

Midterm - INTD262

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1 Unit 0

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

Consolidation of Power and Control, Economic Exploitation, Strategic Military and Political Control, Geopolitical Importance and Trade, and Religious and Cultural Transformation.

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?

The growth of modern science in Latin America initially preceded capitalism, as scientific activity began during the colonial period, primarily driven by European imperial interests. However, the rise of capitalism in the 19th and 20th centuries accelerated scientific development by fostering industrialization and modern education systems. As capitalism expanded, it helped institutionalize and fund scientific research, linking economic growth with scientific progress.

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?

In the 20th century, indigenous knowledge and local agricultural practices in Latin American countries, particularly in Mexico and Peru, contributed significantly to the global understanding of crop biodiversity.

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

Some pseudo-scientific beliefs regarding mythical places are El Dorado, The Fountain of Youth, and the land of the Amazon.

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)

(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 **Answer: 4**

• B: A condor **Answer: 2**

• C: A mercury mine **Answer: 3**

• D: The belief about a certain river among the Lucayo and Carib indigenous **Answer: 1**

• E: The Mexican opossum **Answer: 5**

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6. Nahua scientific activity, second period

(a) 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?

Answer: (a) The idea that this animal can see small things even in fog or darkness suggests that the Nahua had some awareness of heightened sensory abilities in animals, particularly in low-light conditions. This indicates an empirical observation that certain creatures, like jaguars, possess superior night vision. (b) The description of the animal creating sounds to intimidate hunters hints at a basic understanding of how sound travels. The Nahua seemed to grasp that sound is something that moves "through the air" and can be used as a tool for communication or intimidation.

(b) Why did the Spaniards and Aztecs believe that hummingbirds were connected to immortality?

The Aztecs believed in the symbol of Huitzilopochtli which was the symbol of the god of war, the sun, and the Aztec patron deity. They also believed in Renewal and Vitality which meant they saw the Hummingbird as an immense vitality and energy. The Spaniards Believed that the Christian Symbolism of Resurrection meaning that the Spaniards had a Christian worldview. They also believed that they were Exotic and Mystical Creatures.

7. 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

This is deductively valid.

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

1991.

This statement is not deductively valid.

8. 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.

Ultimately, the court ruled that Act 590 was unconstitutional, concluding that creation science was not a legitimate scientific discipline but rather an attempt to introduce religious doctrine into public school curricula. This ruling was significant in the ongoing debate over science education and the teaching of evolution versus creationism in American schools.

9. 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?

The colonization of Nueva España did not trigger a scientific revolution in the same way as the Copernican Revolution, but it significantly impacted the development of science. The exchange of knowledge between European colonizers and indigenous peoples led to new insights into local flora, fauna, and medicinal practices. This period also saw the establishment of universities and scientific institutions, fostering education and research. Overall, while not a formal revolution, this era contributed to the evolution of scientific inquiry and knowledge.

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

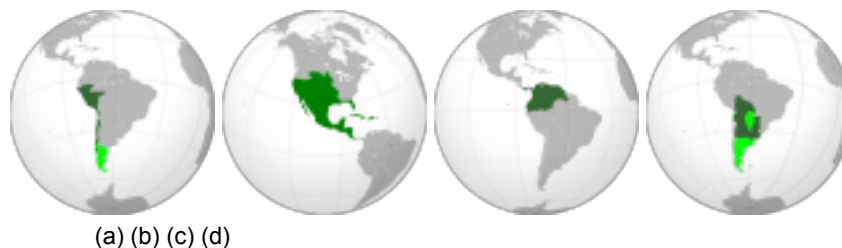


Figure 1: Maps depicting *virreinos* in Latin America, 17th and 18th centuries.

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

Table 1: Fill in the missing information.

