

Multimedia Learning

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Multimedia Learning

- 3. The Promise of Multimedia Learning
- 5. Multimedia Instructional Messages
- 7. A Cognitive Theory of Multimedia Learning
- 9. Principles of Multimedia Learning
- 11. Summary

Take-Home Message

People learn better when multimedia messages are designed in ways that are consistent with how the human mind works and with research-based principles.

Three Views of Multimedia

View	Definition	Example
Delivery media	Two or more delivery devices	Computer screen and amplified speakers
Presentation modes	Verbal and pictorial representations	On-screen text and animation
Sensory modalities	Auditory and visual senses	Narration and animation

Two Approaches to Multimedia Design

Approach	Starting point	Goal	Issues
Technology-centered	Capabilities of multimedia technology	Provide access to information	How can we use cutting edge technology in designing multimedia presentations?
Learner-centered	How the human mind works	Aid to human cognition	How can we adapt multimedia technology to aid human cognition?

Two Metaphors of Multimedia Learning

Metaphor	Definition	Learner	Teacher	Goal of Media
Information acquisition	Adding information to memory	Passive information receiver	Information provider	Deliver information; act as delivery vehicle
Knowledge construction	Building a coherent mental structure	Active sense maker	Cognitive guide	Provide cognitive guidance; act as helpful communicator

Two Goals of Multimedia Learning

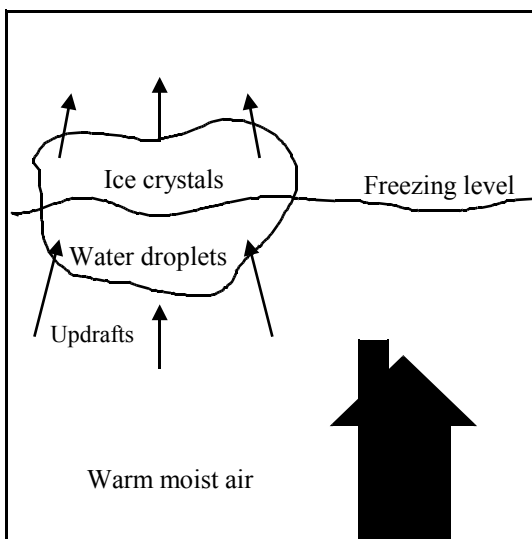
Goal	Definition	Test	Example test item
Remembering	Ability to reproduce or recognize presented material	Retention	Write down all you can remember from the passage you just read.
Understanding	Ability to use presented material in novel situations	Transfer	List some ways to improve the reliability of the device you just read about.

Three Kinds of Multimedia Learning Outcomes

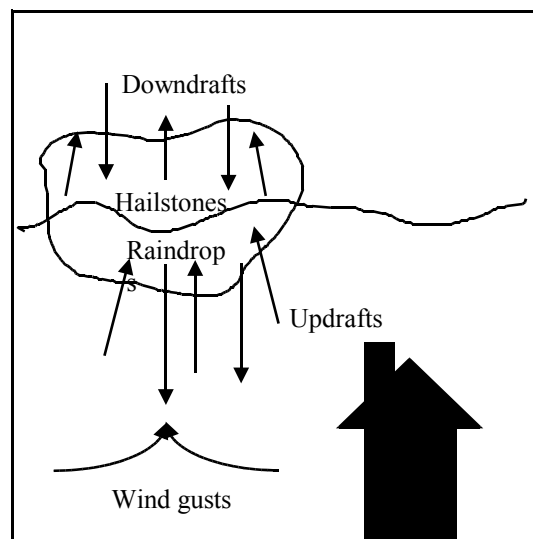
Learning outcome	Cognitive description	Retention test score	Transfer test score
No learning	No knowledge	Poor	Poor
Rote learning	Fragmented knowledge	Good	Poor
Meaningful learning	Integrated knowledge	Good	Good

Two Kinds of Active Learning

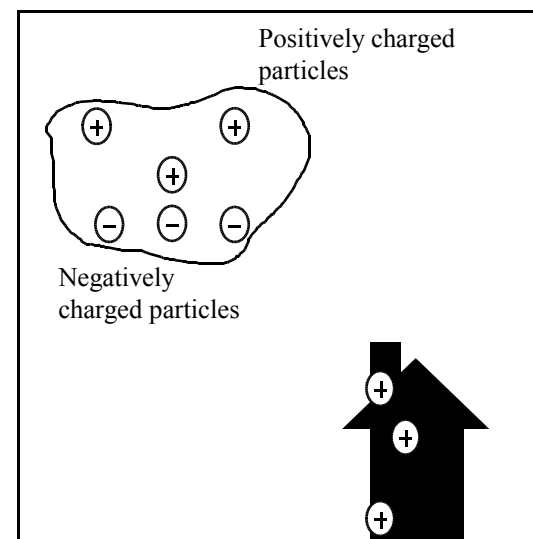
Level of Cognitive Activity			
		Low	High
Level of Behavioral Activity	Low	Does not foster meaningful learning outcome	Fosters meaningful learning outcome
	High	Does not foster meaningful learning outcome	Fosters meaningful learning outcome



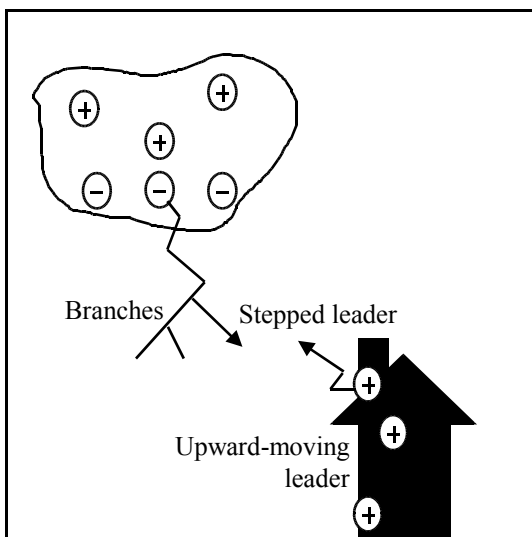
1. Warm moist air rises, water vapor condenses and forms a cloud.



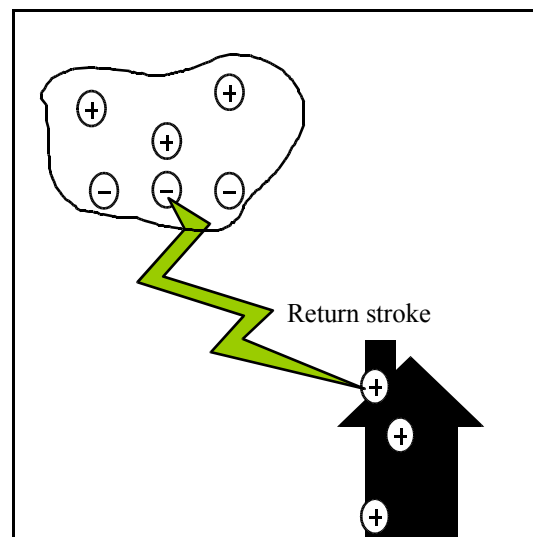
2. Raindrops and ice crystals drag air downward.



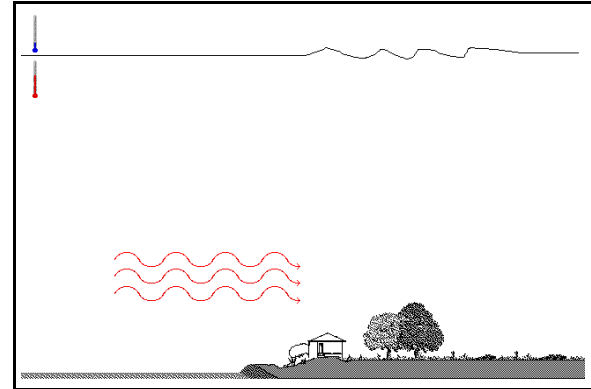
3. Negatively charged particles fall to the bottom of the cloud.



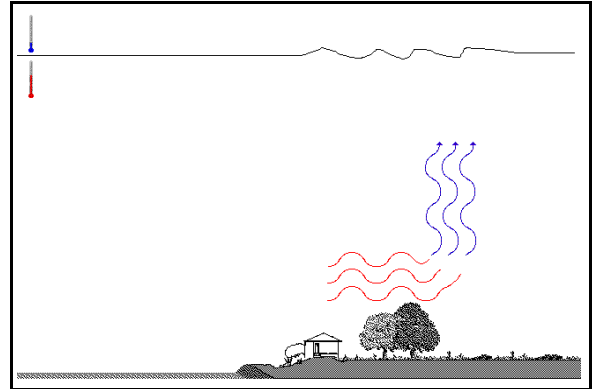
4. Two leaders meet, negatively charged particles rush from the cloud to the ground.



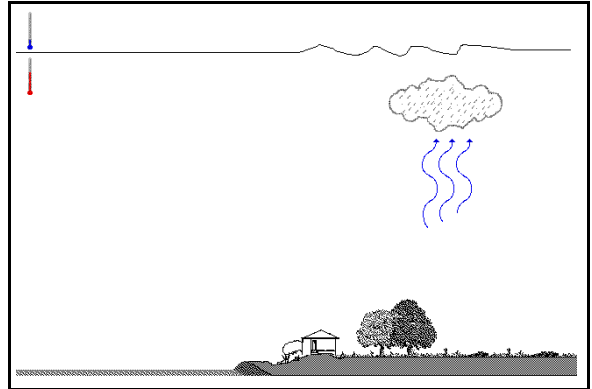
5. Positively charged particles from the ground rush upward along the same path.



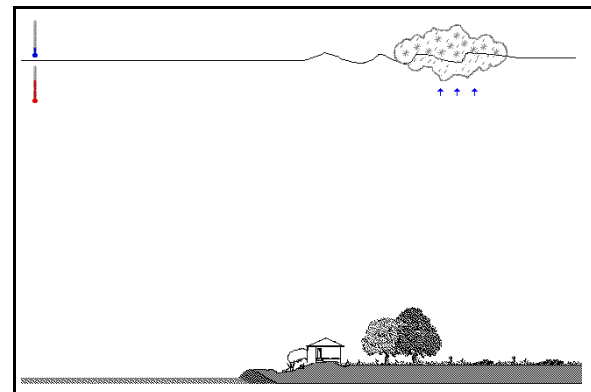
“Cool moist air moves over a warmer surface and becomes heated.”



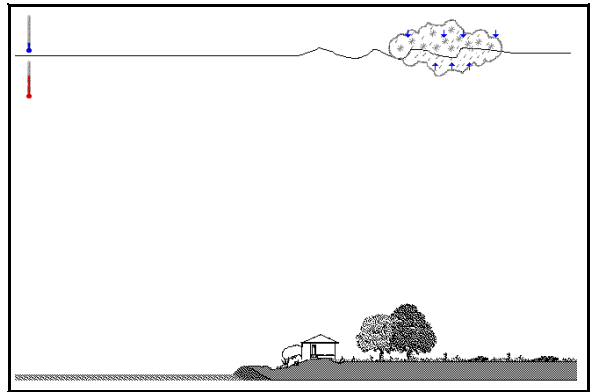
“Warmed moist air near the earth’s surface rises rapidly.”



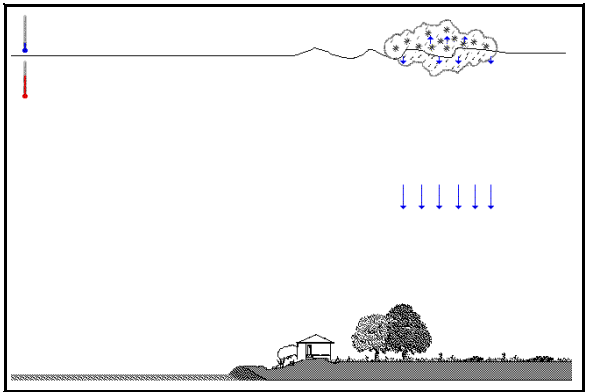
“As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud.”



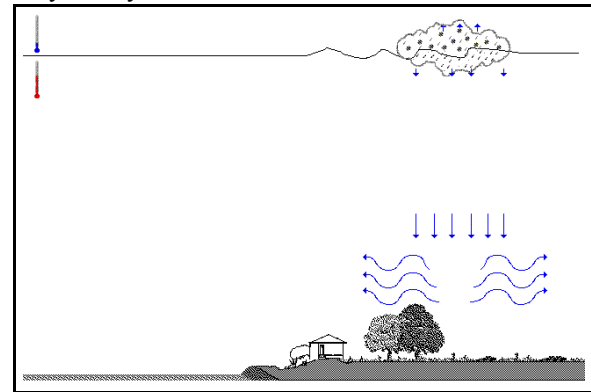
“The cloud’s top extends above the freezing level, so the upper portion of the cloud is composed of tiny ice crystals.”



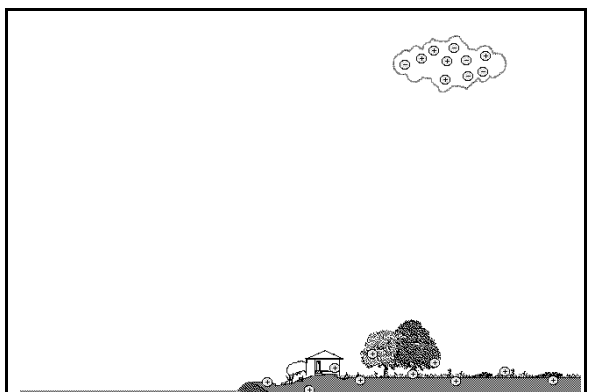
“Eventually, the water droplets and ice crystals become too large to be suspended by the updrafts.”



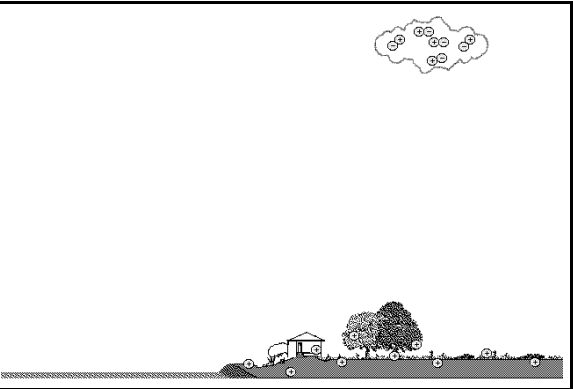
“As raindrops and ice crystals fall through the cloud, they drag some of the air in the cloud downward, producing downdrafts.”



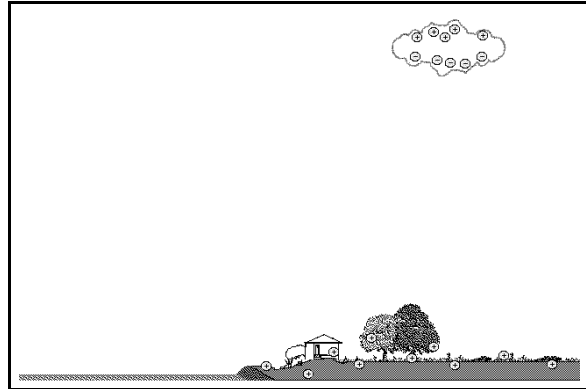
“When downdrafts strike the ground, they spread out in all directions, producing the gusts of cool wind people feel just before the start of the rain.”



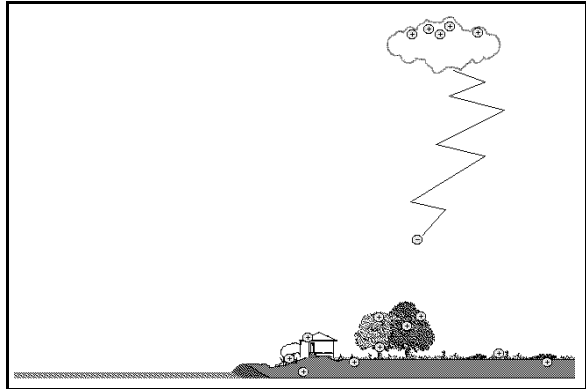
“Within the cloud, the rising and falling air currents cause electrical charges to build.”



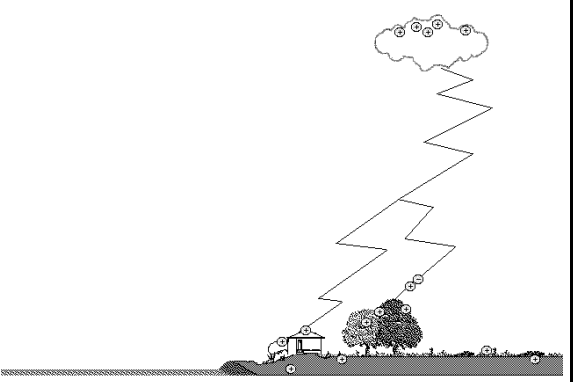
“The charge results from the collision of the cloud’s rising water droplets against heavier, falling pieces of ice.”



