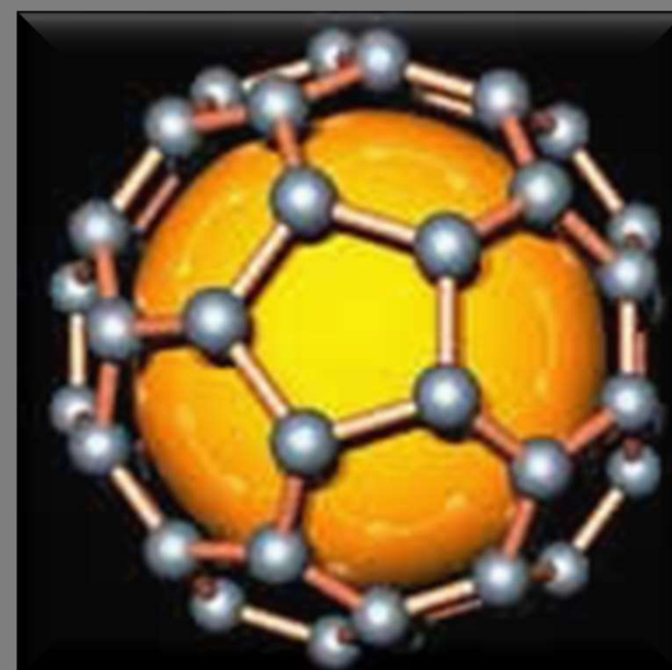
Richard Buckminster fuller

1895-1983



Harry Kroto, 1939

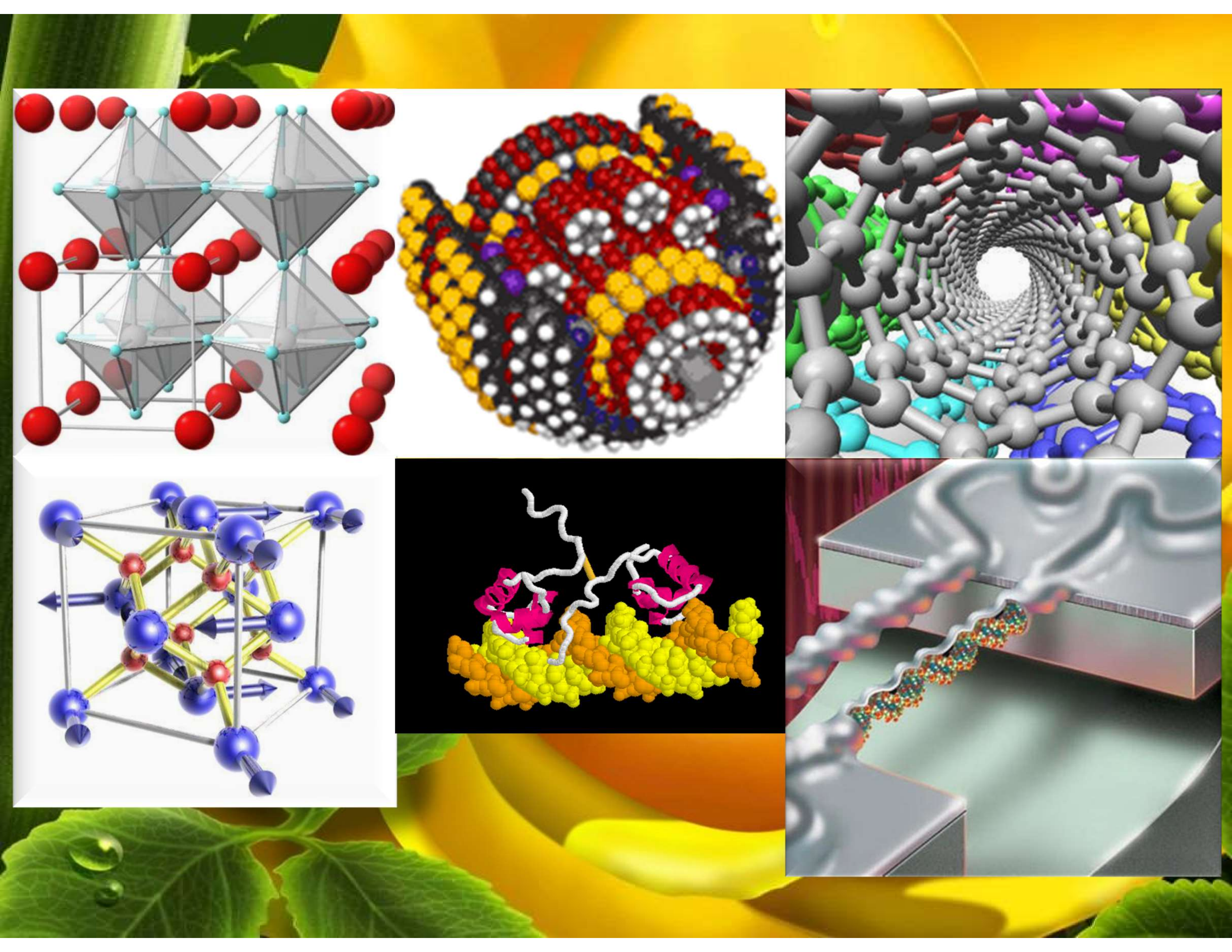




Al-Rad Sura of Quran
In the name of Allah, the Beneficent, the Merciful

ٱللَّهُ ٱلَّذِى رَفَعَ ٱلسَّمَٰوَٰتِ بِغَيۡرِ
عَمَدٍ تَرَوۡنَهَا ۖ ثُمَّ ٱسۡتَوَىٰ عَلَى
ٱلۡعَرۡشِ وَسَخَّرَ ٱلشَّمۡسَ وَٱلۡقَمَرَ
كُلٌّ يَجۡرِى لِأَجَلٍ مُّسَمًّى يُدَبِّرُ
ٱلۡأَمۡرَ يُفَصِّلُ ٱلۡأَيَٰتِ لَعَلَّكُم
بِلِقَآءِ رَبِّكُمۡ تُوقِنُونَ (2)

Allah it is who raised up the universe without visible supports, then mounted the Throne, and compelled the sun and the moon to be of service, each runneth unto an appointed term; He ordereth the course; He detaileth the revelations, that haply ye may be certain of the meeting with your Lord. (2)



