

# **What is science? Can I be a scientist? Which are my scientific careers? What does a STEM graduate degree involve?**

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**The University of Memphis**

**PD UofM Spain Program  
Wednesday, July 5th, 2023**

**Driven by  
doing.**



**THE UNIVERSITY OF  
MEMPHIS.**

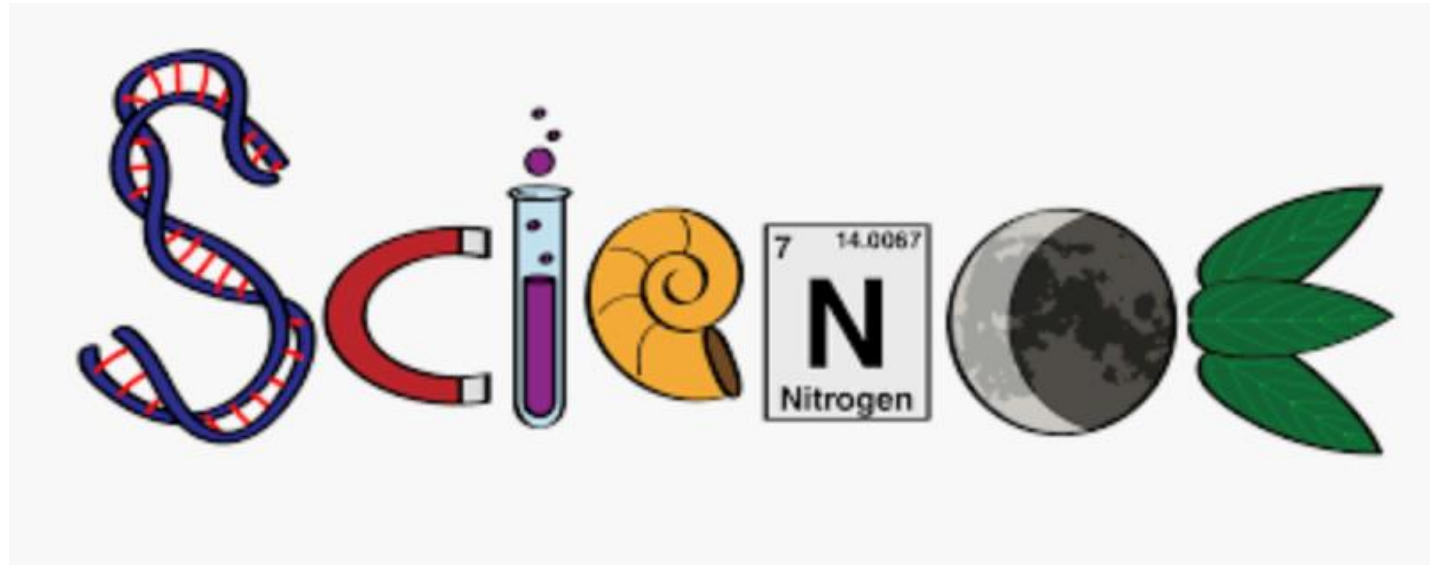
# Objective of this session

At the end of the session, students will be able to

1. Define science
2. Differentiate between the deductive and inductive scientific method
3. Understand the career path for investigators
4. Identify a prestigious STEM degree

# What does Science mean?

The word *science* is understood by many to refer to the process of discovering and understanding of the world.

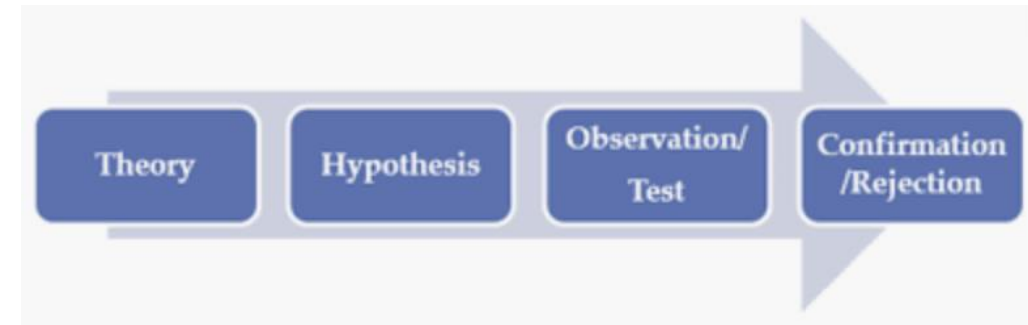


# Aspects of the key word understanding

1. *A foundation in observations* – Observations connect the world to science. Observations can involve quantitative measurements.
2. *A logical framework* – Logic is fundamental to any activity that claims to follow any scientific method.
3. *Predictive power* – Given a validated theory, one can predict outcomes/results in new situations.
4. *Repeatability and testability* – The outcomes of any scientific investigation can be repeated and corroborated through independent testing by other investigator.

# Scientific methods based on deduction

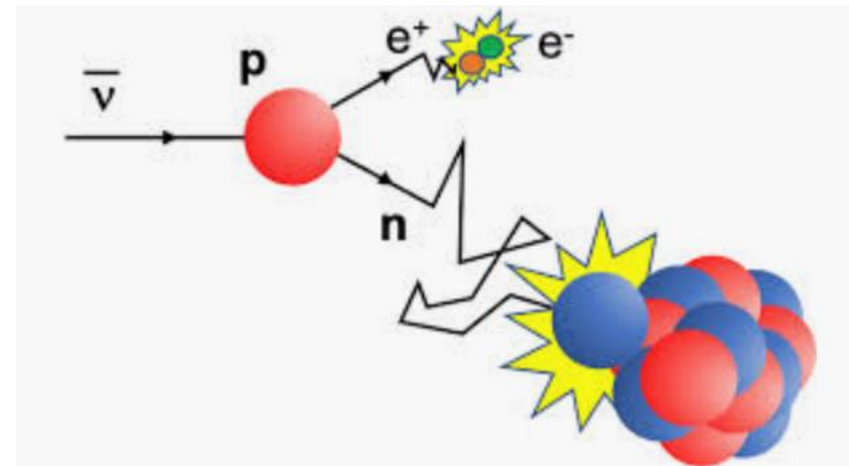
The deductive approach follows logic closely. The reasoning starts with a theory that leads to a new hypothesis. This hypothesis is put to the test by confronting it with observations that either lead to a confirmation or rejection of the hypothesis.



Be careful: agreement of the observation with the hypothesis does not mean that the hypothesis is always valid. Make sure to analyze the hypothesis in several scenarios to provide full support/validation of the hypothesis.