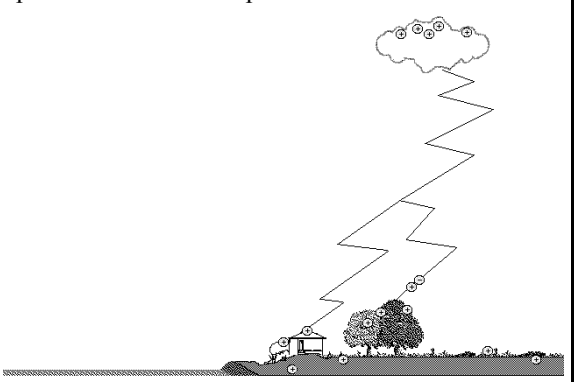
“The negatively charged particles fall to the bottom of the cloud, and most of the positively charged particles rise to the top.”



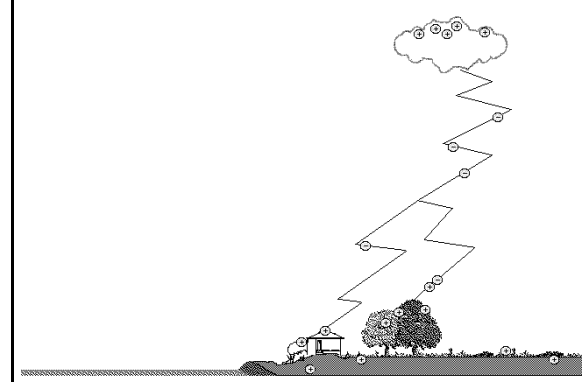
“A stepped leader of negative charges moves downward in a series of steps. It nears the ground.”



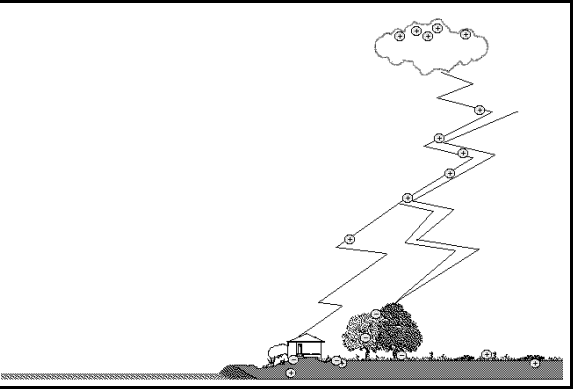
“A positively charged leader travels up from such objects as trees and buildings.”



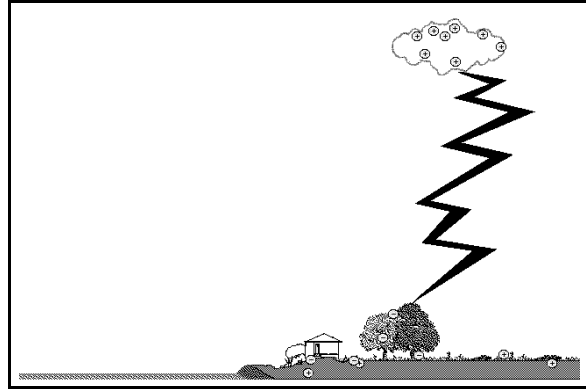
“The two leaders generally meet about 165-feet above the ground.”



“Negatively charged particles then rush from the cloud to the ground along the path created by the leaders. It is not very bright.”



“As the leader stroke nears the ground, it induces an opposite charge, so positively charged particles from the ground rush upward along the same path.”



“This upward motion of the current is the return stroke. It produces the bright light that people notice as a flash of lightning.”

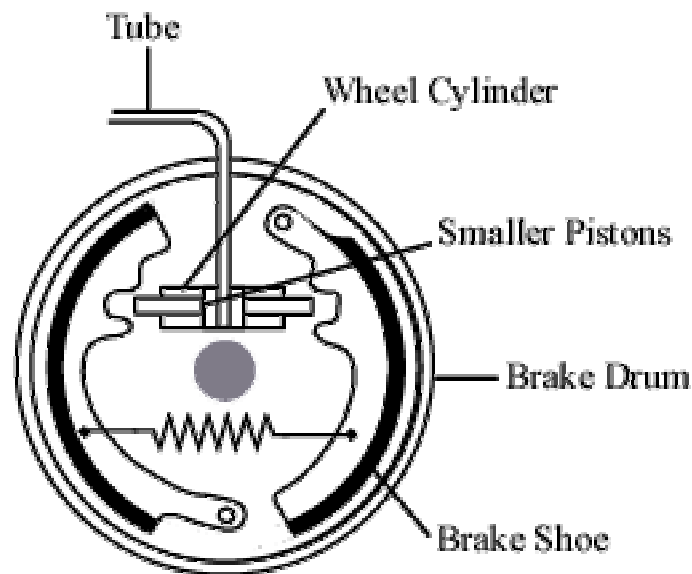
Retention and Transfer Questions for the Lightning Lesson

Retention Test

Please write down all you can remember about how lightning works.

Transfer Test

7. What could you do to reduce the intensity of lightning?
8. Suppose you see clouds in the sky but no lightning. Why not?
9. What does air temperature have to do with lightning?
10. What causes lightning?



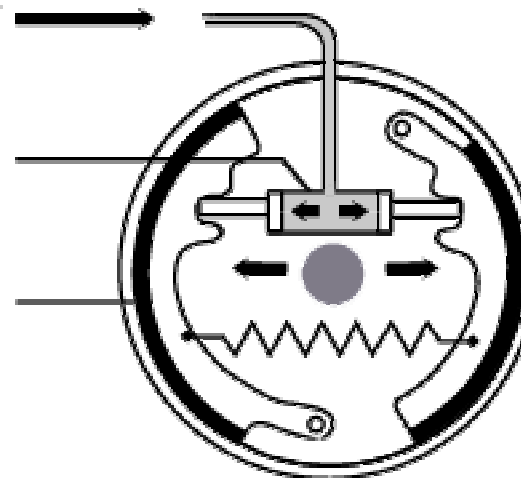
When the driver steps on the car's brake pedal...

A piston moves forward inside the master cylinder (not shown).

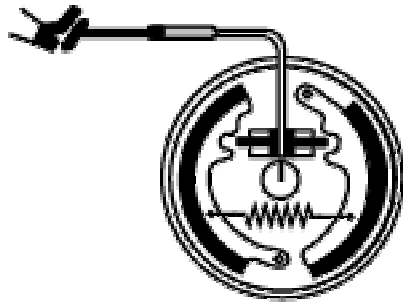
The piston forces brake fluid out of the master cylinder and through the tubes to the wheel cylinders.

In the wheel cylinders, the increase in fluid pressure makes a set of smaller pistons move.

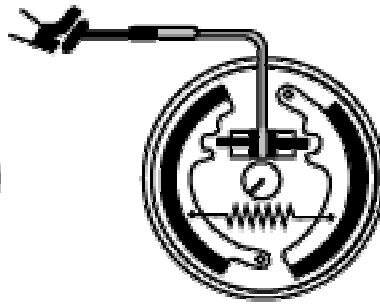
When the brake shoes press against the drum both the drum and the wheel stop or slow down.



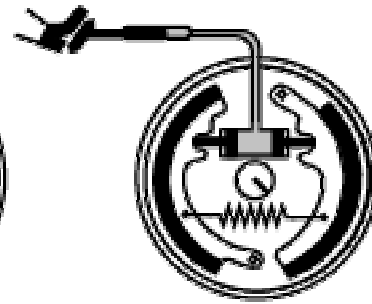
When the driver steps on the car's brake pedal,



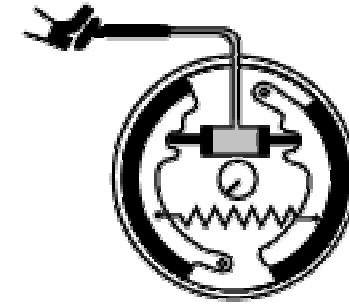
a piston moves forward inside the master cylinder.



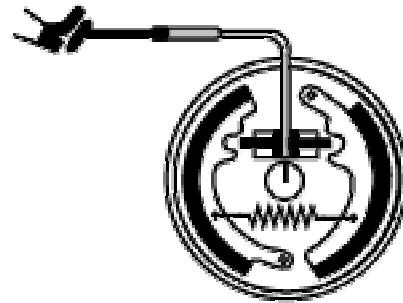
The piston forces brake fluid out of the master cylinder



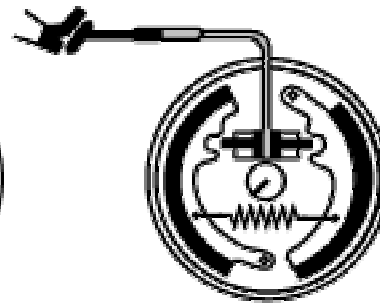
and through the tubes to the wheel cylinders.



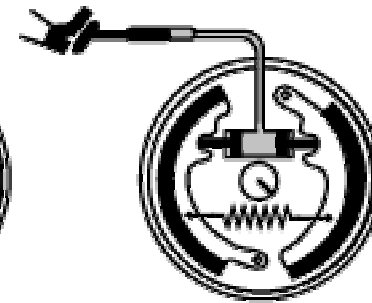
In the wheel cylinders,



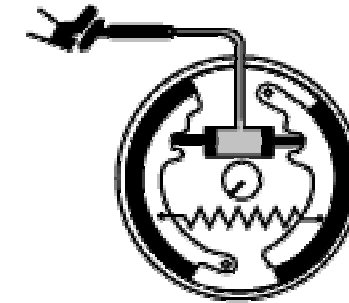
the increase in fluid pressure,



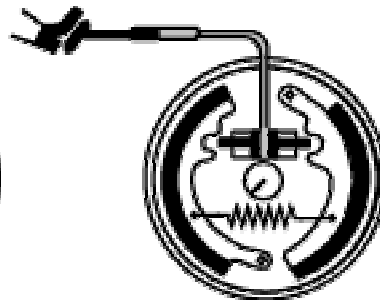
makes a set of smaller pistons move.



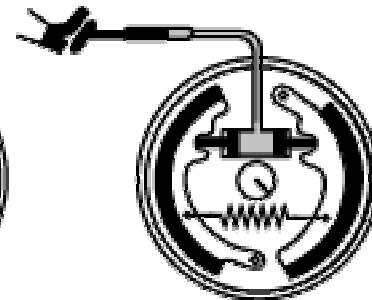
These smaller pistons activate the brake shoes.



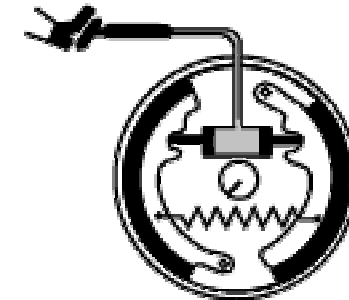
When the brake shoes press against the drum,



both the drum and the wheel stop



or slow down.



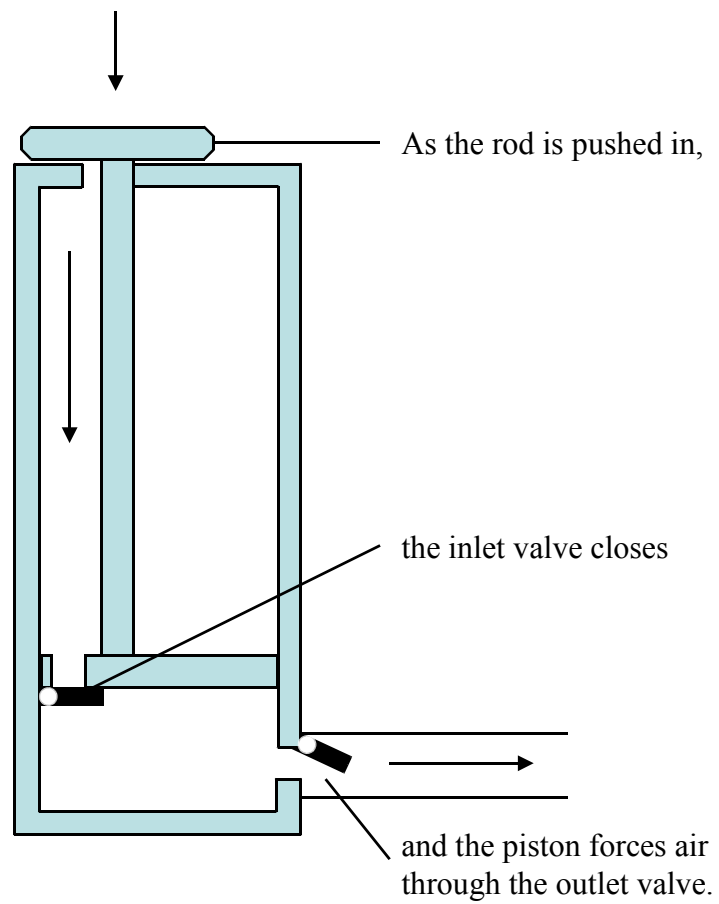
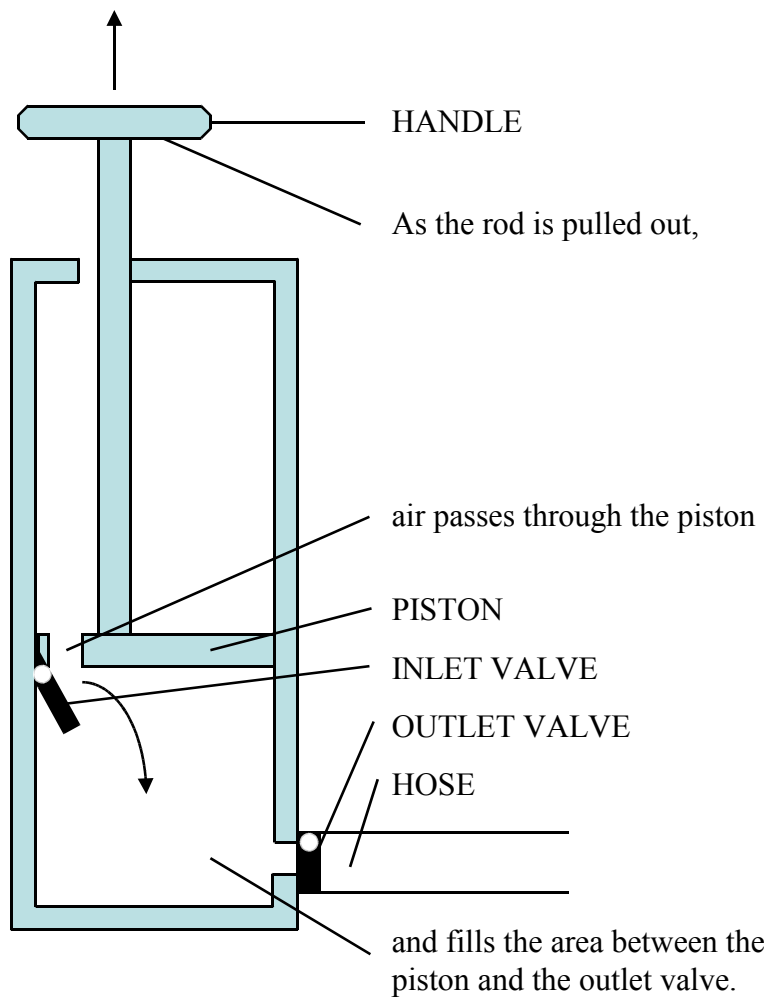
Retention and Transfer Questions for the Brakes Lesson

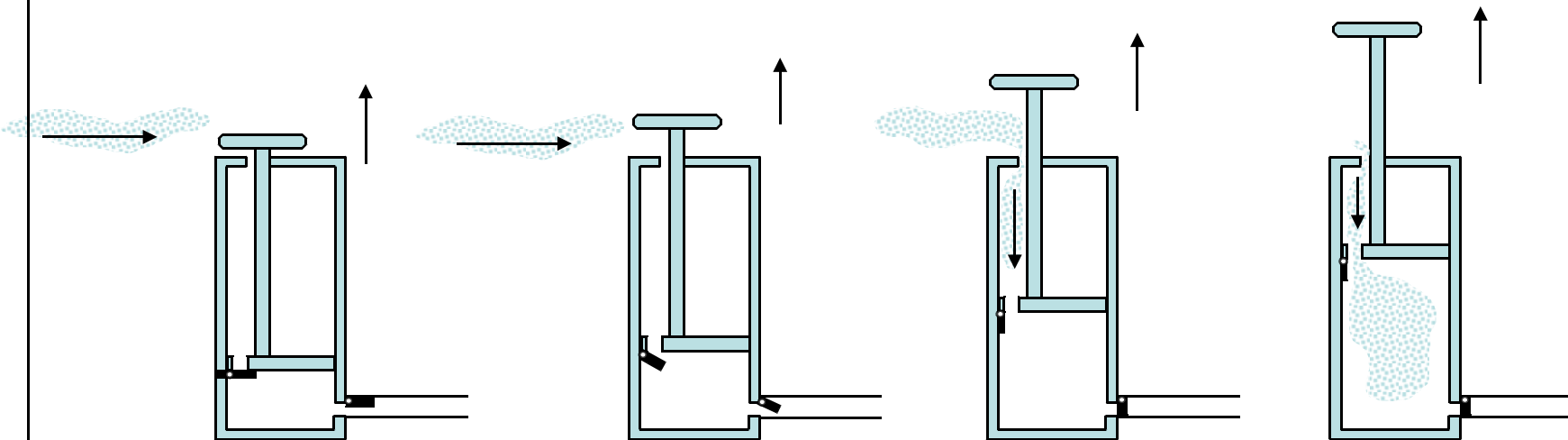
Retention Test

Please write down all you can remember about how a car's braking system works.

