

NOLOGIA

The Scientific Method

9th Grade Advanced Physics | Module 01 – Lesson 01

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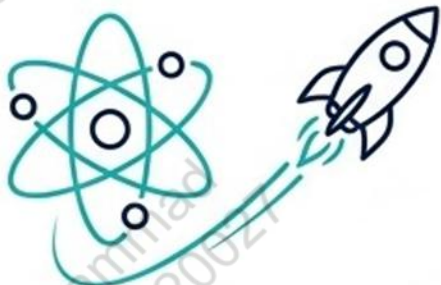
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Defining the Physical World

Physics = Matter + Energy + How They Relate

Relies on inquiry, formulas, and mathematics (e.g., $E = mc^2$, $I = V/R$, $x = (1/2)at^2 + v_{it} + x_0$).

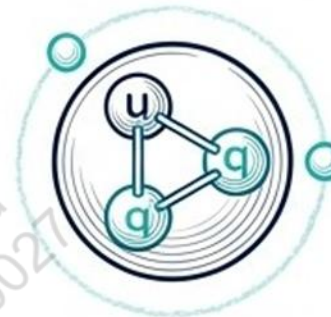
Motion



Energy



Structure (Micro)

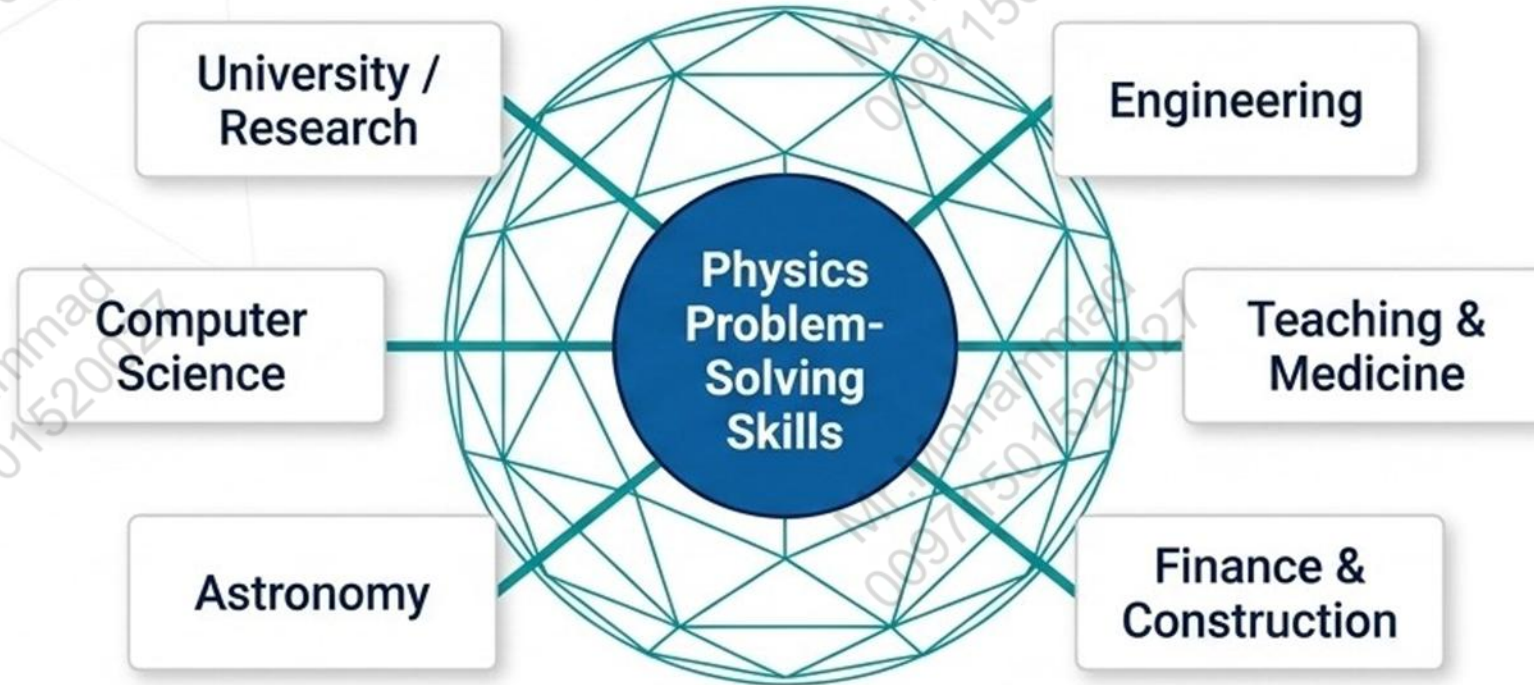


Structure (Macro)



Word Origin Focus: The word 'Science' comes from the Latin word '**scientia**', which means '**knowledge**'.

