

Midterm - INTD262

Dr. Jordan Hanson - Whittier College Dept. of Physics and Astronomy

October 18, 2024

(a) Unit 0

- 1. Offer some reasons why the Spaniards created the *virreinos* of Nueva España and Perú in their respective locations, with Tenochtitlan and Lima as capital cities.**

To begin, Tenochtitlan was already the Aztec Empire's capital, and Lima, while not originally Incan. The Spaniards took over these powerful cities because they already had a large population, resources, and well-organized systems, making it easier to control the region. Second, both regions were abundant in gold, silver, and other valuable minerals. The Spaniards wanted to have authority over these areas so they could mine wealth and return them to Spain. Furthermore, Tenochtitlan (Mexico City) was easily accessible to trade routes, and Lima was close to the Pacific Ocean, allowing Spain to control key trade routes, including those connecting Asia and Europe. This made both cities important centers for trade and wealth distribution.

- 2. Was there a link between the introduction of capitalism and the growth of scientific activity in Latin America, or did the growth of modern science precede capitalism?**

When the Spanish and Portuguese acquired Latin America, their primary goal was to enrich themselves by extracting resources such as gold and silver. This created early forms of capitalism, but science was not a top priority at the time. The primary focus was on making money. In the late 1800s and early 1900s, as Latin American countries became increasingly engaged in global trade and began building industries like factories, railroads, etc, capitalism required science to support agricultural, mining, and technological improvements. This is when governments and businesses began to invest more in science because it boosted the economy.

- 3. Given the definition of *peripheral* scientific activity in the Introduction, can you give an example of the creating and transmission of scientific results from the periphery to the center of science?**

For centuries, indigenous people in South America's Amazon rainforest used rubber tree fluid to make items such as balls and waterproof clothing. In the 1800s, Europeans discovered this rubber from people on the Amazon. They found that rubber could be used to make a variety of products, including tires, hoses, and waterproof materials. Scientists in Europe and the United States began experimenting with it. This is an example of scientific knowledge on how to use rubber, coming from a less developed region and being brought to the world's scientific and industrial centers (Europe and the United States), where it became an important part of modern technology and industry.

- 4. Give some examples of *pseudo-scientific* beliefs regarding mythical places the colonials sought in the New World.**

First, El Dorado was thought to be a city constructed out of gold and ruled by a king who was covered in gold dust. Explorers looked for El Dorado, particularly in South America, but it was only a story. There was no City of Gold.

Second, the Fountain of Youth was believed to be a magical spring that could restore youth to those who drank or bathed in it. However, Juan Ponce de León looked for this in Florida, but it did not exist. It was simply a made-up story.

Early explorers also believed that giants lived in South America's Patagonia region. They probably encountered tall native people, but no actual giants.

5. Multiple Choice - Nahua scientific activity, first period

(a) Which of the following were media through which inhabitants of the Mexica empire recorded scientific observations about the natural world?

- A: *Axolotl* (codices) and *huitzitzilin* (paintings, stelae)
- B: *Amoxtl* (codices) and *tlacuilo* (paintings, stelae)
- C: *Tomatl* (plume, writing tool) and *altepetl* (city-state)
- D: *Quetzal* (plume, writing tool) and *huitzitzilin* (city-state)

Answer: _____ **B** _____

(b) Using information from *Historia natural y moral de las Indias* (de Acosta), *Historia general y natural de las Indias* (Oviedo), *Décadas del Nuevo Mundo* (Anglería), *Historia de Nueva España* (Hernández), match the European story to the indigenous story or piece of knowledge.

- (1): Ponce de León and the Fountain of Youth
- (2): Griffins so large they capture people and calves as prey, with feathers as large as an arm.
- (3): "A fountain running with hot water and as the water runs it turns to stone."
- (4): "fish that as they leave the water turn into butterflies."
- (5): "...a monstrous animal, with the face of a fox, a tail of a cercopithecus, ears of a bat, human hands, and feet of a monkey." Carries young on the belly.

-
- A: A flying fish
 - B: A condor
 - C: A mercury mine
 - D: The belief about a certain river among the Lucayo and Carib indigenous
 - E: The Mexican opossum

Answer:

1 = D

2 = B

3 = A

4 = C

5 = E

- (c) Father Bernardino de Sahagún translates from Nahuatl a description of a “tiger” that the indigenous say can do the following: (a) see small things even though there is fog or darkness (b) creates sounds “through the air” to intimidate hunters. What does this writing tell us about the Nahua understanding of physics?**

The Nahua had a good understanding of how animals used their senses, such as sight and sound, despite the fact that they lacked modern scientific explanations. They learned by carefully observing nature and drawing relationships based on what they saw and heard.