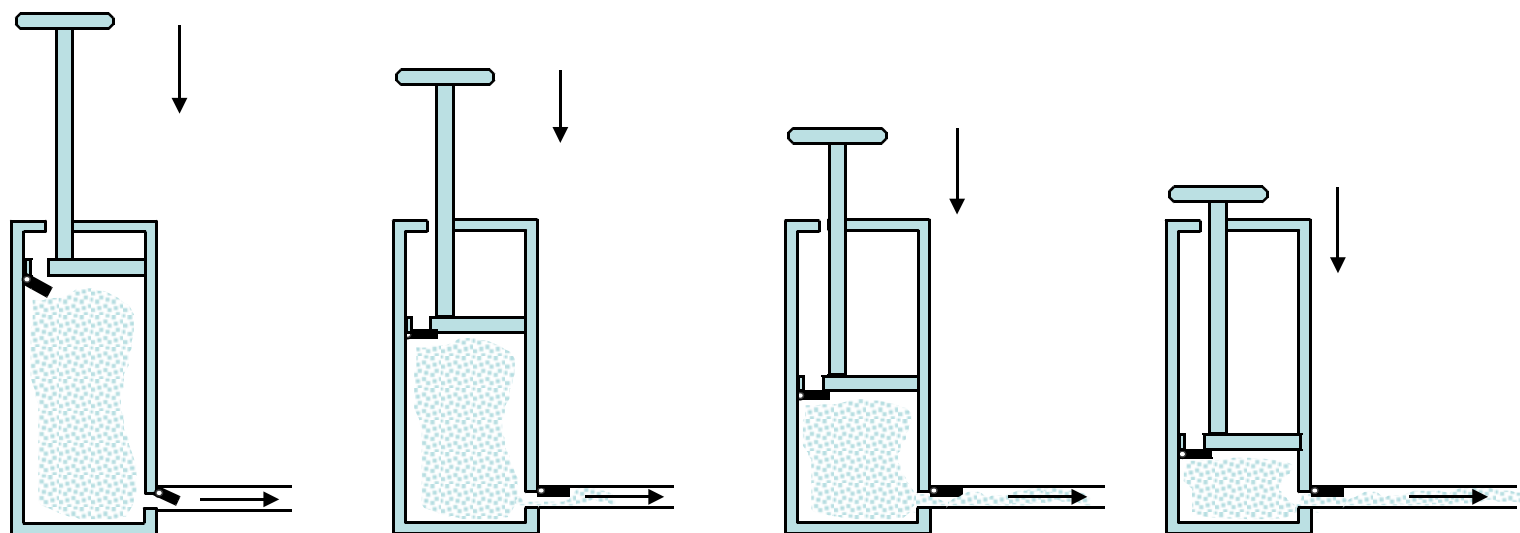
Transfer Test

8. Why do brakes get hot?
9. What could be done to make brakes more reliable--that is, to make sure they would not fail?
10. What could be done to make brakes more effective--that is, to reduce the distance needed bring a car to a stop?
11. Suppose you press on the brake pedal in your car but the brakes don't work. What could have gone wrong?
12. What happens when you pump the brakes (i.e., press the pedal and release the pedal repeatedly and rapidly)?





“When the handle is pulled up, the piston moves up, the inlet valve opens, the outlet valve closes, and air enters the lower part of the cylinder.”



“When the handle is pushed down, the piston moves down, the inlet valve closes, the outlet valve opens, and air moves out through the hose.”

Retention and Transfer Questions for the Pump Lesson

Retention Test

Please write down all you can remember about how a bicycle tire pump works.

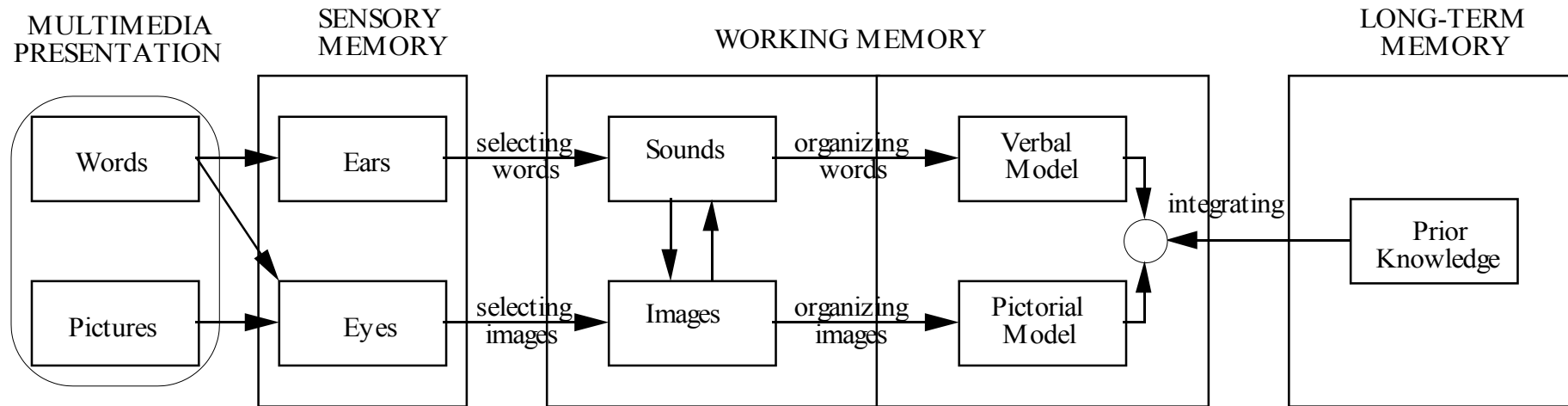
Transfer Test

7. What could be done to make a pump more reliable--that is, to make sure it would not fail?
8. What could be done to make a pump more effect--that is, to make it move more air more rapidly?
9. Suppose you push down and pull up the handle of a pump several times but no air comes out. What could have gone wrong?
10. Why does air enter a pump? Why does air exit from a pump?

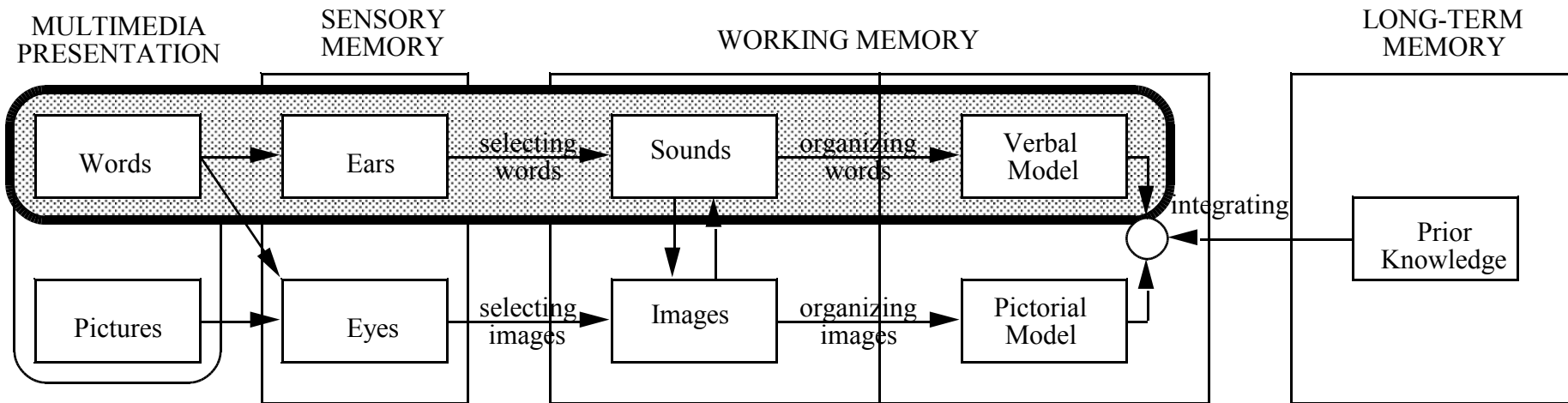
Three Assumptions of a Cognitive Theory of Multimedia Learning

Assumption	Description
Dual channels	Humans possess separate channels for processing visual and auditory information.
Limited capacity	Humans are limited in the amount of information that they can process in each channel at one time.
Active processing	Humans engage in active learning by attending to relevant incoming information, organizing selected information into coherent mental representations, and integrating mental representations with other knowledge.

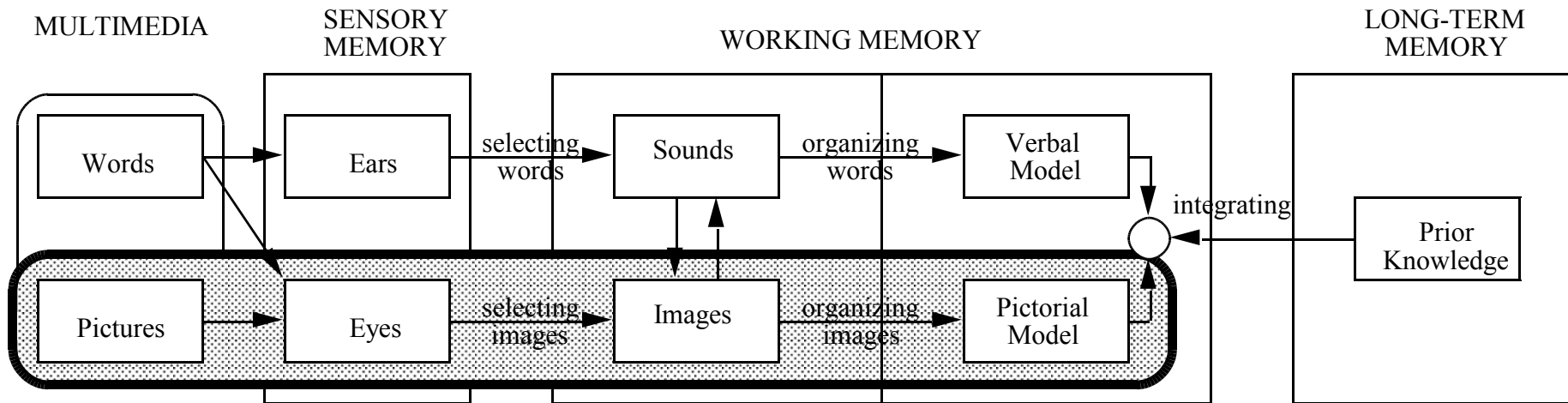
A Cognitive Theory of Multimedia Learning



