Natural Philosophy

Cycle 2: Earth and Sky

	THE HEAVENS	supplemental materials
Week 7	**Rotation of Earth**	globe & flashlight
	sunrises, sunsets, earth around Sun, the ecliptic	
Week 8	**Distances in the Universe**	Created Cosmos DVD, by Jason Lisle
Week 9	**The Solar System to Scale**	Solar System tour
Week 10	**Solar System Tour**	Images of each planet
Week 11	**Constellations**	Constellation map
Week 12	**The Galaxy & Universe**	Images of Deep-Sky Objects
	Light travel time with Dr. Russ Humphreys	

Bonus Astronomy Night! telescope, binoculars

	THE EARTH	supplemental materials
Week 19	**Air & Fire**	candles & jars
Week 20	**More About Air**	rubber band helicopters
Week 21	**Displacement**	floating demonstration
Week 22	**Three States of Matter**	hot plate, freezer, candle
Week 23	**Water: Imbibition**	flowers, sugar cubes, paper
Week 24	**Water & Earth: Water Cycle & Erosion**	dirt, erosion demo (Van Cleave's *Gooey...* #137)

Natural Philosophy

Rotation of the Earth

Cycle 2, Week 7

Supplies/Set-Up

1. Globe
2. *Strong* flashlight

Introductory

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Natural Philosophy

Lesson

1. The Lord's Name is praised from the rising of the sun, unto the going down of the same. Psalm 113:3
    a. What does the motion of the Sun and Earth look like, from our perspective here on earth?
    b. How does God bring that to pass? That's what we're going to learn about today!

2. Show globe.
    a. This is what our world looks like
    b. Show where we are, in North Texas; point out how tiny we are! Or, rather, how huge our world is!
        i. Did you know? If all of the people in the entire world lived as densely as the people of New York City do, we would all fit inside the state of Texas, and have the whole world left over for farmland, energy production, etc. The world is *huge!!!*

3. Introduce the earth's rotation.
    a. God made the earth so that it is spinning.
    b. Turn the globe slowly (in the right direction, toward the East!)
    c. God made it so that the Sun is, compared to the Earth, sitting in one spot, but the Earth spins around, so that when the place where we live is toward the Sun, we have daylight, and when we are on the far side of the Earth from the Sun, we have darkness, nighttime.
    d. Have someone shine the flashlight on the earth, and then spin the earth slowly for the children to see. (Have someone turn off the lights.)
    e. (This is a little sneaky, for what we're going to do next, but you should be standing at the front of the classroom; so tell the flashlight holder to stand near the center of your open area… When you imitate the earth's orbit later, walking in a big circle around the flashlight holder, the children will understand better if the "Sun" was in the middle of your demonstration to begin with, and stays in the same spot.)
    f. Obviously, explain to the children how we're using the flashlight to show how the Sun is shining on the Earth (even though it really shines in all directions).
    g. Pinpoint where we live, then keep slowly spinning. When you get to sunrise, sunset, daytime, and nighttime (from the flashlight), pause the spinning to point that out to the children.
    h. The line that separates day and night is called the *terminator*.

4. Notice the earth's tilt.
    a. God made the Earth so that it spins on a tilt of about 23.5%.
    b. This tilt gives us our seasons!

5. Demonstrate the annual orbit of the Earth around the Sun.
    a. Have the children move out of the way, so you can walk in a big circle, to demonstrate the orbit of the Earth going around the Sun.
       Note: For this to work, you *must* do two things:
        i. Keep the base of the globe parallel to the floor, so your tilt will be just right!
        ii. Don't spin the base of the globe as you walk, but make sure it stays oriented the same way, no matter where you walk. So if there's a little mark on it, point that toward the front of the room, and make sure you keep that little mark on the base pointed toward the front of the room no matter where you walk in your "orbit".
    b. The flashlight helper should shine the flashlight straight onto the globe, wherever you go, and you should walk in a slow circle around the flashlight, so the children can see how the Earth orbits the Sun.
    c. Second time around: Point out the summer and winter solstices, and the spring and fall equinoxes.
    d. Third time around: Point out the place where we live, and when you arrive at the solstices and equinoxes, pause again, and this time show how the place where we live sees sunrises, sunsets, and the path of the Sun throughout the day, at these different times of year.

6. Homework: Watch the Sun's movement at your house every day this week.

Natural Philosophy

Distances in the Universe

Cycle 2, Week 8

(This is the only video lesson in all four cycles; it's wonderful!)

Supplies/Set-Up

1. DVD player & TV (or laptop with DVD player)
2. *Created Cosmos* DVD, by Dr. Jason Lisle (planetarium show from Creation Museum)

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Lesson: Play DVD

Natural Philosophy

The Solar System to Scale

Cycle 2, Week 9

Supplies/Set-Up

1. Not-to-scale images of solar system (3)
2. Measuring Tape
3. Poppyseeds (9)
4. Sticky Page Markers, labeled as the Sun and the eight planets (9)
5. 16 feet of wall space (hallway, perhaps)
6. Set-Up: Use a dot of glue to glue a single poppyseed onto each page marker, and label each page marker for the Sun and each of the eight planets.

