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 established the virreinatos of Nueva España and Perú in Tenochtitlan and Lima due to their strategic locations, which facilitated trade efficiency. These capitals allowed for better governance over large territories and maximized resource exploitation, particularly in silver and agriculture. Additionally, placing capitals in existing indigenous cities aimed to integrate local populations while asserting Spanish dominance.

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 significantly stimulated scientific activity, this was because the demand for resources and technological advancements drove innovations in agriculture, mining, and industry. While some scientific practices existed prior to capitalism, the economic motivations of the capitalist system worked to greatly accelerate research and development. Thus, capitalism and the growth of modern science were interlinked, with each influencing the expansion of the other in the colonial context.

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 of peripheral scientific activity contributing to the center of science is the work of José Celso Barbosa in Puerto Rico during the late 19th and early 20th centuries. José conducted important research in public health and epidemiology, particularly on diseases like tuberculosis and yellow fever. His findings and methodologies were disseminated to the broader scientific community and were influencing public health practices and policies in the United States and beyond, this shows how scientific results from peripheral regions can impact central scientific discourse and practice.

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

Pseudo-scientific beliefs fueled colonial explorations of mythical places like El Dorado, a legendary city of gold that captivated many expeditions despite no evidence. The quest for the Fountain of Youth, believed to restore youth, also led to explorers such as Ponce de León to search in Florida. Similarly, the Seven Cities of Cibola, thought to be rich in gold, inspired numerous quests into North America, showcasing how these legends shaped colonial ambitions and perceptions of the New World.

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

1=D
2=B
3=C
4=A
5=E

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?

Father Bernardino de Sahagún's translation of the Nahua description of a "tiger" highlights their sophisticated understanding of physics, particularly regarding perception and sound. The belief that the creature can see small objects in fog or darkness suggests an awareness of light and visibility, while the idea of creating sounds "through the air" indicates an understanding of acoustics and the transmission of sound. This reflects a nuanced comprehension of natural phenomena within their cultural context.

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

Both the Spaniards and the Aztecs believed hummingbirds were connected to immortality due to their vibrant colors and swift, speedy movements, which seemed to go against the natural order of life and death. In Aztec culture, hummingbirds were associated with the sun and the resurrection, symbolizing the cyclical nature of life. This belief resonated with European notions of the miraculous and the transcendent, linking the tiny birds to themes of eternal life.

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 onlyu 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.

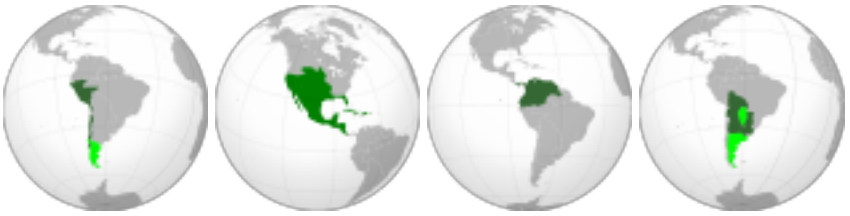
In response to Act 590 in Arkansas, opponents argued that "creation science" lacked empirical support and did not meet the standards of scientific inquiry. They contended that the act blurred the line between science and religion, as creation science was fundamentally rooted in religious beliefs, despite the claim that it would be presented as a scientific perspective. The courts ultimately found that the law violated the Establishment Clause of the First Amendment, as it effectively promoted a religious doctrine under the guise of scientific education, thereby undermining the secular nature of public schooling.

9. Thomas Kuhn wrote a famous book entitled *The Structure of Scientific Revolutions* (1962). Rather than de scribing 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) One example of a scientific revolution is the transition from Newtonian physics to Einstein's theory of relativity in the early 20th century. The anomaly that triggered this revolution was the failure of Newtonian mechanics to accurately describe the motion of light and the behavior of objects at high speeds, particularly observed in experiments such as the Michelson-Morley experiment, which contradicted the then-accepted notion of ether.