Auditory/Verbal Channel Highlighted

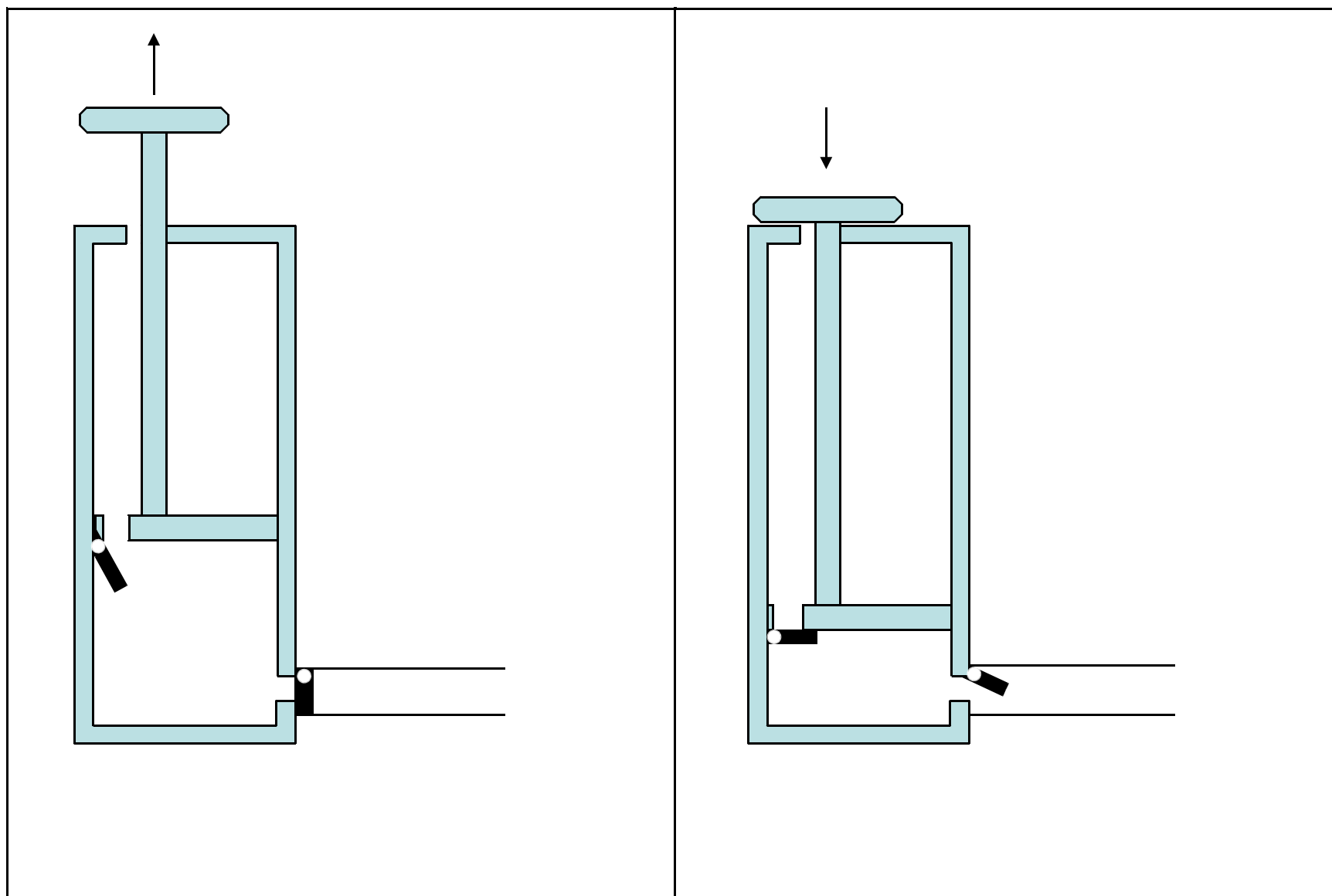


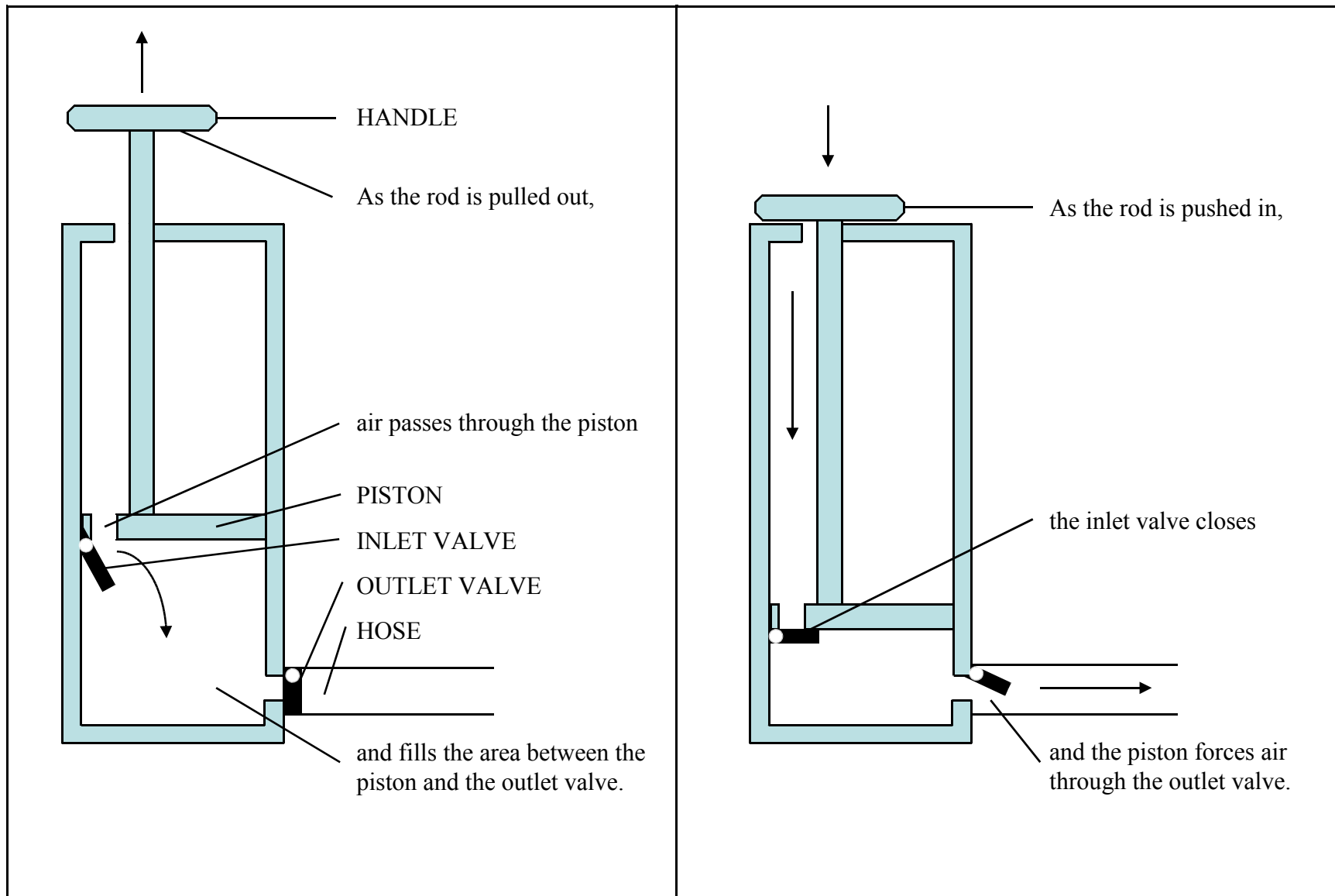
Visual/Pictorial Channel Highlighted



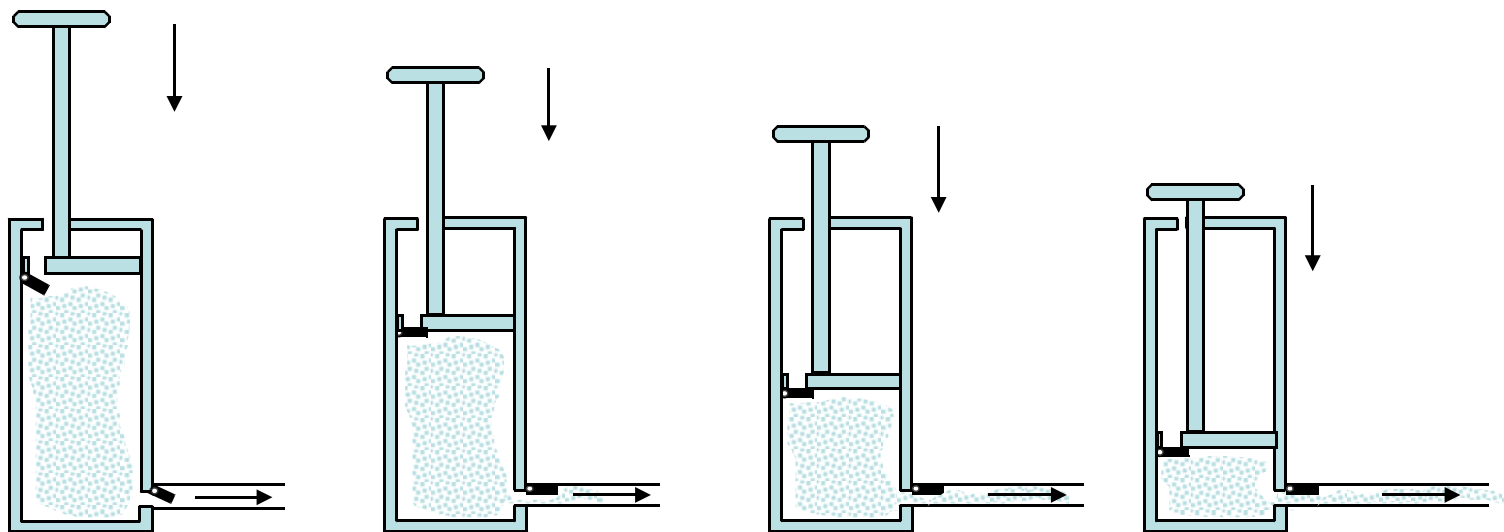
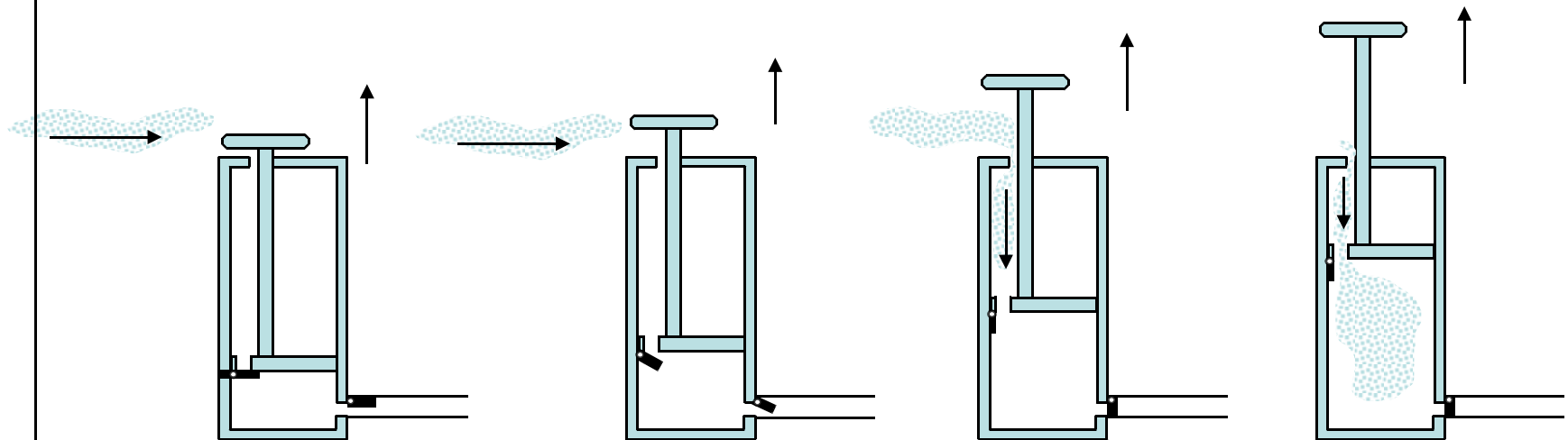
Bicycle tire pumps vary in the number and location of the valves they have and in the way air enters the cylinder. Some simple tire pumps have the inlet valve on the piston and the outlet valve at the closed end of the cylinder. A bicycle tire pump has a piston that moves up and down. Air enters the pump near the point where the connecting rod passes through the cylinder. *As the rod is pulled out, air passes through the piston and fills the area between the piston and the outlet valve. As the rod is pushed in, the inlet valve closes and the piston forces air through the outlet valve.*

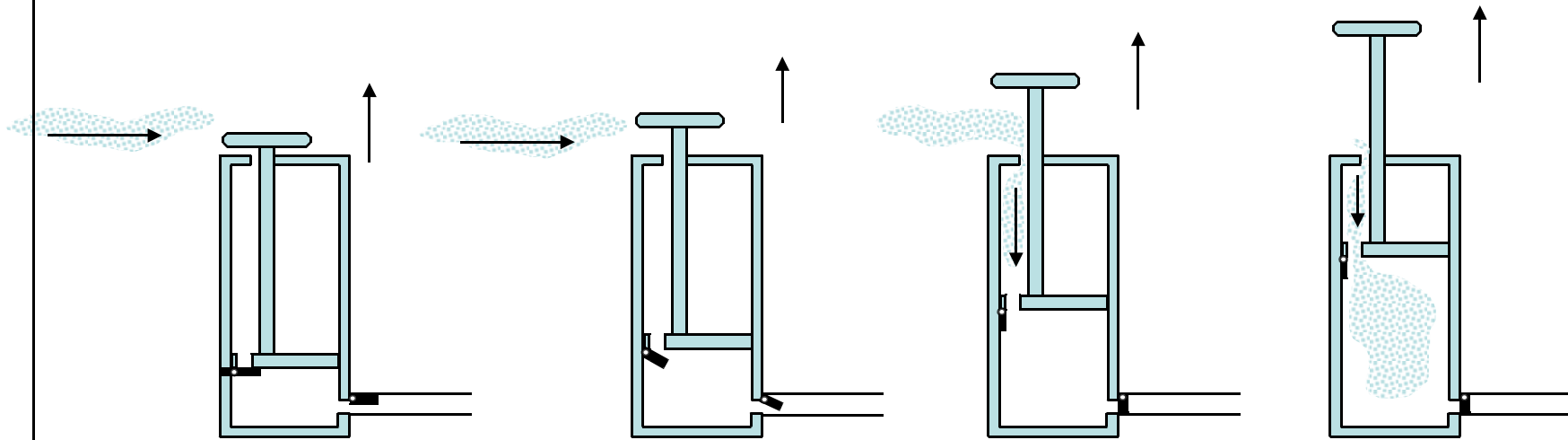
[italics added]



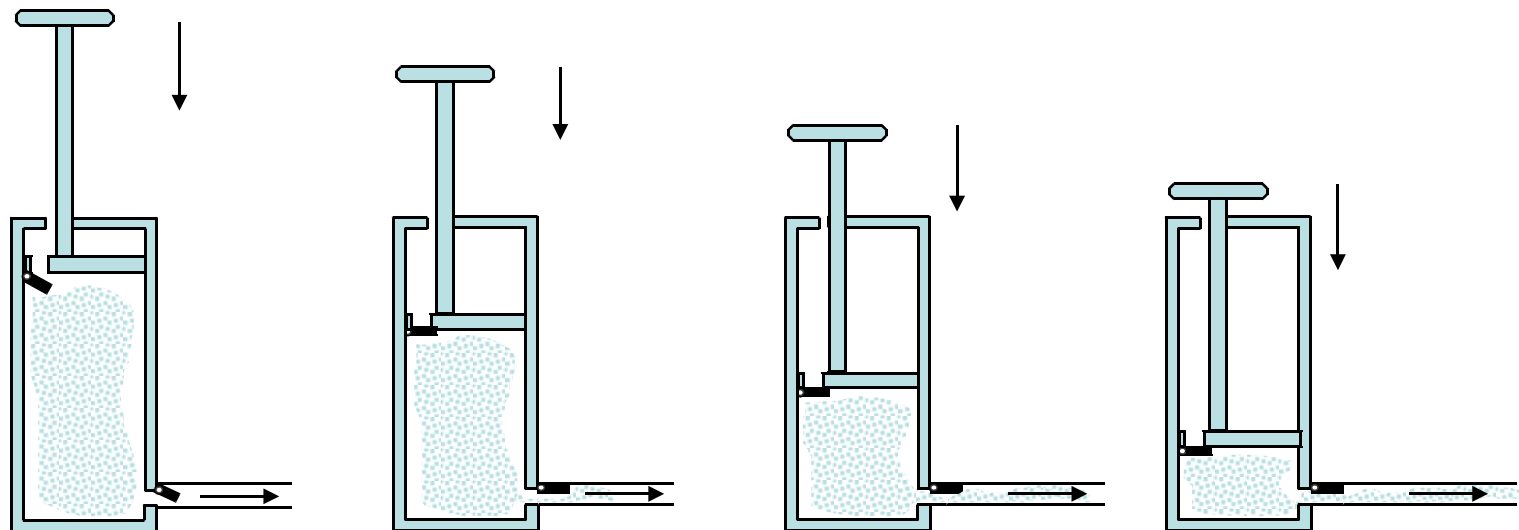


When the handle is pulled up, the piston moves up, the inlet valve opens, the outlet valve closes and air enters the lower part of the cylinder. When the handle is pushed down, the piston moves down, the inlet valve closes, the outlet valve opens, and air moves out through the hose.



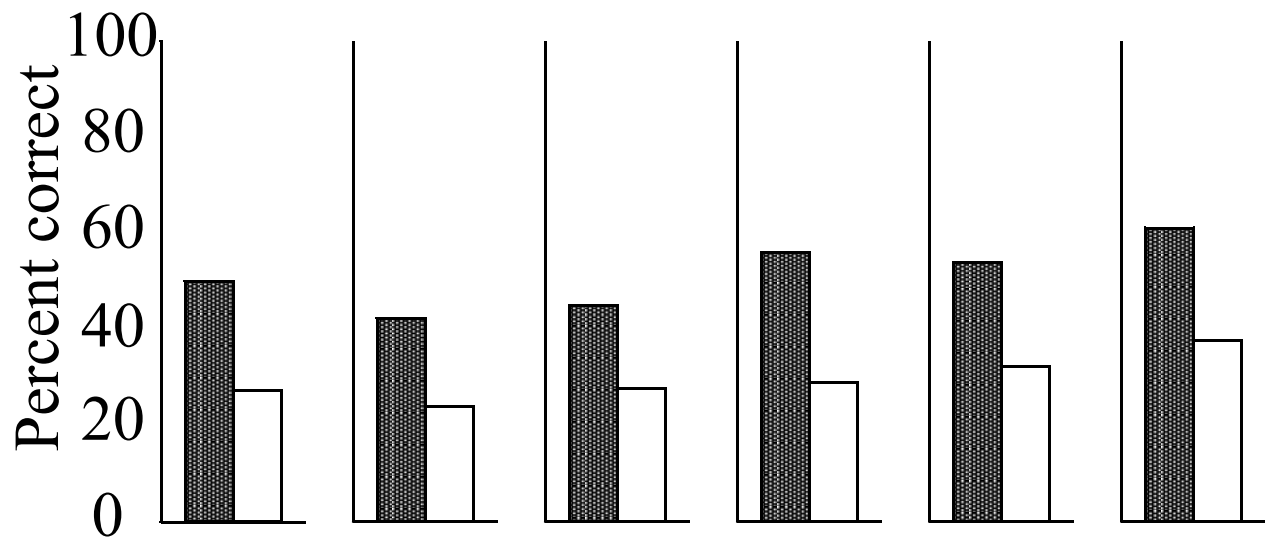
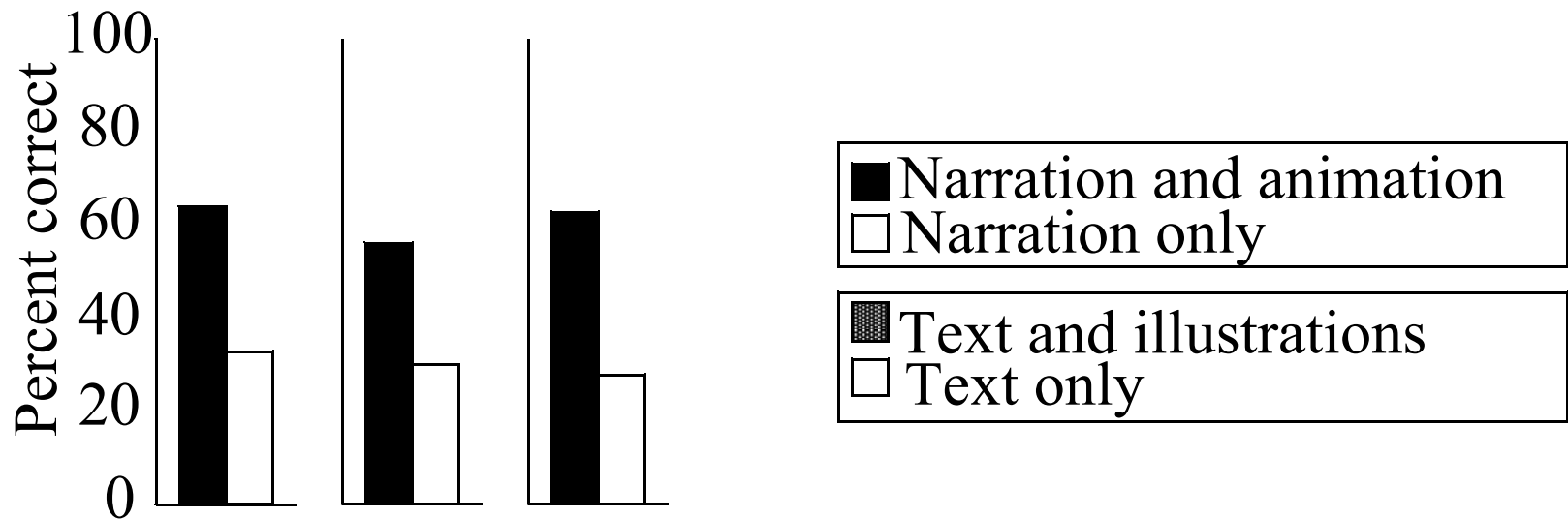


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Multimedia effect: People learn better from words and pictures (dark bars) than from words alone (white bars).



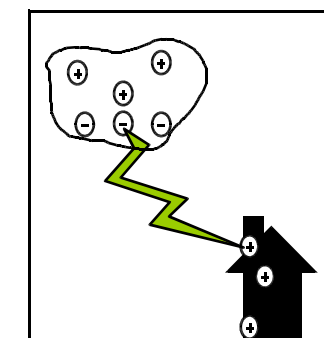
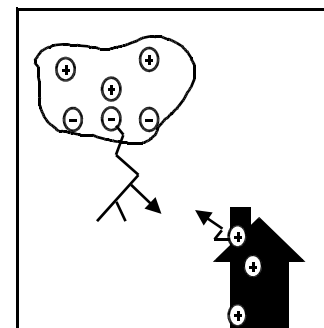
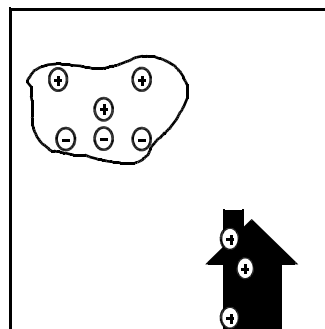
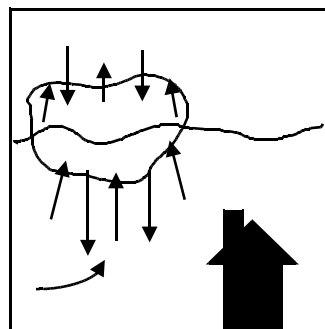
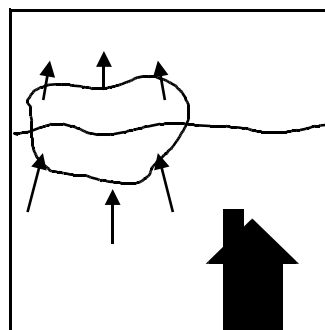
When the surface of the earth is warm, moist air near the earth's surface becomes heated and rises rapidly, producing an updraft. As the air in these updrafts cools, water vapor condenses into water droplets and forms a cloud. The cloud's top extends above the freezing level. At this altitude, the air temperature is well below freezing, so the upper portion of the cloud is composed of tiny ice crystals.

