

Midterm - INTD262

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

October 18, 2024

1 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.

Tenochtitlan, which is now Mexico City, was centrally located, facilitating control over trade routes and access to resources. Lima was located conveniently for trade in the Pacific, making it an important trade port. Establishing *virreinos* allowed for better governing and administration of the large territories, providing a direct line of authority from Spain. Also, both locations were great for resources, Tenochtitlan had access to the silver mines, and Lima was close to fertile lands and ocean resources, essential for the colonial economy.

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 in Latin America was closely tied to the growth of scientific activity. The demands of capitalism, such as the need for agricultural innovations and resource management, encouraged scientific research and exploration. However, some scientific developments did use capitalist practices, particularly in the areas of navigation and cartography.

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?

Peripheral scientific activity in Latin America refers to the way that scientific research in the region is often limited by a number of factors. An example is the contributions of Latin American scientists in the fields of botany and medicine during the colonial period. For instance, the work of indigenous and mestizo healers in herbal medicine was documented and transmitted to Europe, influencing European medicinal practices.

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

An example of *pseudo-scientific* beliefs is the myth El Dorado, the city of gold. It drove expeditions seeking wealth and led to the belief in other mythical places like the Fountain of Youth. These ideas were often based on exaggerated reports and tales from indigenous people, fueling European imagination and colonization efforts.

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**

- **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 **D**
- (2): Griffins so large they capture people and calves as prey, with feathers as large as an arm.

B

- (3): "A fountain running with hot water and as the water runs it turns to stone." **C**
- (4): "fish that as they leave the water turn into butterflies." **A**
- (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. E

- A: A flying fish 4
- B: A condor 2
- C: A mercury mine 3
- D: The belief about a certain river among the Lucayo and Carib indigenous 1
- E: The Mexican opossum 5

1

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?

The description of the "tiger" indicates a nuanced understanding of physics, suggesting that the Nahua recognized phenomena like sound and vision under different conditions. This reflects an awareness of environmental influences on perception and interaction.

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

Hummingbirds were believed to be connected to immortality due to their vibrant appearance and rapid movement, which may have symbolized the fleeting nature of life and the possibility of rebirth.

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.

Arguments used in court against Act 590 included the lack of scientific evidence supporting creation science compared to evolution. Critics highlighted that creation science was based on religious belief rather than empirical data. The distinction was that creationism relied on faith, while the act sought to present creation science as a legitimate scientific alternative without religious backing.

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?

An example of a scientific revolution is the transition from Newtonian physics to Einstein's theory of relativity. The anomaly was the inability of Newtonian physics to explain the orbit of Mercury accurately. Yes, the colonization of Nueva España likely triggered a scientific revolution by introducing new ideas and practices from Europe and

blending them with indigenous knowledge, fostering a unique scientific environment.

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

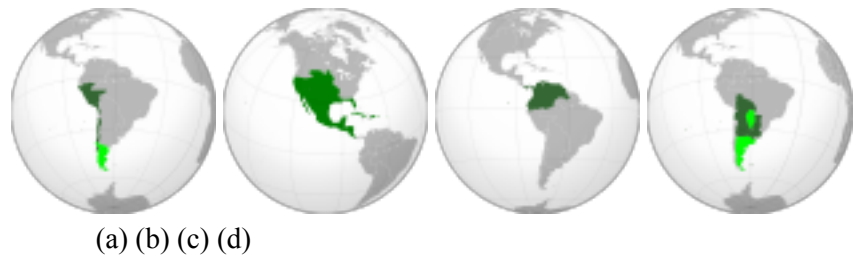


Figure 1: Maps depicting *virreinos* in Latin America, 17th and 18th centuries.

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

Table 1: Fill in the missing information.

2

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 Bartolache's library shows a growing interest in scientific questioning and knowledge among Latin Americans in the 18th century, causing a shift towards a more practical approach to understanding the world. Bartolache owned various scientific items, including instruments and texts on natural history, which suggest a commitment to observed study and a connection to European scientific advancements. Before 1760, the state of science in the American colonies was also developing, but there was a stronger focus on practical applications and self-reliance, contrasting with the more formal European influences seen in Bartolache's library.

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?

Newton's Law of Gravity was not falsified by the disruptions observed in Uranus's orbit. But, it did indicate that there were additional factors or bodies influencing the orbit. The problem was solved by the discovery of Neptune, which accounted for the observed irregularities in Uranus's orbit. This demonstrated that while Newton's laws held true, they needed to be applied within a broader context.

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 just because it fit the data. While it provided a pattern that coincided with the discovered planets, scientific theories require more than empirical fit. They need to be predictive and withstand various testing. Bode's Law was more of a mathematical curiosity rather than a 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*, Gamboa discussed various scientific results aimed at improving mining efficiency, including techniques for ore extraction like the use of mercury amalgamation. He suggested creating institutions such as a mining academy to train professionals and improve practices in the mining industry.

