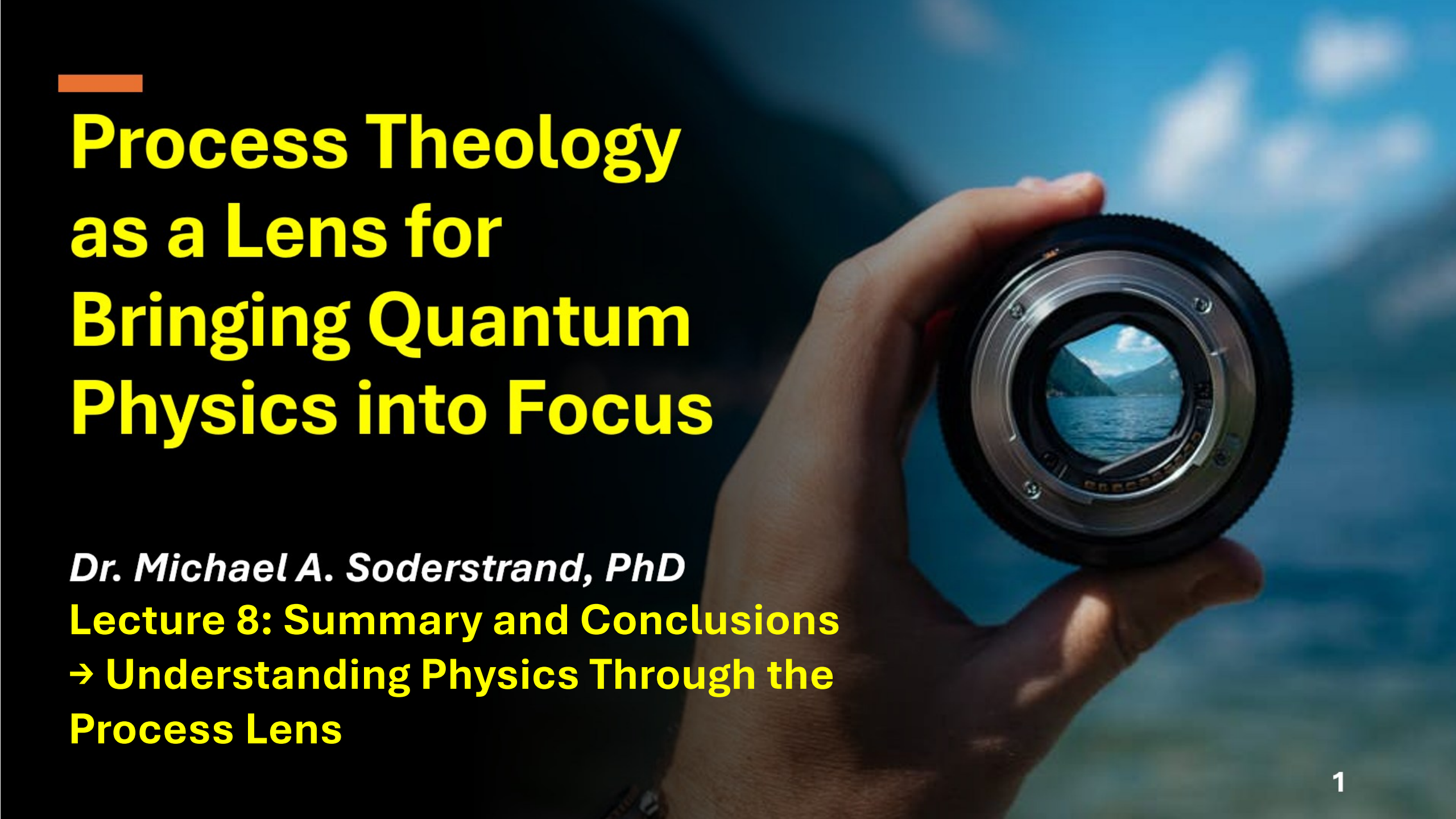
Process Theology as a Lens for Bringing Quantum Physics into Focus



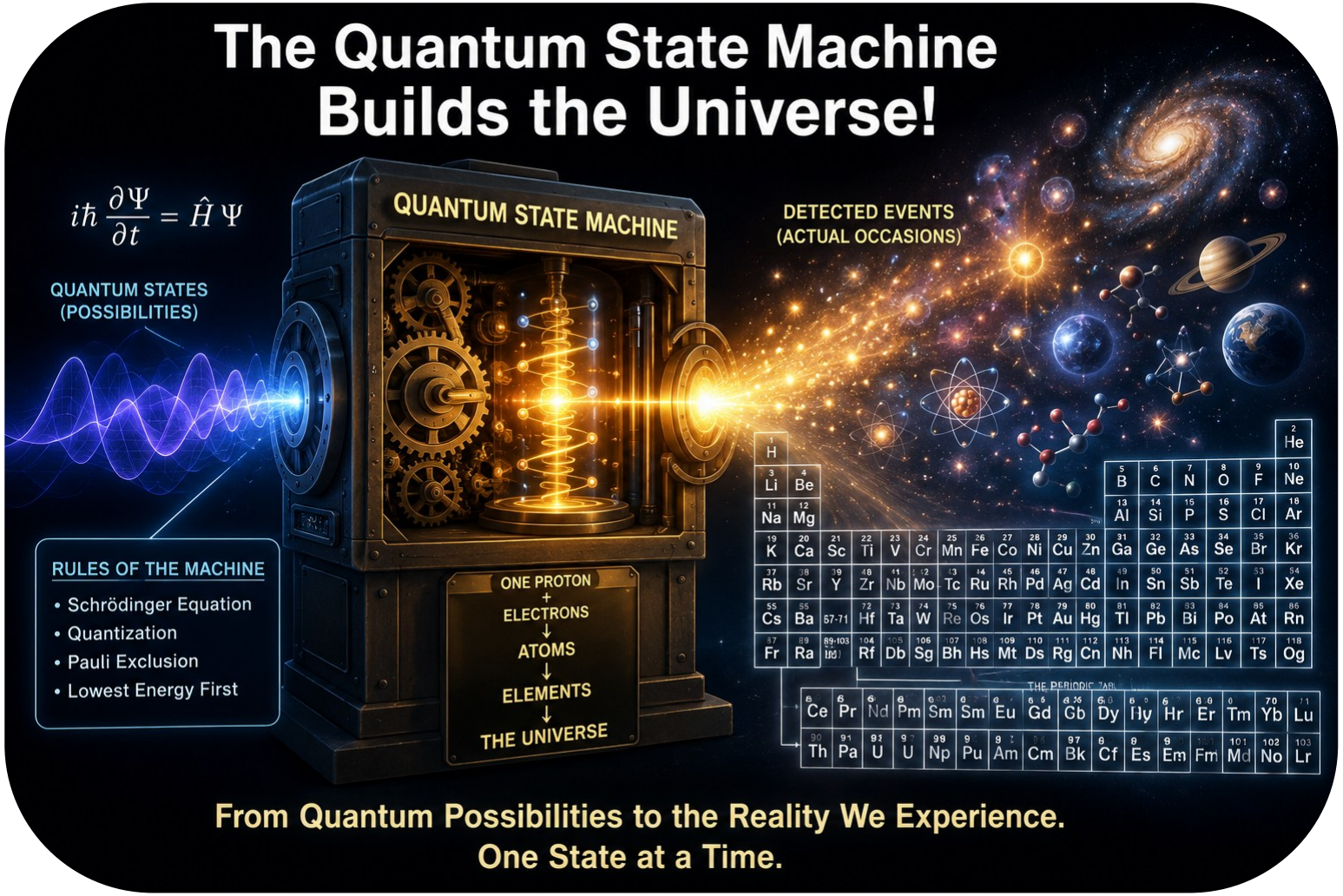
Dr. Michael A. Soderstrand, PhD

Lecture 8: Summary and Conclusions
→ Understanding Physics Through the Process Lens

The Quantum State Machine Builds the Universe!

Looking Back

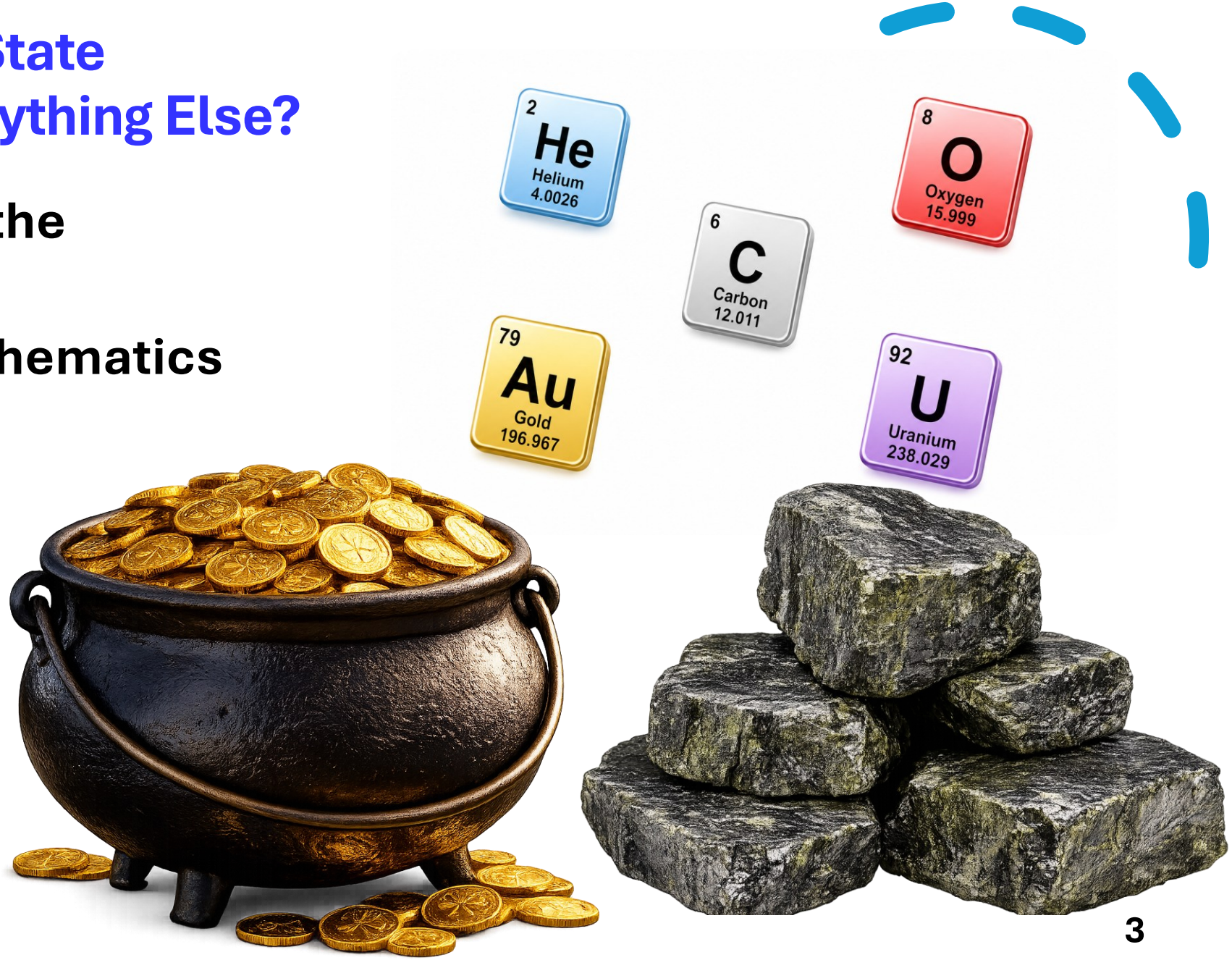
- **Over the past seven lectures we have discovered that**
  - **Quantum mechanics predicts probabilities.**
  - **The Quantum State Machine evolves quantum states.**
  - **Detection events reveal actual outcomes.**
  - **The Quantum State Machine built the hydrogen atom.**
- **Today we ask one final question…**



Can the Quantum State Machine Build Everything Else?

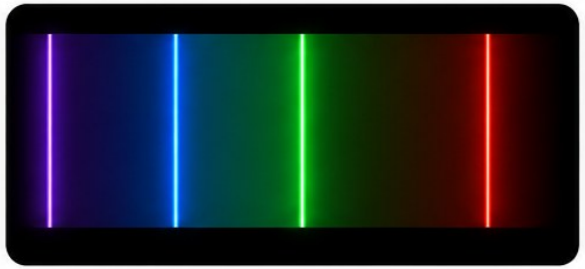
Hydrogen was only the beginning.

- **Can the same mathematics build:**
  - **helium?**
  - **carbon?**
  - **oxygen?**
  - **gold?**
  - **uranium?**



The Two-Electron Quantum State

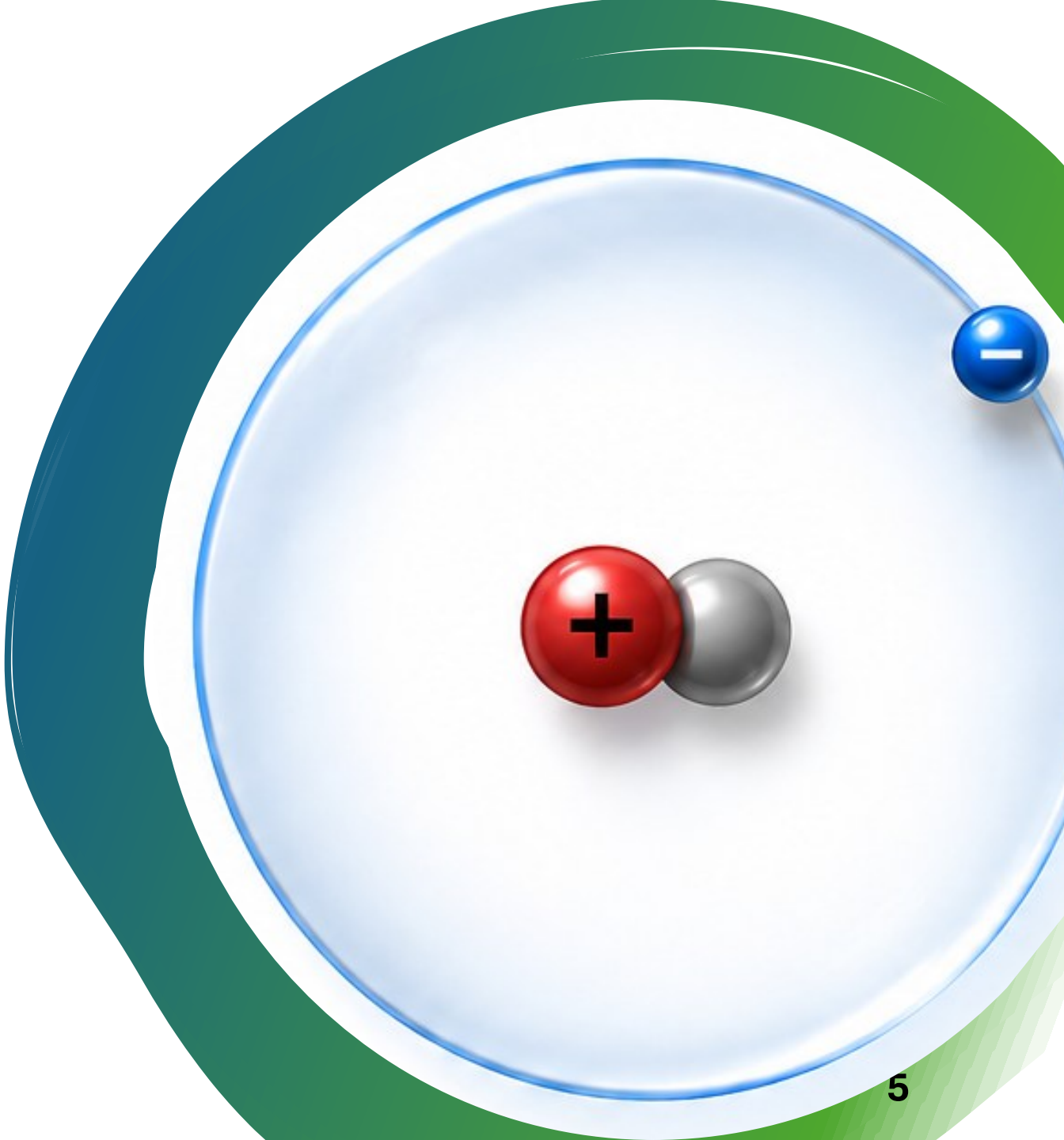
- We Began with Hydrogen in the last lecture
  - One proton
  - One electron
  - The simplest atom.
- The Quantum State Machine predicted
  - An electron shell with its energy levels
  - Its spectrum.



What If We Add One Neutron?

Then we let the Quantum State Machine predict Deuterium:

- **Deuterium**
  - **One proton**
  - **One neutron**
  - **One electron**
- **Chemically,**
  - **it behaves almost exactly like hydrogen.**



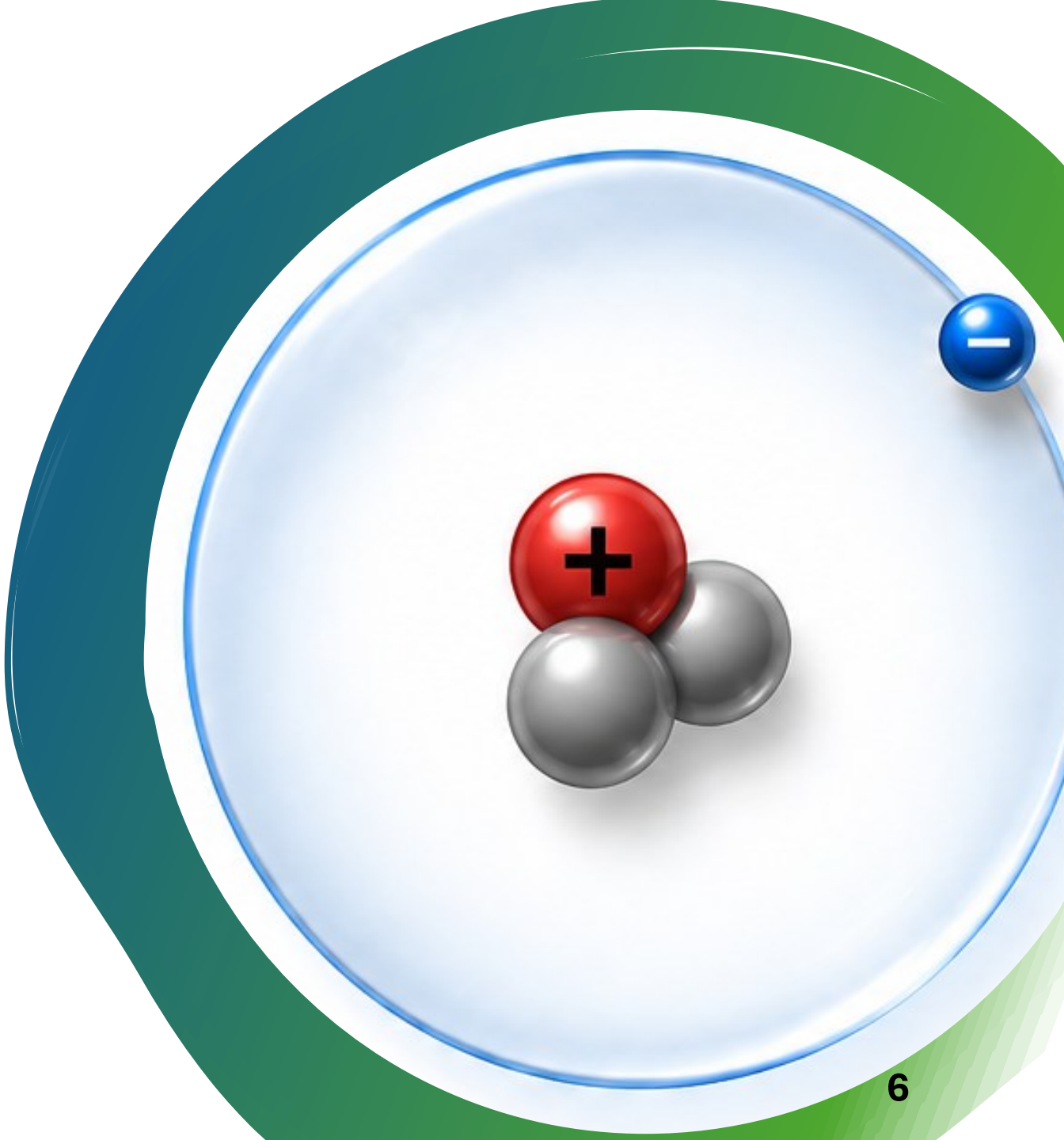
What If We Add Another Neutron?

And moved on to let the Quantum State Machine predict Tritium:

- **Tritium**
  - **One proton**
  - **Two neutrons**
  - **One electron**
  - **Still hydrogen.**

The number of protons

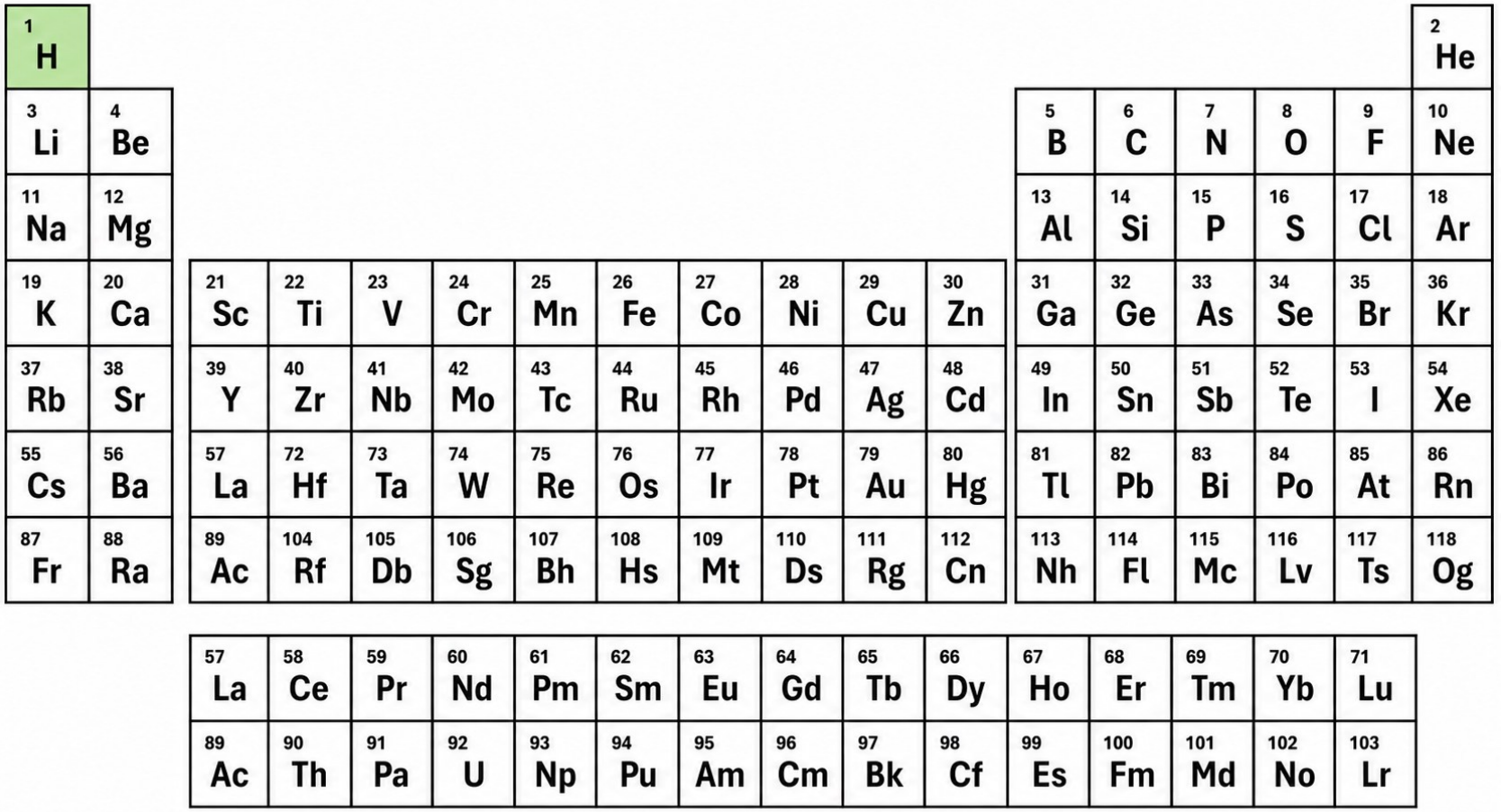
- **has not changed.**
- **It still acts chemically like hydrogen**



What Makes a Chemical Element?