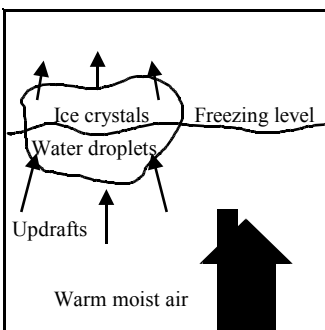
Eventually, the water droplets and ice crystals in the cloud become too large to be suspended by updrafts. As raindrops and ice crystals fall through the cloud, they drag some of the air from the cloud downward, producing downdrafts. The rising and falling air currents within the cloud may cause hailstones to form. When downdrafts strike the ground, they spread out in all directions, producing gusts of cool wind people feel just before the start of the rain.

Within the cloud, the moving air causes electrical charges to build, although scientists do not fully understand how it occurs. Most believe that the charge results from the collision of the cloud's light, rising water droplets and tiny pieces of ice against hail and other heavier, falling particles. The negatively charged particles fall to the bottom of the cloud, and most of the positively charged particles rise to the top.

The first stroke of a cloud-to-ground lightning flash is started by a stepped leader. Many scientists believe that it is triggered by a spark between the areas of positive and negative charges within the cloud. A stepped leader moves downward in a series of steps, each of which is about 50-yards long, and lasts for about 1 millionth of a second. It pauses between steps for about 50 millionths of a second. As the stepped leader nears the ground, positively charged upward-moving leaders travel up from such objects as trees and buildings, to meet the negative charges. Usually, the upward moving leader from the tallest object is the first to meet the stepped leader and complete a path between the cloud and earth. The two leaders generally meet about 165-feet above the ground. Negatively charged particles then rush from the cloud to the ground along the path created by the leaders. It is not very bright and usually has many branches.

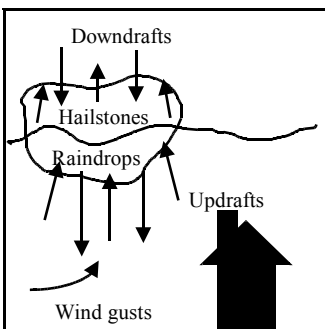
As the stepped leader nears the ground, it induces an opposite charge, so positively charged particles from the ground rush upward along the same path. This upward motion of the current is the return stroke and it reaches the cloud in about 70 microseconds. The return stroke produces the bright light that people notice in a flash of lightning, but the current moves so quickly that its upward motion cannot be perceived. The lightning flash usually consists of an electrical potential of hundreds of millions of volts. The air along the lightning channel is heated briefly to a very high temperature. Such intense heating causes the air to expand explosively, producing a sound wave we call thunder.





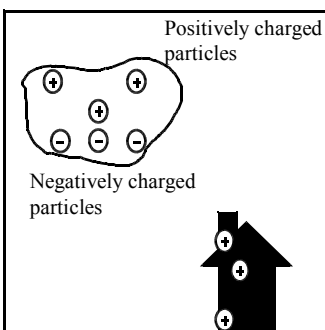
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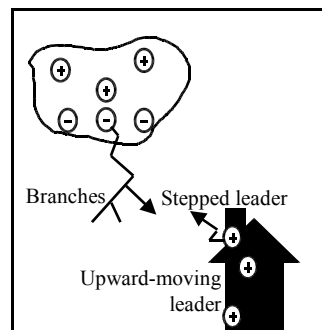
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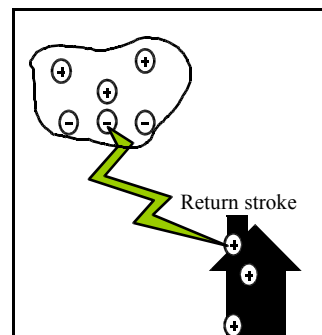
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Two leaders meet, negatively charged particles rush from the cloud to the ground.

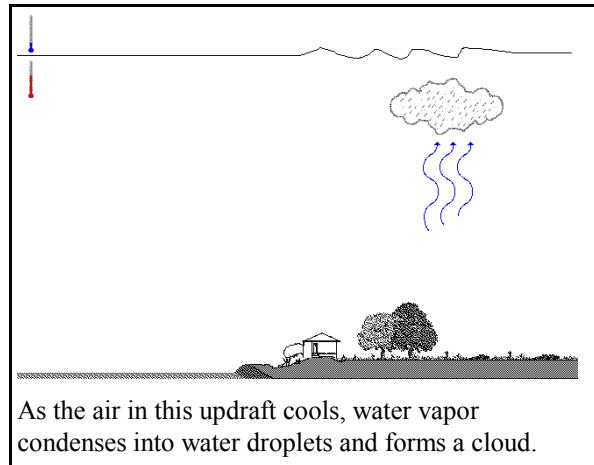
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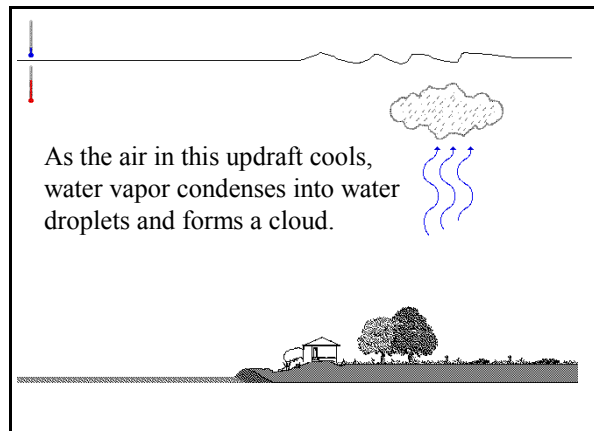
Positively charged particles from the ground rush upward along the same path.

As the stepped leader nears the ground, it induces an opposite charge, so positively charged particles from the ground rush upward along the same path. This upward motion of the current is the return stroke and it reaches the cloud in about 70 microseconds. The return stroke produces the bright light that people notice in a flash of lightning, but the current moves so quickly that its upward motion cannot be perceived. The lightning flash usually consists of an electrical potential of hundreds of millions of volts. The air along the lightning channel is heated briefly to a very high temperature. Such intense heating causes the air to expand explosively, producing a sound wave we call thunder.

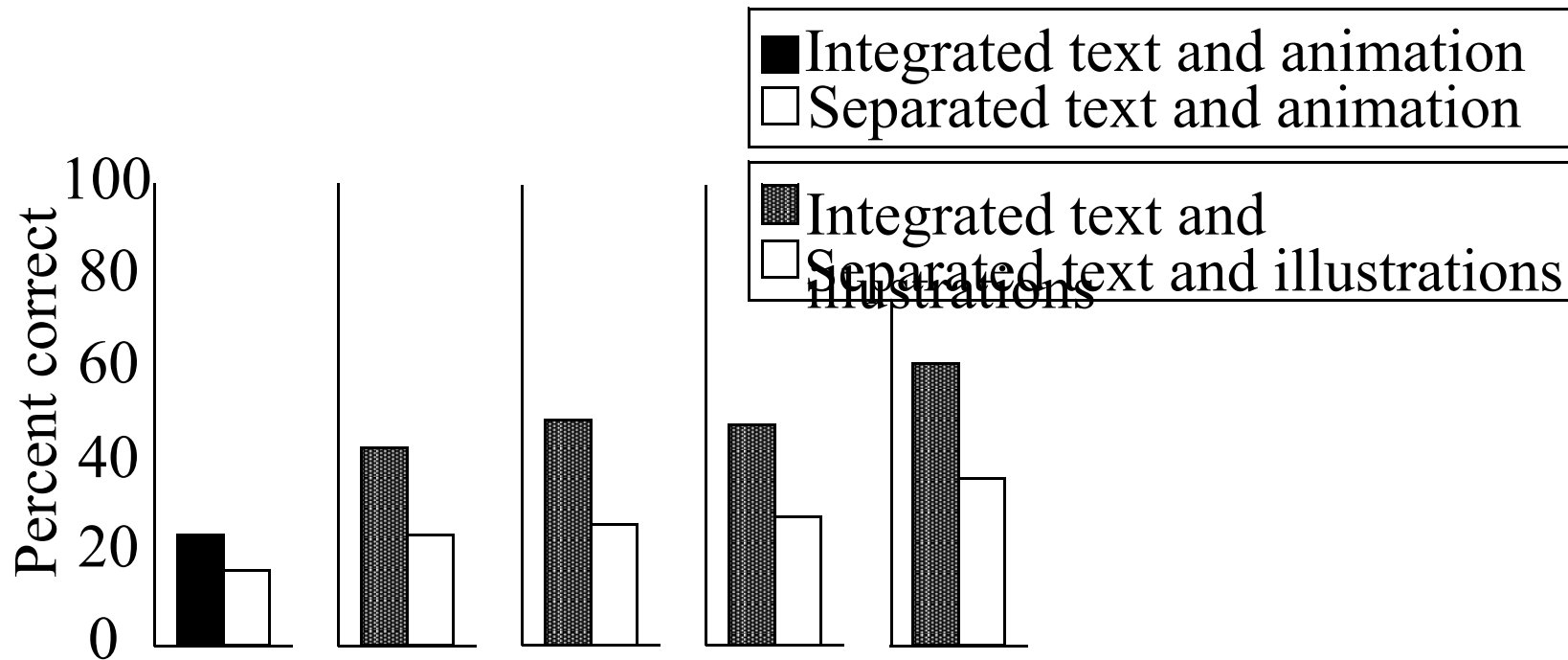
Separated Presentation

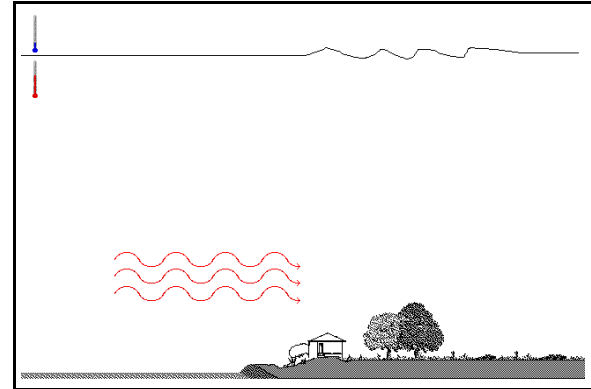


Integrated Presentation

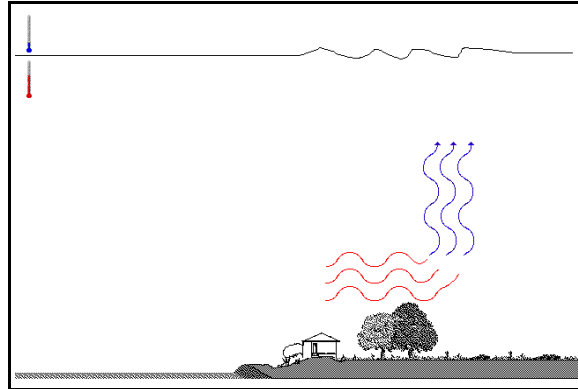


Spatial contiguity effect: People learn better when corresponding words and pictures are presented near (dark bars) rather than far (white bars) from each other on the page or screen.

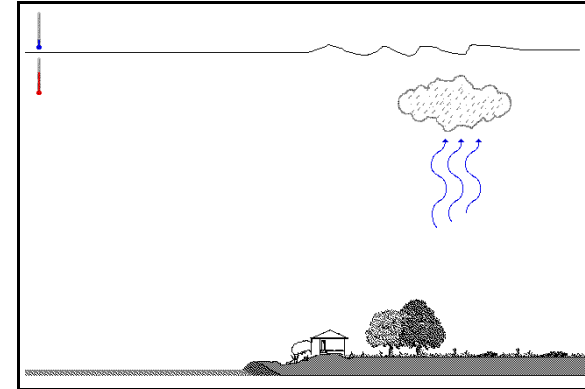




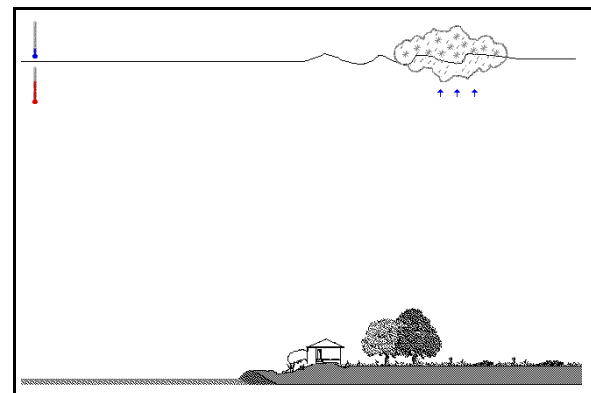
"Cool moist air moves over a warmer surface and becomes heated."



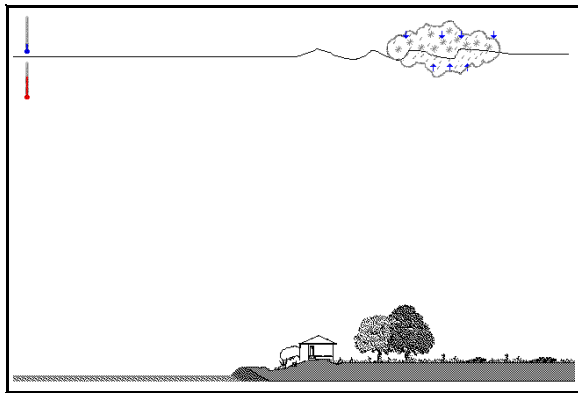
"Warmed moist air near the earth's surface rises rapidly."



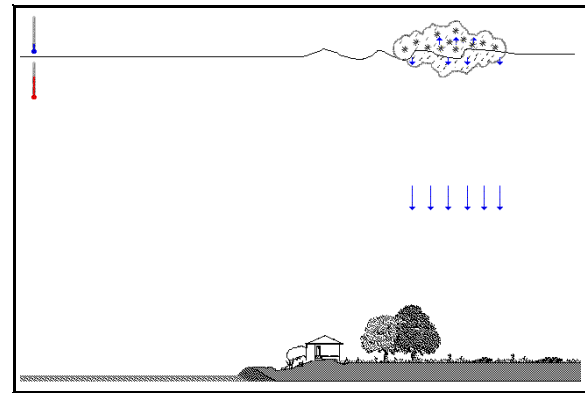
"As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud."



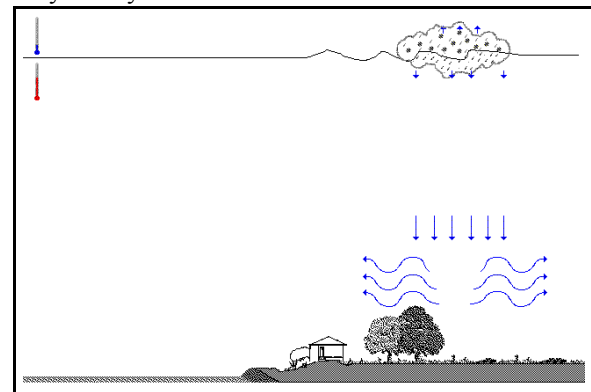
"The cloud's top extends above the freezing level, so the upper portion of the cloud is composed of tiny ice crystals."



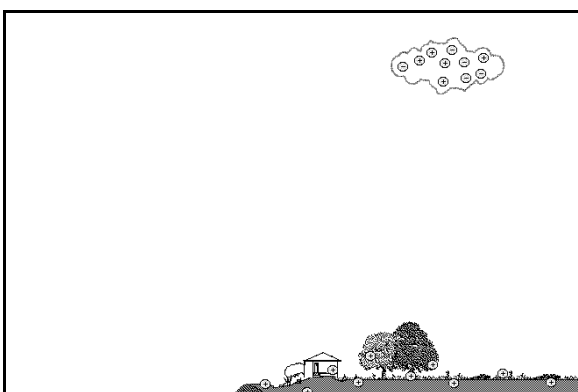
"Eventually, the water droplets and ice crystals become too large to be suspended by the updrafts."



