

THE PHYSICS OF ENERGY



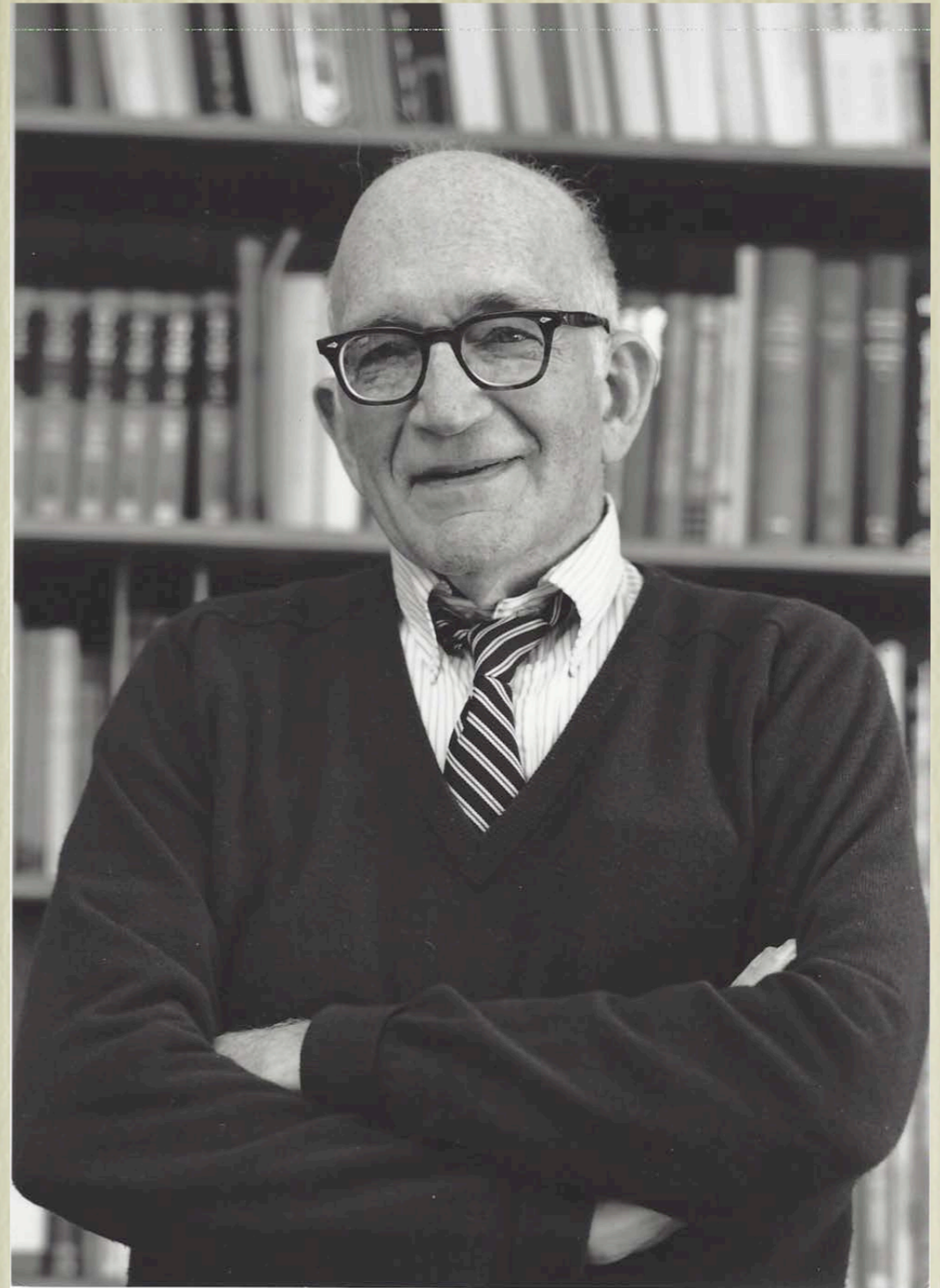
ROBERT L. JAFFE
WASHINGTON TAYLOR

An attempt to develop and encourage adoption of a physics course on the scientific foundation of energy sources, uses, and systems.

with Wati Taylor, MIT

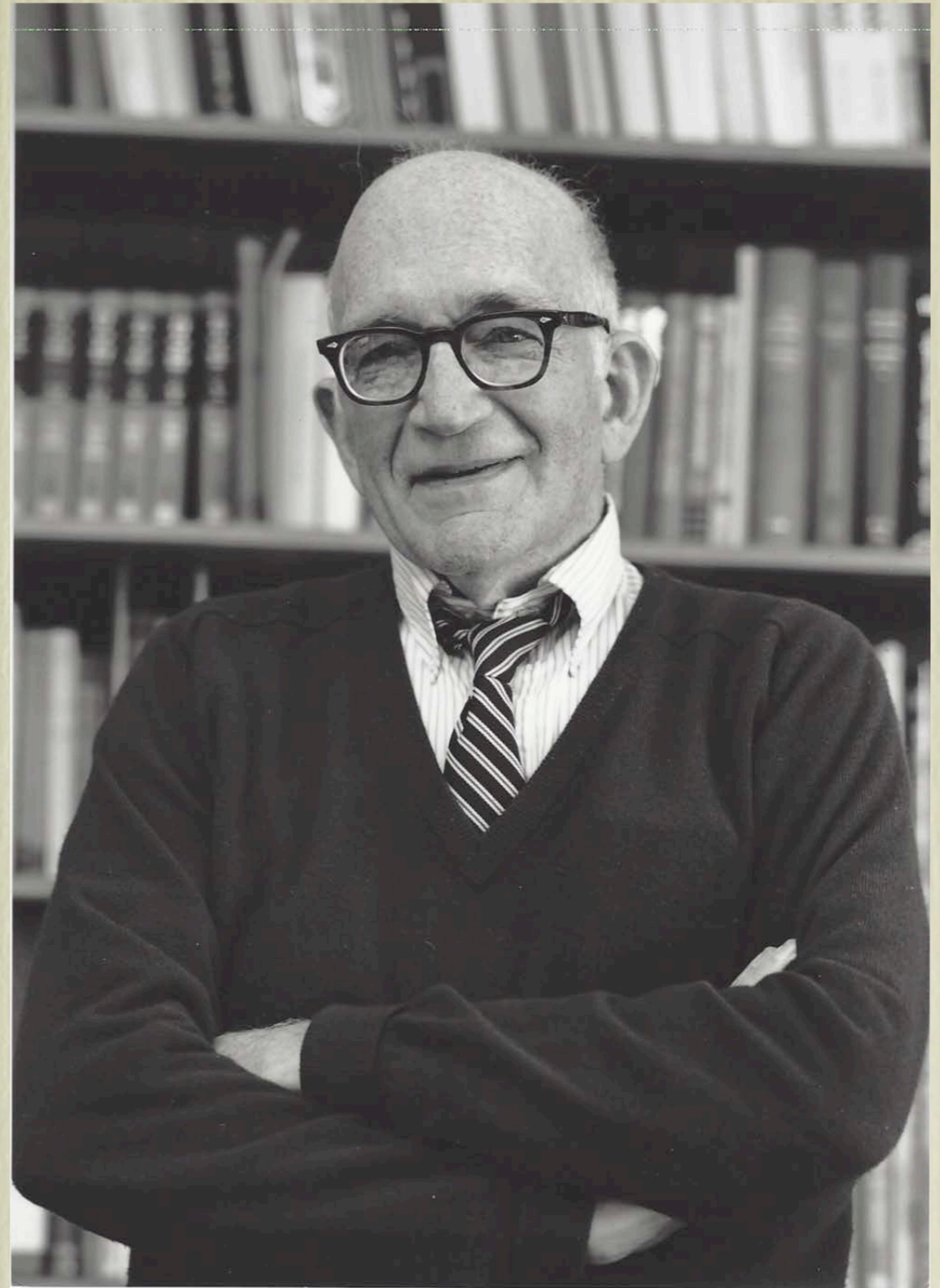


Teaching the Physics of Energy



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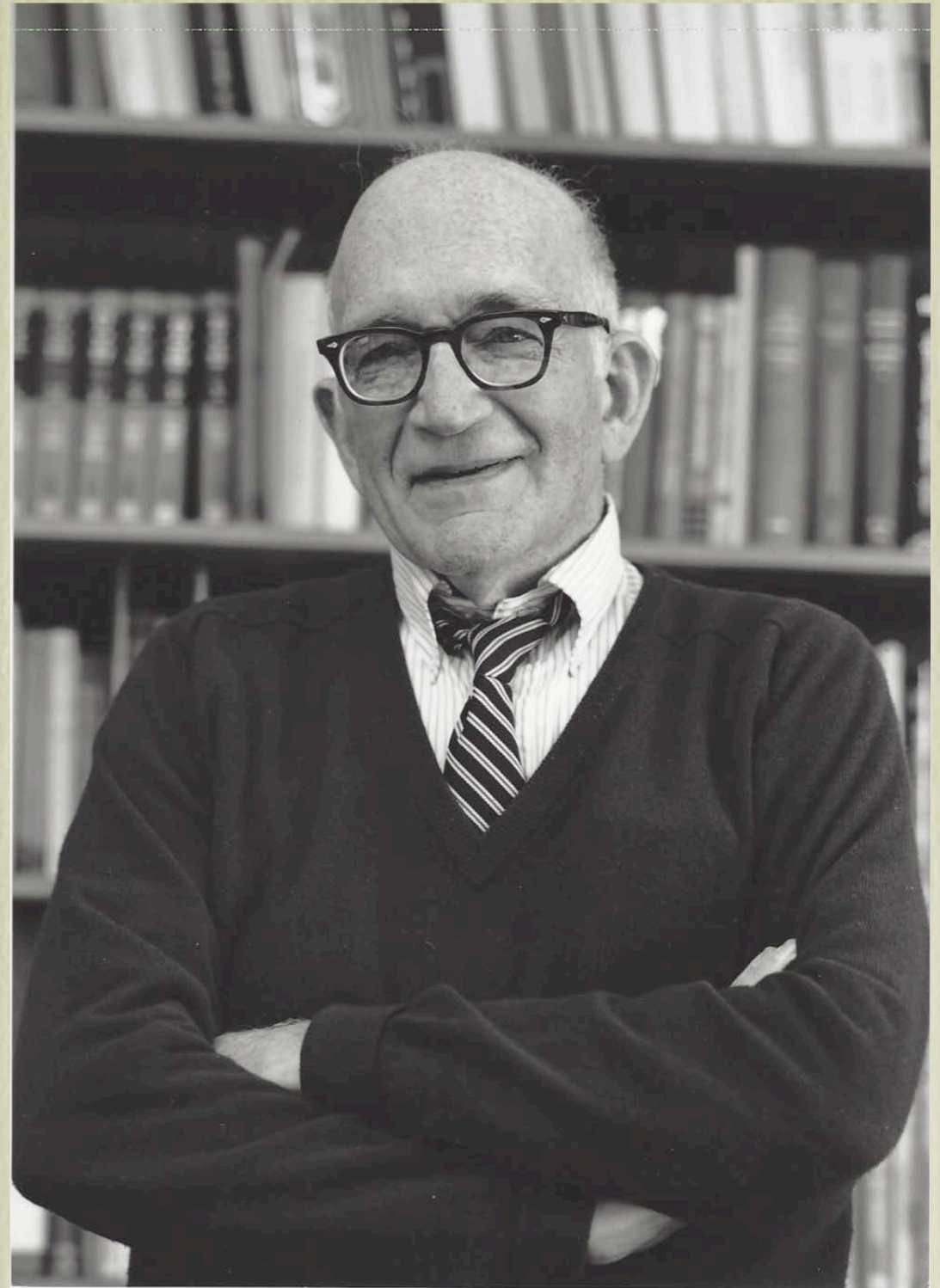
A couple of lessons from Sid's life



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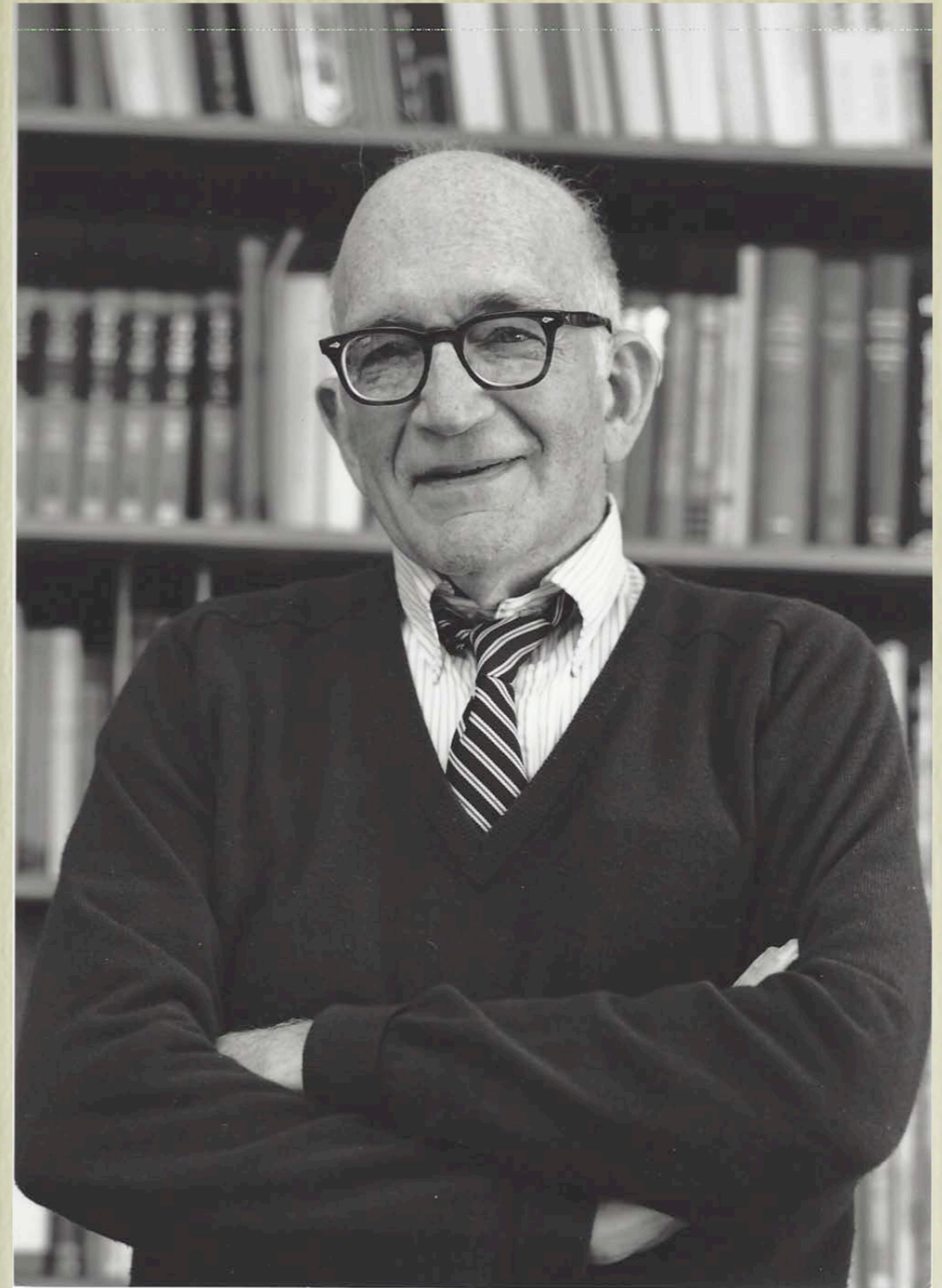
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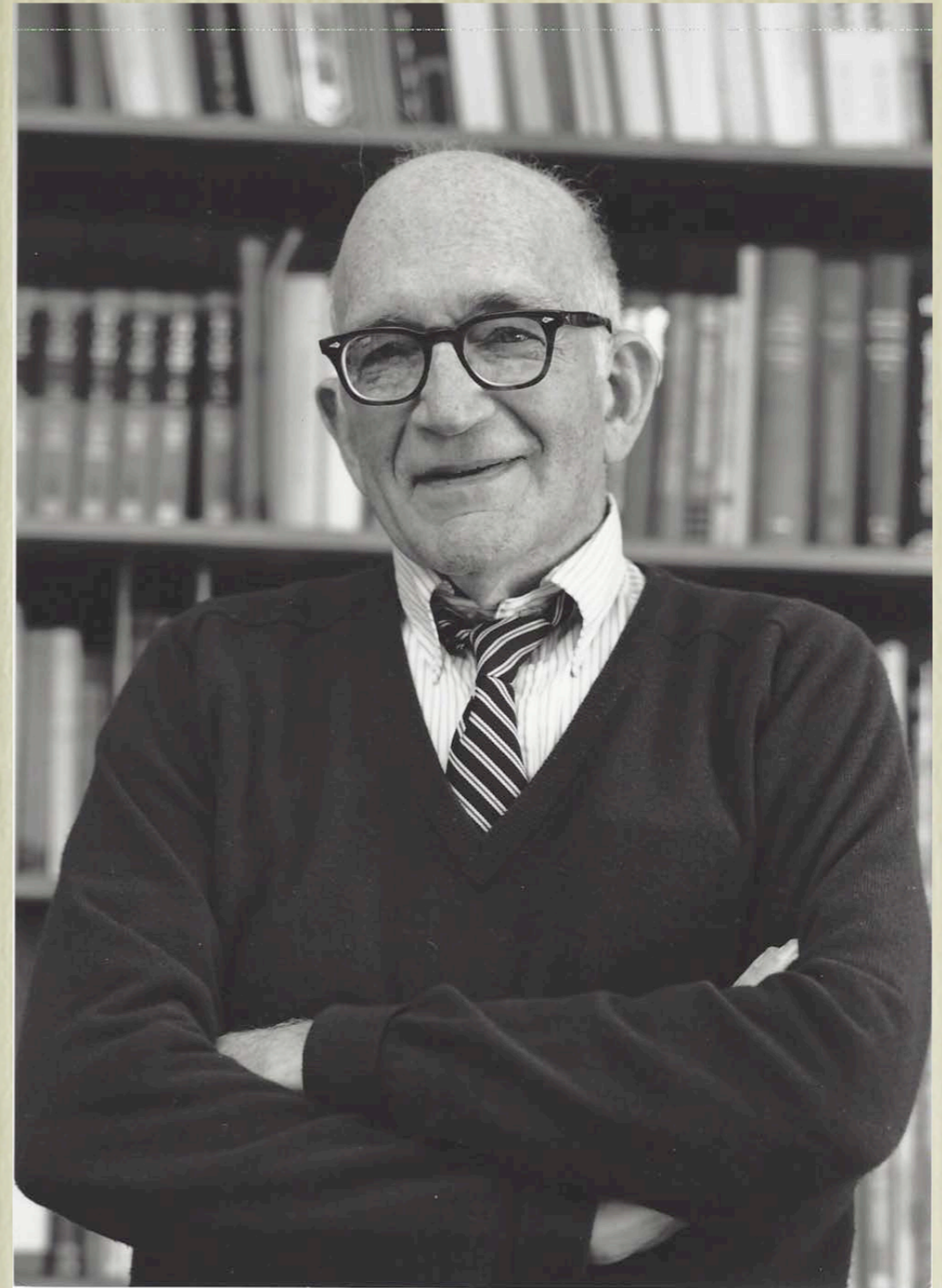


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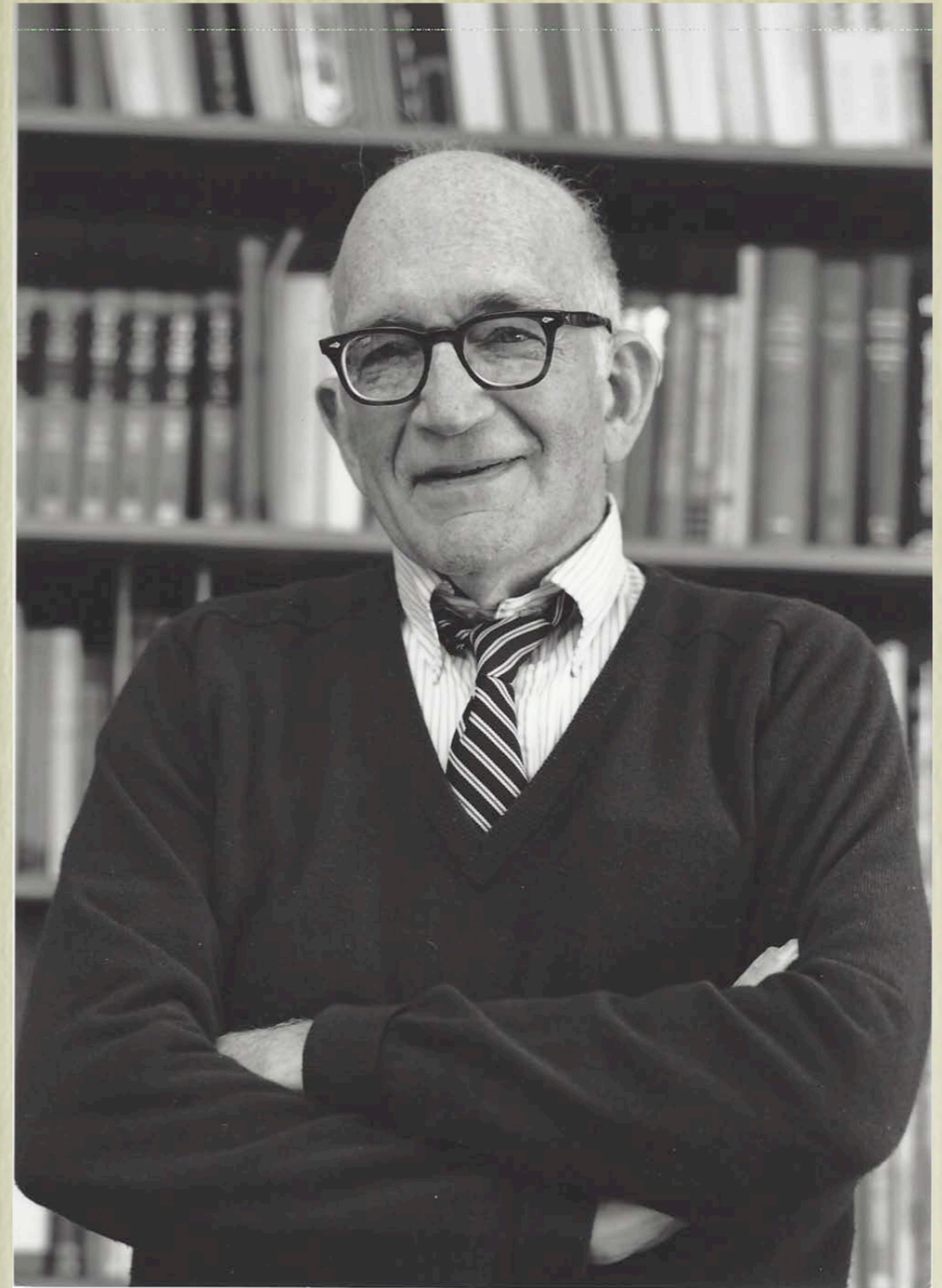
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- **“If you start to write a book and at any time think of laying it aside, you'll be ahead...”**



Why “Physics of Energy”?