The identity of a chemical element is determined by

- **the number of protons.**
- **This number is called the atomic number.**
- **That is the number shown on the Periodic Table**



Let's Add One More Proton

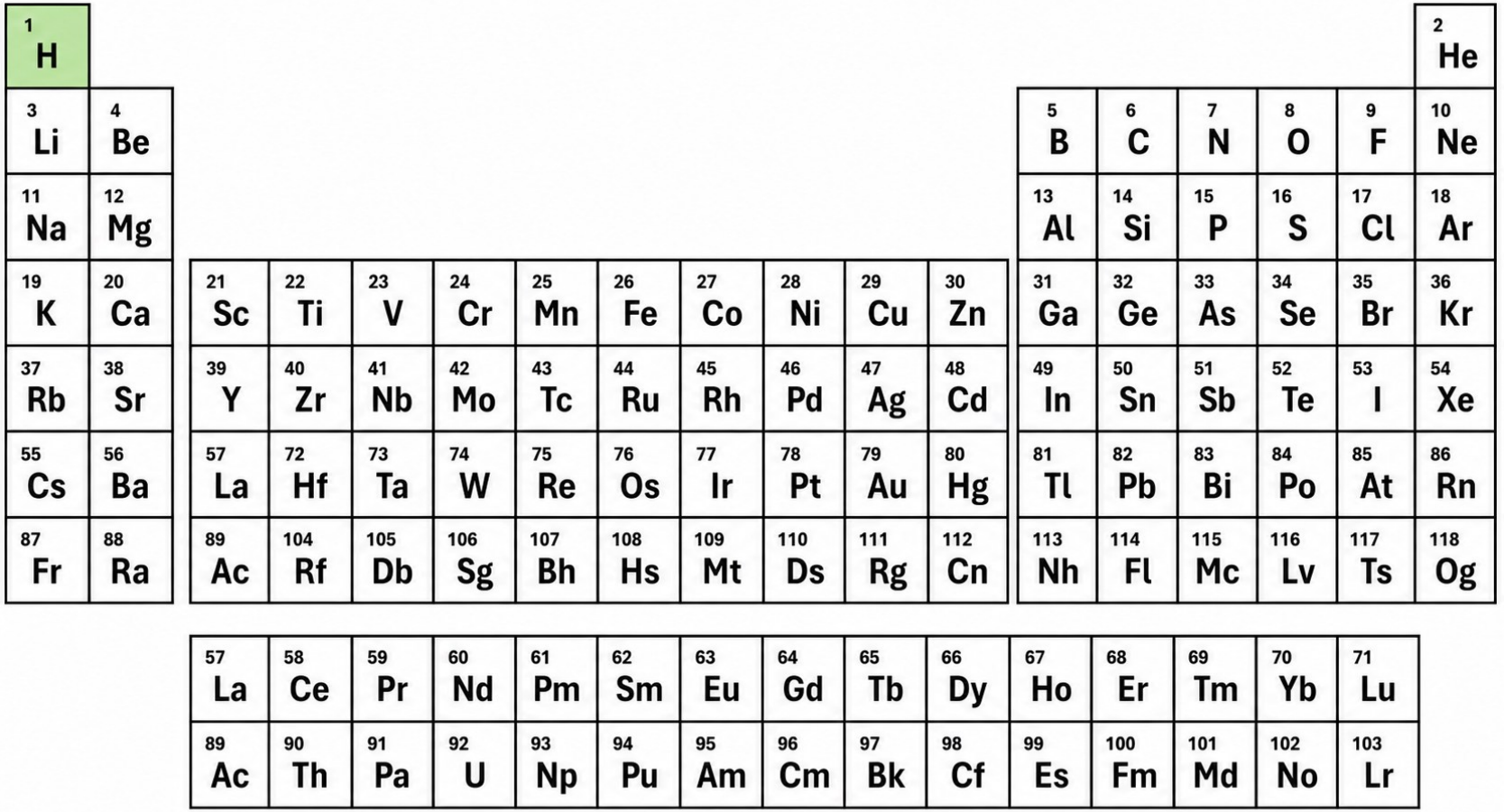
Now the nucleus contains

- Two protons

To remain electrically neutral,

- the atom must also gain
- a second electron.

We have created



Let's Add One More Proton

Now the nucleus contains

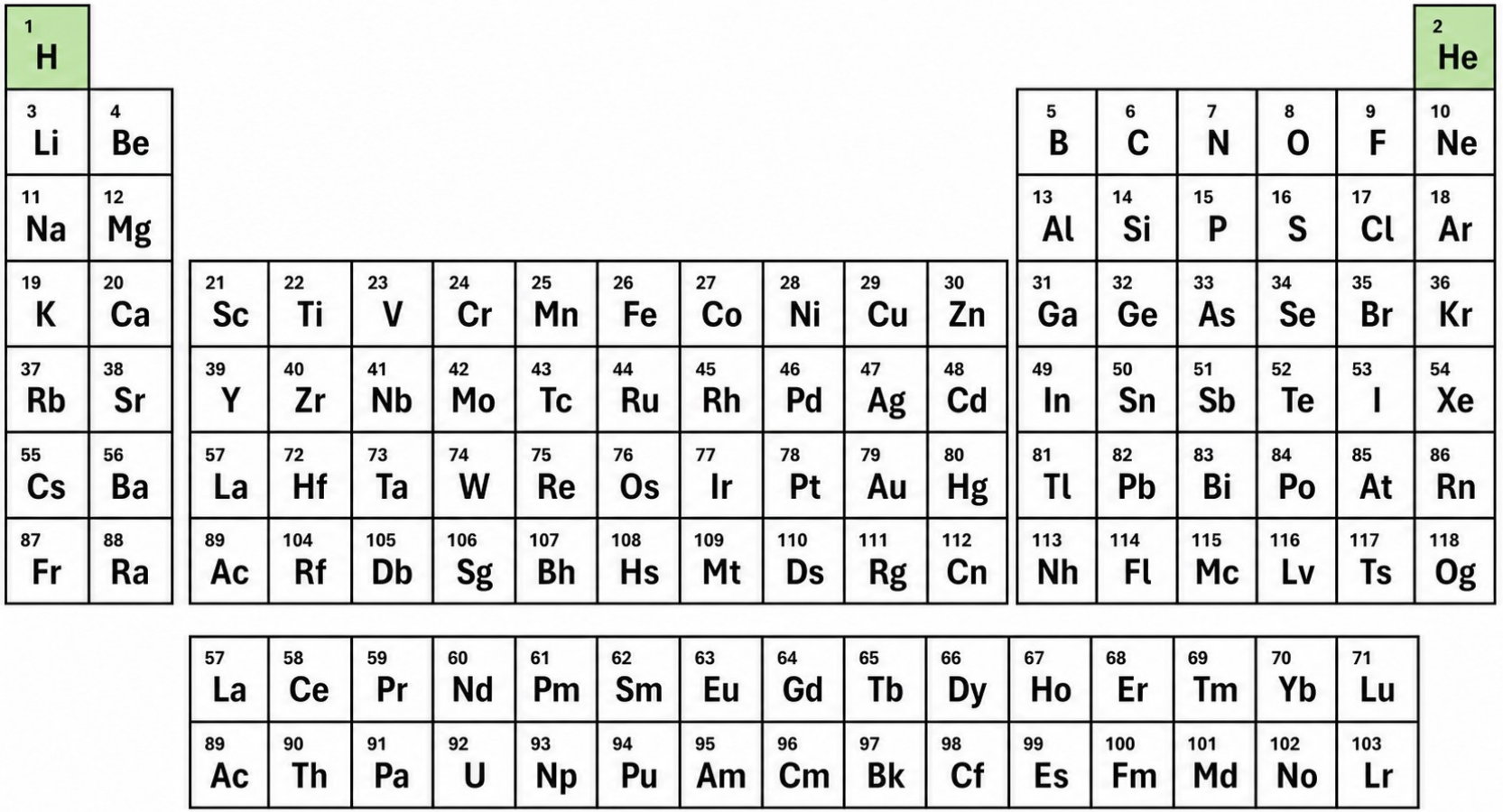
- Two protons

To remain electrically neutral,

- the atom must also gain
- a second electron.

We have created

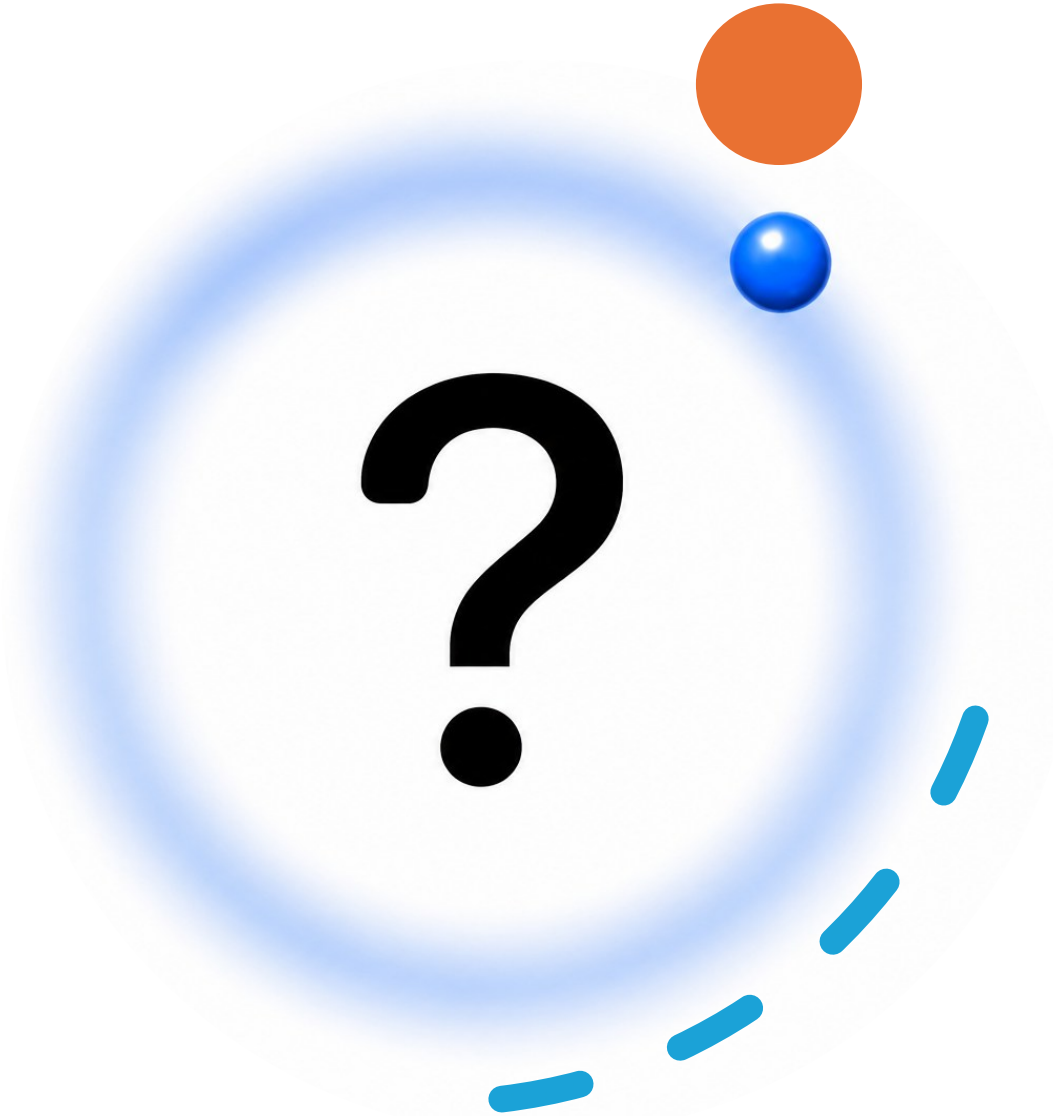
- helium.



The Quantum State Machine Has a New Problem

Where should the second electron go?

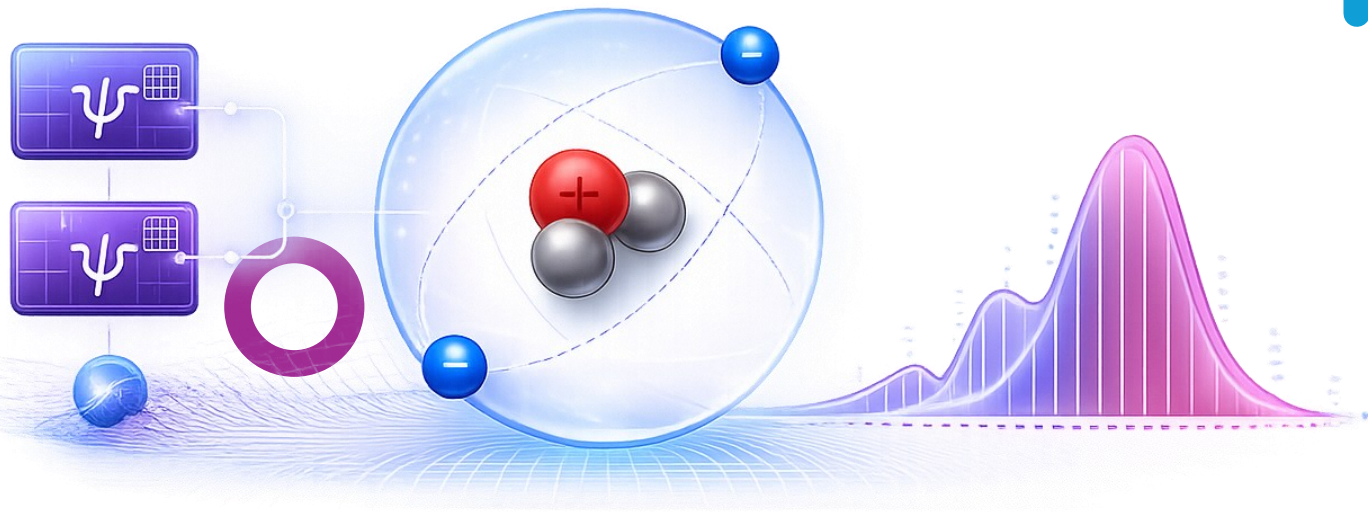
- **The Answer:**
  - **The electron exhibits free will within the probability constraints predicted by the Quantum State Machine.**
  - **Physics cannot tell us where any individual electron will go**
  - **Instead, physics will give us probability distributions.**



The Quantum State Machine is Perfect for Calculating those Probability Distributions

We have seen this before.

- **In the single-slit experiment the Quantum State Machine predicted**
  - **regions of high probability**
  - **regions of low probability**
  - **even regions where detections were very unlikely.**
  - **Many photons revealed the pattern.**
  - **One photon at a time.**



The Quantum State Machine predicts where detections are likely to occur.

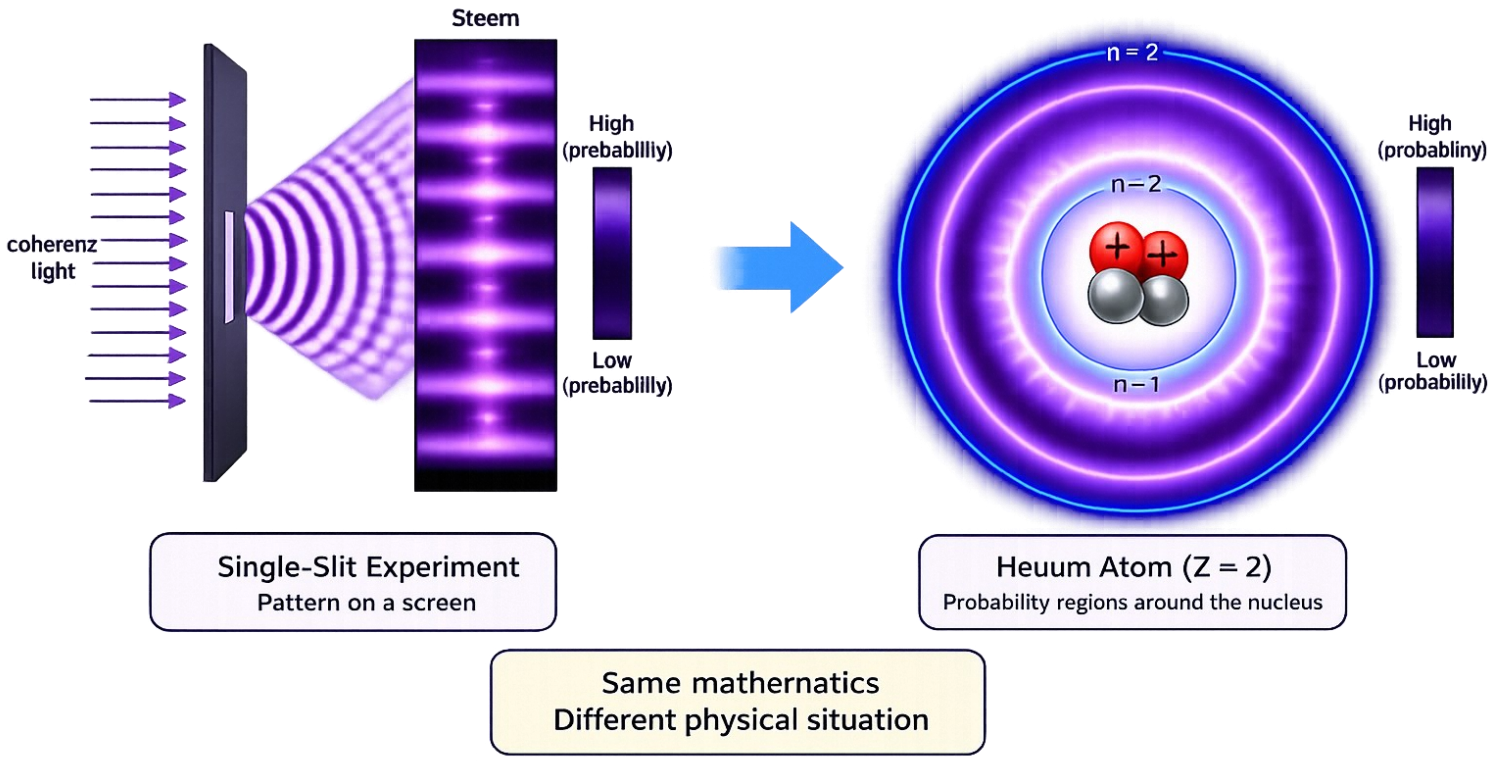
Around a Nucleus the Same Thing Happens

With a positively charged nucleus.

- **The Quantum State Machine now predicts**
- **regions where an electron is likely to be detected**
- **regions where it is unlikely to be detected.**

Instead of a pattern on a screen,

- **The pattern surrounds the nucleus.**
- **Same mathematics**
- **Different physical situation**



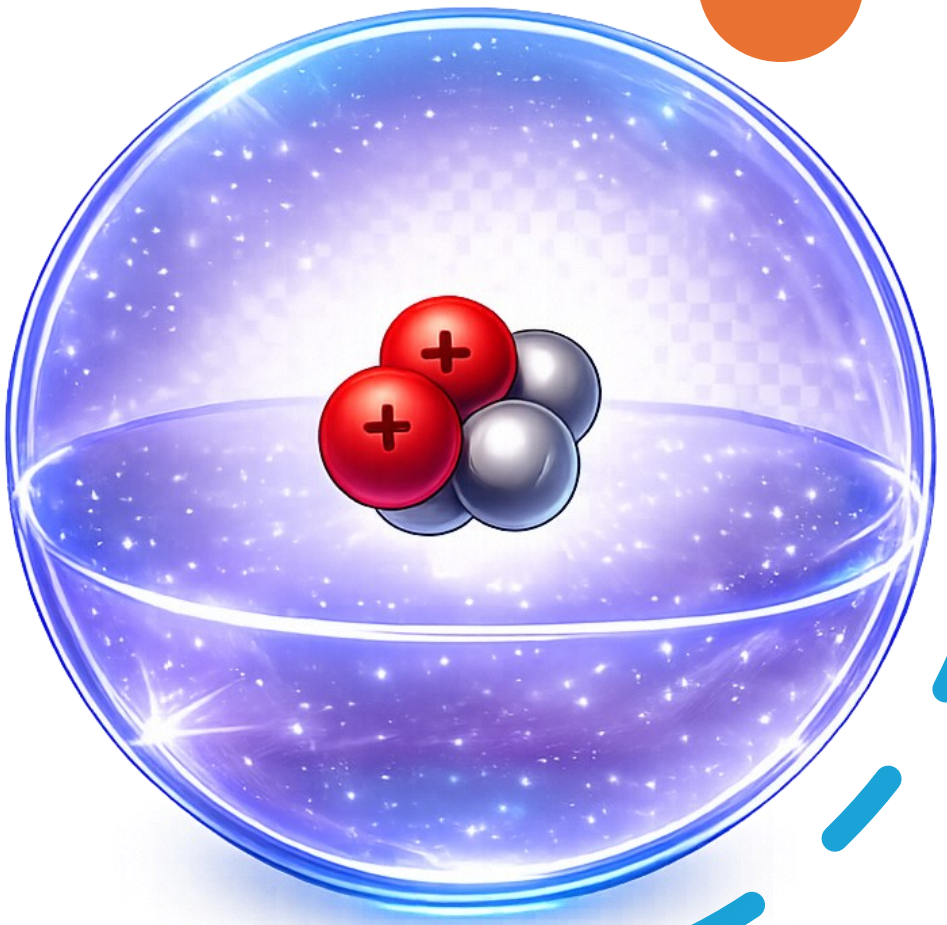
The First Shell Is a Probability Distribution

The first shell is not an orbit.

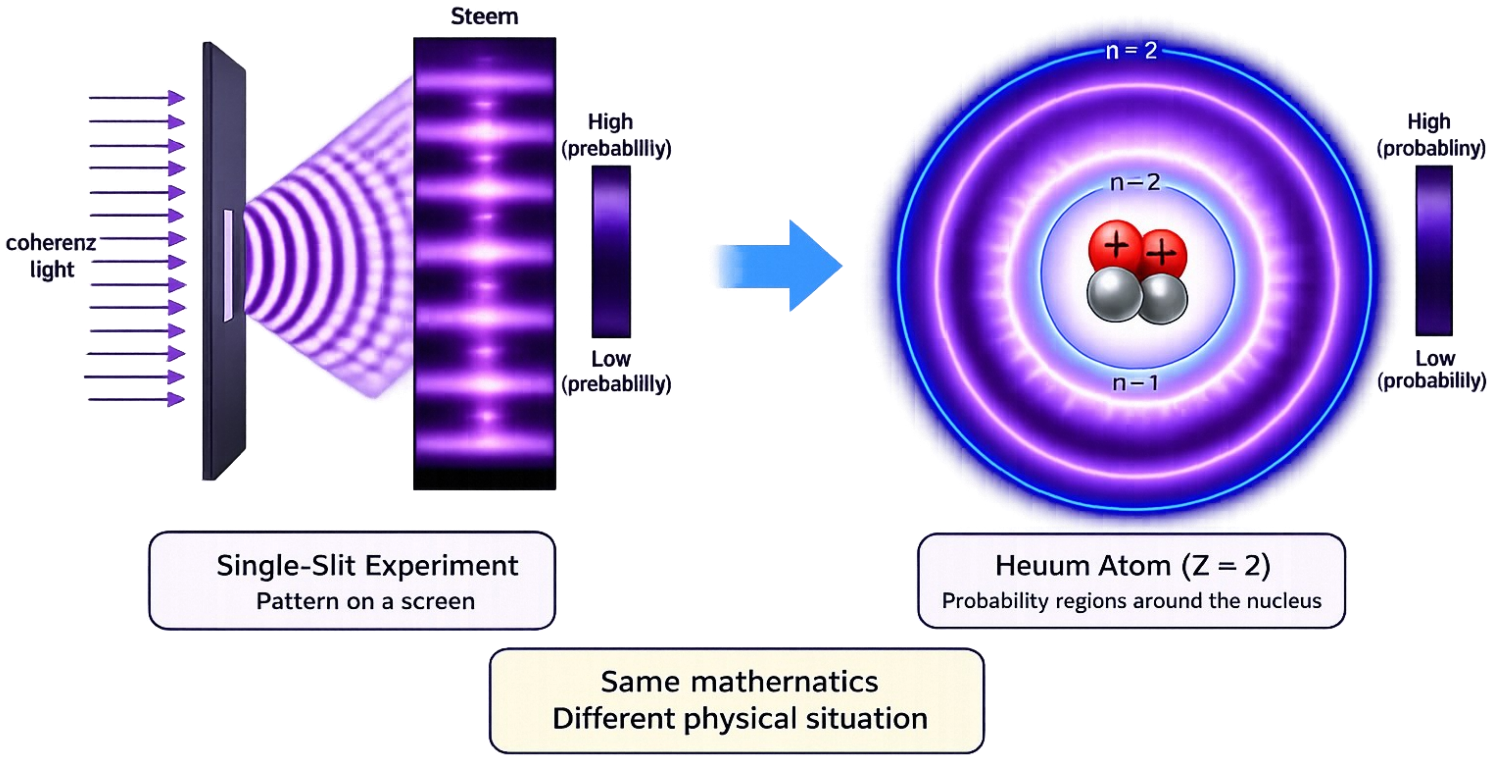
- **It is the first stable probability distribution produced by the Quantum State Machine.**

If we repeatedly detected the electron,

- **The detections would gradually build this pattern.**
- **Exactly like the single-slit experiment.**
- **Thousands of tiny detection dots building the cloud.**



The Pattern Changes, But the Idea Does Not

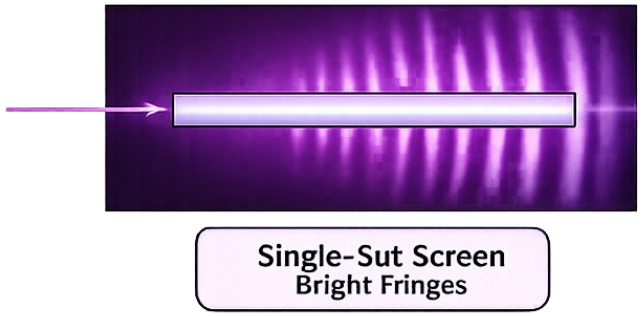


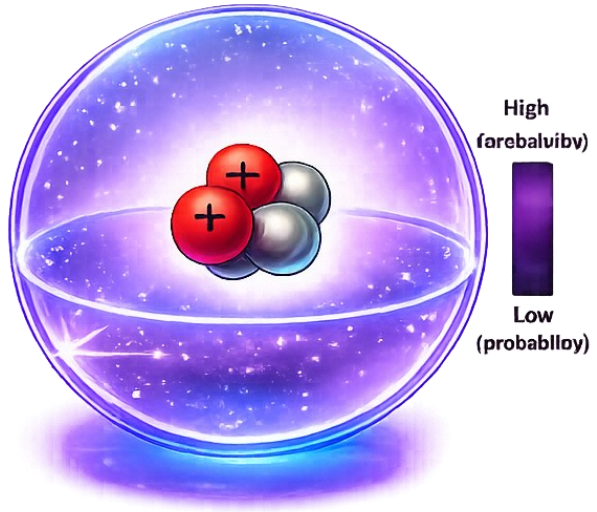
In the single-slit experiment

- **the Quantum State Machine predicted alternating regions**
  - **of high probability**
  - **and low probability**
  - **across a flat screen.**
- **Around a nucleus**
- **the Quantum State Machine predicts alternating regions (shells)**
  - **of high probability**
  - **and low probability**
  - **surrounding the nucleus.**
- **The mathematics is doing exactly what we have learned to expect.**

Key Concept:

- The bright fringes on the single-slit screen and the electron shells around an atom are the same kind of thing.
- Both are stable probability distributions produced by the Quantum State Machine under different physical conditions.
- Both are examples of particle free-will within constraint.