The Reach of Physics: Skills & Careers



STEM Spotlight

Survey or Mapping Technician:

Uses physics, geographic data (elevation and contour), and sophisticated computer software to map the Earth's surface.

Modern Technologies Derived from Physics

1



Weather Satellites

2



Lasers & Satellite-based communications

3



High-speed microscanners to detect disease

The Scientific Method: A Flexible Framework

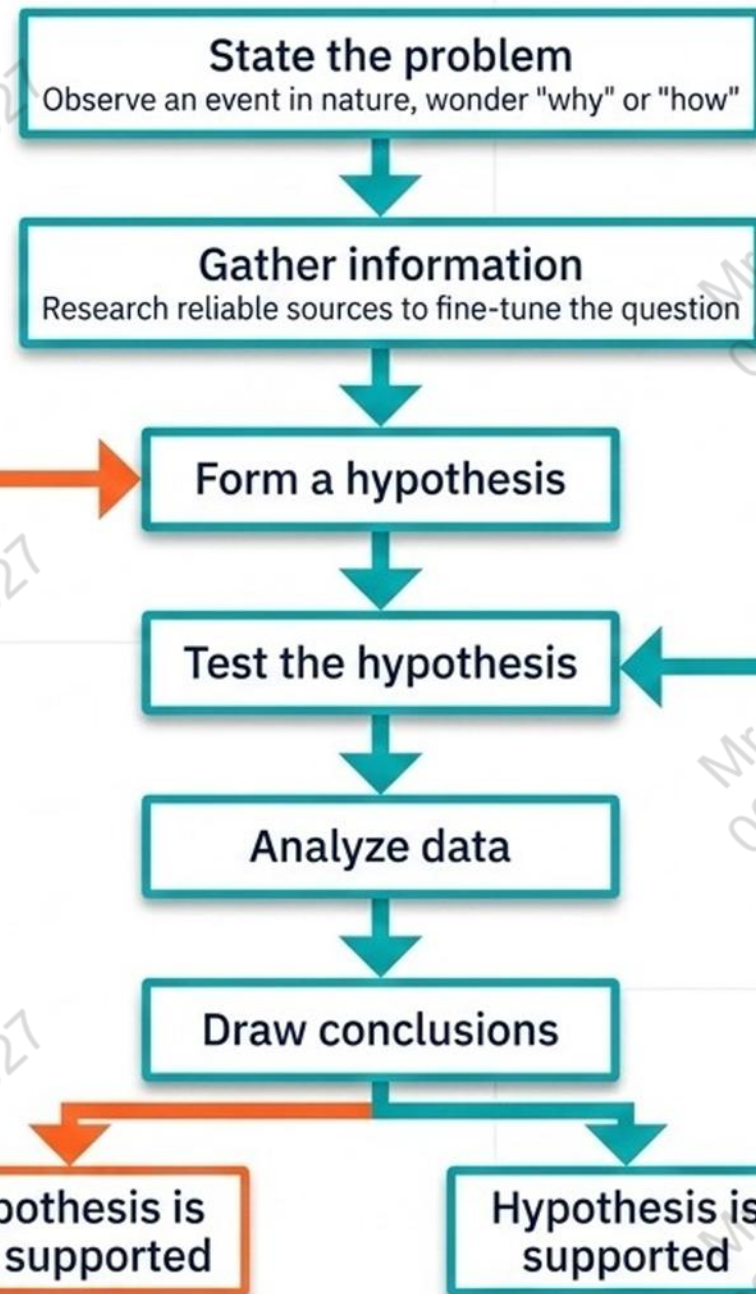
Core Insight: Investigations follow patterns, but physicists do **NOT** always follow a rigid set of steps. They may add, repeat, or skip steps entirely.

