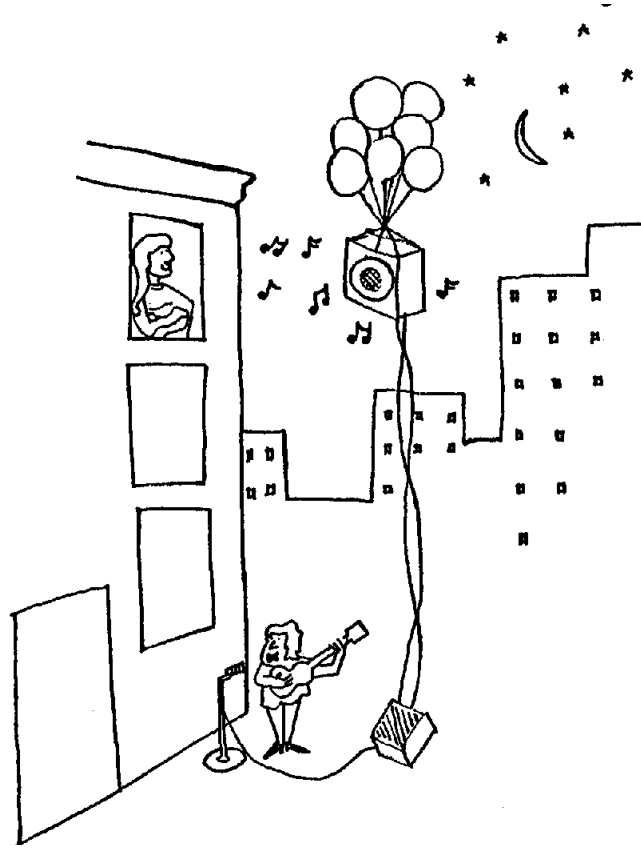


مفهوم‌های علمی تکوین و تغییرات

با مروری بر نظریه محاسباتی ذهن

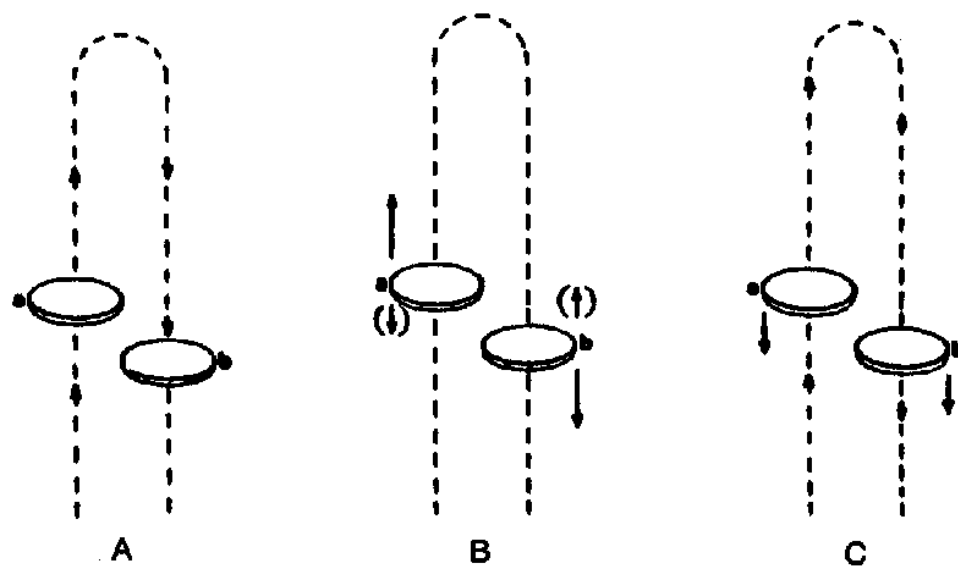


پارادوکس ساخت و ساز گرایی: یادگیری مستلزم تلفیق طرحواره‌های قبلی
و جدید ولی از دیگر سو باید جایگزین آن شود

Novice-expert shift

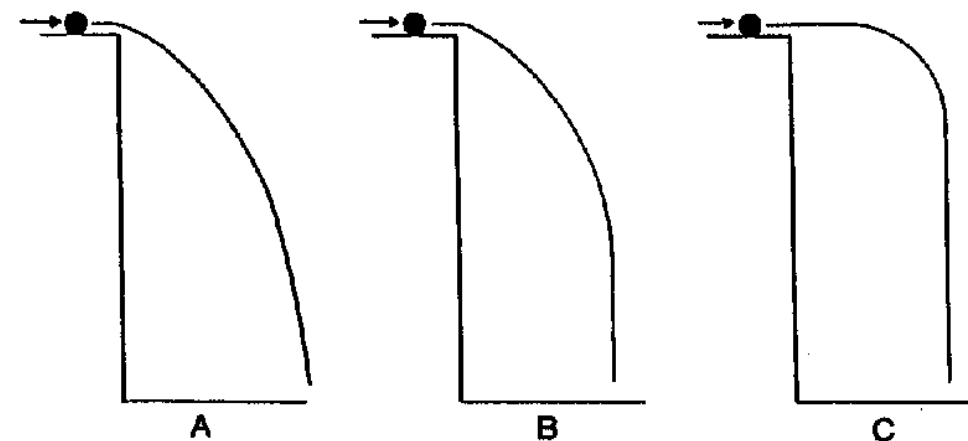
هدف آموزش علوم مانند خواندن نیست بلکه آموختن طرحواره‌های
تازه‌ای برای درک جهان است