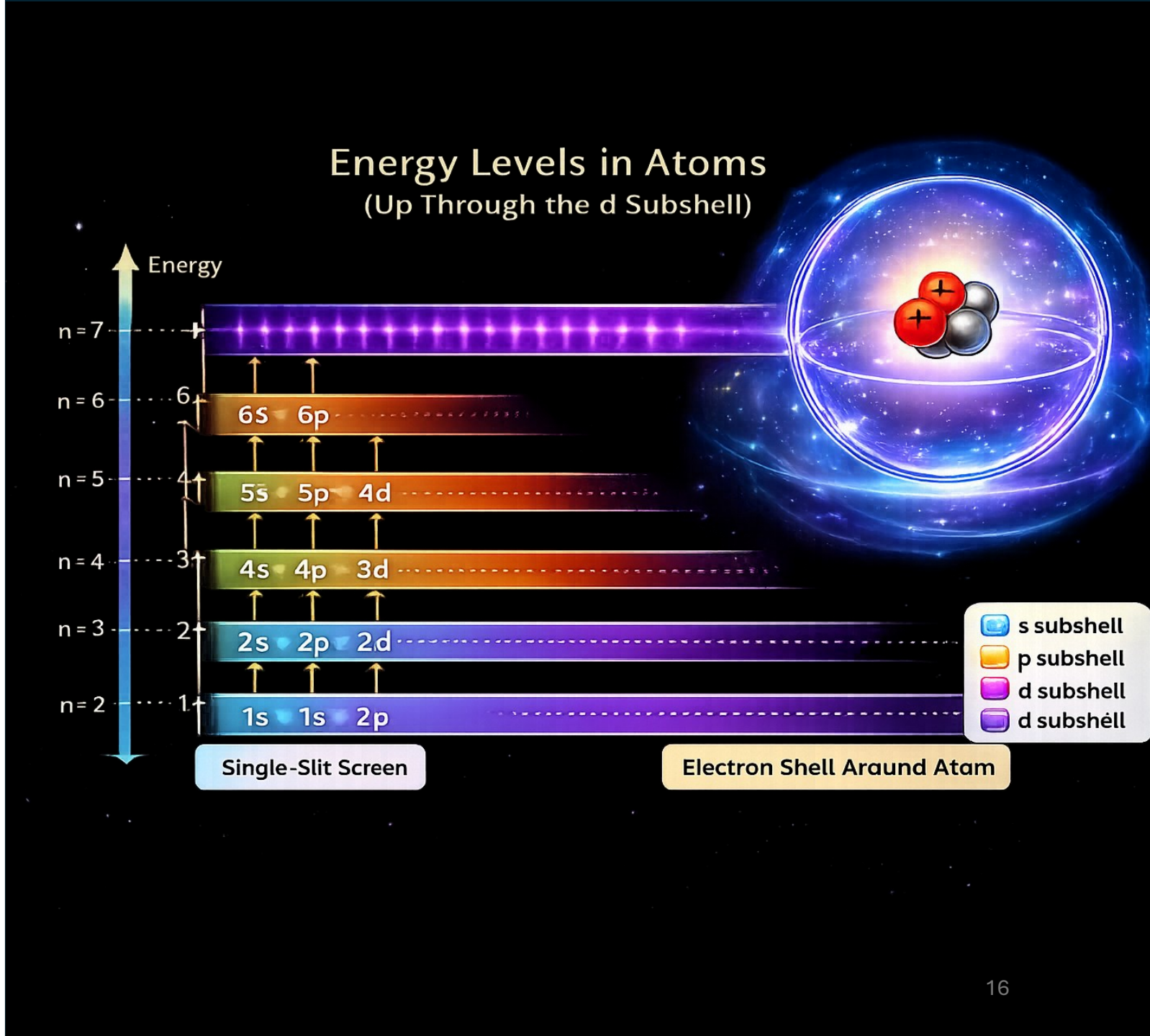




Different Probability Distributions Have Different Energies

Why?

- **Because each stable probability distribution is a different solution of the Quantum State Machine.**
  - **Some probability distributions require more kinetic energy to maintain their shape.**
  - **Others have lower potential energy because they are closer to the nucleus.**
- **The Quantum State Machine balances these effects automatically.**
  - **The result is a ladder of stable energy levels.**



Organizing the Probability Distributions

The Quantum State Machine does not produce just one stable probability distribution.

- It produces a whole family of them.

These probability distributions are organized by

- energy
- size
- shape

These become the electron shells and orbitals.

The Shell Numbers

Physicists give names to these shells and orbitals:

The shells are numbered

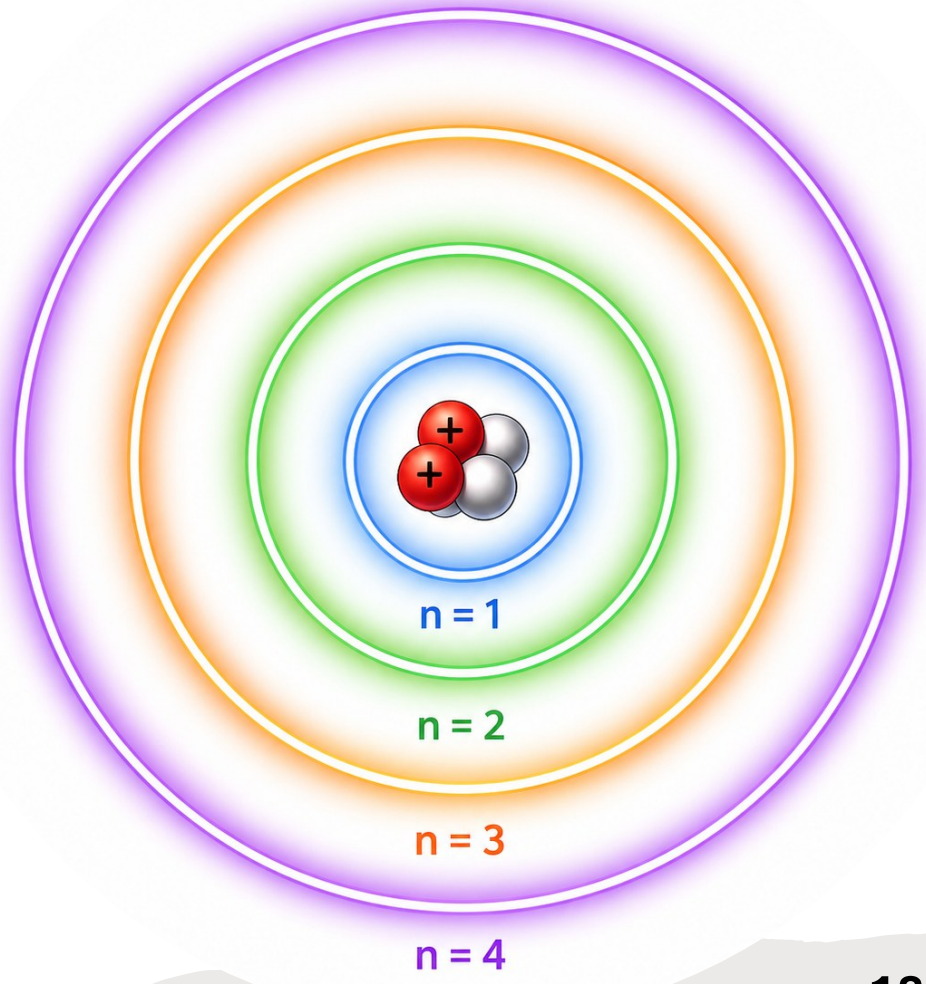
- **1**
- **2**
- **3**
- **…**

The shell number tells us

- **Approximately how far the probability distribution extends from the nucleus and**
- **Its energy level.**

As the shell number increases,

- **average distance increases**
- **energy increases.**



Every Shell Begins With an “s” Orbital

Each shell begins with

- one spherical probability distribution.
- It is called the “s” orbital.
- “s” stands for “sharp”, but it might be more useful to think of it as “spherical”.

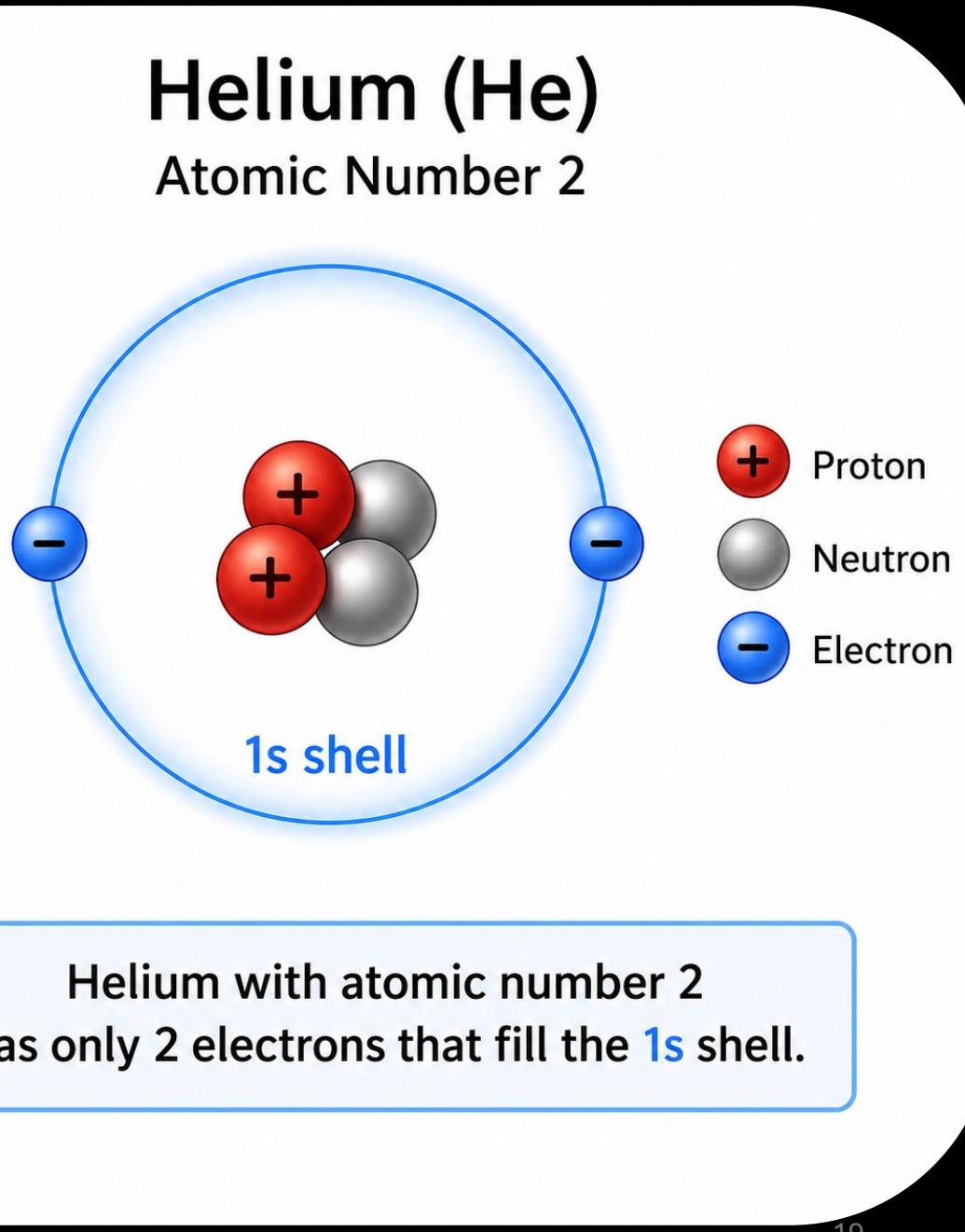
Each orbital can hold

- two electrons.

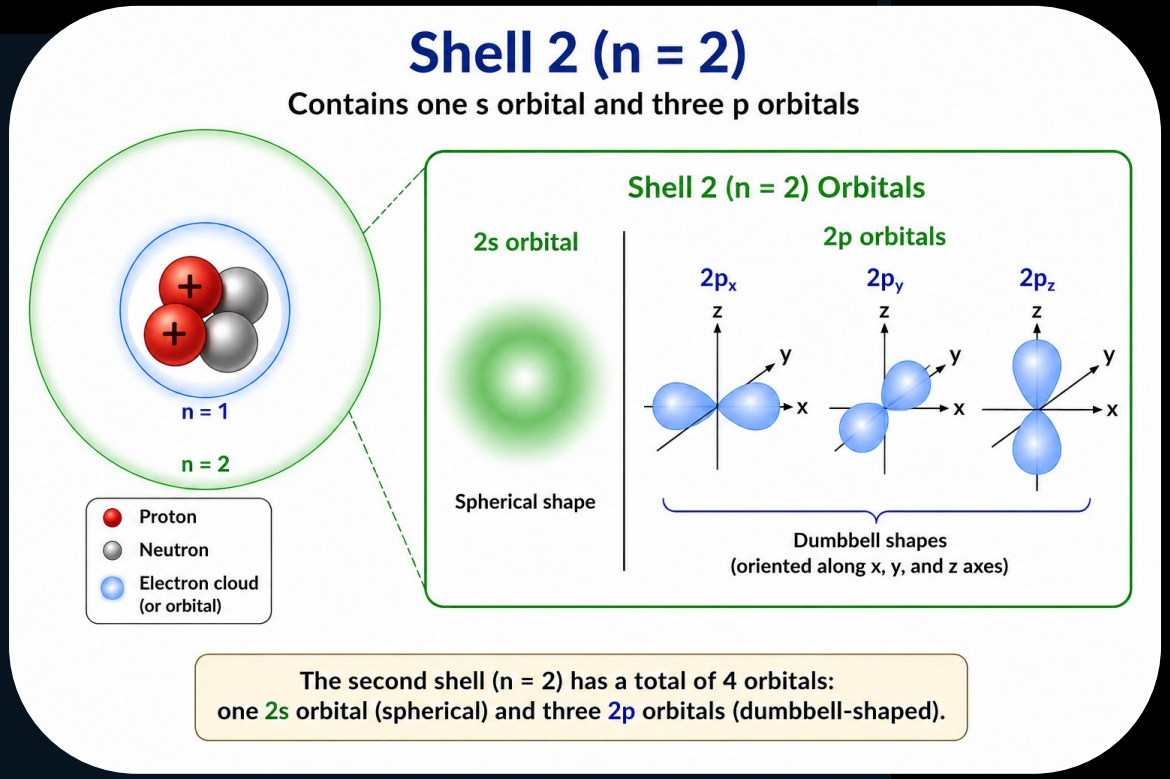
Therefore

- Shell 1
- 1s
- 2 electrons

Helium with atomic number 2 has only 2 electrons that fill the 1s shell.



Shell 2 Introduces New Shapes



The second shell begins the same way. It has

- **one spherical orbital**
- **2s**

But now the Quantum State Machine also predicts

- **three additional probability distributions with equally energetic orbitals.**

These are called

- **2px**
- **2py**
- **2pz**

Each points in a different direction (“p” stands for “principle” but it might be more useful to think of it as “pointing”.

- **Each has a dumbbell-shaped probability distribution.**
- **The p orbitals point in the x, y and z direction.**

Filling the Second Shell
(From Helium to Neon)

Shell 2 contains

- 2s
- $2p_x$
- $2p_y$
- $2p_z$

Each orbital holds two electrons, therefore:

- 2s 1 orbital × 2 electrons
- 2p 3 orbitals × 2 electrons
- 8 electrons total

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Filling the Second Shell

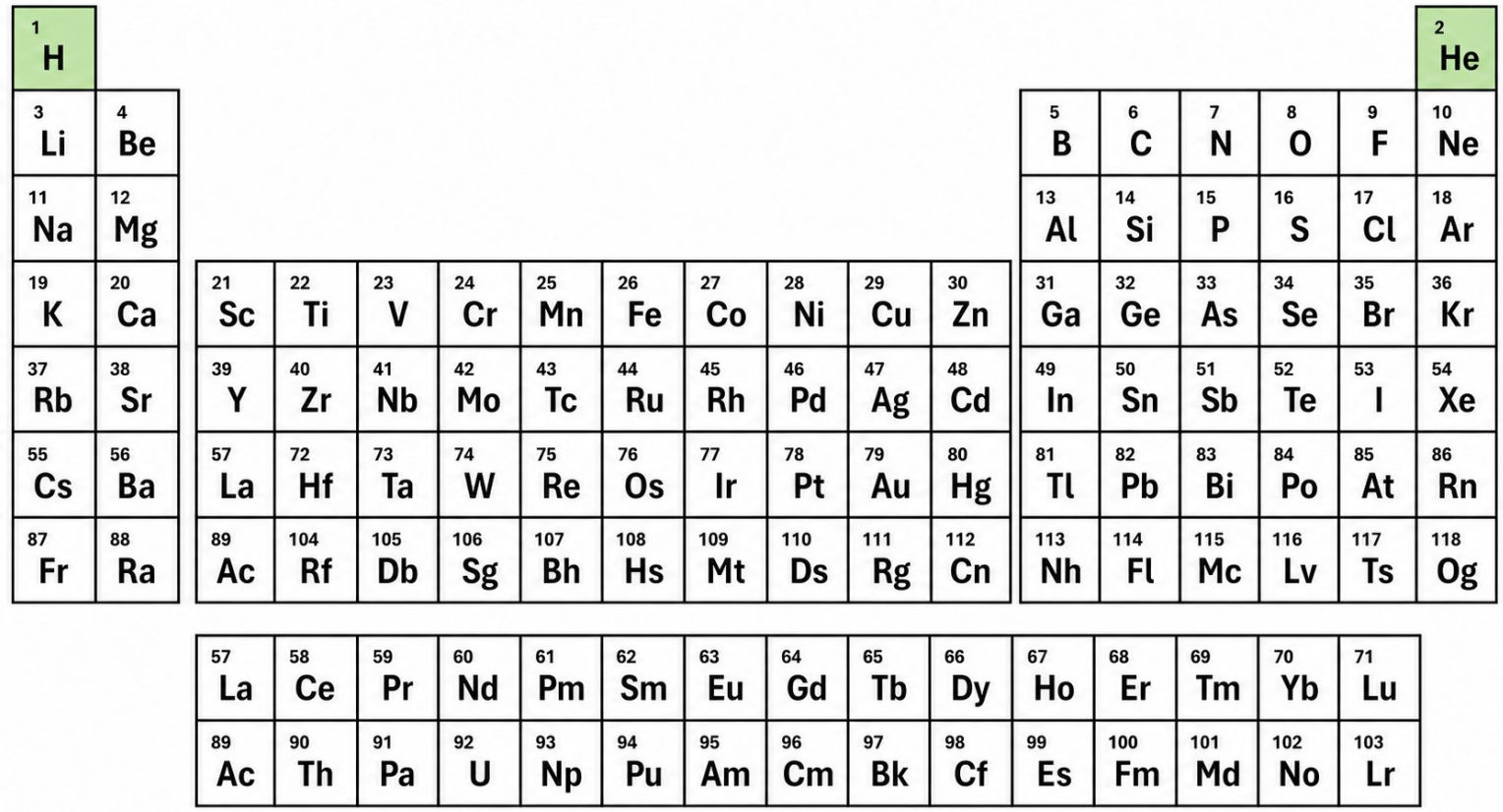
(From Helium to Neon)

We have 8 electrons from Shell 2

Also, in Shell 1:

- **2 electrons**

We now have 10 electrons total.



Filling the Second Shell
(From Helium to Neon)

We have 8 electrons from Shell 2

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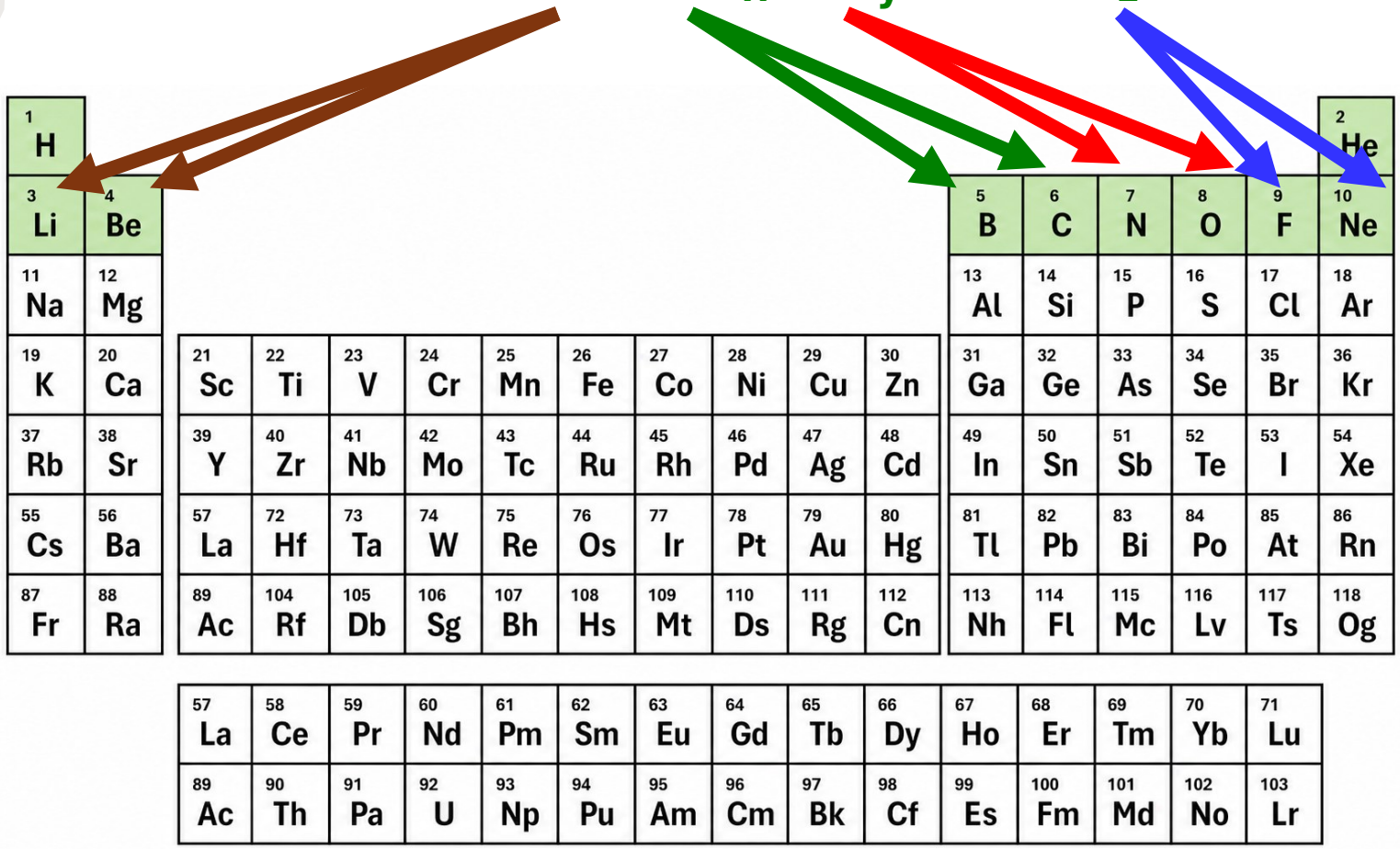
We now have 10 electrons total.