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Natural Philosophy

Lesson

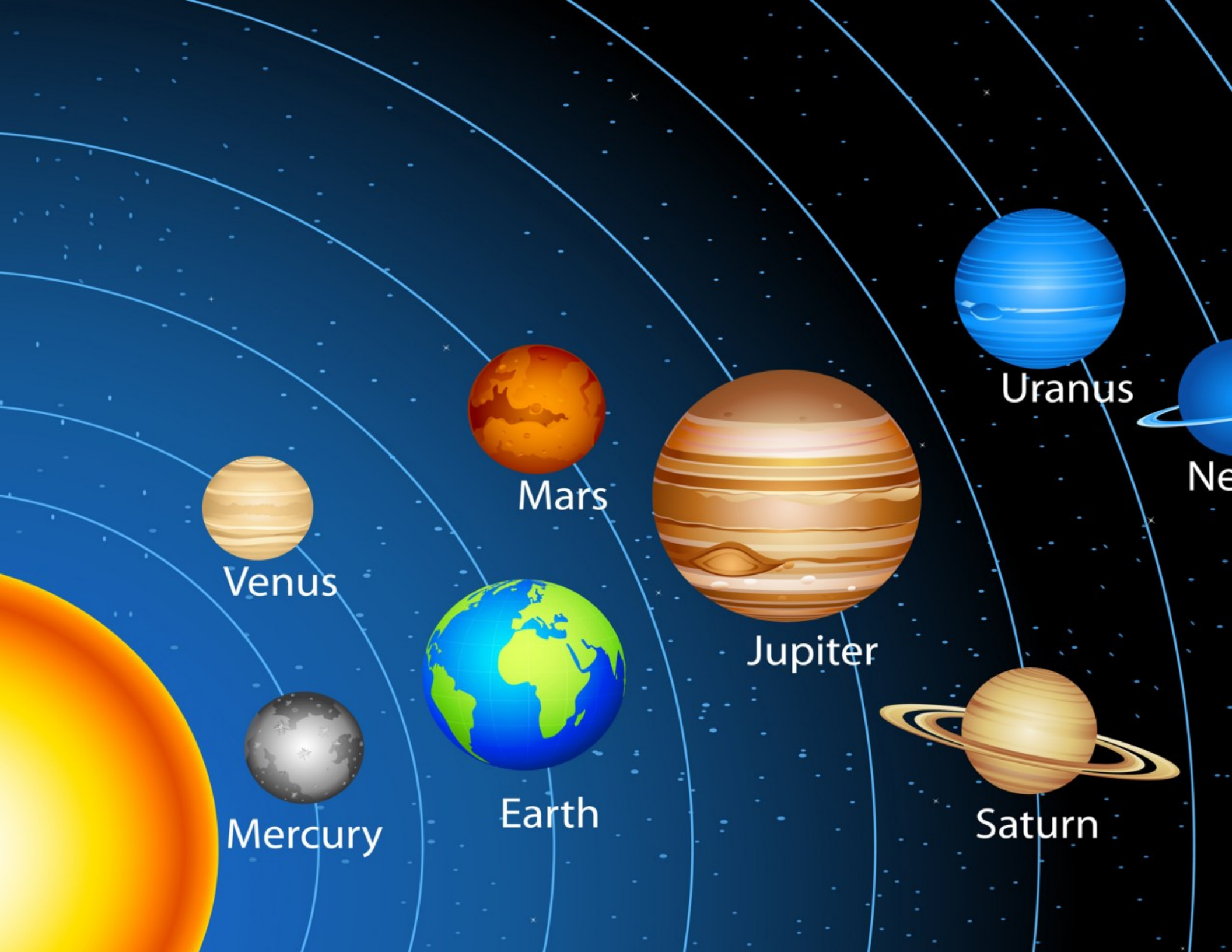
1. The heavens declare the glory of God, and the firmament showeth the work of his hands. Psalm 19:1

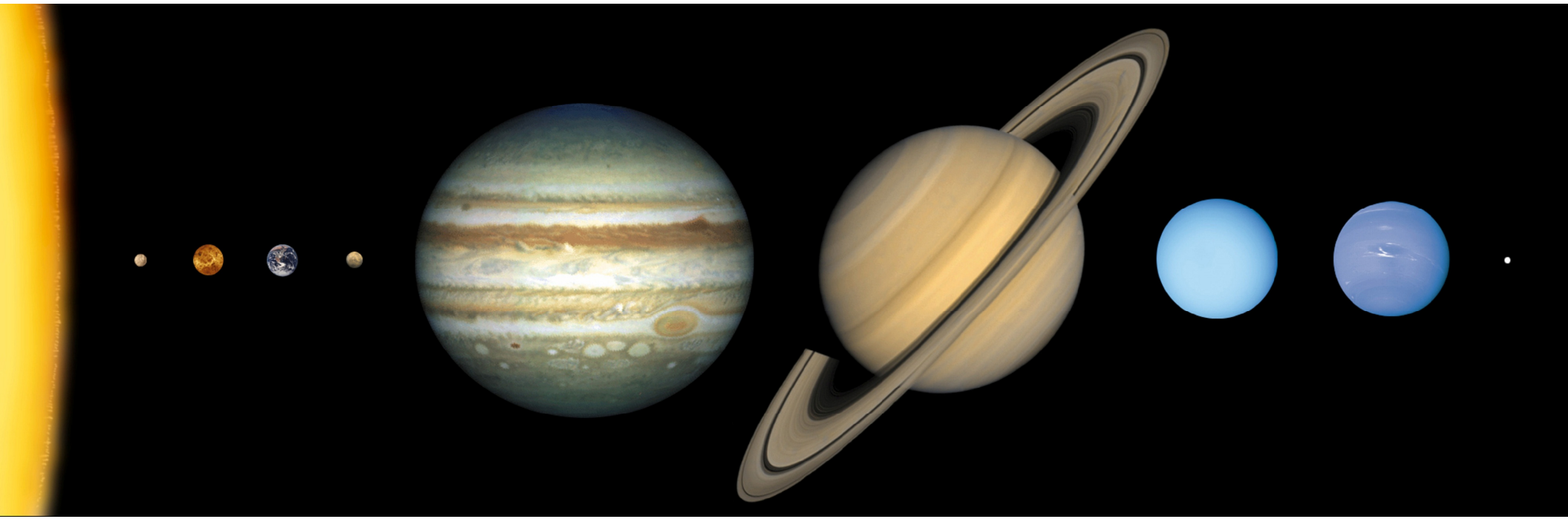
2. Show Not-to-Scale-At-All image of solar system.
    a. This is the kind of image you usually see, of the planets of our solar system.
    b. Because the people who made it want you to see the special features of each planet!
    c. But the sizes of the planets, and the distances between the planets, are all wrong!