Problem (A), Novice Solution (B), and Expert Solution (C)



Note. Adapted from "Students' Preconceptions in Introductory Mechanics" by J. Clement, 1982, *American Journal of Physics*, 50(1), p. 68. Copyright 1982 by the American Association of Physics Teachers. Adapted by permission.

Expert Solution (A) and Two Novice Solutions (B and C)



Note. Adapted from "Naive Theories of Motion" by M. McCloskey. In *Mental Models* by D. Gentner and A. Stevens (Eds.), 1983, Hillsdale, NJ: Lawrence Erlbaum Associates, Inc. Copyright 1983 by Lawrence Erlbaum Associates, Inc. Adapted by permission.

کژفهمی‌های مقاوم به یادگیری

بازنمایی‌ها و شناخت

بازنمایی مانند کلمه سیب یا تصویر خانه، هر بازنمایی یک مرجع دارد.
ویژگی‌های بازنمایی:

- نحوی

- - دلالت شناختی در ارتباط با معنای سمبل

محاسبه: هر نوع عملیات یا دستکاری که ذهن با سمبل بازنمایی می‌کند و نماینده فرآیندهایی است که می‌توانند در خارج ذهن رخ دهند.

شناخت: حاصل محاسبه (پردازش) که ذهن بر روی بازنمایی‌ها انجام می‌دهد.

انواع بازنمایی‌ها و منشاء مفهوم‌ها

بازنمایی‌های ذهنی (حالات سامانه عصبی که محتوا دارند و به ماهیت‌های عینی یا انتزاعی مرتبط‌اند)

منشاء مفهوم‌ها:

بازنمایی‌های مفهومی معمولاً حاصل سه فرآیند با الزام‌های زمانی متفاوت هستند:

- یادگیری انفرادی
- ساخت و ساز تاریخی/فرهنگی (ژن، کایاک و کسر)
- تکامل (جسم، عدد)

انواع بازنمایی‌ها و منشاء مفهوم‌ها

حالات سامانه عصبی: بازنمایی‌های ذهنی: معطوف به ماهیت‌های عینی، انتزاعی و حتی تخیلی، ویژگی‌ها و رویدادها
تحول انواع بازنمایی‌ها: (حسی-ادراکی) رشد و یادگیری زبان نمادی شدن (مفهومی)
بازنمایی‌های مفهومی: بازنمایی چیزهایی که در جهان هستند، دسته‌بندی چیزها (انتزاعی و تئوری-بار)، بازنمایی چیزهایی که برای آن‌ها شواهد حسی مستقیم نداریم

بازنمایی‌ها و مفاهیم

بازنمایی‌های مفهومی: دسته‌بندی ماهیت‌ها با انواع انتزاعی، فرضیه‌بار و بدون حضور شواهد حسی (موجودات زنده، اعداد و ...)