- **The first ten elements of the periodic table.**

Lithium through Neon fill in the entire second shell 2s, $2p_x$, $2p_y$ and $2p_z$



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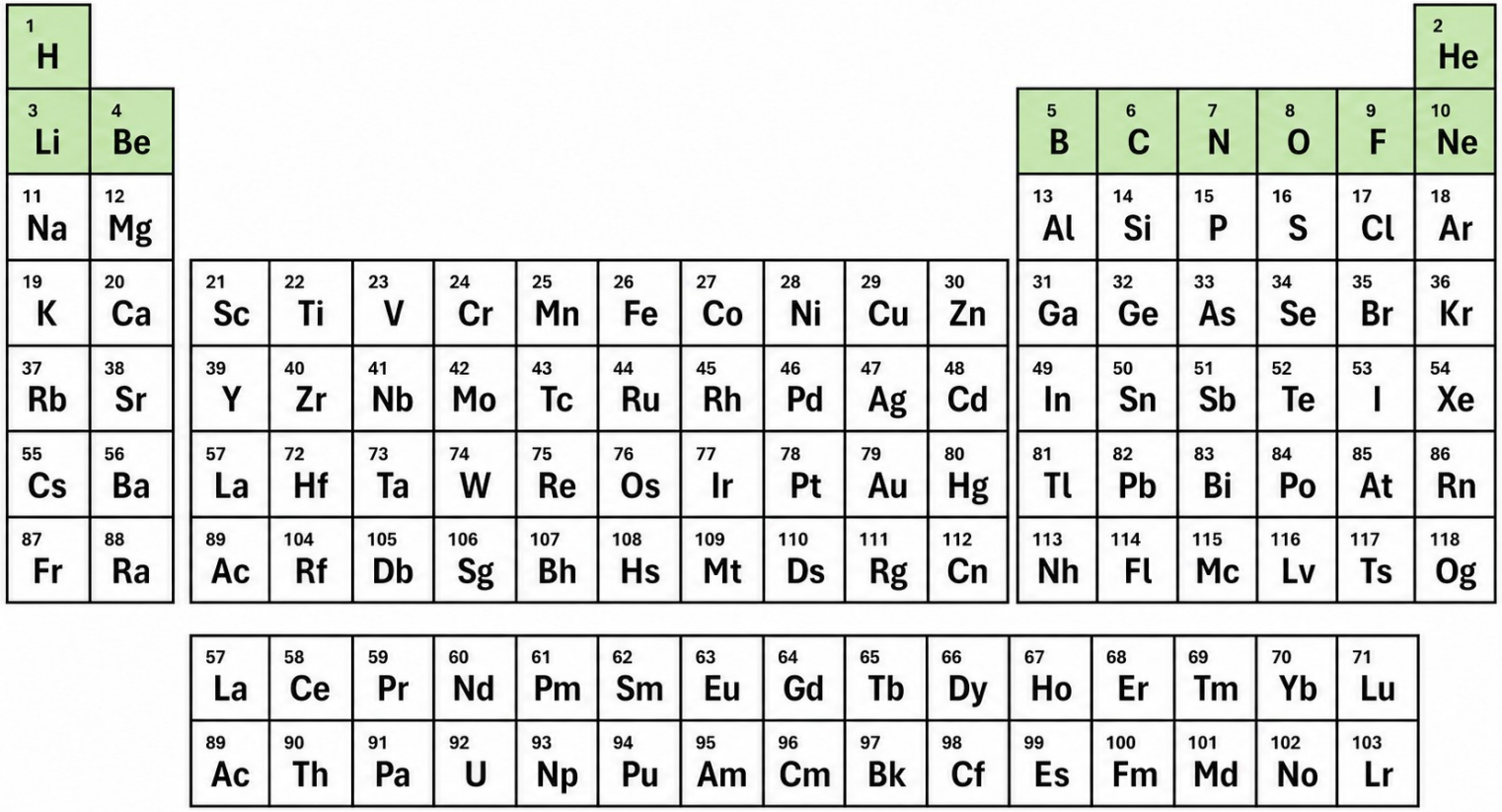
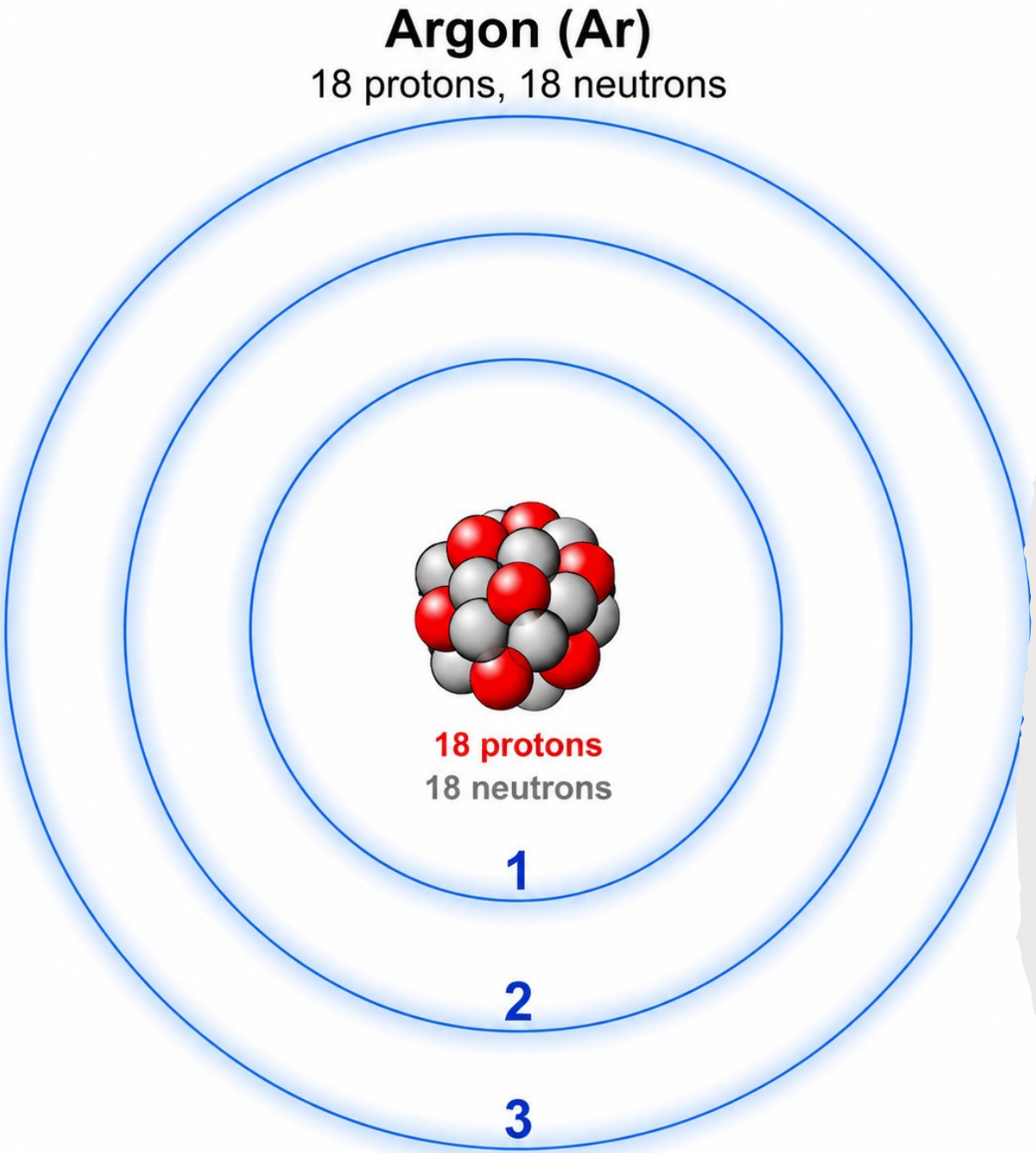
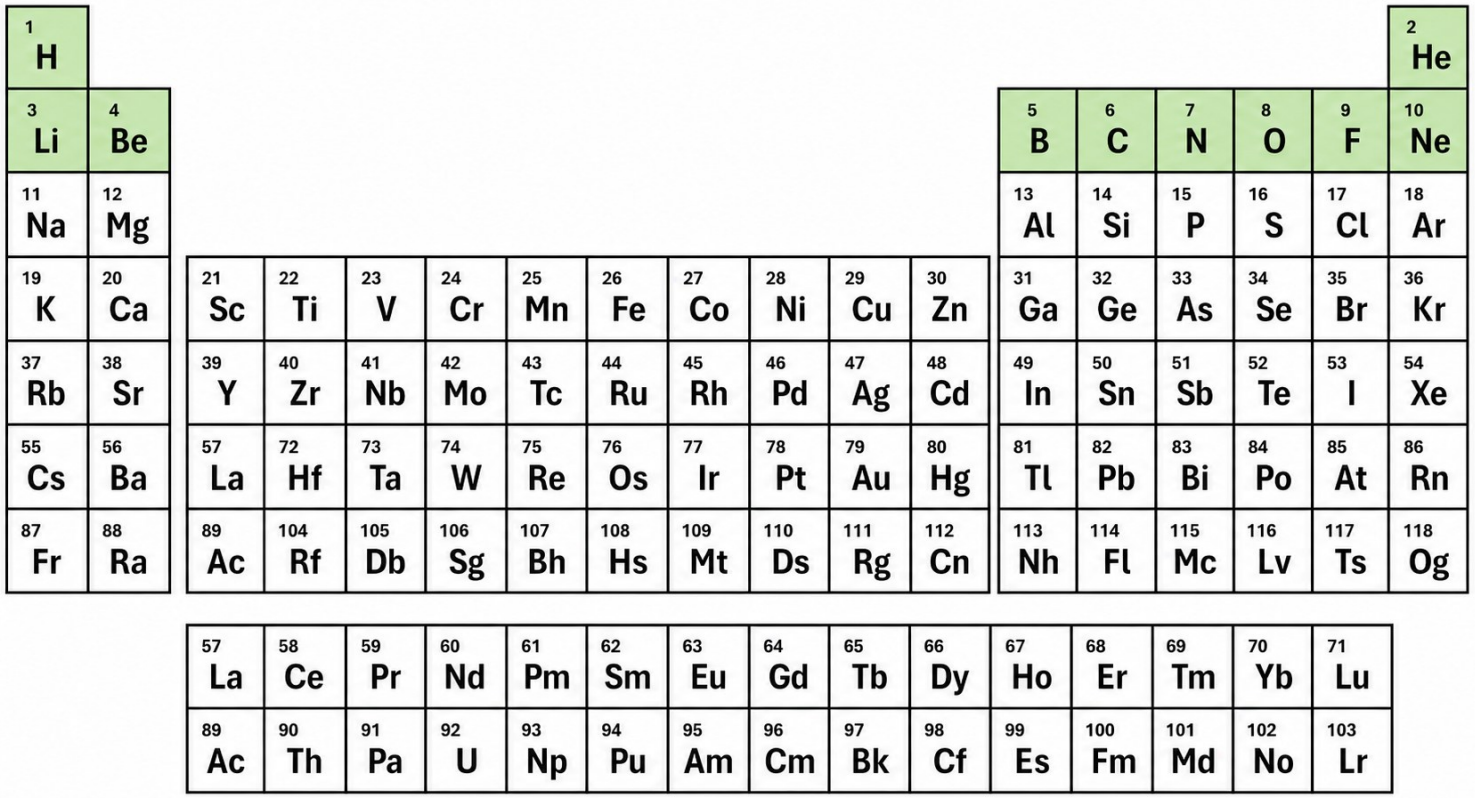




Shell 3

The pattern continues.

- **Shell 3 contains**
  - **3s**
  - **3p**
  - **3d (This is a new set of orbitals called “diffuse”.)**
- **More stable probability distributions.**
- **More places for electrons.**
- **More elements of the periodic table**



Filling the First Three Shells

The Quantum State Machine predicts stable probability distributions.

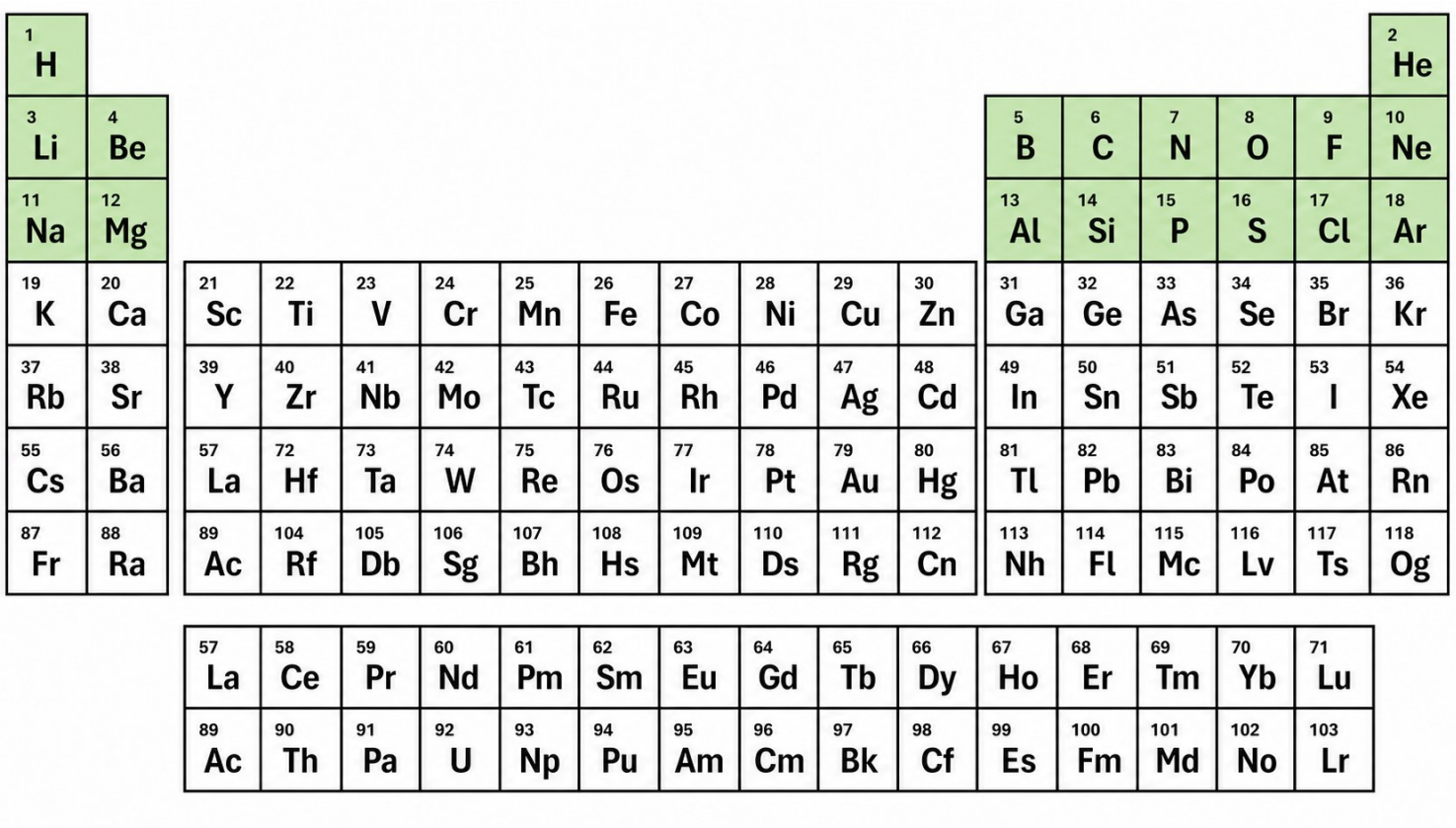
Electrons always occupy the lowest available energy first.

- Shell 1
  - 1s → 2 electrons
- Shell 2
  - 2s 2p → 8 electrons
- Shell 3
  - 3s 3p → 8 electrons
- Total
  - 2 + 8 + 8 = 18 electrons

This brings us to

Sodium (Z=11) through Argon (Z-18) filled in the 4 orbitals (8 electrons) in Shell 3.

The next element is Potassium (Z=19)



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  - 3s 3p → 8 electrons
- Total
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This brings us to

- Argon
- Atomic Number 18

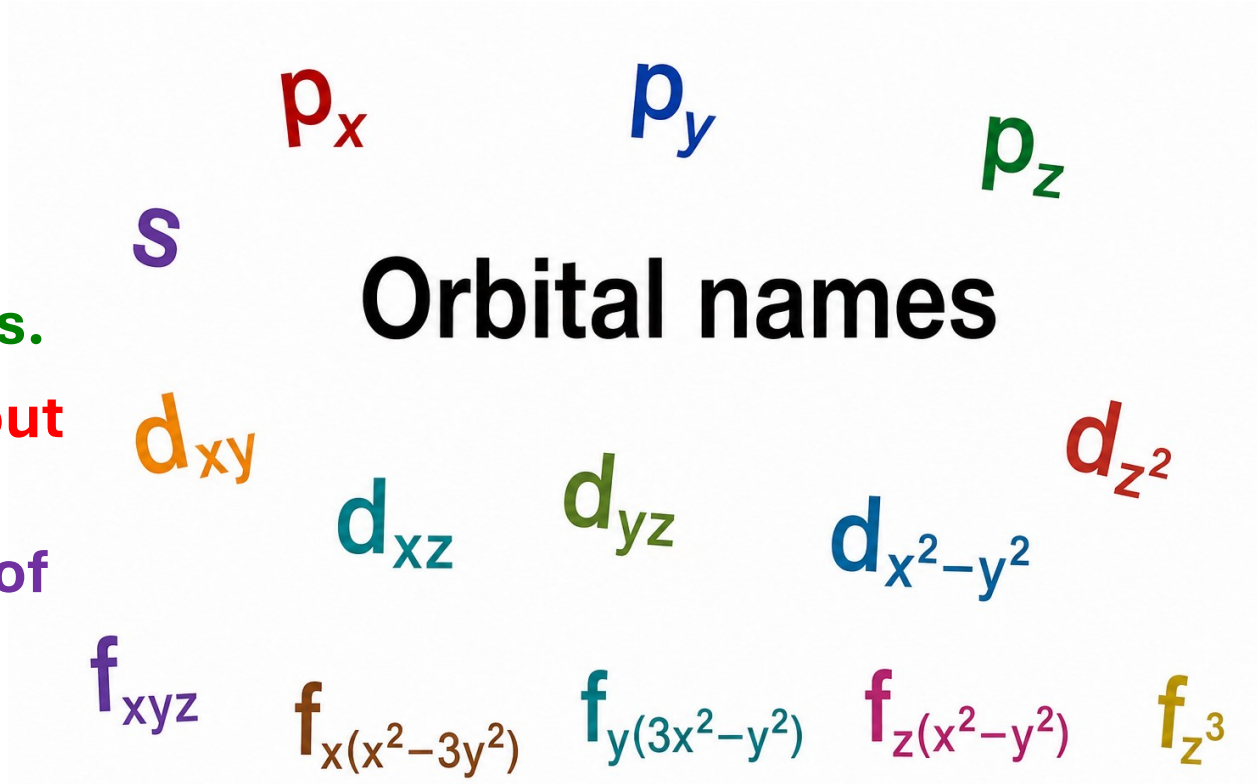
Before We Continue...

Let's pause for just a moment.

- **We need to introduce the names physicists use for the different families of probability distributions.**
- **These names will appear throughout the rest of the lecture.**
- **We also want to look at the shape of these probability distributions.**

Once we know the names and shapes,

- **The rest of the periodic table becomes much easier to understand.**



Four Families of Probability Distributions

The Quantum State Machine predicts four families of stable probability distributions.

These memory aids describe the probability distributions, not the historical origin of the letters.

Physics	Chemistry (Historical)	Our Memory Aid
s	sharp	spherical
p	principal	pointing
d	diffuse	directional
f	fundamental	fancy

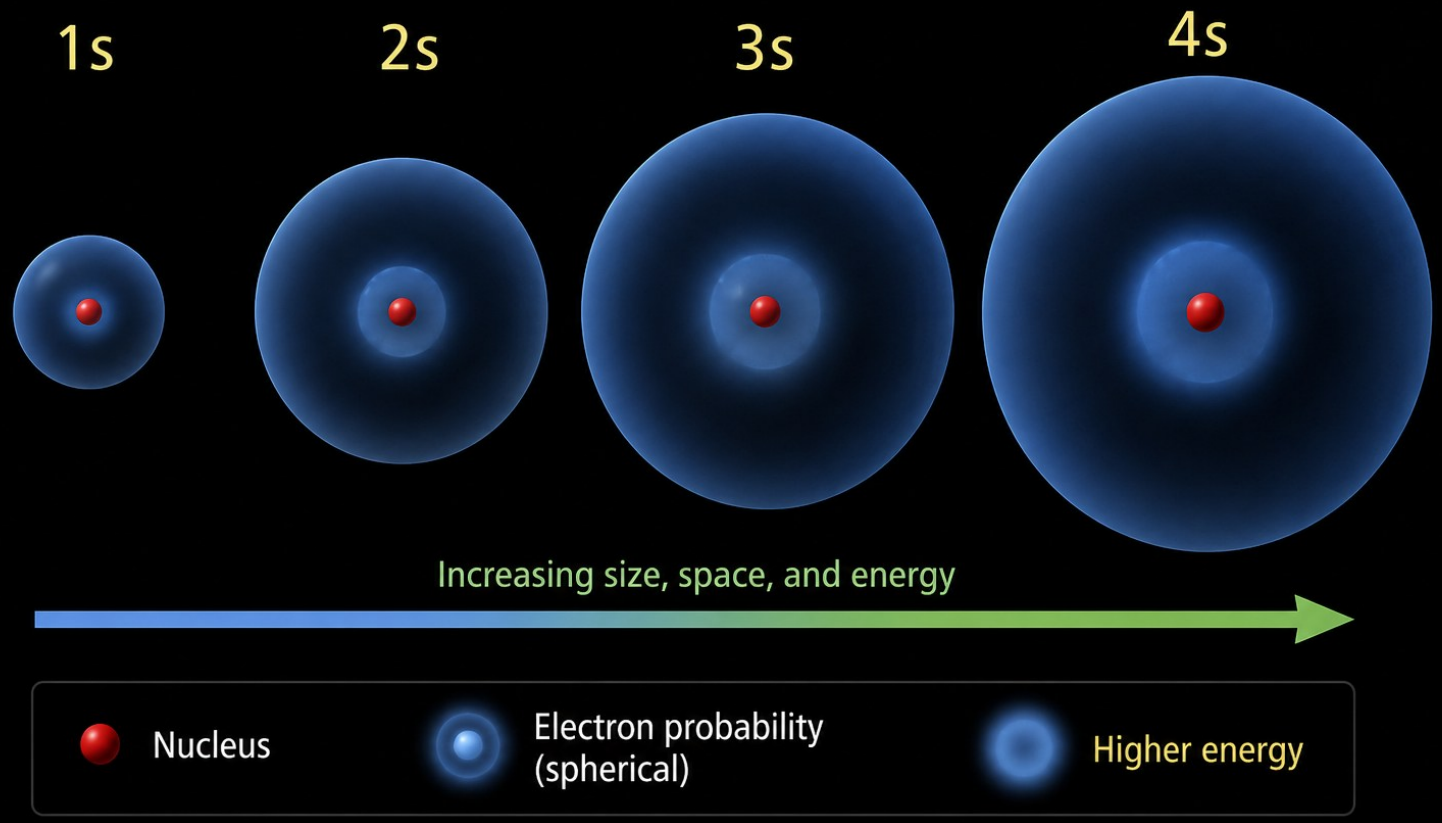
Each Family Provides More Quantum States

Each family contains a different number of probability distributions.

As the shapes become more elaborate the Quantum State Machine provides more places for electrons.

Family	Probability Distributions	Electron States
s = spherical	1	2
p = pointing	3	6
d = directional	5	10
f = fancy	7	14

Higher Shells Extend Farther from the Nucleus



Within one family, each new shell is larger than the previous one.

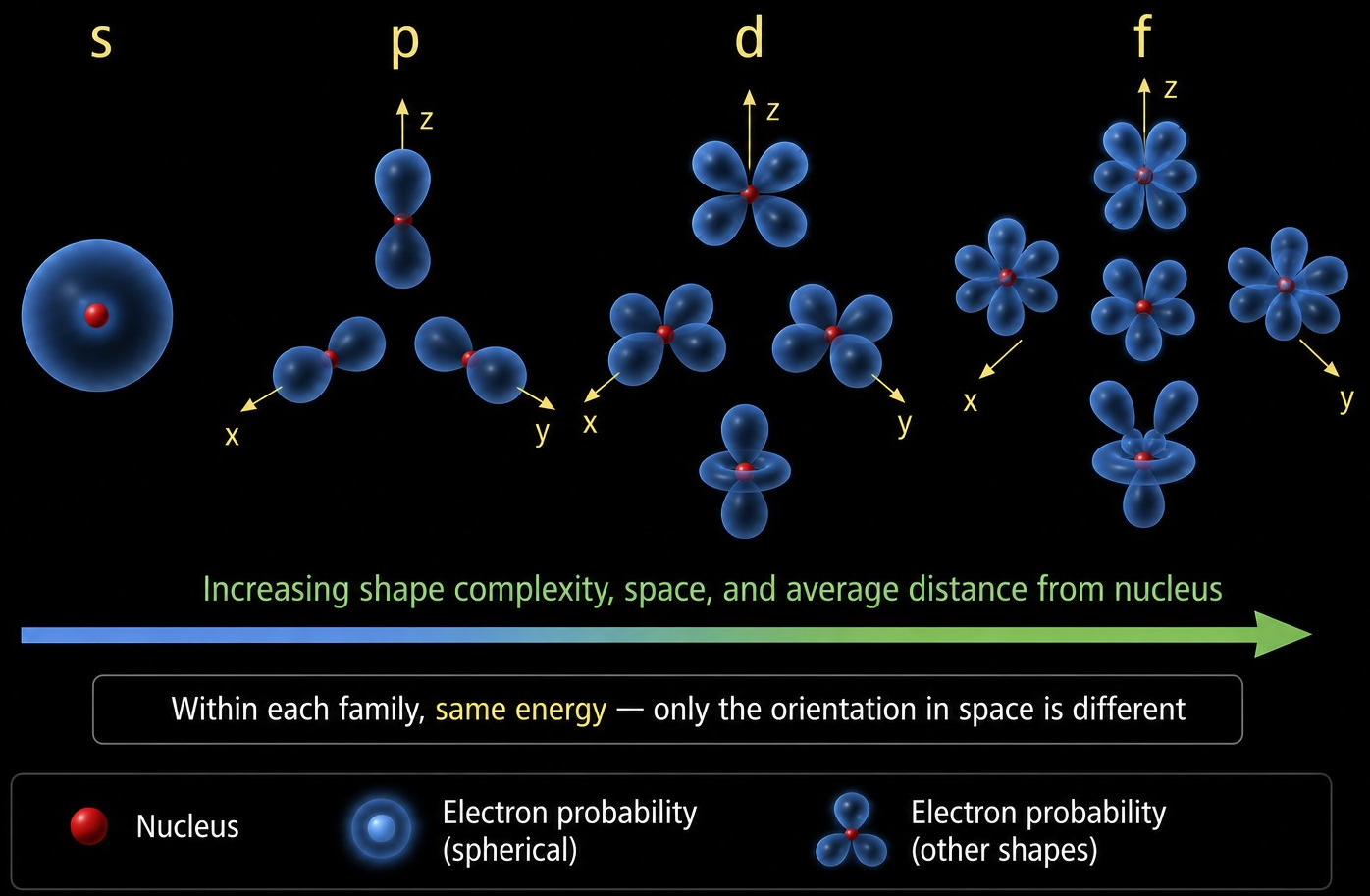
For example,

- **1s**
- **2s**
- **3s**
- **4s**

“s” shells are all spherical probability distributions, but each new shell:

- **extends farther from the nucleus,**
- **occupies more space,**
- **and has higher energy.**

Within a Shell, New Families Become Larger.