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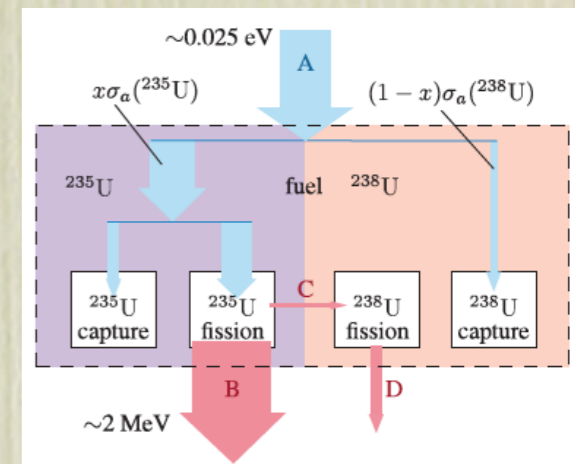
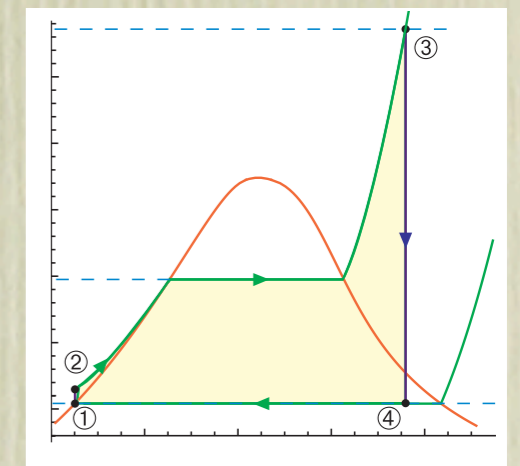
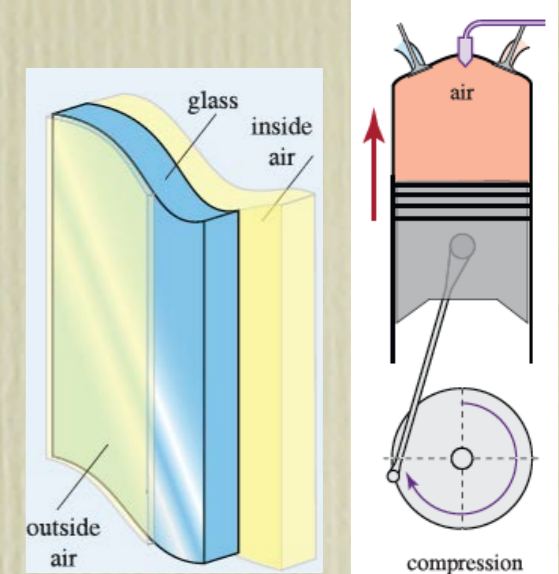
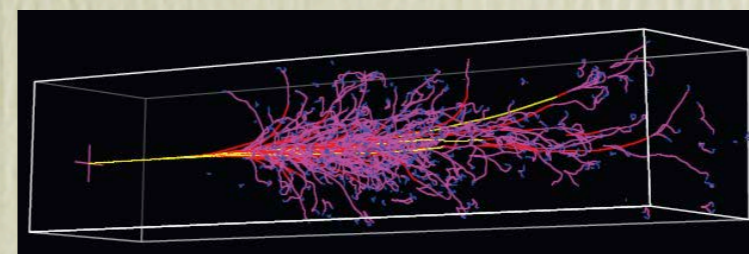
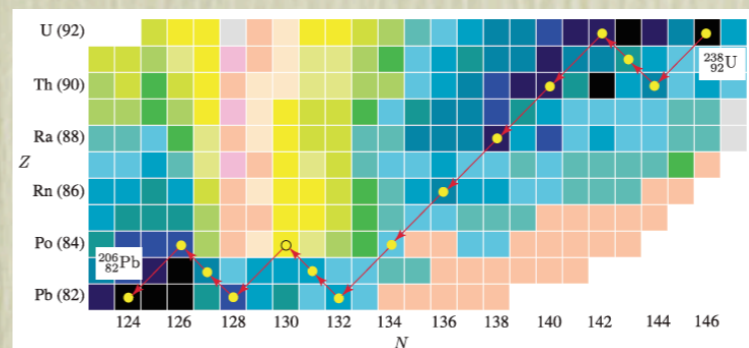
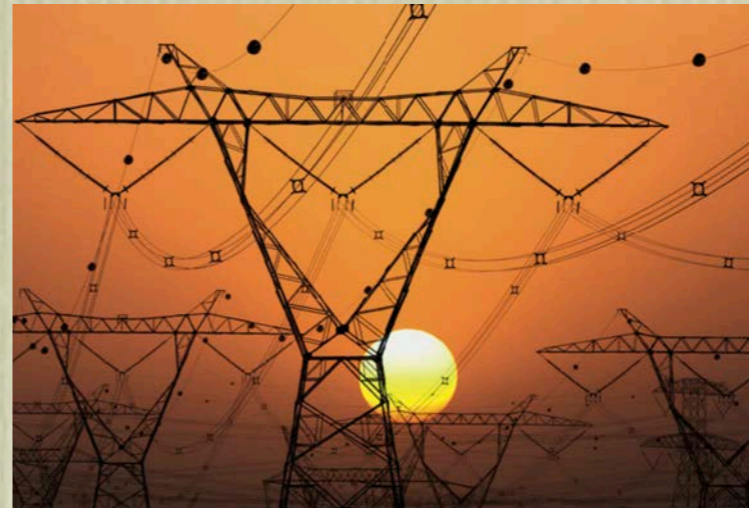


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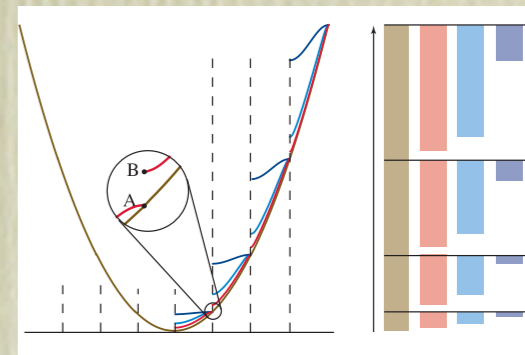
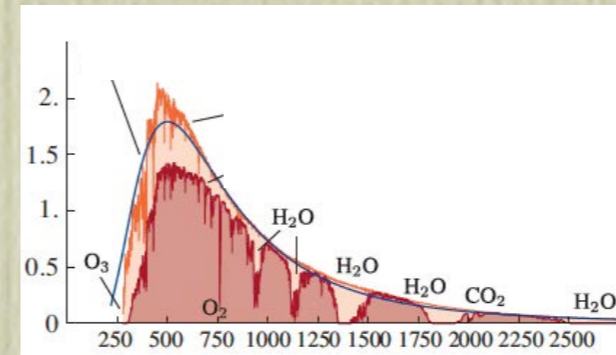
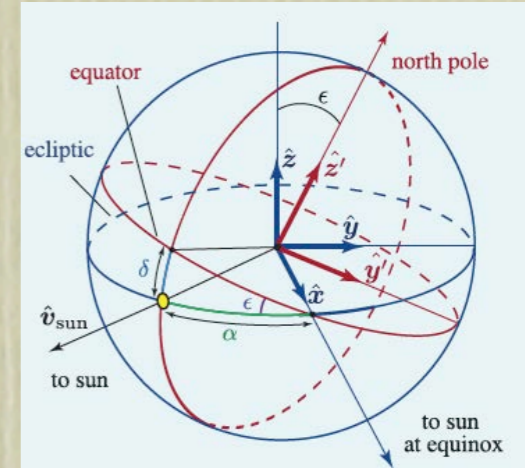
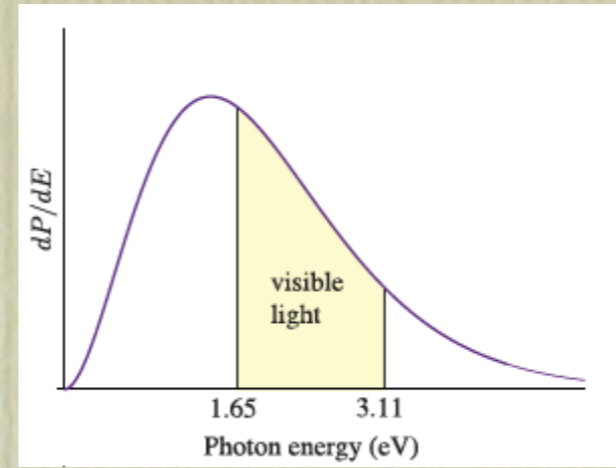
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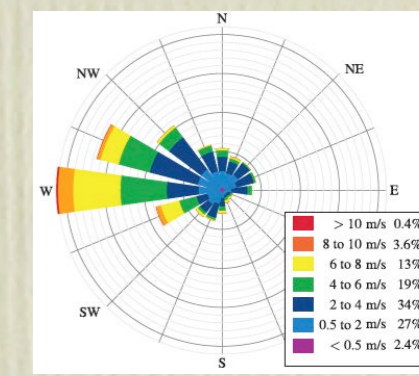
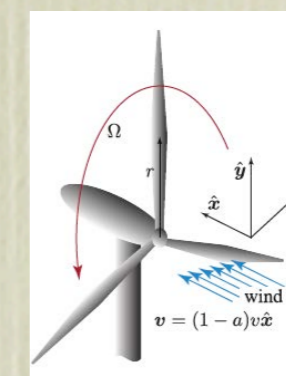
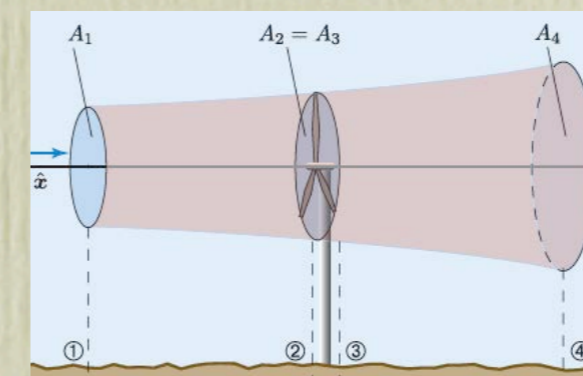
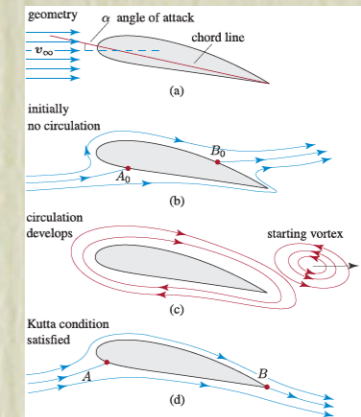
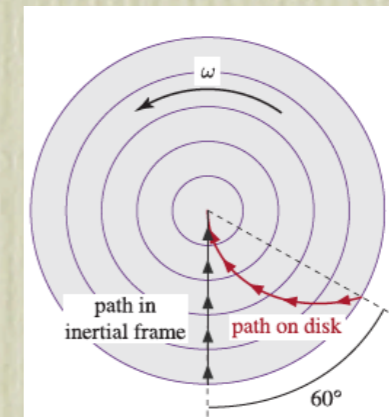
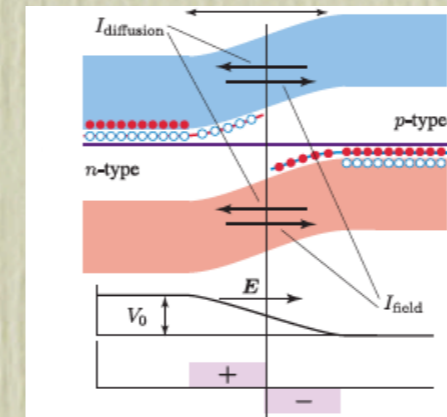
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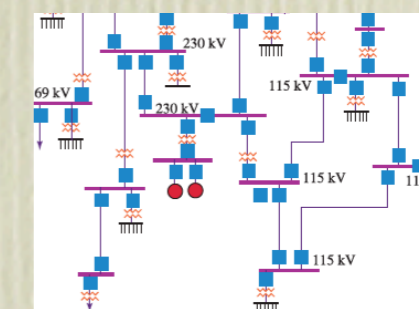
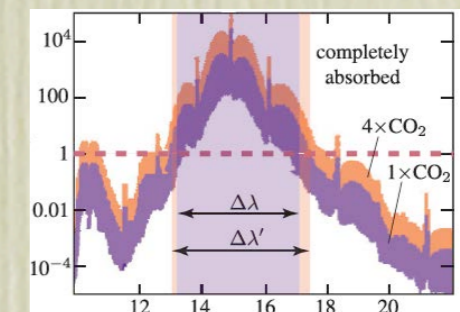
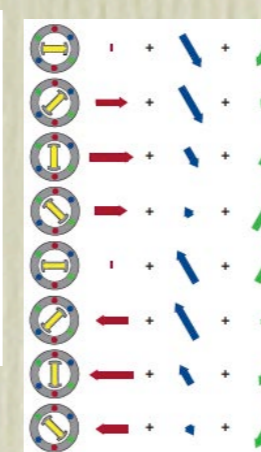
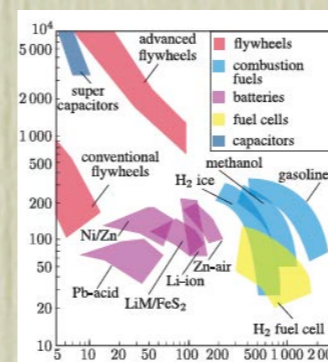
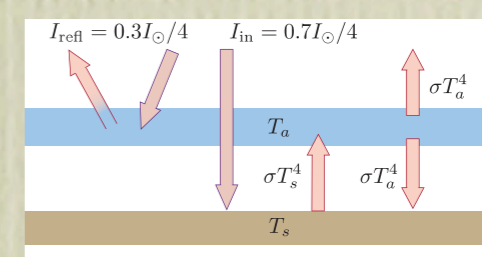
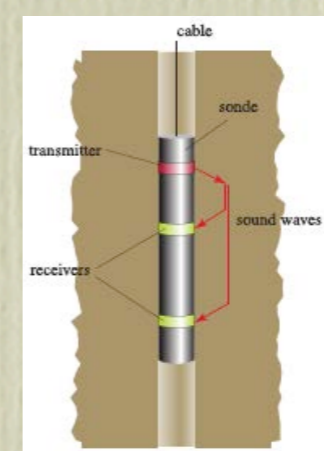
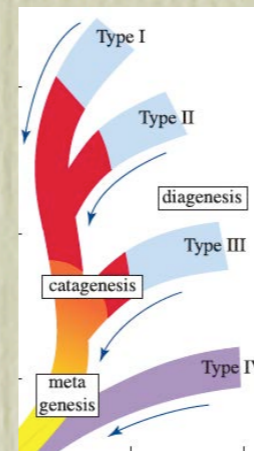
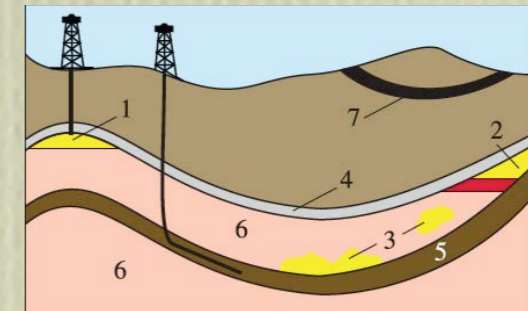
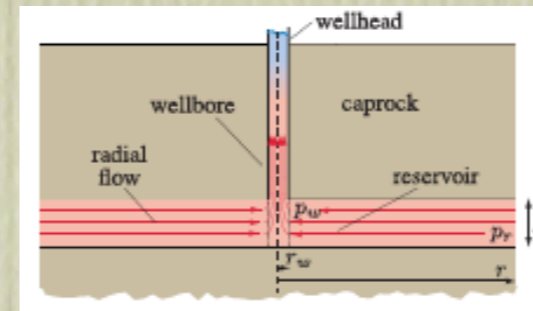
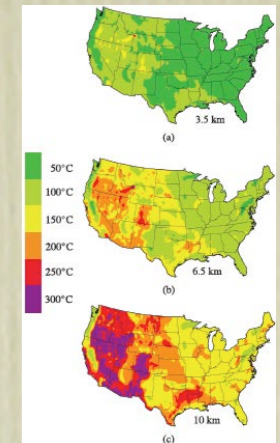
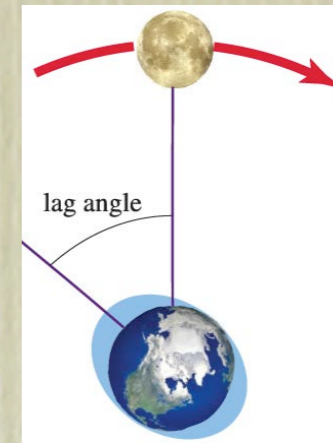
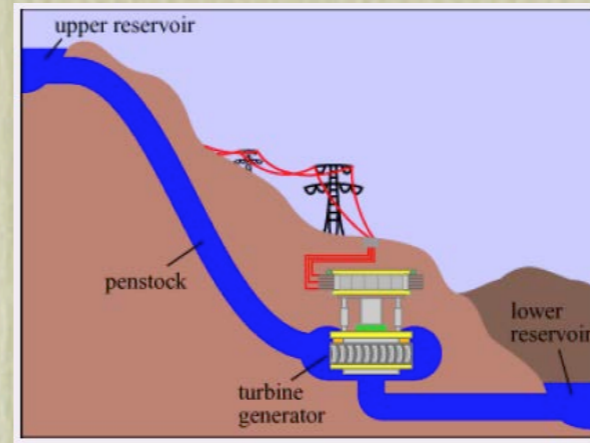