مفاهیم: بازنمایی‌های ذهنی، واحدهای تفکر، سازندگان باورها و تئوری‌ها

چه چیزهایی محتوای یک مفهوم را مشخص می‌کنند؟

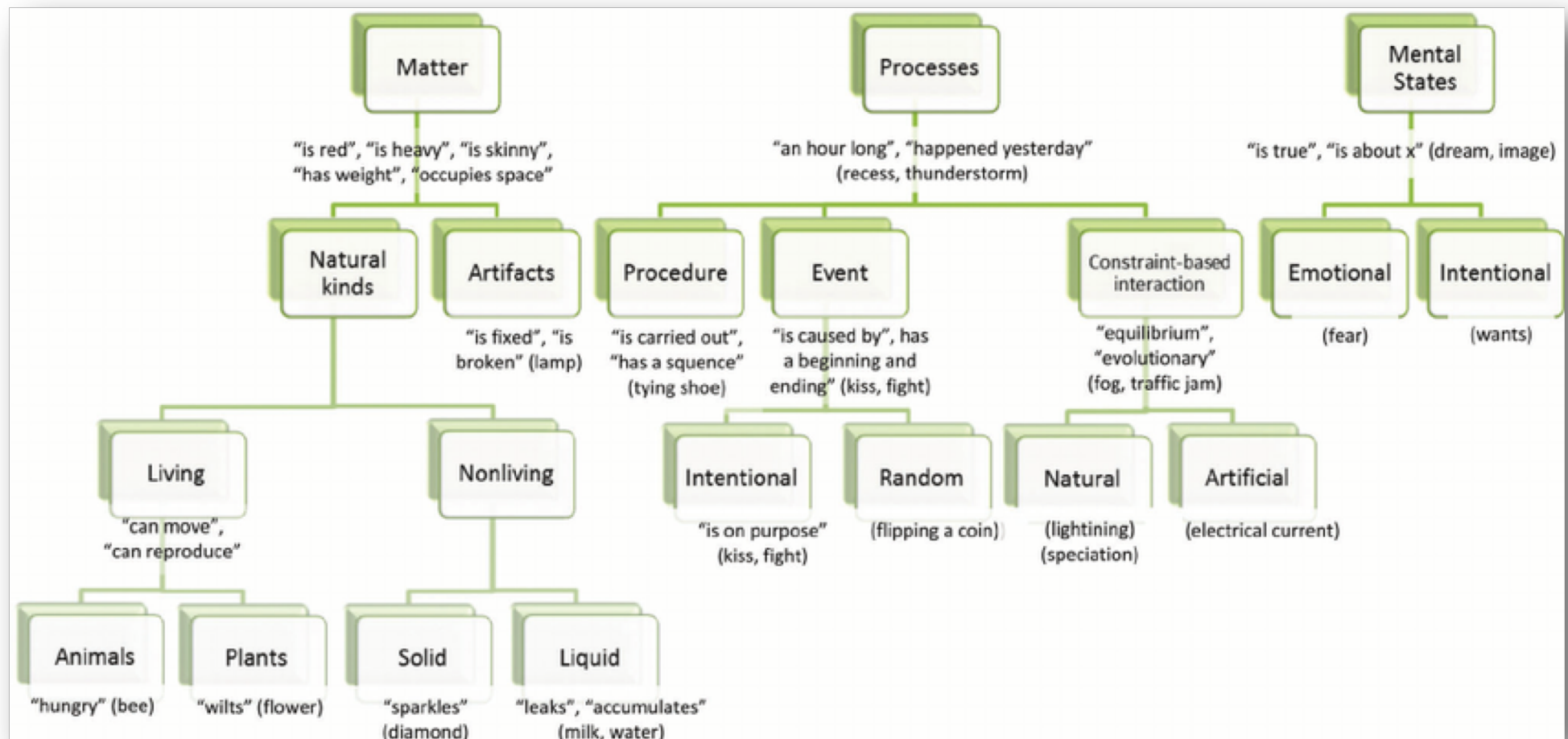
سازوکارهای علی مرتبط کننده بازنمایی به ماهیت‌هایی در جهان در دامنه آن

فرآیند محاسباتی در ذهن که کنش بازنمایی در تفکر را مشخص می‌کند

بازنمایی‌ها و مفاهیم

دسته‌بندی‌های هستی‌شناختی:

چیزها (مواد-اجسام)، فرآیندها (مستقیم-برآ) و حالات ذهنی (قصد‌ها-احساسات)



معنای مفهوم

- ✓ یک ایده‌ی عمومی که توسط جمعیت مورد نظر پذیرفته شده است.
- ✓ یا یک بسته‌ی معنایی در مورد قاعده‌مندی (شباهت‌ها و تفاوت‌ها)، الگوها یا روابط بین اشیاء و روی‌دادها. یک مفهوم با یک برچسب مشخص می‌شود یا گاهی توسط یک نشانه.
- ✓ درونی شدن مفاهیم با توجه به ویژگی‌ها مانند میز یا سگ.
- ✓ مفاهیم انتزاعی هستند و ساخته‌های ذهن بشرند.
- ✓ گاهی مفاهیم از بیش از یک واژه تشکیل شده‌اند مانند پایداری انرژی، یا نیروهای متعادل. اهله‌ی ماه یا انتقال انرژی، تقسیم سلولی، میعان.
- ✓ وقتی سعی می‌کنیم یک مفهوم را توضیح دهیم یا تعریف کنیم به یک ایده تبدیل می‌شود.

هنگامی دانش آموز مفهومی را درک کرده که بتواند:

- ۱- با آن فکر کند.
 - ۲- آن را در مواردی به جز زمینه‌ی یادگیری به کار ببرد.
 - ۳- آن را به زبان خودش بیان کند.
 - ۴- یک استعاره یا مانند آن در موردش پیدا کند.
 - ۵- از آن یک مدل ذهنی یا فیزیکی بسازد.
- مفهوم را مال خود کردن

بچه‌ها باید مفاهیم را تجربه کنند و بعد **واژه‌ها** را به کار ببرند.
بهترین زمان برای معرفی واژه‌ی جدید در حین فعالیت‌ها یا در خلال گفت‌وگو
در مورد فعالیت‌ها است.
برای مثال در حین فعالیت آونگ می‌توان واژه‌ی دامنه را معرفی کرد.

برخی از مفاهیم علمی با درک شهودی بچه‌ها جور در
نمی‌آیند: مانند مفهوم شتاب

شش الزام آموزش برای درک مفهومی:

۱- یادگیری یک فرآیند دراز مدت و با محوریت تفکر است.