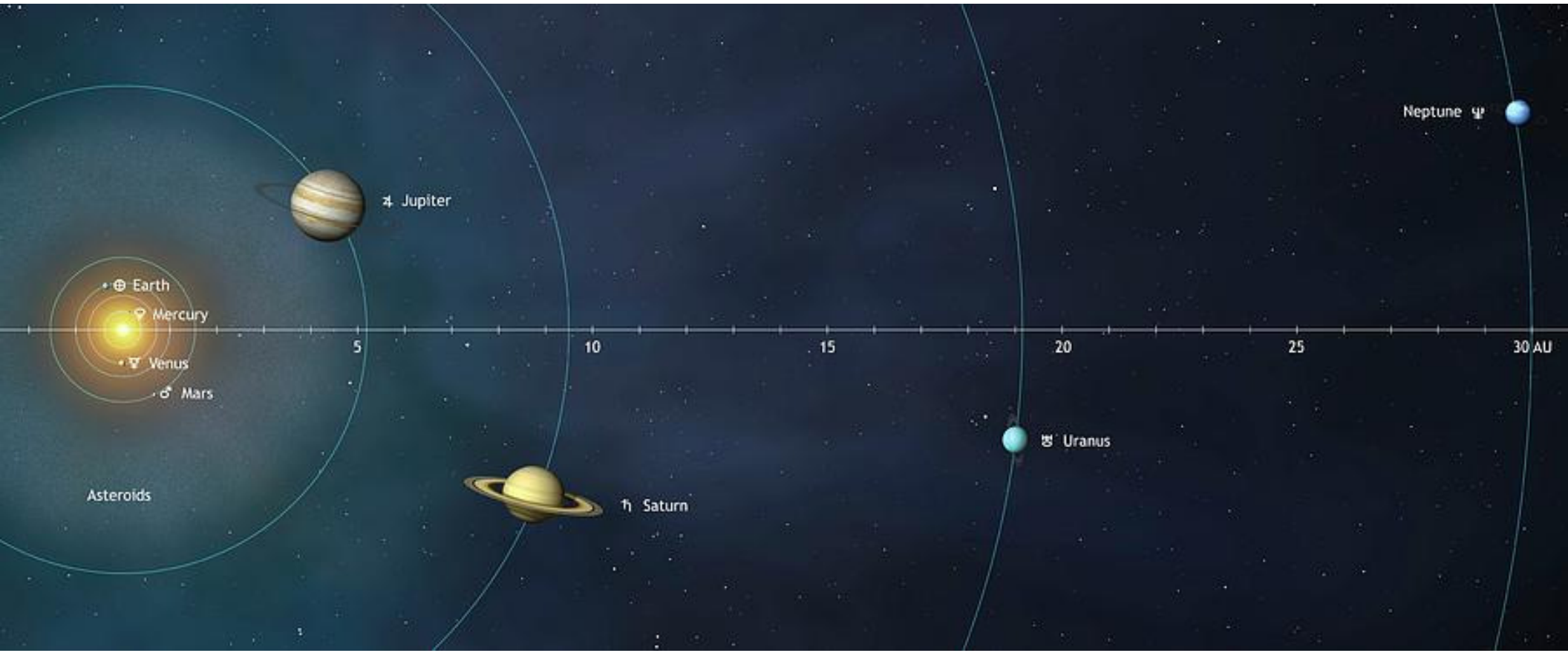
3. Show Not-to-Scale-Distance image of solar system.
    a. This image shows the sizes of the planets, compared to each other.
    b. Notice that the Sun is so huge, it doesn't even fit on the page! If you took the entire mass of everything in our solar system—the Sun, planets, moons, asteroids, comets, etc.—the Sun all by itself is 99.8% of the mass of the entire solar system!
    c. Next shocker: Jupiter contains more than half of the remaining mass of the solar system… So if you combined Saturn, the Earth, and everything else in the solar system, and weighed it against Jupiter, Jupiter would be more than everything else combined!
    d. But this image, another sort of image you might be familiar with of our solar system, is completely inaccurate about distance.
    e. Also, the planets can *never* be lined up in one line.

4. Show Not-to-Scale-Planet-Size image of solar system.
    a. This image shows how far apart the Sun and planets are from each other, to scale.
    b. But there are several inaccuracies about this image, too!
    c. The planet sizes are way too big! If the planet sizes were accurate on this picture, they would be too small for you to see!!
    d. The planets are mostly all in the same direction (not lined up completely, but pretty close to it).
        i. In reality, the orbits of the planets are almost circular… but to fit those entire orbits on the page, everything would have to be even smaller, and it would be much harder for you to see these relative distances.
        ii. (Notice how hard it is to see how far apart the four inner planets are, because it's all so little.)
        iii. Consider how far apart Uranus, Saturn, and Jupiter would be, when they are in opposite sides of their orbits!

5. Hallway Display
    a. First, measure out your 16 feet of hallway space, so the children can get a sense of the scale we're working with, here.
    b. Explain to the children that, even with this much space, we still can't make a solar system model to scale!!
        i. At this scale, if these sixteen feet were the distance between the Sun and Neptune, the Sun would be the size of a poppyseed. (Show them the Sun poppyseed glued onto the sticky marker.)
        ii. Stick the Sun poppyseed/marker on the wall, at your beginning point.
        iii. Teach: All of the planets, even Jupiter, would be so small at this scale that you could not see them! We'll use poppyseeds for all of the planets, because that's the smallest thing we can practically use for this demonstration, but understand that this is *not* to scale; these planets, at this scale, would be *much, much smaller* than the poppyseeds we're using to show them.
    c. From here, measure out the correct scale distances for each planet, and place the correct poppyseed/marker at the correct spot on the wall:
        i. Sun (beginning)
        ii. Mercury—2 ½ in.
        iii. Venus—4 ¾ in.
        iv. Earth—6 ½ in.
        v. Mars—9 ¾ in.
        vi. Jupiter—33 ¼ in.
        vii. Saturn—61 ¼ in.
        viii. Uranus—122 ¾ in.
        ix. Nepture—192 in. (16 ft.)
    d. Once again, remember that the planets are never lined up in a straight line!! So not only are the planets much smaller than this, but the whole model should go up 16 feet, and down 16 feet, and back the other way 16 feet, and the planets all circle around the Sun all around like this.
    e. Finally, Pluto and the other dwarf worlds beyond Neptune circle the Sun in a different plane from the plane of the larger planets' orbits.


Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Ne




Neptune ♆
Jupiter ♃
Earth ♁
Mercury ☿
Venus ♀
Mars ♂
5
10
15
20
25
30 AU
Uranus ♅
Asteroids
Saturn ♄

	Actual Diameter (km)	Scale Diameter (in)	Actual Distance from Sun (km)	Scale Distance from Sun (in)	Scale Distance from Sun (ft)
Sun	1,391,400	0.0594311139			
Mercury	4,879	0.0002083976	57,900,000	2.4730929234	0.2060910770
Venus	12,104	0.0005170003	108,200,000	4.6215657049	0.3851304754
Earth	12,756	0.0005448493	149,600,000	6.3898912149	0.5324909346
Mars	6,792	0.0002901079	227,900,000	9.7343329403	0.8111944117
Jupiter	142,984	0.0061073008	778,600,000	33.2564792774	2.7713732731
Saturn	120,536	0.0051484755	1,433,500,000	61.2293386132	5.1024448844
Uranus	51,118	0.0021834122	2,872,500,000	122.6935996974	10.2244666415
Neptune	49,528	0.0021154982	4,495,100,000	192.0000000000	16.0000000000

figure to make everything fit in 16': 0.0000000427

Natural Philosophy

Solar System Tour

Cycle 2, Week 10

Supplies/Set-Up

1. Images of Each Planet (digital files: Solar System Tour)
2. Laptop (for displaying images)
3. Optional: TV & cable to connect laptop, for bigger display
4. Other Option: print images and display them that way

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Natural Philosophy

Lesson

1. The heavens declare the glory of God, and the firmament showeth the work of his hands. Psalm 19:1

2. Explain about the ecliptic.

3. Mercury

4. Venus

5. Earth

6. Mars

7. Asteroid Belt

8. Jupiter

9. Saturn

10. Uranus

11. Neptune

12. Pluto, Eris, & the Dwarf Planets

13. Comets

Natural Philosophy

Constellations

Cycle 2, Week 11

Supplies/Set-Up

1. Book: *Stargazer's Guide to the Night Sky*, by Dr. Jason Lisle
2. Planisphere
3. Email scanned copy of p. 50 to mothers
4. Optional: use home planetarium in darkened room
5. Optional: also plan Astronomy Night

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Lesson

1. He maketh the stars Arcturus, Orion, and Pleiades, and the climates of the South. Job 9:9
    - Canst thou restrain the sweet influences of the Pleiades, or loose the bands of Orion? Job 38:31

2. Turn to chapter 4, "Astronomy with the Unaided Eye"; read pages 48–49.

3. Point out:

    (As you point out these constellations, teach how to find it in the sky, what to look for; and also teach about special stars like Betelgeuse, Regulus, Polaris.)

    - Ecliptic
    - Orion
    - Ursa Major & Big Dipper
    - Ursa Minor
    - Draco (time permitting)
    - Cassiopeia (time permitting)
    - Leo

4. Show Planisphere, and explain how to use it.



4.1 The winter sky with labeled constellations: mid-January around 9:00 p.m. standard time. This map is for observers at north latitude 40°. Observers at latitudes farther north will see these stars shifted southward; observers farther south will see these stars shifted farther northward.

Natural Philosophy

The Galaxy & Universe

Cycle 2, Week 12

Supplies/Set-Up

1. Images of… (digital files: Galaxies)
    a. Milky Way Galaxy (generic spiral galaxy)
    b. Milky Way as seen from Earth
    c. Milky Way with arrow showing where we are
    d. Artist's rendering of black hole at center of our galaxy
    e. Globular star cluster
    f. Nebulae
    g. Binary/Ternary star system
    h. Quasar
    i. Other Galaxies
    j. The pattern of galaxies in the universe
2. Laptop (for displaying images)
3. Optional: TV & cable to connect laptop, for bigger display
4. Other Option: print images and display them that way
5. Completely different option: Watch the episode of Origins (show) called *Starlight and Time*, with Russell Humphries. (You can find it on youtube.)

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Lesson

1. He sitteth upon the circle of the earth, and the inhabitants thereof are as grasshoppers, he stretcheth out the heavens as a curtain, and spreadeth them out, as a tent to dwell in. Isaiah 40:22

2. Go through images and tell about these wonderful things in space ☺

3. Address the light travel time problem

Natural Philosophy

Air & Fire

Cycle 2, Week 19

Supplies/Set-Up

1. 3 Jars, different sizes
2. Plate or dish
3. Candle (tea light is good)
4. Lighter/match
5. Water
6. Stopwatch/watch with a second hand.

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3. Afterward God said, Let the waters bring forth in abundance every creeping thing that hath life: and let the fowl fly upon the earth in the open firmament of the heaven. **Genesis 1:20**

   Think about **air**: If air's nothing, then what are birds flying on?

Natural Philosophy

Does a fish know it's wet?

Does a fish know it's wet? (Discuss.)

You are likewise living and moving inside of an "ocean" of air! (Discuss.) Things to note:

1. You can feel it
   a. breathe in
   b. beathe out
   c. fan your neighbor

2. It's putting *lots* of pressure on everything right now! But it's just the right amount of pressure for you to live, so it doesn't feel bad!! On the other hand, if there were no air pressure on you at all, your blood would go from liquid to gas, and you would die from that. That's why when astronauts go into space, they don't just use oxygen tanks to breathe, but their whole bodies have to be protected in spacesuits!

1st Demonstration

1. Light candle.
2. Place one of the jars over it, upside down.
3. What happens?
4. Explain: Fire needs oxygen to burn. Our air is about 21% oxygen, 78% nitrogen, a tiny bit argon, carbon dioxide, and other gases. When a fire burns, it's using oxygen; but when the fire uses up all of the oxygen, it's like when your car runs out of gas; the fire dies.

2nd Demonstration

1. Light candle, place the littlest jar over it, and time how long it takes for the flame to go out.
2. Light candle, place the middlest jar over it, and time how long it takes for the flame to go out.
3. Light candle, place the biggest jar over it, and time how long it takes for the flame to go out.
4. What happens?
5. Explain: Even though you can't see it, air takes up space, just like water, and rocks, and puppy dogs, and everything else that you can see. Air is *stuff*, it's just invisible stuff! The same little flame uses the same amount of oxygen for fuel while it's burning; there's less oxygen in a smaller space, and more oxygen in a bigger space, so that's why the flame could burn for longer inside the biggest jar.

3rd Demonstration

1. Place the candle in the middle of the plate/dish.
2. Pour a bit of standing water in the plate/dish (but not enough to overflow the candle!).
3. Light the candle again, and place one of the jars over it (choose the narrowest one you have).
4. As the candle burns, water is sucked up into the jar.
5. Explain: Remember that 21% of the air inside of the jar is oxygen, and the flame burned up all of the oxygen. This shows how strong the air pressure all around us is! The air all around us is pushing down on us all of the time. The air around the jar was pushing down on the water all along, but before the flame ate up the oxygen, the air inside of the jar was also pushing down on the water, keeping the water down where it belonged. When that oxygen was taken out of the jar, the air pressure outside of the jar *pushed down on the water outside of the jar, pushing some of the water up on the inside of the jar.*
6. Do the demonstration more than once, to help the children think about what's happening.