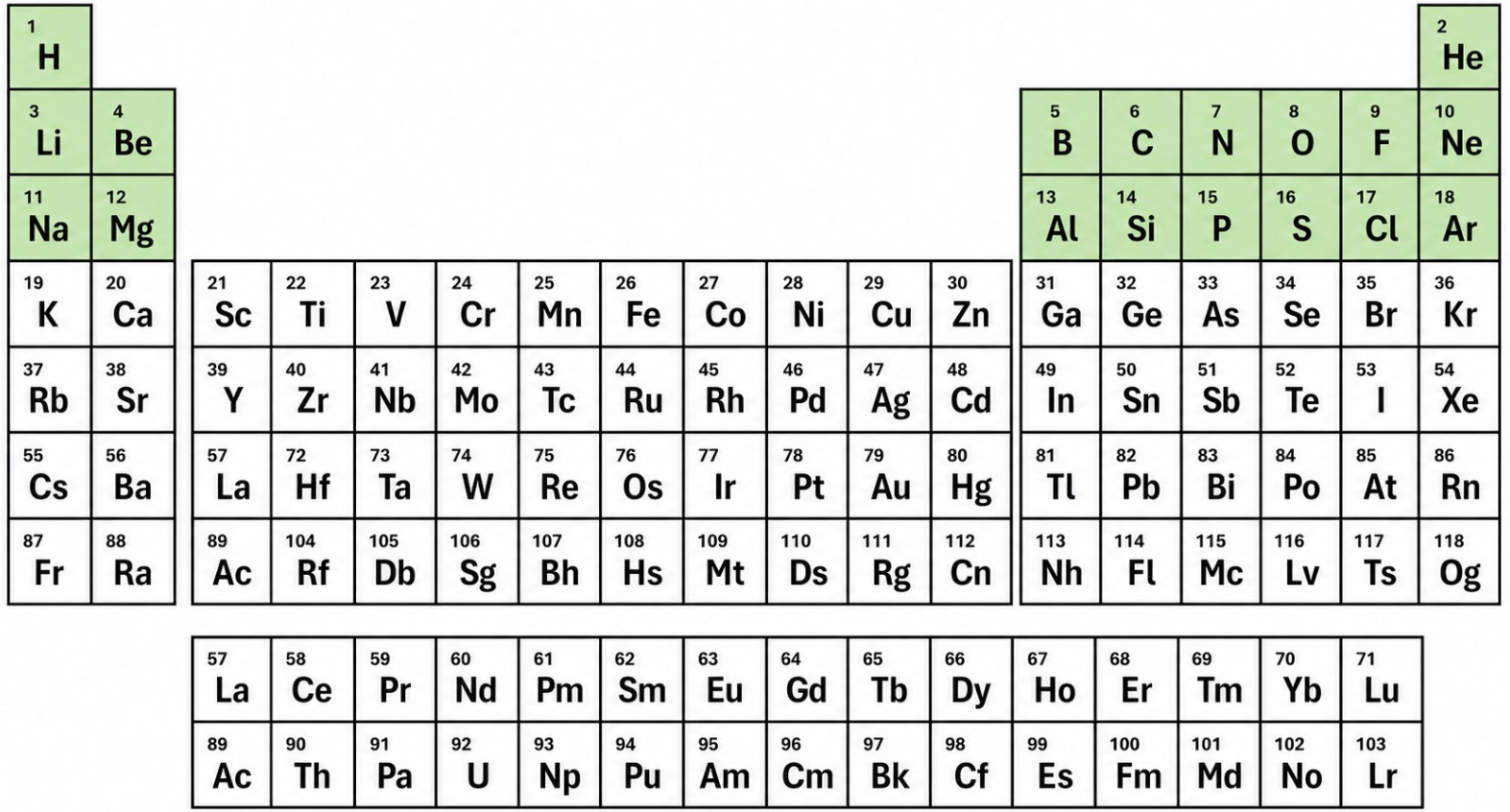
The Quantum State Machine predicts four families of probability distributions.

- As we move s → p → d → f
  - the shapes become more elaborate,
  - the probability distributions occupy more space,
  - and the average electron distance from the nucleus increases.
- Yet within each family,
  - all p orbitals have the same energy,
  - all d orbitals have the same energy,
  - all f orbitals have the same energy.
- Only their orientation in space is different.

Now Let's Continue Building the Atom

We paused to learn the language. Now let's continue building the periodic table:

- **So far we have reached**
  - **Argon (18)**
- **The next two elements should be**
  - **Potassium (19)**
  - **Calcium (20)**
- **So let's continue to add protons and electrons one at a time?**
- **What happens next?**



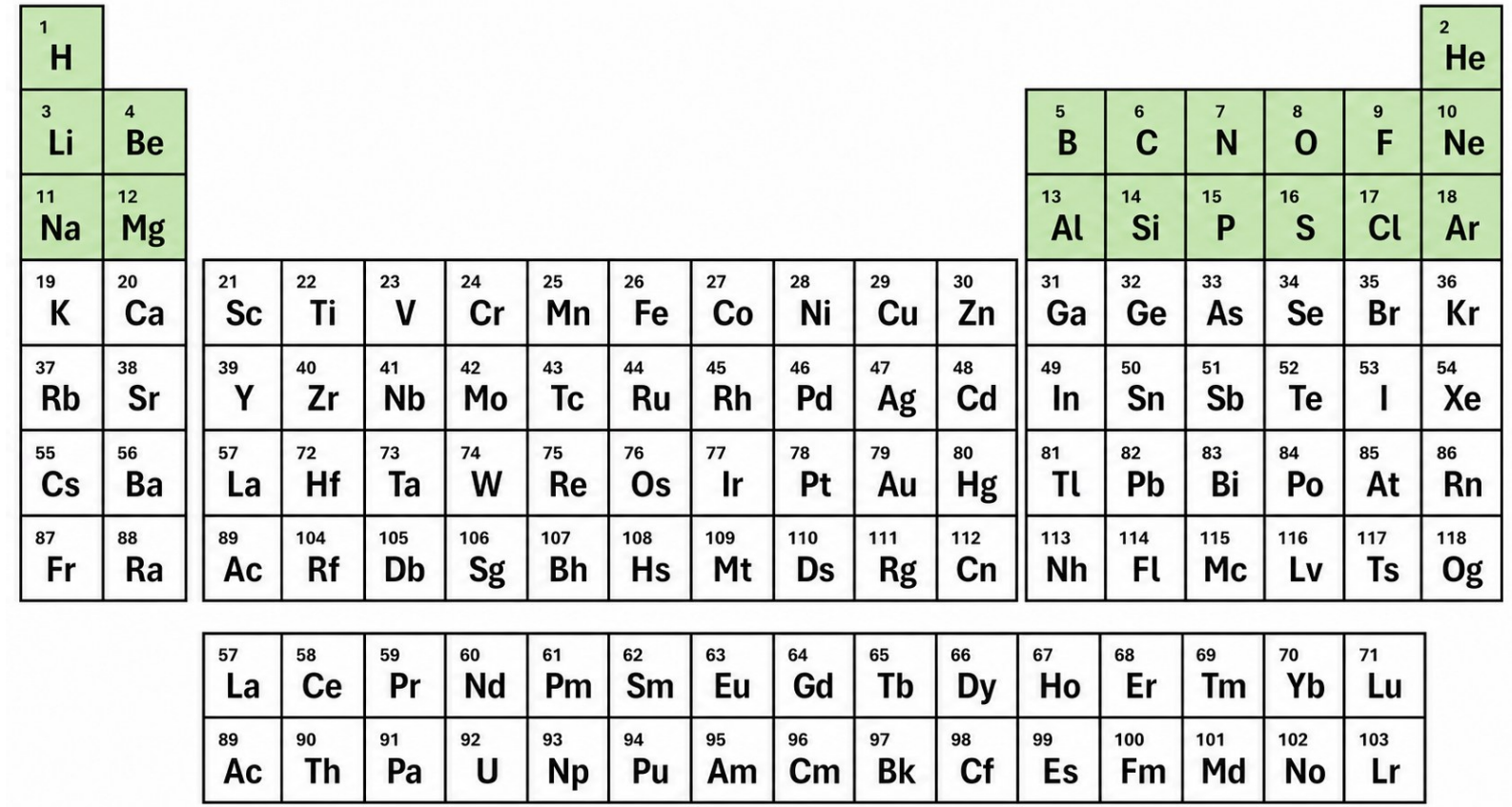
The Quantum State Machine Predicts a Surprise!

Argon's outer shell has 3s and 3p completely filled.

Physicists predicted 3d to fill next before moving to the next shell 4s.

- **But the Quantum State Machine predicts that:**
  - **4s has slightly lower energy.**
- **Therefore**
  - **the next two electrons enter 4s (not 3d)**

This produces



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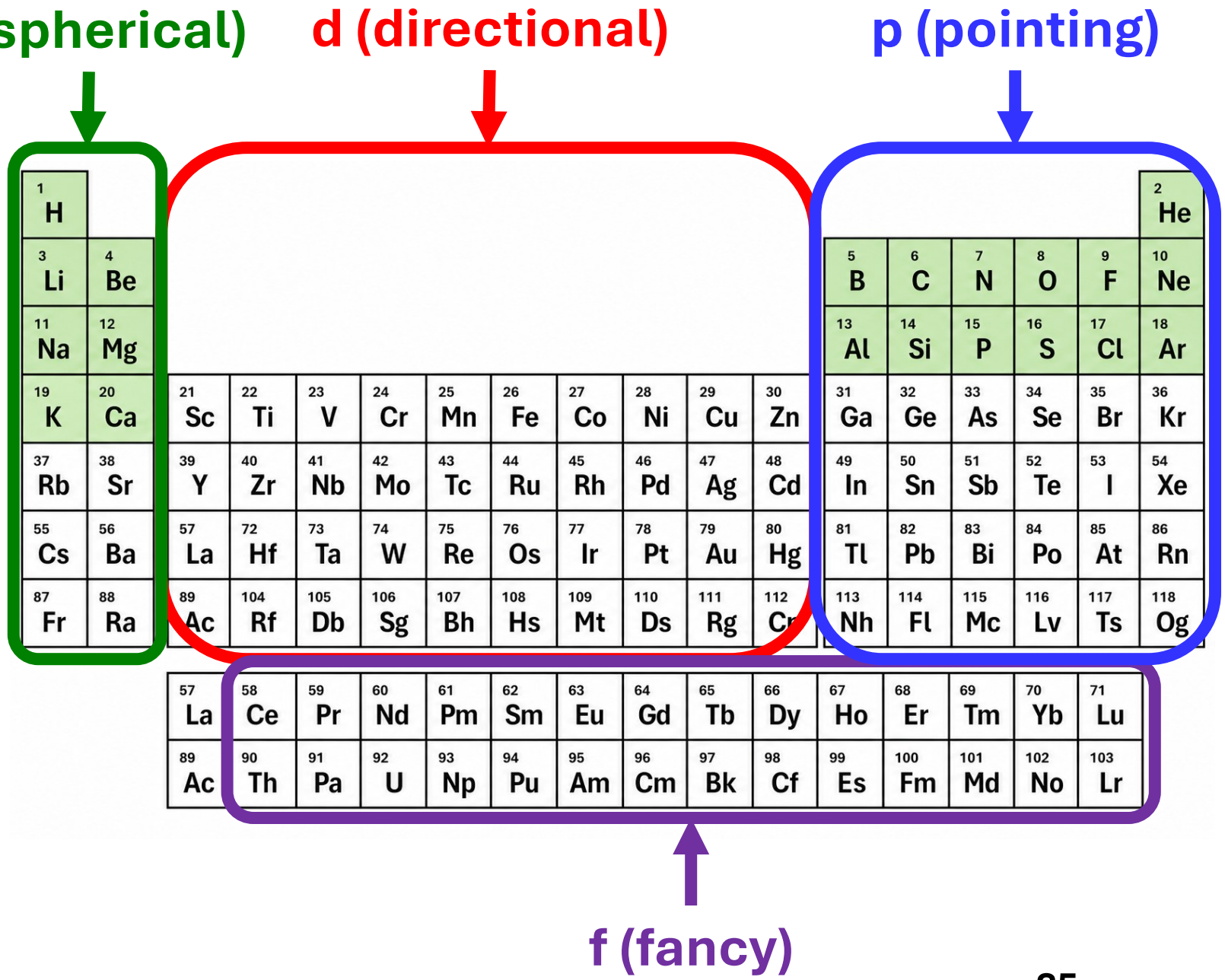

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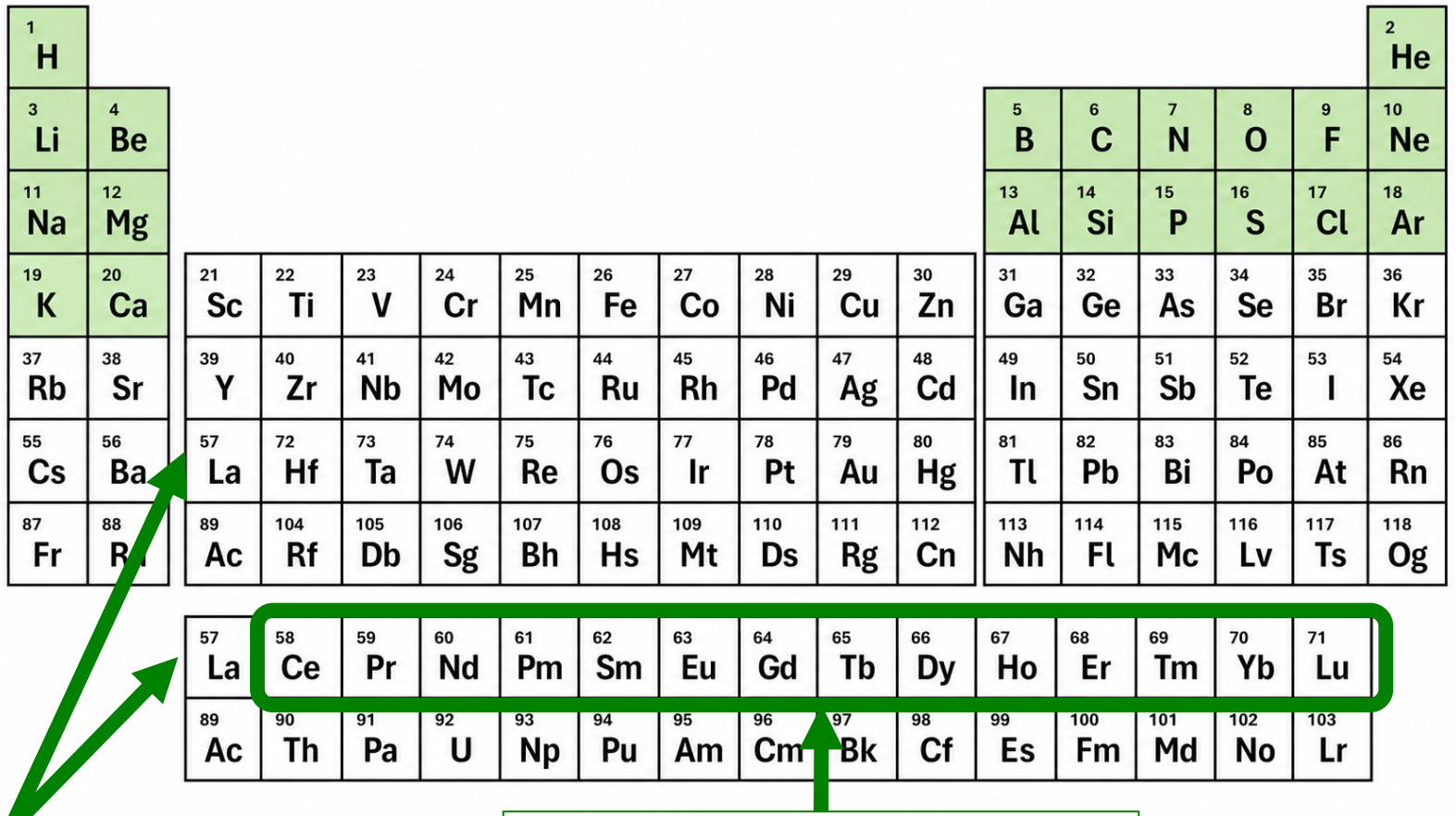

The chemical properties of these elements are like Lanthanum

Lanthanum Series
4f (fancy)

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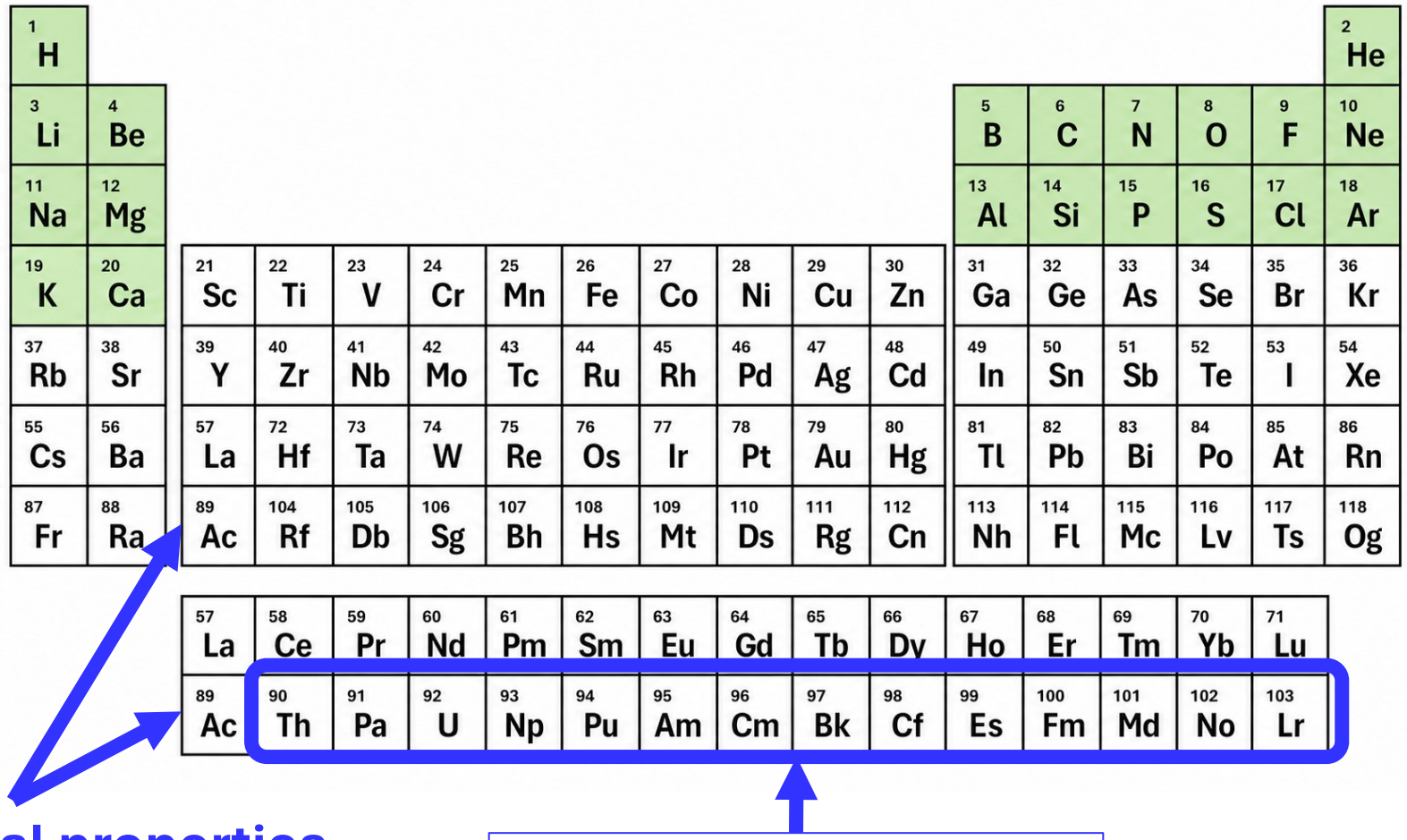
- **Potassium (19)**
- **Calcium (20)**



The chemical properties of these elements are like Actinium

Actinium Series
5f (fancy)

