Midterm - INTD262

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1 Unit 0

1. **Offer some reasons why the Spaniards created the *virreinatos* of Nueva España and Perú in their respective locations, with Tenochtitlan and Lima as capital cities.** The Spaniards created these viceroyalties to maintain control over vast territories, manage resources (such as gold and silver), and spread Christianity. Tenochtitlan and Lima were strategic as central hubs of power and trade in their respective regions.

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 introduction of capitalism and scientific activity were linked but uneven. In many cases, scientific advances were driven by capitalist endeavors such as mining, but modern science did not always precede capitalism. Instead, they co-evolved, with scientific advancements often supporting capitalist ventures.

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?** An example is the botanical research conducted in Nueva Granada (Colombia), which was later transmitted to Europe and helped advance botanical knowledge in the center of science

4. **Give some examples of *pseudo-scientific* beliefs regarding mythical places the colonials sought in the New World.** Myths include the Fountain of Youth sought by Ponce de León, large griffins capable of carrying humans, and rivers with stones formed from water.

5. **Multiple Choice - Nahua scientific activity, first period**

   (a) Which of the following where 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 *tlacuiloll* (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 **(4)**
- B: A condor **(2)**
- C: A mercury mine **(1)**
- D: The belief about a certain river among the Lucayo and Carib indigenous **(3)**
- E: The Mexican opossum **(5)**

6. Nahua scientific activity, second period

(a) Father Bernardino de Sahagún translates from Nahuatl a description of a "tiger" that the indigenous saycan 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 description of the "tiger" that can see small things in fog or darkness suggests that the Nahua had some understanding of optics, particularly related to vision in low-light conditions, which modern physics would explain in terms of the behavior of light and the sensitivity of the eyes. The reference to creating sounds "through the air" to intimidate hunters shows an awareness of acoustics and sound transmission. This indicates that the Nahua recognized fundamental concepts of both light and sound, even if they described them in mythological or symbolic terms.

(b) Why did the Spaniards and Aztec believe that hummingbirds were connected to immortality? The Spaniards and Aztec believed that hummingbirds were connected to immortality because these birds were seen as messengers of the gods and were associated with the soul's journey after death. In Aztec culture, warriors who died in battle were believed to transform into hummingbirds and live forever, feeding on the nectar of flowers in the afterlife. The hummingbird's swift, vibrant nature symbolized vitality and eternal life, linking it to immortality in the cultural narratives of both the Spaniards and the Aztecs.

7. Suppose the following statement is given: "If someone was born between 1945 and 1991, then they haveStrontium-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.

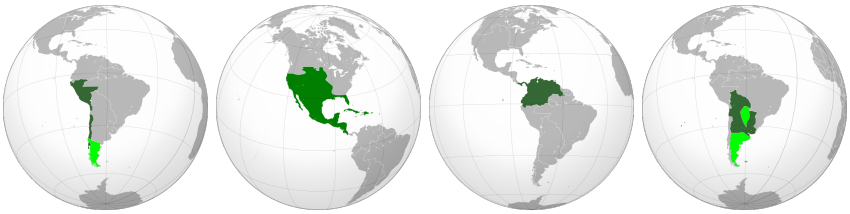
8. Consider the following passage from Chapter 1 of *The Scientific Attitude*:

> 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. 1) Creation science lacked scientific evidence and did not meet the criteria of the scientific method. **2)** It violated the First Amendment by promoting religious views in public schools. **3)** Creationism is inherently religious, not scientific, and could not be taught as science.

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? A) The Copernican Revolution is a classic example. The anomaly was the inability of the geocentric model to explain retrograde motion of planets, which led to the heliocentric model. **B)** The colonization of Nueva España did not directly trigger a scientific revolution, but it introduced European science and methods, which influenced the development of local scientific practices. It was more a transfer of knowledge than a full revolution.

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



(a) (b) (c) (d)

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

Map in Fig. 1 (a-d)	***Virreinato***	Captial
B	*Nueva España*	Mexico City
C	*Nueva Granada*	Bogota
A	*Río de la Plata*	Buenos Aires
D	*Perú*	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). A) Bartolache's library included a wide range of texts in natural philosophy, medicine, and mathematics, reflecting the broad and interdisciplinary scientific curiosity of Latin American scholars in the 18th century. **B)** Bartolache owned scientific instruments like barometers and telescopes, which showed a commitment to empirical research and experimentation, key aspects of the scientific attitude at the time. **C)** Before 1760, science in Latin America was closely tied to European influences and religious institutions. In contrast, the American colonies were beginning to foster more independent scientific inquiry, though still influenced by Europe.

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, the law wasn't falsified. The anomaly (perturbation of Uranus' orbit) was explained by the discovery of Neptune, which influenced Uranus' orbit.