A hypothesis is a possible explanation for a problem using what you know and have observed.

A scientific hypothesis can be tested through experimentation and observation.

Sometimes scientists must wait for new technologies before a hypothesis can be tested.

Modify the hypothesis.



The Method in Action: Percy Spencer & The Microwave

The Context (1940s)



Researcher Percy Spencer is trying to mass-produce magnetron tubes for military radar systems.



The Observation



Standing in front of an operating magnetron, he notices a candy bar in his pocket has completely melted.



The New Problem



A completely new question is posed during the investigation: How did the magnetron cook the food?

Key Takeaway: An investigation into one problem (radar) can spontaneously lead to the statement of an entirely new problem (microwaves).

Safeguarding Science: Accuracy & Objectivity

Peer Review



Definition: Science-based information reviewed by peers (scientists in the same field) BEFORE it is made public.

Purpose: To rigorously evaluate procedures and results. Reviewing other scientists' work is a core responsibility.

Being Objective



The Threat (Bias): Occurs when a scientist's expectations affect how results are analyzed or conclusions are made (e.g., hiding product drawbacks for a promotion).

The Solution (How to lessen bias):

1. Run as many trials as possible.
2. Keep accurate notes of EVERY single observation.

Scientific Models: Representing the Unseen

A representation of an idea, event, structure, or object that helps people better understand it.

"Why" Diagnostic Grid



Too Large

Processes on an astronomical scale, like the expanding universe.



Too Small

Microscopic structures, like the inner workings of an atom.



Too Slow

Geological or evolutionary processes that take too much time to see completely.



Too Hazardous

Handling dangerous materials or studying extreme disaster situations.

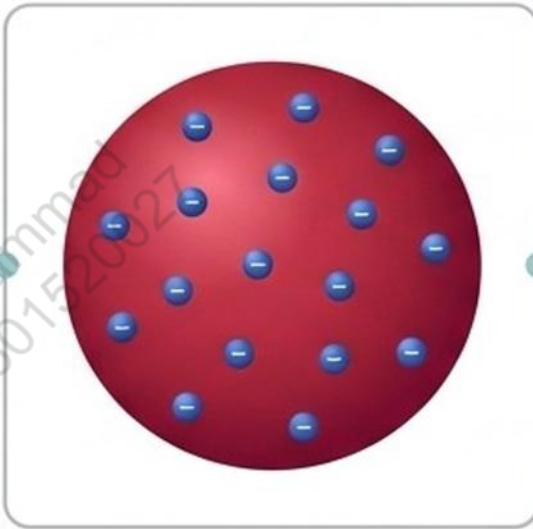


High-Tech Models

Computers run simulations to test solutions efficiently. Flight simulators allow pilots to practice all aspects of flight and harsh weather conditions safely on the ground without leaving the building.

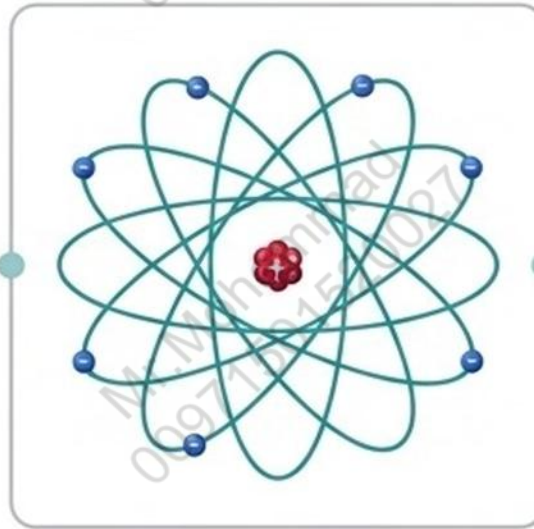
Evolution in Action: Models of the Atom

Thomson's Model
(1904)



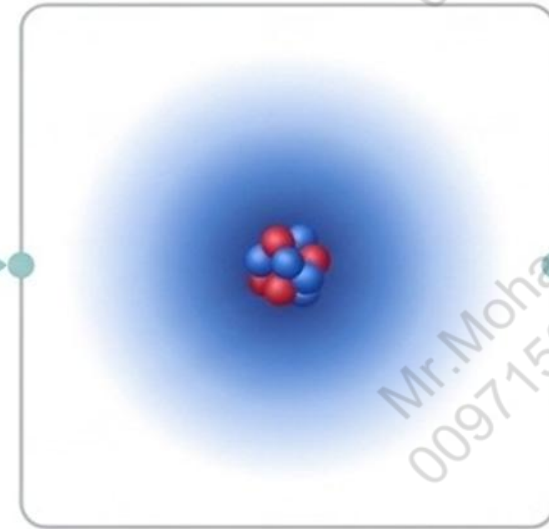
Matter containing evenly distributed positive charge with electrons embedded in it.