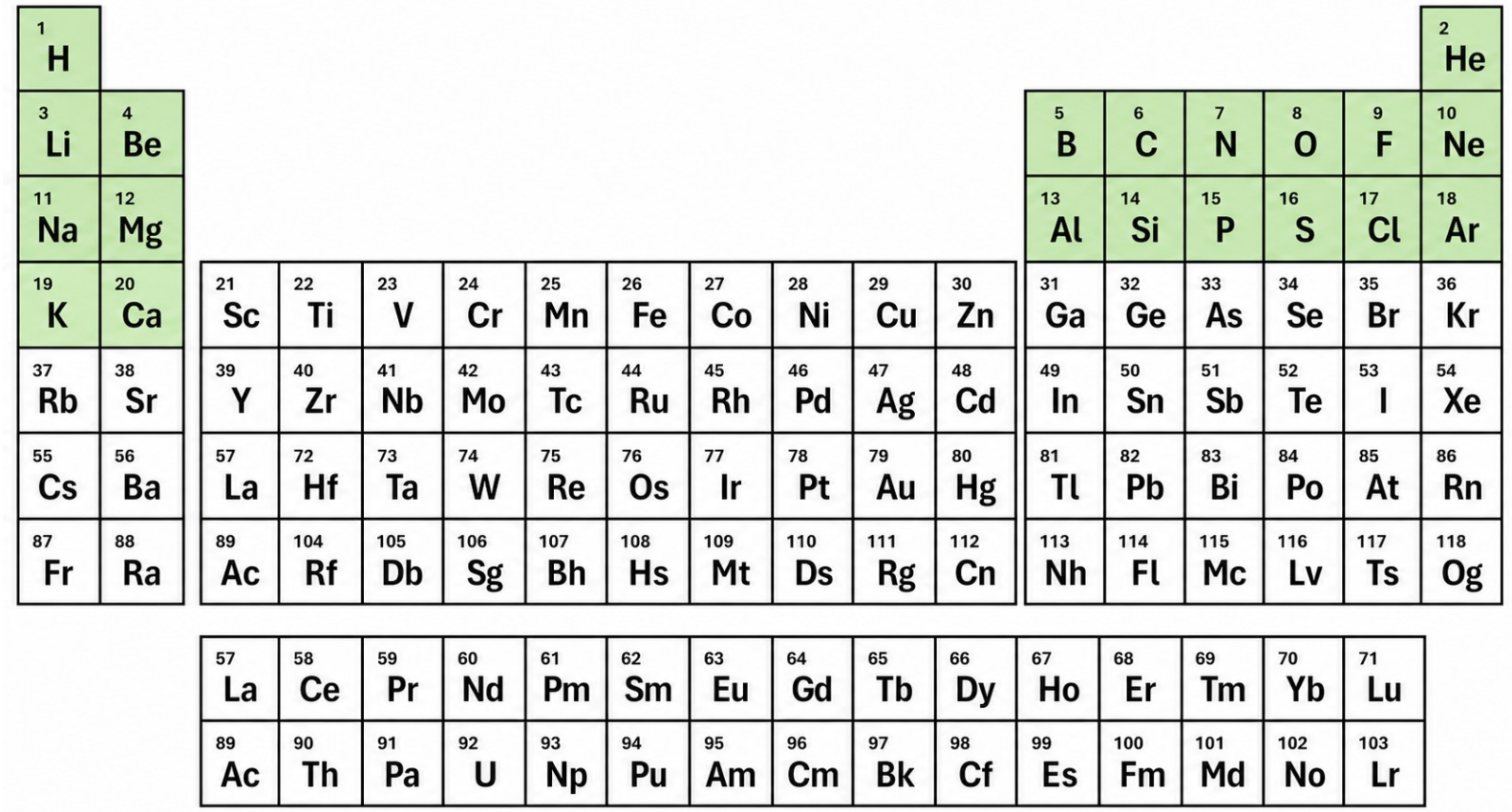
The Transition Metals

Once 4s is filled, the Quantum State Machine returns to

- **3d**

Those five d orbitals hold 10 electrons

- **As they fill, we move across the transition metals:**



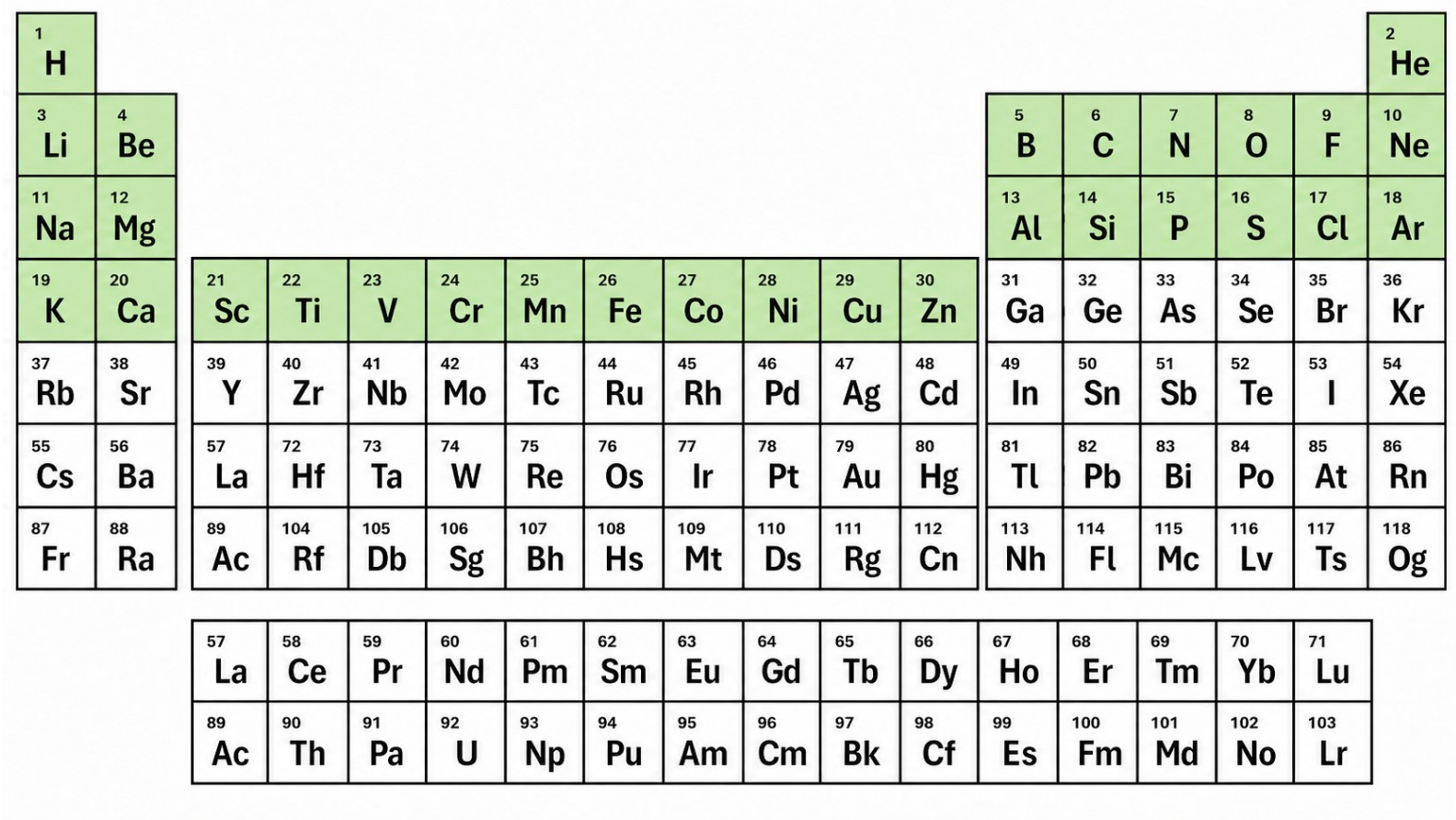
The Transition Metals

Once 4s is filled, the Quantum State Machine returns to

- **3d**

Those five d orbitals hold 10 electrons

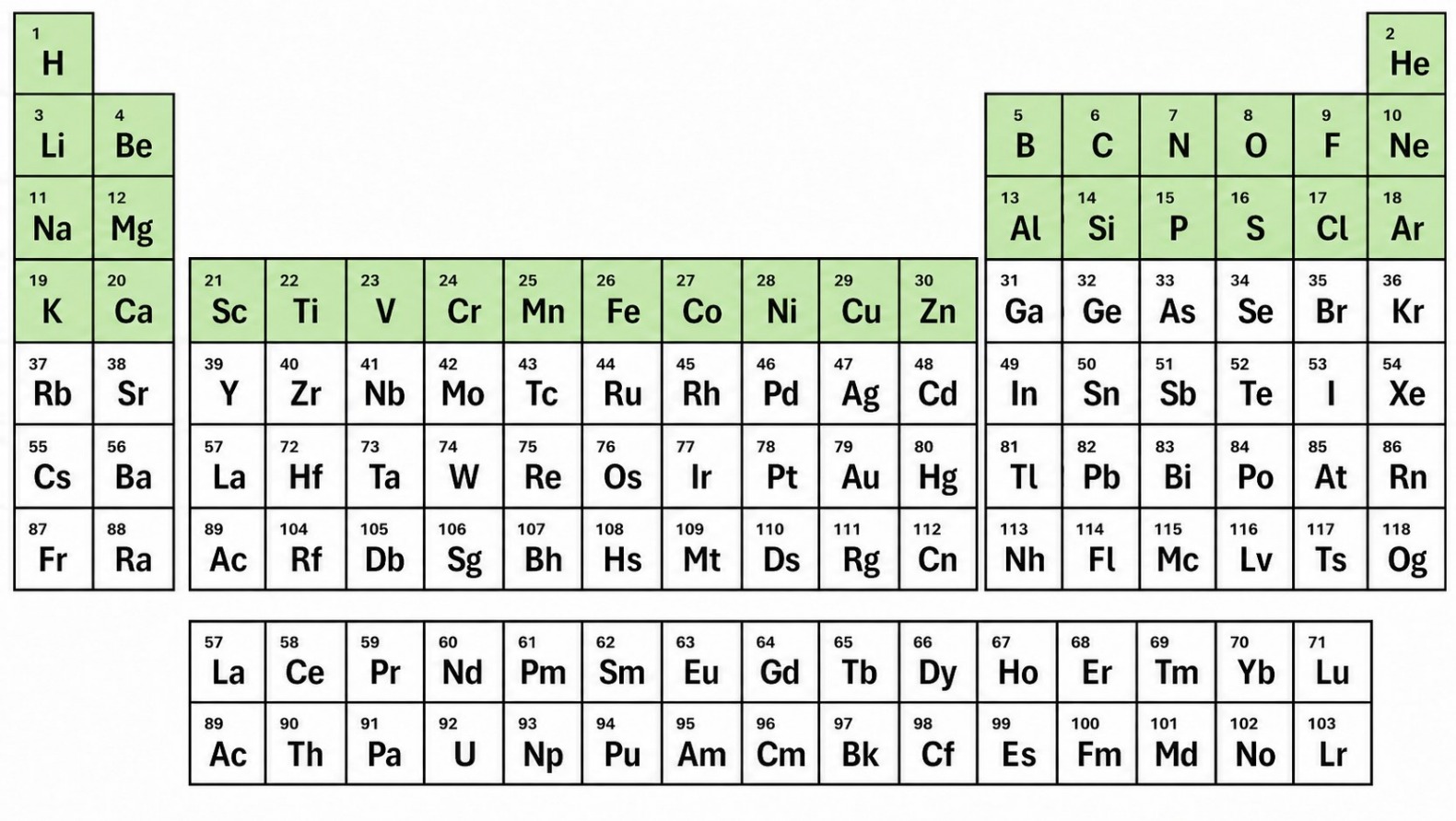
- **As they fill, we move across the transition metals:**
  - **Scandium (21)**
  - **↓**
  - **…**
  - **↓**
  - **Zinc (30)**



Completing the Fourth Shell

After 3d is full, the Quantum State Machine fills 4p

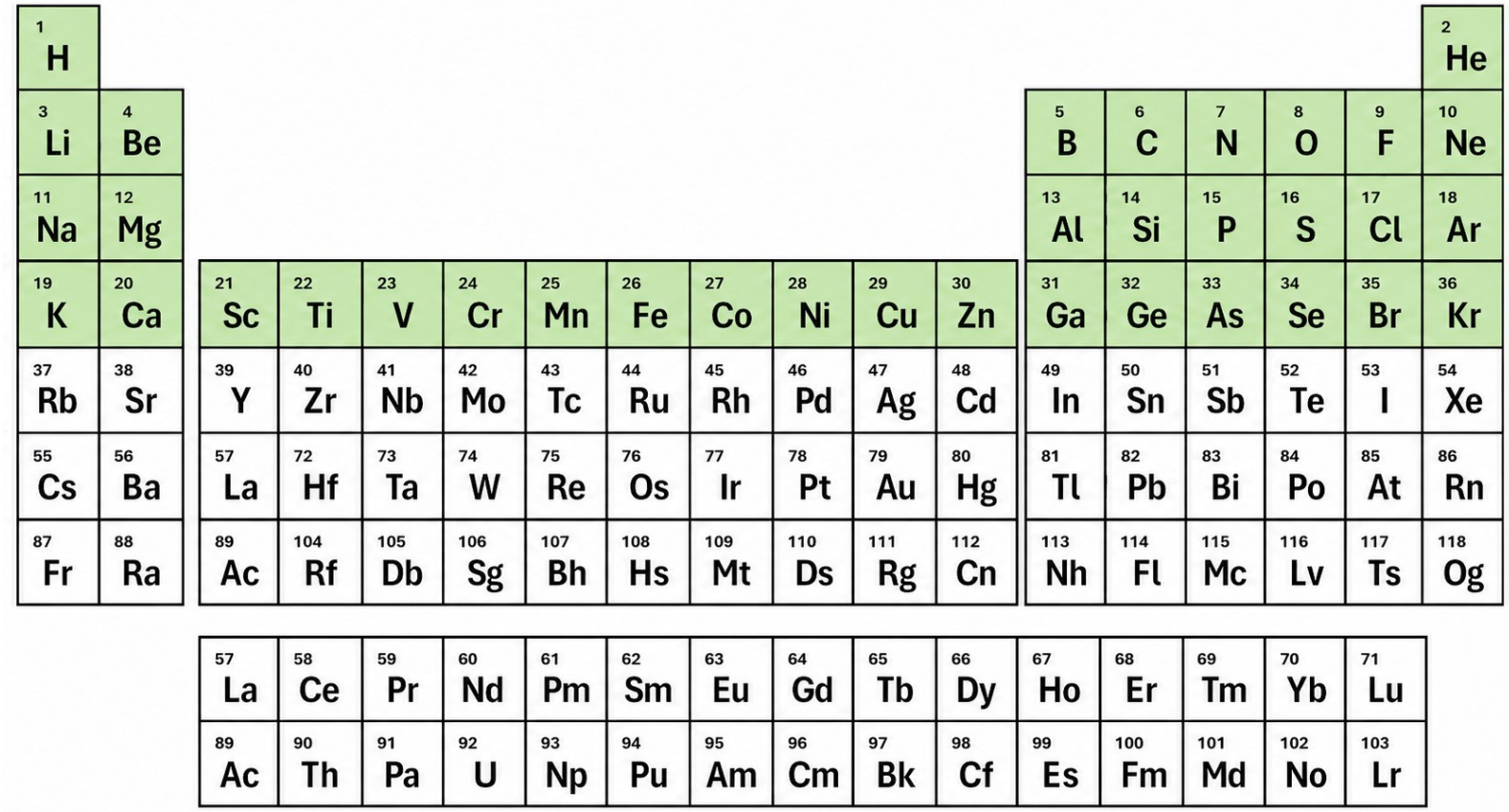
- **These six electrons carry us to**



Completing the Fourth Shell

After 3d is full, the Quantum State Machine fills 4p

- **These six electrons carry us to**
  - **Krypton**
  - **Atomic Number 36**

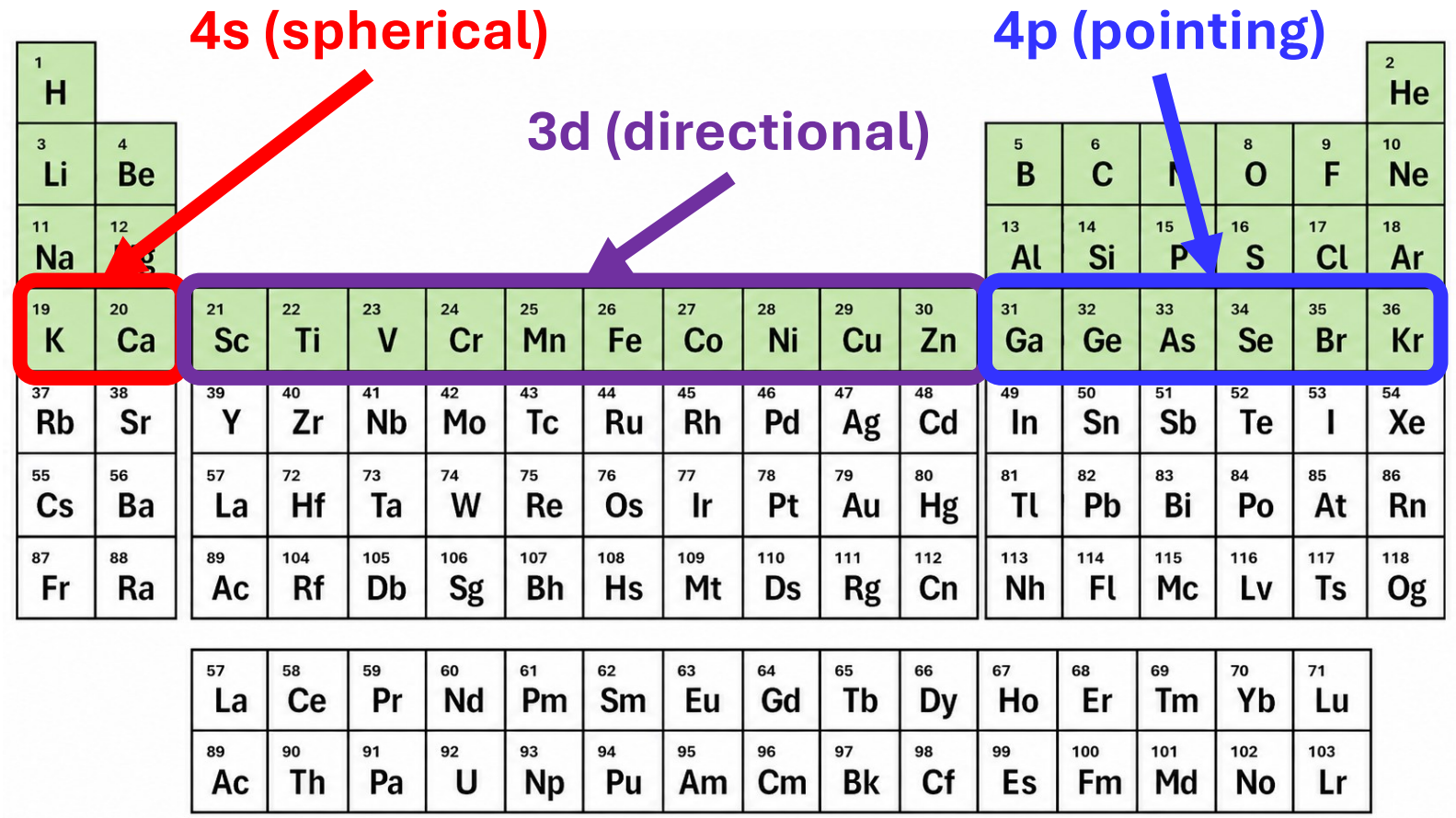


Completing the Fourth Shell

IMPORTANT:

- **Starting with row 4**
  - **The two 4s electrons are filled**
  - **Then the 10 3d electrons are filled**
  - **Finally the 6 4p electrons are filled**

The s and p orbitals are from the current shell but the d orbitals are from the previous shell

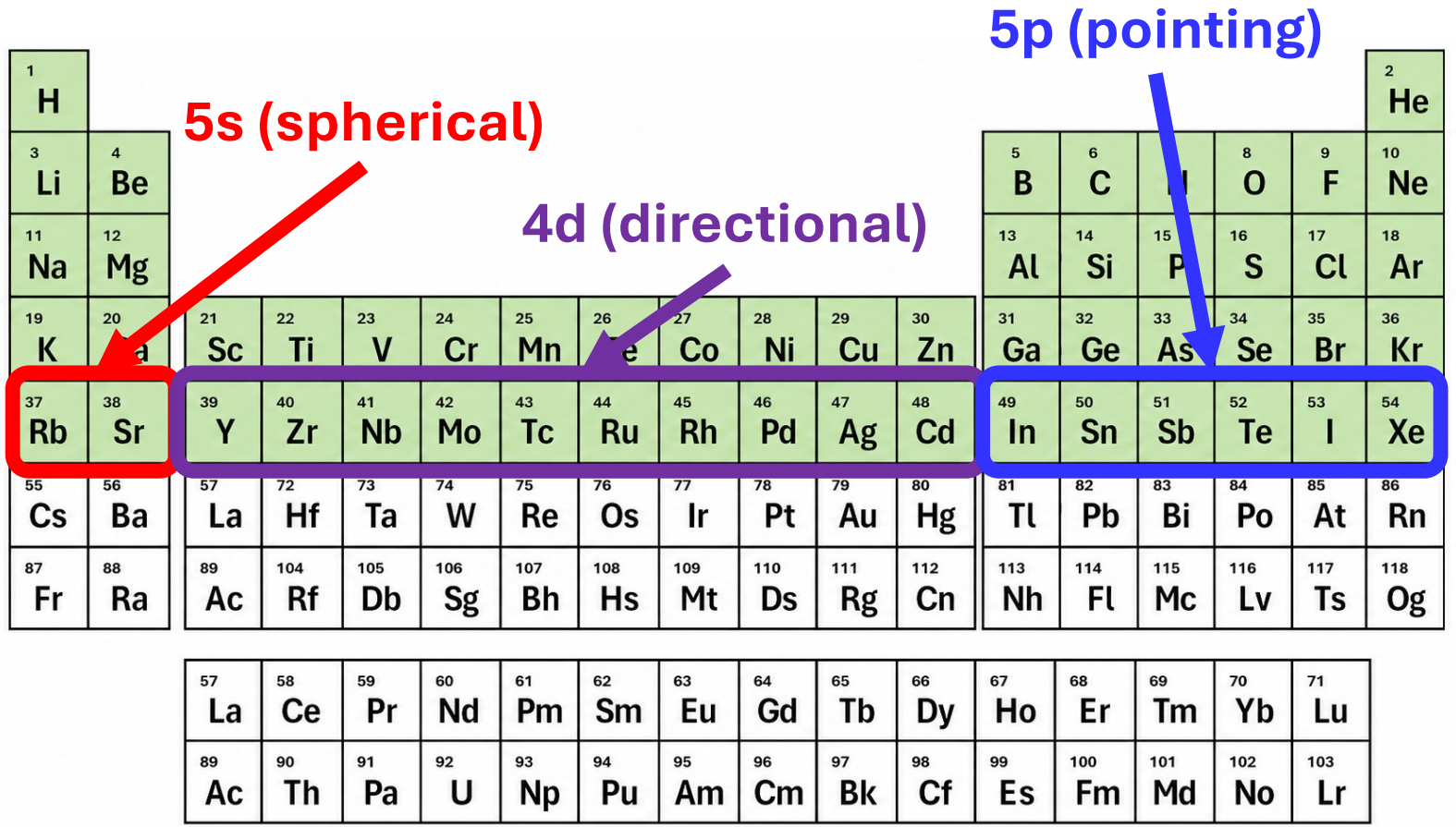


Completing the Fifth Shell

The same filling order as the fourth shell:

- **Starting with row 5**
  - **The two 5s electrons are filled**
  - **Then the 10 4d electrons are filled**
  - **Finally the 6 5p electrons are filled**

The s and p orbitals are from the current shell but the d orbitals are from the previous shell

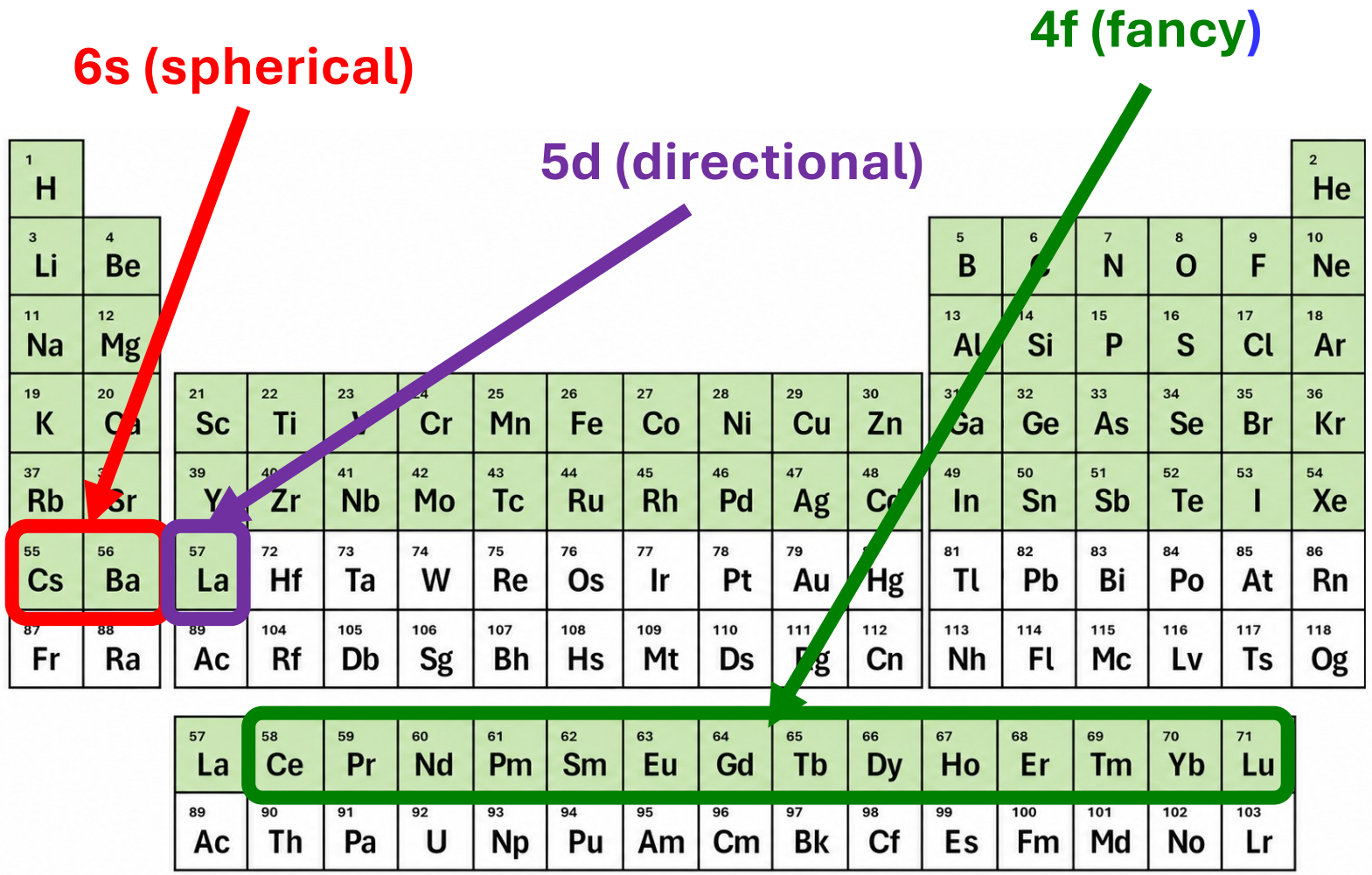


Filling the Sixth Shell

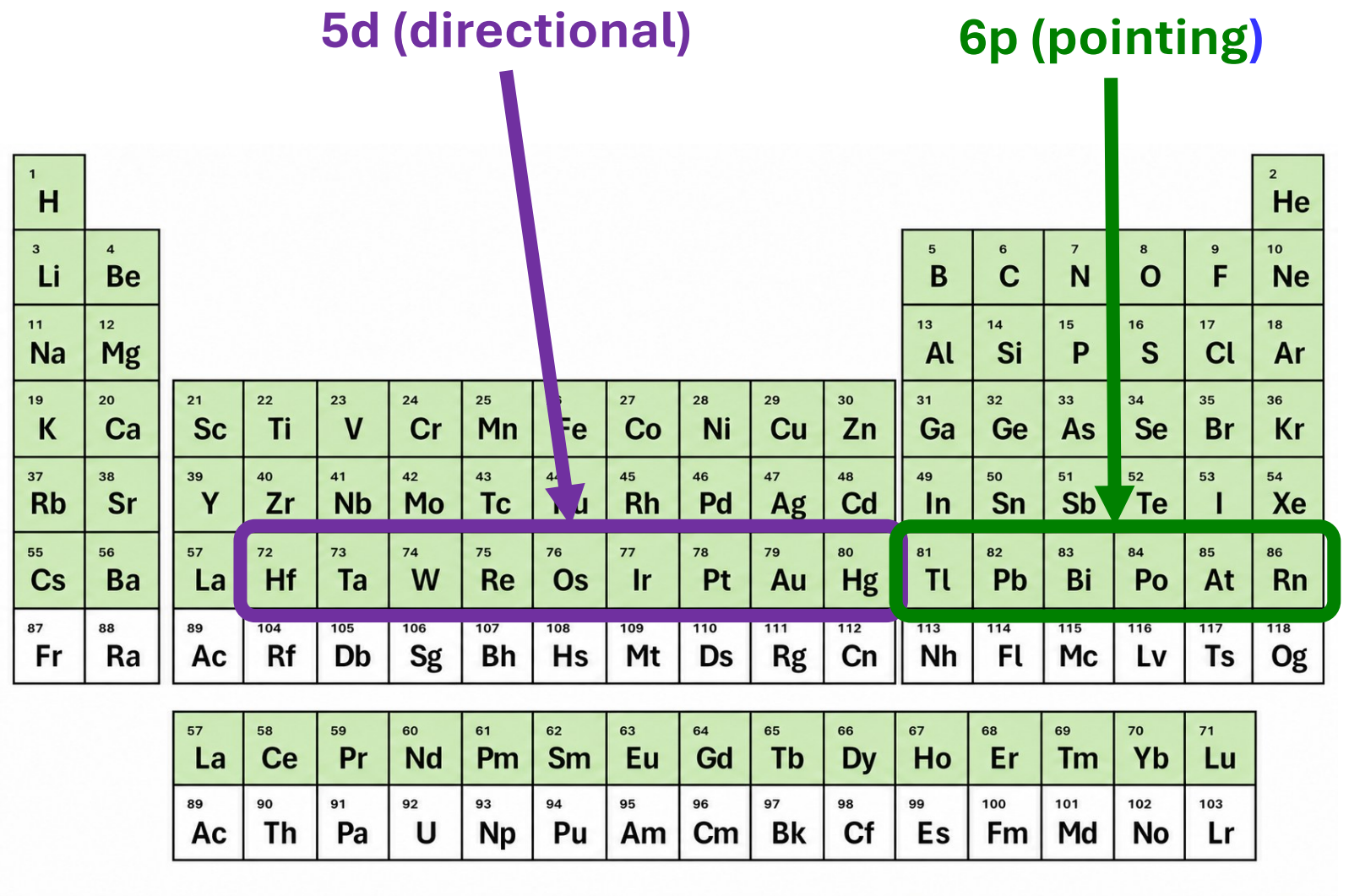
This is where both d an f enter the picture:

- Starting with row 6
  - The two 6s electrons are filled.
  - Then ONE 5d electron is filled.
  - Then the 14 electrons of the 4f subshell are filled.