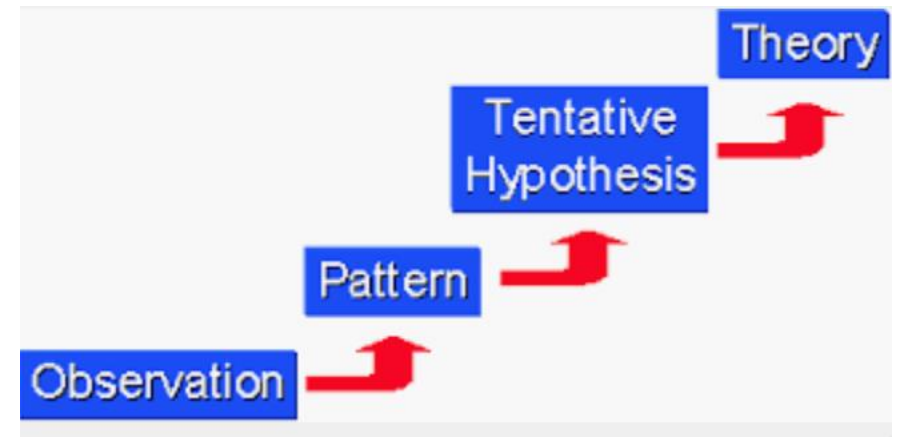
# The discovery of the neutrino - Example of the deductive approach

According to theory, mass, energy and electric charge are conserved. It was discovered in 1930 that the process of beta decay did not comply with conservation of the mass and energy. This led Enrico Fermi to propose the existence of an electrically neutral particle without rest-mass (i.e., neutrino). In 1930, the presence of the neutrino was hypothesized. After an intense effort of 26 years, the neutrino was detected by Cowan et al. in 1956, proving its existence.



# Scientific methods based on induction

The induction approach is the reversed of the deductive. Observations might reveal patterns, leading to the formulation of a hypothesis for an underlying cause explaining such patterns. The hypothesis, or a combination of hypotheses, can lead to a new theory.



Be careful: the theory is totally dependent on the observations. It is not a global method.

# The discovery of how cholera spreads - Example of the inductive approach

In 1854, bacteria and viruses were unknown; how and why contagious diseases spread thus was not understood. John Snow noticed a pattern in patients with cholera; many of them had been drinking water from a particular pump in London. This observation led him to hypothesize that cholera was spread through drinking water. This major step led Louis Pasteur to formulate the germ theory in 1857. The presence of bacteria and viruses was later confirmed by observations, establishing their connection with several diseases.



*Vibrio cholerae* growing on thiosulphate citrate bile salt sucrose (TCBS) agar plates



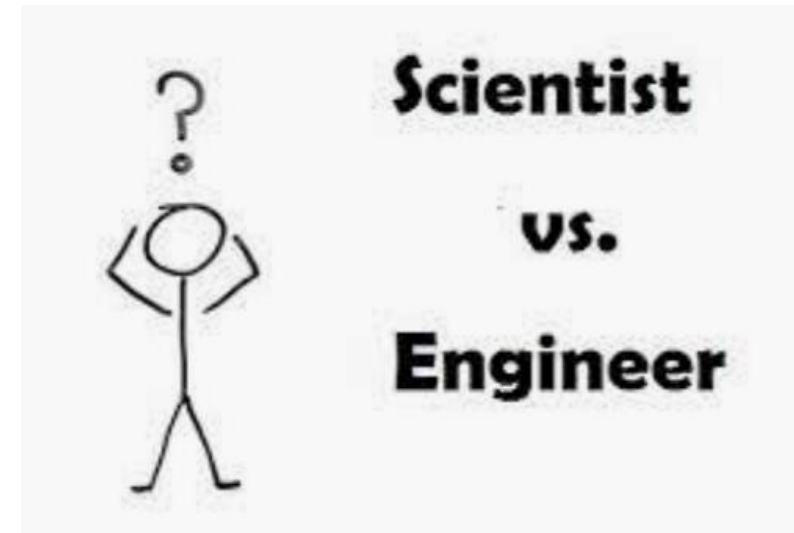
# Discussion: Are AI/ML models based on deductive or inductive approaches?



# The difference between Scientists and Engineers

While a scientist usually wants to discover *how* and *why* things work, the engineer's primary aim is to *make* things work (problem-solving mindset). Therefore, it seems that the engineer takes a more pragmatic approach than the scientist does.

However, this distinction between science and engineering is not factual. For example, any creative engineer needs to first know why things work.



# Discussion: How do you identify yourself?



**Scientist**

**vs.**

**Engineer**

# Signs You Were Born to be a Scientist

- Interested in scientific activities at an early age
- Obsessed with problem solving
- You understand that science is never easy and that's ok
- Prefer to watch TED Talks and Discovery Channel than blockbusters movies
- Your heroes are well-known scientists
- More interested in scientific events than going to prom/club/disco



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**MYTHS!**



# The Scientific Career

- Your scientific career starts at, and is shaped by Graduate School
- Your scientific career may lead you to job opportunities in academia, industry and/or government
- Your career choices may change over time, requiring flexibility and adaptability
- Stay informed, plan ahead, and be open to unexpected changes in your career path