Natural Philosophy

More About Air

Cycle 2, Week 20

Supplies/Set-Up

1. Rubber Band Helicopter project kits (for each student & tutor), or get separately:
    a. Propellers
    b. Card stock
    c. Craft sticks
    d. Masking tape
    e. 3.5" rubber bands (note: 2 rubber bands per helicopter)
    f. Rubber band hooks (or paperclips)
    g. (make sure you have scissors for each, too)
    h. Instructions
    i. Template (if desired)
2. Alternatively: Use Dr. Marcus Ross'/funpaperairplanes' materials.

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1. NATURAL, adjective [to be born or produced.] Pertaining to nature; produced or effected by nature, or by the laws of growth, formation or motion impressed on bodies or beings by divine power. Thus we speak of the natural growth of animals or plants; the natural motion of a gravitating body; natural strength or disposition; the natural heat of the body; natural color; natural beauty. In this sense, natural is opposed to artificial or acquired. (Noah Webster's 1828)

2. PHILOS'OPHY, noun [Latin philosophia; Gr. love, to love, and wisdom.]

    a. Literally, the love of wisdom. But in modern acceptation, philosophy is a general term denoting an explanation of the reasons of things; or an investigation of the causes of all phenomena both of mind and of matter. When applied to any particular department of knowledge, it denotes the collection of general laws or principles under which all the subordinate phenomena or facts relating to that subject, are comprehended. Thus, that branch of philosophy which treats of God, etc. is called theology; that which treats of nature, is called physics or natural philosophy; that which treats of man is called logic and ethics, or moral philosophy; that which treats of the mind is called intellectual or mental philosophy or metaphysics.

    The objects of philosophy are to ascertain facts or truth, and the causes of things or their phenomena; to enlarge our views of God and his works, and to render our knowledge of both practically useful and subservient to human happiness.

    True religion and true philosophy must ultimately arrive at the same principle.

3. Afterward God said, Let the waters bring forth in abundance every creeping thing that hath life: and let the fowl fly upon the earth in the open firmament of the heaven. **Genesis 1:20**

   Think about **air**: If air's nothing, then what are birds flying on?

Review: Just like the question*, Does a fish know it's wet?*, you are living and moving inside of an "ocean" of air! (Discuss.)

1. You can feel it:
   a. You breathe it.
   b. You feel the wind blow.
   c. You can feel it when you wave your arms around (if you're wearing short sleeves!)

2. It's putting *lots* of pressure on everything right now! But everything on the surface of the earth is designed to function perfectly under 1 Atmosphere (1,013 millibars) of pressure.
   a. Remember last week, how when we removed a little bit of the air from inside of a jar, that the pressure of the air around us was so strong that it pushed water up, *against gravity!!*

Lesson

1. Today, we're going to think about how much air is above the land and sea on the earth, by—instead of thinking about how heavy it is and how much it's pushing down on us—thinking about seeing if it's strong enough hold things up!

2. How Lift works (see diagram, next page):
   a. Draw a side view of a wing on the whiteboard.
   b. Do you know who learned how to create airplanes? (The Wright Brothers.)
   c. How did men discover the secret of Flight? (By studying the flying creatures God had designed to fly, and copying their design! Airplane wings are shaped the exact same way that bird wings are, with the exact same shape.)
   d. Explain how Lift works (again, see diagram).
   e. What happens when you have an area with lower air pressure next to an area with higher air pressure? Just like how the air pressure last week forced the water up into the jar (even against the force of gravity!), air will always flow from a higher density (pressure) to a lower density (pressure). *And if there's an airplane, with big old wings in the way to ride on top of the high air pressure heading upwards, that airplane will be* ***lifted*** *up.*
   f. Review: So there are 2 things wings do that allow for flight:
      i. They create low air pressure above the wings with their front edge.

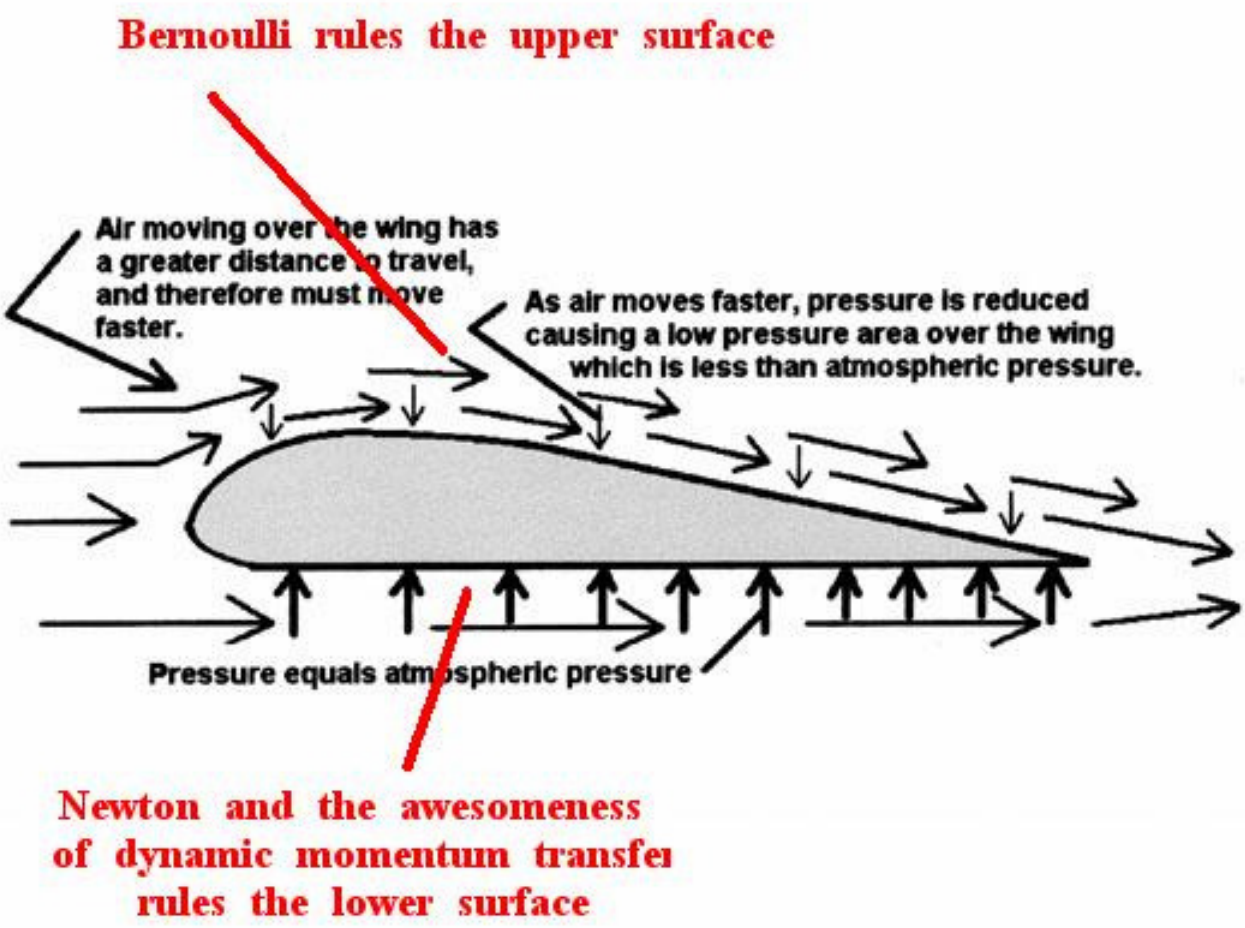
ii. The rest of their shape is a big flat surface that will catch the high air pressure below the wing and ride on top of it, as that high air pressure rises up.