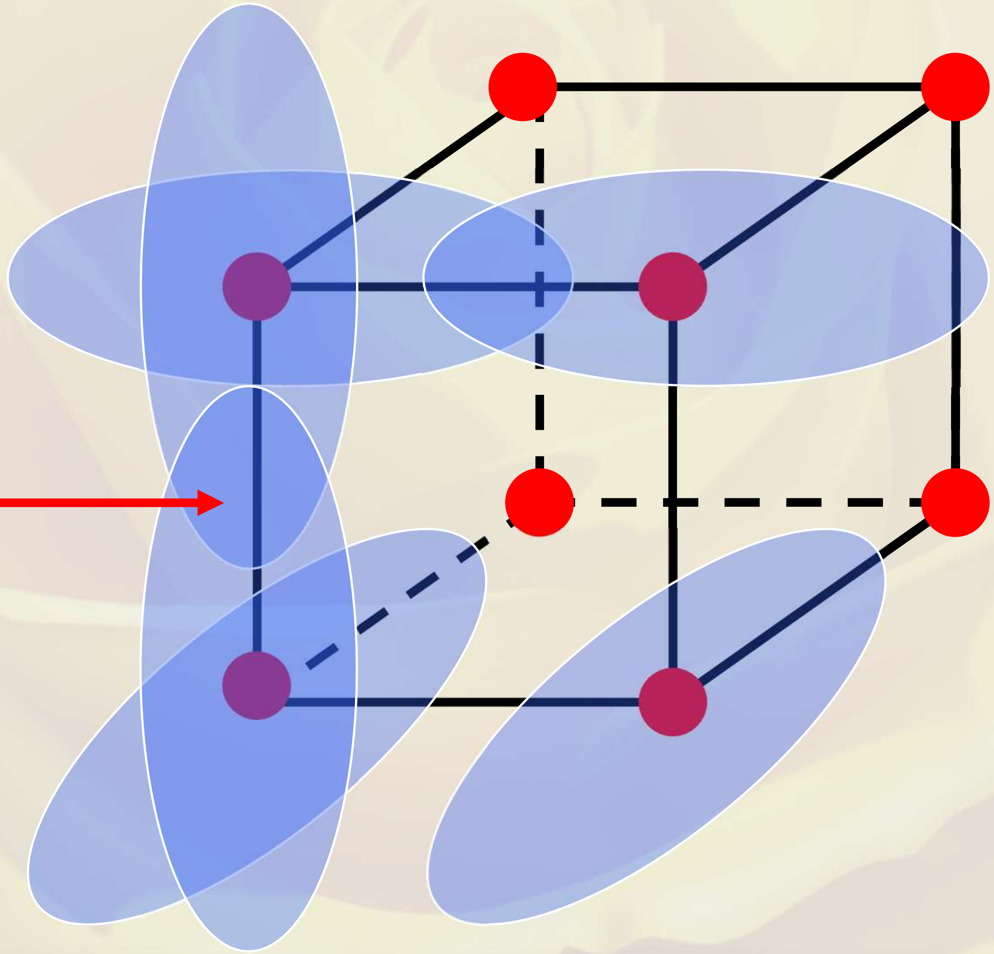

CHEMISTRY
MATHEMATICS
PHYSICS

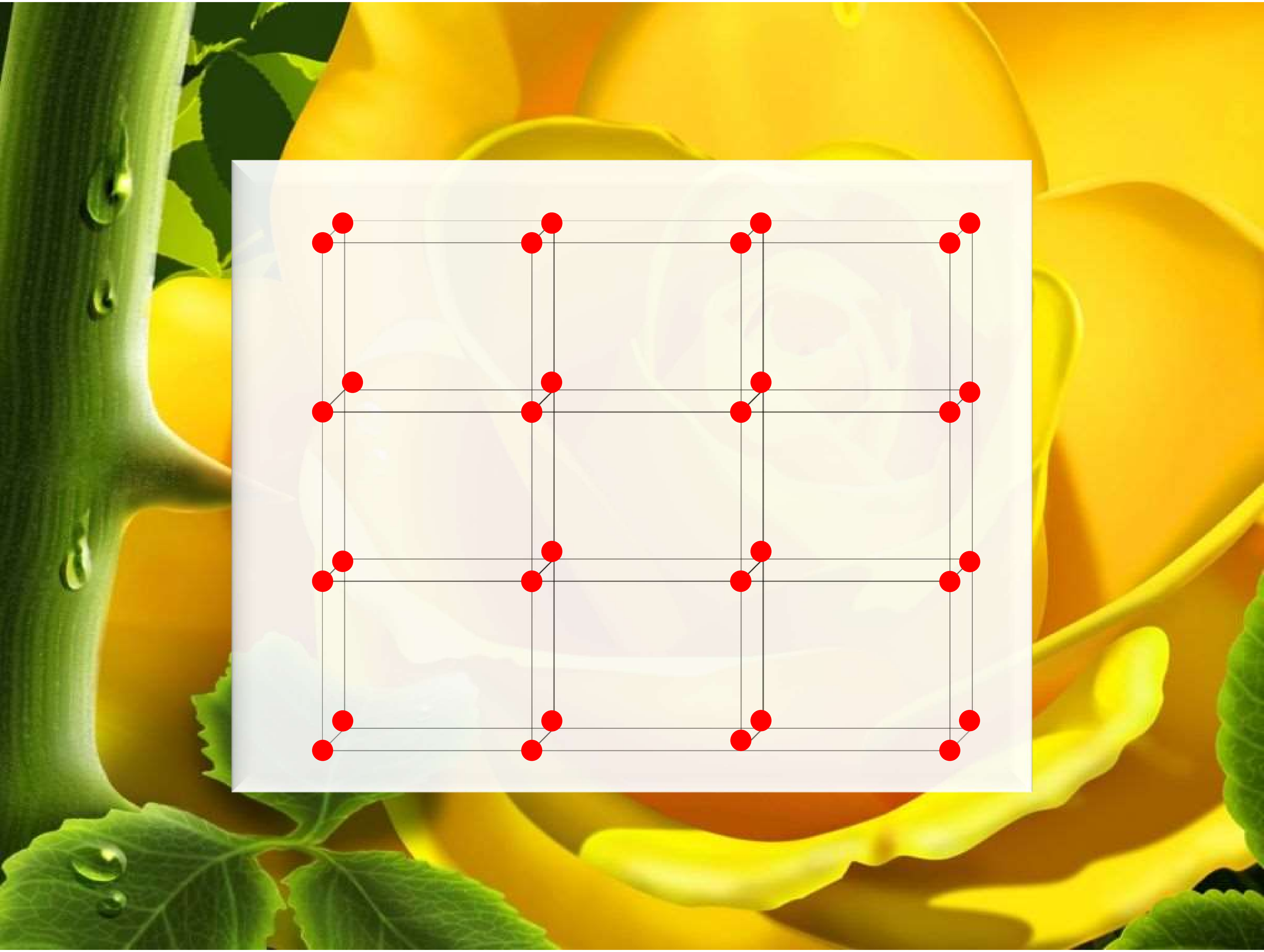

CHEMISTRY
MATHEMATICS
PHYSICS
BIOLOGY

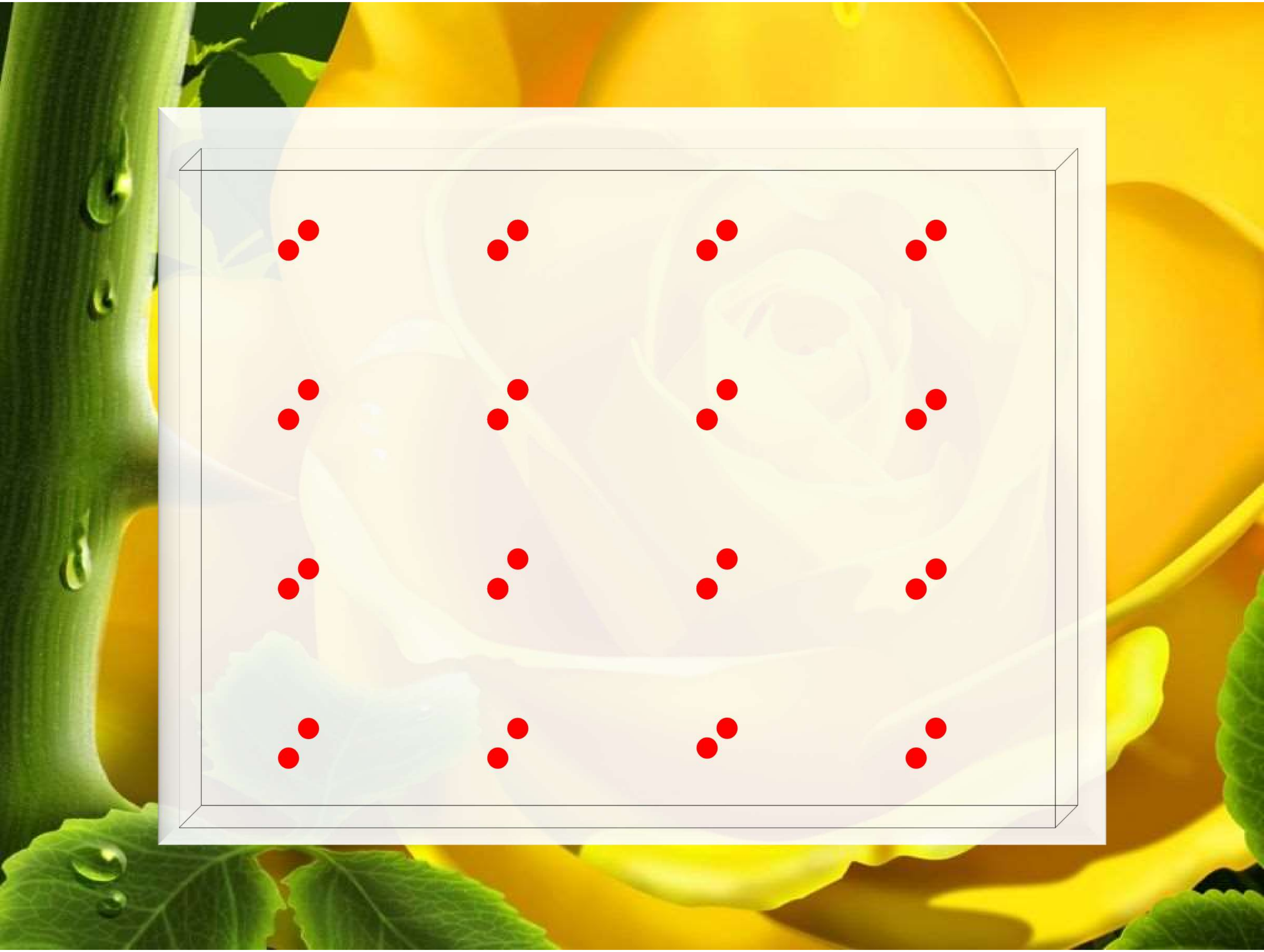
The classical ideal gas

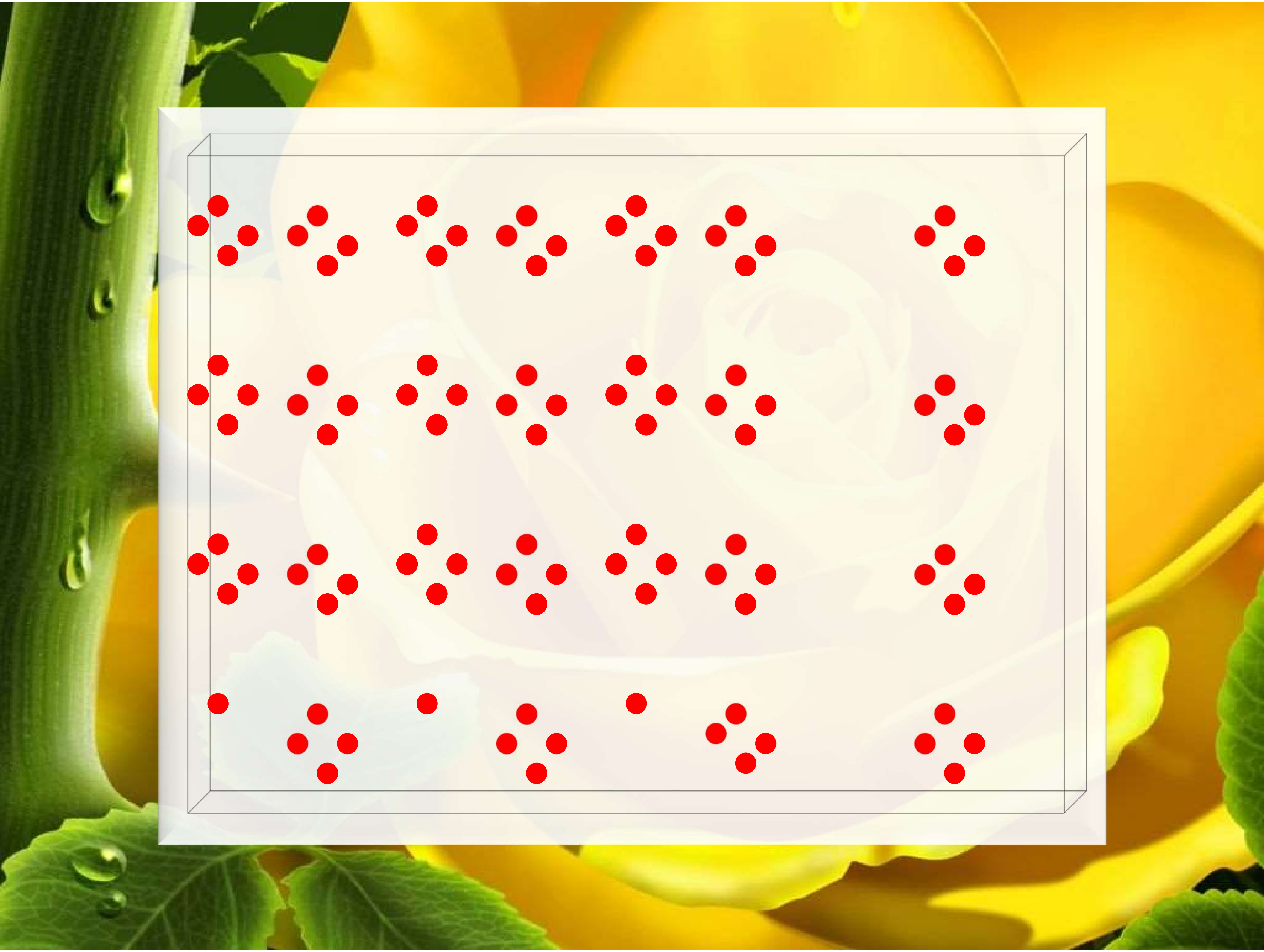
$$H\Psi = E\Psi$$

$$H = T + V$$





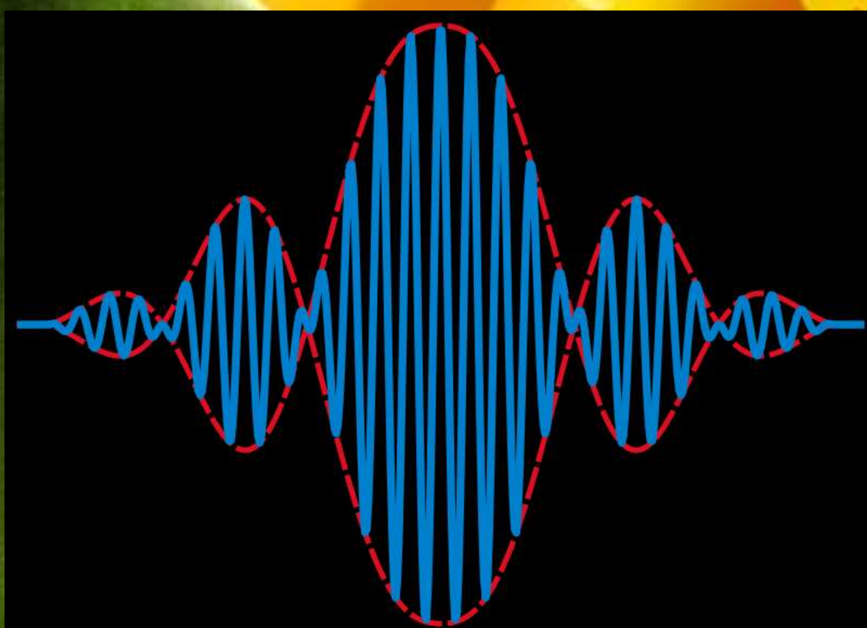


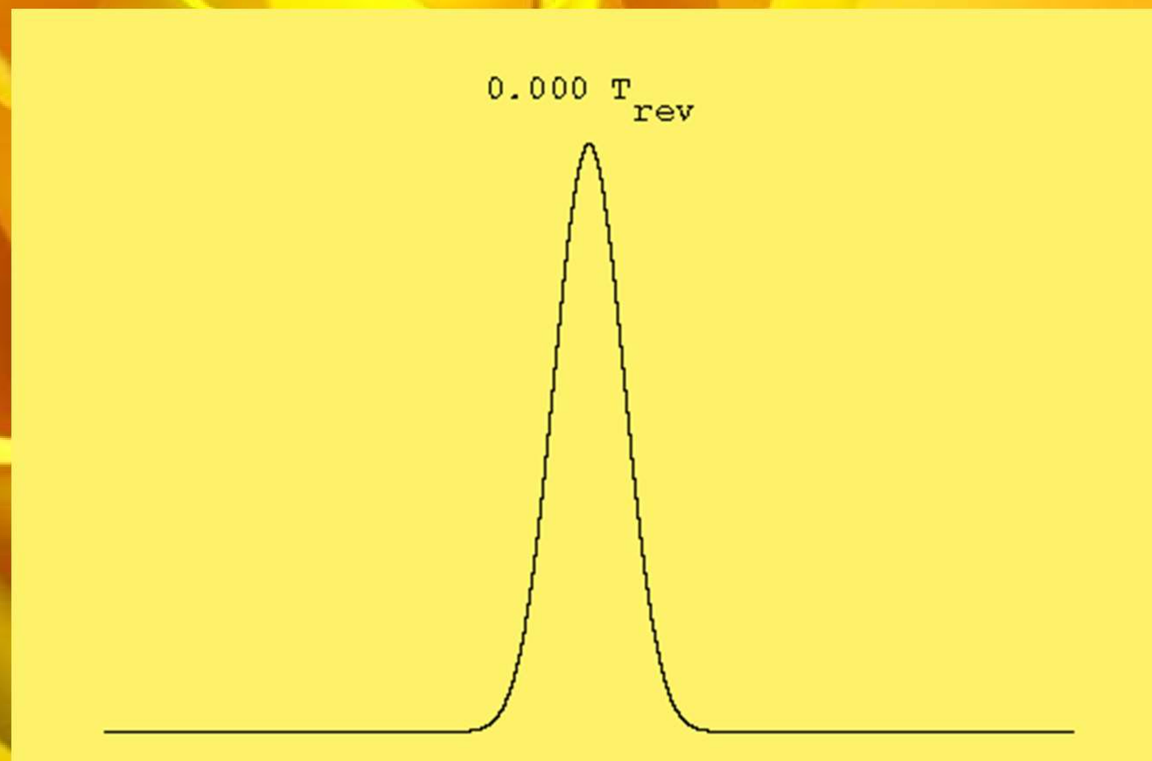


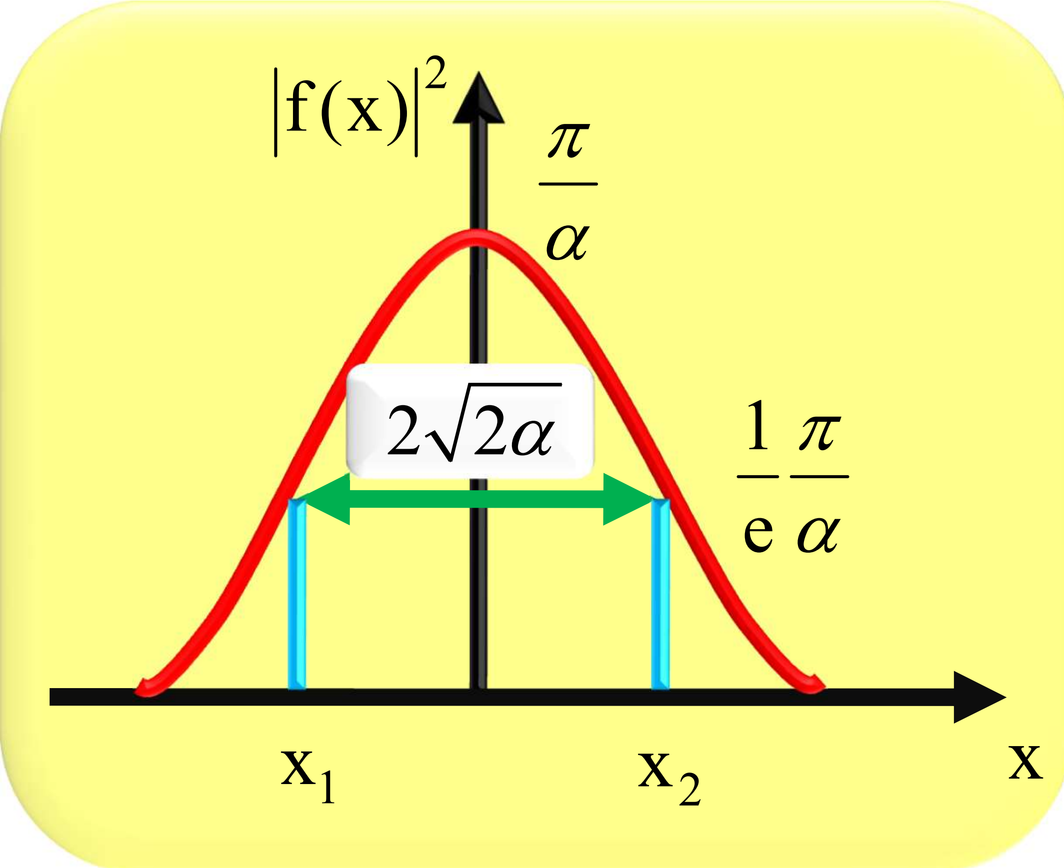
Tsunami

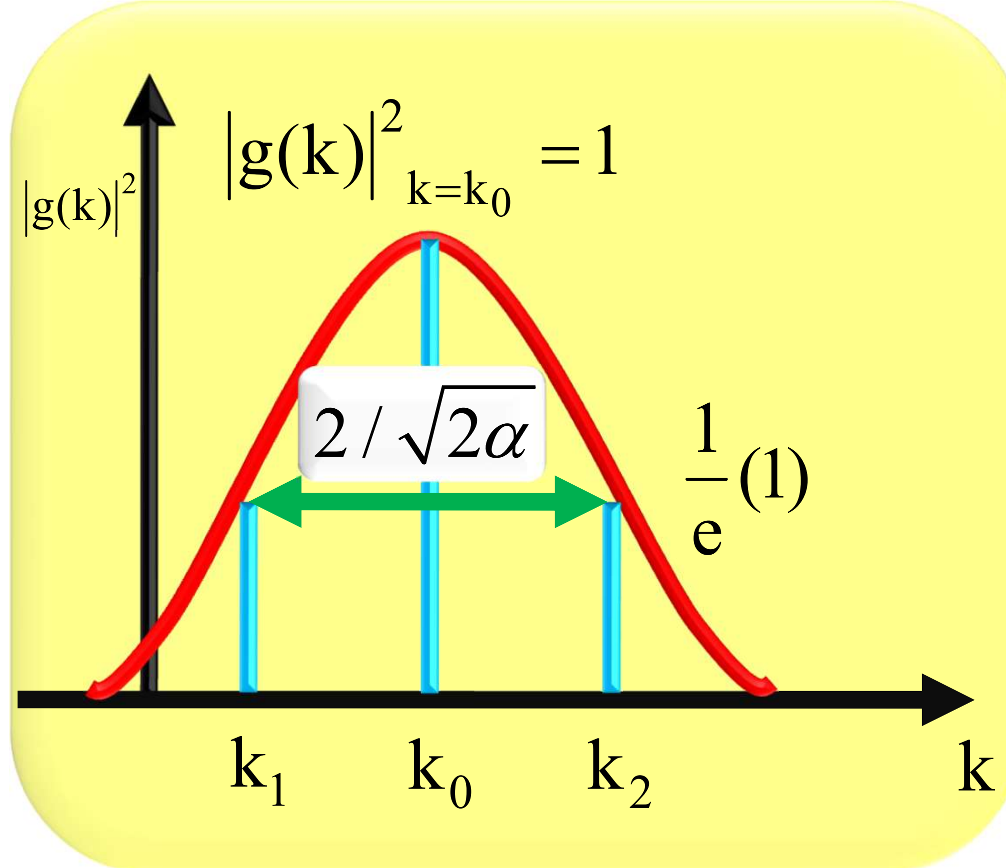
Theoretical Tools to Study Wave Packet

$$f(x) = \int_{-\infty}^{\infty} dk\, g(k)\, e^{ikx}$$









