

MIDTERM - INTD 262
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October 18, 2024

1 Unit O

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.

The Spaniards created *virreinos* in Tenochtitlan, Nueva España, and Lima, Perú because they were recognized for their wealth and abundance. These territories were considered pre-established civilizations with an abundance of natural resources like silver deposits. Both regions were centrally located and served as hubs for trade, commerce, and resource exploitation.

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?

There is an argument that the growth of modern science preceded capitalism by two centuries. It was Latin America's natural resources and diverse ecosystems that persuaded scientists to research there before a capitalist economy was fully developed. The pursuit of scientific knowledge was driven by curiosity, exploration, and a desire to understand the natural world – not capitalism.

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?

Science in Latin America was considered “secret”. An example of this is the 1783 Expedición Botánica in Nueva Granada. José Celestino Munis created scientific results through detailed cataloging and empirical observation. He transmitted these scientific results to the center of science through publication and correspondence with European scientists – like Carl Linnaeus.

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

One example of a pseudo-scientific belief regarding mythical places the colonials sought in the New World was the Fountain of Youth. The Fountain of Youth was believed to be a spring that could restore youth to anyone who drank from it.

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 *tlacuillol* (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.

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- 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

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?

This tells us that the Nahua understood optics and sound. The ability of the tiger to see small things even through fog or darkness suggests that they understood that sensory perception has limitations as a result of environmental conditions. They also understood that acoustic awareness can be used for communication. They make different sounds that are useful.

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

The Spaniards and Aztec believe that hummingbirds are connected to immortality because they observed it. When they die, they believe that trees bring them back to life. They adopted this belief into their religious practices. They believe that their God – Huitzilopochtli – is immortal like a hummingbird.

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

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.

In 1982, *McLean versus Arkansas Board of Education* held that Act 590 – the act that mandates teaching creation science in public schools – was unconstitutional because it violated the Establishment Clause. The court ruled that Act 590 was unconstitutional because creation science was a religious doctrine more than a scientific theory.

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?

One example of a scientific revolution was the Copernican Revolution. The anomaly that triggered this revolution was observing retrograde motion in planets like Mars. It suggested a heliocentric model – where the Earth revolves around the Sun – and was a much simpler and more accurate explanation of the planetary movement. I do not think that the colonization of Nueva España triggered a scientific revolution. This is because they did not listen to the indigenous people at the beginning of its colonization, but instead tried to erase their knowledge. Their religious perspective played a pivotal part. Eventually, however, they began to accumulate and exchange information between Europe and the New World to support broader scientific advancements.

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

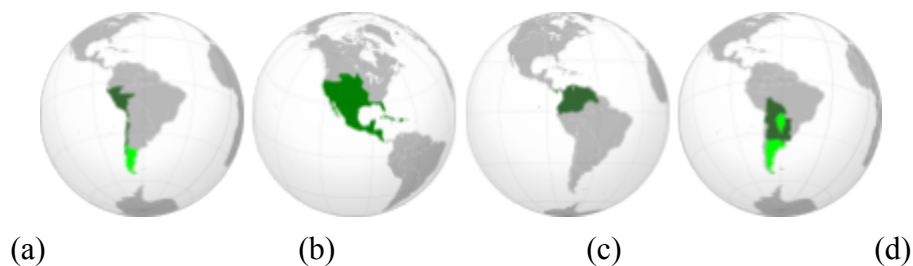


Figure 1: Maps depicting *virreinos* in Latin America, 17th and 18th centuries.

Map in Fig. 1 (a-d)	<i>Virreinos</i>	Capital
B	<i>Nueva España</i>	Mexico City
C	<i>Nueva Granada</i>	Bogota
D	<i>Río de la Plata</i>	Buenos Aires
A	<i>Perú</i>	Lima

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).