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 not considered a

scientific fact because it was a heuristic rule that happened to fit some data. Its success in predicting Uranus and the asteroid belt was coincidental rather than based on fundamental principles.

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 suggested the amalgamation technique using mercury for ore extraction and recommended creating specialized mining institutions.

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 bankrupcy. Describe the Mexican efforts to preserve it.** Mexican efforts included funding reforms and restructuring the curriculum to align with the needs of the mining industry, but external factors, including political instability, contributed to its financial problems.

5. **What are the two tenets of the scientific attitude, or ethos, according to the author of *The Scientific Attitude*?** According to McIntyre, the two main tenets are openness to evidence (willingness to revise beliefs based on new data) and transparency in methods and reasoning.

6. **Recall the story of Ignaz Semmelweis and antiseptic handwashing in maternity wards. Discuss how the scientific attitude was applied in this situation.** Semmelweis applied the scientific attitude by using empirical evidence (reduced mortality rates after handwashing) to challenge prevailing medical practices, even though his ideas were initially rejected.

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 the researchers did not provide sufficient empirical evidence, the results were not reproducible, and they lacked transparency in their methods. There was also a rush to announce results before proper peer review. **B)** An example from Latin American history is the Expedición Botánica in Nueva Granada, led by José Celestino Mutis. The scientific attitude was applied here through meticulous data collection, transparency, and sharing of findings, which contributed significantly to botanical science and were empirically validated by European scientists.

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 in Nueva Granada. **B)** The debate on Copernicanism reflected the tension between traditional (geocentric) and emerging scientific views. **C)** The expedition's achievements included extensive botanical research and collections that contributed to global knowledge.

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)** Caracas was in the viceroyalty of Nueva Granada**. B)** The Jesuit expulsion shifted academic control to the Dominicans, affecting the progress of scientific inquiry, as Jesuits were leading in science education.

3. **What scientific publication was created by José Celestino Mutis?** José Celestino Mutis created *El Arcano de la Medicina*, a key publication on medical and botanical topics.

4. **Evaluate the logical truth of this claim: "anti-vaccination campaigns do not have the scientific attitude, therefore these are not scientific endeavors."** Anti-vaccination campaigns lack the scientific attitude because they reject overwhelming evidence supporting vaccines' effectiveness and safety.

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, such as advanced agricultural techniques in the Andes, should be considered scientific even though it was often disregarded by European standards.

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

> *La Universidad Gegoriana* 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 because 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 Fransisco 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 led to the incorporation of European scientific methods, blending indigenous knowledge with Enlightenment ideals. This fostered a transition toward more empirical, observational sciences in Ecuador. **B)** The ratio of native to foreign professors (21:71) suggests that foreign professors dominated the academic scene, which indicates that much of the scientific knowledge and teaching were influenced by external, European perspectives. **C)** The Ptolemaic system posited an Earth-centered universe. The Copernican system introduced a Sun-centered solar system, while the Tychonic system was a hybrid, placing Earth at the center but with planets orbiting the Sun. This shows Aguilar's broad approach to teaching diverse astronomical models.

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 this work, José Celestino Mutis defended the Tychonic system, a geocentric model where planets revolve around the Sun, but the Sun revolves around the Earth. He argued that this system was compatible with both observational evidence and religious beliefs**. B)** Yes, it was controversial because the Copernican heliocentric system was gaining wider acceptance in scientific circles, while the Tychonic system was seen as a compromise that aligned more closely with the church's teachings, thus drawing criticism from both scientists and theologians.

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? A)** Velázquez de León and José de Gálvez made astronomical and geographical measurements, including mapping the region and observing celestial events such as the Venus transit. **B)** These measurements significantly improved the geographic and scientific understanding of Nueva España, helping to produce more accurate maps and contributing to global knowledge of the region's topography and astronomical phenomena. **C**) Velázquez de León remained in Real de Santa Ana to observe the Venus transit, while Chappe d'Auteroche worked in San José del Cabo. Their collaboration provided crucial data for the international effort to calculate the distance from the Earth to the Sun, contributing to the field of astronomy.

9. **What was notable about the explorations of José Sanchez Labrador?** Sanchez Labrador explored Paraguay and made significant contributions to ethnobotany and zoology.

4 Applications, Mayan and Incan Number Systems

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

   (a) $365+365=730$

   (b) $1024-512=512$

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

   (a) $512+256=768$

   (b) $365-67=298$

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 x 20^1) + (4 x 20^0)

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 that 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

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 and Milagro have detected sources of high-energy gamma rays, including supernova remnants and active galactic nuclei.

6 Modern Science in Latin America - Cosmic Ray Physics

1. **What is the purpose of the Pierre Auger Observatory?** To detect and study high-energy cosmic rays entering Earth's atmosphere.

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