Sierra Nishizaki

# Evolving/adaptability is a key element to have a successful scientific career

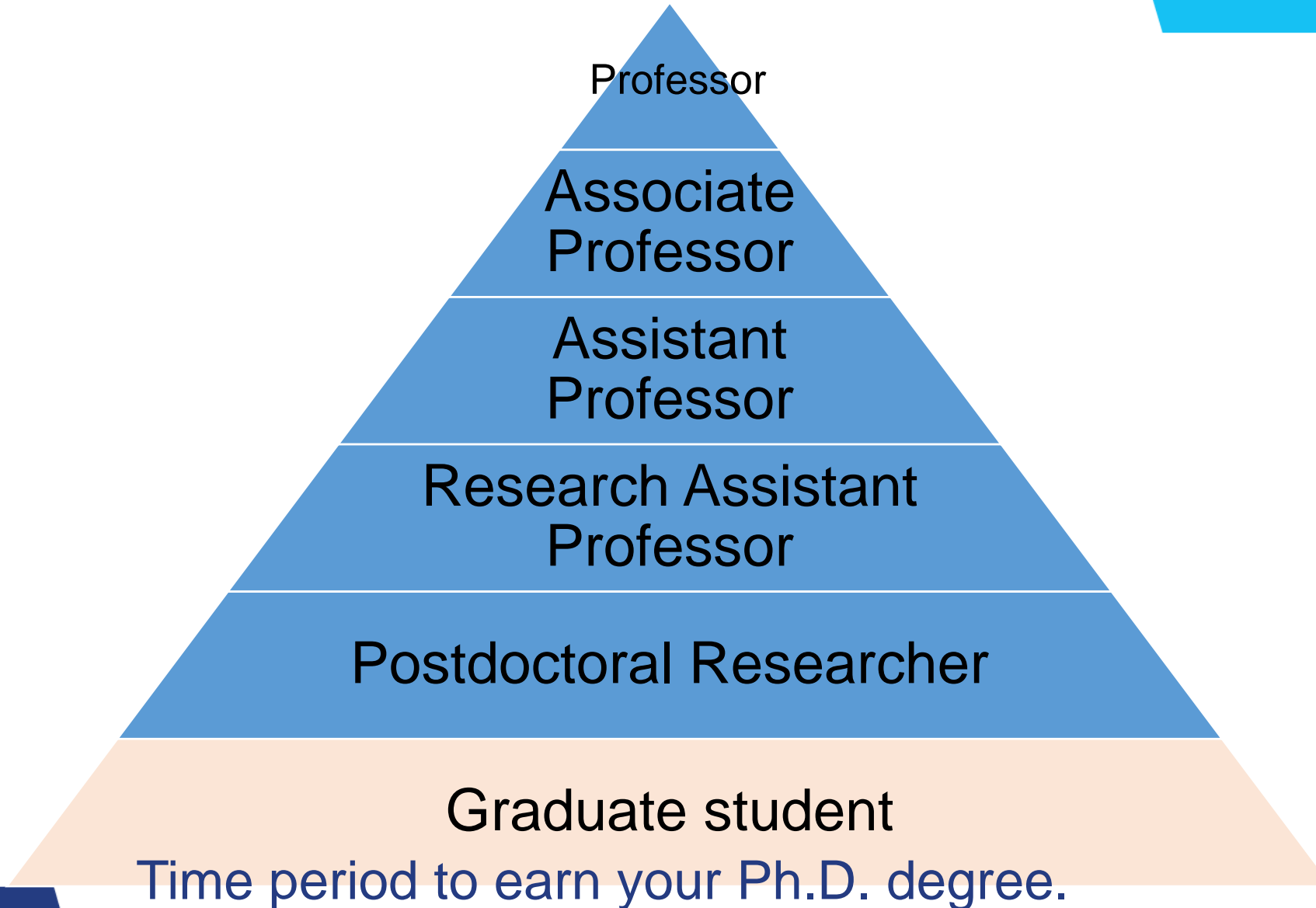
- The field of scientific careers is complex and constantly evolving
- Society plays a role in shaping the types of career choices available
- Stay informed about the latest hot topics in your research interesting areas/topics and always keep up with the science



MAY 10, 2023

FACT SHEET: Biden-Harris  
Administration Outlines Priorities for  
Building America's Energy  
Infrastructure Faster, Safer,  
and Cleaner

# The Scientific Career – Academia



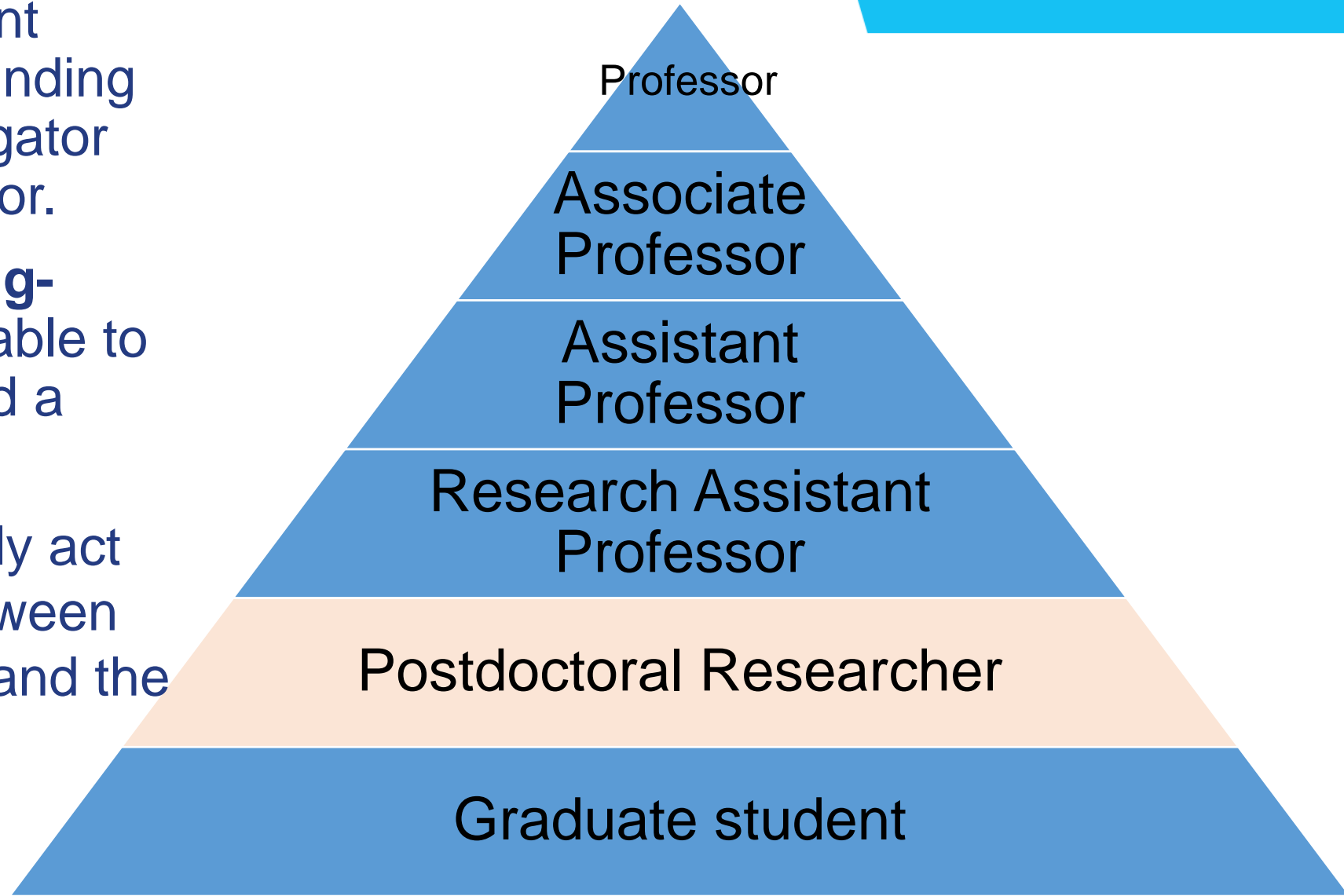


# The Scientific Career – Academia

Non-tenured appointment (temporary) based on funding of your Principal Investigator (PI), which is your advisor.