The distribution of texts in this library tells us that the scientific attitude of 18th-century Latin Americans were diverse in topics and cultural origins. Bartolache possessed a wide variety of texts including medicine, natural history, and philosophy. This means he was interested in both practical and theoretical thought, meaning he had a scientific attitude toward empirical observation and rationality. Bartolache also owned other scientific items like scales, microscopes, and telescopes. This clue adds to our picture of the scientific attitude by suggesting that Bartolache used to do hands-on experimentation. The state of science in the American colonies was similar to that of Latin America because they were both influenced by the Enlightenment and the practical knowledge and study of history. However, the American colonies had fewer resources and less institutional support compared to Latin America where the Crown funded this exploration.

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?

The law of gravity was not falsified. The slight perturbations suggested that there was another planet exerting gravitational force on Uranus. This was solved by the discovery of Neptune – which confirmed Newton's Law of Gravity.

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 did not become a scientific fact. It explained nothing and had no scientific theory for its prediction to confirm. It was an honest attempt but wrong. Instead, Bode's Law is considered an empirical observation.

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?

Judge Francisco Javier Gamboa shared the patio process with The Crown. He used mercury for amalgamation in silver ore extraction – which allowed for more efficient separation of silver from the ore. Gamboa suggested creating schools for miners' children. He wanted to create specialized institutions to regulate mining activities and train professionals in new mining techniques and technologies.

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.

Not only did the mine owners support the effort, but the scientific community did as well. Professors translated fundamental science texts into Spanish.

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

The two tenets of the scientific attitude are empirical evidence and the willingness to accept new ideas.

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

The scientific attitude was applied in this situation because Ignaz Semmelweis did not assume that he knew the answer. Instead, he left himself open to new ideas and changed his ideas based on new data. He used observation, controlled experimentation, and tested various hypotheses one by one.

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.

The scientific attitude was not applied in this situation because they failed to accept that their evidence did not line up with their theory and instead tweaked their findings – they

were not transparent. They were unable to reproduce their findings, nor did they leave enough time for skepticism. One example of the scientific attitude in Latin America is José Ignacio Bartolache of New Spain. He wanted to improve medical and scientific practices through observation, hypothesis, experimentation, analysis, and publication. For example, he observed epidemics and their effects on the population, he hypothesized that certain practices could prevent the spread of diseases, implemented public health measures like a smallpox inoculation, analyzed the results, and shared his findings.

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?

The city of Santa Fe de Bogotá was in the viceroyalty of Nueva Granada. The scientific implications of the “half-century-long polemic on Copernican theories” include the discovery of astronomy, the heliocentric solar system, and Newtonian physics. One of the goals and achievements of the Expedición Botánica was the understanding of country borders. Latin American travelers had to build a scientific base of people to do these calculations. They needed to create detailed maps and document the region’s natural resources.

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?

The city of Caracas was in the viceroyalty of Nueva Granada. The scientific implication of the Dominican order recovering authority over some colleges and universities was that there would be a significant decline in scientific advancement. The Dominicans did not have as strong a commitment to education and scientific inquiry.

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

José Celestino Mutis published *Flora de Bogotá o de Nueva Granada*. It contained more than six thousand illustrations of various plants. However, it was so massive and expensive that the Spanish government could not afford to print it.

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

The scientific attitude involves observation, skepticism, and reliance on empirical evidence and reproducibility. Ant-vaccination campaigns involve anecdotal evidence, misinformation, and lack of methodology. This contradicts the scientific attitude and therefore does not qualify as a scientific endeavor.

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.

The Expedición Botánica led by José Celestino Mutis is an example of an event that is not considered scientific by Western standards but should be. This is because it pertained to fieldwork more than theoretical studies. It involved systematic collection and documentation, empirical observation, and publication. They had to catalog, detail, and illustrate thousands of plant species and their plant's physiology and ecology.

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?

The interaction between foreign and Ecuadorian professors led to a scientific transition toward modern scientific methods and rationalism. At the university, roughly a quarter of the professors were native. This means that there was still a significant presence of local scholarship among the majority of foreign professors. The Ptolemaic system is a geocentric model with the Earth at the center of the universe, the Copernican system is a heliocentric model with the Sun at the center of the universe, and the Tychonic system is a hybrid model with the Earth at the center and the Sun and moon orbiting it.