11. 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) The distribution of texts in José Ignacio Bartolache's library shows that Latin Americans in the 18th century were engaged with diverse scientific topics, including natural history, astronomy, and mathematics. This reflects a commitment to the values of the Enlightenment, emphasizing reason and empirical inquiry. Overall, it suggests an active participation in the global scientific discourse of the time. (b) Bartolache owned various scientific instruments, such as astronomical devices and globes, indicating he was not just a reader but also a practitioner of science. This suggests a community of intellectuals in Latin America who were involved in hands-on scientific work. It highlights a growing appreciation for empirical research and experimentation during the 18th century. (c) Before 1760, American colonies had a scientific culture that included informal experiments and practical studies, as seen in figures like Benjamin Franklin. However, the scientific community in the colonies was less formalized compared to Latin America. Bartolache's well-developed library and scientific instruments indicate a more vibrant and institutionalized scientific culture in Latin America during this period.

2 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?

No, Newton's Law of Gravity was not falsified by the slight perturbation observed in the orbit of Uranus. Instead, the perturbation indicated that there was an additional gravitational influence on Uranus that was not accounted for by Newton's laws.

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?

No, Bode's Law did not become a scientific fact simply because it fit the data. While Bode's Law provided a mathematical pattern that corresponded to the distances of several known planets from the Sun, it was more of a heuristic or a rule of thumb rather than a fundamental scientific principle.

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?

In his *Comentarios a las ordenanzas de minas*, Judge Francisco Javier Gamboa shared several scientific results aimed at reforming and improving the mining industry. One important chemicometallurgical technique he discussed was the use of mercury amalgamation for ore extraction, which allowed for more efficient recovery of precious metals, particularly silver, from ores.

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.

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

Empiricism: This tenet emphasizes the importance of observation and experience as the foundation of knowledge. It encourages relying on empirical evidence gathered through experimentation and observation rather than on dogma or tradition.

Skepticism: This tenet advocates for questioning claims and assertions rather than accepting them at face value. It promotes a critical approach to knowledge, encouraging scientists to remain open-minded while rigorously testing ideas and hypotheses against evidence.

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 application of the scientific attitude—through careful observation, hypothesis testing, and an emphasis on evidence—eventually contributed to significant advancements in medical hygiene and the understanding of infection control, despite the initial resistance he faced from the medical community.

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) **In the cold fusion case, the scientific attitude was not applied because researchers Martin Fleischmann and Stanley Pons made unverified claims about achieving nuclear fusion at room temperature without thorough testing or peer review. They ignored skepticism from the scientific community, which is essential for validating experimental results, leading to widespread misinformation. This highlights the critical importance of evidence and rigorous evaluation in scientific inquiry.**
- (b) **José Ignacio Bartolache's work in mining reform is an example of applying the scientific attitude in**

Latin American history. He conducted empirical studies and advocated for mercury amalgamation to improve ore extraction, emphasizing evidence-based practices. By proposing educational institutions for mining knowledge, Bartolache demonstrated a commitment to empirical inquiry and collaboration, reflecting the core principles of the scientific attitude.

3 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) Santa Fe de Bogotá was located in the Viceroyalty of New Granada, which included present-day Colombia, Venezuela, Ecuador, and Panama.
 - (B) The debate that began in 1773 between José Celestino Mutis and the Dominican Congregation over Copernican theories underscored the conflict between scientific ideas and traditional religious views. Mutis defended the heliocentric model, promoting acceptance of empirical evidence and scientific inquiry, which contributed to the Enlightenment in Latin America.
 - (C) The Expedición Botánica, starting in 1783, aimed to study the region’s flora, fauna, and natural resources. It documented many plant species, explored their medicinal uses, and laid the groundwork for future botanical research, significantly enhancing knowledge of Colombia’s biodiversity and its economic potential.

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) The city of Caracas was located in the Viceroyalty of New Granada.
 - (b) The expulsion of the Jesuit order in 1767 led to the Dominican order taking over some colleges and universities, which had significant implications for science. The Jesuits had been instrumental in advancing education and scientific inquiry, so their removal created a vacuum in scientific leadership. The Dominicans, while continuing educational efforts, often focused more on religious teachings, which may have slowed the progress of empirical research and scientific exploration during that period.

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

Jose Celestino created the Flora de Nueva Granada.