- (d) Why did the Spaniards and Aztec believe that hummingbirds were connected to immortality?**

The Aztecs thought hummingbirds were important because they were associated with their god of war and the sun. They thought that warriors who died in battle would return to life as hummingbirds. As a result, hummingbirds represent life after death. The Spaniards viewed hummingbirds as a symbol of the soul's eternal life. Birds in Christian tradition represent the soul ascending to heaven, and the hummingbird's quick and mysterious movements made it appear almost magical as if it was linked to something beyond this world.

- 6. Suppose the following statement is given: “If someone was born between 1945 and 1991, then they have Strontium-90 in their bones.” Which of the following statements is *deductively valid*?**

- Adam was born in 1963. Therefore, Adam has Strontium-90 in his bones
- Eve has Strontium-90 in her bones. Therefore, Eve was born between 1945 and 1991.

The statement "A" is valid because it states that anyone born between 1945 and 1991 has Strontium-90 in their bones. Adam was born in 1963, so we can conclude that he has Strontium-90 in his bones.

- 7. Consider the following passage from Chapter 1 of *The Scientific Attitude*:**

In 1981, the state of Arkansas passed Act 590, which required that public school teachers give “balanced treatment” to “creation science” and “evolution science” in the biology classroom. It is clear from the act that religious reasons were not to be offered as support for the truth of creation science, for this would violate federal law. Instead, the curriculum was expected to concentrate only on the “scientific evidence” for creation science. But was there any? And, how precisely was creation science different from creationism?

Explain the arguments used in court to thwart Act 590 the following year.

Some argue that creation science did not rely on scientific evidence or the scientific method. Unlike evolution, which is supported by an extensive amount of scientific research, creation science is based on religious beliefs and lacks testable hypotheses. This lack of scientific support was a major reason why the court considered teaching it alongside evolution in a science classroom inappropriate.

8. Thomas Kuhn wrote a famous book entitled *The Structure of Scientific Revolutions* (1962). Rather than describing science as a global accumulation of progress, he argues that, sociologically, scientists move between periods of “puzzle-solving” within an accepted framework and revolution triggered by unavoidable experimental anomalies. (a) Give one example of a scientific revolution, and note the anomaly. (b) Do you think that the colonization of Nueva España triggered a scientific revolution?

(a) For ages, individuals thought in the geocentric model, which held that the Earth was at the center of the universe, with everything (the sun, stars, and planets) orbiting it. However, astronomers began to notice anomalies, such as unusual backward rotations of planets like Mars. These observations did not fit well with the geocentric model. Copernicus proposed the heliocentric model in the 16th century, which positioned the sun at the center of the solar system and orbited by the Earth and other planets. This model accounted for anomalies that the geocentric model did not.

(b) The colonization of Nueva España did not lead to a significant scientific revolution, unlike Einstein's theory. However, it did introduce new knowledge to Europe.

9. Fill in Tab. 1 below, using Fig. 1.

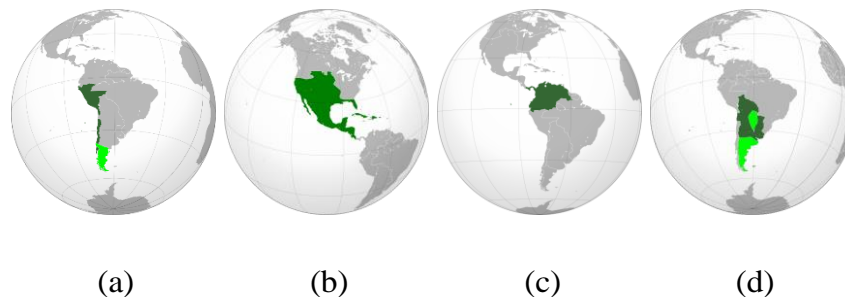


Figure 1: Maps depicting *virreinos* in Latin America, 17th and 18th centuries.

Map in Fig. 1 (a-d)	<i>Virreinato</i>	Capital
(b)	<i>Nueva España</i>	Mexico City
(a)	<i>Nueva Granada</i>	Bogota
(c)	<i>Río de la Plata</i>	Buenos Aires
(d)	<i>Perú</i>	Lima

Table 1: Fill in the missing information.