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

The main point of this publication was to discuss the Tychonic system and its validity. He wanted the system to be valid in terms of reconciling observed astronomical phenomena with religious beliefs. It was considered controversial because this system served as a compromise that attempted to hold Earth's central position in the universe while incorporating more heliocentric elements.

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'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?

They made geodetic measurements, astronomical observations, and mineralogical surveys to map the area accurately, determine its longitude and latitude, and assess its mining potential. This improved local knowledge of Nueva España by providing precise data and understanding of its natural resources, which contributed to better navigation and mapping. As a result of this collaboration for the Venus transit measurements, more accurate observations and calculations of the Earth-Sun distance were obtained. This led to more astronomical knowledge and understanding of the solar system.

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

His explorations were notable because they involved scientific documentation, ethnographic studies, and publication of his findings. He provided information on the region's biodiversity and culture.

4 Applications, Mayan and Incan Number Systems

1. Work out the following exercises using the *Mayan system*.
(a) $365 + 365 = 730$

365	365	730
$\begin{array}{r} \dots \\ \text{---} \\ \text{---} \\ \text{---} \end{array}$	$\begin{array}{r} \dots \\ \text{---} \\ \text{---} \\ \text{---} \end{array}$	$\begin{array}{r} \cdot \\ \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \end{array}$

(b) $1024 - 512 = 512$

1024	512	512
$\begin{array}{c} \cdot \quad \cdot \\ \hline \cdot \\ \hline \end{array}$	$\begin{array}{c} \cdot \\ \hline \end{array}$	$\begin{array}{c} \cdot \\ \hline \end{array}$
$\begin{array}{c} \cdot \quad \cdot \\ \hline \cdot \quad \cdot \\ \hline \end{array}$	$\begin{array}{c} \cdot \quad \cdot \\ \hline \end{array}$	$\begin{array}{c} \cdot \quad \cdot \\ \hline \end{array}$

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

(a) $512 + 256 = 768$	(b) $365 - 67 = 298$
$\begin{array}{r} \\ \hline \hline \hline \hline \hline \hline \hline \hline \end{array}$ $\begin{array}{r} \\ . \\ . \\ . \\ . \\ . \\ \\ . \\ . \\ . \\ . \\ . \\ \end{array}$	$\begin{array}{r} \\ \hline \hline \hline \hline \hline \hline \hline \end{array}$ $\begin{array}{r} \\ . \\ . \\ . \\ . \\ . \\ . \\ \\ . \\ . \\ \end{array}$

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.

$$(3 \times 20^1) + (4 \times 20^0)$$

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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.

[illegible]

Potato Terrace Area = 30 m x 5 m = 150 m² per terrace

Area for Potatos = 150 m^2 per terrace $\times 2 = 300 \text{ m}^2$

Space Required per Potato Plant = $0.2 \text{ m} \times 0.2 \text{ m} = 0.04 \text{ m}^2$

Number of Potato Plants = $300 \text{ m}^2 \times 0.04 \text{ m}^2 = 7,500 \text{ plants}$

Quinoa Terrace Area = 30 m x 5 m = 150 m² terrace

Area for Quinoa = 150 m^2 per terrace $\times 4 = 600 \text{ m}^2$

Space Required per Quinoa Plant = 0.3 m x 0.3 m = 0.09 m²

Number of Quinoa Plants = $600 \text{ m}^2 \times 0.09 \text{ m}^2 = 6,666 \text{ plants}$

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

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.

HAWC discovered ultra-high-energy gamma-ray sources, gamma-ray halos, and solar gamma rays. Milagro discovered TeV gamma-ray sources and diffuse emission mapping.

6 Modern Science in Latin America - Cosmic Ray Physics

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

The purpose of the Pierre Auger Observatory is to detect and study ultra-high-energy cosmic-rays. These cosmic rays travel almost at the speed of light with maximum energy 10^{18} eV . They want to study where these rays originate from and how it is even physically possible to produce such high-energy particles.

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