Rubber Band Helicopters

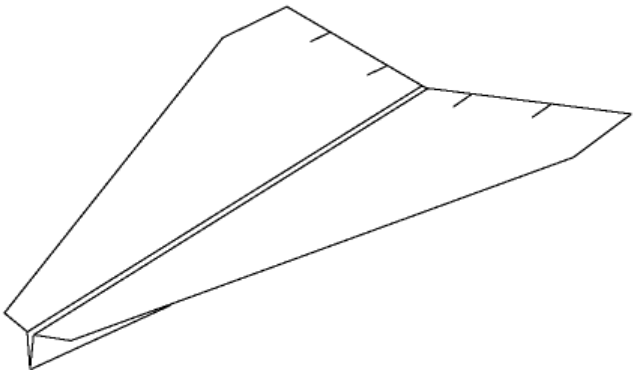
1. Follow instructions for each child to make his own rubber band helicopter.

2. Examine the propellors' motion; first, what makes them spin? (The rubber bands' being stretched.)

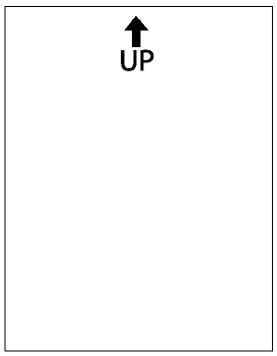
3. Examine the propellors' motion some more; what makes the helicopter lift? (The propellors are creating an area of high air pressure below the prop, and low air pressure above the prop, just like an airplane wing would do.)



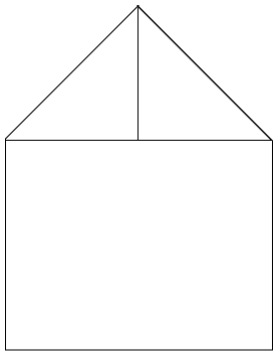
Arrow



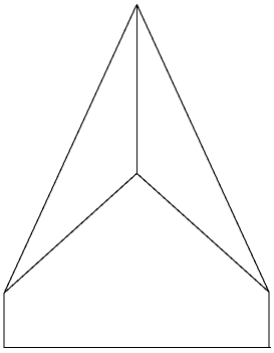
This plane is easy to fold and flies straight and smooth. Add a small amount of up elevator for long level flights.



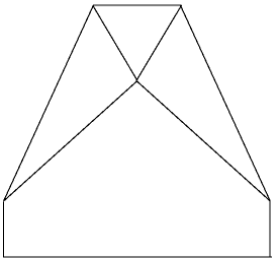
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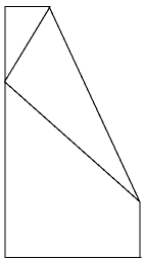
Pull the top right corner down toward you until fold line 1 is visible and crease along the dotted line. Repeat with the top left corner.



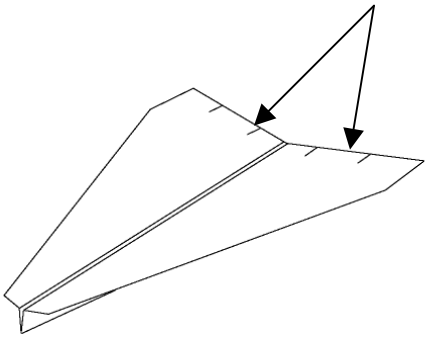
Fold the right side over again and crease along fold line 2. Repeat with the left side.



Fold the tip down toward you and crease along fold line 3.