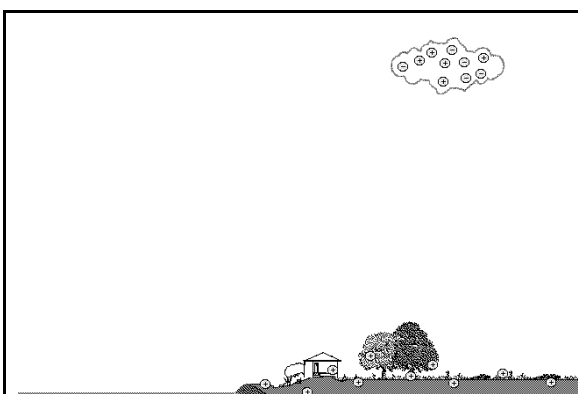
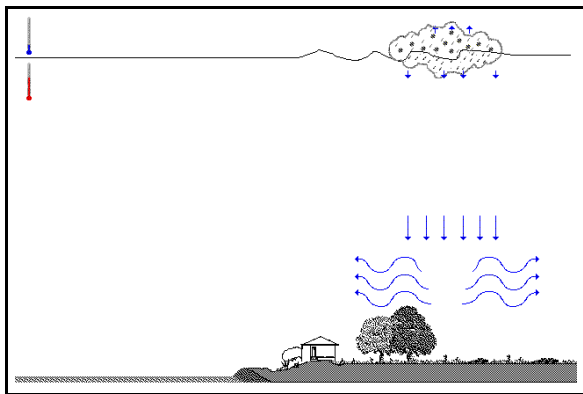
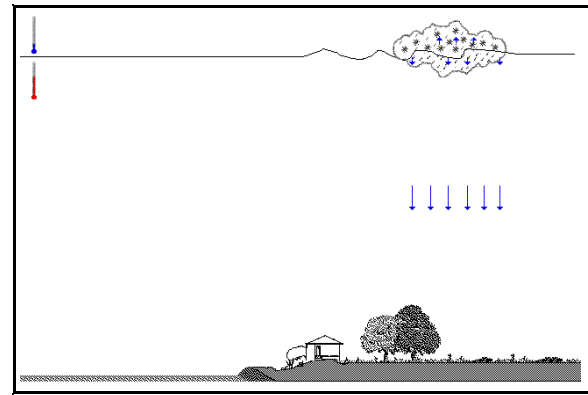
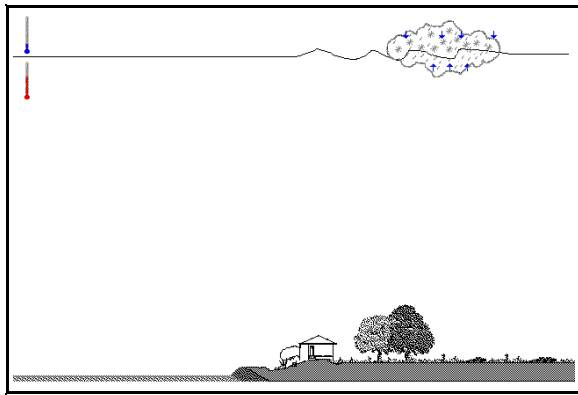
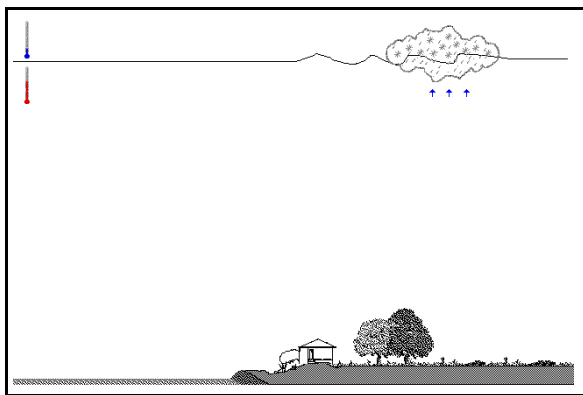
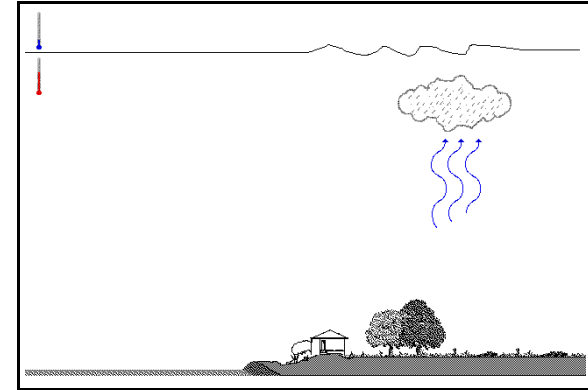
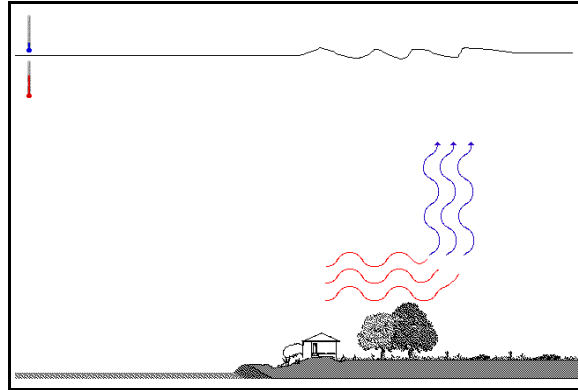
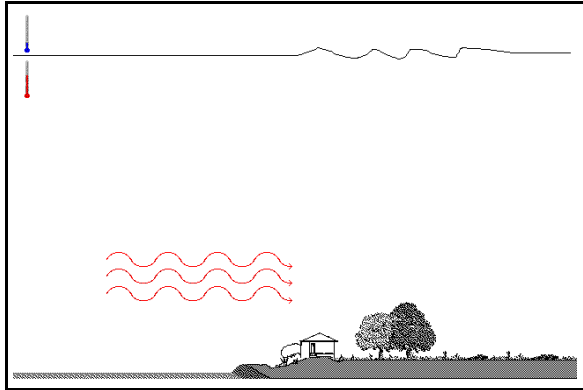
"As raindrops and ice crystals fall through the cloud, they drag some of the air in the cloud downward, producing downdrafts."



"When downdrafts strike the ground, they spread out in all directions, producing the gusts of cool wind people feel just before the start of the rain."

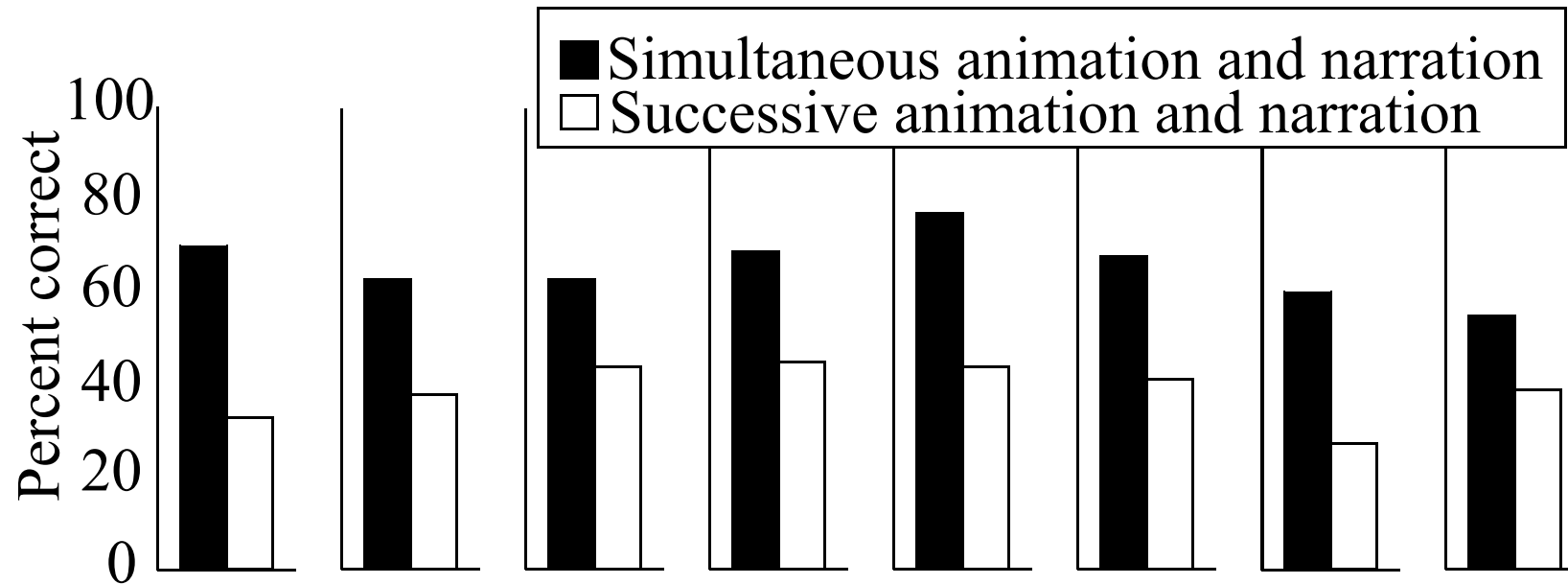


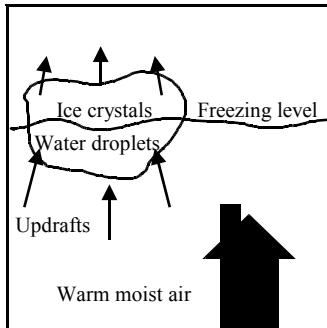
"Within the cloud, the rising and falling air currents cause electrical charges to build."



“Cool moist air moves over a warmer surface and becomes heated. Warmed moist air near the earth’s surface rises rapidly. As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud. “The cloud’s top extends above the freezing level, so the upper portion of the cloud is composed of tiny ice crystals. Eventually, the water droplets and ice crystals become too large to be suspended by the updrafts. As raindrops and ice crystals fall through the cloud, they drag some of the air in the cloud downward, producing downdrafts. When downdrafts strike the ground, they spread out in all directions, producing the gusts of cool wind people feel just before the start of the rain. Within the cloud, the rising and falling air currents cause electrical charges to build....”

Temporal contiguity effect: People learn better when corresponding words and pictures are presented simultaneously (dark bars) rather than successively (white bars).



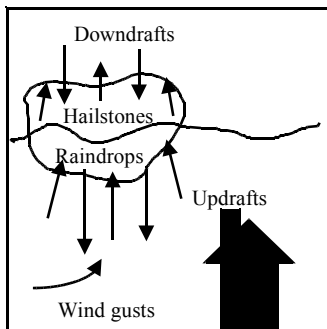


Warm moist air rises, water vapor condenses and forms a cloud.

When the surface of the earth is warm, moist air near the earth's surface becomes heated and rises rapidly, producing an updraft. As the air in these updrafts cools, water vapor condenses into water droplets and forms a cloud. When flying through updrafts, an airplane ride can become bumpy. Metal airplanes conduct lightning very well, but they sustain little damage because the bolt, meeting no resistance, passes right through. The cloud's top extends above the freezing level. At this altitude, the air temperature is well below freezing, so the upper portion of the cloud is composed of tiny ice crystals.

Actual picture of airplane being struck by lightning

Metal airplanes conduct lightning, but sustain little damage.

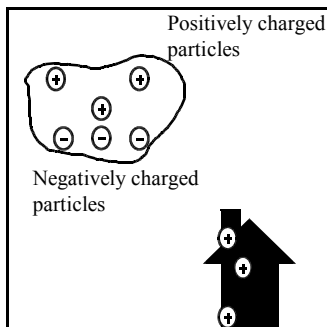


Raindrops and ice crystals drag air downward.

Eventually, the water droplets and ice crystals in the cloud become too large to be suspended by updrafts. As raindrops and ice crystals fall through the cloud, they drag some of the air from the cloud downward, producing downdrafts. When lightning strikes the ground, fulgurites may form, as the heat from the lightning fuses sand into the shape of the electricity's path. The rising and falling air currents within the cloud may cause hailstones to form. When downdrafts strike the ground, they spread out in all directions, producing gusts of cool wind people feel just before the start of the rain.

Actual picture of lightning fusing sand into the shape of the electricity's path

Lightning fuses sand into the shape of the electricity's path.

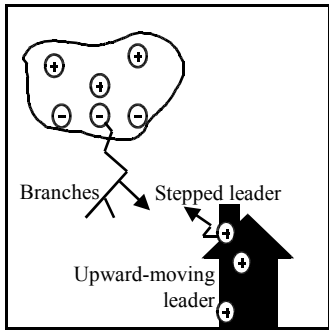


Negatively charged particles fall to the bottom of the cloud.

Within the cloud, the moving air causes electrical charges to build, although scientists do not fully understand how it occurs. Most believe that the charge results from the collision of the cloud's light, rising water droplets and tiny pieces of ice against hail and other heavier, falling particles. In trying to understand these processes, scientists sometimes create lightning by launching tiny rockets into overhead clouds. The negatively charged particles fall to the bottom of the cloud, and most of the positively charged particles rise to the top.

Actual picture of a rocket flying into clouds

Scientists create lightning by launching tiny rockets.

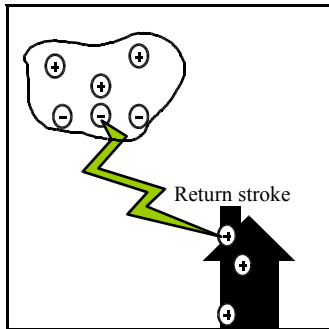


Two leaders meet, negatively charged particles rush from the cloud to the ground.

The first stroke of a cloud-to-ground lightning flash is started by a stepped leader. Many scientists believe that it is triggered by a spark between the areas of positive and negative charges within the cloud. A stepped leader moves downward in a series of steps, each of which is about 50-yards long, and lasts for about 1 millionth of a second. It pauses between steps for about 50 millionths of a second. As the stepped leader nears the ground, positively charged upward-moving leaders travel up from such objects as trees and buildings, to meet the negative charges. Golfers are prime targets of lightning strikes because they tend to stand in open grassy fields, or to huddle under trees. Usually, the upward moving leader from the tallest object is the first to meet the stepped leader and complete a path between the cloud and earth. The two leaders generally meet about 165-feet above the ground. Negatively charged particles then rush from the cloud to the ground along the path created by the leaders. It is not very bright and usually has many branches.

**Actual picture
of a golfer**

Golfers are prime targets of lightning strikes.



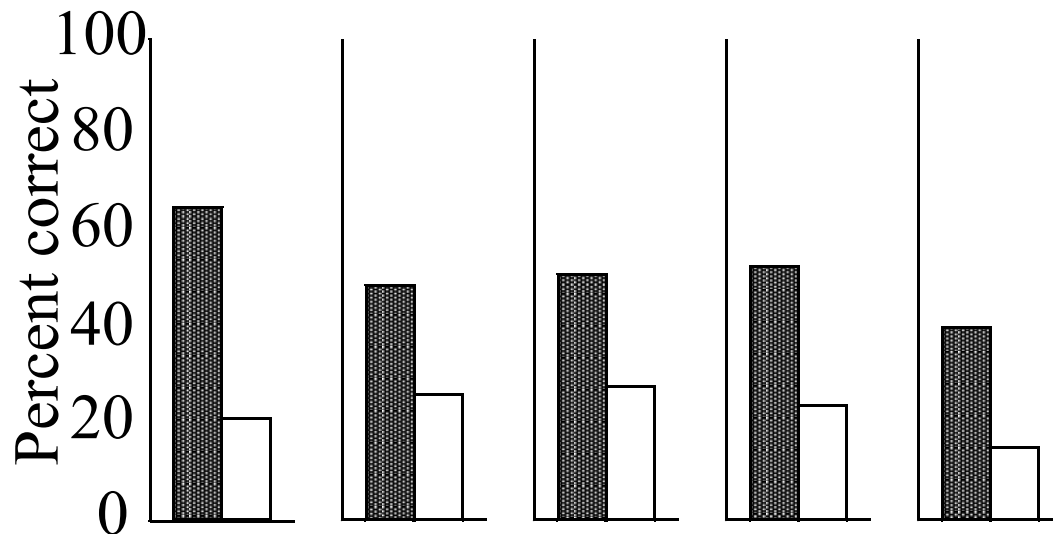
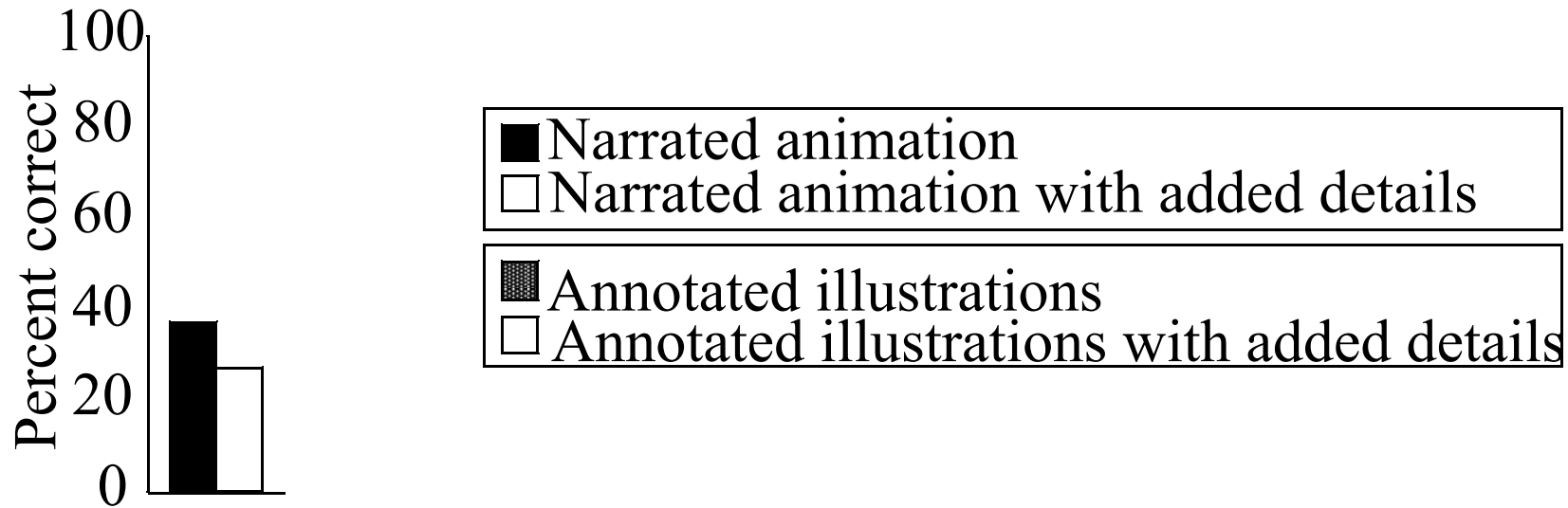
Positively charged particles from the ground rush upward along the same path.