$$\Delta x = x_2 - x_1 = 2\sqrt{2\alpha}$$

$$k_2 - k_1 = \Delta k = 2/\sqrt{2\alpha}$$

Larger alpha results in larger width
This gives rise to wider function.

Smaller alpha results in smaller width
This gives rise to more localized function.

Larger alpha results in smaller width
This gives rise to thiner function.

Smaller alpha results in larger width
This gives rise to more itinerant function.

$$\Delta x = x_2 - x_1 = 2\sqrt{2\alpha}$$

$$k_2 - k_1 = \Delta k = 2/\sqrt{2\alpha}$$

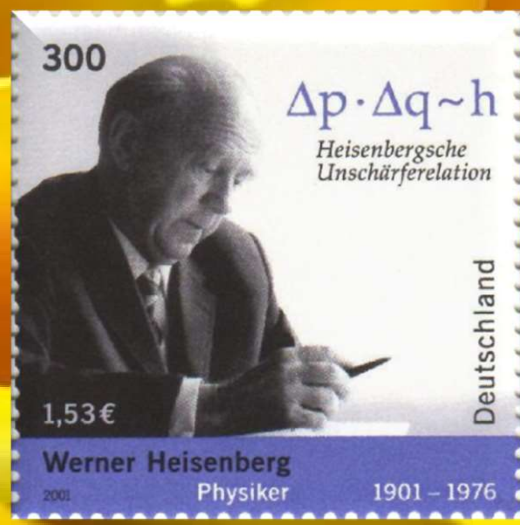
$$\Delta k\,\Delta x = \left(2/\sqrt{2\alpha}\right)\left(2\sqrt{2\alpha}\right) = 4$$