The s electrons are from the current shell, then one d electron from the previous shell, and then the 14 f electrons from two shells back!



Completing the Sixth Shell



This is where both d an f enter the picture:

- **Continuing with 5d and 6p**
  - **The remaining 9 5d electrons are filled.**
  - **Then the 6 6p electrons are filled.**

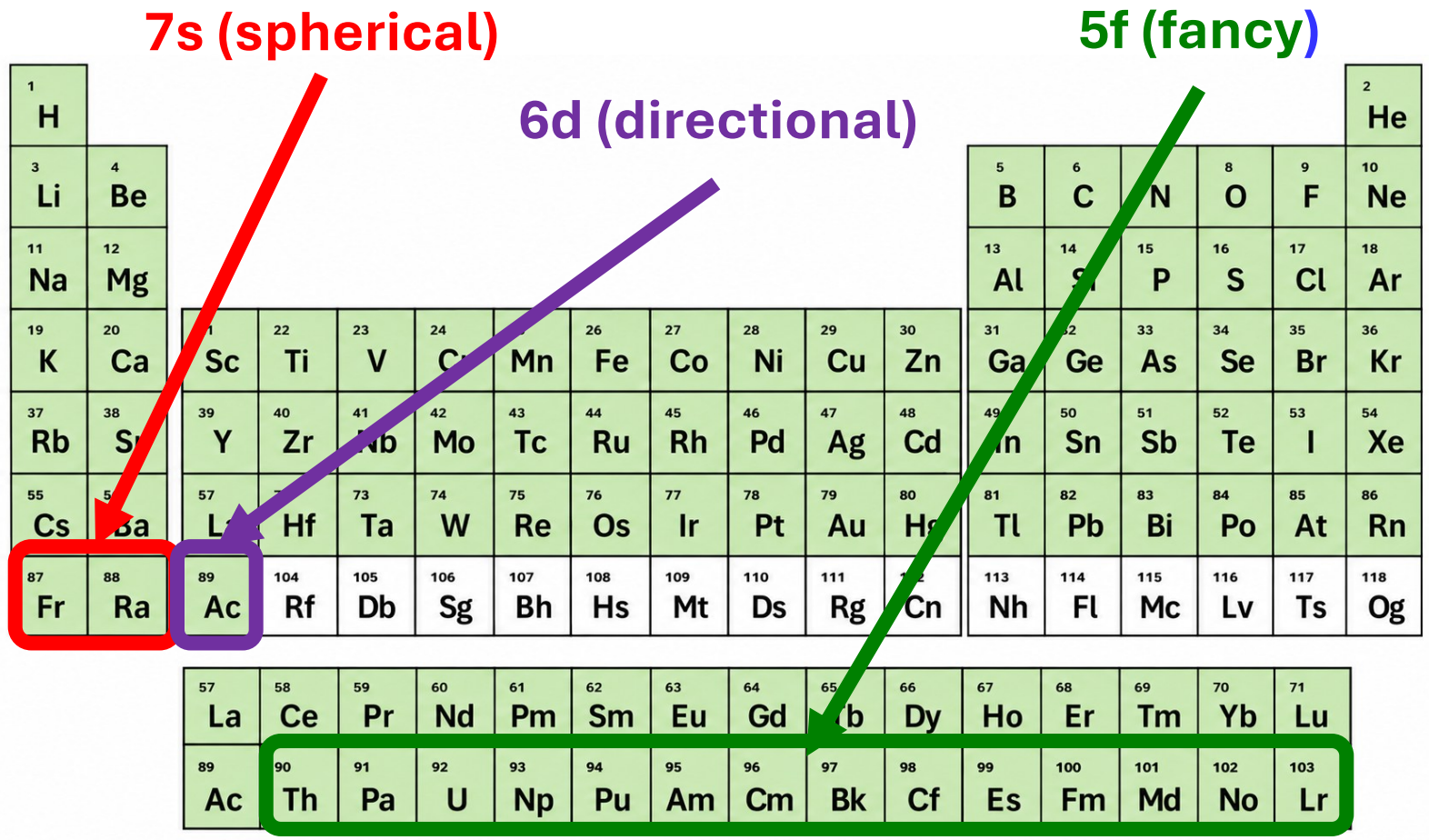
The 2 s and 6 p electrons are from the current shell, then 10 d electrons are from the previous shell, and the the 14 f electrons from two shells back!

Filling the Seventh Shell

This is where both d an f enter the picture:

- Starting with row 7
  - The two 7s electrons are filled.
  - Then ONE 6d electron is filled.
  - Then the 14 electrons of the 5f subshell are filled.

The s electrons are from the current shell, then one d electron from the previous shell, and then the 14 f electrons from two shells back!

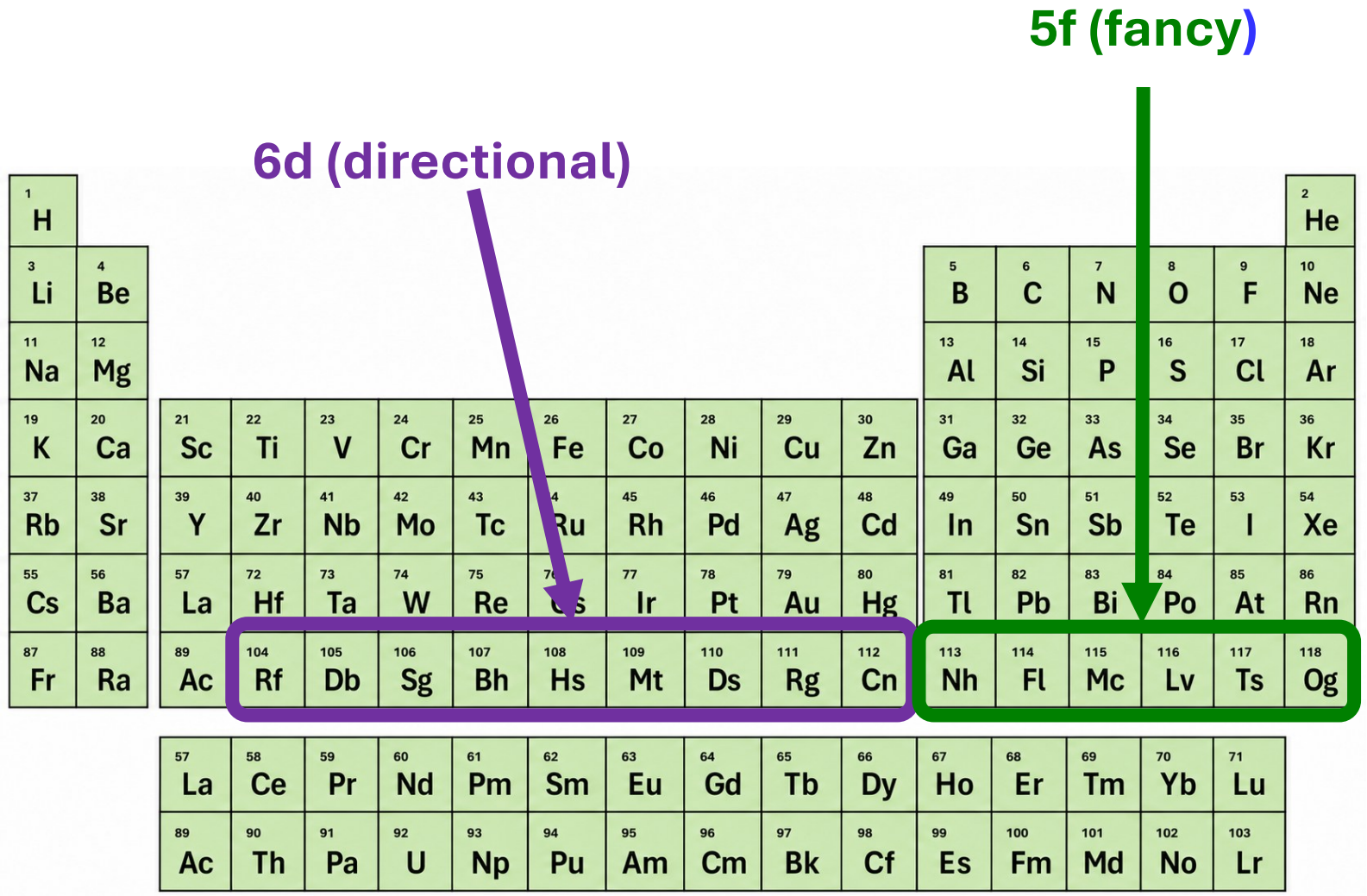


Completing the Seventh Shell

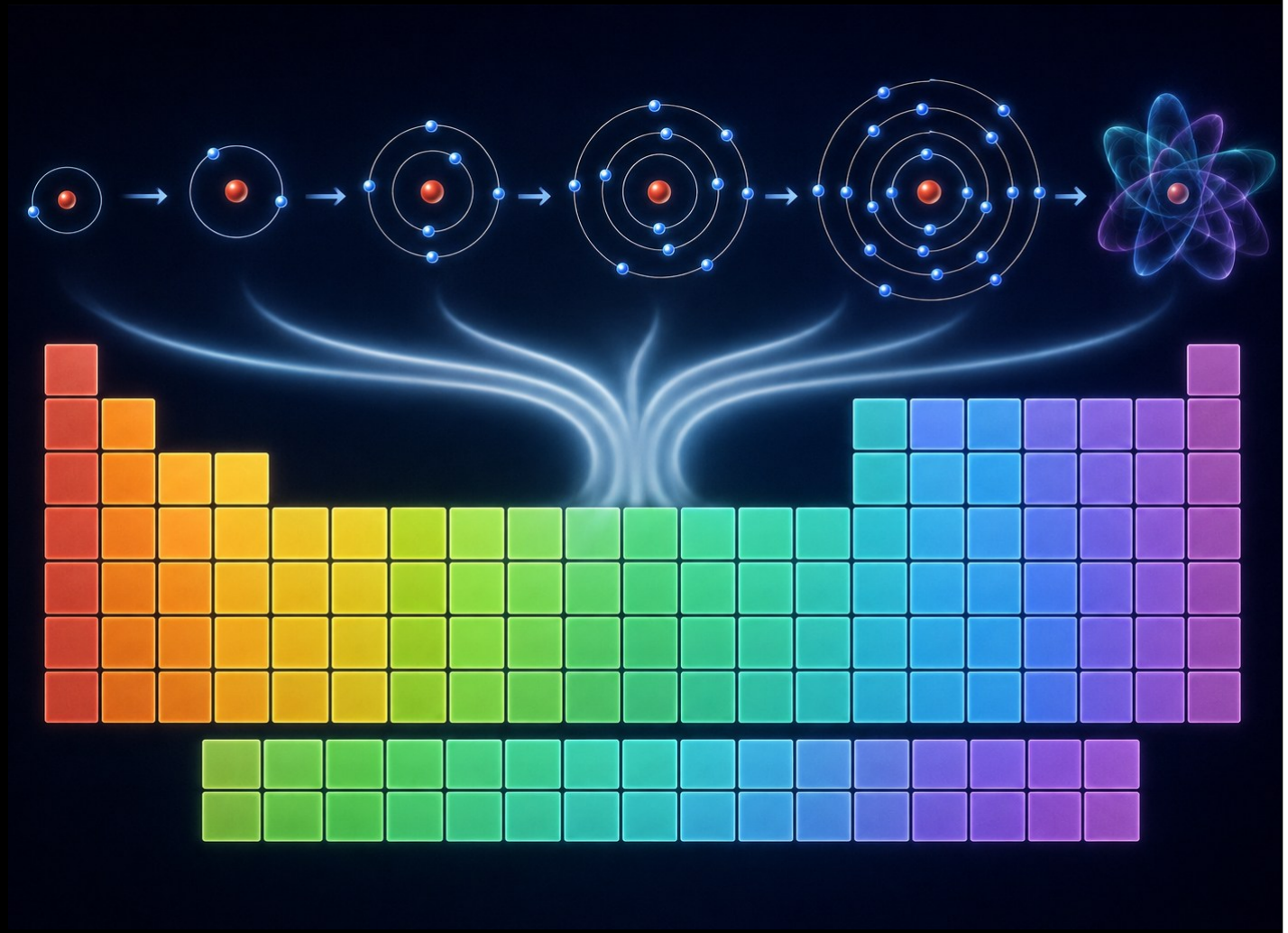
This is where both d an f enter the picture:

- Continuing with 6d and 7p
  - The remaining 9 6d electrons are filled.
  - Then the 6 6p electrons are filled.

The s electrons are from the current shell, then one d electron from the previous shell, and then the 14 f electrons from two shells back!



The Periodic Table Emerges Naturally



Every element is produced by adding one proton and one electron at a time.

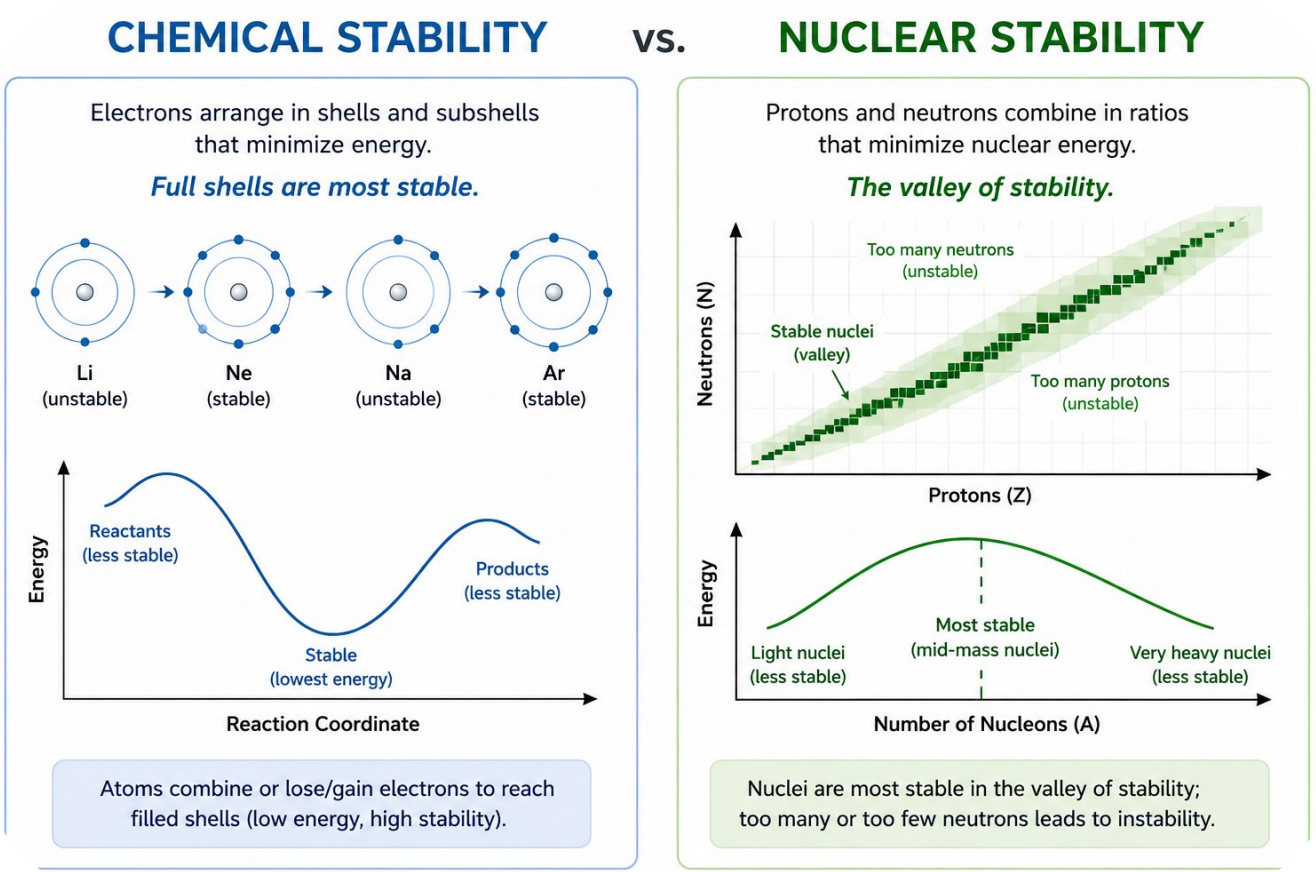
- **Each new electron occupies the lowest-energy probability distribution predicted by the Quantum State Machine.**
- **The periodic table is simply the record of that filling process.**

What are the Most Chemically Stable Elements?

Chemical Stability

- **Filled outer electron shells produce**
  - **chemical stability.**
- **Examples**
  - **Helium**
  - **Neon**
  - **Argon**

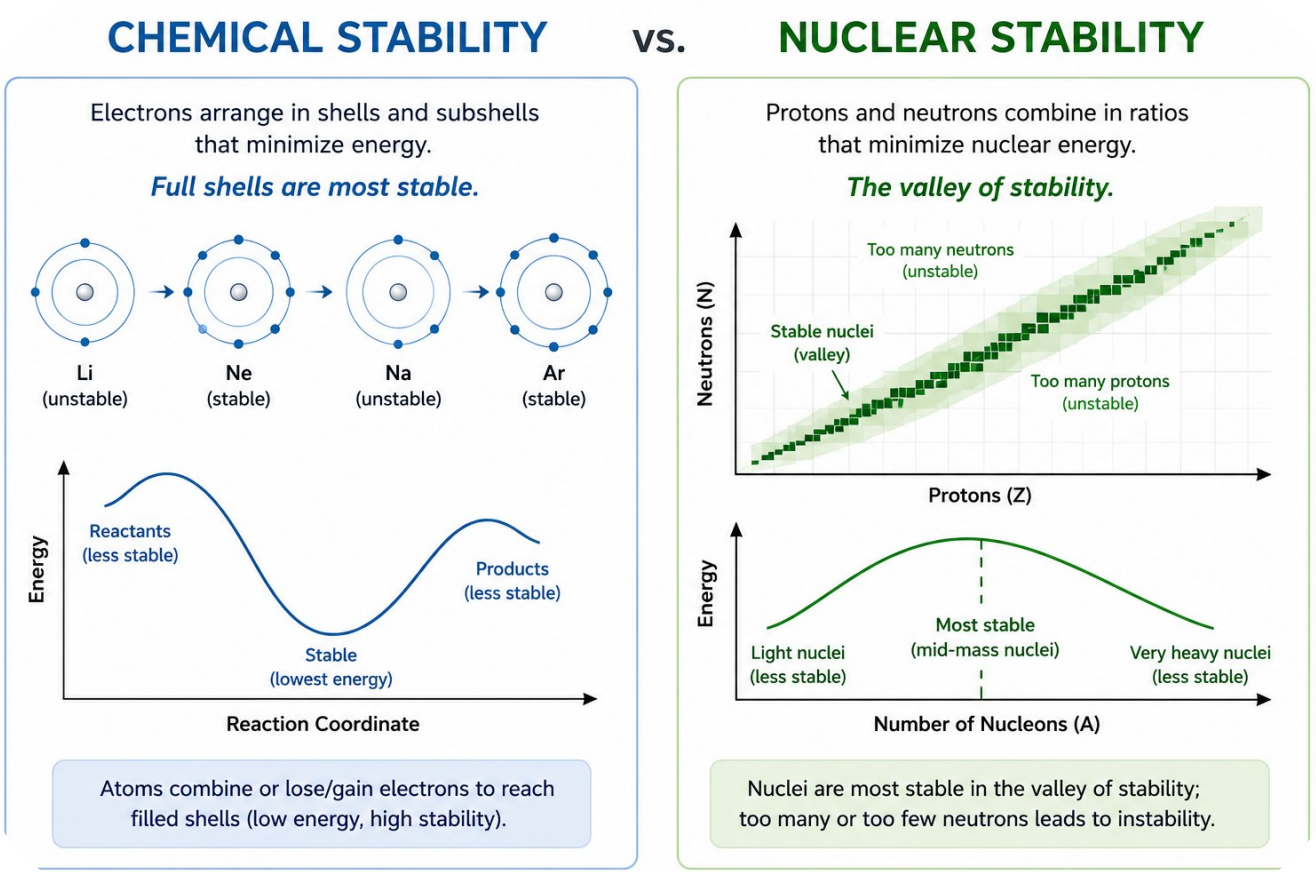
These atoms are the noble gases.



Two Different Concepts of Stability

Nuclear Stability Is Different

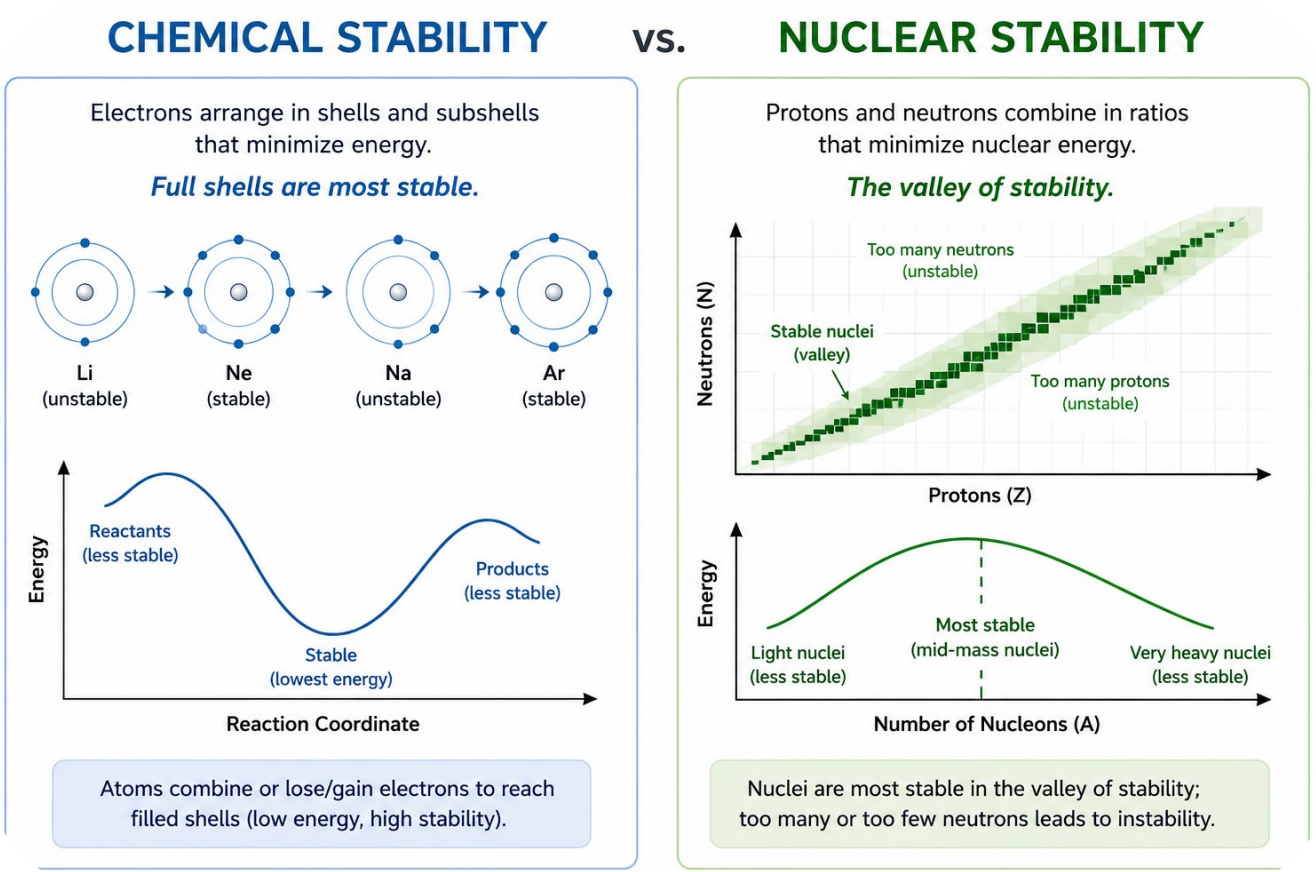
- **Do not confuse**
  - **chemical stability**
- **with**
  - **nuclear stability.**
- **They arise from completely different physics.**



The Quantum State Machine Predicts Both

Nuclear Binding Energy

- The most tightly bound nuclei are near
  - Iron-56
- and
  - Nickel-62
- Fusion in stars naturally moves toward this region.
  - This is Nuclear Stability (refers to the nucleus)
  - Chemical stability refers to the electrons and their shells