10. Consider the library of José Ignacio Bartolache. (a) What does the distribution of texts in this library tell us about the scientific attitude of Latin Americans in the 18th Century? (b) What other scientific items did Bartolache own, and what clues does this add to our picture of the scientific attitude in that time and place? (c) Considering these collections were built before 1760, draw a comparison to the state of science in the American colonies (later the United States).

(a) José Ignacio Bartolache's library included a variety of books on astronomy, physics, and philosophy. This demonstrates that people in 18th-century Latin America showed an interest in a wide range of scientific and educational topics and they began to appreciate facts, studies, and logical thinking.

(b) Aside from books, Bartolache owned telescopes and compasses. He also collected plant and animal samples that demonstrated a strong interest in the natural world.

(b) Unit 1

1. In Chapter 2 of *The Scientific Attitude*, we encounter the following quote:

Samir Okasha recounts the example of John Couch Adams and Urbain Le Verrier ... they were working (independently) within the Newtonian paradigm and noticed a slight perturbation in the orbit of the planet Uranus.

Newton's Law of Gravity predicts perfectly elliptical orbits for the planets, with no perturbations. Was the law of gravity therefore *falsified*? What solved the problem in the end?

Newton's law was not false; there was simply a hidden explanation for Uranus' unusual movement. The discovery of Neptune solved the mystery and demonstrated how scientists can look for missing pieces of the puzzle rather than abandoning a theory right away.

2. Bode's Law was an attempted mathematical explanation of the planetary orbits. Bode's sequence was the pattern 0, 3, 6, 12, 24, ..., plus 4 to each, then divide the sequence by 10. The result is 0.4, 0.7, 1.0, 1.6, 2.8, 5.2, 10.0, 19.6, 38.8, 77.2,. At the time (1772), the radii of the planets from the Sun were 0.387, 0.723, 1.0, 1.524, 5.203, 9.539.

Nine years later, Uranus was discovered at 19.18. Twenty years later, the asteroid belt between Mars and Jupiter was discovered at 2.77. Did Bode's Law become a scientific fact because it fit the data?

Bode's Law was an effort to lay out exactly how far the planets are from the Sun using a simple mathematical formula. When the pattern was first created in the 1700s, it closely matched the estimated distances between planets at the time. Later, when Uranus was discovered, they appeared to fit the pattern as well, leading some to believe it was a natural rule. However, as more planets, such as Neptune, were discovered, the pattern no longer worked. Scientists concluded Bode's Law was more of an unplanned prediction or coincidence, rather than a true scientific law based on how planets form and move.

- 3. In 1761, Judge Francisco Javier Gamboa created a set of legal and scientific studies that were meant to reform the mining industry, to make it more efficient. Recall some scientific results that he shared within his *Comentarios a las ordenanzas de minas*. What chemicometallurgical technique, important for ore extraction, did he share with The Crown? What institutions did he suggest creating?**

Gamboa discussed the amalgamation process, which makes use of mercury for obtaining silver from rocks. This was an essential method at that point because it made it easier to extract silver from the ore. He proposed establishing mining schools to teach miners better techniques and skills. He also proposed establishing special mining courts to resolve mining-related issues and disputes, ensuring that laws were followed and mining operations ran smoothly.

- 4. *El Real Seminario de Minería* was created by Joaquín Velázquez de León, Fausto de Elhúyar, and others. However, several factors might have driven it to bankruptcy. Describe the Mexican efforts to preserve it.**

The Mexican government attempted to keep the school operational by providing funding, but because the country was poor, support was limited. There were initiatives aimed at updating the school by teaching new mining techniques and technologies, making it more beneficial and relevant. Later, the government tried to combine the seminary with other schools in order to preserve its existence and keep offering mining and engineering classes. Despite these efforts, the school struggled, but it left an indelible mark on mining education in Mexico.

- 5. What are the two tenets of the scientific attitude, or ethos, according to the author of *The Scientific Attitude*?**

The two tenets are – Communalism and Skepticism

- 6. Recall the story of Ignaz Semmelweis and antiseptic handwashing in maternity wards. Discuss how the scientific attitude was applied in this situation.**

Semmelweis's work demonstrates the scientific attitude by challenging conventional beliefs and depending on evidence (skepticism), as well as emphasizing the significance of sharing discoveries with others (communalism). Even though he struggled to obtain funding at the time, his discoveries were critical to altering health practices and saving lives.