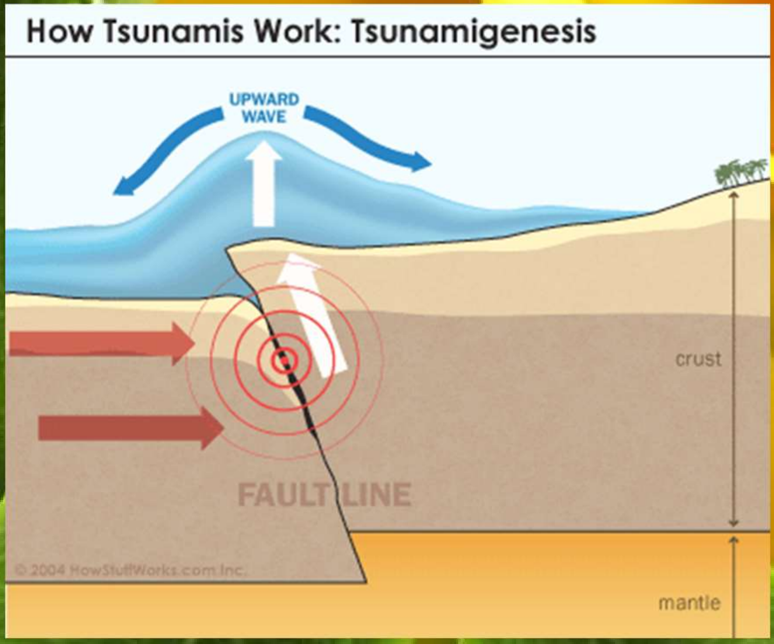
$$\Delta k\,\Delta x = 4$$

Wave vector k space behaves as inverse (reciprocal) of real x space.

$$\Delta k\,\Delta x \geq O(1)$$

This is independent of alpha. It is a general characteristic of wave packets. But we will soon see that this fact refers to a deep aspect in quantum mechanics.




How Tsunamis Work: Tsunamigenesis
UPWARD WAVE
crust
FAULT LINE
mantle
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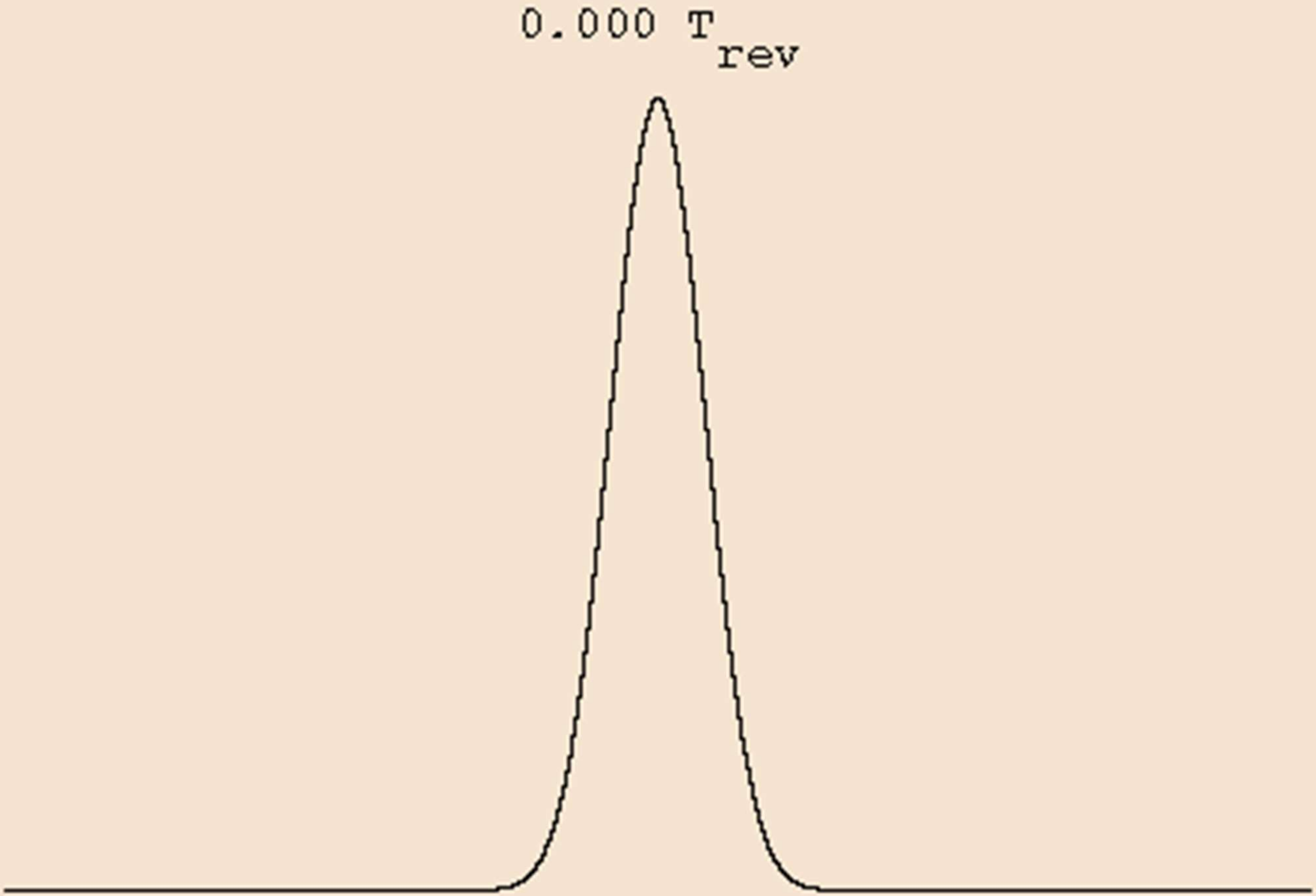
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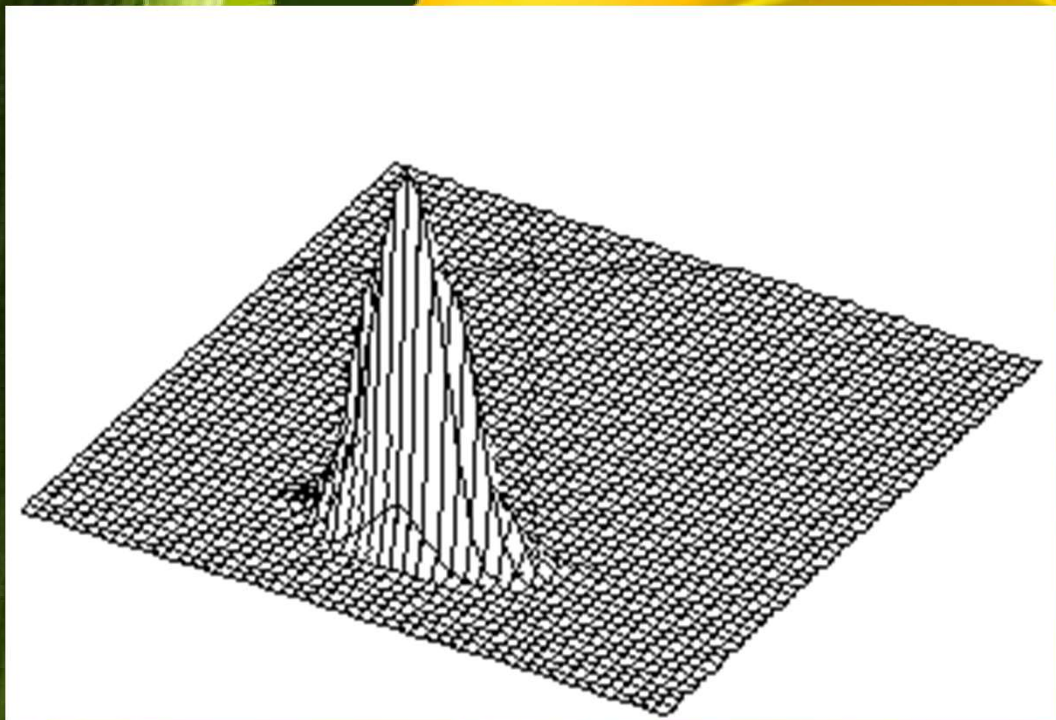

