

Children's Misconceptions about Science

A list compiled by the Operation Physics Elementary/middle school physics educationoutreach project of the American Institute of Physics. Author/editor is unknown. Thanks to Bill Weiler of U. Illinois for posting this via the PHYS-L group 9/1998.

Astronomy

1. Stars and constellations appear in the same place in the sky every night.
2. The sun rises exactly in the east and sets exactly in the west every day.
3. The sun is always directly south at 12:00 noon.
4. The tip of a shadow always moves along an east-west line.
5. We experience seasons because of the earth's changing distance from the sun (closer in the summer, farther in the winter).
6. The earth is the center of the solar system. (The planets, sun and moon revolve around the earth.)
7. The moon can only be seen during the night.
8. The moon does not rotate on its axis as it revolves around the earth.
9. The phases of the moon are caused by shadows cast on its surface by other objects in the solar system.
10. The phases of the moon are caused by the shadow of the earth on the moon.
11. The phases of the moon are caused by the moon moving into the sun's shadow.
12. The shape of the moon always appears the same.
13. The earth is the largest object in the solar system.
14. The solar system is very crowded.
15. The solar system contains only the sun, planets and the moon.
16. Meteors are falling stars.
17. Comets and meteors are out in space and do not reach the ground.
18. The surface of the sun is without visible features.
19. All the stars in a constellation are near each other.
20. All the stars are the same distance from the earth.
21. The galaxy is very crowded.
22. Stars are evenly distributed throughout the universe.
23. All stars are the same size.
24. The brightness of a star depends only on its distance from the earth.
25. Stars are evenly distributed throughout the galaxy.
26. The constellations form patterns clearly resembling people, animals or objects.

Atmosphere

1. Rain comes from holes in clouds.
2. Rain comes from clouds sweating.
3. Rain occurs because we need it.
4. Rain falls from funnels in the clouds.
5. Rain occurs when clouds get scrambled and melt.
6. Rain occurs when clouds are shaken.
7. God and angels cause thunder and lightning.
8. Clouds move because we move.
9. Clouds come from somewhere above the sky.
10. Empty clouds are filled by the sea.
11. Clouds are formed by vapor from kettles.
12. The sun boils the sea to create water vapor.
13. Clouds are made of cotton, wool, or smoke.

14. Frontal rain is caused by "cooling by contact" between fronts.
15. The oxygen we breathe does not come from plants.
16. Gas makes things lighter.
17. One degree of temperature is smaller on the Celsius scale than on the Fahrenheit scale.
18. All rivers flow from North to South.

Biosphere

1. Coral reefs exist throughout the Gulf and North Atlantic waters.
2. Dinosaurs and cavemen lived at the same time.
3. Acquired characteristics can be inherited.
4. Winter weather can be predicted by studying the thickness of the fur of some animals.
5. Humans are responsible for the extinction of the dinosaurs.
6. Some human races have not evolved as much as others.
7. Evolution is goal-directed.
8. Evolutionary changes are driven by need.

Color and Vision

1. The pupil of the eye is a black object or spot on the surface of the eye.
2. The eye receives upright images.
3. The lens is the only part of the eye responsible for focusing light.
4. The lens forms an image (picture) on the retina. The brain then "looks" at this image and that is how we see.
5. The eye is the only organ for sight; the brain is only for thinking.
6. A white light source, such as an incandescent or fluorescent bulb, produces light made up of only one color.
7. Sunlight is different from other sources of light because it contains no color.
8. When white light passes through a prism, color is added to the light.
9. The rules for mixing color paints and crayons are the same as the rules for mixing colored lights.
10. The primary colors for mixing colored lights are red, blue and yellow.
11. A colored light striking an object produces a shadow behind it that is the same color as the light. For example, when red light strikes an object, a red shadow is formed.
12. The shades of gray in a black and white newspaper picture are produced by using inks with different shades of gray.
13. When white light passes through a colored filter, the filter adds color to the light.
14. The different colors appearing in colored pictures printed in magazines and newspapers are produced by using different inks with all the corresponding colors.
15. The mixing of colored paints and pigments follow the same rules as the mixing of colored lights.
16. The primary colors used by artists (red, yellow and blue) are the same as the primary colors for all color mixing.
17. Color is a property of an object, and is independent of both the illuminating light and the receiver (eye).
18. White light is colorless and clear, enabling you to see the "true" color of an object.
19. When a colored light illuminates a colored object, the color of the light mixes with the color of the object.
20. Naïve explanations of visual phenomena involving color perception usually involve only the properties of the object being observed, and do not include the properties of the eye-brain system.