۲- فراهم آوردن ارزش یابی پیش برنده و غنی

۳- حمایت از یادگیری با ارائه های نیرومند

۴- توجه به عوامل رشد دهنده

۵- برقرار کردن نظم برای دانش آموز

۶- تدریس به منظور انتقال

دیدگاه برگرفته از تاریخ علم: knowledge restructuring

معنای یک مفهوم در یک دوره تاریخی در ارتباط با سایر مفاهیم در **تئوری**
غالب آن دوره مشخص می شود.

آموزش برای درک مفهومی در علوم تجربی

Marfolamine is a gadabolic cupertance essential for our jamination. Marfolamine was discovered in a zackadago. It was chemovated from the zackadago by ligitizing the pogites and then bollyswagging it. Marfolamine will eventually micronate our gladivones so that we can homitote our tonsipows more demicly.

1. What is marfolamine?
2. Where was marfolamine discovered?
3. How is marfolamine chemovated?
4. Why is marfolamine important to us?

ایجاد تغییر مفهومی: از پیش مفهوم‌ها به سوی مفاهیم نزدیک‌تر
به مفاهیم علمی

پیاژه: دانش سامانه‌ای از تحولات است که به طور ارتقاء
یابنده به کفایت نزدیک می‌شود، تا به حد شایستگی برسند.

تفاوت ساختن گرایی و رویکرد اکتشافی:
ما حقیقت را درباره‌ی جهان کشف نمی‌کنیم ما توضیح‌ها را به وجود می‌آوریم،
آن‌ها را با قدرت‌شان برای پیش‌بینی کردن جهان می‌آزماییم و به گونه‌ای
تغییرشان می‌دهیم بر اساس توانایی‌شان برای خدمت به ما.
این کار را انفرادی و اجتماعی انجام می‌دهیم.

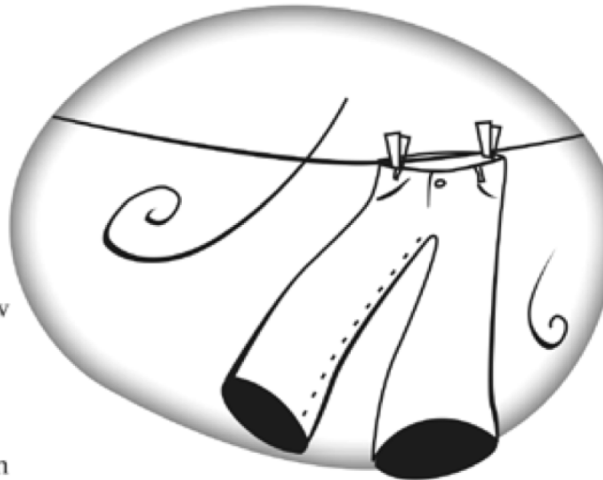
درک مفهومی مثل درست کردن کیک از آرد به
جای درست کرن کیک طبق دستور با پودر
آماده

Wet Jeans

Sam washed his favorite pair of jeans. He hung the wet jeans on a clothesline outside. An hour later the jeans were dry.

Circle the answer that best describes what happened to the water that was in the wet jeans *an hour later*.

- A** It soaked into the ground.
- B** It disappeared and no longer exists.
- C** It is in the air in an invisible form.
- D** It moved up to the clouds.
- E** It chemically changed into a new substance.
- F** It went up to the Sun.
- G** It broke down into atoms of hydrogen and oxygen.



Describe your thinking. Provide an explanation for your answer.

مثال: مفهوم تبخیر

کاوندهای ارزشیابی تشخیصی-تکوینی

How Long Is a Day on the Moon?



Four students were designing a Moon base for a science project. Planning the Moon base was easy. But deciding what a day-night cycle on the Moon base would be like was hard! All four students had different ideas. Here is what they said:

Hannah: "I think the length of the day-night cycle on the Moon is 24 hours."

Sachet: "It depends where the Moon base is. If it is on the dark side of the Moon, there will never be daytime."

Ravi: "I think there would be about two weeks of sunlight and two weeks of darkness."

Manuel: "It depends on the Moon phase. In a crescent Moon, daylight would be much shorter. When there's a full Moon, daylight would be much longer."

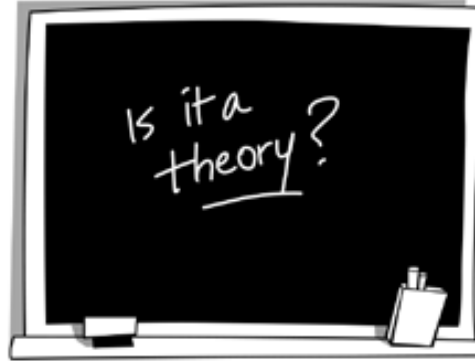
Which student do you think has the best idea? _____ Explain why you agree.

Source: Keeley and Sneider 2012.

Is It a Theory?

Put an X next to the statements you think best apply to scientific theories.