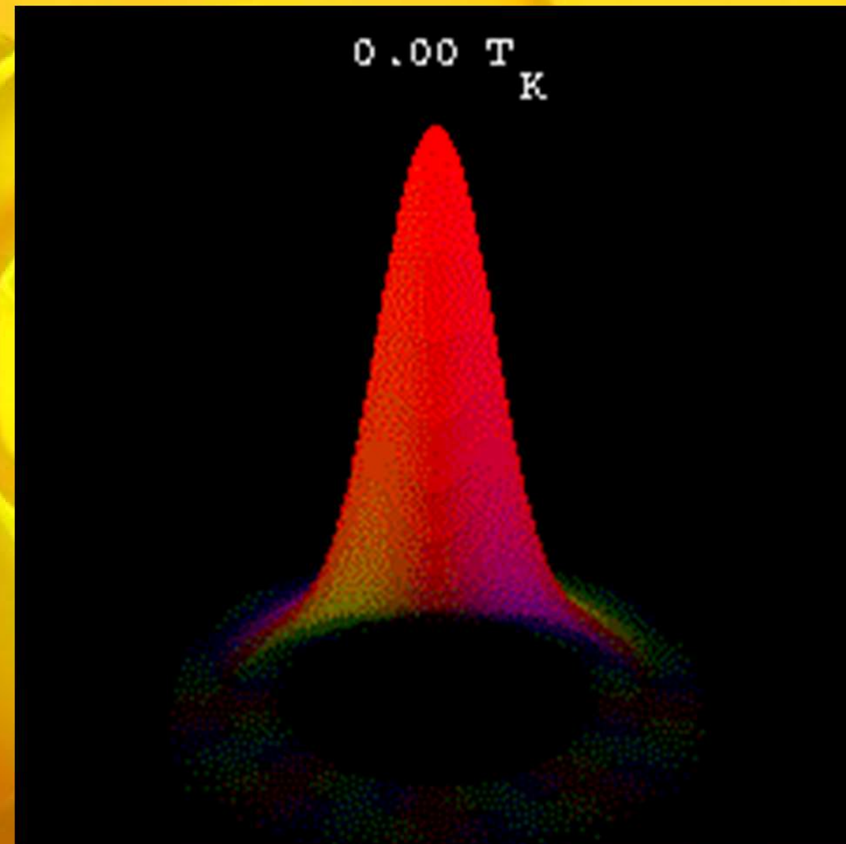
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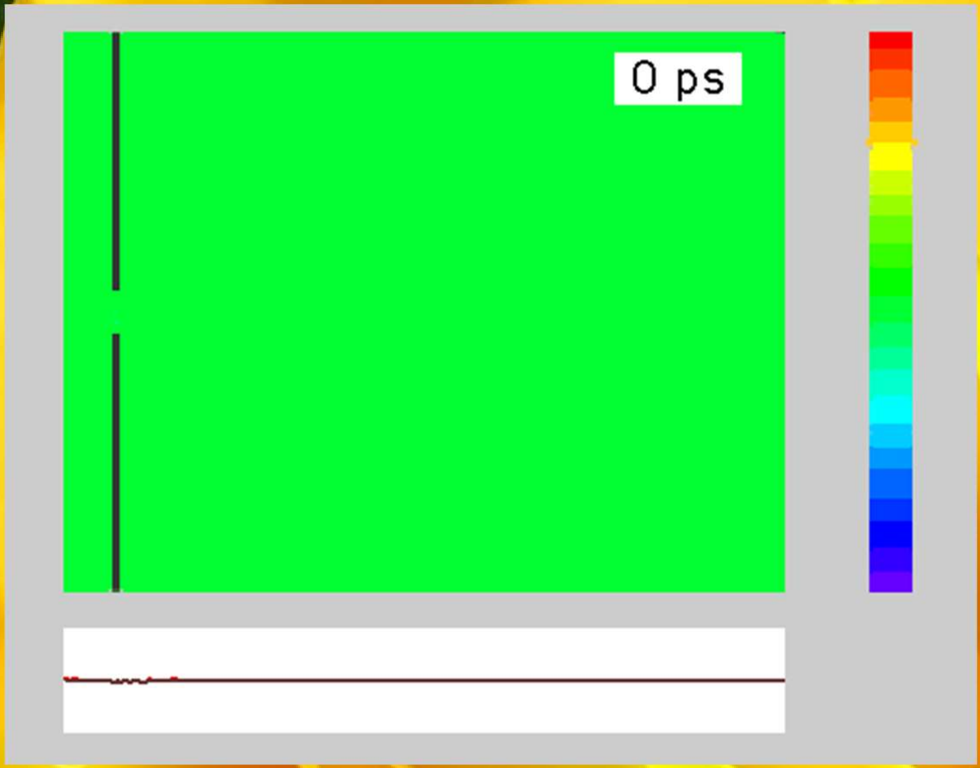
Canon
HDV
Canon
HDV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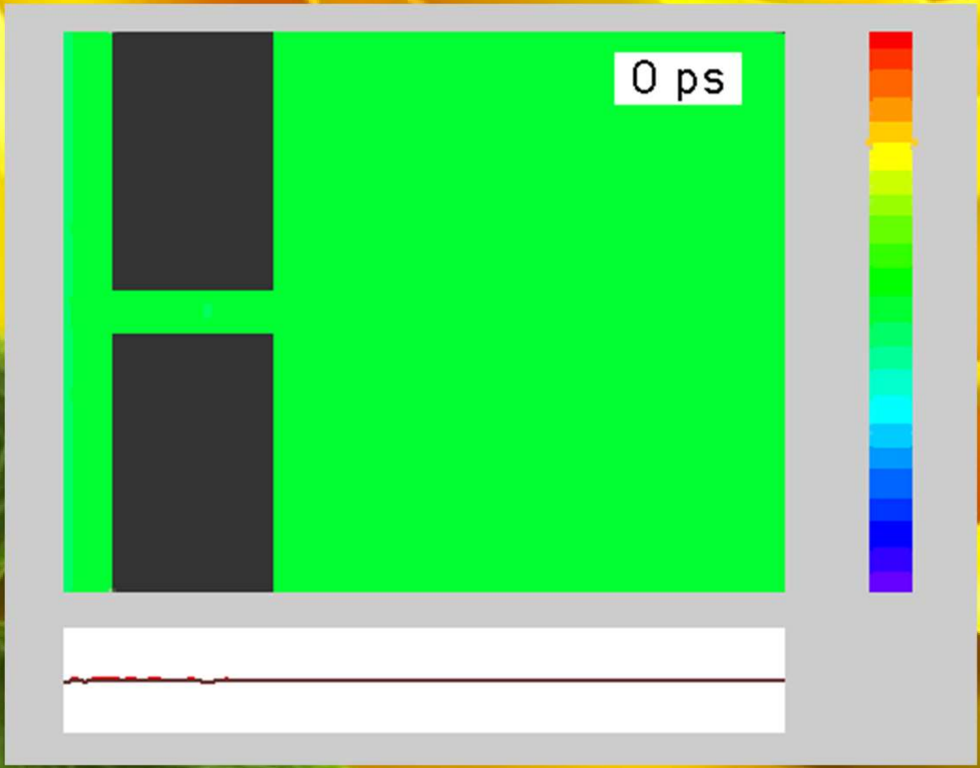
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Canon
HDV
Canon
HDV


Canon
HDV
Canon
HDV

The revolutions in physics inspired revolutions in other fields, too.