Electricity

1. Positively charged objects have gained protons, rather than being deficient in electrons.
2. Electrons which are lost by an object are really lost (no conservation of charge).
3. All atoms are charged.
4. A charged object can only attract other charged objects.
5. The electrostatic force between two charged objects is independent of the distance between them.
6. Gravitational forces are stronger than electrostatic forces.
7. Batteries have electricity inside them.

Three common misconceptions about electric circuits are shown below.

8. This figure represents the source-consumer model in which electricity travels along one wire from the cell to the lamp.
9. This figure illustrates a two wire modification of the source-consumer model.
10. This figure depicts a model that is closer to the physicist's model. However, in this model electricity is used by the lamp, causing less current on one side of the lamp.

Energy

1. Energy is a thing. This is a fuzzy notion, probably because of the way that we talk about newton-meters or joules. It is difficult to imagine an amount of an abstraction.
2. The terms "energy" and "force" are interchangeable.
3. From the non-scientific point of view, "work" is synonymous with "labor". It is hard to convince someone that more work is probably being done playing football for one hour than studying an hour for a quiz.
4. An object at rest has no energy.
5. The only type of potential energy is gravitational.
6. Gravitational potential energy depends only on the height of an object.
7. Doubling the speed of a moving object doubles the kinetic energy.
8. Energy can be changed completely from one form to another (no energy losses).
9. Things "use up" energy.
10. Energy is confined to some particular origin, such as what we get from food or what the electric company sells.
11. Energy is truly lost in many energy transformations.
12. There is no relationship between matter and energy.
13. If energy is conserved, why are we running out of it?

Forces and Motion

1. The only "natural" motion is for an object to be at rest.
2. If an object is at rest, no forces are acting on the object.
3. A rigid solid cannot be compressed or stretched.
4. Only animate objects can exert a force. Thus, if an object is at rest on a table, no forces are acting upon it.
5. Force is a property of an object. An object has force and when it runs out of force it stops moving.
6. The motion of an object is always in the direction of the net force applied to the object.
7. Large objects exert a greater force than small objects.
8. A force is needed to keep an object moving with a constant speed.
9. Friction always hinders motion. Thus, you always want to eliminate friction.
10. Frictional forces are due to irregularities in surfaces moving past each other.
11. Rocket propulsion is due to exhaust gases pushing on something behind the rocket.

12. Time is defined in terms of its measurement.
13. The location of an object can be described by stating its distance from a given point (ignoring direction).
14. The terms distance and displacement are synonymous and may be used interchangeably. Thus the distance an object travels and its displacement are always the same.
15. Velocity is another word for speed. An object's speed and velocity are always the same.
16. Acceleration is confused with speed.
17. Acceleration always means that an object is speeding up.
18. Acceleration is always in a straight line.
19. Acceleration always occurs in the same direction as an object is moving.
20. If an object has a speed of zero (even instantaneously), it has no acceleration.

Forces and Fluids

1. Objects float in water because they are lighter than water.
2. Objects sink in water because they are heavier than water.
3. Mass/volume/weight/heaviness/size/density may be perceived as equivalent.
4. Wood floats and metal sinks.
5. All objects containing air float.
6. Liquids of high viscosity are also liquids with high density.
7. Adhesion is the same as cohesion
8. Heating air only makes it hotter.
9. Pressure and force are synonymous.
10. Pressure arises from moving fluids.
11. Moving fluids contain higher pressure.
12. Liquids rise in a straw because of "suction".
13. Fluid pressure only acts downward.

Heat and Temperature

1. Heat is a substance.
2. Heat is not energy.
3. Temperature is a property of a particular material or object. (Metal is naturally cooler than plastic).
4. The temperature of an object depends on its size.
5. Heat and cold are different, rather than being opposite ends of a continuum.
6. When temperature at boiling remains constant, something is "wrong".
7. Boiling is the maximum temperature a substance can reach.
8. Ice cannot change temperature.
9. Objects of different temperature that are in contact with each other, or in contact with air at different temperature, do not necessarily move toward the same temperature.
10. Heat only travels upward.
11. Heat rises.
12. The kinetic theory does not really explain heat transfer. (It is recited but not believed).
13. Objects that readily become warm (conductors of heat) do not readily become cold.
14. The bubbles in boiling water contain "air", "oxygen" or "nothing", rather than water vapor.