As the stepped leader nears the ground, it induces an opposite charge, so positively charged particles from the ground rush upward along the same path. This upward motion of the current is the return stroke and it reaches the cloud in about 70 microseconds. Approximately 10,000 Americans are injured by lightning every year. Eyewitnesses in Burtonville, Maryland, watched as a bolt of lightning tore a hole in the helmet of a high school football player during practice. The bolt burned his jersey, and blew his shoes off. More than a year later, the young man still won't talk about his near death experience. The return stroke produces the bright light that people notice in a flash of lightning, but the current moves so quickly that its upward motion cannot be perceived. The lightning flash usually consists of an electrical potential of hundreds of millions of volts. The air along the lightning channel is heated briefly to a very high temperature. Such intense heating causes the air to expand explosively, producing a sound wave we call thunder.

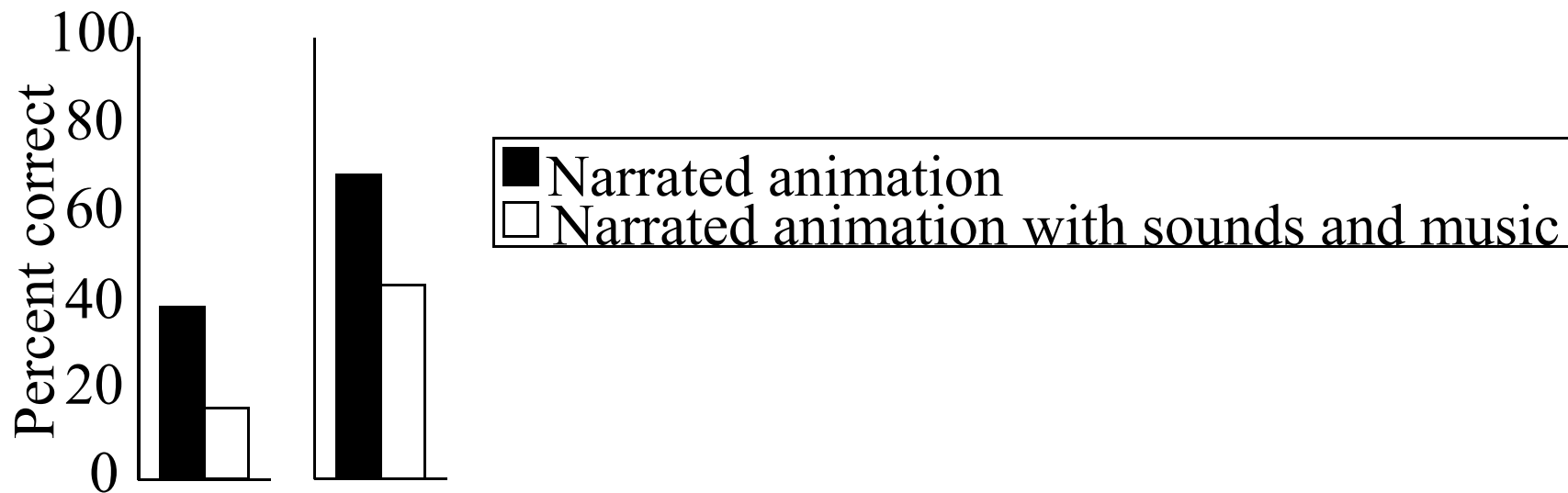
**Actual picture
the football player's
uniform struck by
lightning**

A lightning bolt tore a hole in the helmet of a football player, burned his jersey, and blew his shoes off.

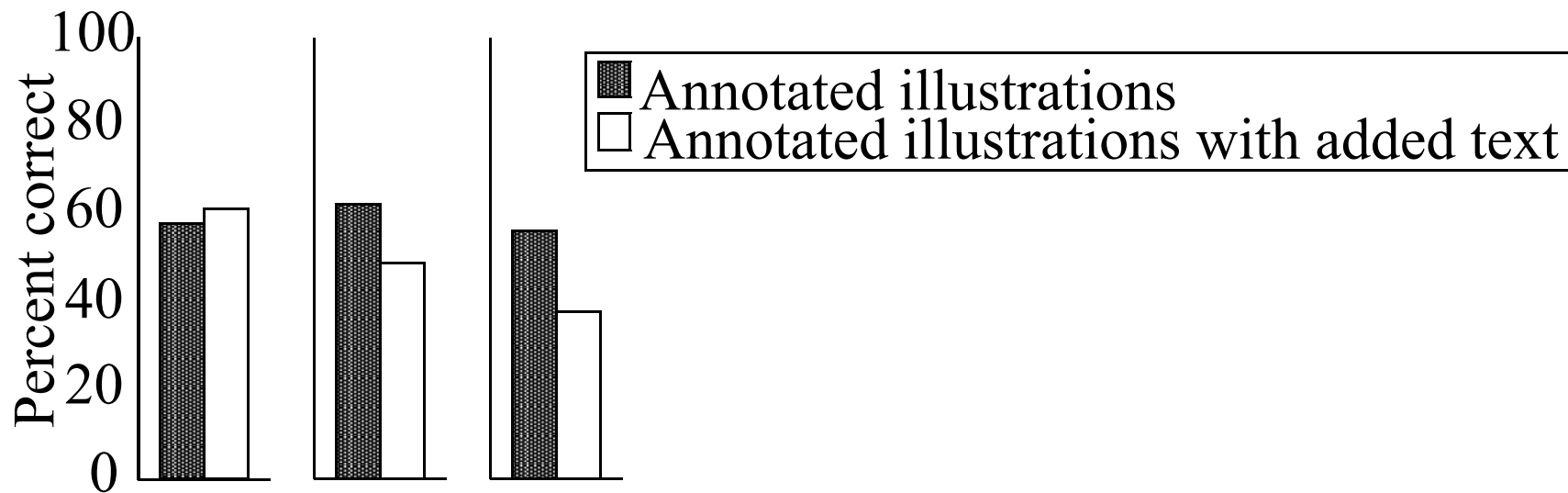
Coherence effect (type 1): People learn better when interesting but irrelevant details are excluded (dark bars) rather than included (white bars).



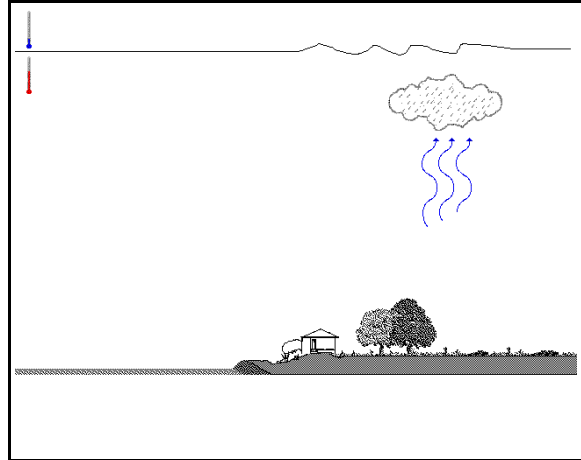
Coherence effect (type 2): People learn better when interesting but irrelevant sounds and music are excluded (dark bars) rather than included (white bars).



Coherence effect (type 3): People learn better or just as well when nonessential words are excluded (dark bars) rather than included (white bars).

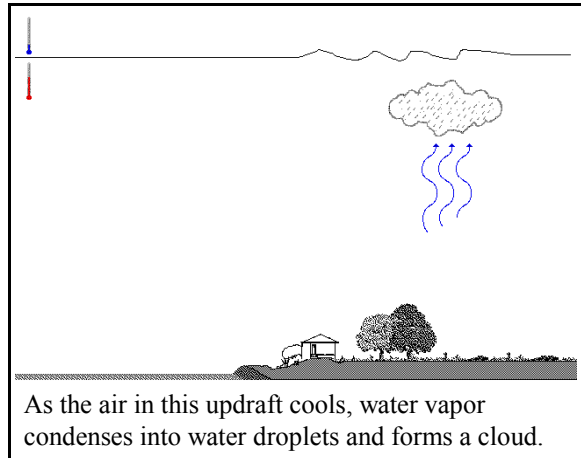


Words as Narration



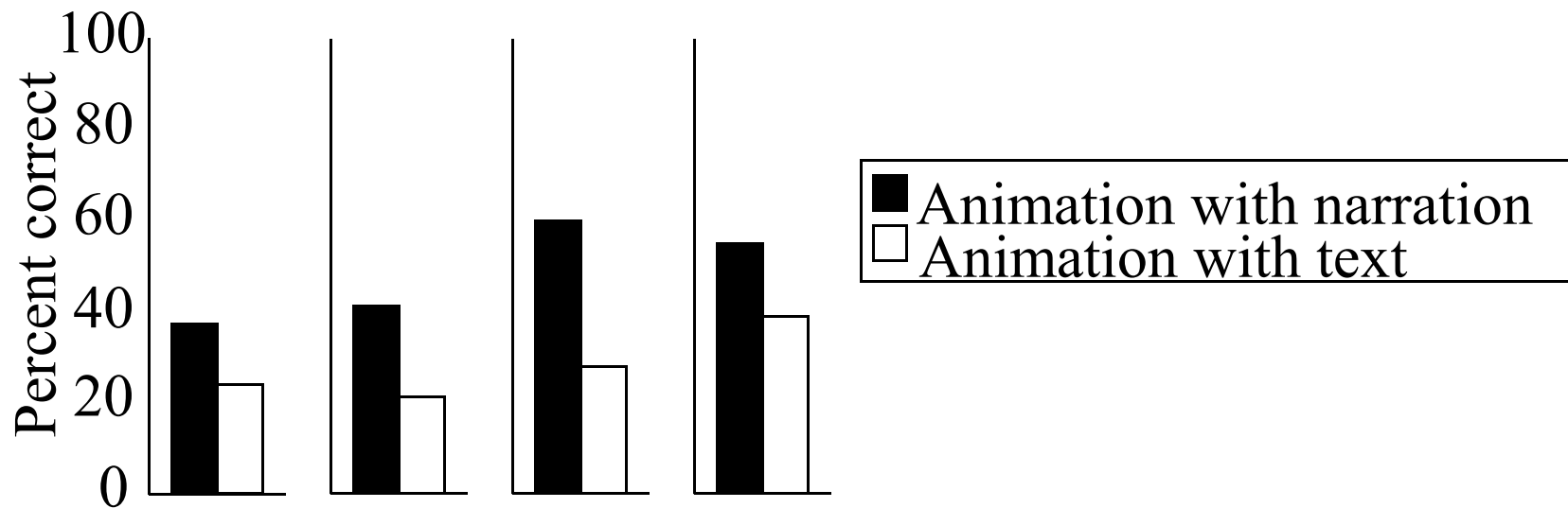
“As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud.”

Words as On-Screen Text

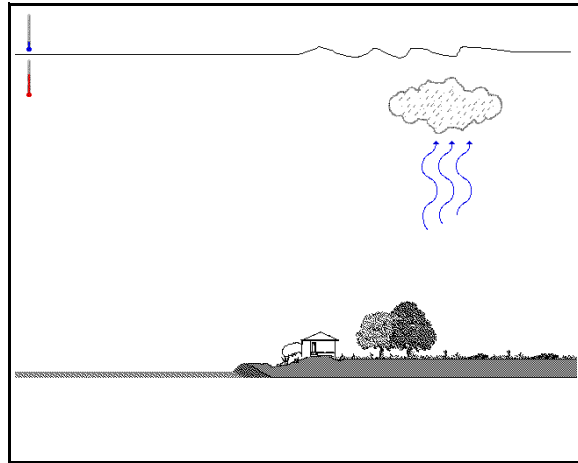


As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud.

Modality effect: People learn better when words are presented as narration (dark bars) rather than as on-screen text (white bars).

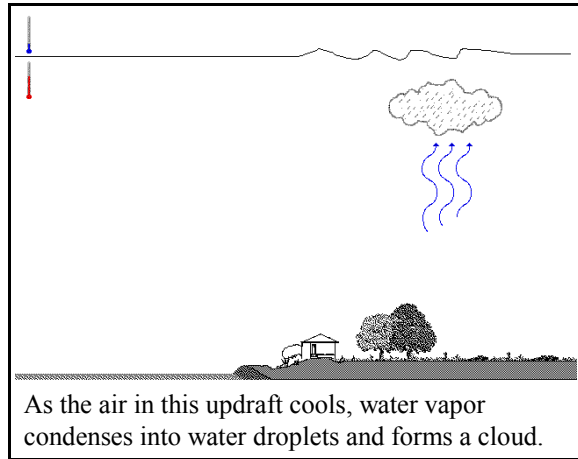


Animation with Narration



“As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud.”

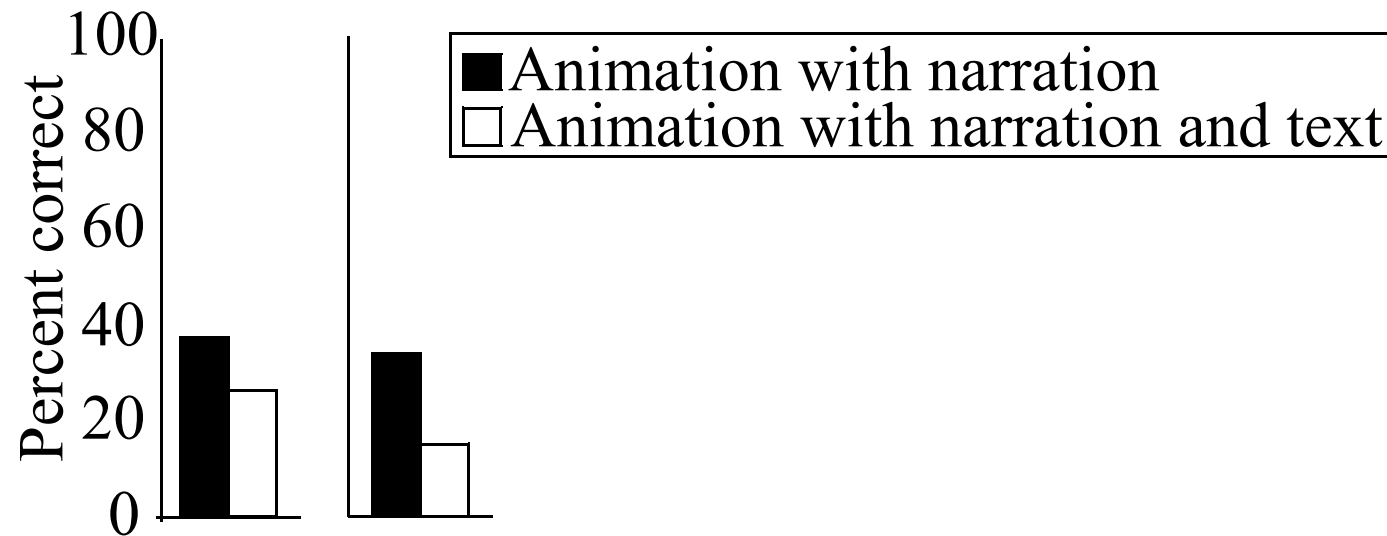
Animation with Narration and On-Screen Text



As the air in this updraft cools, water vapor
condenses into water droplets and forms a cloud.

“As the air in this updraft cools, water vapor
condenses into water droplets and forms a cloud.”

Redundancy effect: People learn better when words are presented as narration (dark bars) rather than as narration and on-screen text (white bars).