Fields like chemistry, engineering, and biology necessarily also underwent revolutions because physics is their basis.

And mathematics also began to see flaws in its fundamental foundations.

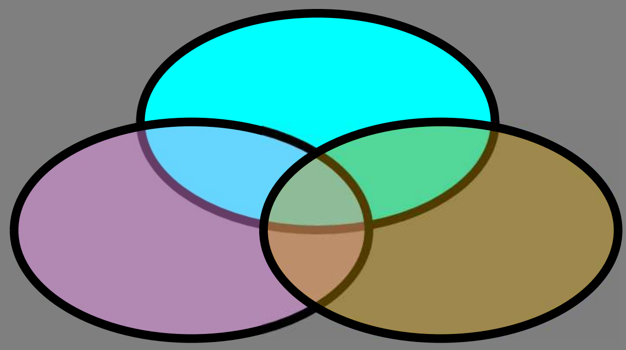
And the revolutions in physics spurred revolutions in art, music, architecture, and psychology and even changed the way the average person saw the world.

Bertrand Russell

(1872-1970)

http://en.wikipedia.org/wiki/Bertrand_Russell

Weirdness in mathematics: Russell's Paradox (1901)



Consider a set that contains itself.

Example: { {}, { {}, {{}} }, … }

Next consider the set of all sets that contain themselves.

Now consider **the set of all sets that don't contain themselves**.

Does this last set contain itself?

If it doesn't, then it does. But if it does, then it doesn't.

Because set theory is the basis of all mathematics (and numbers!), this fundamental paradox is a serious crack in the foundations of mathematics.

Russell's Paradox

Let you tell me a famous story:

There was once a barber. Some say that he lived in Seville. Wherever he lived, all of the men in this town either shaved themselves or were shaved by the barber. And the barber only shaved the men who did not shave themselves.

That is a nice story. But it raises the question: **Did the barber shave himself?** Let's say that he did shave himself. But we see from the story that he shaved only the men in town who did not shave themselves. Therefore, he did not shave himself. But we again see in the story that every man in town either shaved himself or was shaved by the barber. So he did shave himself. We have a contradiction. What does that mean?

Maybe it means that the barber lived outside of town. That would be a loophole, except that the story says that he did live in the town, maybe in Seville. Maybe it means that the barber was a woman. Another loophole, except that the story calls the barber "he." So that doesn't work. Maybe there were men who neither shaved themselves nor were shaved by the barber. Nope, the story says, "All of the men in this town either shaved themselves or were shaved by the barber." Maybe there were men who shaved themselves **AND** were shaved by the barber. After all, "either ... or" is a little ambiguous. But the story goes on to say, "The barber only shaved the men who did not shave themselves." So that doesn't work either. Often, when the above story is told, one of these last two loopholes is left open. So I had to be careful, when I wrote down the story.

More weirdness in Mathematics: Gödel's Incompleteness Theorem (1931)

In 1931, Kurt Gödel proved that there are **theorems that can neither be proven nor disproven**.

This solved the second of David Hilbert's famous list of the 23 most important unsolved math problems.

And Hilbert's first problem turned out to be one of Gödel's unprovable theorems ("the continuum hypothesis"—whether there's an infinity between the number of integers, $\aleph_0$, and the number of real numbers, $\aleph_1$)!

Kurt Gödel (1906 – 1972)

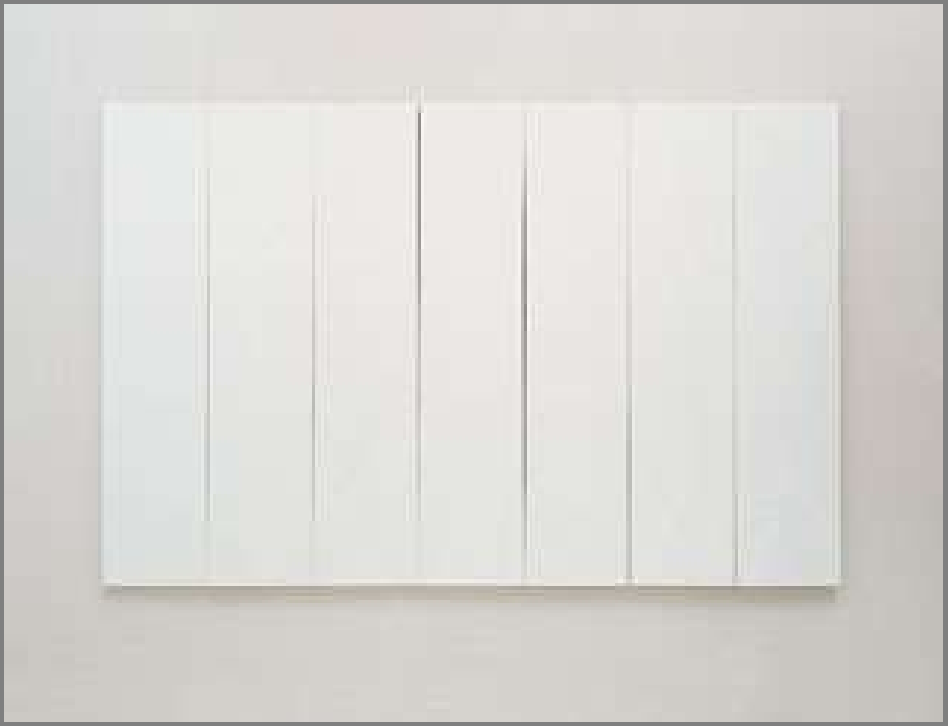
Weirdness in Art

Whereas pre-20th-century art was very literal, modern art has become very abstract and unintuitive.

Pre-1905 art

The Death of Socrates (1787)
Jacques-Louis David

Post-1905 art

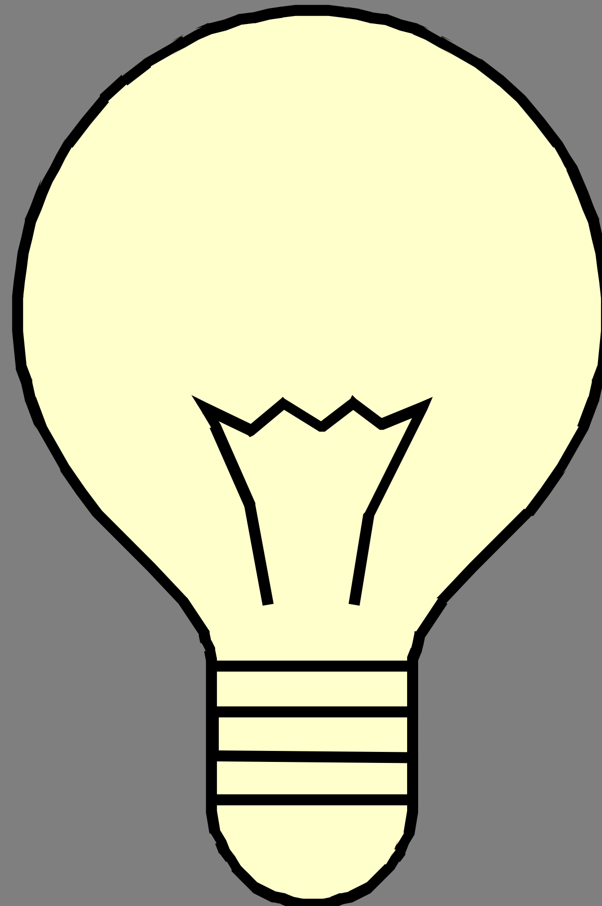


White Painting (1951)
Robert Rauschenberg

Interestingly, most "great" works of modern art have only required a few minutes of effort to create.

Modern art is getting weirder and weirder.

"Light in [an empty] room turning on and off" won the top British art prize (The Turner Prize, £20,000) in 2001.

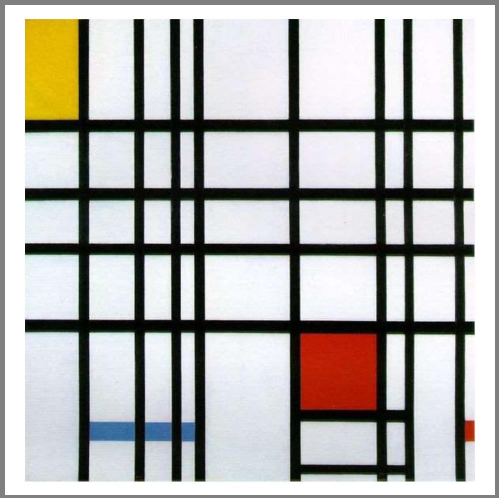


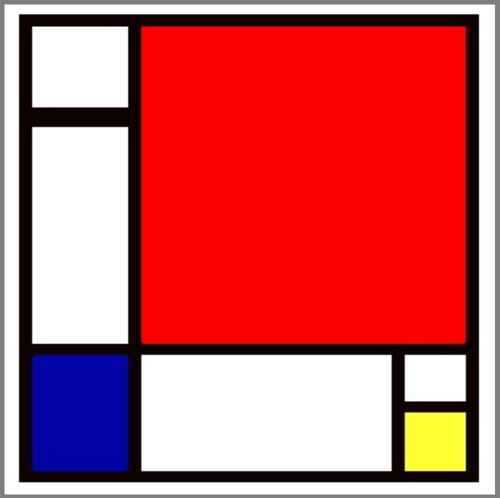
Martin Creed
Winner of prize

And this is one of the least objectionable and ridiculous winners of this prize.