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

The claim that "anti-vaccination campaigns do not have the scientific attitude, therefore these are not scientific endeavors" presents a logical fallacy. While it is true that anti-vaccination campaigns often lack the principles of the scientific attitude, such as reliance on empirical evidence and skepticism, this does not automatically render them "not scientific endeavors."

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.

One example from scientific history that should count as science, despite not traditionally being viewed as such, is the work of José Celestino Mutis in the *Expedición Botánica*. Although this expedition took place during a time when scientific inquiry was often overshadowed by religious and philosophical dogmas, Mutis conducted extensive empirical research on the flora of New Granada.

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) The interaction between foreign and Ecuadorian professors at the Universidad Gregoriana in Quito facilitated a shift from traditional, dogmatic science to modern, empirical approaches. This exchange of ideas encouraged the adoption of contemporary scientific principles in fields like mathematics and astronomy.

(b) The presence of only twenty-one native professors out of ninety-two suggests a heavy reliance on foreign expertise, highlighting a gap in local scholarly authority. This indicates that local scholars had limited prominence within the educational system.

© Father Francisco Javier Aguilar taught three major astronomical models: the **Ptolemaic system**, which was Earth-centered; the **Copernican system**, which was heliocentric; and the **Tychonic system**, which combined both by having the Earth stationary while other planets orbited the Sun. Each model represented a different understanding of the universe's structure and contributed to the evolution of astronomical thought.

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

- (a) In *Reflexiones sobre el sistema tycónico*, José Celestino Mutis described the Tychonic system, which posits that the Earth is stationary while the Sun and Moon orbit it, and other planets revolve around the Sun. He highlighted the system's observational compatibility and its ability to explain celestial phenomena.
- (b) Yes, the publication was controversial as it challenged prevailing geocentric views and deviated from traditional models. It sparked debates among scholars and religious authorities, reflecting tensions between established beliefs and emerging scientific ideas during the Enlightenment.

8. 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'Aueroche that he would help with the Venus transit measurements, and d'Aueroche suggested that Velázquez de León remain in Real de Santa Ana, while

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d'Aueroche would work in San José del Cabo. What happened as a result?

- (a) Joaquín Velázquez de León and José de Gálvez made geodetic surveys, astronomical observations, and topographic assessments in Baja California, along with recording climatic data and evaluating natural resources.
- (b) Their measurements enhanced local knowledge of Nueva España by providing detailed information about Baja California's geography, climate, and resources, aiding in agricultural and settlement planning.
- (c) As a result of their collaboration, Velázquez de León remained in Real de Santa Ana while d'Aueroche worked in San José del Cabo, allowing for more comprehensive measurements during the Venus transit and improving astronomical knowledge of the region.

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

José Sánchez Labrador's explorations were notable for extensively surveying and mapping northern Mexico and the southwestern United States in the 18th century. He documented natural resources, native populations, and ecological conditions, enhancing understanding of the region's geography. His detailed maps and observations laid the groundwork for future research and military expeditions.

4 Applications, Mayan and Incan Number Systems

1. Work out the following exercises *using the Mayan system*.

(a) $365 + 365 =$

(b) $1024 - 512 =$

2. Work out the following exercises *using the Incan quipu*:

(a) $512 + 256 =$

(b) $365 - 67 =$

3. 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.

4. 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.

5 Modern Science in Latin America - Gamma Ray Astrophysics 1.

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

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2. 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

3. 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

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

The Milagro discoveries would be Detection of Galactic Gamma-ray Sources and Gamma-ray Emission from the Cygnus Region. Then for the HAWC, it is the discovery of the New gamma-ray sources and the PeVatron Candidates.

6 Modern Science in Latin America - Cosmic Ray Physics 1.

What is the purpose of the Pierre Auger Observatory?

The Pierre Auger Observatory is designed to study ultra-high-energy cosmic rays (UHECRs). Its primary goal is to understand the origins and nature of these cosmic rays, which are subatomic particles (mostly protons and atomic nuclei) that travel through space with extremely high energy. It aims to determine their sources, composition, and how they are accelerated to such high energies, which can exceed even those produced by human-made accelerators.

2. 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