The postdoc is a **training-focused position** available to people who have earned a doctorate.

Postdoc positions usually act as a stepping-stone between the student experience and the full-time professional experience.

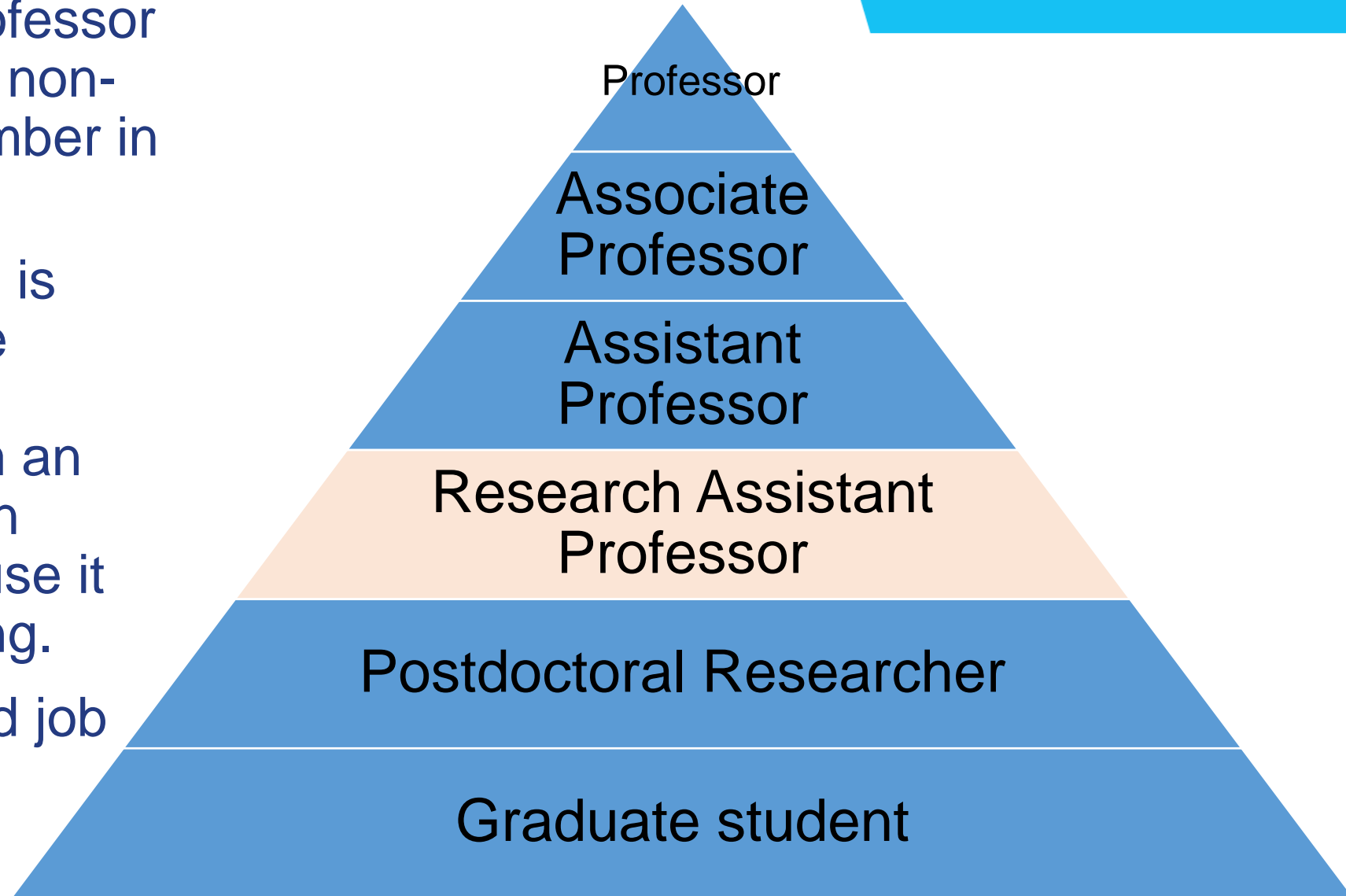


# The Scientific Career – Academia

A research assistant professor works in academia as a non-tenure-track faculty member in a specific department.

Funding for this position is associated to a PI of the institution. This role is somewhat different from an assistant professor or an adjunct professor because it does not require teaching.

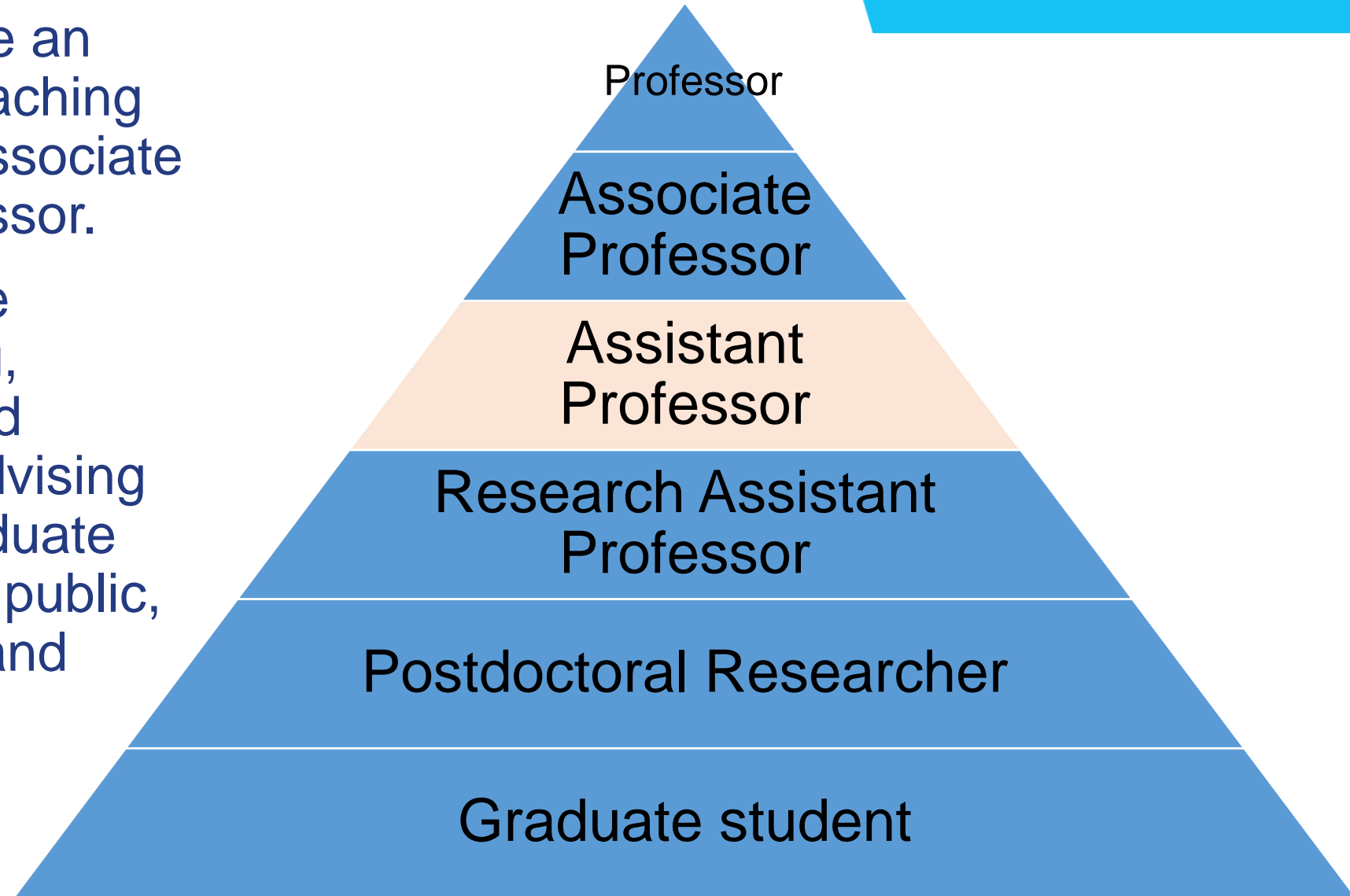
Mostly a research-based job position.