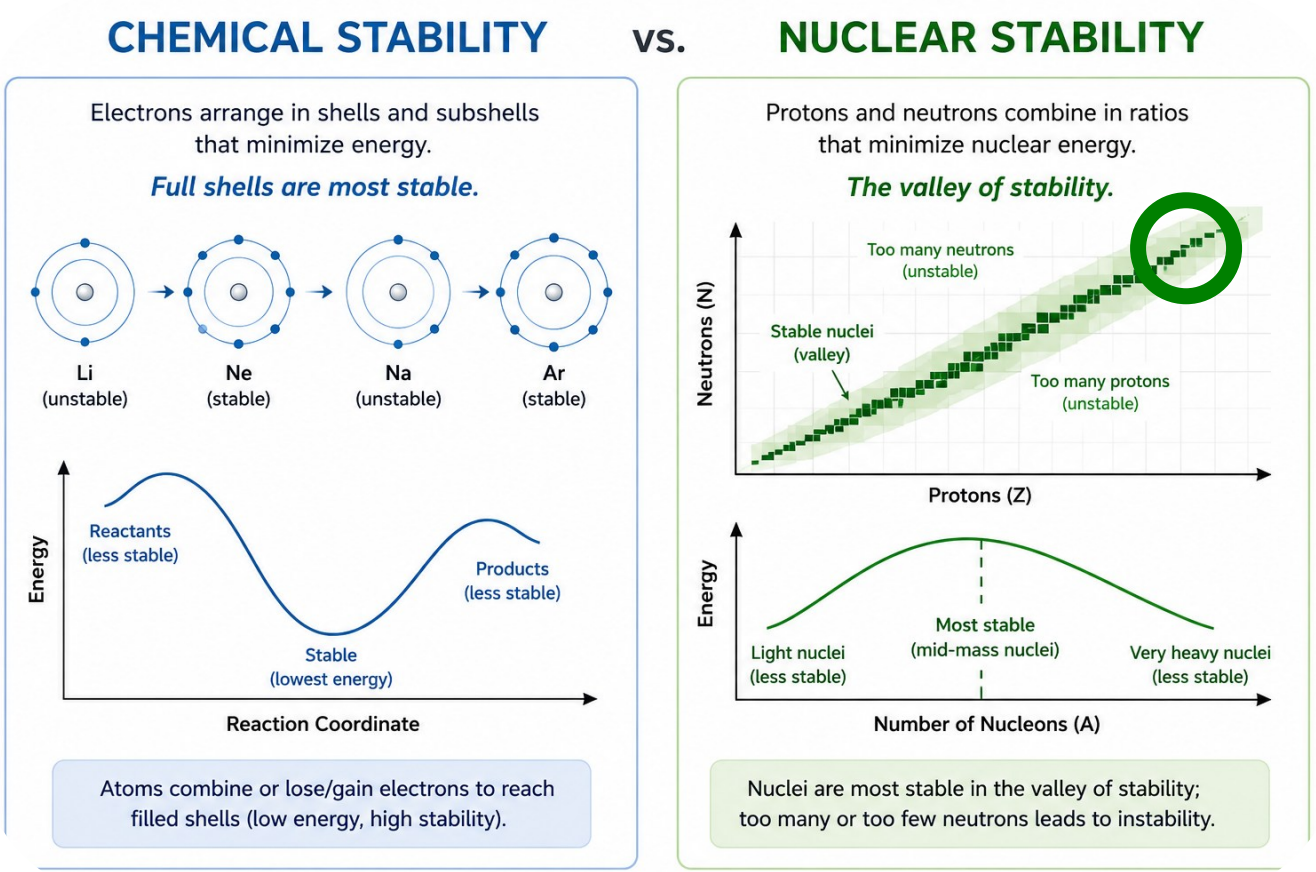
The Quantum State Machine Predicts Both

Why Lead Matters

- **Lead is not the most tightly bound nucleus.**

However,

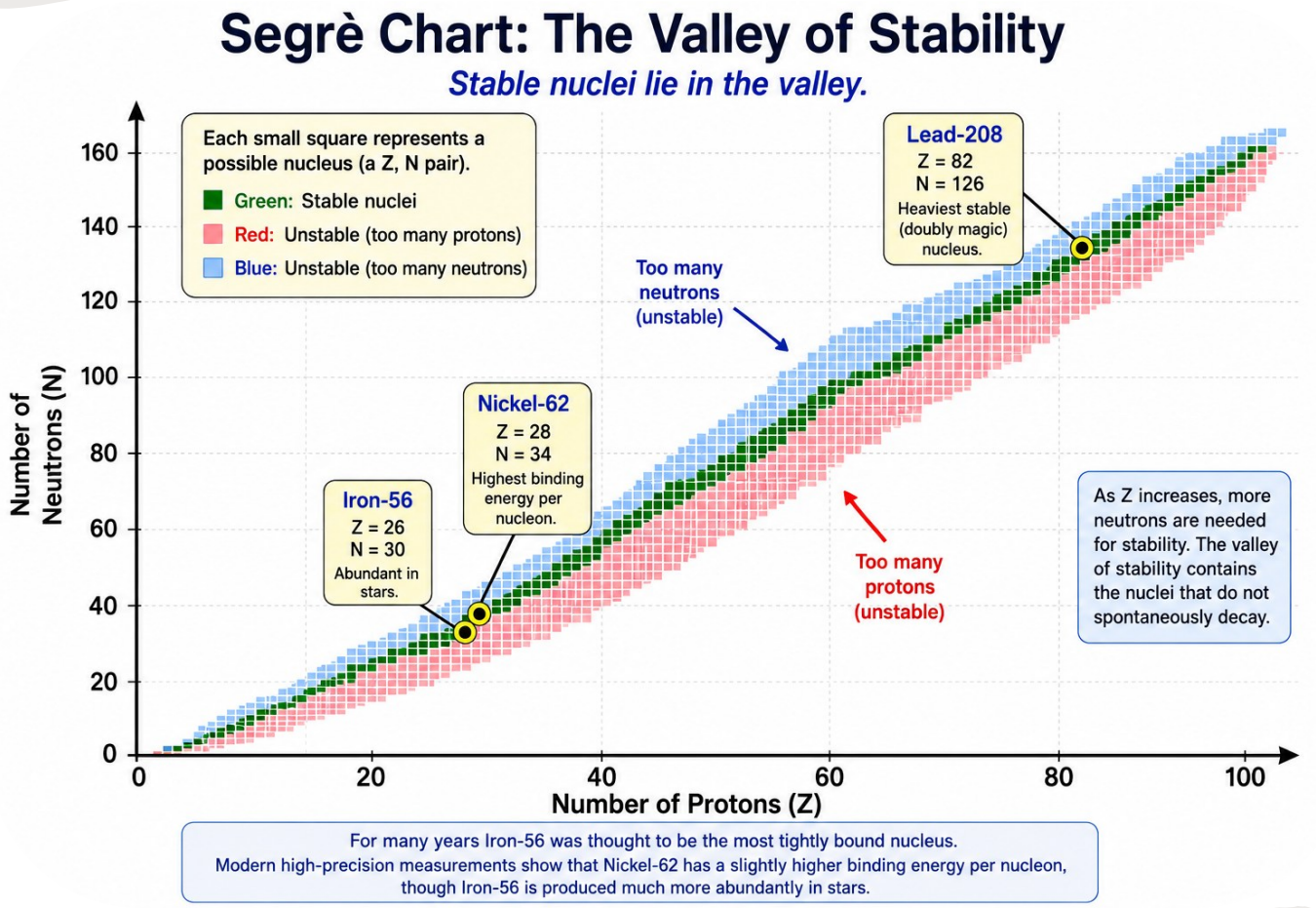
- **many radioactive decay chains eventually end**
- **at stable isotopes of lead.**



Lead-208 — A Doubly Magic Nucleus

Magic Numbers

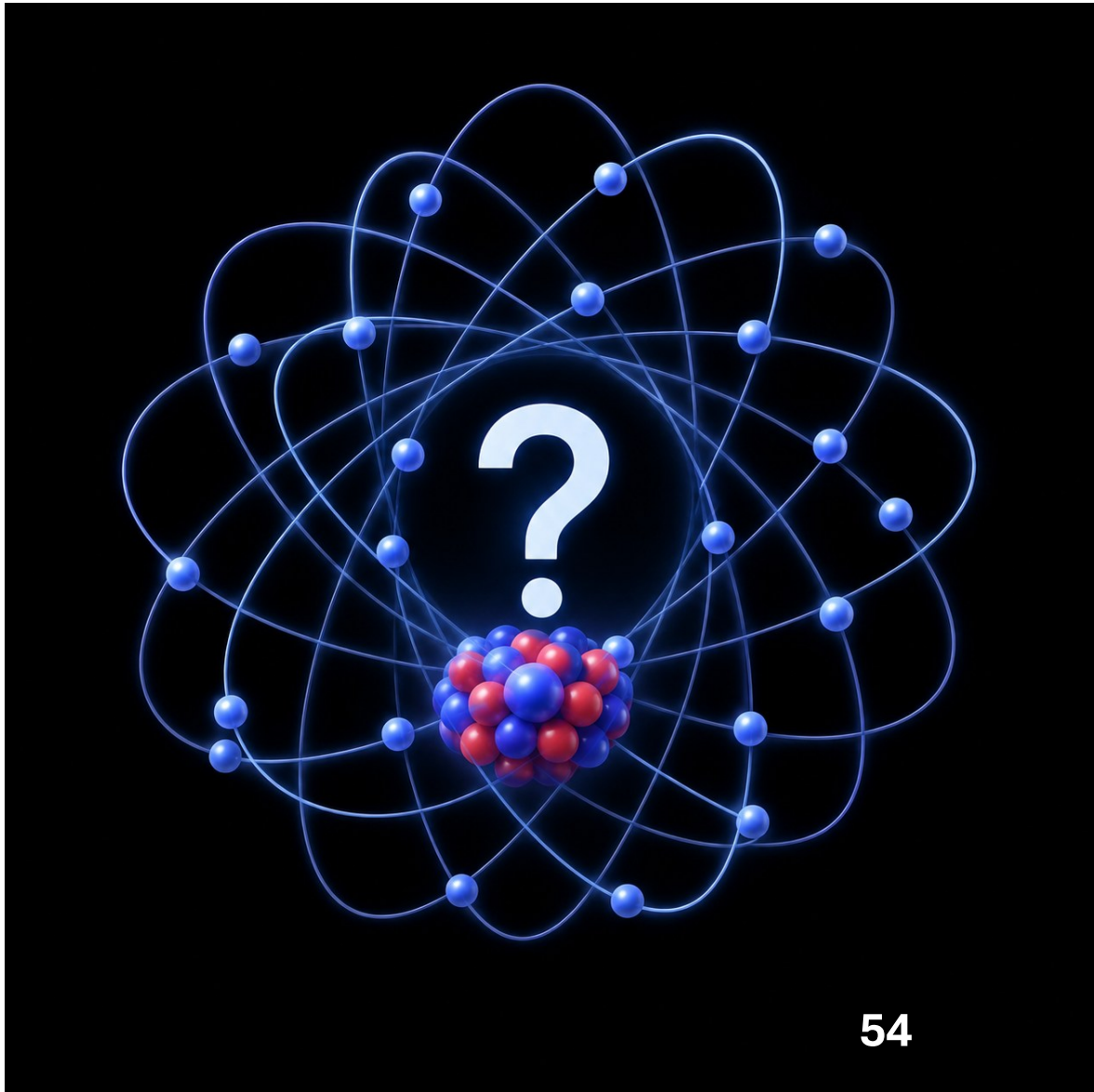
- The nucleus has shells, much like the electron shells surrounding the nucleus.
- A filled nuclear shell is called a magic number.
- Nuclei with filled proton and neutron shells are especially stable.
- Five naturally occurring nuclei are doubly magic:
  - Helium-4 (2 protons, 2 neutrons)
  - Oxygen-16 (8 protons, 8 neutrons)
  - Calcium-40 (20 protons, 20 neutrons)
  - Calcium-48 (20 protons, 28 neutrons)
  - Lead-208 (82 protons, 126 neutrons)



Naturally Occurring Chemical Elements

The Big Picture

- The Quantum State Machine has now built
  - Hydrogen
  - Helium
  - Every atom
  - The Periodic Table
  - Chemistry
- The next question is…
  - Where did all of these atoms come from?



Next Our Final Video from Nick Lucent

Video Introduction

- The Origin of the Chemical Elements
- Hydrogen and helium formed in the Big Bang.
- Stars forged heavier elements through nuclear fusion.
- Supernovae and neutron-star mergers created the heaviest elements.

Those elements eventually became

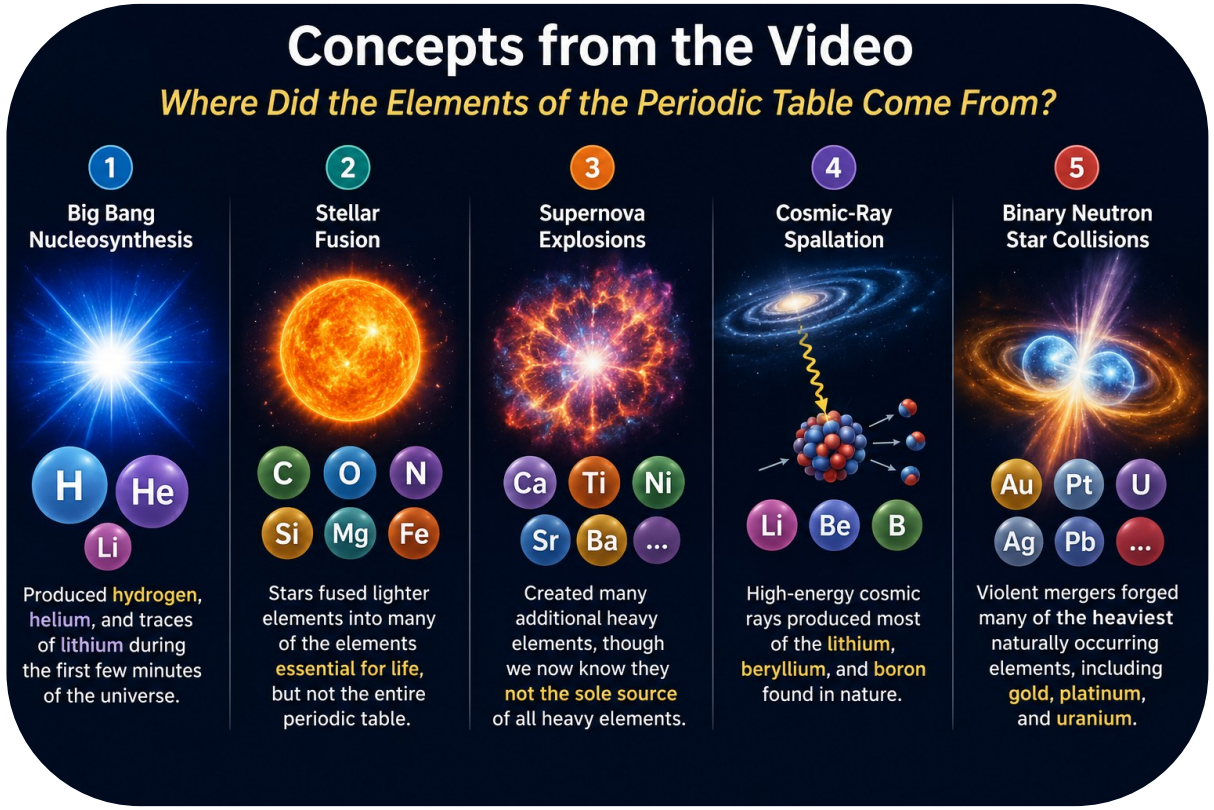
- planets,
- living organisms,
- and us.


METHOD OF OPERATING ARC LAMPS
NIKOLA TESLA
0:00 / 19:36
Intro
CC

Concepts from the Video

Where Did the Elements of the Periodic Table Come From?

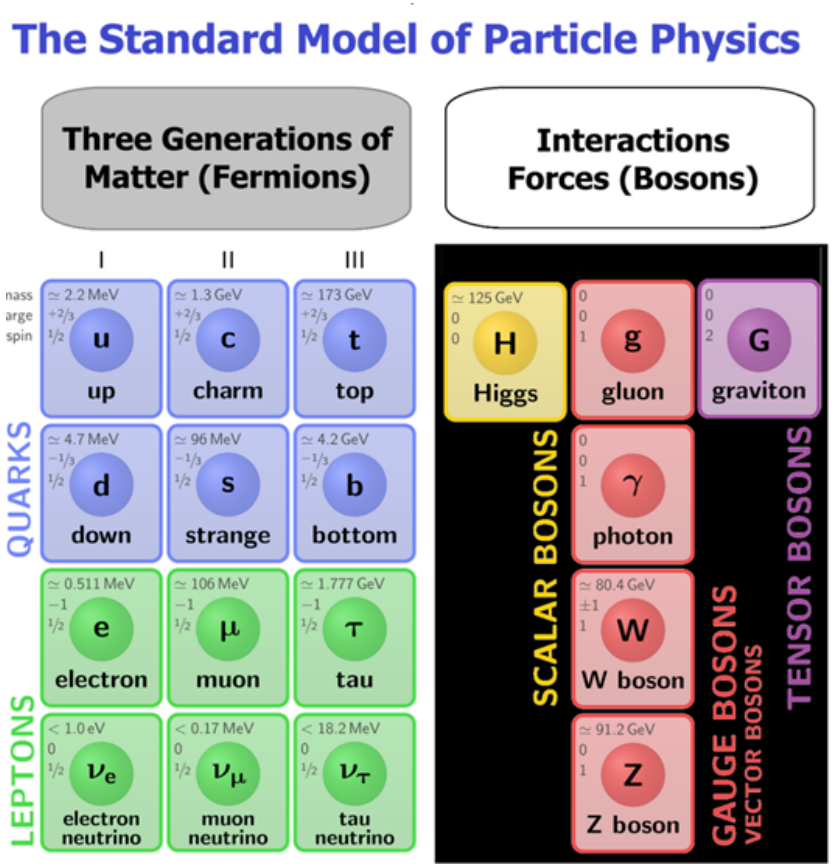
1. **Big Bang Nucleosynthesis** — Produced **hydrogen, helium, and traces of lithium** during the first few minutes of the universe.
2. **Stellar Fusion** — Stars fused lighter elements into **many of the elements essential for life**, but not the entire periodic table.
3. **Supernova Explosions** — Created **many additional heavy elements**, though we now know they are **not the sole source** of all heavy elements.
4. **Cosmic-Ray Spallation** — High-energy cosmic rays produced **most of the lithium, beryllium, and boron** found in nature.
5. **Binary Neutron Star Collisions** — Violent mergers forged **many of the heaviest naturally occurring elements**, including gold, platinum, and uranium.



Beyond the Standard Model

Throughout this lecture series we have focused on the Standard Model of particle physics.

- **It explains:**
  - **The elementary particles**
  - **Three of the four fundamental forces**
  - **Atoms**
  - **Chemistry**
  - **The periodic table**
- **It is one of the most successful scientific theories ever developed.**



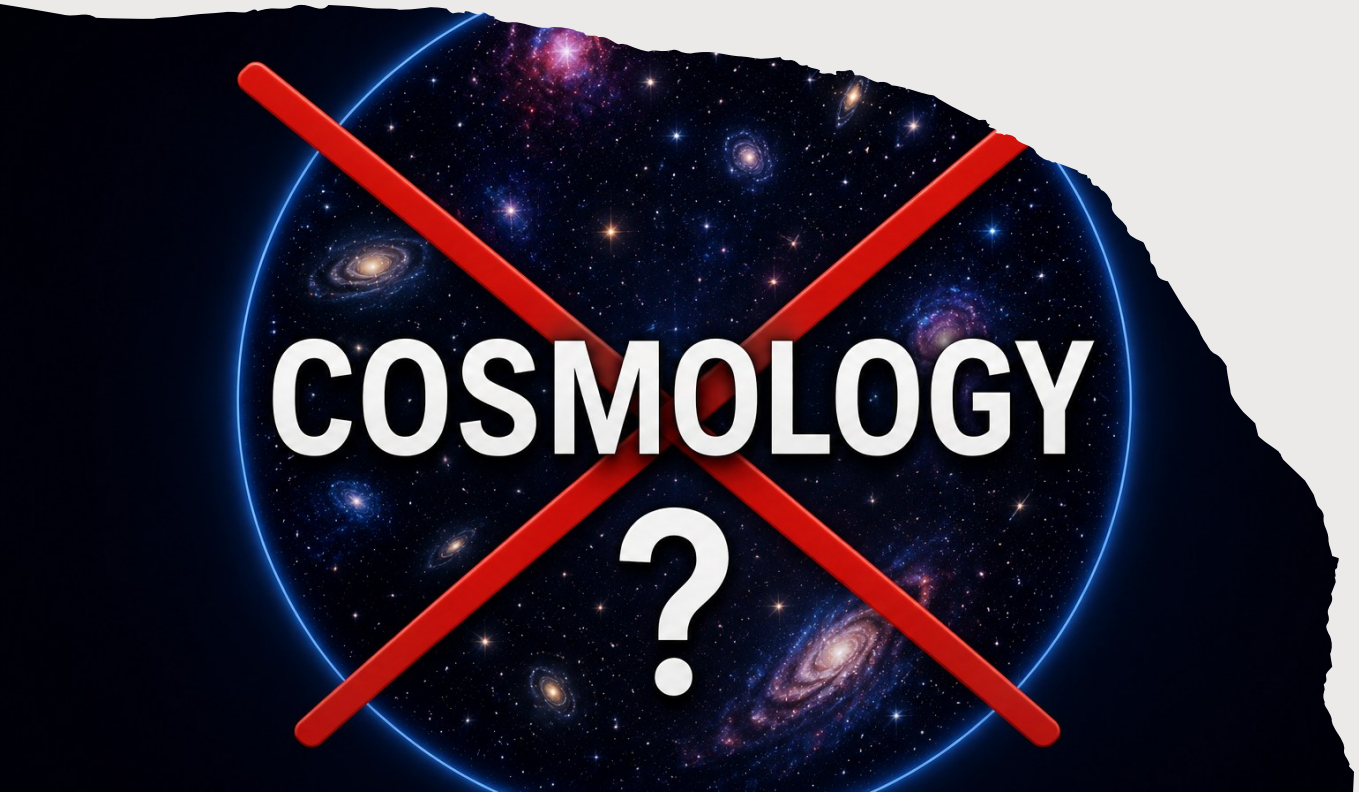
One Important Force Is Missing

There is one force we have intentionally left out.

- **Gravity.**

- Gravity is described by Einstein's General Theory of Relativity, **not by the Standard Model.**
- Developing a quantum theory that successfully unifies gravity with the Standard Model remains one of the greatest challenges in modern physics.

Why I Didn't Cover Cosmology



Popular science books and videos often discuss

- quantum physics
- the Standard Model
- black holes
- dark matter
- dark energy
- the Big Bang

- as though they are all part of one theory.

They are not.

- This lecture series has focused on the Standard Model of particle physics.
- Cosmology is a different field that studies the universe on its largest scales.

What Cosmologists Observe

Astronomers have discovered that

- galaxies rotate faster than expected
- the universe is expanding at an accelerating rate

These observations are well established.

The challenge is explaining why they occur.

- Current leading explanations include
  - dark matter
  - dark energy
- Their true physical nature remains unknown.

Open Questions

Many exciting questions remain.

- Can gravity be successfully unified with quantum physics?
- What are dark matter and dark energy?
- Will future discoveries connect these questions?

Today, no one knows.

- These remain active areas of scientific research.

A New Window on the Universe

In recent years, scientists have opened an entirely new way of observing the universe.

- **Instead of seeing only light, we can now detect gravitational waves produced by violent cosmic events.**
- **Nick Lucent mentioned in the video that new observations such as the collision of two neutron stars creates both gravitational waves and electromagnetic radiation.**
- **These observations allow scientists to test General Relativity with extraordinary precision and to explore some of the most extreme environments in nature.**

The Journey Continues...

We have explored

- ✓ quantum states
- ✓ probability amplitudes
- ✓ quantum state machines
- ✓ atoms
- ✓ the periodic table

- **These ideas explain an enormous range of the physical world.**

Yet one great challenge remains:

- **bringing gravity and quantum physics together into a single coherent theory.**

Thank You

Two Transformative Physics Models:

- The Standard Model has transformed our understanding of nature.
- General Relativity has transformed our understanding of gravity.
- Together they represent two of humanity's greatest intellectual achievements.

Yet they are still incomplete.

- The search for a deeper theory—and the continuing exploration of our universe—is one of the greatest scientific adventures of our time.
- Thank you for joining me on this journey.

Suggested Reading: Process Theology

- **Suggested Reading – Process Theology**
- **1.** Introduction to Process Theology
  C. Robert Mesle
  A friendly, non-technical introduction—the perfect place to begin.
- **2.** Process Theology: An Introductory Exposition
  John B. Cobb Jr. & David Ray Griffin
  The classic introduction—a deeper and more systematic exploration of Process Theology.
- **3.** God, Christ, Church: A Practical Guide to Process Theology
  Marjorie Hewitt Suchocki
  Discover how Process Theology reshapes traditional Christian beliefs and practices.
- **4.** The Promise of Process Theology
  Bruce G. Epperly
  See how Process Theology is applied to contemporary spirituality and everyday life.
- **5.** The Heart of Christianity
  Marcus J. Borg
  An inspiring bridge from Process Theology to Progressive Christianity.

Suggested Reading : Quantum Physics

- **1.** Waves in an Impossible Sea
  Matt Strassler
  The best modern introduction to the Standard Model and quantum fields.
- **2.** QED: The Strange Theory of Light and Matter
  Richard P. Feynman
  Discover how quantum probabilities successfully predict the behavior of light and matter.
- **3.** In Search of Schrödinger's Cat
  John Gribbin
  Follow the remarkable history that led to the quantum revolution.
- **4.** Fearful Symmetry
  A. Zee
  Explore why symmetry became the organizing principle of modern particle physics.
- **5.** Reality Is Not What It Seems
  Carlo Rovelli
  Look beyond the Standard Model toward the frontier where quantum physics meets gravity.

Where Do We Go From Here?

We have spent eight weeks learning how quantum physics works.

- **The Standard Model**
  - **Quantum states**
  - **Time evolution**
  - **Probability**
  - **Atoms**
  - **The Periodic Table**
- **But one fascinating question still remains…**
  - **What does quantum physics tell us about the nature of reality?**

A Possible Future Lecture Series

Interpretations of Quantum Physics
Using Process Theology as a Lens

- **Why are there so many interpretations of quantum physics?**
  - **The Copenhagen Interpretation**
  - **The Many-Worlds Interpretation**
  - **Bohm's Hidden Variables**
  - **Objective Collapse Theories**
  - **Relational Quantum Mechanics**
  - **Theological Perspectives on Quantum Reality**
- **What have we learned?**
  - **One mathematical theory… many different views of reality.**


"That's all Folks!"
lsberg©