Rutherford's Model
(1911)



Created based on new research. A solid positive nucleus surrounded by orbiting electrons.

Electron Cloud Model
(Present-day)



Nucleus of protons and neutrons surrounded by a blurry electron cloud.

Takeaway: Models are never final; they adapt and change continuously as physicists discover more about the physical world.

Deciphering the Rules: Scientific Theory vs. Scientific Law

	Scientific Theory	Scientific Law
Definition	An explanation of things/events based on knowledge gained from many observations and investigations.	A statement about what happens in nature that seems to be true all the time.
Function (The Core Difference)	Explains WHY or HOW something happens.	Tells you WHAT will happen under certain conditions (does not explain why).
Can it change?	Yes. Can be refined or modified as new information becomes available. (Note: A theory is not a guess).	Extremely Rare. To date, no experiments have performed that disprove the law of gravity.
The Relationship	Theories are proposed to explain laws.	Theories DO NOT become laws.

How Theories Evolve: The Behavior of Falling Objects

Greek Philosophers: Proposed that objects fall because they seek their natural places. The more massive the object, the faster it falls.



Revision based on new evidence

Galileo: Showed that the speed at which an object falls depends on the amount of time for which that object has fallen and not on the object's mass.



Revision based on new evidence

Newton: Provided an explanation for why objects fall. Proposed that objects and Earth are attracted by a force. Stated that there is a force of attraction between any two objects with mass.



Revision based on new evidence

Einstein: Suggested that the force of attraction between two objects is due to mass causing the space around it to curve.

The Boundaries of Science: Testable vs. Untestable

Core Principle: Science requires **testable and verifiable guesses**. It can explain many things, but it cannot explain or solve everything.

Scientific & Testable

- ☒ Motions of electrons
- ☒ Energy in sound waves
- ☒ Speed of falling objects
- ☒ Calculating free-fall acceleration (9.8 m/s^2)

Non-Scientific & Untestable

- ☒ Personal Opinions
- ☒ Human Values
- ☒ Complex Emotions
- ☒ Whether a particular piece of art is beautiful

The Pizza Survey Case Study

Scenario: A survey finds 90% of students like pizza. A friend claims this "scientifically proves" everyone likes pizza.

The Scientific Reality: This is just data about opinions. It does not scientifically prove pizza is delicious, because "delicious" is an untestable emotion/opinion and not true for everyone.

Lesson 1: The NOLOGIA Master Summary

The Physics Concept

- Study of matter, energy, and their relationships.
- Relies on inquiry and mathematics.

The Process

- Scientific method is flexible, not a rigid checklist.
- Observe, Hypothesize, Test, Conclude.
- Scientists may skip, add, or repeat steps.

The Safeguards

- Peer Review: External validation by scientists in the same field before publication.
- Lessening Bias: Run many trials, take accurate notes to prevent expectations from skewing results.

The Tools

- Models represent things too big, small, fast, slow, or dangerous.
- Physical models and high-tech computer simulations.
- Models evolve over time with new data.

The Outputs

- Scientific Law: WHAT happens in nature under certain conditions.
- Scientific Theory: WHY or HOW it happens.
- **CRITICAL**: Theories never become Laws.

The Limits

- Science only deals in the testable and verifiable.
- Opinions, values, and emotions are strictly excluded.

NOLOGIA ACADEMY

The Scientific Method Assessment

THE METHODS OF SCIENCE: EVALUATION MODULE

Active Learning Evaluation

QUESTION 1 OF 13

According to the scientific method diagram, what should you do if your hypothesis is not supported?