# The Scientific Career – Academia

Assistant Professors are an entry-level university teaching position below that of associate professor and full professor.

Assistant professors are responsible for teaching, conducting research and publishing its results, advising undergraduate and graduate students, and providing public, departmental, college, and university service.

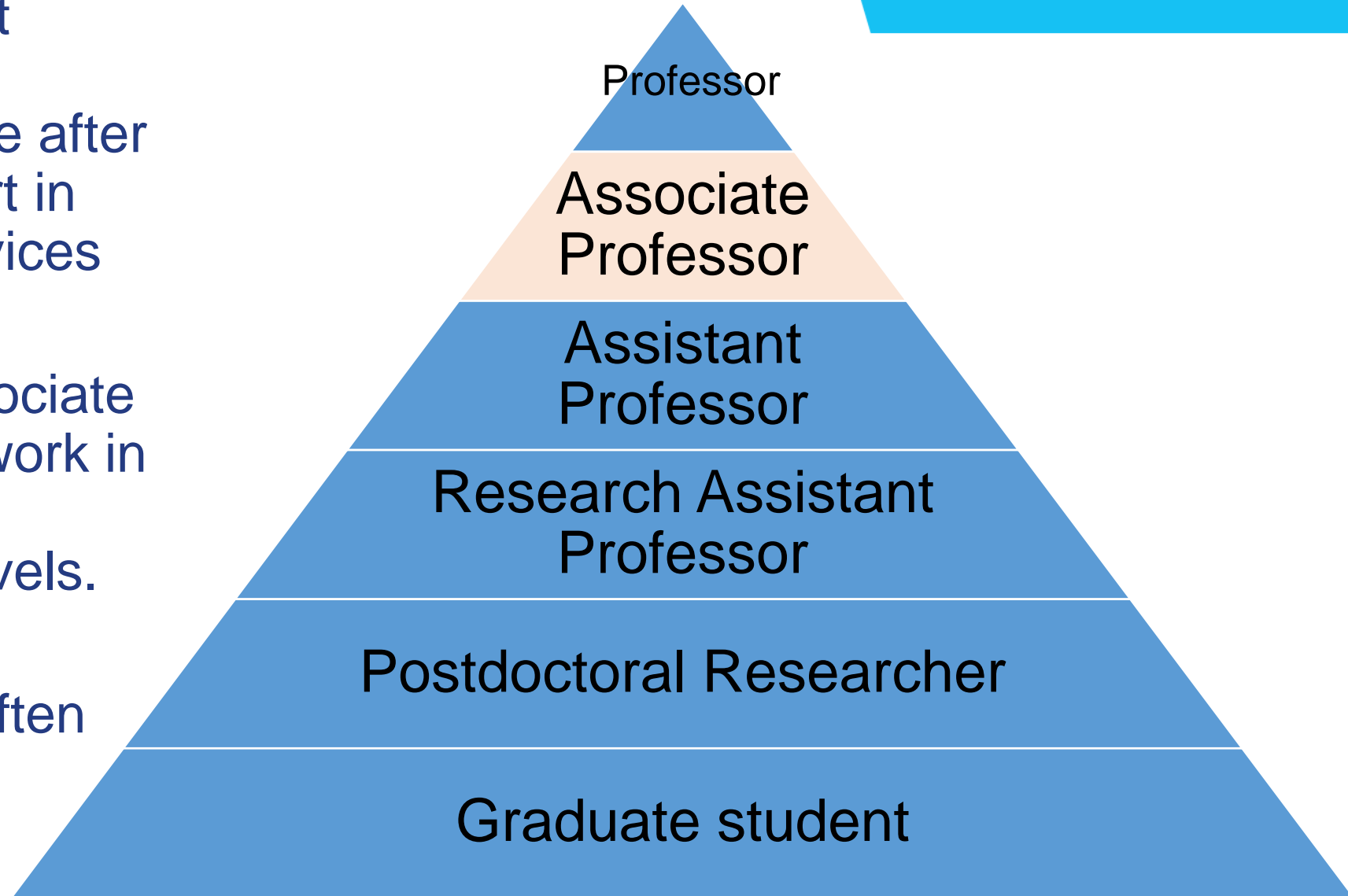


# The Scientific Career – Academia

Assistant Professors get promoted to Associate Professor and get tenure after showing significant effort in research, teaching, services and outreach.

Once promoted, an associate professor continues to work in teaching, research, and service, but at higher levels.