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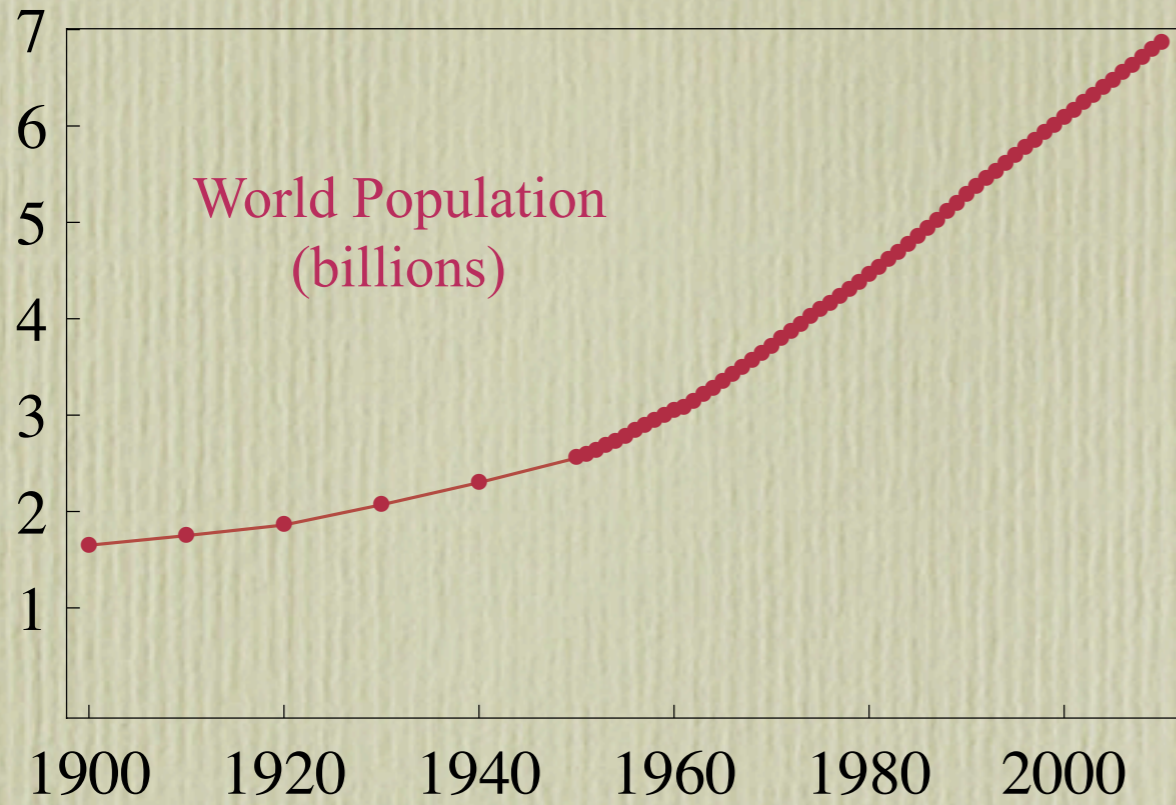
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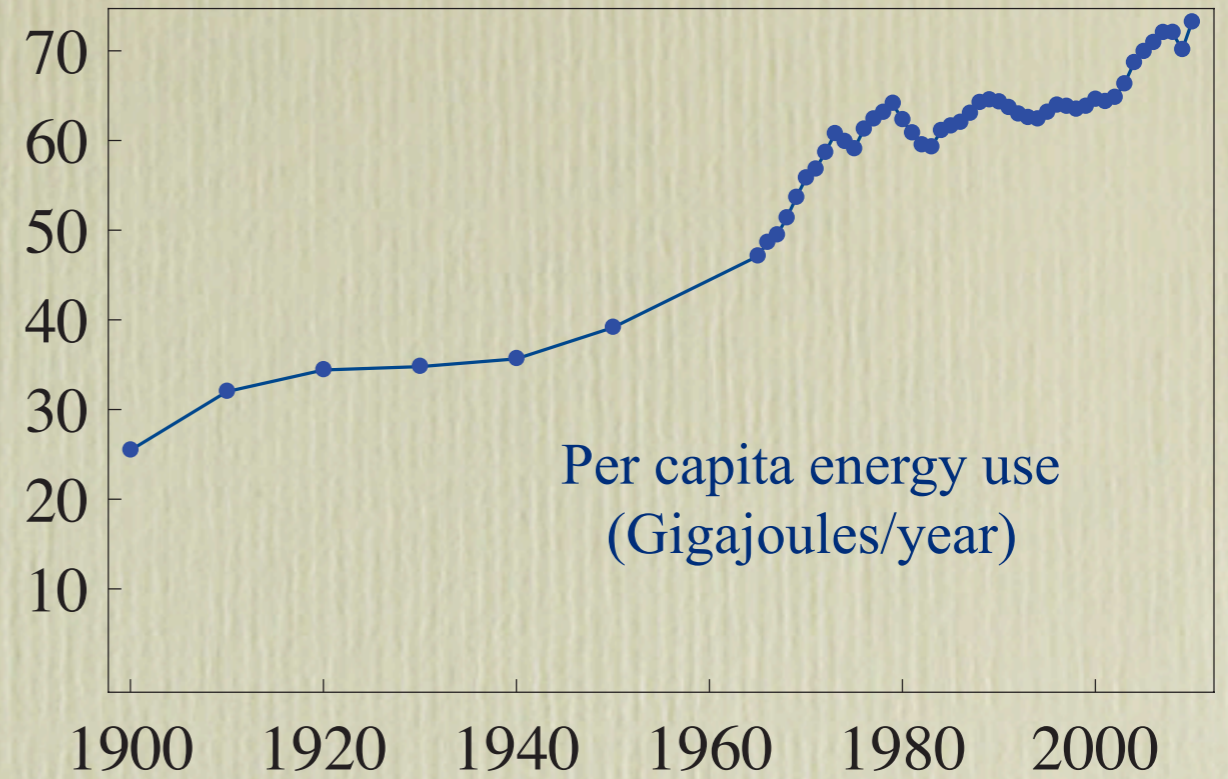
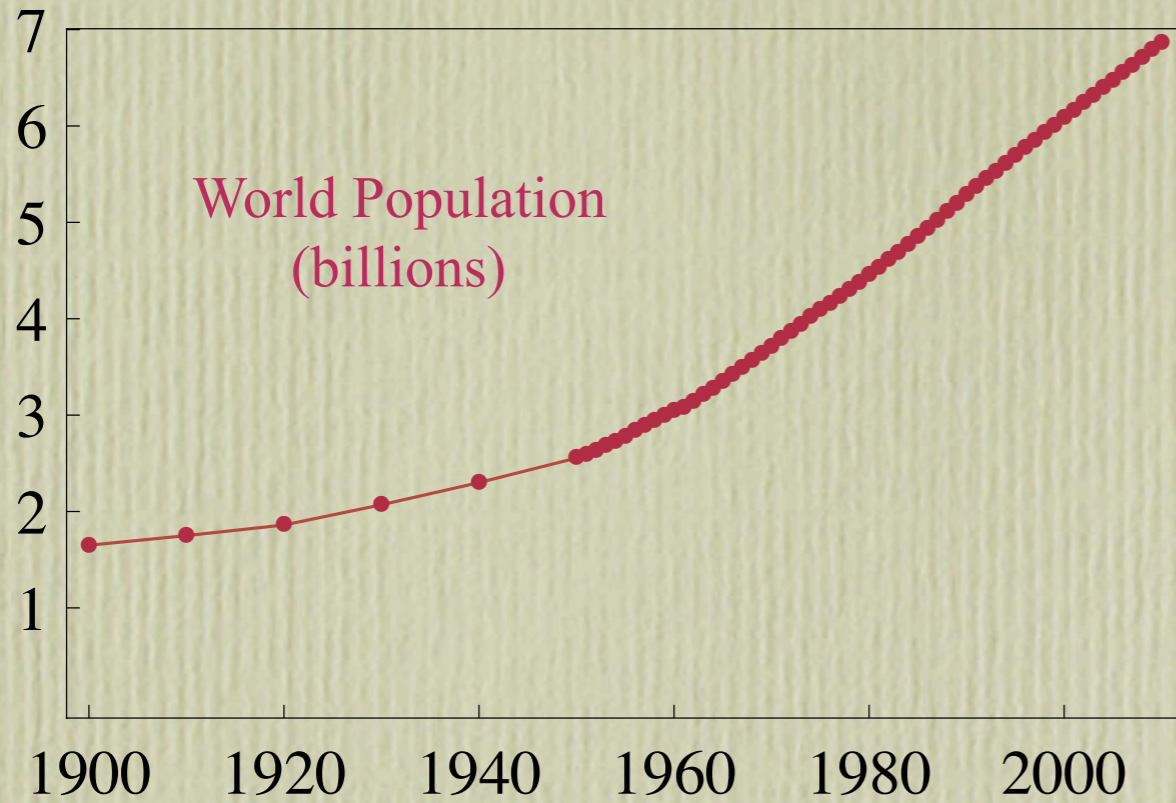
I. THE PROBLEM: Sustainable energy for an energy hungry world