وفقًا لمخطط المنهج العلمي، ماذا يجب أن تفعل إذا لم يتم دعم فرضيتك؟

A Publish the results immediately.
نشر النتائج فورًا.

B Modify the hypothesis and repeat the process.
تعديل الفرضية وتكرار العملية.

C Reject all prior research data.
رفض جميع بيانات الأبحاث السابقة.

D Conclude that the question is unanswerable.
الاستنتاج أن المسألة غير قابلة للإجابة.

Active Learning Evaluation

QUESTION 2 OF 13

What is the first step shown in the scientific method diagram to start the scientific process?

ما هي الخطوة الأولى الموضحة في مخطط المنهج العلمي لبدء العملية العلمية؟

A Form a hypothesis.
تكوين فرضية

B Observe an event in nature and ask "why" or "how".
ملاحظة حدث في الطبيعة وطرح سؤال "لماذا" أو "كيف"

C Analyze data immediately.
تحليل البيانات فوراً

D Draw conclusions.
استخلاص النتائج

Active Learning Evaluation

QUESTION 3 OF 13

What is the purpose of repeating the cycle several times as shown in the scientific method diagram?

ما هو الغرض من تكرار الدورة عدة مرات كما هو موضح في مخطط المنهج العلمي؟

A To make the research longer.
لجعل البحث أطول.

B To refine the hypothesis until it is supported.
لتحسين الفرضية حتى يتم دعمها.

C To avoid drawing conclusions.
لتجنب استخلاص النتائج.

D To replace observation with guessing.
لاستبدال الملاحظة بالتخمين.

Active Learning Evaluation

QUESTION 4 OF 13

Which of the following is NOT a step shown in the scientific method diagram?

أي من التالي ليس خطوة موضحة في مخطط المنهج العلمي؟

A Gather information from reliable sources.
جمع المعلومات من مصادر موثوقة

B Form a hypothesis.
تكوين فرضية

C Publish the results before testing.
نشر النتائج قبل الاختبار

D Analyze data and draw conclusions.
تحليل البيانات واستخلاص النتائج

Active Learning Evaluation

QUESTION 5 OF 13

What is a hypothesis?

ما هي الفرضية؟

A A final proven fact based on reliable sources.

حقيقة مثبتة نهائية بناءً على مصادر موثوقة

B A possible explanation for a problem using what you know and have observed.

تفسير محتمل لمشكلة باستخدام ما تعرفه وما لاحظته

C A random guess without any prior observation.

تخمين عشوائي دون أي ملاحظة مسبقة

D A conclusion drawn after analyzing data.

استنتاج يتم التوصل إليه بعد تحليل البيانات

Active Learning Evaluation

QUESTION 6 OF 13

Which statement about testing a hypothesis is TRUE?

أي عبارة حول اختبار الفرضية صحيحة؟

A All hypotheses can be tested immediately using current technology.

يمكن اختبار جميع الفرضيات فورًا باستخدام التكنولوجيا الحالية.

B A hypothesis can only be tested through controlled experiments.

لا يمكن اختبار الفرضية إلا من خلال تجارب مضبوطة.

C Sometimes scientists must wait for new technologies before a hypothesis can be tested.

أحيانًا يجب على العلماء انتظار تقنيات جديدة قبل أن يمكن اختبار الفرضية.

D If an experiment is not possible, scientists cannot learn anything about the problem.

إذا كانت التجربة غير ممكنة، فلا يمكن للعلماء تعلم أي شيء عن المشكلة.

Active Learning Evaluation

QUESTION 7 OF 13

Which of the following is NOT one of the ways that used to test hypothesis?

أي من التالي ليس من الطرق المستخدمة لاختبار الفرضية؟

A Performing a controlled experiment.

إجراء تجربة مضبوطة

B Making direct observations.

إجراء ملاحظات مباشرة

C Publishing the hypothesis in a scientific journal.

نشر الفرضية في مجلة علمية

D Building a model and relating it to real-life situations.

بناء نموذج وربطه بمواقف من الحياة الواقعية

Active Learning Evaluation

QUESTION 8 OF 13

Why do scientists use models?

لماذا يستخدم العلماء النماذج؟

A Because models are always more accurate than direct observation.

لأن النماذج دائماً أكثر دقة من الملاحظة المباشرة.