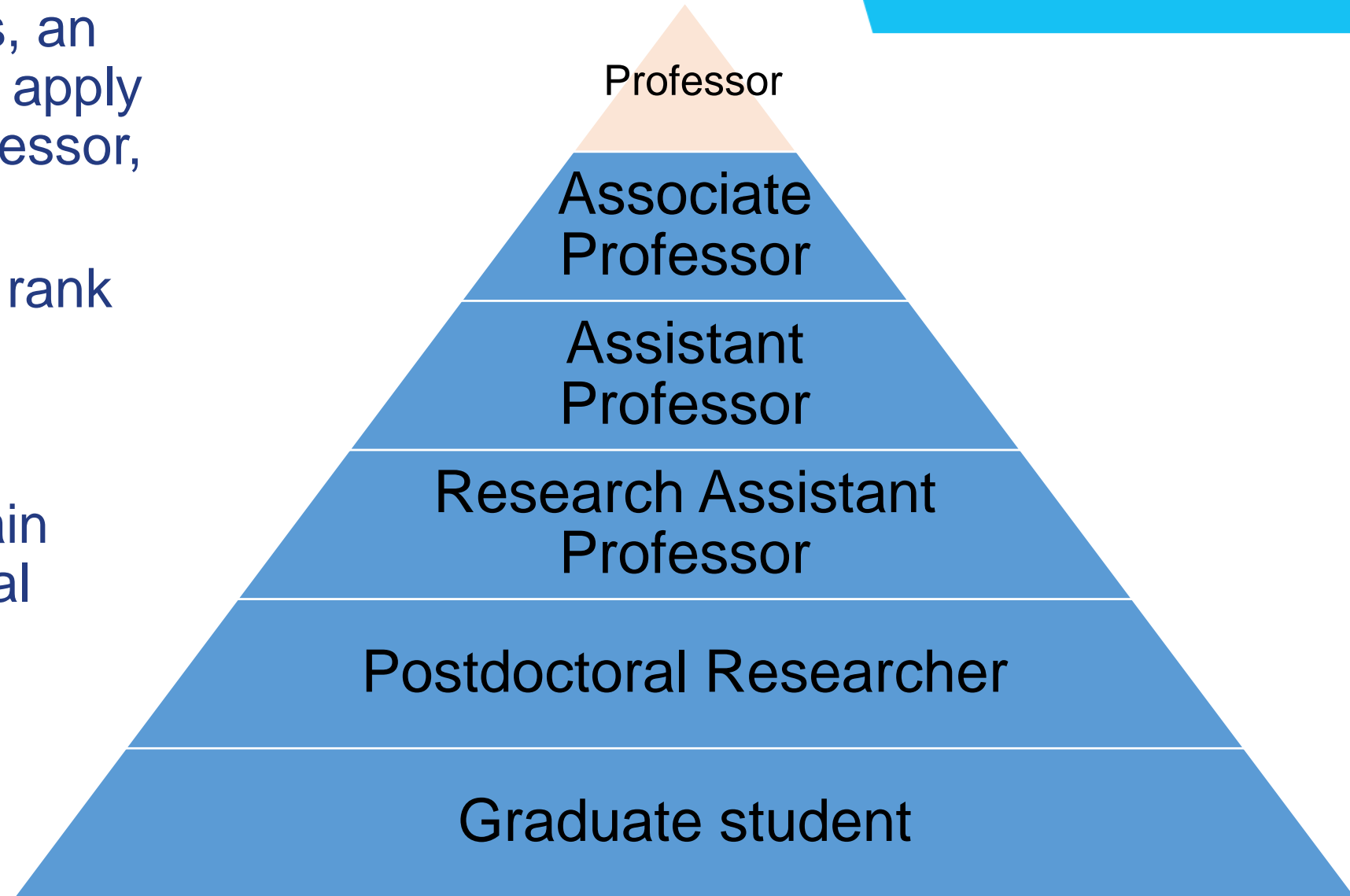
The biggest shift for an associate professor is often an expansion of service activities.



# The Scientific Career – Academia

After five to seven years, an associate professor can apply for promotion to full professor, or simply, professor.

Professor is the highest rank on a tenure track. Chair departments should be Professors. To become professors, one must gain national and international prestige.



# The Scientific Career – Industry

Industry scientists use their analytic skills to contribute to the creation of meaningful products within a corporate setting.

There is a broad diversity of industrial careers with different expectations and policies. Some companies even have an academic-like research environment.

The final career position is to become manager or non-research positions in some companies.



# The Scientific Career – Non-profit research organization

In the United States there are several non-profit research organizations that lead research in some areas.

For example, St. Jude Children's Research Hospital is leading the way the world understands, treats and defeats childhood cancer and other life-threatening diseases.



# The Scientific Career – Non-profit research organization

St. Jude Hospital supports scientific research by investing in resources, technologies, and infrastructure that represent a robust discovery and development pipeline that is unusual among academic institutions.

Funding can come through donations or applying well-established external proposal in US agencies like NIH.



St. Jude Children's  
Research Hospital<sup>®</sup>  
*Finding cures. Saving children.*



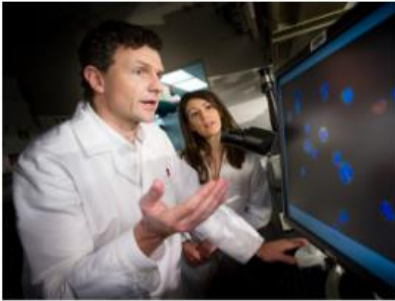
# The Scientific Career – Non-profit research organization

The engine of discovery at St. Jude is powered by some of the brightest minds in science and medicine, equipped with world-class resources and driven by the shared mission of advancing cures. We understand that fundamental science builds the foundation for clinical impact, and we are committed to supporting hypothesis-driven and exploratory research that asks daring questions to drive innovation



St. Jude Children's  
Research Hospital<sup>®</sup>  
Finding cures. Saving children.

# The Scientific Career – Non-profit research organization



## Faculty Jobs

Lead your own innovative research program in an exceptional environment.

[LEARN MORE](#) [SEE JOBS](#)



## Scientific Research Jobs

Do the science that drives tomorrow's discoveries.

[LEARN MORE](#) [SEE JOBS](#)



## Clinical Research Jobs

Join the quest for better treatments.

[LEARN MORE](#) [SEE JOBS](#)



## Bioinformatics Jobs

Harness big data to make a difference for patients worldwide.

[LEARN MORE](#) [SEE JOBS](#)



## Postdoctoral Fellowships

Launch your career with a unique training experience.

[LEARN MORE](#) [SEE JOBS](#)



## Good Manufacturing Practice (GMP) Jobs

Produce innovative biological therapies that go straight to our patients.

[LEARN MORE](#) [SEE JOBS](#)

# The Scientific Career – National Laboratories

The National Laboratories conduct scientific research and development in areas related to energy and technology.