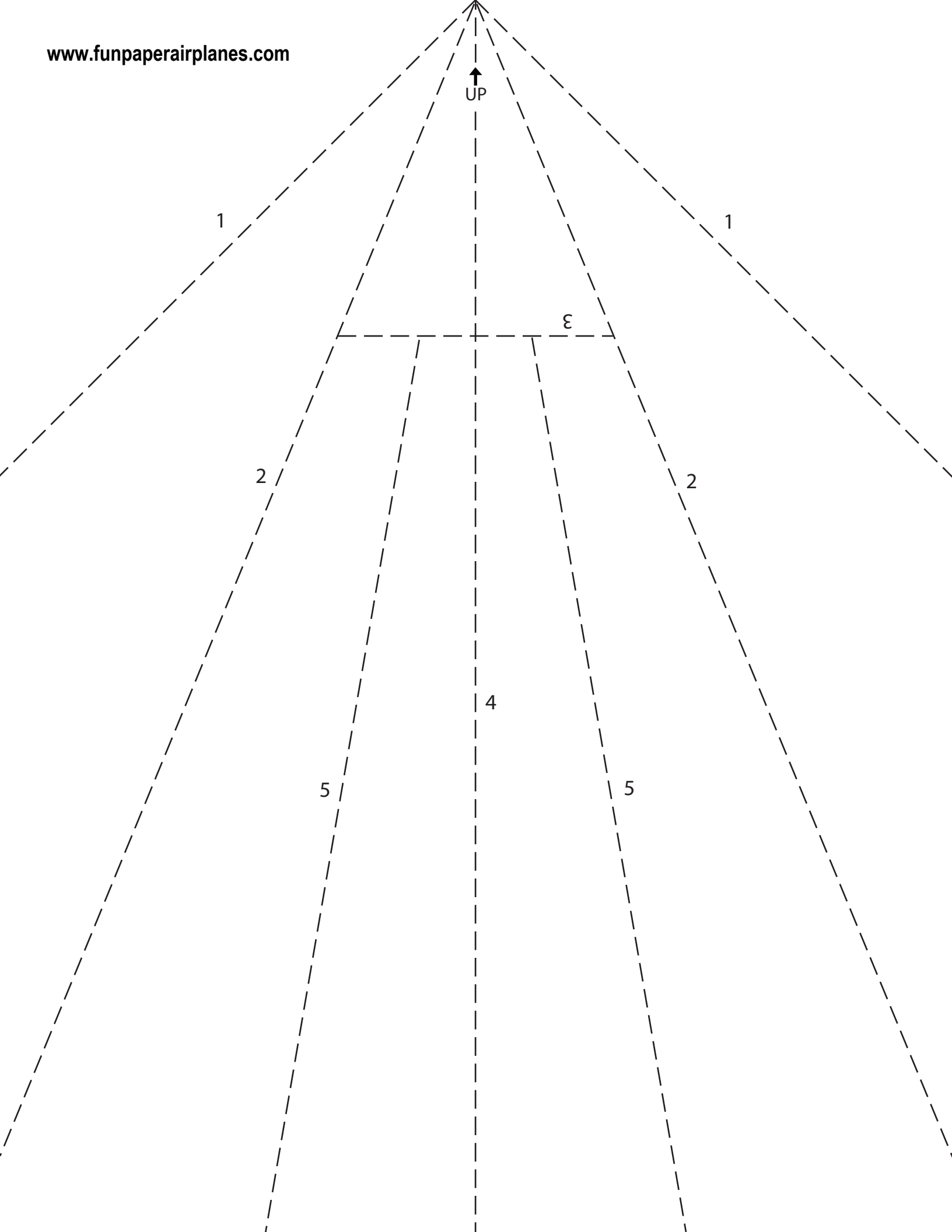


Now, flip the paper over. Then, fold the left side over onto the right side and crease along fold line 4 so that the outside edges of the wings line up.

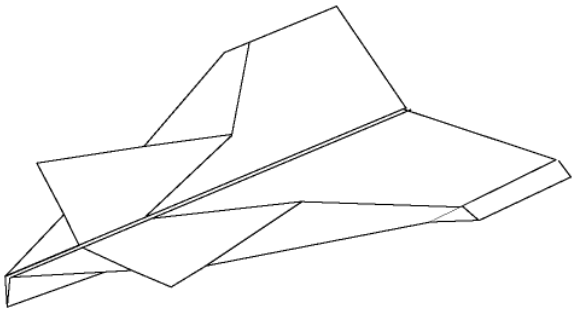


Fold the wings down along fold lines 5. Partially open the folds you just created so that the wings stick out straight. Cut two slits, one inch apart, along the back edge of each wing for elevator adjustments. Add wing dihedral by tilting the wings up slightly away from the fuselage. The wings will have a slight "V" shape when viewed from the front. Read the Introduction for more information about dihedral. Now you are ready to fly!

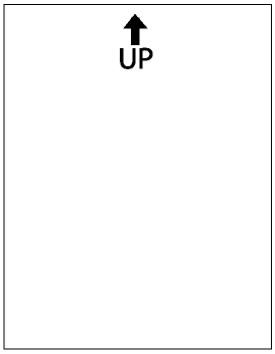
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Canard



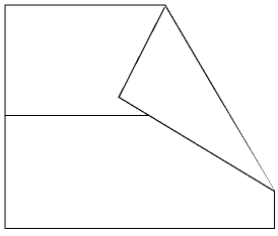
This unique plane has small wings at the front called “canards.” This design is surprisingly stable and will float long and straight if folded carefully.



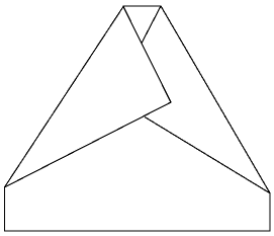
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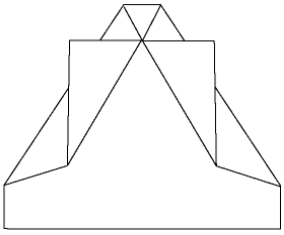
Fold the top edge of the paper down toward you until fold line 1 becomes visible. Make a crease along the dotted line.



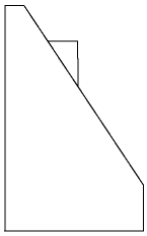
Fold the top right corner down and toward you and make a crease along fold line 2. Be aware that you will not be able to see the fold line after making this fold.



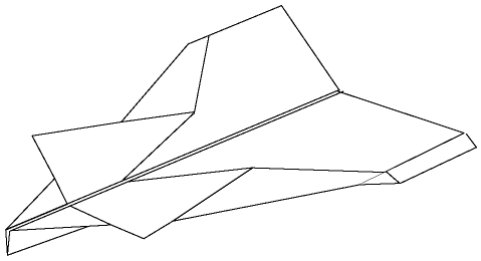
Fold the top left corner down and toward you and make a crease along fold line 3.



Fold the corners of the flaps you just folded up along fold lines 4.



Fold the left half of the plane over onto the right half along fold line 5 so that the outside edges of the wings line up.



Fold the wings down along fold lines 6 and winglets down along fold lines 7. Add wing dihedral by tilting the wings up slightly away from the fuselage. The wings will have a slight "V" shape when viewed from the front. You are ready to fly!