B Because scientists sometimes cannot see everything they are testing (e.g., objects too small, too large, hazardous, or processes too slow).

لأن العلماء أحياناً لا يستطيعون رؤية كل ما يختبرونه (مثل: أجسام صغيرة جداً، كبيرة جداً، خطيرة، أو عمليات بطيئة جداً).

C Because models are easier to publish than real experiments.

لأن النماذج أسهل في النشر من التجارب الحقيقية.

D Because models replace the need for any further research.

لأن النماذج تلغي الحاجة إلى أي بحث إضافي.

THE METHODS OF SCIENCE: EVALUATION MODULE

Active Learning Evaluation

QUESTION 9 OF 13

A student surveys 90% of cafeteria students who like pizza and concludes this scientifically proves everyone likes pizza.

What is the best response?

طالبة استطلعت رأي 90% من طلاب الكافتيريا الذين يحبون البيتزا، واستنتجت أن هذا يثبت علمياً أن الجميع يحب البيتزا. ما هو الرد الأفضل؟

A She is correct because 90% is a high percentage.

هي محقة لأن 90% نسبة عالية.

B This is not scientific proof because the sample is biased, and liking pizza is a personal opinion that cannot be proven true or false scientifically.

هذا ليس دليلاً علمياً لأن العينة منحازة، وأن حب البيتزا رأي شخصي لا يمكن إثبات صحته أو خطئه علمياً.

C She should publish the results immediately.

يجب عليها نشر النتائج فوراً.

D She should repeat the survey once more.

يجب عليها إعادة الاستطلاع مرة أخرى.

THE METHODS OF SCIENCE: EVALUATION MODULE

Active Learning Evaluation

QUESTION 10 OF 13

In an experiment, you calculate free-fall acceleration as 9.4 m/s^2 , while the accepted value is 9.8 m/s^2 . Should the accepted value be rejected based on your finding?

في تجربة، قمت بحساب تسارع السقوط الحر بـ 9.4 م/ث^2 ، بينما القيمة المقبولة هي 9.8 م/ث^2 . هل يجب رفض القيمة المقبولة بناءً على نتيجتك؟

A Yes, because your experiment shows a different value, so the accepted value must be wrong.

نعم، لأن تجربتك أظهرت قيمة مختلفة، لذا يجب أن تكون القيمة المقبولة خاطئة.

B No, because your single experiment may contain errors, and you should repeat it multiple times before questioning the accepted value.

لا، لأن تجربتك المنفردة قد تحتوي على أخطاء، ويجب عليك تكرارها عدة مرات قبل التشكيك في القيمة المقبولة.

C Yes, because any difference, no matter how small, means the accepted value is invalid.

نعم، لأن أي اختلاف مهما كان صغيراً يعني أن القيمة المقبولة غير صالحة.

D No, because the accepted value is always correct and never needs to be tested.

لا، لأن القيمة المقبولة صحيحة دائماً ولا تحتاج أبداً إلى اختبار.

Active Learning Evaluation

QUESTION 11 OF 13

According to the scientific method, if the hypothesis is supported which step should be repeated?

وفقاً للمنهج العلمي، إذا كانت النتائج تؤيد الفرضية، فما الخطوة التي يجب تكرارها؟

Previous Exam Questions

A Draw a different conclusion.
كتابة نتيجة مختلفة

B Modify the hypothesis and form a new one.
تعديل الفرضية ووضع فرضية جديدة

C Test the hypothesis again.
اختبار الفرضية مرة أخرى

D Analyze data.
تحليل البيانات

THE METHODS OF SCIENCE: EVALUATION MODULE

Active Learning Evaluation

QUESTION 12 OF 13

The Greek philosopher and scientist Aristotle proposed the idea that the Earth is at the center of the universe, and that the stars, planets, and moons revolve around it. After him came the Polish astronomer Nicolaus Copernicus, who, through his questions and gathering of information, said that "the Earth is not the center of the universe, but the sun". Thus, he is considered the first to propose the centrality of the sun, and that the Earth is a body that revolves in its orbit. However, Copernicus did not prove or test his bold proposal, but later scientists confirmed what Copernicus had stated that the sun is the center of our solar system, but not the universe.

In the previous paragraph, we noticed that scientists follow a fixed set of steps in their studies and research known as the scientific method. Which of the steps of the scientific method in the previous paragraph is expressed by the underlined part?