An outgrowth of immense investment in scientific research initiated by the U.S. Government during World War II, the National Laboratories have served as the leading institutions for scientific innovation in the United States for more than seventy years.

The 17 National Labs tackle the critical scientific challenges of our time -- from combating climate change to discovering the origins of our universe -- and possess unique instruments and facilities, many of which are found nowhere else in the world. They address large scale, complex research and development challenges with a multidisciplinary approach that places an emphasis on translating basic science to innovation.

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# The Scientific Career – National Laboratories



Examples of breakthroughs by US National Labs:

Decoded DNA ; Put eyes in the sky ; Revolutionized medical diagnostics and treatment ; Brought safe water to millions ; Filled the Protein Data Bank; Invented new materials; Mapped the universe — and the dark side of the moon; Shed light on photosynthesis ; Revealed the secrets of matter; Confirmed the Big Bang and discovered dark energy; Invented a magic sponge to clean up oil spills; Pioneered efficient power lines ; Improved automotive steel; Pioneered nuclear safety modeling ; Identified good and bad cholesterol ; Created a pocket-sized DNA sampler; Exposed explosives; Toughened airplanes; Simulated reality; Detected the neutrino; Created the first 100-Tesla magnetic field; Froze smoke for hot uses; Invented the cell sorter; Ushered a domestic energy renaissance; Enabled space exploration ....



# Discussion: Differences between academic and industry jobs?

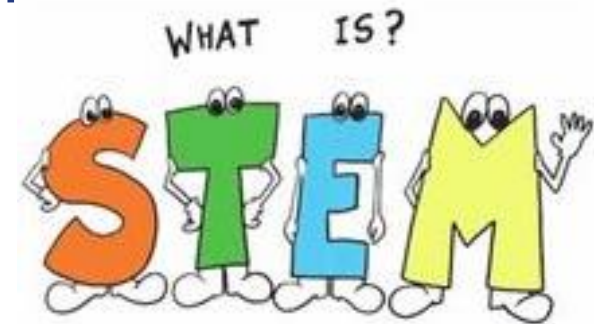
- Job security / Stability
- Academic Freedom
- Salary
- Job responsibility
- Collaboration
- Work pace
- Project volume
- Funding
- Applied research



# Definition of STEM

**STEM = Science, Technology, Engineering & Mathematics**

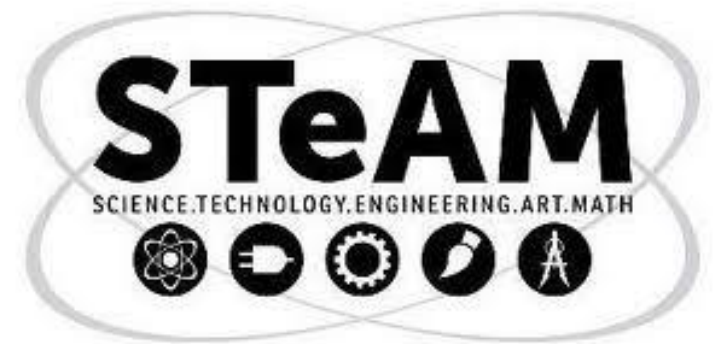
- **Science** - Discover and describe to provide a better understanding of the world
- **Technology** – Invent and innovate to improve the world
- **Engineering** – Control, modify and/or design materials, processes and systems to improve the world
- **Mathematics** – Symbolic language/model to represent the world



# Adding the Arts to create STEAM

**STEAM = Science, Technology, Engineering, Arts & Mathematics**

*The arts aim to teach students the value of creativity, innovation, communication, and contemplation. These skills are often in high demand within the workforce, where creative solutions to problems are needed and where different perspectives can be useful.*

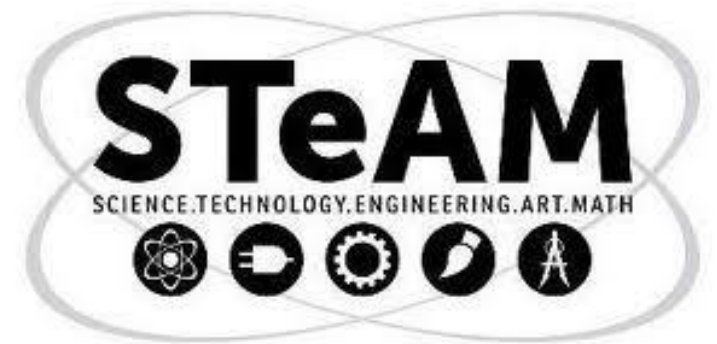




# STEAM Education involves the integration of all components

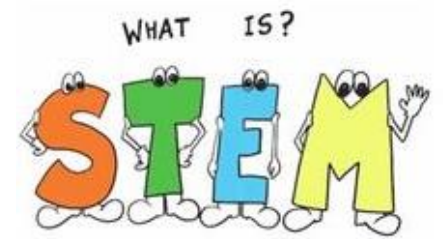
One of the big focuses of STEAM education is to facilitate **integration**.

The late CEO and co-founder of Apple, Steve Jobs, said: *“It is in Apple’s DNA that technology alone is not enough – that it’s technology married with liberal arts, married with the humanities, that yields us the results that make our hearts sing.”*



# Why is STEM important?

- ❑ STEM is synonym of innovation and creativity
  - *Think of the power of internet, or your cell phone – how they have affected how we interact, think & act*
- ❑ STEM changes our society
  - *Politics, Culture, Economics, Art, Music all have profound influences on STEM*
- ❑ All STEM activities seek the understanding of our world and improve it
- ❑ STEM fields are alive, always evolving and interacting



# What is a STEM Graduate degree?

- A STEM graduate degree is typically pursued after completing a bachelor's degree in a related discipline
- It is a specialized program of study that focuses on one of the disciplines within the STEM fields
- It involves advanced coursework, intensive research, and specialized training within a specific STEM discipline
- It provides opportunities for intellectual growth, skill development, and making original contributions to the field through research
- It prepares you for a wide range of career possibilities in industry, academia, government agencies, and non-profits

# Common aspects of a STEM Graduate Degree

- **Specialization:** STEAM graduate degrees allow students to specialize in a particular field or subfield of a discipline
- **Coursework:** STEAM graduate degrees place emphasis on advanced and specialized coursework (at least in the US)
- **Research:** Opportunities for doing research in a particular field or subfield
- **Seminars and conferences:** Opportunities for discussing current research, presenting work, and engaging in scientific discussions
- **Teaching and Assistantships:** Involvement in assisting undergraduate courses, grading assignments, leading tutorials, or teaching classes
- **Collaboration and Networking:** Opportunities to work together on projects and share ideas
- **Evolving:** Good STEM programs must be adaptable to the current needs