Light

1. Light is associated only with either a source or its effects. Light is not considered to exist independently in space; and hence, light is not conceived of as "travelling".

2. An object is "seen" because light shines on it. Light is a necessary condition for seeing an object and the eye.
3. Lines drawn outward from a light bulb represent the "glow" surrounding the bulb.
4. A shadow is something that exists on its own. Light pushes the shadow away from the object to the wall or the ground and is thought of as a "dark " reflection of the object.
5. Light is not necessarily conserved. It may disappear or be intensified.
6. Light from a bulb only extends outward a certain distance, and then stops. How far it extends depends on the brightness of the bulb.
7. The effects of light are instantaneous. Light does not travel with a finite speed.
8. A mirror reverses everything.
9. For an observer to see the mirror image of an object, either the object must be directly in front of the mirror, or if not directly in front, then the object must be along the observer's line of sight to the mirror. The position of the observer is not important in determining whether the mirror image can be seen.
10. An observer can see more of his image by moving further back from the mirror.
11. The mirror image of an object is located on the surface of the mirror. The image is often thought of as a picture on a flat surface.
12. The way a mirror works is as follows: The image first goes from the object to the mirror surface. Then the observer either sees the image on the mirror surface or the image reflects off the mirror and goes into the observer's eye.
13. Light reflects from a shiny surface in an arbitrary manner.
14. Light is reflected from smooth mirror surfaces but not from non-shiny surfaces.
15. Curved mirrors make everything distorted.
16. Light shines on a translucent material and illuminates it so it can be seen. Light does not travel from the translucent material to the eye.
17. Light always passes straight through a transparent material without changing direction.
18. When an object is viewed through a transparent solid or liquid material the object is seen exactly where it is located.
19. Students will often think about how a lens forms an image of a self-luminous object in the following way. They envision that a "potential image" which carries information about the object leaves the self-luminous object and travels through the space to the lens. When passing through the lens, the "potential image" is turned upside down and may be changed in size.
20. When sketching a diagram to show how a lens forms an image of an object, only those light rays are drawn which leave the object in straight parallel lines.
21. Blocking part of the lens surface would block the corresponding part of the image.
22. The purpose of the screen is to capture the image so that it can be seen. The screen is necessary for the image to be formed. Without a screen there is no image.
23. An image can be seen on the screen regardless of where the screen is placed relative to the lens. To see a larger image on the screen, the screen should be moved further back.
24. An image is always formed at the focal point of the lens.
25. The size of the image depends on the size (diameter) of the lens.
26. When a wave moves through a medium, particles of the medium move along with the wave.
27. Gamma rays, x-rays, ultraviolet light, visible light, infrared light, microwaves and radio waves are all very different entities.
28. When two pulses, travelling in opposite directions along a spring or rope meet, they bounce off each other and go back in the opposite direction.
29. Colors appearing in soap films are the same colors that appear in a rainbow.
30. Polaroid sunglasses are just dark glass or dark plastic.

Lithosphere

1. Any crystal that scratches glass is a diamond.
2. Rocks must be heavy.
3. Soil must have always been in its present form.
4. Mountains are created rapidly.
5. Earth is molten, except for its crust.
6. Earth's gravitational attraction is drastically reduced on mountaintops.
7. Continents do not move.
8. Boiling or burning radioactive material can reduce radiation.
9. All radioactivity is man-made.

Magnets and Magnetism

1. All metals are attracted to a magnet.
2. All silver colored items are attracted to a magnet.
3. All magnets are made of iron.
4. Larger magnets are stronger than smaller magnets.
5. The magnetic and geographic poles of the earth are located at the same place.
6. The magnetic pole of the earth in the northern hemisphere is a north pole, and the pole in the southern hemisphere is a south pole.