الفيلسوف والعالم اليوناني أرسطو طرح فكرة أن الأرض هي مركز الكون، وأن النجوم والكواكب والأقمار تدور حولها، وبعده جاء عالم الفلك البولندي نيكولاس كوبرنيكوس، الذي قال من خلال تساؤلاته وجمعه للمعلومات إن "الأرض ليست مركز الكون، بل الشمس". وبهذا يُعتبر أول من طرح فكرة مركزية الشمس، وأن الأرض جسم تابع لها يدور في مدارها. غير أن كوبرنيكوس لم يثبت أو يختبر اقتراحه الجريء، لكن العلماء لاحقاً أكدوا ما ذكره كوبرنيكوس من أن الشمس هي مركز نظامنا الشمسي، وليس الكون.

في الفقرة السابقة، نلاحظ أن العلماء يتبعون مجموعة ثابتة من الخطوات في دراساتهم وأبحاثهم تعرف بالمنهج العلمي، أي من خطوات المنهج العلمي في الفقرة السابقة يعبر عنها الجزء الذي تحته خط؟

A State the problem.

تحديد المشكلة

B Form a hypothesis.

وضع الفرضية

C Research and gather information.

البحث وجمع المعلومات

D Test a hypothesis.

اختبار الفرضية

THE METHODS OF SCIENCE: EVALUATION MODULE

Active Learning Evaluation

QUESTION 13 OF 13

1. A representation of an idea, event, structure, or object that helps people better understand it.

تمثيل لفكرة، أو حدث، أو بنية، أو جسم يساعد الناس على فهمه بشكل أفضل.

2. An explanation of things or events based on knowledge gained from many observations and investigations, which is subject to modification and refinement.

تفسير الأشياء أو الأحداث بناءً على معرفة مكتسبة من العديد من الملاحظات والتحقيقات، وهو قابل للتعديل والتحسين.

3. A possible explanation for a problem based on knowledge and observation and can be tested through experimentation and observation.

تفسير محتمل لمشكلة ما بناءً على المعرفة والملاحظة، ويمكن اختبارها من خلال التجريب والملاحظة.

4. A statement about what happens in nature, and seems to be true all the time, but does not explain why or how it happens.

عبارة تصف شيئاً يحدث في الطبيعة، ويبدو أنها صحيحة في كل الحالات، لكنها لا تفسر سبب أو كيفية حدوثه.

A Scientific methods.
المنهج العلمي

B Hypothesis.
الفرضية

C Model.
النموذج

D Scientific theory.
النظرية العلمية

E Scientific law.
القانون العلمي

The Methods of Science: Answer Key

COMPLETE SYSTEM KEY

Q01 (B)

Q07 (C)

Q02 (B)

Q08 (B)

Q03 (B)

Q09 (B)

Q04 (C)

Q10 (B)

Q05 (B)

Q11 (C)

Q06 (C)

Q12 (B)

The Methods of Science: Answer Key

COMPLETE SYSTEM KEY

Q13

1. A representation of an idea, event, structure, or object that helps people better understand it.

تمثيل لفكرة، أو حدث، أو بُنية، أو جسم يساعد الناس على فهمه بشكل أفضل.

C

2. An explanation of things or events based on knowledge gained from many observations and investigations, which is subject to modification and refinement.

تفسير الأشياء أو الأحداث بناءً على معرفة مكتسبة من العديد من الملاحظات والتحقيقات، وهو قابل للتعديل والتحسين.

D

3. A possible explanation for a problem based on knowledge and observation and can be tested through experimentation and observation.

تفسير محتمل لمشكلة ما بناءً على المعرفة والملاحظة، ويمكن اختبارها من خلال التجريب والملاحظة.

B

4. A statement about what happens in nature, and seems to be true all the time, but does not explain why or how it happens.

عبارة تصف شيئاً يحدث في الطبيعة، ويبدو أنها صحيحة في كل الحالات، لكنها لا تفسر سبب أو كيفية حدوثه.

E

A Scientific methods.
المنهج العلمي

B Hypothesis.
الفرضية

C Model.
النموذج

D Scientific theory.
النظرية العلمية

E Scientific law.
القانون العلمي

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