- 7. Recall the story of the false discovery of cold fusion. (a) Discuss how the scientific attitude was not applied in this situation. (b) Now select a piece of science from Latin American history that we have encountered thus far, and apply the criteria of the scientific attitude to it.**

- (a) They did not provide sufficient reliable evidence for their discovery. They made bold claims without properly testing them or seeking suggestions from other scientists. When other scientists criticized their findings and were unable to replicate them, Fleischmann and Pons did not take these concerns seriously and continued to promote their ideas. Rather than publishing their methods and findings in a scientific journal, they disclosed their discovery at a press conference. This made it difficult for other scientists to review their work.

(c) Unit 2

- 1. (a) In what viceroyalty (Fig. 1) was the city of Santa Fe de Bogotá? (b) Discuss the scientific implications of the “half century-long polemic on Copernican theories, which started in 1773 between José Celestino Mutis and the Dominican Congregation of Santa Fe de Bogotá. (c) In 1783, the Expedición Botánica began in Santa Fe. What were some of its goals and achievements?**

- (a) The city of Santa Fe de Bogotá was located in the Viceroyalty of New Granada.
- (b) The debate over Copernican theories began in 1773 between José Celestino Mutis and the Dominican Congregation. It demonstrated that some people, particularly those in the church, were unwilling to accept new scientific concepts, showing a conflict among traditional beliefs and modern science. The conflict highlighted the necessity to enhance science education. Mutis wanted schools to teach modern scientific theories, which altered the way science was taught in the region.
- (c) The main goal was to collect and document plant species in order to gain a greater understanding of the region's biodiversity, with the hope of discovering beneficial species that could help enhance farming and boost the local economy.
Their work resulted in books that described new species and their applications, setting a foundation for future botanical research.

- 2. (a) In what viceroyalty (Fig. 1) was the city of Caracas? (b) In 1767, the Jesuit order was expelled from the Spanish colonies. The Dominican order recovered authority over some colleges and universities. What was the implication for science?**

- (a) Viceroyalty of New Granada.
- (b) The Jesuits were renowned for their strong emphasis on science, which included subjects such as math, astronomy, and nature. With their departure, the Dominicans, who took a different approach, may not have focused these scientific subjects as much. This could have resulted in an overall reduction in scientific learning. Additionally, the Enlightenment influenced the Jesuits, who encouraged new ideas and scientific reasoning. The Dominicans were more traditional and emphasized religious teachings, which may have limited their acceptance of new scientific ideas.

- 3. What scientific publication was created by José Celestino Mutis?**

José Celestino Mutis created the scientific publication called "Flora de Nueva Granada," which recorded thousands of plant species, most of which were unknown to science at the time.

- 4. Evaluate the logical truth of this claim: “anti-vaccination campaigns do not have the scientific attitude, therefore these are not scientific endeavors.”**

The statement is correct because if we do not follow the fundamental rules of science, such as being accessible to new evidence and evaluating ideas with facts, we are not practicing science. Thus, anti-vaccination campaigns cannot be regarded as scientific.

5. Discuss one example we have encountered from our scientific history that should count as science, even though it has not traditionally been considered scientific.

Indigenous knowledge about plants and medicine in Latin America is a historical example that should be considered science, despite the fact that it has not traditionally been considered such. Indigenous people discovered about plants' healing properties through careful observation and testing over time. Even though they weren't committed to the modern scientific method, they experimented with various plants and treatments to determine which ones worked. This is similar to the way scientists conduct experiments today.

6. In Chapter 3 of *Science in Latin America*, we encounter the following quote:

La Universidad Gregoriana in Quito alone had “seventy-one foreign professors teaching at the university ... Native professors were twenty-one, of whom five were from Loja, four from Quito, three from Guayas, three from Cuenca, three from Riobamba, two from Ibarra, and one from Ambato.” ... As a consequence, it is not strange that in a center of cultural ferment such as Quito, intellectual Jesuits were most closely linked to the Franco-Spanish geodetic mission directed by La Condamine and Jorge Juan.

(a) What scientific transition began to take place as a result of the interaction between foreign and Ecuadorian professors? (b) What can we infer about the ratio of the native professors at the university? (c) Consider Father Francisco Javier Aguilar, who taught physics and mathematics at Universidad Gregoriana. He taught no less than five world systems, and focused on three: Ptolemaic, Copernican, and Tychonic. What distinguished these?

- (a) When foreign scientists collaborated with Ecuadorian professors, they introduced new ideas and ways of thinking. This marked a significant shift in how science was presented and understood. The emphasis shifted away from traditional religious beliefs and toward more modern science based on observation, measurement, and testing.
- (b) There were twenty-one native professors. This demonstrates that there were few local professors at the university.
- (c) Three different world theories were taught: Ptolemaic, which holds that the Earth is the center. Copernicus states that the Sun is at the center. Finally, there's Tychonic, which combines the two ideas.