- ____ **A** Theories include observations.
- ____ **B** Theories are “hunches” scientists have.
- ____ **C** Theories can include personal beliefs or opinions.
- ____ **D** Theories have been tested many times.
- ____ **E** Theories are incomplete, temporary ideas.
- ____ **F** A theory never changes.
- ____ **G** Theories are inferred explanations, strongly supported by evidence.
- ____ **H** A scientific law has been proven and a theory has not.
- ____ **I** Theories are used to make predictions.
- ____ **J** Laws are more important to science than theories.

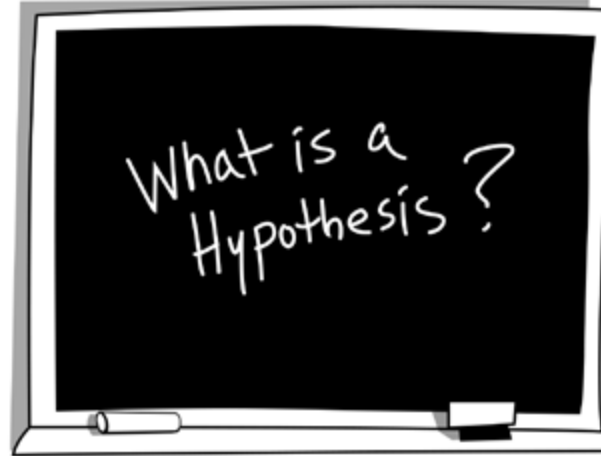


Examine the statements you checked off. Describe what a theory in science means to you.

What Is a Hypothesis?

Hypotheses are used widely in science. Put an X next to the statements that describe a hypothesis.

- _____ **A** A tentative explanation
- _____ **B** A statement that can be tested
- _____ **C** An educated guess
- _____ **D** An investigative question
- _____ **E** A prediction about the outcome of an investigation
- _____ **F** A question asked at the beginning of an investigation
- _____ **G** A statement that may lead to a prediction
- _____ **H** Included as a part of all scientific investigations
- _____ **I** Used to prove whether something is true
- _____ **J** Eventually becomes a theory, then a law
- _____ **K** May guide an investigation
- _____ **L** Used to decide what data to pay attention to and seek
- _____ **M** Developed from imagination and creativity
- _____ **N** Must be in the form of "if...then..."



Describe what a hypothesis is in science. Include your own definition of the word *hypothesis* and explain how you learned what it is.

Rolling Marbles

Jan, Debra, and Greg are playing with ramps and marbles. They decide to have a contest to see who can make a marble roll down a ramp the fastest. Each friend uses the same height and identical marbles.



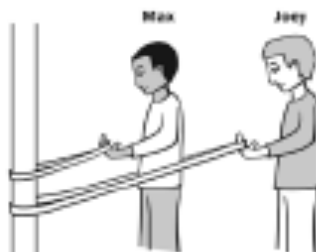
Circle whose marble will reach the bottom of the ramps first.

- A** Jan's marble
- B** Debra's marble
- C** Greg's marble
- D** No one will win—it will be a tie.

Explain your thinking. Describe your ideas about the time it takes for the marble to reach the end of the different ramps.

Finger Strength Contest

Max and Joey are having a strength contest (see illustration at right). They are using two identical rubber bands to see how much of the rubber band each of them can pull with one finger. They each slip one end of a rubber band around a pole and pull as hard as they can. Joey is able to stretch the rubber band twice as much as Max.



Next, the boys tie two new identical rubber bands together (see illustration at right). On the count of three, Max and Joey both pull in opposite directions as hard as they can.



Max's rubber band stretches 16 cm. How far do you think Joey's rubber band will stretch? Circle your answer.

- ☐ A 32 cm.
- ☐ B 16 cm.
- ☐ C 8 cm.

Explain your thinking. What reasoning did you use to decide how far Joey's rubber band will stretch?

دشواری‌های درک مفهوم نیرو و شتاب:

۱- درک نسبت یک نسبت (با این که

سرعت زیاد می‌شود شتاب کم‌تر می‌شود.

۲- نیرو را در زبان روزمره خاصیت یک

جسم می‌دانند تا برهمکنش دو جسم.

۳- ایده‌ی این که حرکت بدون علت

اتفاق نمی‌افتد. اما، فقط تغییر حرکت به

یک علت که همان برهمکنش دو جسم

است نیاز دارد.

در زندگی روزمره وضعیت بدون

برهمکنش (نیرو) بسیار نادر است.

تغییر حرکت حاصل حضور نیروهای

نامتوازن است.

حرکت یکنواخت حاصل نیروهای متوازن

یا نبود برهمکنش.

معمولا در حرکت‌های یکنواخت یک

برهمکنش پنهان به نام اصطکاک حضور

دارد.

Can It Reflect Light?

What types of objects or materials can reflect light? Put an X next to the things you think can reflect light.



☐ water
☐ gray rock
☐ leaf
☐ mirror
☐ glass
☐ sand
☐ potato skin
☐ wax paper
☐ tomato soup
☐ crumpled paper
☐ shiny metal

☐ dull metal
☐ red apple
☐ rough cardboard
☐ the Moon
☐ rusty nail
☐ clouds
☐ soil
☐ wood

☐ milk
☐ bedsheet
☐ brand new penny
☐ old tarnished penny
☐ smooth sheet of aluminum foil

Explain your thinking. Describe the “rule” or the reasoning you used to decide if something can reflect light.