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.

Efforts to preserve *El Real Seminario de Minería* included attempts to secure funding from the Crown and local governments, as well as fostering partnerships with private mining companies. There were also initiatives to adapt its curriculum to modern practices and to promote research that could lead to innovations in the mining sector.

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 skepticism, a questioning approach to knowledge claims, emphasizing the need for evidence and critical thinking, and open-mindedness, willingness to consider new evidence and revise beliefs in light of new findings.

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 continuously observing the outcomes of handwashing practices in maternity wards and correlating them with rates of infection. His skepticism about existing medical practices and his willingness to test new methods demonstrated the essence of the scientific attitude, although his ideas faced significant resistance before being accepted.

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 the cold fusion situation due to a lack of rigorous peer review, insufficient reproducibility of results, and the premature announcement of findings without thorough validation. This led to significant skepticism and ultimately the discrediting of the claims. An example from Latin American history could be the work of José Celso Barbosa in public health reform. Applying the scientific attitude to his efforts, he emphasized

data collection and analysis of health statistics to identify public health issues, advocated for evidence-based policies, and encouraged a systematic approach to improve sanitation and health outcomes.

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 located in the Virreinato del Nuevo Granada. The polemic on Copernican theories initiated by José Celestino Mutis and the Dominican Congregation highlighted the tension between traditional religious beliefs and emerging scientific ideas. This debate reflected broader Enlightenment challenges to established doctrines, ultimately having a more critical scientific conversation in the region. The Expedición Botánica aimed to explore and document the rich biodiversity of New Granada. Its achievements included extensive collections of plant species, the establishment of botanical gardens, and contributions to the field of natural history, which laid the groundwork for future scientific exploration in the Americas.

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 Virreinato de Nueva Granada. The expulsion of the Jesuit order in 1767 led to a change in educational authority to the Dominicans, which had implications for science, as the Dominicans were more conservative and less engaged in the emerging scientific communication. This may have set back the advancement of scientific thought in some institutions.

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

José Celestino Mutis created the *Flora de Nueva Granada*, a significant botanical publication documenting the diverse plant life of the region.

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 “anti-vaccination campaigns do not have the scientific attitude, therefore these are not scientific endeavors” is logically inaccurate. While anti-vaccination campaigns may lack a scientific basis, the mere absence of the scientific attitude does not limit a topic from being labeled as “scientific.” Scientific endeavors can come from a variety of perspectives, including those that are ultimately misguided.

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 is the work of indigenous healers who used traditional medicinal practices. Besides not fitting the Western scientific model, their extensive knowledge of local flora and healing methods represents a form of trustworthy knowledge that has been increasingly recognized in recent years.

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 uni versity ... 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 at the Universidad Gregoriana led to a transition from Aristotelian natural philosophy to more modern scientific methods and ideas, particularly those coming from the Enlightenment. The ratio of native professors suggests a minority presence, indicating that the intellectual landscape was significantly influenced by foreign scholars, which may have created a disconnect with local academic traditions. The Ptolemaic system was geocentric, placing Earth at the center. The Copernican system was heliocentric, placing the Sun at the center, and the Tychonic system combined both perspectives, proposing a geocentric model with the Sun and Moon orbiting Earth while other planets orbited the Sun.

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

In his publication, Mutis argued for the validity of the Tychonic system as a compromise between the Ptolemaic and Copernican models, emphasizing observational data supporting its use for practical astronomical calculations. Yes, it was considered controversial, as it challenged established views and aligned with the broader debates about heliocentrism during the period.

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 various measurements, including astronomical observations and geographical mapping. These measurements improved local knowledge of Nueva España by providing more accurate geographical and astronomical data, which facilitated navigation and resource management. As a result of Velázquez de León’s communication with Chappe d’Auteroche, coordinated efforts were made for the observations of the Venus transit, which contributed to the scientific understanding of planetary transits and distance measurements.

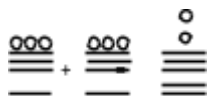
9. What was notable about the explorations of José Sanchez Labrador?

José Sánchez Labrador is notable for his extensive explorations of the Pacific coast and interior regions of Mexico, contributing to the mapping and understanding of the geography and natural resources of the area. His work also highlighted the importance of scientific exploration in the context of colonial expansion.

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) $512 + 256 =$

(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

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 has discovered several high-energy gamma-ray sources, such as supernova remnants, pulsar wind nebulae, and potential sites of cosmic ray acceleration. It has also provided insights into the nature of dark matter and the origins of cosmic rays.

6 Modern Science in Latin America - Cosmic Ray Physics

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

The Pierre Auger Observatory's purpose is to study cosmic rays, particularly ultra-high-energy cosmic rays, by detecting air showers produced when these cosmic rays interact with the 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