Weirdness in Art Appreciation

Pieter
Mondrian
1872 - 1944





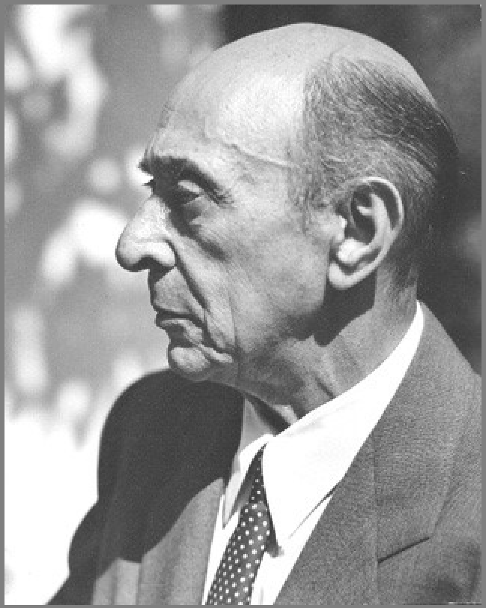
Mondrian's art "was, in the end, to be so fine that, having induced a radiant harmony and balance throughout society, the need for painting itself would no longer be necessary."

Bennett Schiff, *Smithsonian* 1995

Mondrian died in 1944, a time of complete radiant harmony and balance throughout society...

Weirdness in Music

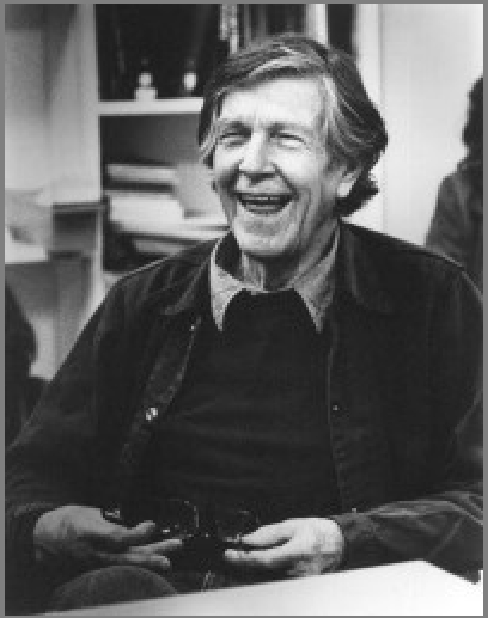
In 1907 Schoenberg, who stated publicly that he wanted to do for music what Einstein did for physics, introduced **atonal music**, which violated all known principles of what constituted good music and, for the most part, sounds like noise.



Arnold Schoenberg (1874 - 1951)

Stephen Reich (1936 -)

John Cage (1912 - 1992)



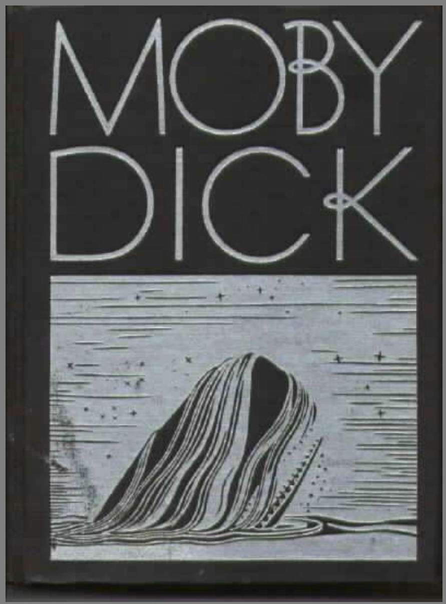
John Cage is best known for his 1952 composition, *4′33″*, whose three movements are each composed entirely of silence.

Weirdness in Literature

19th century literature:

"Call me Ishmael…"

Herman Melville's *Moby Dick* (1851) was first and foremost a simple whaling story, but it was also a superb study of human obsession and taught us about human nature.



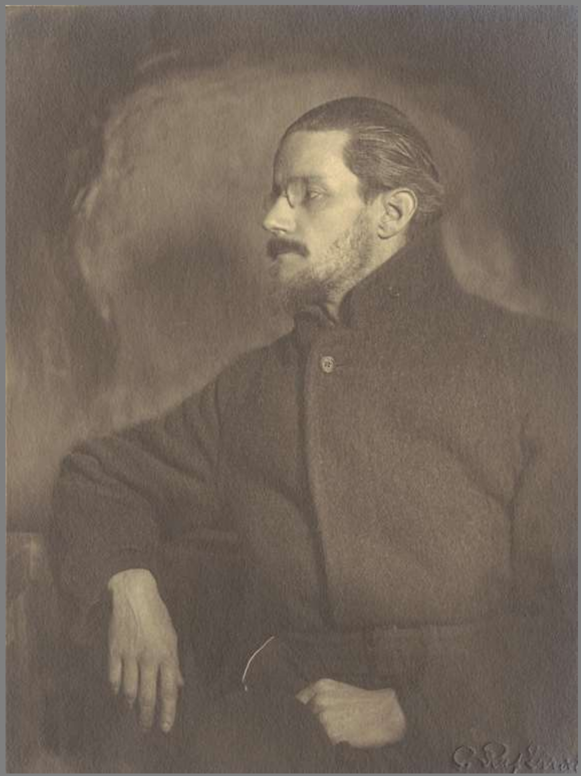
20th century literature:

"…Throgmoggle Fordful
mantly overgoo
bog manty gong goppling
rill cum nack throgginds.
Choomin:
Chillchinchar Engestchin
chanty chopcharchill
chorey chopcharchill chooley
chingle choon chingley
choodle.
Throgmoggle Fordful?
Chillchincar Engestchin?
Fulford mog-gle throg
Throggins…"

Colleen Thibaudeau's *From Throgmoggle & Engestchin: A relationship* (1991)

20th Century Literature

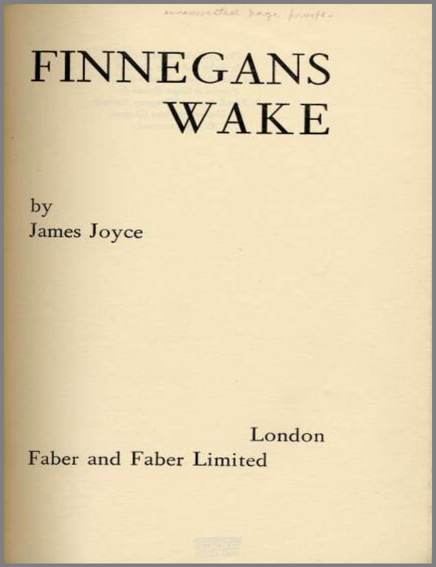
John Bishop, in his introduction to James Joyce’s *Finnegans Wake* in 1999, wrote these less-than-encouraging words: “There is no agreement as to what *Finnegans Wake* is about, whether or not it is ‘about’ anything, or even whether it is, in any ordinary sense of the word, ‘readable.’ Since Joyce's sentences are packed with obscure allusions, often written in dozens of different languages, it remains impossible to compile a definite synopsis of *Finnegans Wake*.”



James Joyce
1882 - 1941

Literary critic Fritz Senn said of the currently available summaries: “We have some traditional summaries, some by Joyce himself. I find them most unsatisfactory and unhelpful…”

Excerpt from *Finnegans Wake*



You're probably thinking that I'm exaggerating.

Here's an excerpt (chosen at random) from this "classic" of modern literature:

"…The fall (bababadalgharaghtakamminarronnkonnbronntonner-ronntuonnthunntrovarrhounawnskawntoohoohoordenenthur-nuk!) of a once wallstrait oldparr is retaled early in bed and later on life down through all christian minstrelsy. The great fall of the offwall entailed at such short notice the pftjschute of Finnegan, erse solid man, that the humptyhillhead of humself prumptly sends an unquiring one well to the west in quest of his tumptytumtoes: and their upturnpikepointandplace is at the knock out in the park where oranges have been laid to rust upon the green since dev-linsfirst loved livvy. …"

Weirdness in Sculpture, and Architecture

The architect himself says his $300 million new computer science and artificial intelligence building at M.I.T. “looks like a party of drunken robots got together.”

Sigmund Freud
(1856 – 1939)

Weirdness in Psychology

Sigmund Freud (and others) developed a bizarre and complex theory of human behavior—psychoanalysis—based mostly on sexual desire.

Psychoanalysis is **unfalsifiable**. If you deny your Oedipal complex, then you're repressing it!