(b) Yes, the colonization of Nueva España can be seen as triggering a scientific revolution in certain respects. The encounter with new ecosystems, diverse indigenous knowledge, and unfamiliar natural phenomena led to significant shifts in scientific understanding and methodologies, prompting Europeans to reevaluate and expand their scientific frameworks to incorporate this new-found information about the natural world. This period also marked a melding of European and indigenous knowledge systems, fostering advancements in fields like botany, medicine, and astronomy.

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*	*Santa Fe*
D	*Río de la Plata*	*Buenos Aires*
A	*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) The distribution of texts in José Ignacio Bartolache's library reflects a diverse scientific curiosity among 18th-century Latin Americans, showing strong engagement with both European developments and local knowledge.

(b) Bartolache also owned scientific instruments and natural specimens, highlighting an empirical approach to science and indicating that Latin Americans were actively involved in observation and experimentation.

(c) Before 1760, both Latin America and the American colonies demonstrated a blend of European influence and local experimentation, but while the colonies focused more on practical applications like invention, Latin America showed a deeper integration of European scholarly works, reflecting different trajectories in scientific development.

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 perturbation in Uranus's orbit; rather, the anomaly prompted further investigation within the Newtonian framework. John Couch Adams and Urbain Le Verrier independently proposed the existence of another planet, which led to the discovery of Neptune. This resolution demonstrated that while Newton's laws remained valid, they required expansion to account for new phenomena, illustrating the process of scientific refinement rather than outright falsification.

2. **Bode's Law** was an attempted mathematical explanation of the planetary orbits. Bode's sequence was the pat tern 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 simply because it fit the data; rather, it served as a useful heuristic or pattern that prompted further exploration of planetary distances. While the law accurately predicted the positions of known planets and the asteroid belt, its lack of a robust theoretical foundation meant it was more of an empirical observation than a confirmed 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 proposed the introduction of new techniques such as the use of mercury amalgamation for ore extraction, which was significant for improving efficiency in mining operations. He suggested creating institutions like mining schools and scientific societies to foster education and innovation in mining practices, emphasizing the need for systematic reform to enhance the industry's productivity.

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 to preserve El Real Seminario de Minería included advocating for increased government support and funding to sustain its operations during financial difficulties. Key figures emphasized the institution's importance for training skilled miners and promoting scientific advancements in the mining industry, arguing that its closure would negatively impact national economic interests. Additionally, reforms were proposed to modernize the curriculum and enhance its relevance to contemporary mining practices, which aimed to attract more students and secure the institution's financial future.

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, according to The Scientific Attitude, are empirical evidence and critical inquiry. Empirical evidence emphasizes the necessity of observation and experimentation to support scientific claims. Critical inquiry encourages skepticism and rigorous testing, promoting the revision or rejection of theories based on 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.

Ignaz Semmelweis applied the scientific attitude by systematically observing the rates of puerperal fever in maternity wards and hypothesizing that hand hygiene among medical staff was a critical factor. He implemented antiseptic handwashing protocols and documented the resulting decrease in infection rates, demonstrating a commitment to empirical evidence and critical inquiry. His approach highlighted the importance of data-driven practice and the need for healthcare professionals to question existing norms to improve patient outcomes.

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 case of the false discovery of cold fusion, the scientific attitude was not applied because the researchers failed to adequately test their claims and did not subject their findings to rigorous peer review. Their initial enthusiasm led to a lack of skepticism and critical inquiry, resulting in widespread media coverage without sufficient validation of the results.

(b) An example from Latin American history is the work of José Celso Barbosa in public health. He applied the scientific attitude by gathering empirical evidence about diseases like tuberculosis and advocating for public health reforms based on his findings. His approach involved critical inquiry into the causes of disease, demonstrating a commitment to evidence-based practices that ultimately improved community 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?