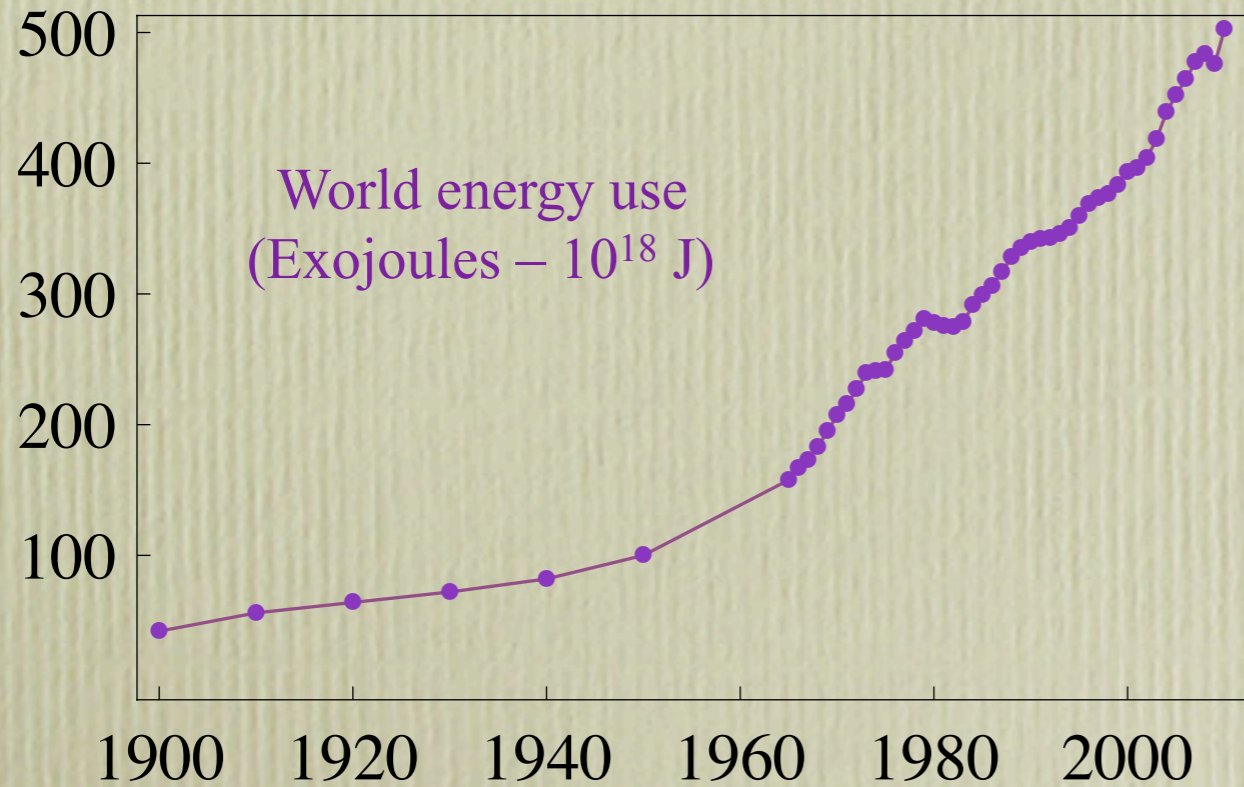
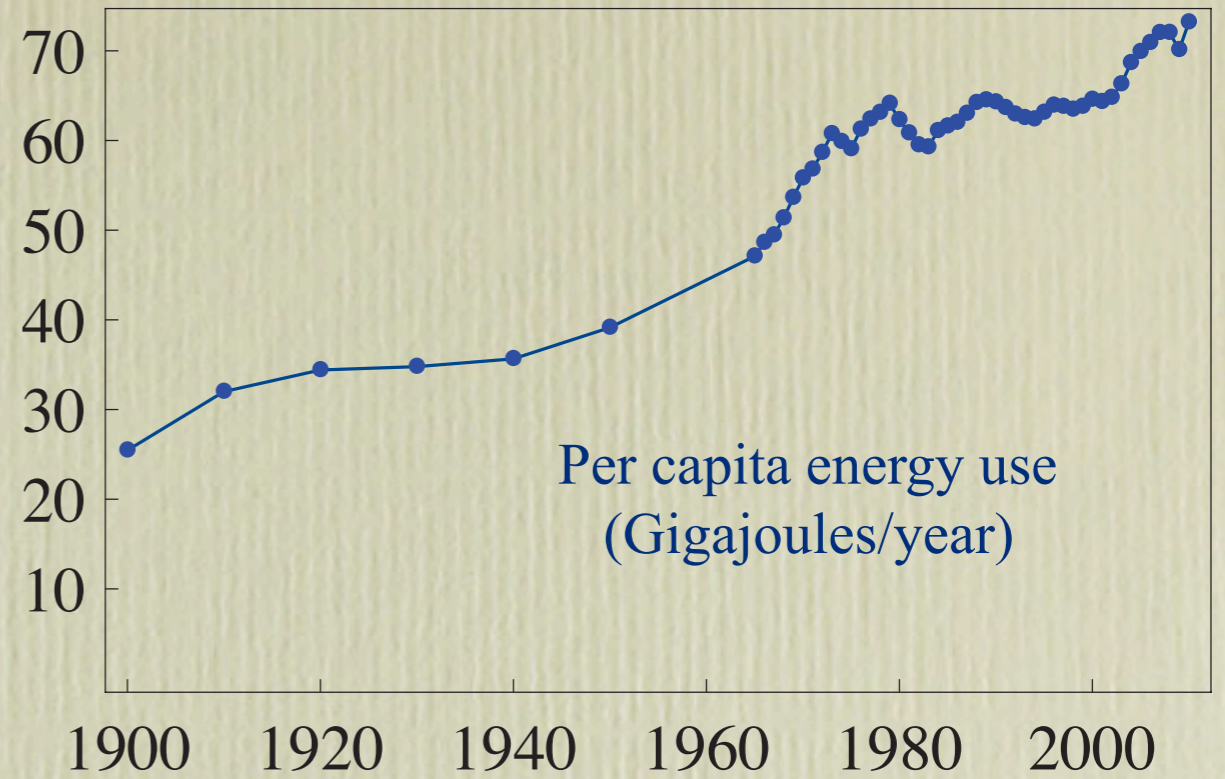
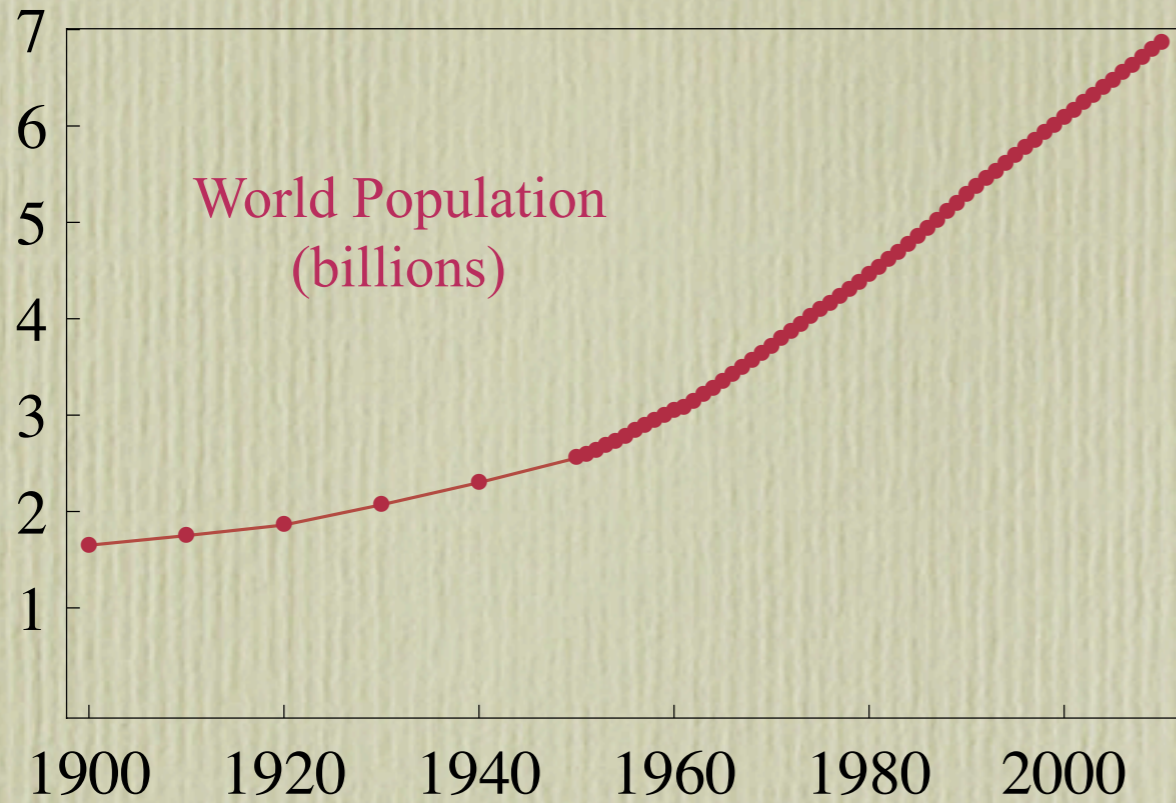
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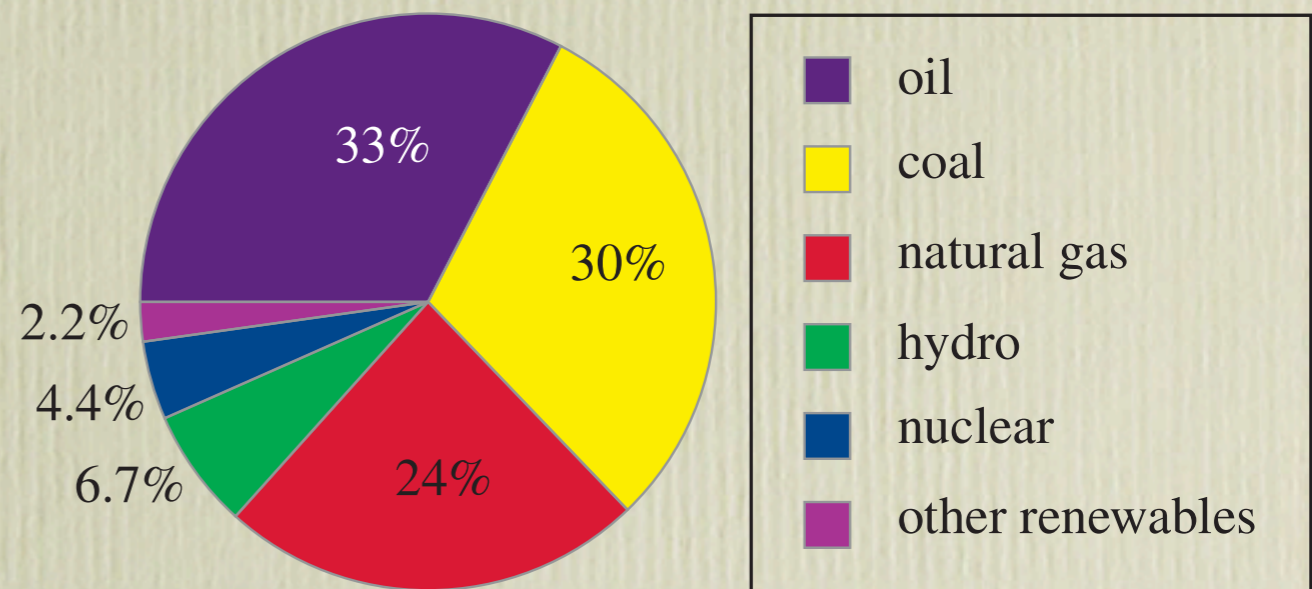
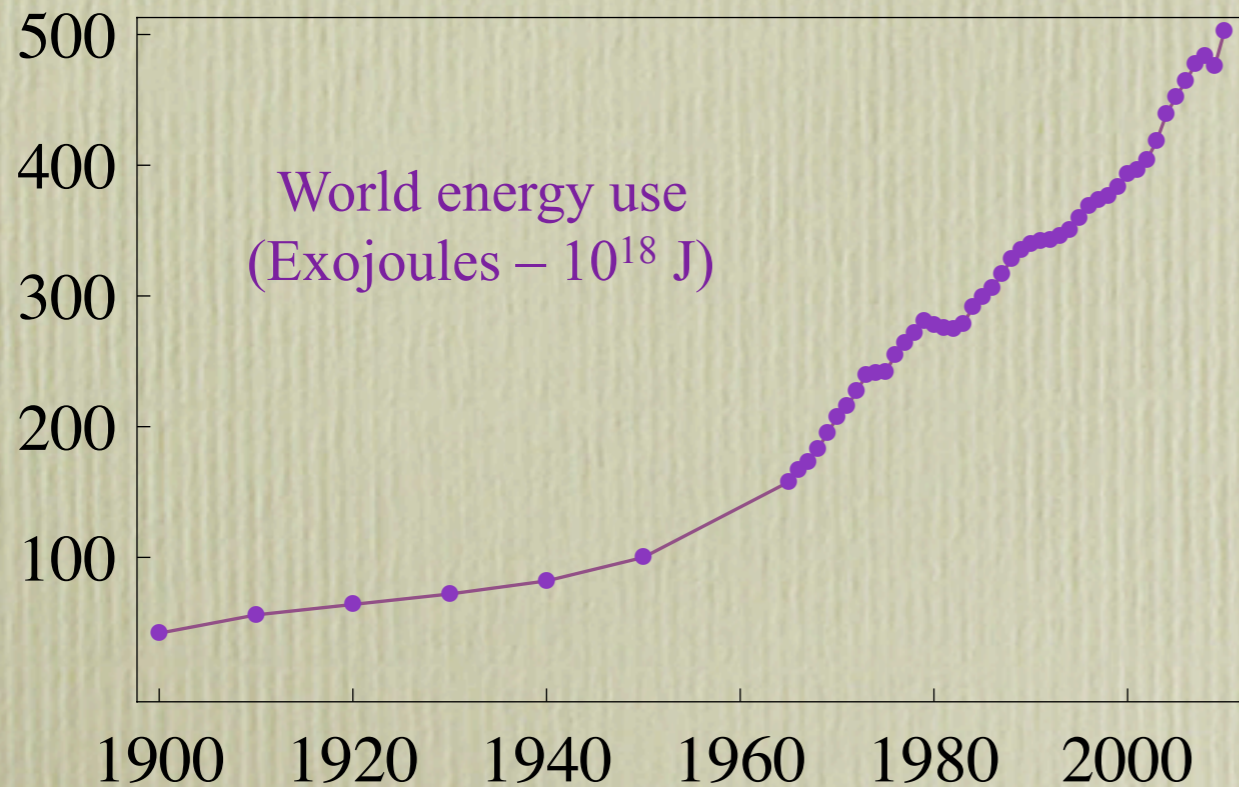
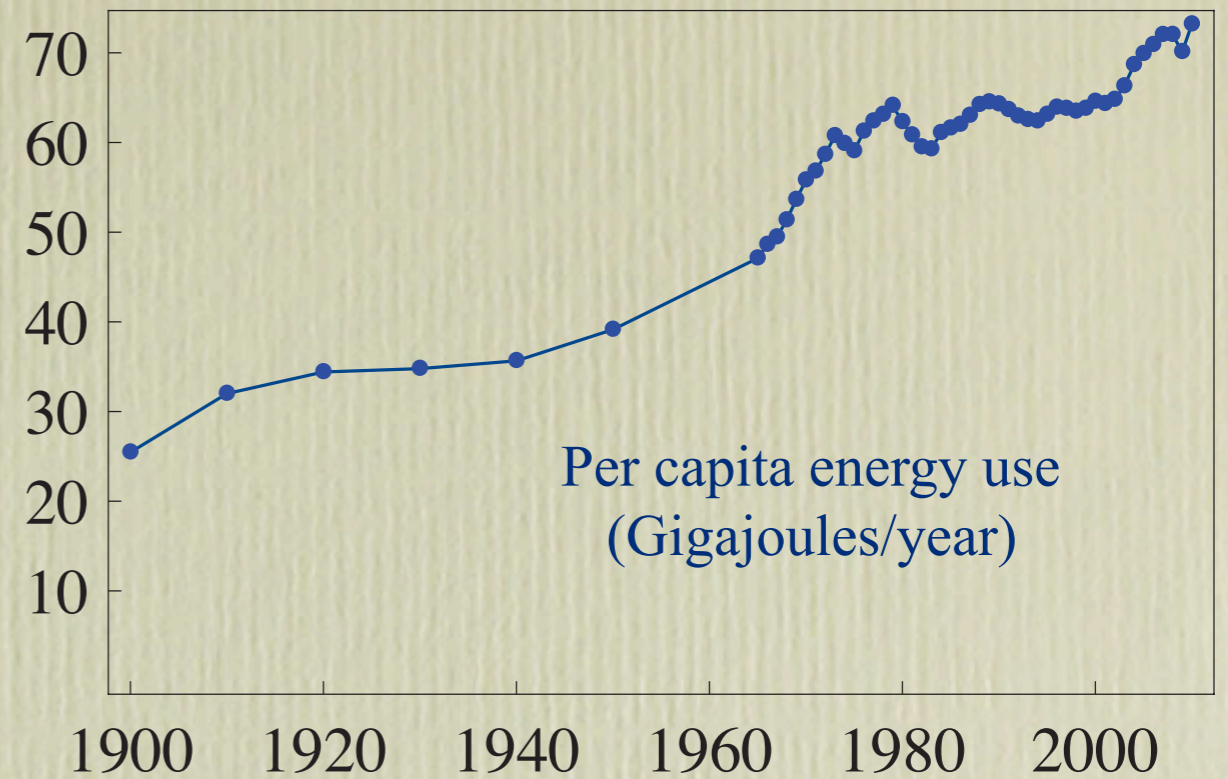
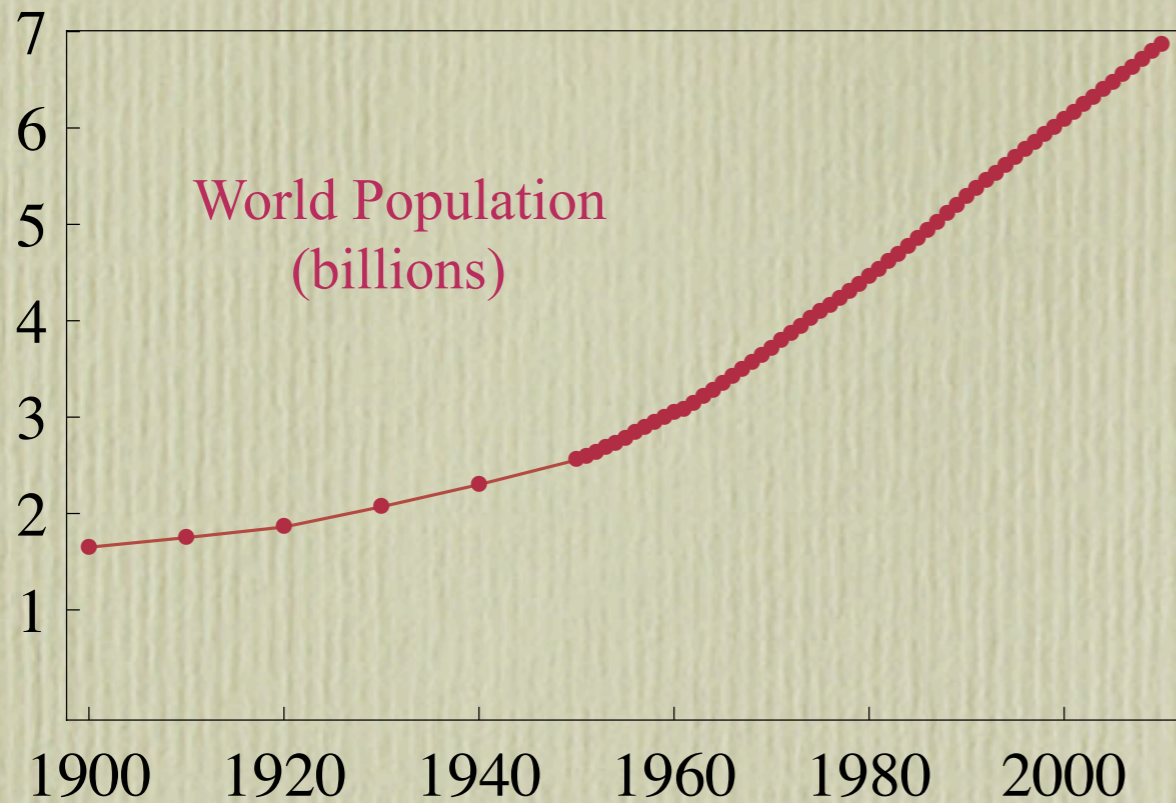
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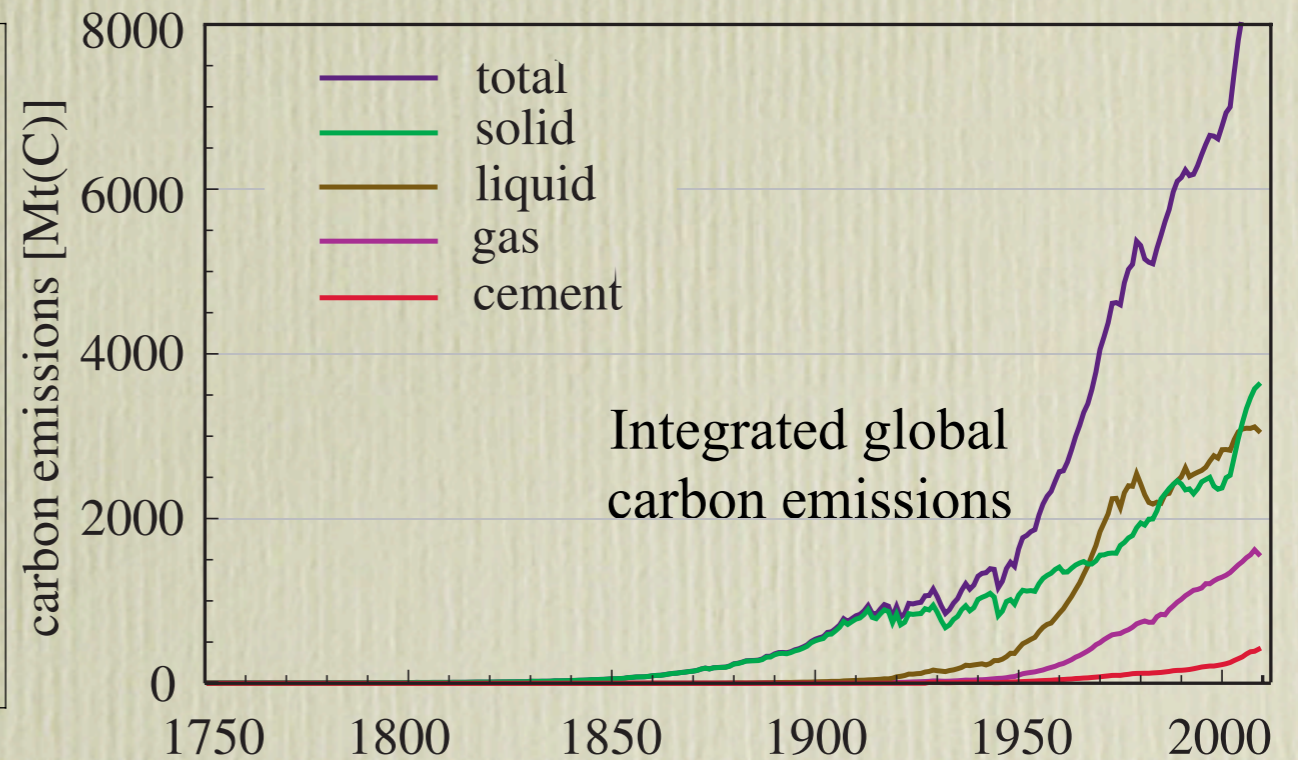
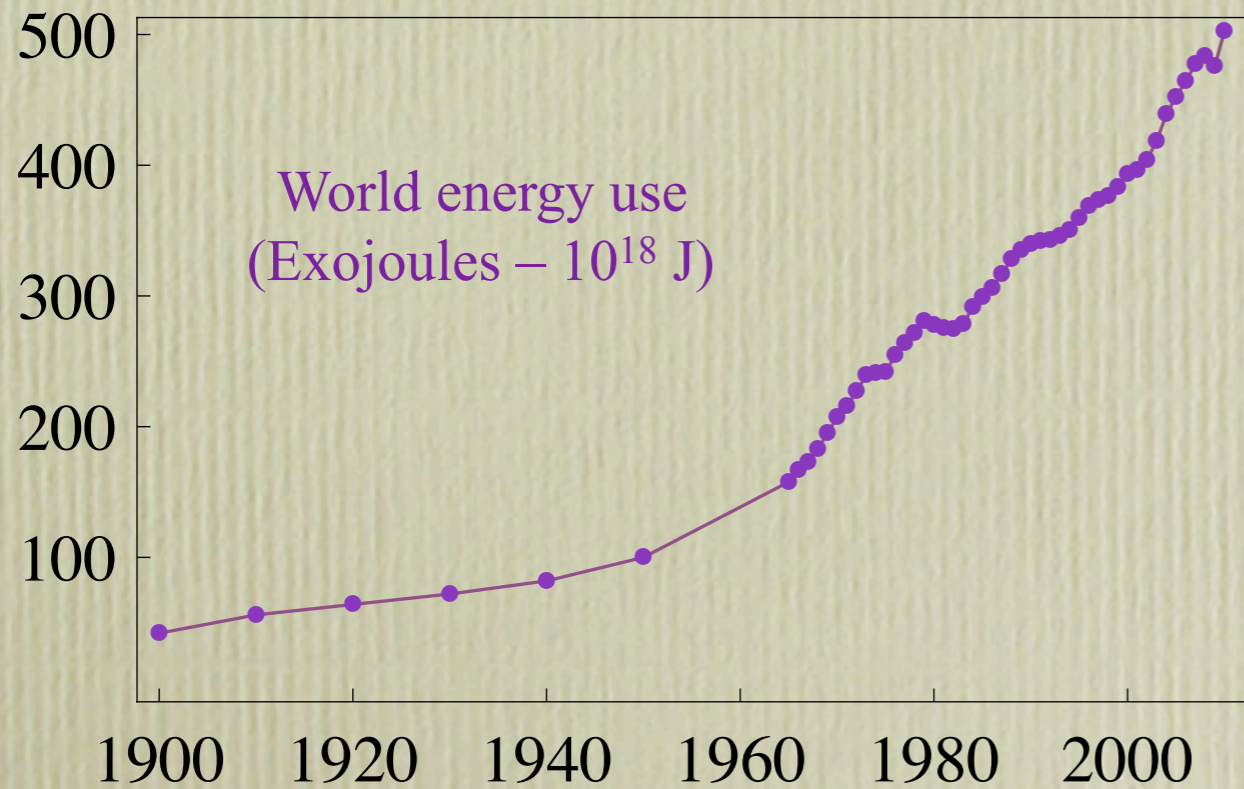
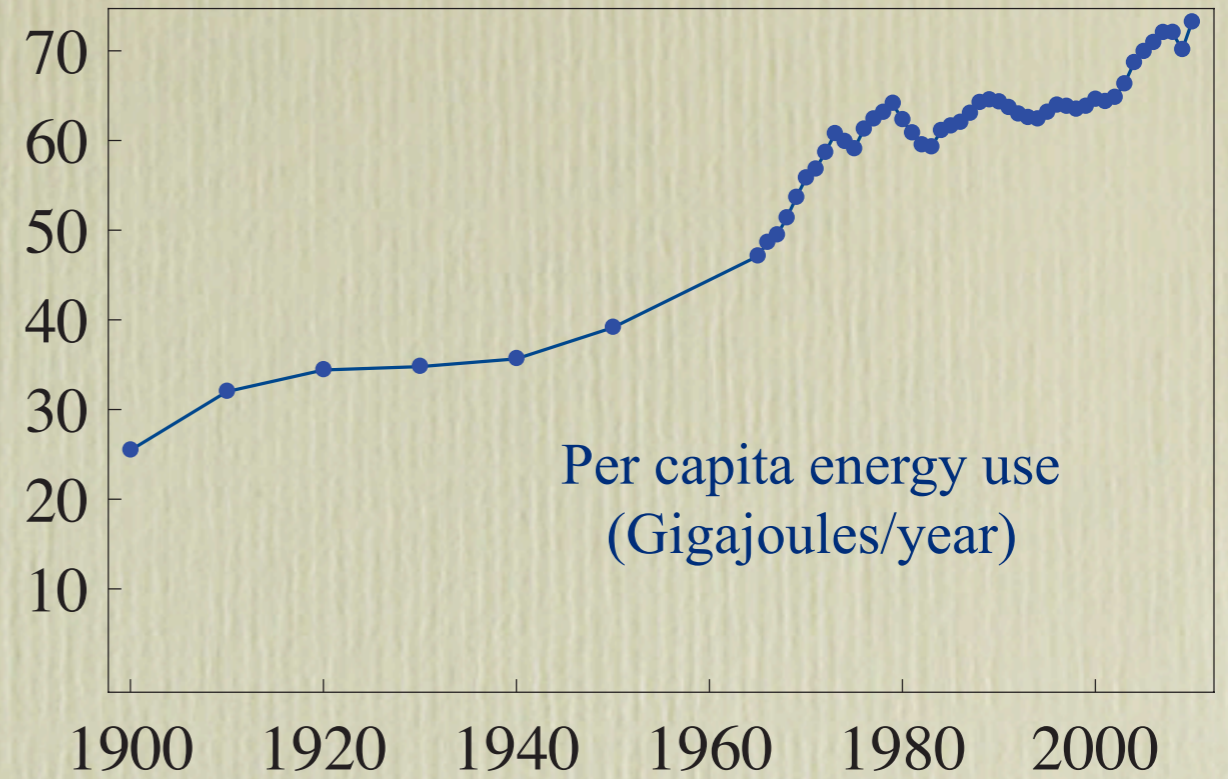
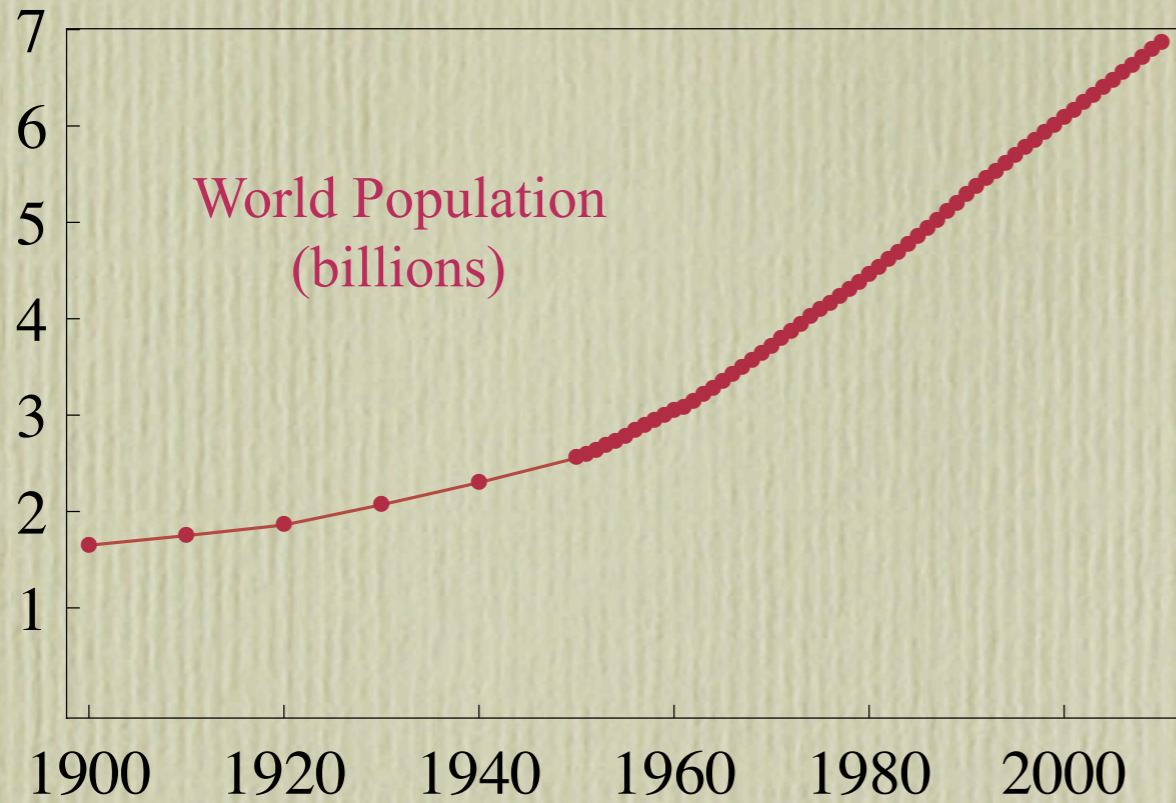
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Three Gorges Dam capacity 22.5 GW

To supply world primary energy needs entirely from

- **Hydro: 775 x Three Gorges dams @ 100% capacity**





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550,000 t capacity ultra-large tanker