In 1767, Mutis published *Reflexiones sobre el sistema tyconico*. (a) What were the main points of this publication? (b) Was it considered controversial?

Mutis advocated a model in which the Earth remains in the center and the Sun revolves around it, while the planets revolve around the Sun. Tycho Brahe created this model. Mutis' approach maintained the Earth as a special place, which was consistent with religious beliefs at the time, while also accepting some new scientific findings.

Mutis' ideas attempted to satisfy both followers of religion and scientists. However, as time passed, most scientists shifted to the idea that the Sun was at the center, making Mutis' ideas less accepted.

When Joaquín Velázquez de León and José de Gálvez arrived in Baja California, they remained there for three years. (a) What types of measurements did they make? (b) How did this improve local knowledge of Nueva España? (c) Velázquez de León communicated with Chappe d’Auteroche that he would help with the Venus transit measurements, and d’Auteroche suggested that Velázquez de León remain in Real de Santa Ana, while d’Auteroche would work in San José del Cabo. What happened as a result?

- (a) They mapped the area. They studied Astronomy and investigated natural resources.
- (b) The precise maps they developed made it simpler for people to figure out and explore the area, which was critical for settlers and traders. Studying the Venus transit contributed to scientific understanding of astronomy and connected Nueva España to global scientific efforts. Furthermore, learning about local resources helped strengthen the economy by identifying possibilities like farming and mining.
- (c) They could gather more information and improve the accuracy of their findings by observing transit from various points. Their collaboration demonstrated how scientists collaborated together at the time to accomplish common goals, thereby increasing the effectiveness of their research.

a. What was notable about the explorations of José Sanchez Labrador?

José Sánchez Labrador was notable because he created precise maps, investigated local plants and animals, discovered natural resources, learned about Indigenous cultures, and contributed to our scientific understanding of Baja California. His explorations aided other explorers and settlers in the region.

(d) Applications, Mayan and Incan Number Systems

a. Work out the following exercises using the Mayan system.

(a) $365 + 365 =$

(b) $1024 - 512 =$

b. Work out the following exercises using the Incan quipu:

(a) $512 + 256 =$

(b) $365 - 67 =$

- c. Suppose we are looking for a set of trees tall enough to supply sixteen four-meter beams. Using the Mayan system, create a calculation showing that the total number of beams is sixty-four.

d. Suppose you have six terrace plots in the Andean mountains to use to survive. You and your cohort of fellow Incans decide to grow potatoes and quinoa. Quinoa actually do better at higher altitudes than potatoes. So the plan is to use the two lowest terraces for potatoes, and the upper four for quinoa. Each terrace is 30 meters by 5 meters. A potato plant requires a 0.2 meter by 0.2 meter patch, and a quinoa plant requires a 0.3 meter by 0.3 meter patch. How many potato plants and how many quinoa plants can you plant? Store the results in a diagram of quipu knot system.

(e) Modern Science in Latin America - Gamma Ray Astrophysics

a. What is a gamma-ray?

- A: A charged particle with mass
- B: A neutral particle with mass
- C: A quantum of light
- D: A radio wave

Answer: ____C____

b. What was the purpose of the Milagro experiment?

- A: To observe the direction of incoming gamma-rays
- B: To observe the energy of incoming gamma-rays
- C: To observe the direction and energy of incoming gamma-rays
- D: To observe the charge of incoming gamma-rays

Answer: ____C____

c. What upgrades to the Milagro concept were made that produced the HAWC design?

- A: Using oil instead of water as the detection medium
- B: Increasing the amount of water tanks to improve the sensitivity
- C: Moving the tanks to a higher altitude
- D: Both B and C

Answer: ____D____

d. List some of the discoveries of HAWC and/or Milagro in the field of gamma-ray astrophysics.

- ➔ Supernova Remnants
- ➔ Active Galactic Nuclei (AGN)
- ➔ Pulsars
- ➔ Gamma-Ray Showers
- ➔ High-Energy Cosmic Rays
- ➔ TeV Emission Regions

(f) Modern Science in Latin America - Cosmic Ray Physics

a. What is the purpose of the Pierre Auger Observatory?

The Pierre Auger Observatory is a large scientific tool that allows researchers to study some of the universe's most powerful particles and learn more about their origins and behavior.

b. What is the typical energy of a cosmic-ray observed at Auger?

- A: 10^{12} eV
- B: 10^{14} eV
- C: 10^{16} eV
- D: 10^{18} eV

Answer: _____D_____