(a) The city of Santa Fe de Bogotá was located in the Viceroyalty of New Granada.

(b) The half-century-long polemic on Copernican theories, initiated in 1773 between José Celestino Mutis and the Dominican Congregation, had significant scientific implications as it reflected the tension between traditional religious views and emerging scientific ideas. Mutis championed the Copernican heliocentric model, advocating for a shift in astronomical understanding, while the Dominicans resisted this change, emphasizing the geocentric view supported by religious doctrine. This conflict highlighted the broader struggle for scientific progress in Latin America during a time when Enlightenment ideas were beginning to influence intellectual thought.

(c) The Expedición Botánica, initiated in 1783, aimed to explore and document the flora and fauna of the New Granada region, promoting the study of natural history and agriculture. Its achievements included the collection of many plants, which contributed to the understanding of biodiversity and led to the classification of numerous species. Additionally, the expedition led to collaboration between scientists and indigenous peoples, enhancing knowledge exchange and supporting the development of botany as a field in Latin America.

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 had significant implications for science in the Spanish colonies, as the Jesuits were key proponents of education and scientific inquiry. With the Dominicans recovering authority over some colleges and universities, there was a shift in the academic environment, as the Dominicans often followed more closely to traditional doctrines and practices. This change potentially delayed the progressive scientific advancements encouraged by the Jesuits, leading to a more conservative approach to education and limiting the adoption of Enlightenment ideas in the region.

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

José Celestino Mutis created the "Flora de Nueva Granada," a comprehensive scientific publication that documented the diverse plant life of the New Granada region. This work was significant for its systematic classification and detailed descriptions of numerous species, contributing to the field of botany and advancing knowledge about the flora of Latin America.

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" presents a logical evaluation that requires careful consideration. While it is true that anti-vaccination campaigns often lack the scientific attitude, such as reliance on empirical evidence and critical inquiry, this does not automatically mean they are entirely devoid of scientific elements or that they cannot be studied scientifically. In essence, the logical truth of the claim hinges on the definition of "scientific endeavors." If defined strictly by adherence to the scientific method, then the claim holds some validity. However, anti-vaccination campaigns can still be analyzed using scientific methods, even if the campaigns themselves do not embody the scientific attitude. Therefore, the conclusion may not be universally applicable, and the statement could benefit from further nuance in defining what constitutes 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.

One example from our scientific history that should count as science, despite not traditionally being considered so, is the work of indigenous herbalists and traditional healers in Latin America. These practitioners have long utilized empirical knowledge of local plant life to treat various illnesses, often relying on generations of observation and experimentation. While their methods may not exactly fit conventional scientific frameworks or methodologies, the systematic gathering of knowledge about medicinal plants and their effects demonstrates a rich understanding of biology and pharmacology, highlighting the validity of their contributions to science.

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 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 at the Universidad Gregoriana in Quito facilitated a scientific transition from traditional, local knowledge systems to a more modern, European-based scientific framework. This exchange fostered the adoption of Enlightenment ideas and methodologies, enriching the local intellectual environment and promoting advancements in fields such as astronomy, mathematics, and natural sciences.

(b) The ratio of native professors at the university suggests that they were significantly outnumbered by foreign professors, with only twenty-one native professors compared to seventy-one foreign professors. This indicates a reliance on foreign expertise, which likely influenced the curriculum and teaching methods, emphasizing European scientific traditions over local knowledge.

(c) The Ptolemaic, Copernican, and Tychonic systems are distinguished by their models of the universe. The Ptolemaic system is geocentric, placing Earth at the center, while the Copernican system is heliocentric, positioning the Sun at the center of the universe. The Tychonic system is a hybrid, proposing that the Earth is at the center, but the other planets orbit the Sun, which in turn orbits the Earth, reflecting a compromise between the two earlier 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 Reflexiones sobre el sistema tycónico, José Celestino Mutis presented key arguments supporting the Tychonic system, emphasizing its pragmatic approach to astronomy. He highlighted the system's ability to account for observed celestial phenomena while avoiding the complexities and controversies of both the Ptolemaic and Copernican models. Mutis also discussed the implications of this model for understanding the universe and promoted the importance of empirical observation in astronomical studies.