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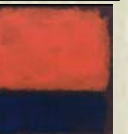
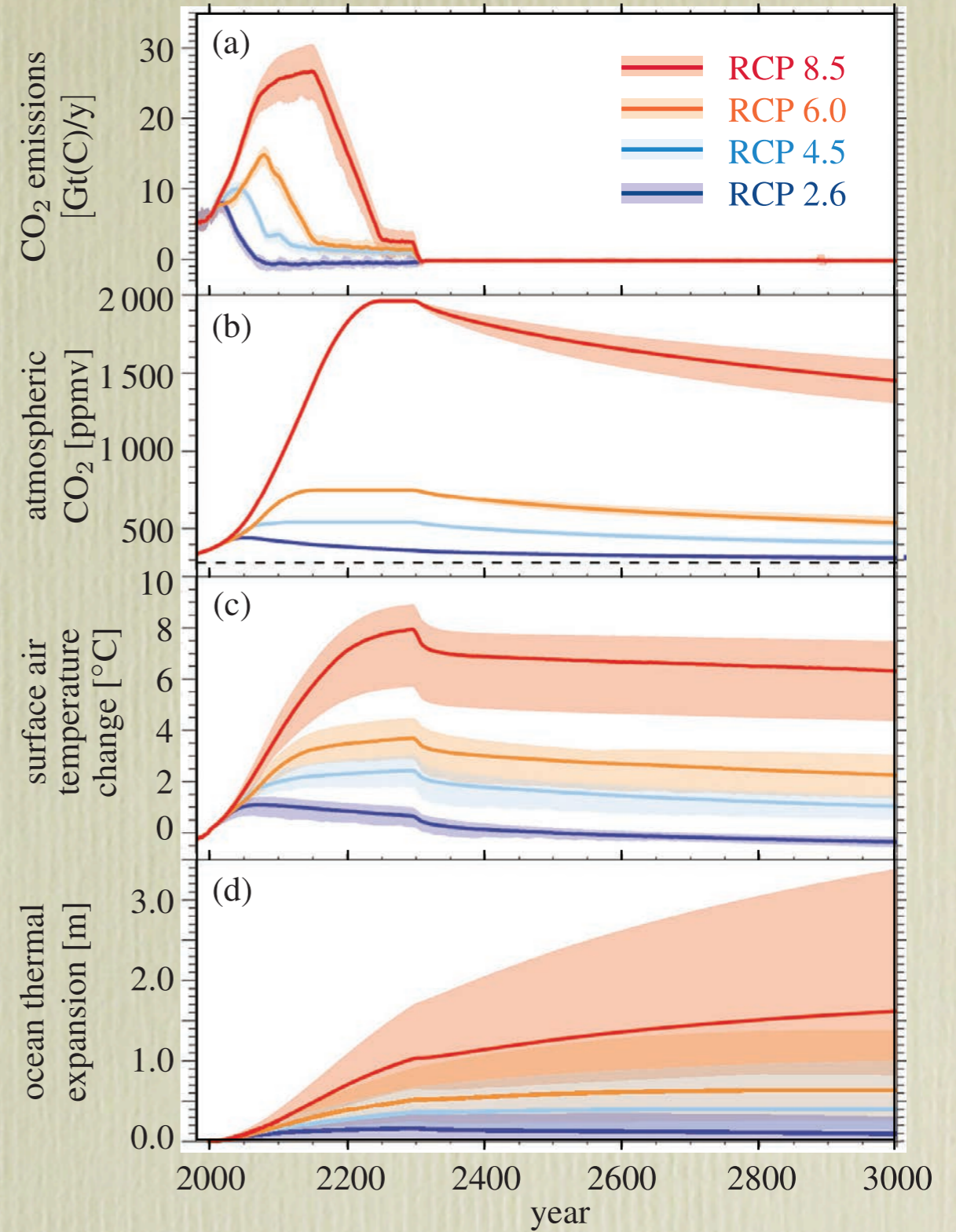
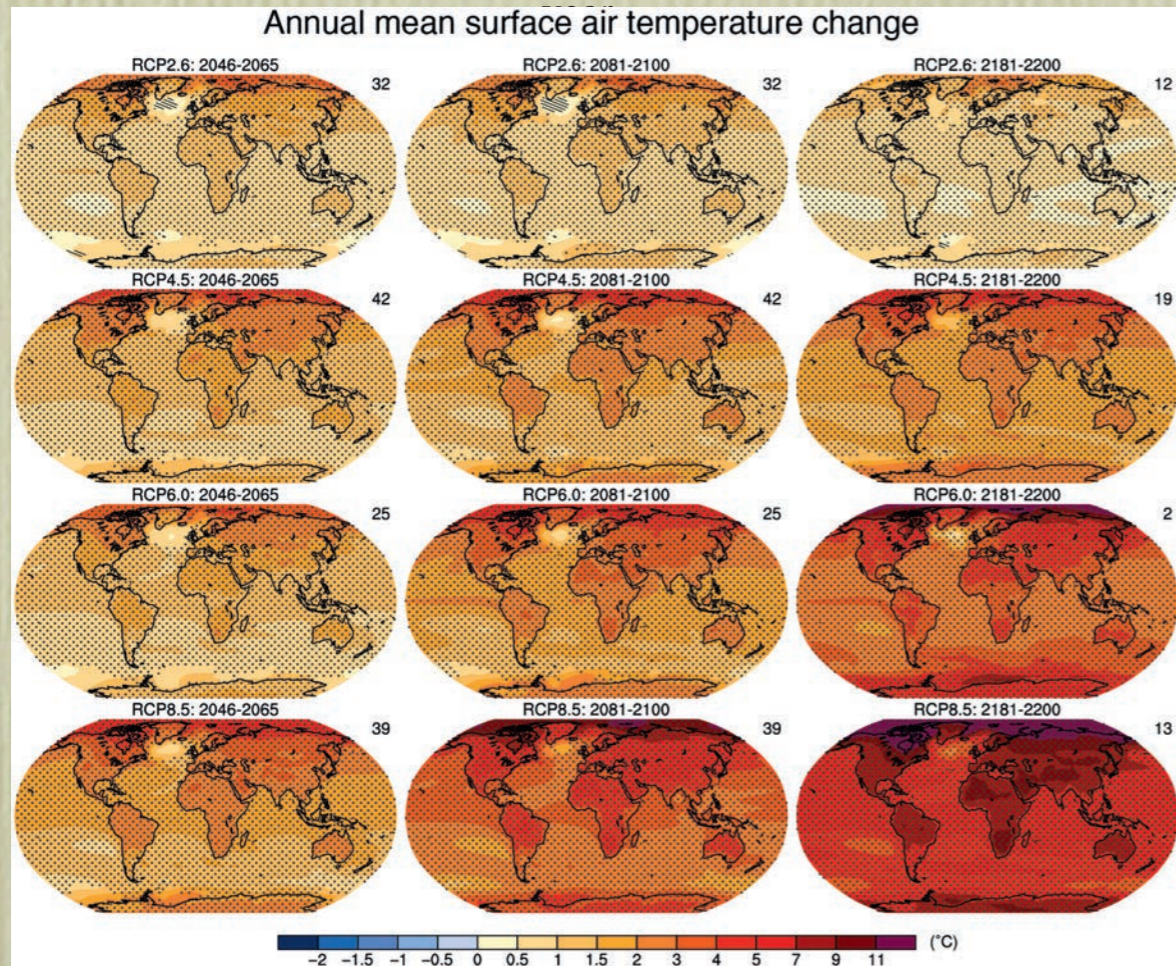
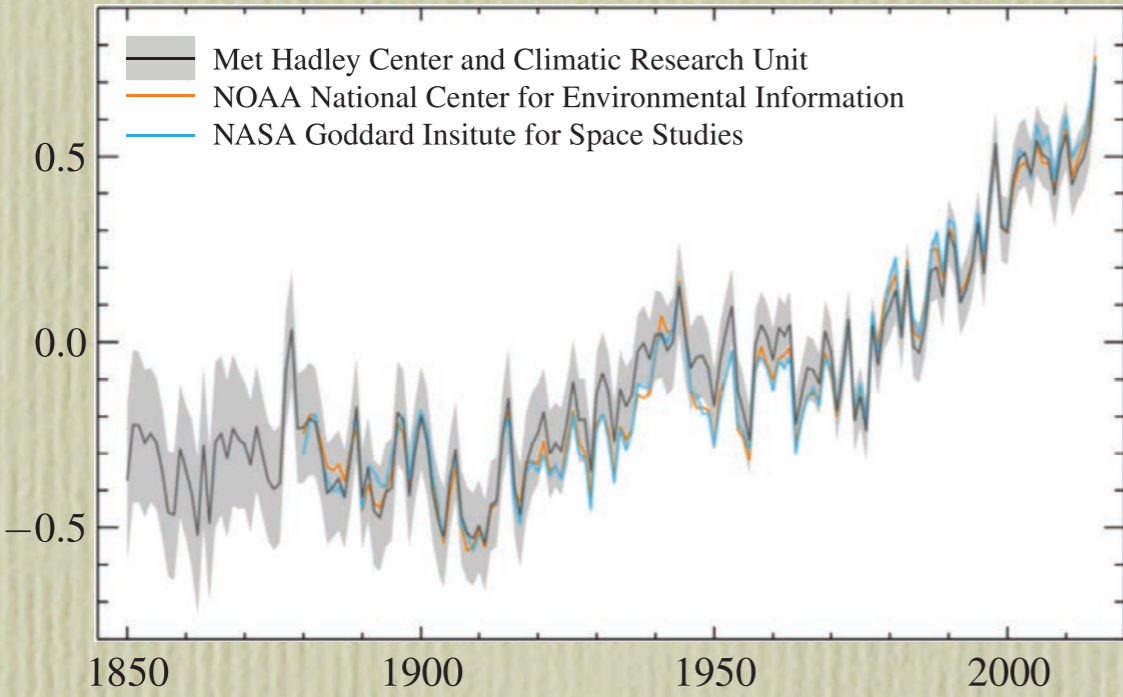
1 km² PV array in equatorial desert

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difference from 1961–1990 average [°C]



SCIENCE



**ECONOMICS &
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SCIENCE



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graph BT; S(SCIENCE) --> ESE(ECONOMICS & SOCIAL SCIENCE); S --> PPR(POLICY, POLITICS & REGULATION)
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No equations

Few derivations

Energy & environment

Mix of physics, economics,
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“Physics for future presidents”

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“Energy through
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and

“Physics through
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THE PHYSICS CORE: Energy flow in the Universe and on Earth



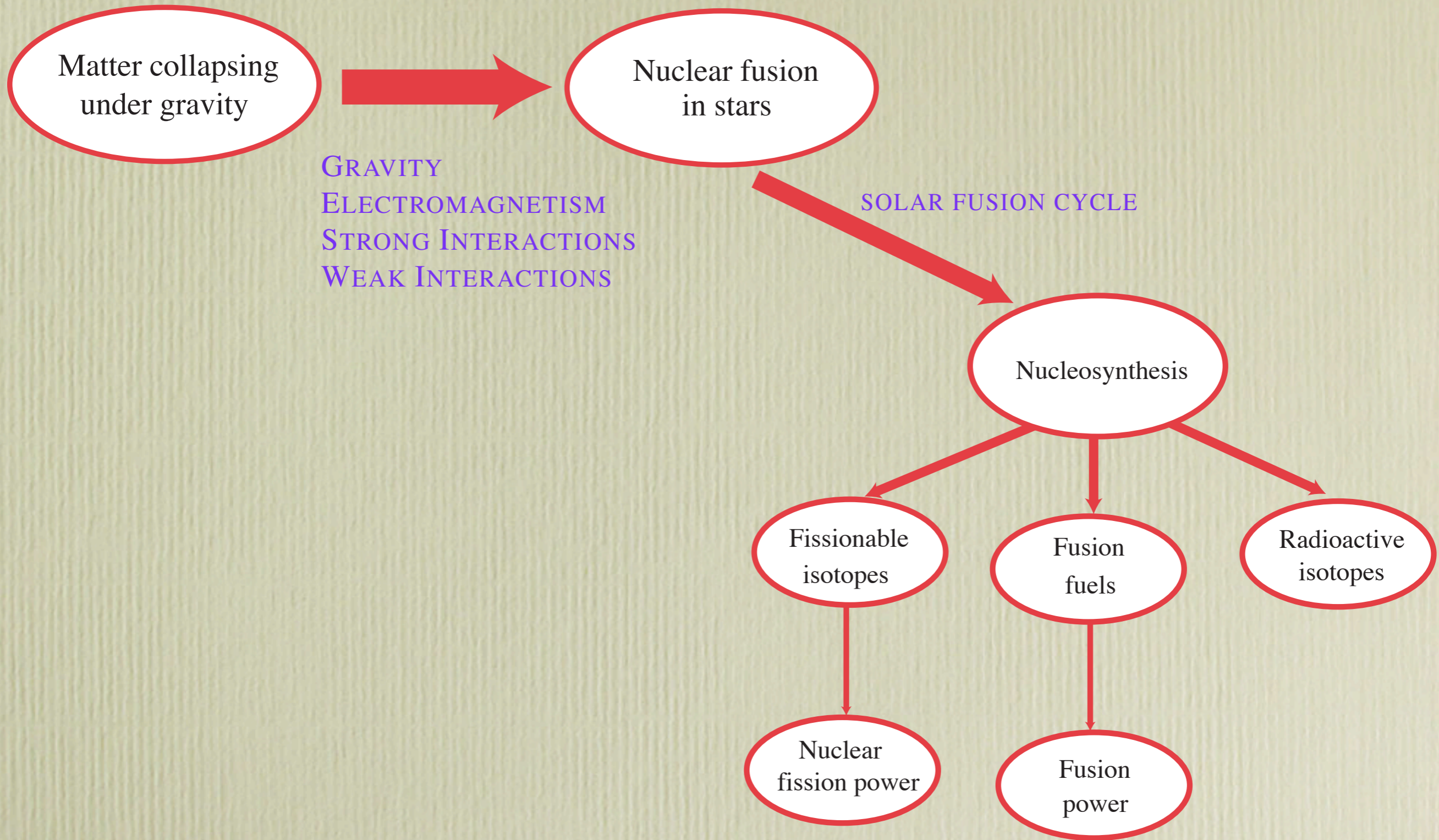
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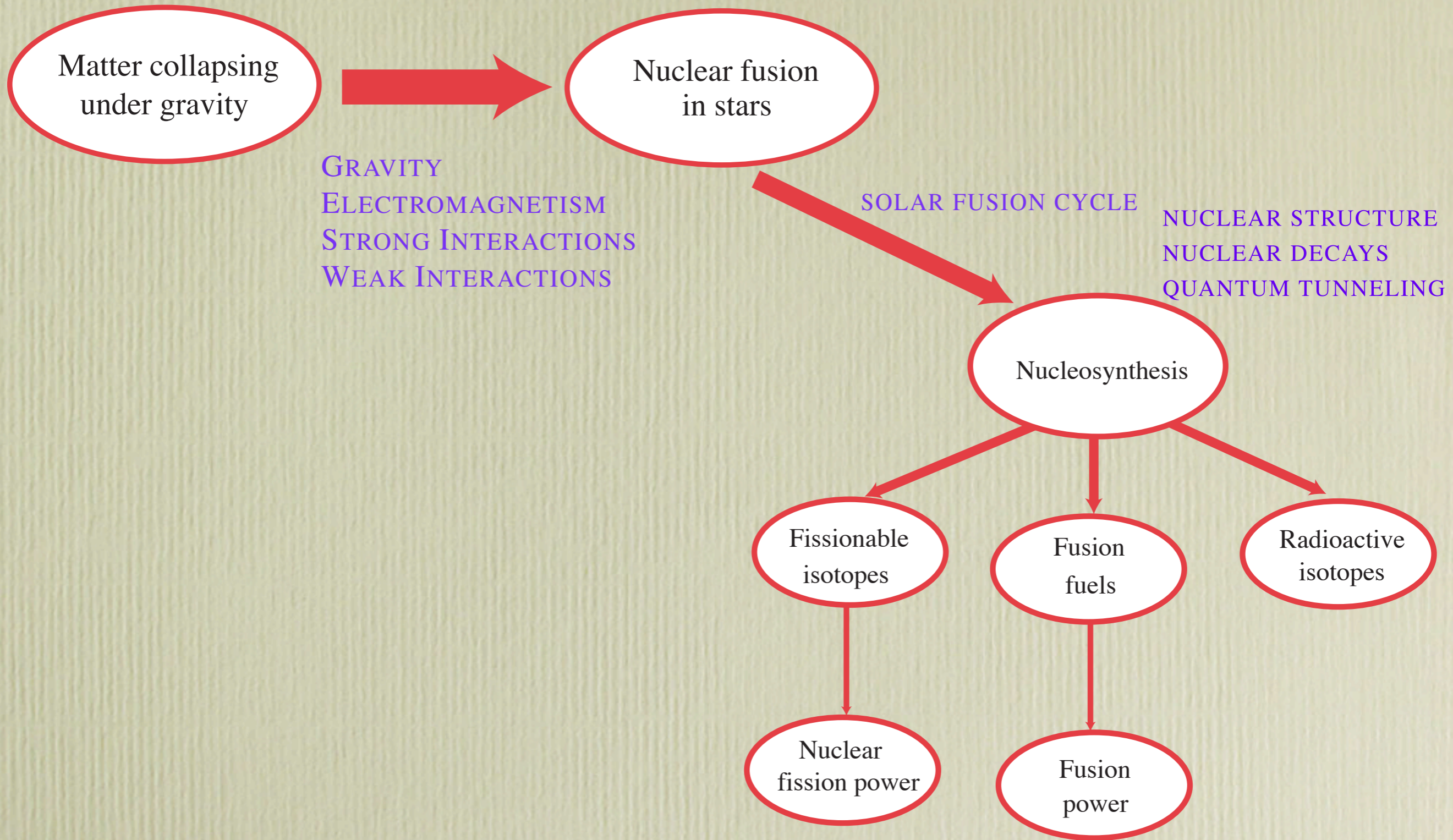
GRAVITY
ELECTROMAGNETISM
STRONG INTERACTIONS
WEAK INTERACTIONS