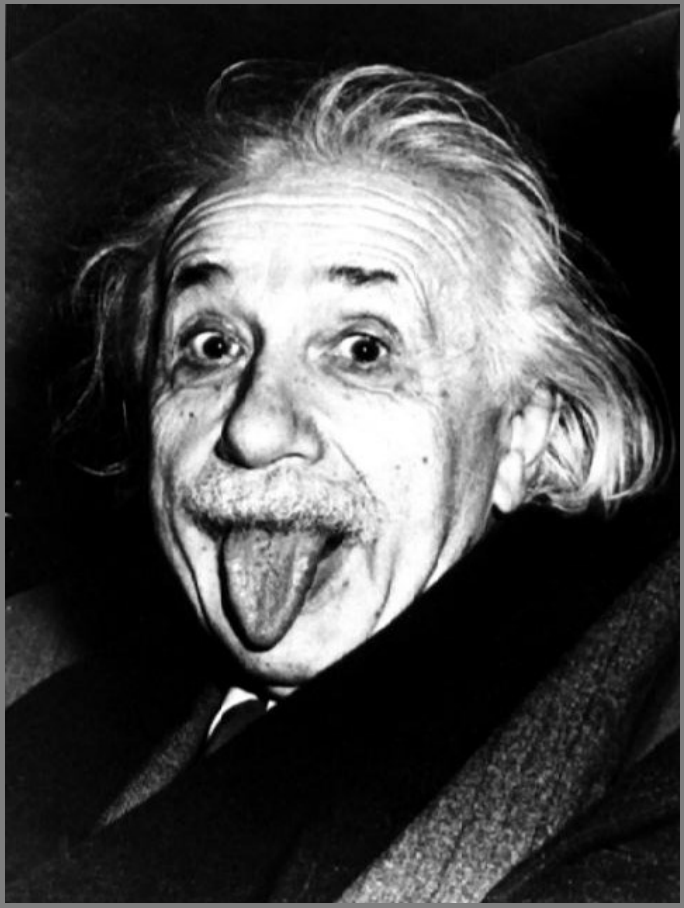
Richard Webster called psychoanalysis "one of the great follies of Western civilization."

H. J. Eysenck says that Freud "set psychiatry back 100 years," consistently misdiagnosed his patients, fraudulently misrepresented case histories, and that "what is true in Freud is not new, and what is new in Freud is not true."

J. von Scheidt speculated that Freud's theories were due to his cocaine use, which increases sexual interest and obsessive thinking.

In any case, Freud was clearly **subconsciously** influenced by physics!

Genuine vs. Artificial Revolutions

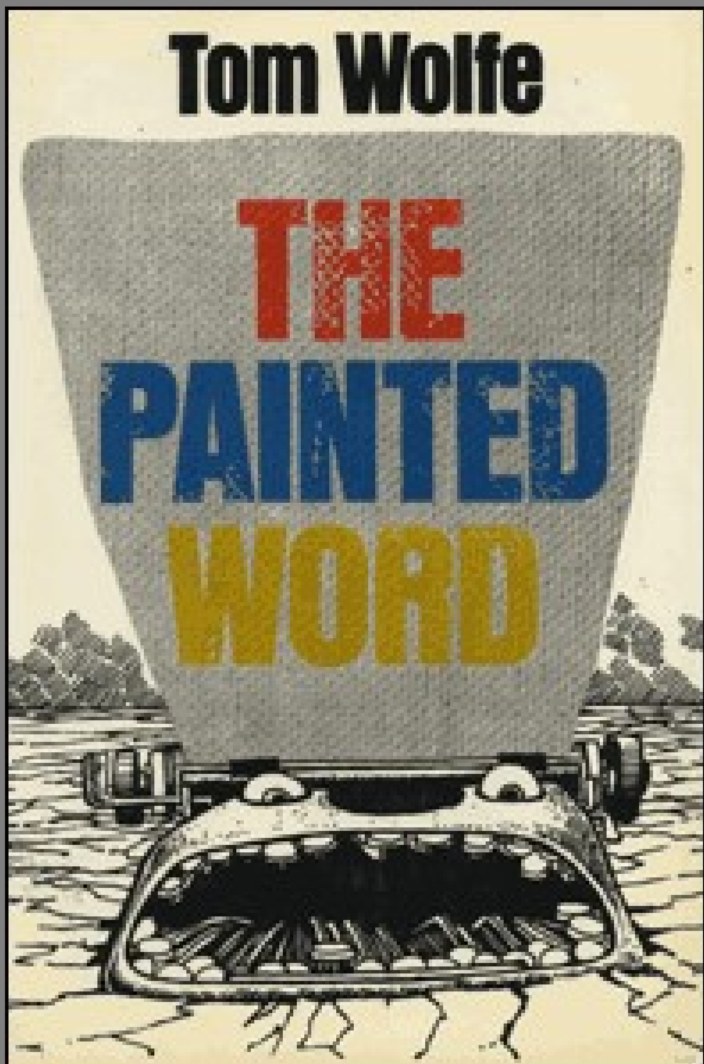


The revolutions in physics were the result of new **experiments** and **observations** and so were **forced** upon us by the world around us.

That they involved weird ideas that average people couldn't understand is due to the fact that the universe is, in fact, weird.

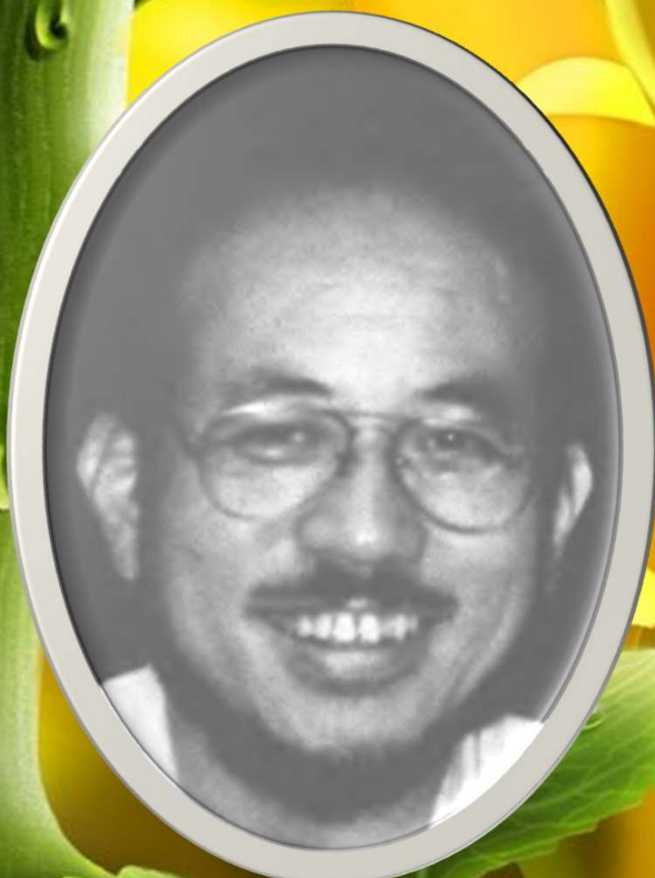
The "revolutions" in art, literature, psychology, and music were the result of simple arrogance of the practitioners and their desire to have their own unintuitive ideas that only they could "understand"—what I like to call **Physics Envy**. But they nicely illustrate the dramatic effects on others of the genuine revolutions that occurred in physics.

To read more about weirdness in modern art and architecture…

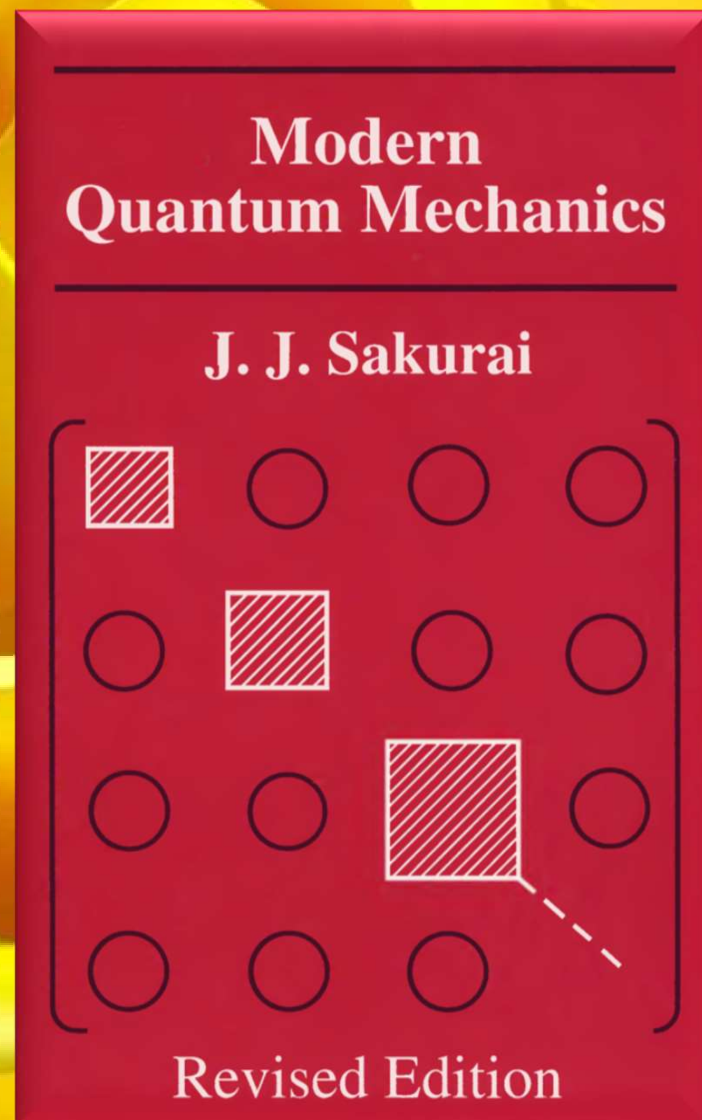


Artists and architects hate these two books…

Modern Quantum Mechanics



J. J. Sakuri (1933-1982)



What we will learn

Modern Quantum Mechanics I

1) FUNDAMENTAL CONCEPTS

2) QUANTUM DYNAMICS

3) THEORY OF ANGULAR MOMENTUM

Modern Quantum Mechanics II

4) SYMMETRY IN QUANTUM MECHANICS

5) APPROXIMATION METHODS

6) IDENTICAL PARTICLES

7) SCATTERING THEORY