(b) Yes, the publication was considered controversial, particularly due to its challenge to the traditional Ptolemaic view and its endorsement of the Tychonic model, which had not gained widespread acceptance among the academic community. Mutis's work sparked debates about the validity of different astronomical systems, reflecting broader tensions between established beliefs and emerging scientific ideas during the Enlightenment. This controversy was further exacerbated by the influence of the Church, which often supported the Ptolemaic system.

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) Joaquín Velázquez de León and José de Gálvez conducted various measurements, including astronomical observations, geographic surveys, and environmental assessments. They focused on mapping the region, recording the latitude and longitude, and collecting data on local flora and fauna.

(b) Their work significantly improved local knowledge of Nueva España by providing detailed geographic and scientific information about Baja California, contributing to better navigation, resource management, and understanding of the region's ecology. This data also enhanced the Spanish Crown's knowledge of its territories and supported future expeditions and settlement efforts.

(c) As a result of Velázquez de León's communication with Chappe d'Auteroche regarding the Venus transit measurements, Velázquez de León remained in Real de Santa Ana while d'Auteroche conducted observations in San José del Cabo. This collaboration allowed for comprehensive measurements of the transit, leading to valuable astronomical data that contributed to the understanding of celestial mechanics and improved scientific communication between the two locations.

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

José Sánchez Labrador was notable for his extensive explorations as well as his contributions to the geographic and scientific understanding of the northern regions of New Spain, particularly present-day California and the Pacific Northwest. His expeditions included detailed mapping and observations of the geography, flora, fauna, and indigenous cultures in these areas, working towards enhancing European knowledge of the region. Additionally, his work laid the groundwork for future explorations and settlements, highlighting the importance of scientific inquiry in the expansion of Spanish territories.

4 Applications, Mayan and Incan Number Systems

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

   (a) 365 + 365 = 36 (1 bar and 16 dots) in the 20s place (representing 720). 10 (2 bars and 0 dots) in the units place.

(b) 1024 − 512 = 25 (1 bar and 5 dots) in the 20s place (representing 500). 12 (2 bars and 2 dots) in the units place.

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

(a) 512 + 256 = 7 knots in the 100s place, 6 knots in the 10s place, 8 knots in the units place.

(b) 365 − 67 = 2 knots in the 100s place, 9 knots in the 10s place, 8 knots in the units place.

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.

16 beams×4 meters/beam=64 meters, Representation in the Mayan System:

- 16 is represented as 3 bars (which equal 15) and 1 dot (for the additional 1)
- 4 is 4 dots
- 3 in the 20s place (3 bars), 4 in the units place (4 dots). (64)

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.

Potato Plants: 7500, Quinoa Plants: 6666

- Quipu Representation: Potato Plants (7500): 7 knots in the 1000s place, 5 knots in the 100s place, 0 knots in the 10s place, 0 knots in the units place. Quinoa Plants (6666), 6 knots in the 1000s place, 6 knots in the 100s place, 6 knots in the 10s place.

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 both made significant contributions to gamma-ray astrophysics by identifying cosmic sources of gamma rays, including supernova remnants and active galactic nuclei. HAWC mapped gamma-ray emissions across the Milky Way, revealing regions of high-energy processes and enhancing our understanding of cosmic rays.

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 study cosmic rays, particularly ultra-high-energy cosmic rays, by detecting and analyzing their interactions with the Earth's atmosphere. It aims to understand the origins, composition, and behavior of these high-energy particles, which can provide insights into astrophysical processes and the universe's fundamental properties. The observatory combines surface detectors and air fluorescence telescopes to capture data on cosmic ray events over a vast area.

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