Is It Food for Plants?

Organisms, including plants, need food to survive.
Put an X next to the things you think plants
use as food.

___ sunlight

___ plant food from a garden store

___ sugar

___ carbon dioxide

___ minerals

___ fertilizer

___ soil

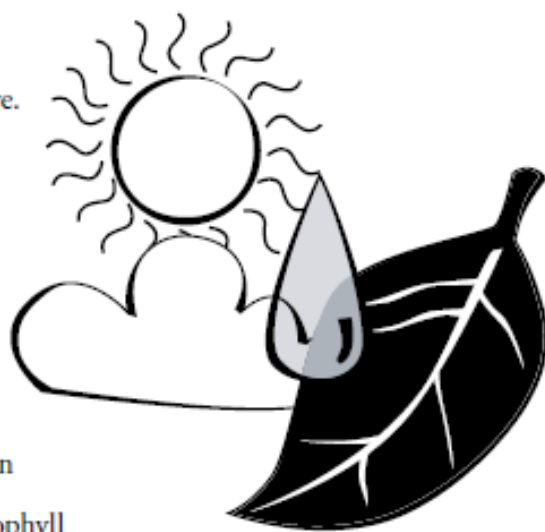
___ water

___ leaves

___ oxygen

___ chlorophyll

___ vitamins



Explain your thinking. How did you decide if something on the list is food
for plants?

Where Did the Water Come From?

Latisha took a sealed, plastic container of ice cubes out of the freezer. The outside of the container was dry when she took it out of the freezer. She set the container on the counter. She did not open the container. Half an hour later she noticed the ice had melted inside the container. The container was full of water. A small puddle of water had formed on the kitchen countertop, around the outside of the container. Which best describes where the puddle of water came from?



- A** A gas in the air.
- B** Melted ice inside the container.
- C** Cold on the outside of the container.
- D** Condensation from water inside the container.
- E** Water that evaporated from inside the container.
- F** Cold changed hydrogen and oxygen atoms to water.

Describe your thinking about where the water came from. Provide an explanation for your answer.

Me and My Shadow

Five friends were looking at their shadows early one morning. They wondered what their shadows would look like by the end of the day. This is what they said:

Jamal: "My shadow will keep getting longer throughout the day."

Morrie: "My shadow will keep getting shorter throughout the day."

Amy: "My shadow will keep getting longer until it reaches its longest point and then it will start getting shorter."

Fabian: "My shadow will keep getting shorter until noon and then it will start getting longer."

Penelope: "My shadow will stay about the same from morning to day's end."

Which friend do you most agree with? _____

Describe your thinking. Explain the reason for your answer.

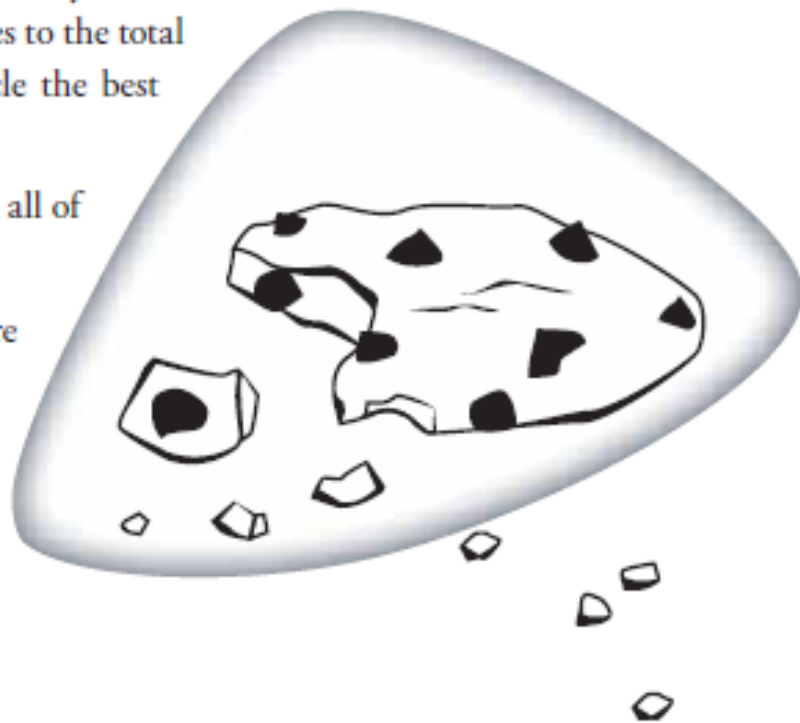


Cookie Crumbles

Imagine you have a whole cookie. You break the cookie into tiny pieces and crumbs. You weigh all of the pieces and crumbs. How do you think the weight of the whole cookie compares to the total weight of all the cookie crumbs? Circle the best answer.