# What are some Careers in STEM?

## Computer Science

[What you can do with a computer science degree](#) may include roles working alongside:

- **Full-stack developers** - develop and troubleshoot the front end and back end of an application. Front-end developers focus on user engagement, experience and interface, and back-end developers concentrate on the functionality of the site or application between the database and the browser. As a full-stack developer, you must be knowledgeable about both. According to estimates from Payscale, the average full-stack web developer earned an annual salary of [\\$80,180](#) as of 2022.
- **Mobile app developers** - design applications for mobile devices and make sure they work properly. The most important critical skill you need to become an app developer is the ability to code. As of 2022, they earn a median annual salary of [\\$76,247](#), according to PayScale.
- **Web developers** - build and maintain websites. They develop, create, and test websites or interface layouts, functions and navigation for maximum usability. They earned a median annual salary of [\\$78,300](#) in 2021, according to BLS. Through 2031, this job is supposed to grow 23%, much faster than average.
- **Computer programmers/software developers** - write and test code that allows computer applications and software programs to function properly. In 2021, they earned a median annual salary of [\\$93,000](#), according to BLS.

# What are some Careers in STEM?

## Cyber Security

Some [types of cyber security roles](#) may include:

- **Information security analysts** - plan and execute security measures aimed to protect an organization's computer networks and systems. In 2021, they earned a median annual salary of [\\$102,600](#). The job is expected to grow 35% through 2031, much faster than the average, BLS reports.
- **Cyber security analysts** - focus on safeguarding information and network security and earn a median annual salary of [\\$78,483](#) as of 2022, according to Payscale, with top earners making upwards of \$115,000.
- **IT auditors** - analyze a company's network infrastructure and regularly conduct risk assessments and test for compliance. They earn a median annual salary of about [\\$72,262](#) according to data published as of 2022, according to Payscale.

<https://www.snhu.edu/about-us/newsroom/stem/what-nobody-told-you-about-being-a-stem-major#:~:text=STEM%20majors%20can%20be%20challenging,variety%20of%20projects%20and%20experiments.>

## Data Analytics

Some [careers data analysts](#) can pursue include working with:

- **Database administrators and architects** - design or organize systems that store and secure data. They earned a median annual salary of [\\$101,000](#) in 2021, according to BLS.
- **Operations research analysts** - solve business, healthcare or logistics problems by gathering and analyzing data gleaned from computer databases, sales histories and customer feedback. In 2021, they earned a median annual salary of [\\$82,360](#), BLS reports.

# What are some Careers in STEM?

## Information Technologies

There are many types of IT careers, including:

- **Computer and information systems managers** - plan, coordinate and oversee all computer-related activities in an organization. They earned a median annual salary of **\$159,010** in 2021, according to BLS. Job growth in this role is expected to be 16% through 2031, much faster than average.

## Mathematics

With a math degree, you can consider careers, such as:

- **Actuaries** - apply mathematics, statistics and financial theory to assess financial risk. This profession is in particularly high demand in the insurance industry, with some specializing in health insurance, life insurance and property and casualty insurance, but may also extend to the public sector. According to BLS, job prospects for actuaries are set to **soar 21%** through 2031, far faster than the national average. The median annual salary for actuaries was \$105,900 in 2021.
- **Mathematicians and Statisticians** - analyze data and apply computational techniques to solve problems. In this role, you are often required to have a master's degree. Individuals in these roles earned a median annual salary of **\$96,280** in 2021, according to BLS. The job is expected to grow 31% through 2031, much faster than average.

# What are some Careers in STEM?

## Environmental Science

Education in environmental science could pair well with these roles:

- **Conservation scientists and foresters** - study the land quality of forests, parks, rangelands and other natural resources. They earned a median annual salary of [\\$63,750](#) in 2021, according to BLS.
- **Environmental scientists and specialists** - apply what they've learned in the natural sciences to protect the environment. They may clean up polluted areas, develop policies or work with companies to reduce waste. They earned a median annual salary of [\\$76,530](#) in 2021, according to BLS.

## Game Programming and Development

If video games interest you, a degree in game programming and development could help you work alongside:

- **Game developers** - work on teams to write code for video game software. They bring video games to life on computers and gaming consoles. The median annual salary for this job as of 2022 is [\\$86,062](#), according to Payscale.
- **Game artists** - focus on the design aspect of game development by creating virtual game worlds or designing the characters that appear in games. The median annual salary for this role as of 2022 is [\\$58,837](#), according to Payscale, with experienced artists earning more than \$75,000.



# What are some Careers in STEM?

## Geoscience

Some geoscience job titles include:

- **Environmental protection technicians** - work in the field as consultants for various projects from construction to clean-up efforts. They also work in test labs or for the government, according to the BLS. In 2021, technicians earned a median annual salary of [\\$47,370](#), BLS reported. The role is expected to grow 6% through 2031, which is faster than average.
- **Geophysical data technicians** - draw upon their data analysis skills to better understand the earth to help locate and evaluate natural resources. They often help discover valuable resources, such as coal and oil. Professionals in this field earned a median salary of [\\$50,080](#) in 2021, BLS reports.

# Employment projections for STEM occupations

- STEM occupations will grow over 2X faster than the total for all occupations in the next decade
- The U.S. Bureau of Labor Statistics (BLS) 2019–29 employment projections show that occupations in STEM fields are expected to grow 8.0 percent by 2029, compared with 3.7 percent for all other occupations

**Table 1. Projected employment by STEM occupational group, 2019–29**

Occupation title	Employment		Percent change	Employment change
	2019	2029	2019–29	2019–29
<b>STEM occupations</b>	<b>9,955.1</b>	<b>10,752.9</b>	<b>8.0</b>	<b>797.8</b>
Computer occupations	4,633.4	5,164.6	11.5	531.2
Engineers	1,810.1	1,879.1	3.8	69.0
Life scientists	344.8	361.4	4.8	16.6
STEM post secondary teachers <sup>1</sup>	294.1	308.8	5.0	14.7
Physical scientists	276.6	291.4	5.3	14.7
Mathematical science occupations	211.7	267.8	26.5	56.1

<sup>1</sup> Aggregate employment for 11 different STEM post-secondary teacher occupations.

Notes: Employment numbers in thousands.




Not all STEM occupations are represented in the table above. A complete list of occupations included in the STEM definition is available at

[www.bls.gov/oes/stem\\_list.xlsx](http://www.bls.gov/oes/stem_list.xlsx).

Source: U.S. Bureau of Labor Statistics.

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