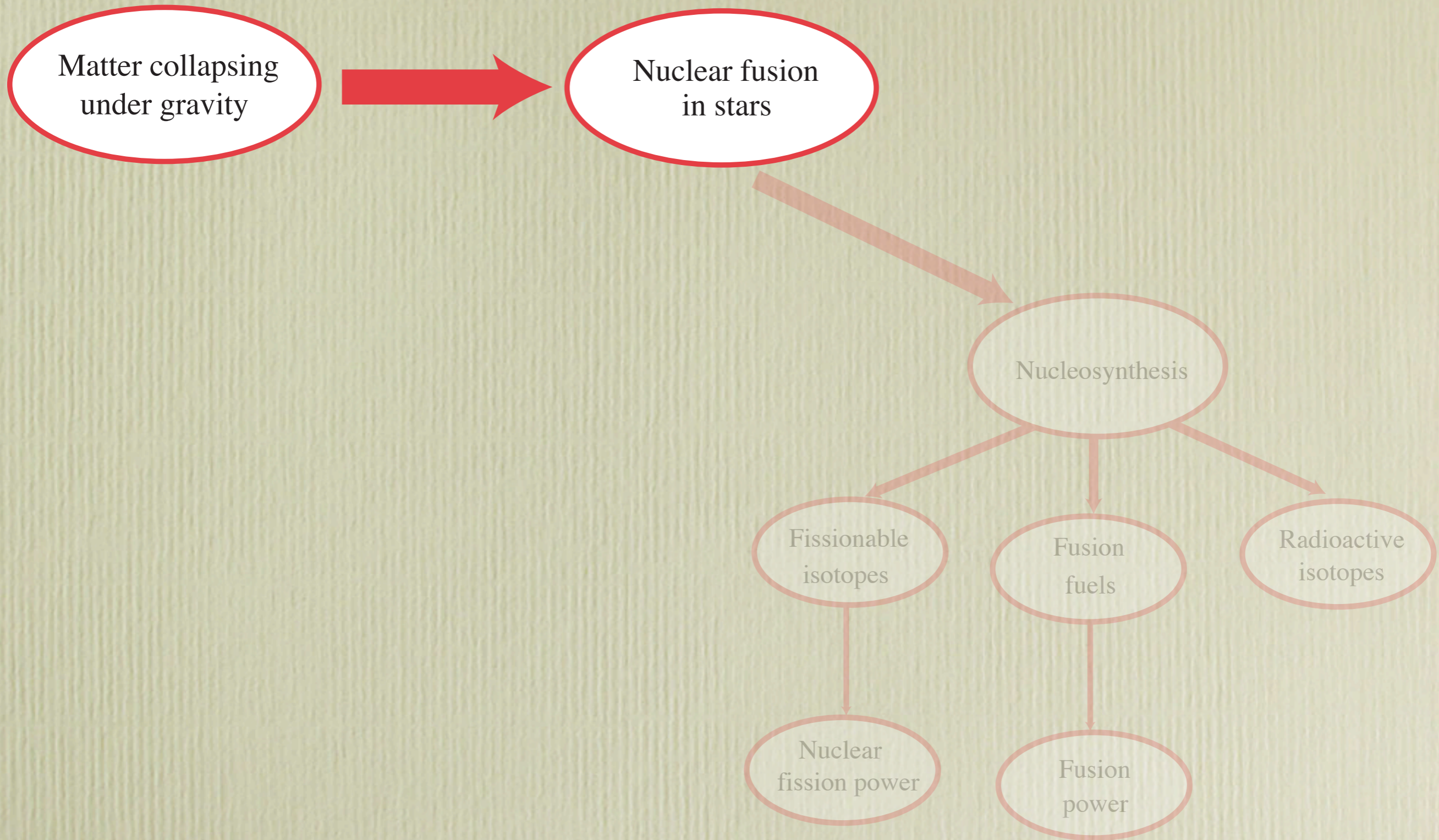
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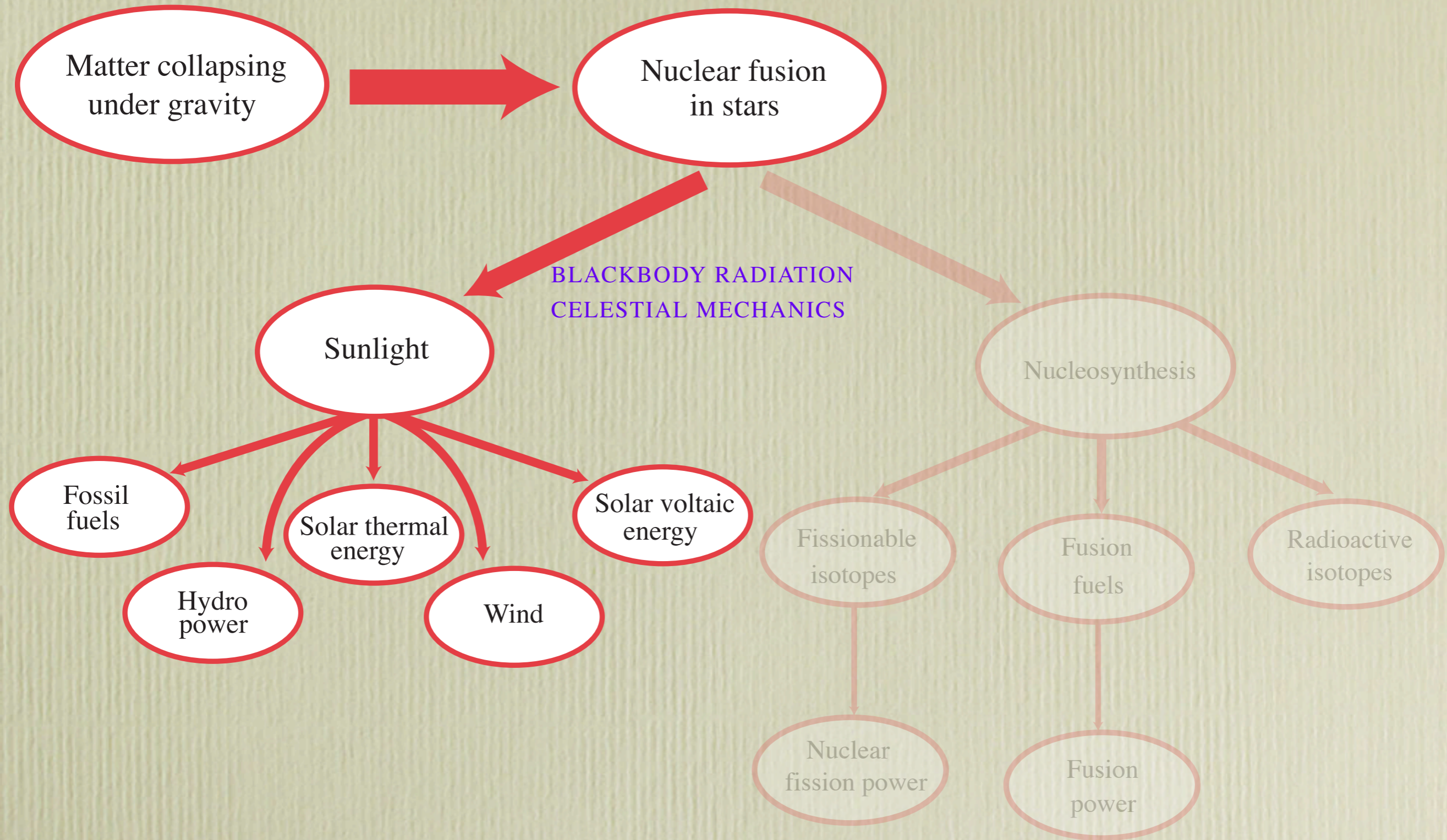
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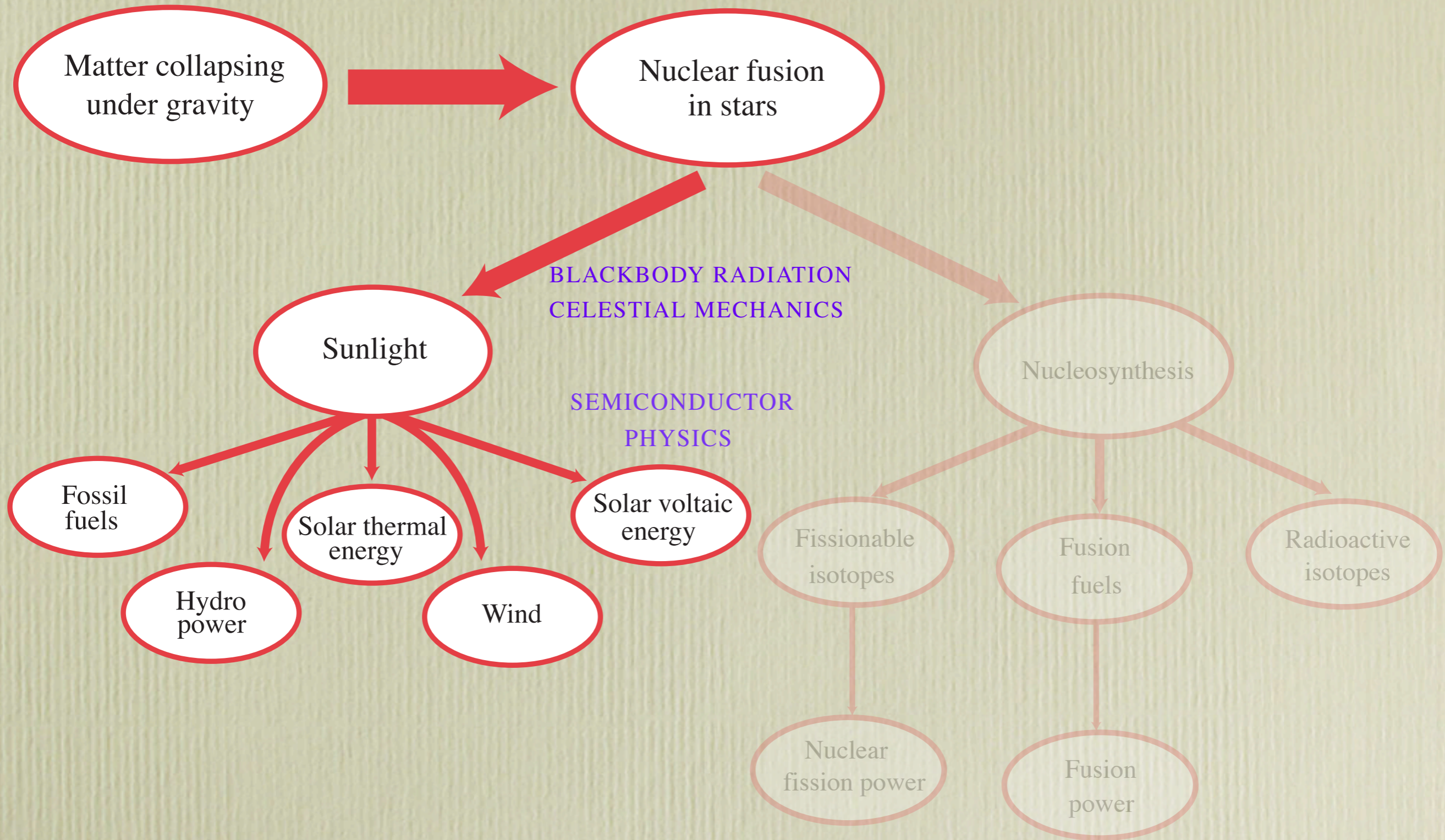
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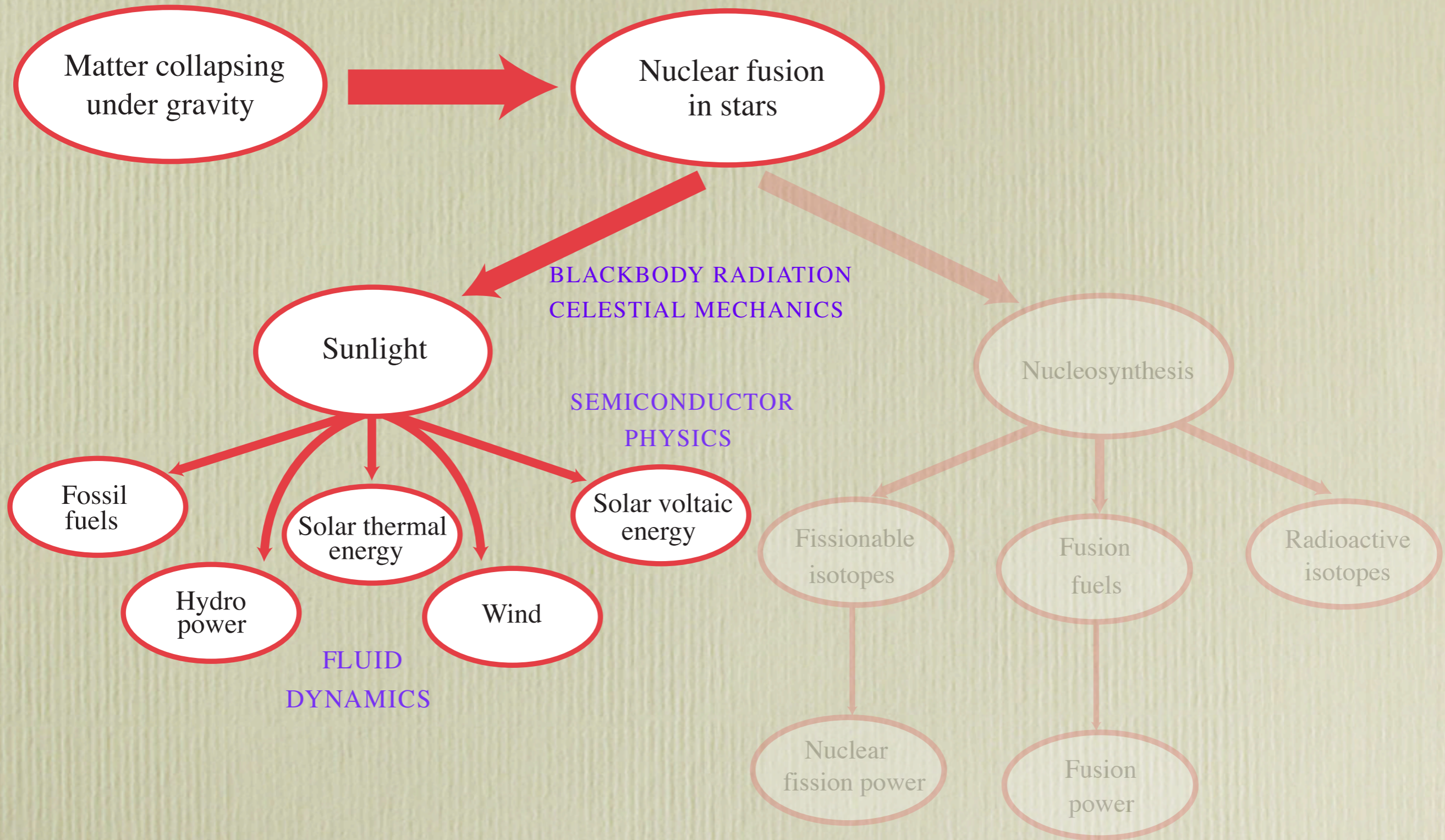
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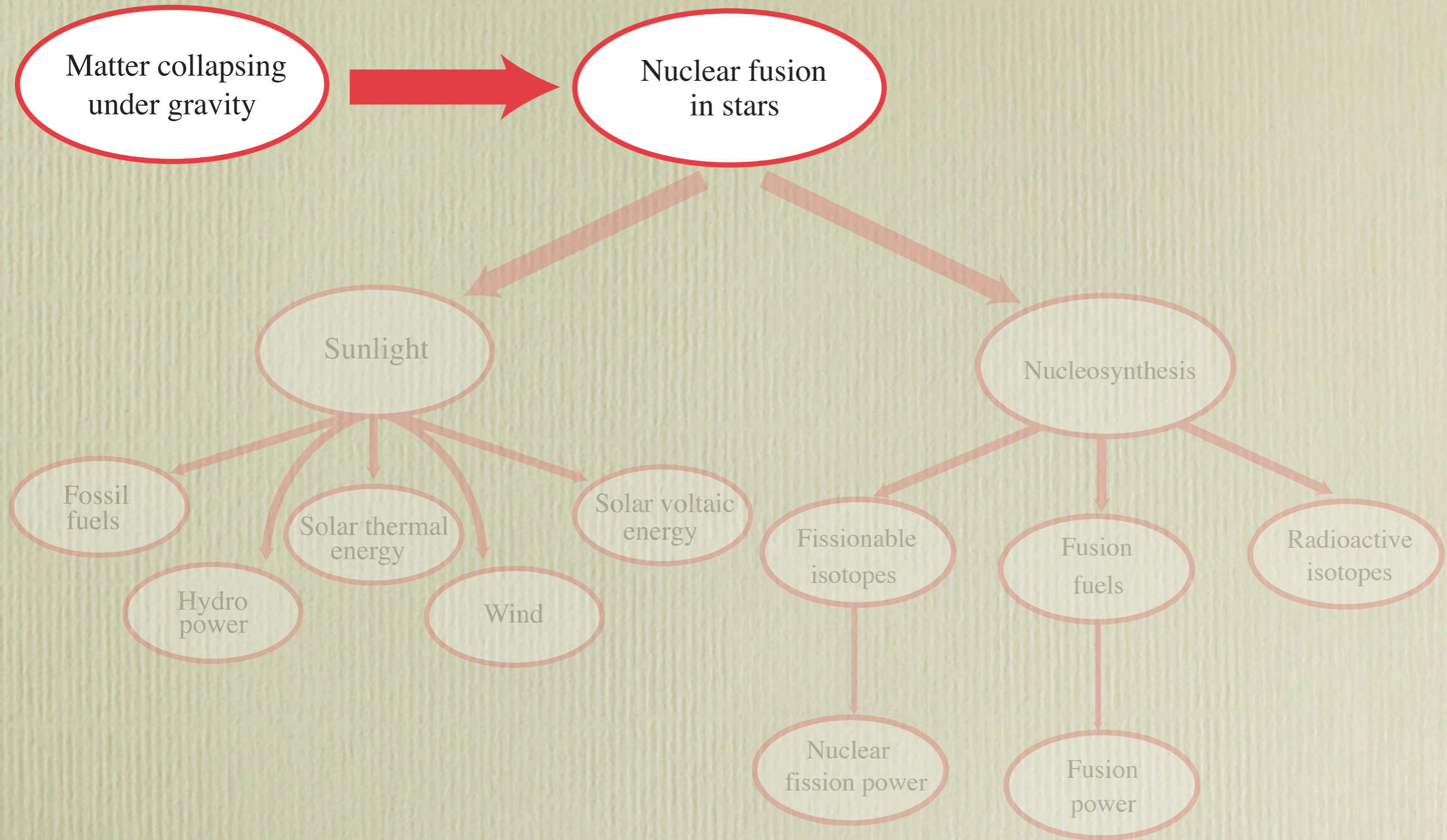
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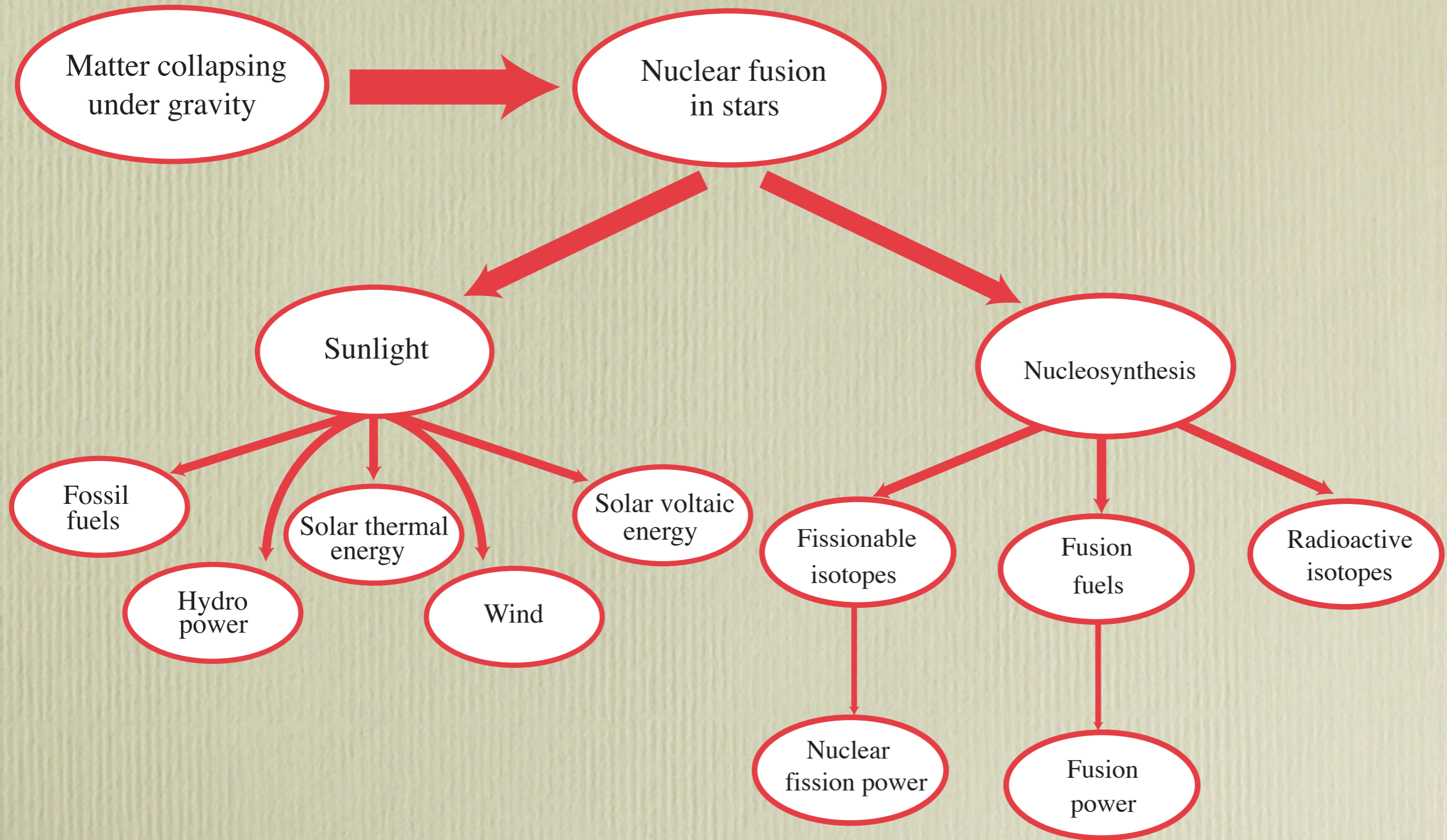
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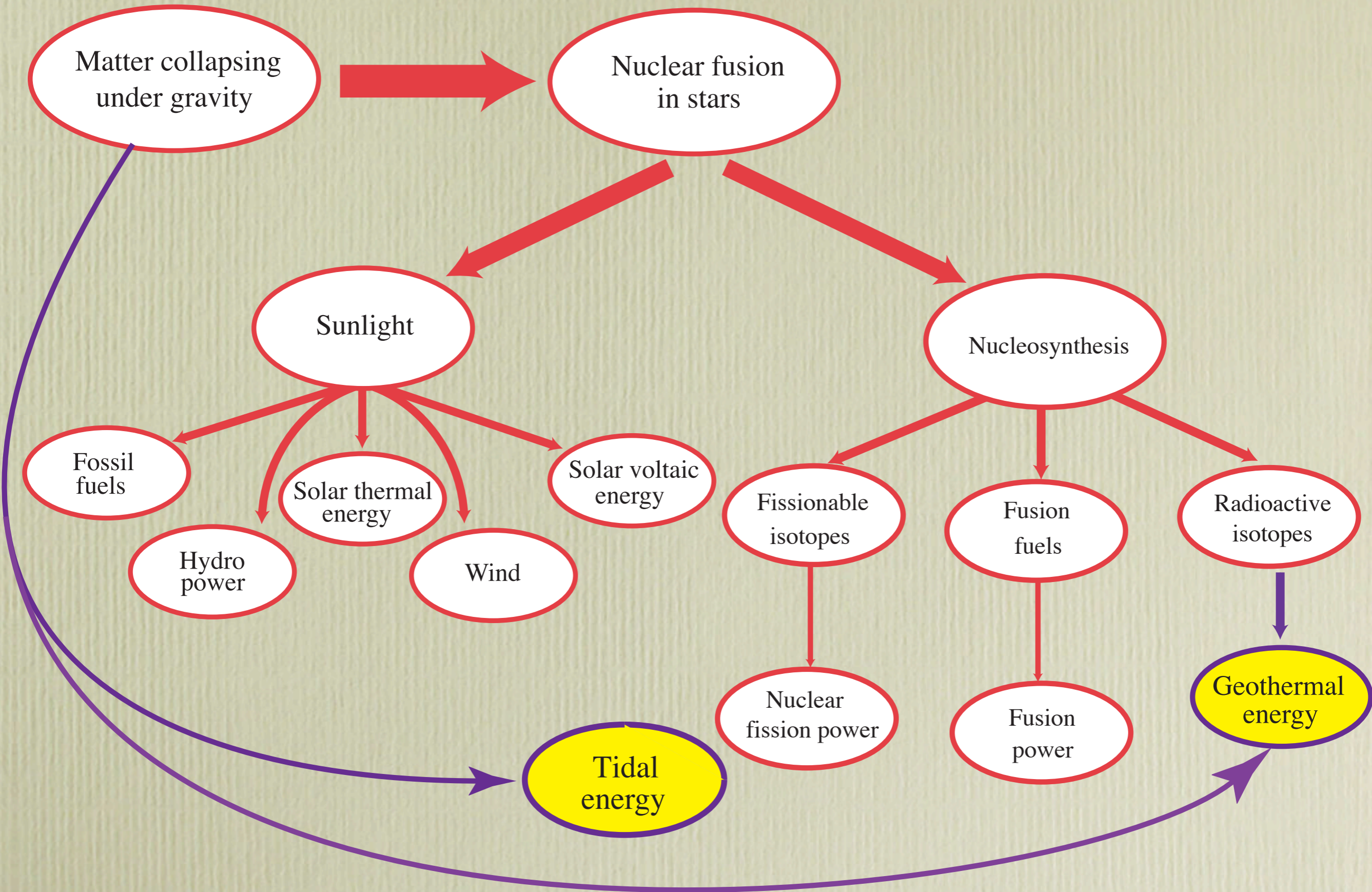
THE PHYSICS CORE: Energy flow in the Universe and on Earth



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PEDAGOGY: WHY QUANTUM?