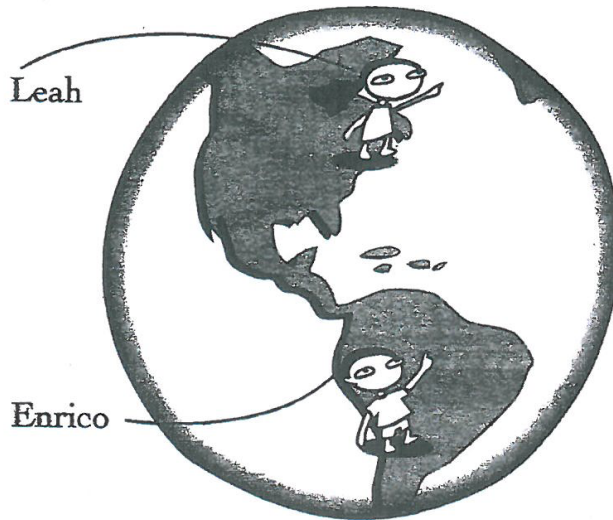
- A** The whole cookie weighs more than all of the cookie crumbs.
- B** All of the cookie crumbs weigh more than the whole cookie.
- C** The whole cookie and all of the cookie crumbs weigh the same.

Describe your thinking. Provide an explanation for your answer.



Gazing at the Moon

Enrico and Leah live in opposite hemispheres. Enrico lives in Santiago, Chile, which is in the Southern Hemisphere. Leah lives in Boston, Massachusetts, which is in the Northern Hemisphere. They both gazed at the Moon on the same evening. Enrico noticed there was a full Moon when he looked up at the sky from his location (the Southern Hemisphere). What do you predict Leah saw when she looked up in the sky from her location (the Northern Hemisphere)?



- A New Moon (no part of the Moon is visible)
- B Crescent Moon (a quarter of the face of the Moon is visible)
- C Half Moon (half of the face of the Moon is visible)
- D Gibbous Moon (three-quarters of the face of the Moon is visible)
- E Full Moon (the entire face of the Moon is visible)

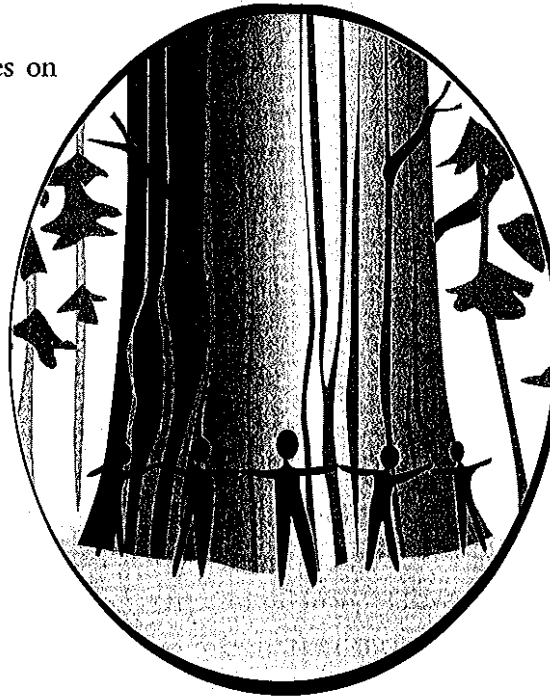
Provide an explanation for your answer. How did you decide what the Moon would look like in the opposite hemisphere?

Giant Sequoia Tree

The giant sequoia tree is one of the largest trees on earth. It starts as a small seedling and grows into an enormous tree. Five children can stretch their arms across the width of the trunk of one of the large sequoia trees!

Where did most of the matter that makes up the wood and leaves of this huge tree originally come from? Circle the best answer.

- A** sunlight
- B** water
- C** soil
- D** carbon dioxide
- E** oxygen
- F** minerals
- G** chlorophyll



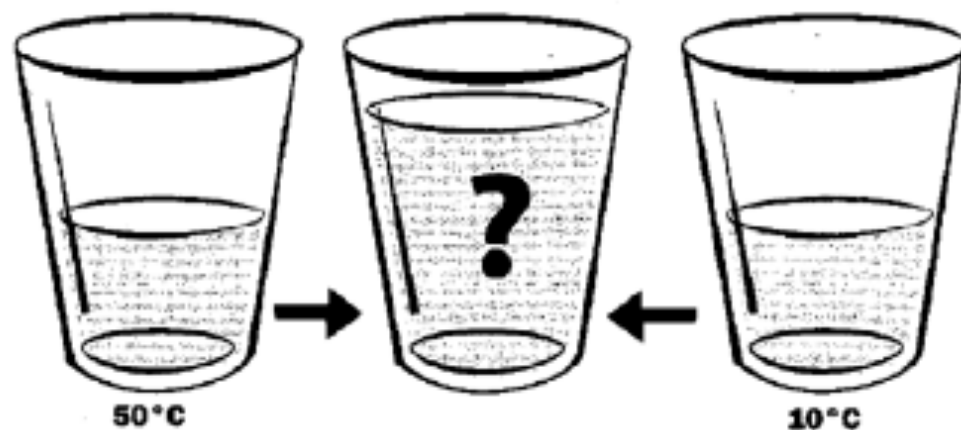
Explain your thinking. How did you decide where most of the matter that makes up this tree came from?