Examples as Personalized and Non-Personalized Speech

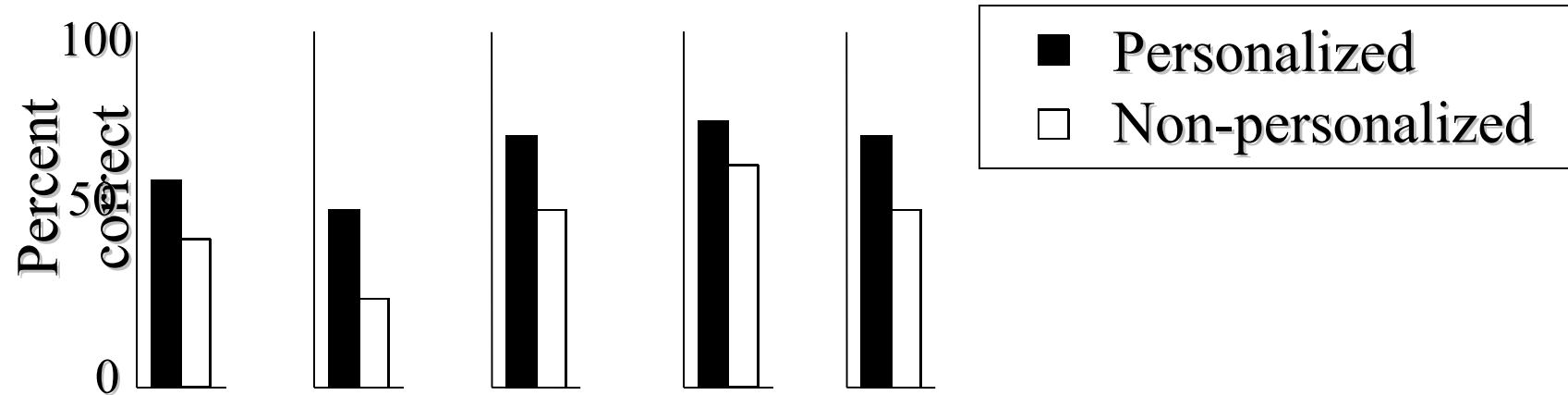
Personalized Speech

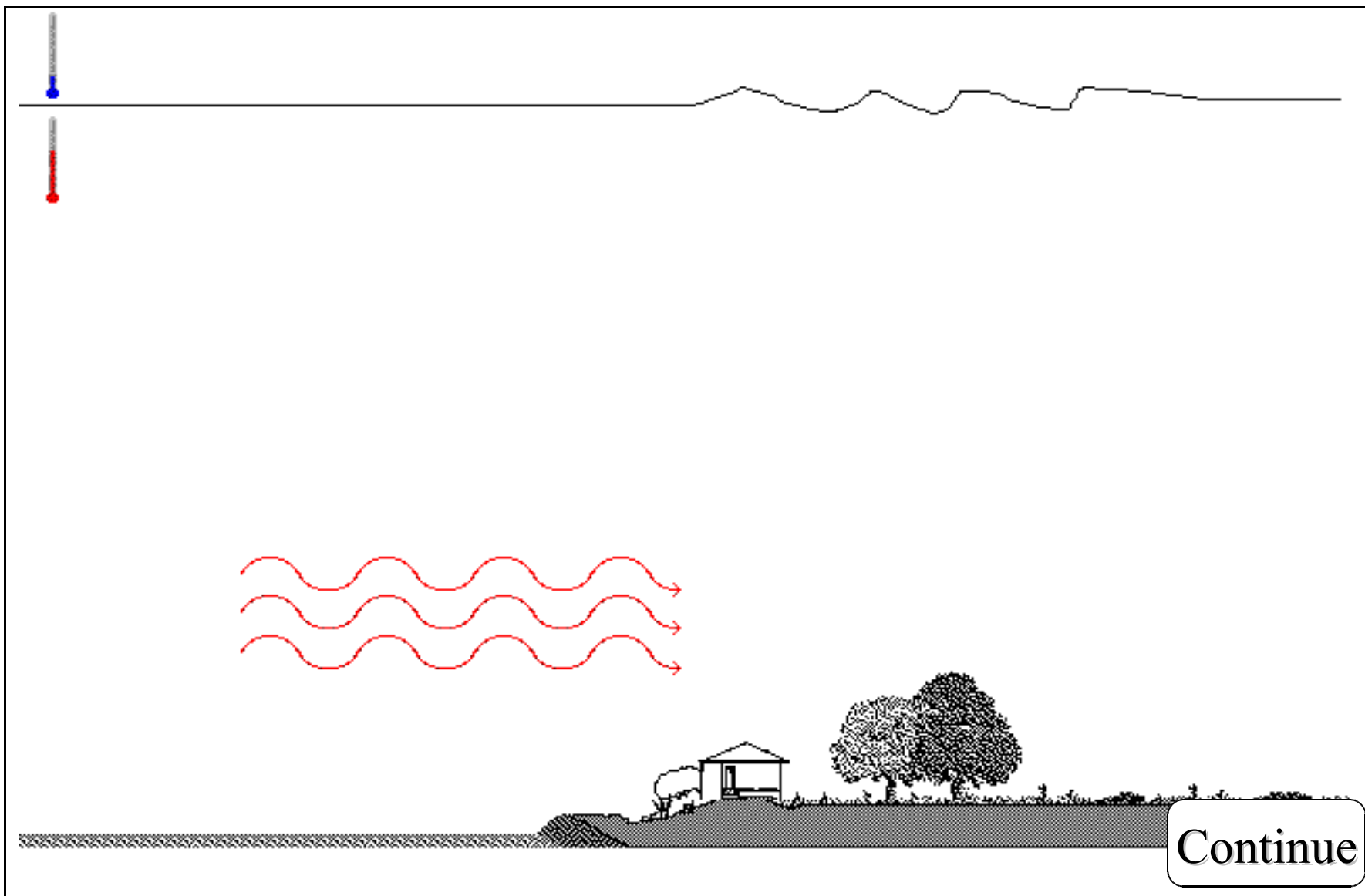
“As you watch you tilt your head skyward. Your cloud’s top extends above the freezing level, so the upper portion of your cloud is composed of tiny ice crystals.”

Non-Personalized Speech

“The cloud’s top extends above the freezing level, so the upper portion of the cloud is composed of tiny ice crystals.”

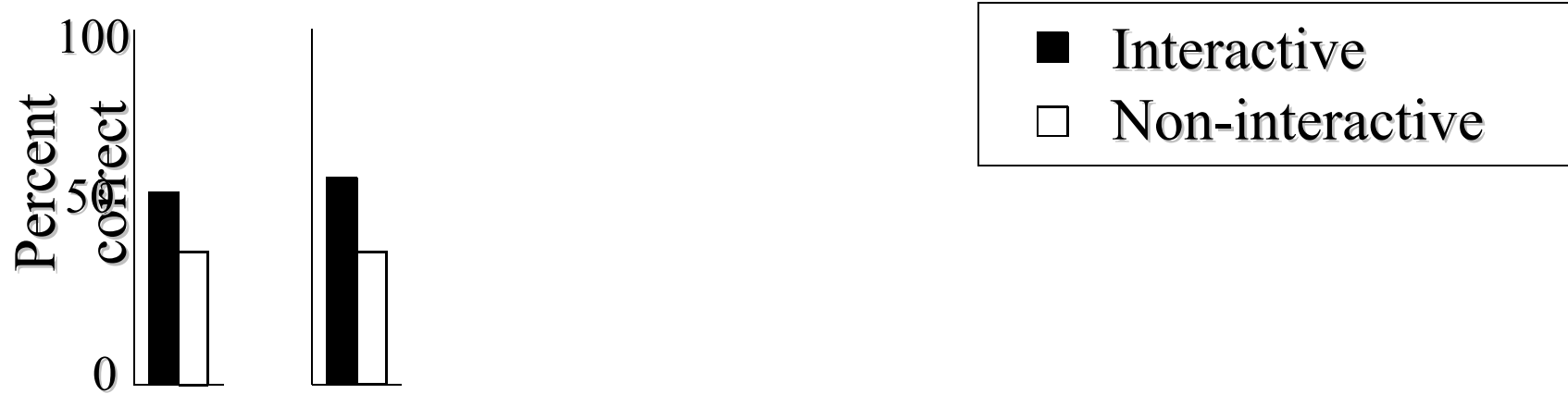
Personalization effect: People learn better when words are in conversational style rather than formal style.





“Cool moist air moves over a warmer surface and becomes heated.”

Interactivity effect: People learn better when they have control over the pace of presentation (dark bars) than when they do not (white bars).



Examples of Signaled and Non-Signaled Speech

Signaled Speech

Contains heading: “**Wing shape: Curved upper surface is longer.**”

Emphasizes key information, adds connectives: “The upper surface of the wing is curved more than the bottom surface. Because it’s curved, the surface on the **top** of the wing is **longer** than on the **bottom.**”

Non-Signaled Speech

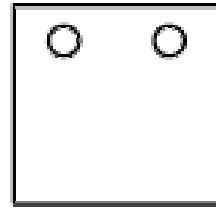
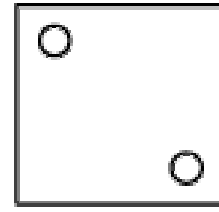
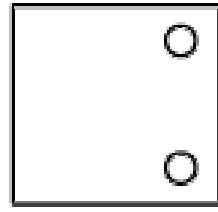
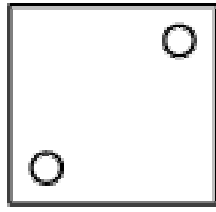
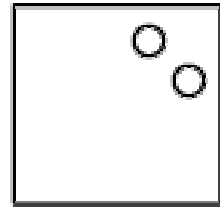
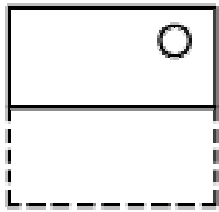
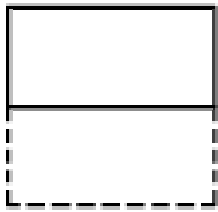
Does not contain heading.

Does not emphasize key information or add connectives: “The upper surface of the wing is curved more than the bottom surface. The surface on the top of the wing is longer than on the bottom.”

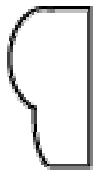
Signaling effect: People learn better when the words include cues about the organization of the presentation (dark bars) rather than no cues (white bars).



Paper Folding



Card Rotations



S□ D□

S□ D□

S□ D□

S□ D□

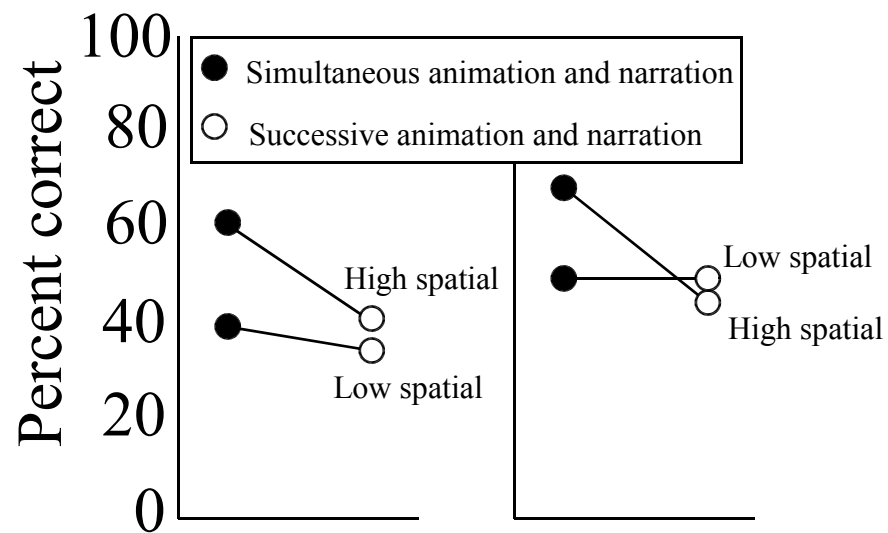
S□ D□

S□ D□

S□ D□

S□ D□

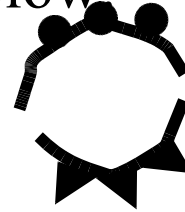
Individual differences effect: Strong effects for high spatial ability learners but not for low spatial ability learners.



Meteorology Questionnaire

Please place a check mark next to the items that apply to you:

- ☐ I regularly read the weather maps in a newspaper.
- ☐ I know what a cold front is.
- ☐ I can distinguish between cumulus and nimbus clouds.
- ☐ I know what low pressure is.
- ☐ I can explain what makes wind blow.
- ☐ I know what this symbol means:
- ☐ I know what this symbol means:



Please place a check mark indicating your knowledge of meteorology (weather):

- ☐ very much
- ☐ average
- ☐ very little

Car Mechanics Questionnaire

Please place a check mark next to the things you have done:

- ☐ I have a driver's license.
- ☐ I have put air into a car's tire.
- ☐ I have changed a tire on a car.
- ☐ I have changed the oil in a car.
- ☐ I have installed spark plugs in a car.
- ☐ I have replaced the brake shoes in a car.

Please place a check mark indicating your knowledge of car mechanics and repair:

- ☐ very much
- ☐
- ☐ average
- ☐
- ☐ very little
- ☐

Household Repair Questionnaire

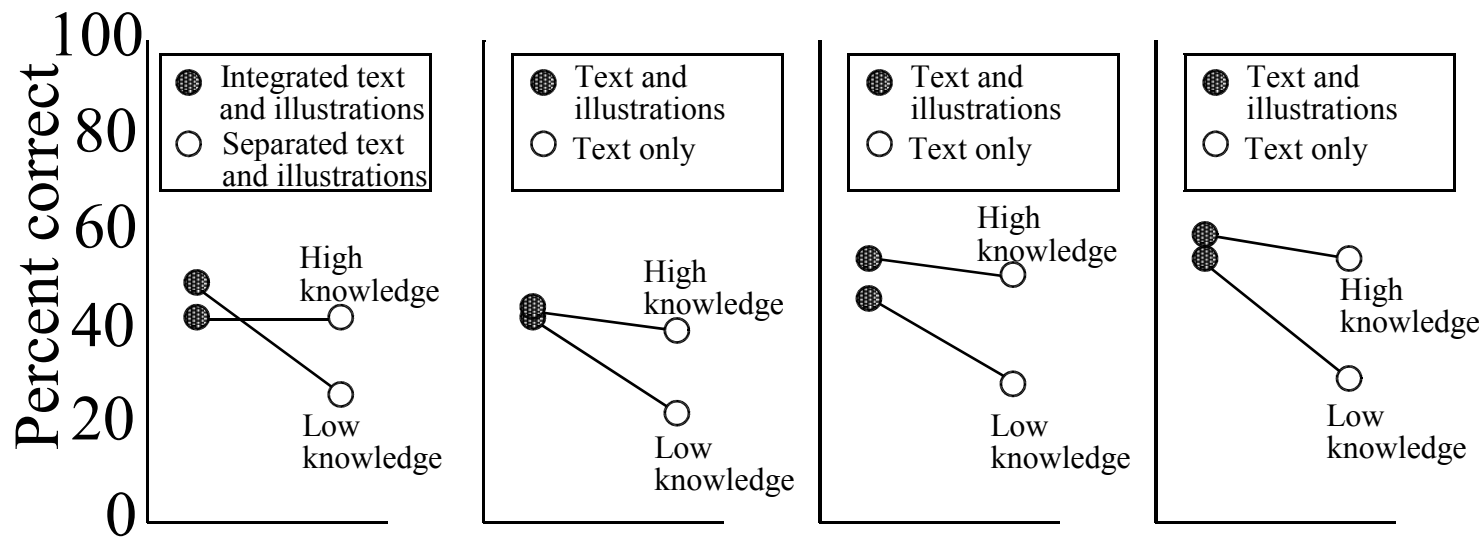
Please place a check mark next to the things you have done:

- ☐ I own a screw driver.
- ☐ I own a power saw.
- ☐ I have replaced the heads on a lawn sprinkler system.
- ☐ I have replaced the washer in a sink faucet.
- ☐ I have replaced the flush mechanism in a toilet.
- ☐ I have replaced installed plumbing pipes or fixtures.

Please place a check mark indicating your knowledge of how to fix household appliances and machines:

- ☐ very much
- ☐ average
- ☐ very little

Individual differences effect: Strong effects for low knowledge learners but not for high knowledge learners.



Research-Based Principles for the Design of Multimedia Messages

Multimedia principle: People learn better from words and pictures than from words alone. (9 of 9; ES = 1.50)

Spatial contiguity principle: People learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen. (5 of 5; ES = 1.12)

Temporal contiguity principle: People learn better when corresponding words and pictures are presented simultaneously rather than successively. (8 of 8; ES = 1.30)

Coherence principle: People learn better when extraneous words, pictures, and sounds are excluded rather than included. (10 of 11; ES = 1.17)

Modality principle: People learn better from animation and narration than from animation and on-screen text. (4 of 4; ES = 1.17)

Redundancy principle: People learn better from animation and narration than from animation, narration, and on on-screen text. (2 of 2; ES = 1.24)

Research-Based Principles for the Design of Multimedia Messages (Continued)

Personalization principle: People learn better when the words are in conversational style rather than formal style (5 of 5; ES = 1.55)

Interactivity principle: People learn better when they have control over the pace of the presentation. (2 of 2; ES = 1.36)

Signaling principle: People learn better when the words include cues about the organization of the presentation. (2 of 2; ES = 0.63)

Individual differences principle: Design effects are stronger for low-knowledge learners than for high-knowledge learners. (4 of 4, ES = 0.80) Design effects are stronger for high-spatial learners than for low-spatial learners. (2 of 2; ES = 1.13)

Conclusions About the Design of Multimedia Learning

- 1. Theory-based.* The design of multimedia messages should be based on a theory of how the human mind works.
- 2. Research-based.* The design of multimedia messages should be based on research findings.

Bottom line: People learn better when multimedia messages are designed in ways that are consistent with how the human mind works and with research-based principles.

Mayer, R. E. (2001). *Multimedia learning*.
New York: Cambridge University Press.

Clark, R. C., & Mayer, R. E. (2003). *E-learning and the science of instruction*. San Francisco: Jossey-Bass.

Mayer, R. E. (2003). *Learning and instruction*.
Upper Saddle River. NJ: Prentice Hall.