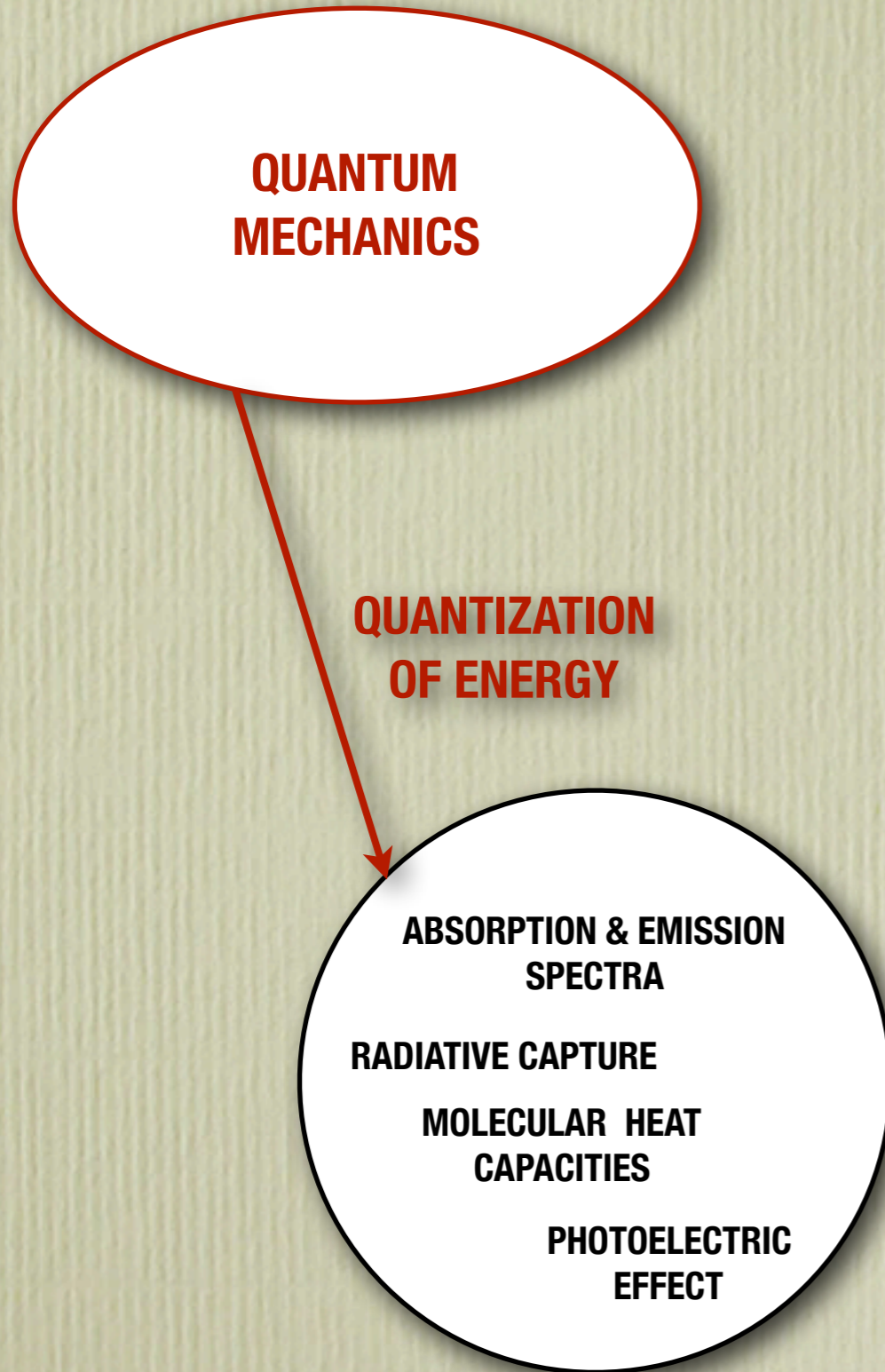


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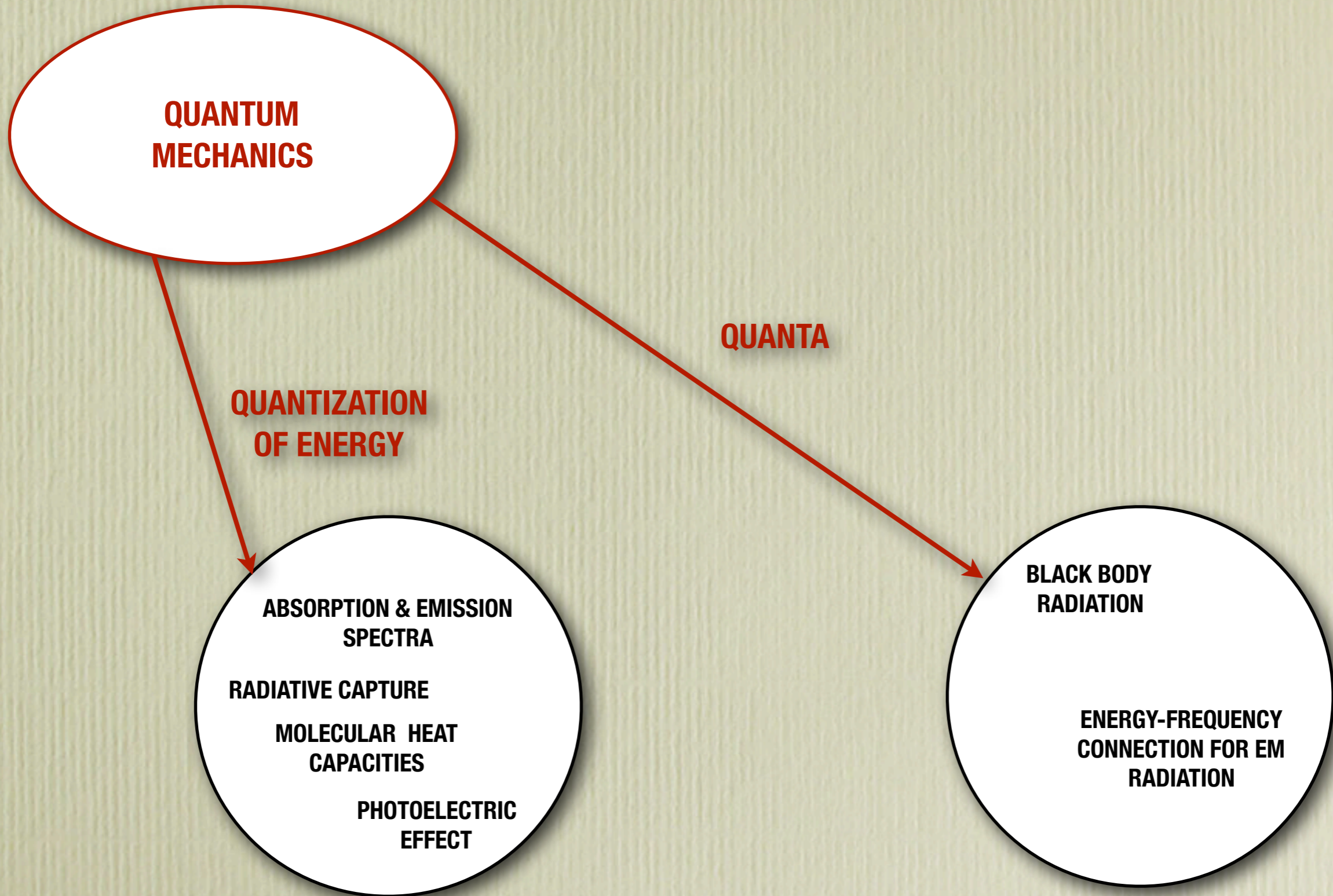
**QUANTUM
MECHANICS**



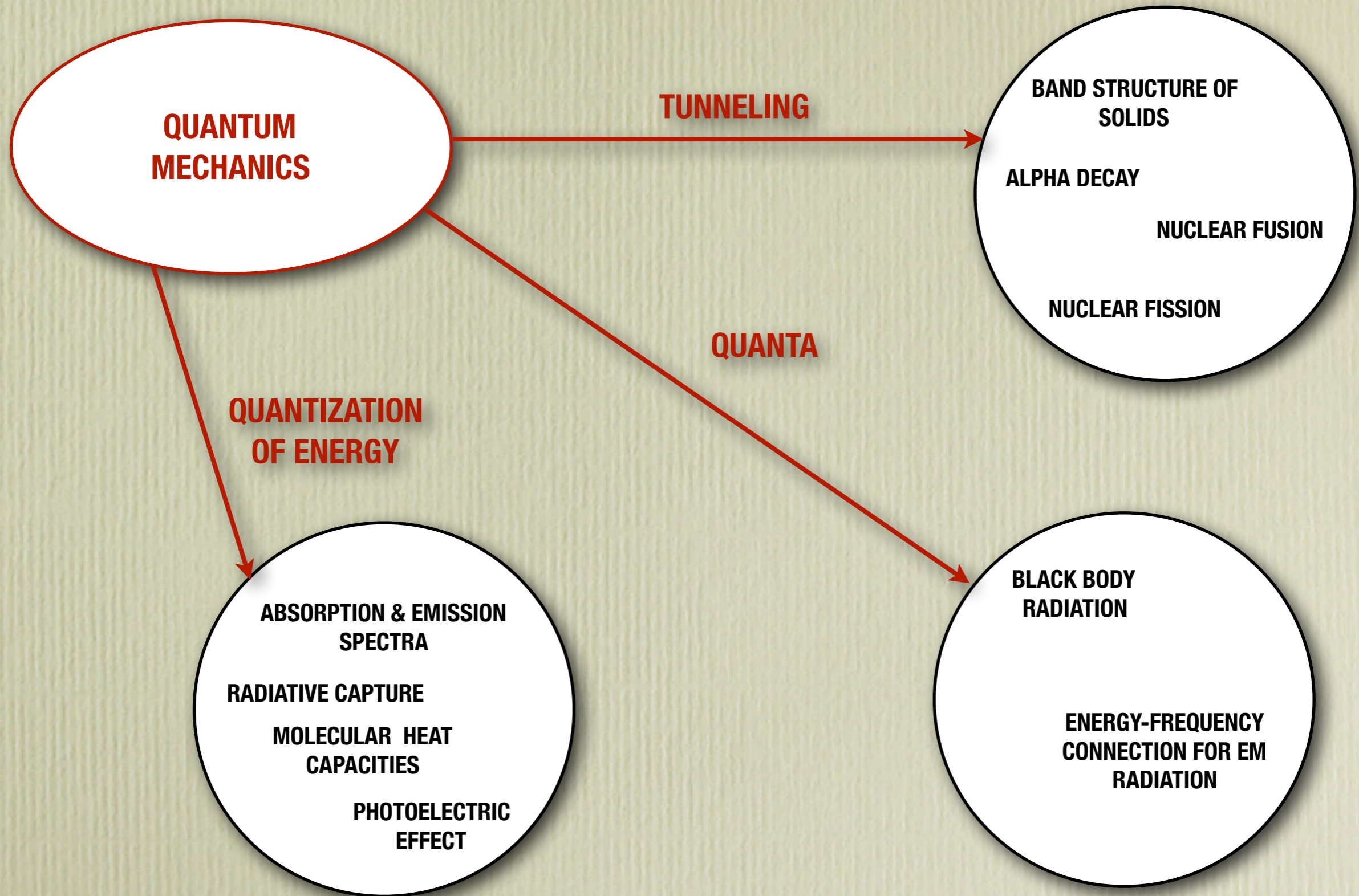
PEDAGOGY: WHY QUANTUM?



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PEDAGOGY: WHY STAT MECH?

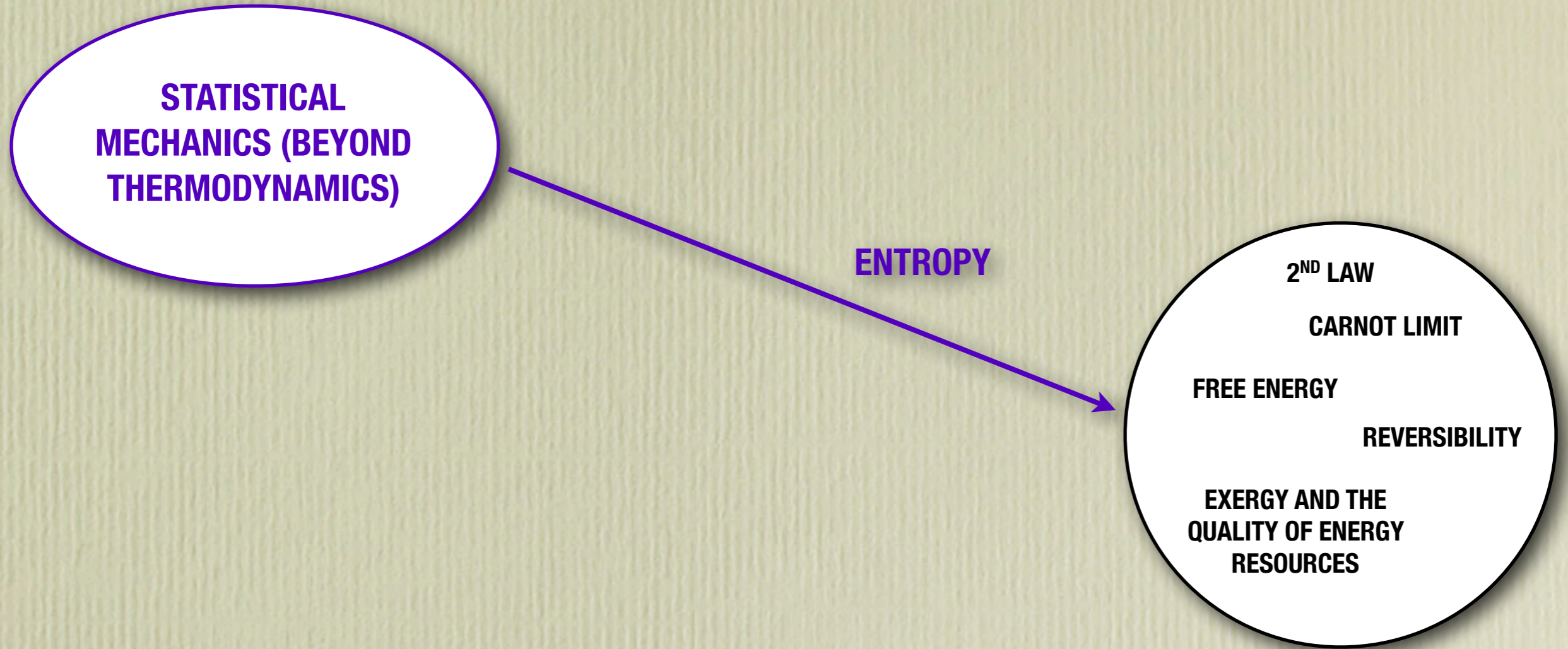


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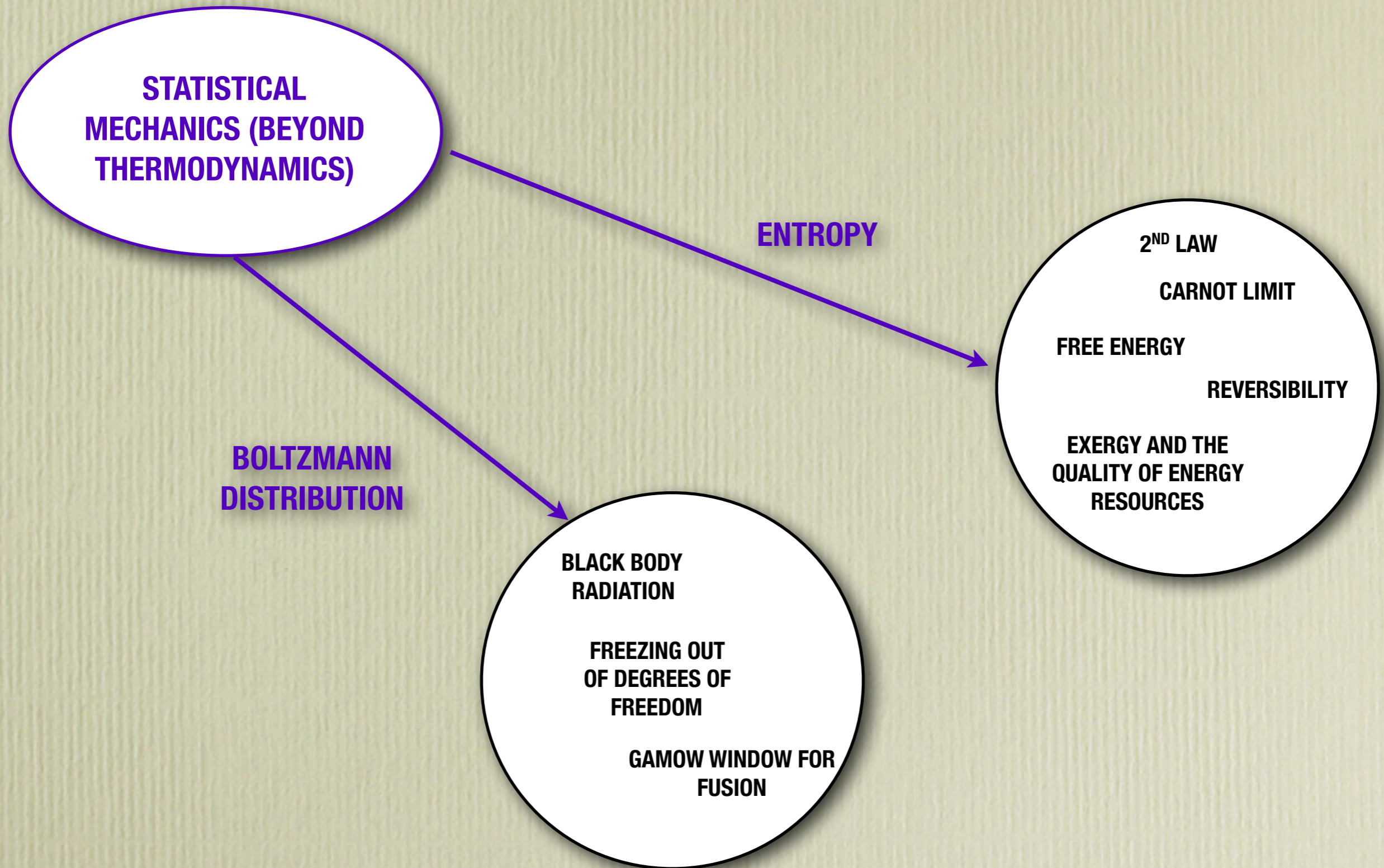
**STATISTICAL
MECHANICS (BEYOND
THERMODYNAMICS)**



PEDAGOGY: WHY STAT MECH?