Mixing Water

Melinda filled two glasses of equal size half-full with water. The water in one glass was 50 degrees Celsius. The water in the other glass was 10 degrees Celsius. She poured one glass into the other, stirred the liquid, and measured the temperature of the full glass of water.

What do you think the temperature of the full glass of water will be after the water is mixed? Circle your prediction.

- A** 20 degrees Celsius
- B** 30 degrees Celsius
- C** 40 degrees Celsius
- D** 50 degrees Celsius
- E** 60 degrees Celsius



Explain your thinking. Describe the "rule" or reasoning you used for your answer.

Name _____

💧 100 Drops of Water 💧

Directions: Predict how much of the jar will be filled after adding 100 drops of water. Draw your prediction. Then add 100 drops and draw the actual answer.

Prediction:



Actual



Write your results here:

Rolling Marbles

Five friends built a marble tower. The marble tower had a curved track. The track was designed so that the marbles would move down the track in a circular path. The track ended on the floor. Each friend predicted how he or she thought the marble would move when it rolled off the end of the track onto the floor. This is what they said:

Magda: "I think it will roll in circles."

Soledad: "I think it will curve for a bit and then straighten out."

Allen: "I think it will roll in one big curve."

Keira: "I think it will roll in a straight line."

Rafael: "I think it will zigzag for a little while."



Which friend do you most agree with? _____

Use the picture above to draw the path you think the marble will take when it gets to the end of the track.

Explain your thinking. Why do you think the marble will move that way?

Making Sound

All of the objects listed below make sounds. Put an X next to the objects you think involve vibrations in producing sound.

___ guitar strings

___ drum

___ dripping faucet

___ barking dog

___ piano

___ screeching brakes

___ radio speaker

___ crumpled paper

___ car engine

___ chirping cricket

___ singer

___ popped balloon

___ drum

___ wind

___ wood saw

___ clapped hands

___ bubbling water

___ rustling leaves



___ hammer

___ flute

___ thunderstorm

___ two stones rubbed together

___ snapped fingers

Explain your thinking. What "rule" or reasoning did you use to decide which objects involve vibrations in producing sound?

Talking About Gravity

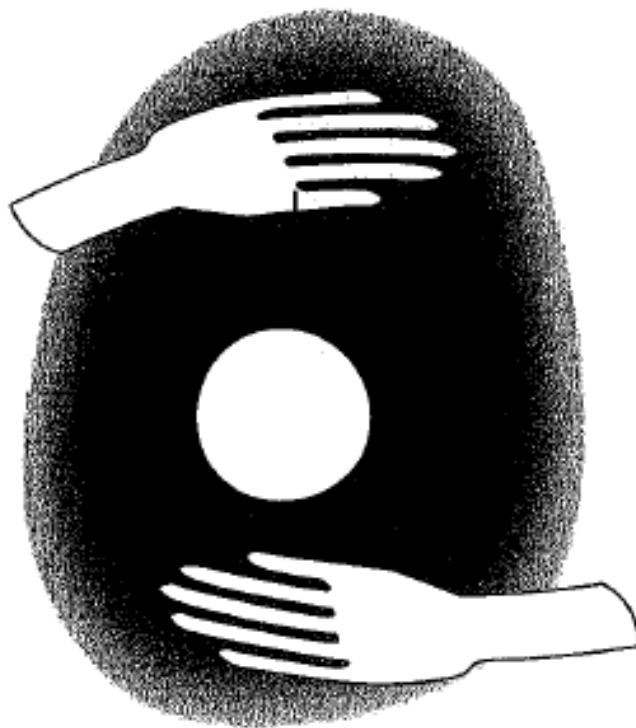
Two friends were talking about gravity.

Ben said, "Gravity needs an atmosphere or air. If there is no air or atmosphere, there will be no gravity."

Kelly said, "Gravity doesn't need an atmosphere or air. If there is no air or atmosphere, there will still be gravity."

Which friend do you agree with? _____

Describe your thinking. Explain why you agree with one friend and disagree with the other.



The Mitten Problem

Sarah's science class is investigating heat energy. They wonder what would happen to the temperature reading on a thermometer if they put the thermometer inside a mitten.

Sarah's group obtained two thermometers and a mitten. They put one thermometer inside the mitten and the other thermometer on the table next to the mitten. An hour later they compared the readings on the two thermometers. The temperature inside the room remained the same during their experiment.



What do you think Sarah's group will discover from their investigation? Circle the response that best matches your thinking.

- A** The thermometer inside the mitten will have a lower temperature reading than the thermometer on the table.
- B** The thermometer inside the mitten will have a higher temperature reading than the thermometer on the table.
- C** Both thermometers will have the same temperature reading.

Describe your thinking. Provide an explanation for your answer.