Properties of Matter

1. Gases are not matter because most are invisible.
2. Gases do not have mass.
3. A "thick" liquid has a higher density than water.
4. Mass and volume, which both describe an "amount of matter" are the same property.
5. Air and oxygen are the same gas.
6. Helium and hot air are the same gas.
7. Expansion of matter is due to expansion of particles rather than to increased particle spacing.
8. Particles of solids have no motion.
9. Relative particle spacing among solids, liquids and gases (1:1:10) is incorrectly perceived and not generally related to the density of the states.
10. Materials can only exhibit properties of one state of matter.
11. Particles possess the same properties as the materials they compose. For example, atoms of copper are "orange and shiny", gas molecules are transparent, and solid molecules are hard.
12. Melting/freezing and boiling/condensation are often understood only in terms of water.
13. Particles are viewed as mini-versions of the substances they comprise.
14. Particles are often misrepresented in sketches. No differentiation is made between atoms and molecules.
15. Particles misrepresented and undifferentiated in concepts involving elements, compounds, mixtures, solutions and substances.
16. Frequent disregard for particle conservation and orderliness when describing changes.
17. Absence of conservation of particles during a chemical change.
18. Chemical changes perceived as additive, rather than interactive. After chemical change the original substances are perceived as remaining, even though they are altered.

19. Failure to perceive that individual substances and properties correspond to certain types of particles (i.e. formation of a new substance with new properties is seen as simple happening rather than as the result of particle rearrangement).

Measurement

1. Measurement is only linear.
2. Any quantity can be measured as accurately as you want.
3. Children who have used measuring devices at home already know how to measure.
4. The metric system is more accurate than the other measurement systems.
5. The English system is easier to use than the metric system.
6. You can only measure to the smallest unit shown on the measuring device.
7. You should start at the end of the measuring device when measuring distance.
8. Some objects cannot be measured because of their size or inaccessibility.
9. The five senses are infallible.
10. An object must be "touched" to measure it.
11. Mass and weight are the same and they are equal at all times.
12. Mass is a quantity that you get by weighing an object.
13. Mass and volume are the same.
14. The only way to measure time is with a clock or watch.
15. Time has an absolute beginning.
16. Heat and temperature are the same.
17. Heat is a substance.
18. Cold is the opposite of heat and is a different substance.
19. There is only one way to measure perimeter.
20. Only the area of rectangular shapes can be measured in square units.
21. Surface area can be found only for two-dimensional objects.
22. Surface area is a concept used only in mathematics classes.
23. You cannot measure the volume of some objects because they do not have "regular" lengths, widths, or heights.
24. An objects' volume is greater in water than in air.
25. The density of an object depends only on its volume.
26. Density for a given volume is always the same.
27. The density of two samples of the same substance with different volumes or shapes cannot be the same.

Sound

1. Loudness and pitch of sounds are confused with each other.
2. You can see and hear a distant event at the same moment.
3. The more mass in a pendulum bob, the faster it swings.
4. Hitting an object harder changes its pitch.
5. In a telephone, actual sounds are carried through the wire rather than electrical pulses.
6. Human voice sounds are produced by a large number of vocal chords.
7. Sound moves faster in air than in solids (air is "thinner" and forms less of a barrier).
8. Sound moves between particles of matter (in empty space) rather than matter.
9. In wind instruments, the instrument itself vibrates not the internal air column.
10. As waves move, matter moves along with them.
11. The pitch of whistles or sirens on moving vehicles is changed by the driver as the vehicle passes.

12. The pitch of a tuning fork will change as it "slows down", (i.e. "runs" out of energy)

Space

1. The earth is sitting on something.
2. The earth is larger than the sun.
3. The sun disappears at night.
4. The earth is round like a pancake.
5. We live on the flat middle of a sphere.
6. There is a definite up and down in space.
7. Seasons are caused by the earth's distance from the sun.
8. Phases of the moon are caused by a shadow from the earth
9. Different countries see different phases of the moon on the same day.
10. The amount of daylight increases each day of summer.
11. Planets cannot be seen with the naked eye.
12. Planets appear in the sky in the same place every night.
13. Astrology is able to predict the future.
14. Gravity is selective; it acts differently or not at all on some matter.
15. Gravity increases with height.
16. Gravity requires a medium to act through.
17. Rockets in space require a constant force.
18. The sun will never burn out.
19. The sun is not a star.

Work and Power

1. Failing to be able to identify the direction in which a force is acting.
2. Believing that any force times any distance is work.
3. Believing that machines put out more work than we put in.
4. Not realizing that machines simply change the form of the work we do (i.e. trade off force for distance or distance for force).

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