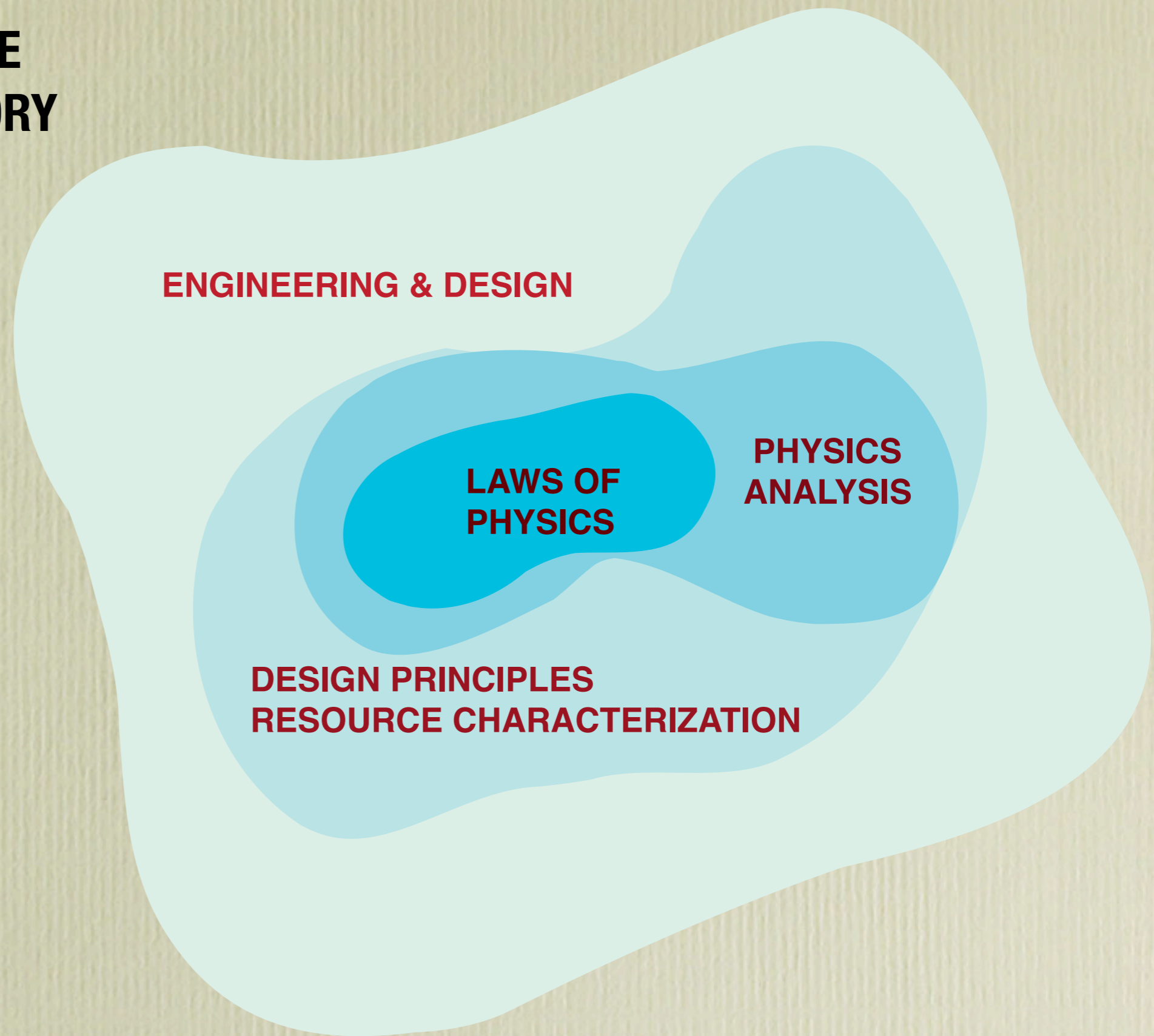


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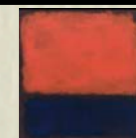
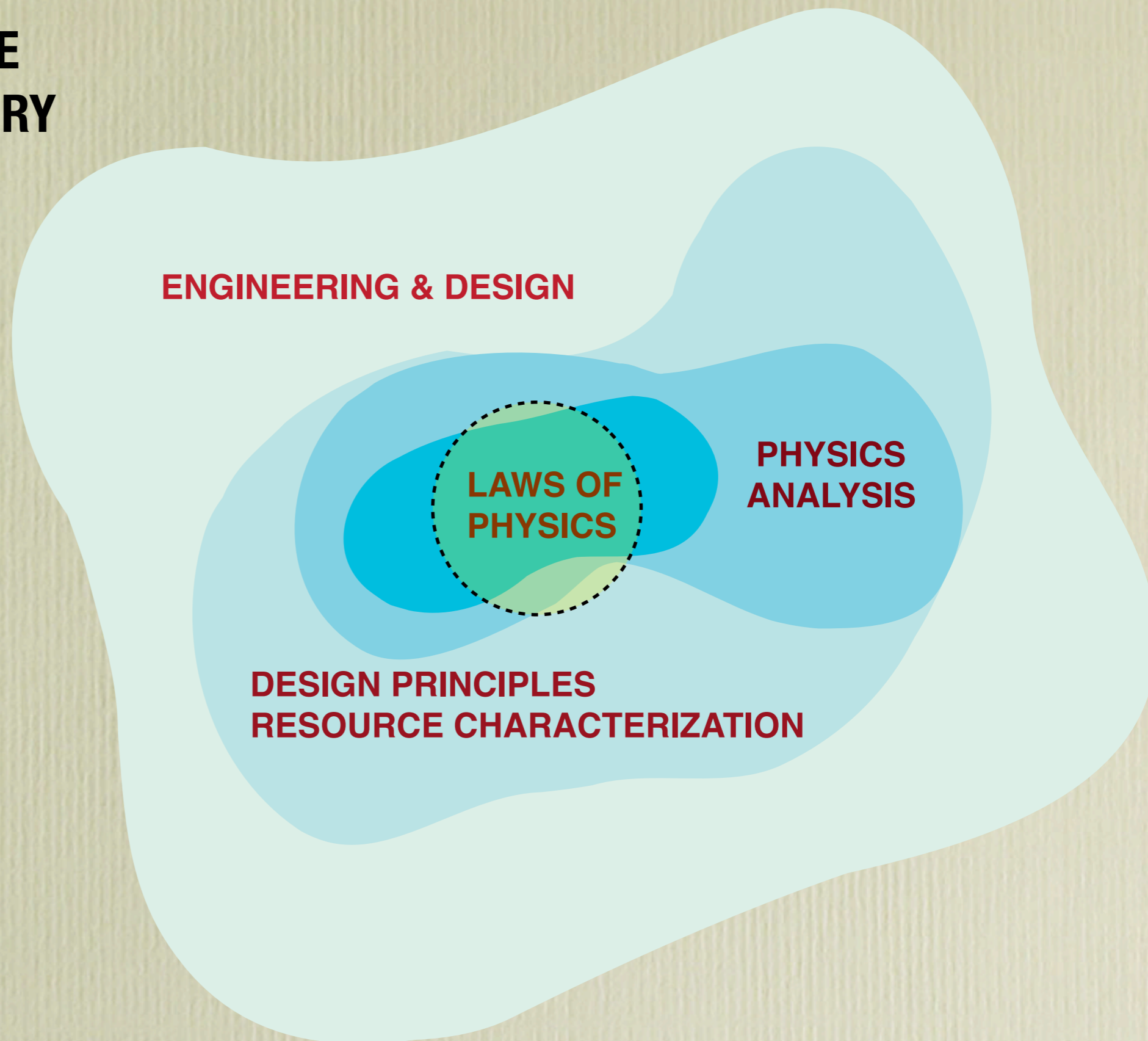
WHERE TO DRAW THE LINE BETWEEN THEORY AND PRACTICE?

On each topic, must decide where to draw the line between basic physics principles and engineering and design principles.



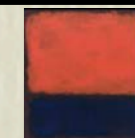
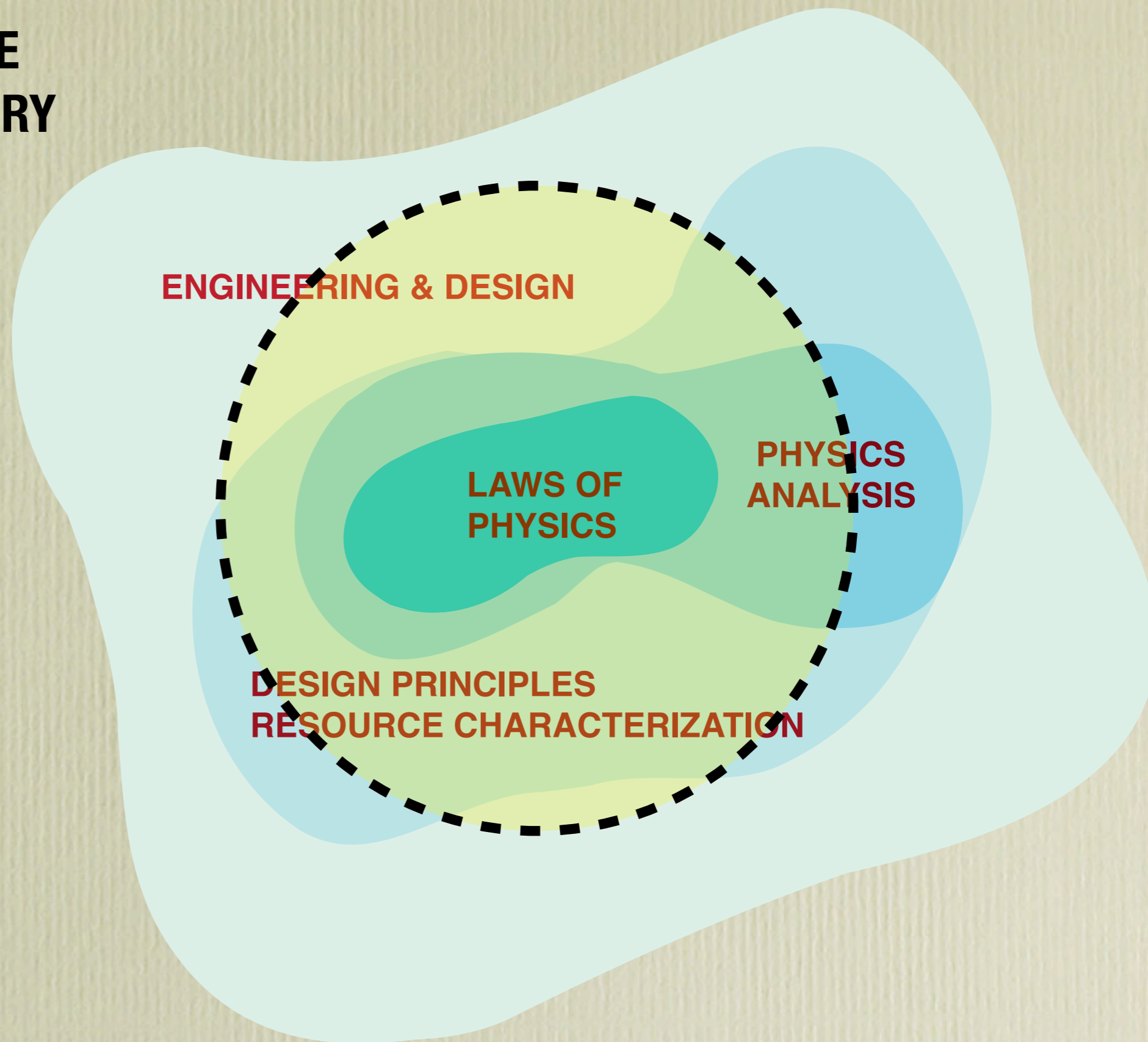
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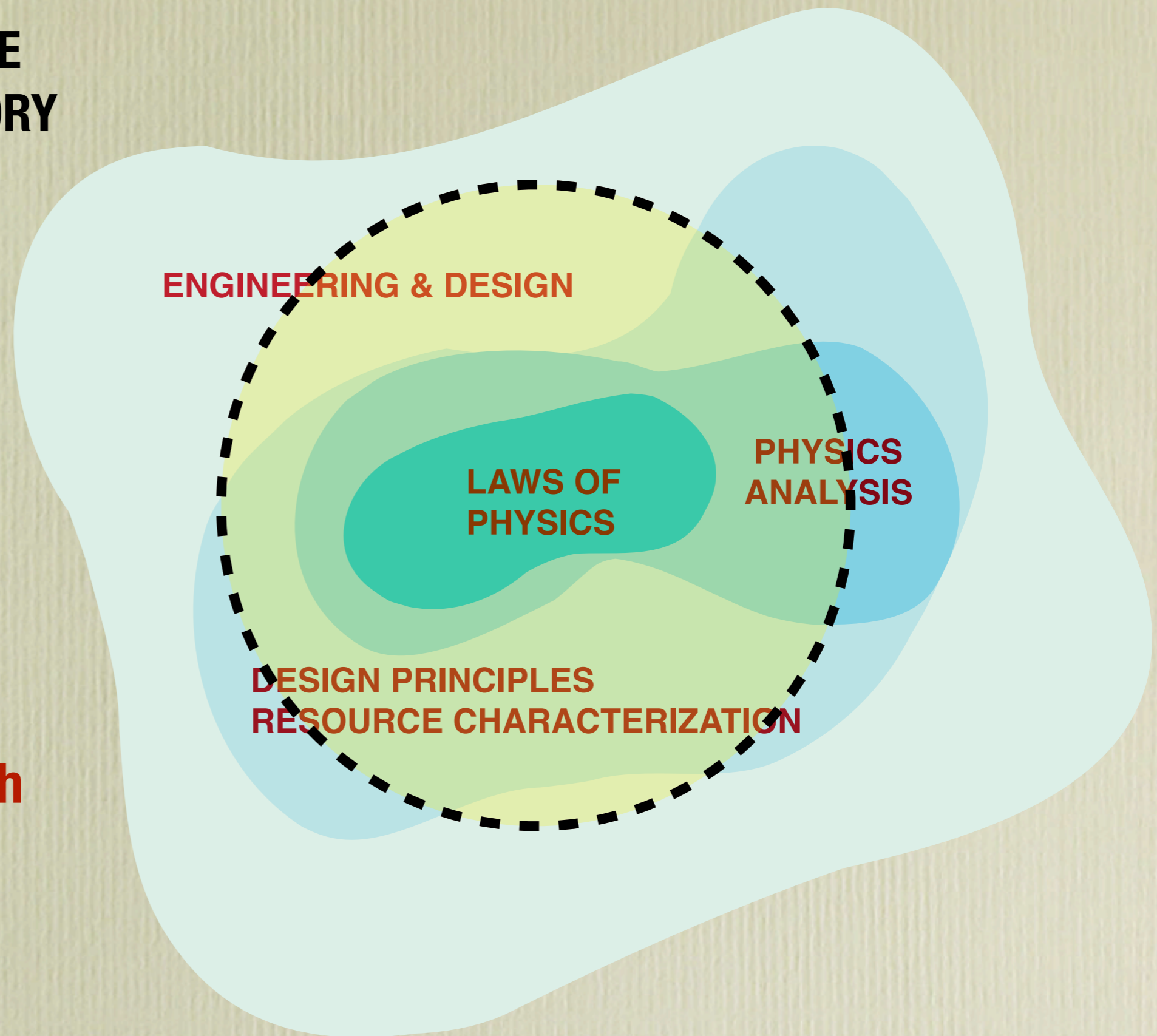
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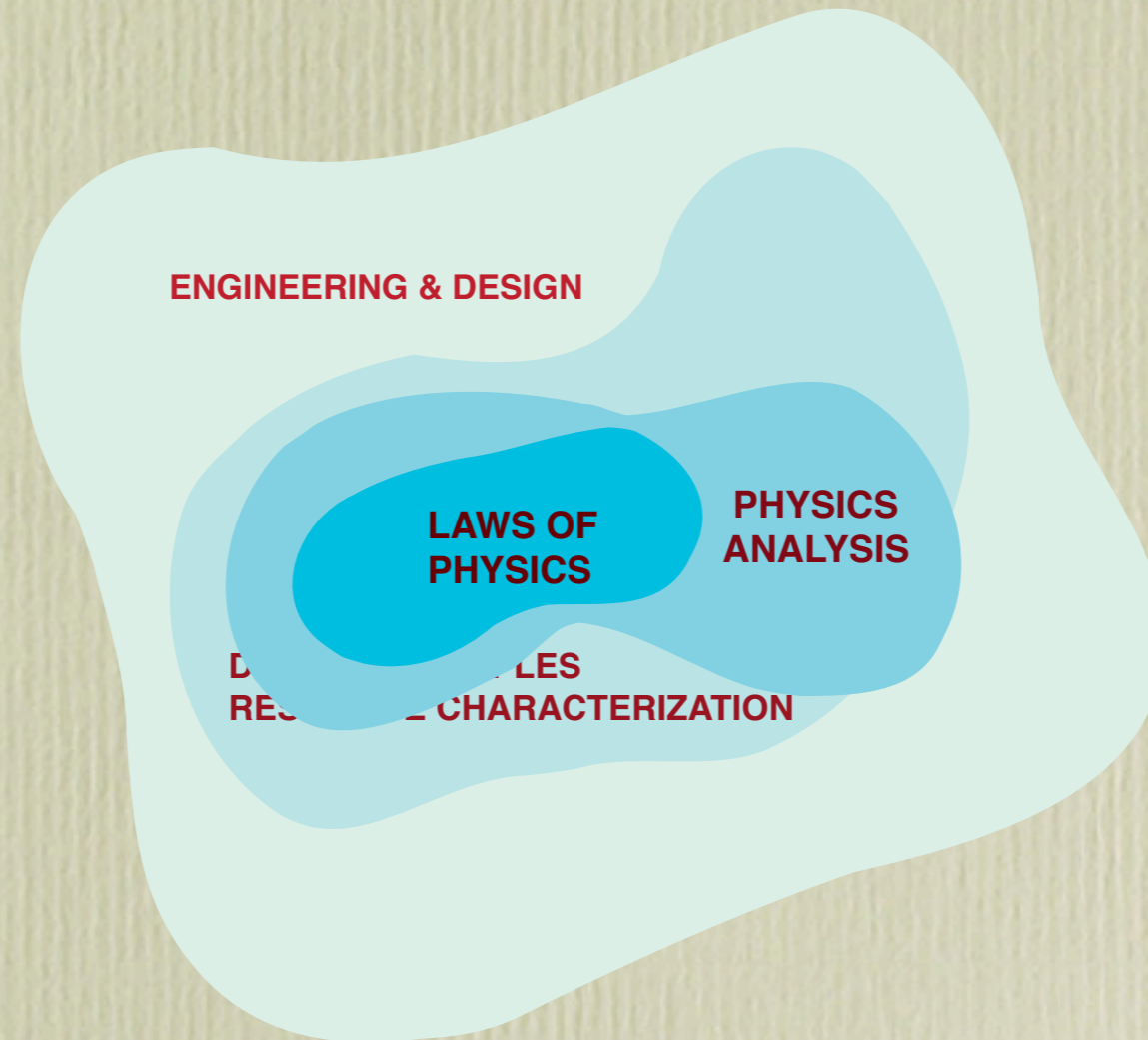
Resolution: follow the physics through its applications



EXAMPLE: WIND ENERGY



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EXAMPLE: WIND ENERGY

**LAWS OF
PHYSICS**

**PHYSICS
ANALYSIS**

**DESIGN PRINCIPLES
RESOURCE CHARACTERIZATION**

ENGINEERING & DESIGN



EXAMPLE: WIND ENERGY

What is a fluid?

LAWS OF
PHYSICS

Fluid flow

viscosity, vorticity,
laminar flow
& turbulent flow
Reynolds number

PHYSICS
ANALYSIS

Navier Stokes

ENGINEERING & DESIGN

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Betz's
limit

Thermal
fluids

PHYSICS
ANALYSIS

Bernoulli's
principle

Lift

Circulation

Kutta-Zhukovskii Thm

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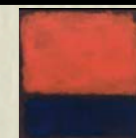
Kutta-Zhukovskii Thm

Airfoils

Axial momentum
theory

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Weibull distributions &
intermittency

Airfoils

Axial momentum
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DESIGN PRINCIPLES
RESOURCE CHARACTERIZATION

Wind roses and
atlases

Height distribution and
surface roughness

ENGINEERING & DESIGN



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RESOURCE CHARACTERIZATION

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atlases

Height distribution and
surface roughness

ENGINEERING & DESIGN

Blade element
theory

Stall & rotor
control



THE PHYSICS OF ENERGY



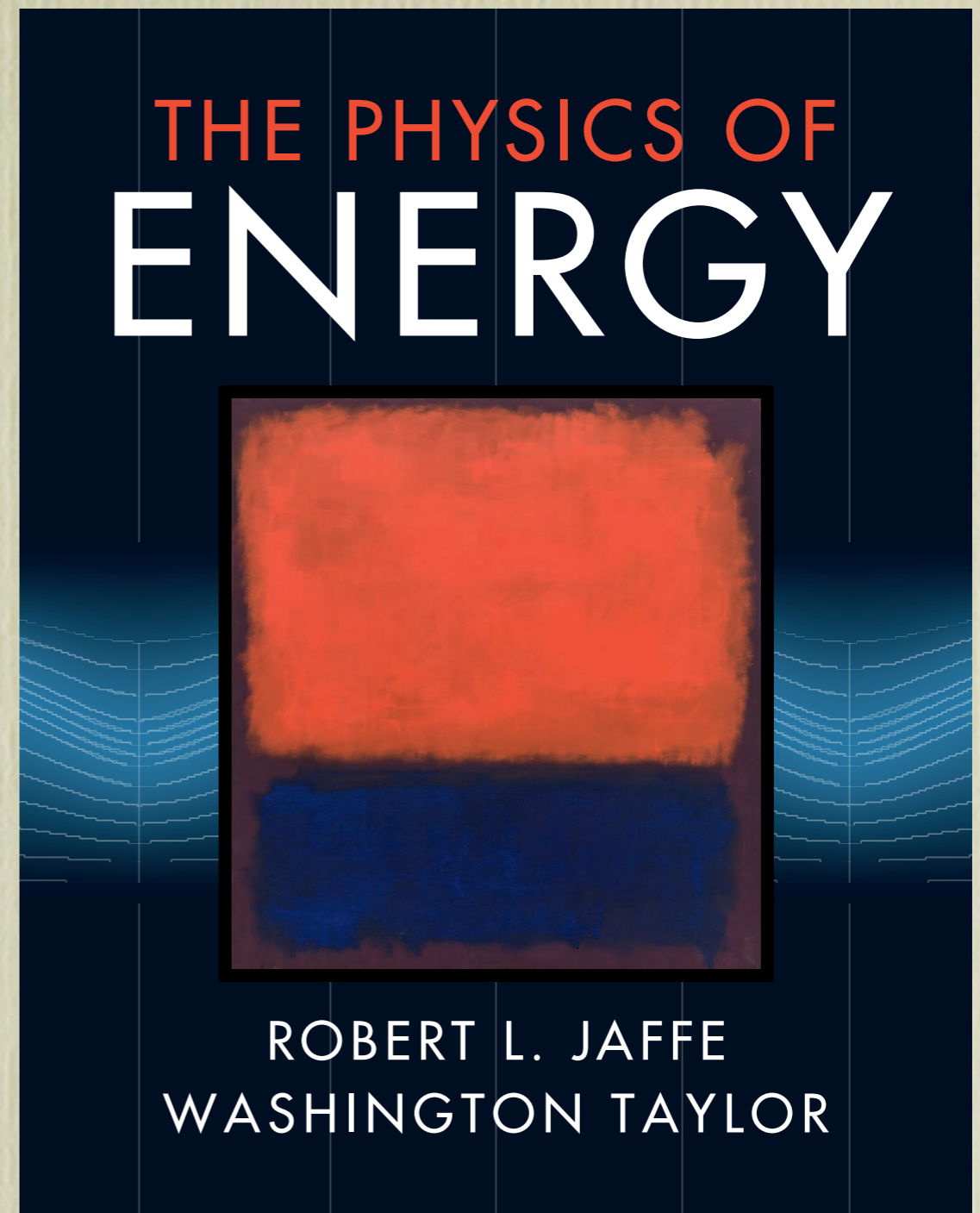
ROBERT L. JAFFE
WASHINGTON TAYLOR



Thank you!

If your task was to jump-start civilization, but had access to only one book, then *The Physics of Energy* would be your choice. Professors Taylor and Jaffe have written a comprehensive, thorough, and relevant treatise. It's an energizing read as a stand-alone book, but it should also be a course, offered at every college, lest we mismanage our collective role as shepherds of our energy-hungry, energy-dependent civilization.

*Neil deGrasse Tyson,
Astrophysicist, American Museum
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AVAILABLE MID-FEBRUARY