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UP

2

3

1

4

4

5

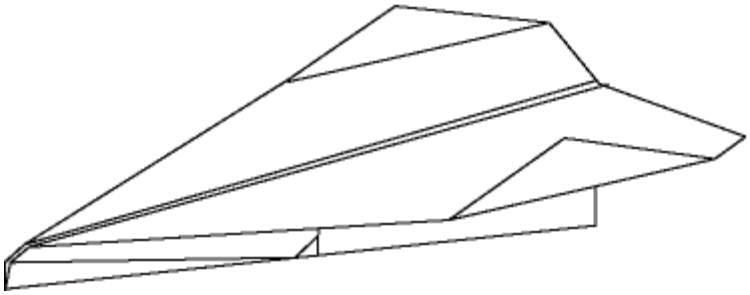
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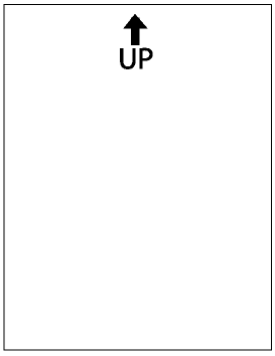
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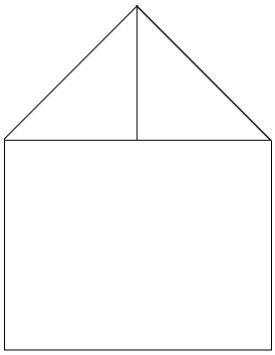
Classic Dart



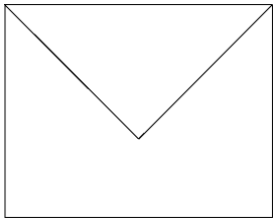
This plane is the classic schoolyard dart. It has short, compact wings and will fly straight as an arrow. It generally needs some up elevator along the back wing edges to fly properly.



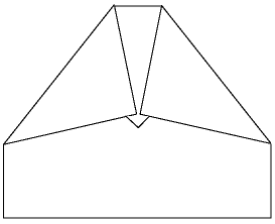
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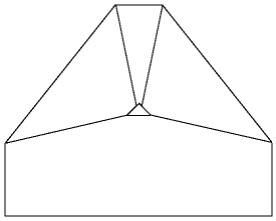
Pull the top right corner down toward you until fold line 1 is visible and crease along the dotted line. Repeat with the top left corner.



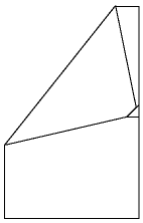
Fold the top point down toward you until fold line 2 is visible and crease along the dotted line.



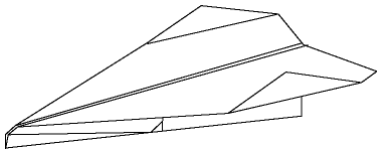
Fold the top left and top right corners down and toward you and crease along fold lines 3.



Fold the tip up and over the two diagonal folds along fold line 4 to secure them in place.



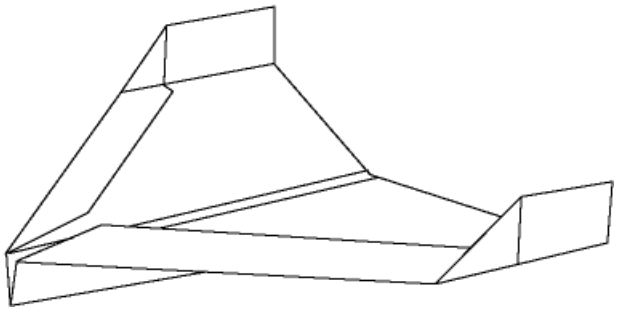
Flip the plane over and fold the right side over onto the left side as shown along fold line 5 so that the outside edges of the wings line up. Also make sure the diagonal folds do not become untucked from the tip you folded up in the previous step.



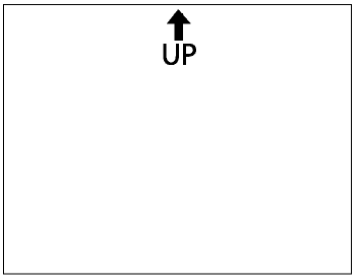
Fold the wings down along fold lines 6 and the winglets up along fold lines 7. Add wing dihedral by tilting the wings up slightly away from the fuselage. The wings will have a slight "V" shape when viewed from the front. Cut two slits, one inch apart, along the back edge of each wing to make elevator adjustments. Start out by trying some up-elevator. You are ready to fly!

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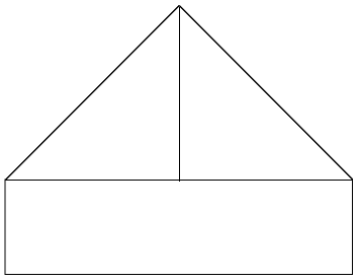
Condor



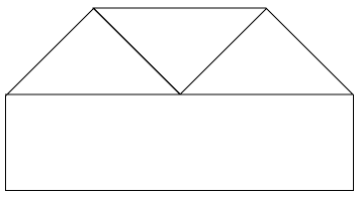
This plane produces tremendous lift at low speed, giving it a very low glide slope. It is an excellent indoor flier and will coast across the room on slow, smooth glides.



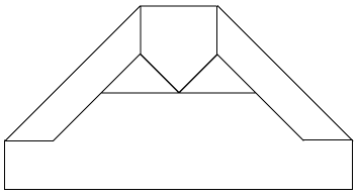
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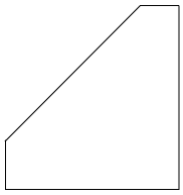
Fold the top left corner down toward you until fold line 1 becomes visible. Crease along the dotted line and repeat with the top right corner.



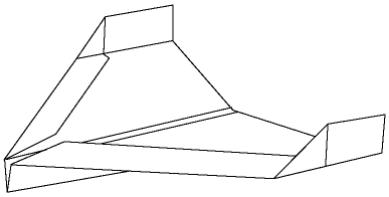
Fold the nose down until fold line 2 becomes visible and crease along the dotted line.



Fold the outside wing edges in and crease along fold lines 3.



Fold the right half of the plane over the left half and crease along fold line 4 so that the outside edges of the wings line up.



Fold the wings down along fold lines 5 and the winglets up along fold lines 6. Add wing dihedral by tilting the wings up slightly away from the fuselage. The wings will have a slight "V" shape when viewed from the front. Add elevator slits along the back edge of the wings to adjust the flight if necessary. You are ready to fly!

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Cycle 2, Week 19 – Paper Airplanes

Using paper airplanes, students will learn about the four forces most important to flight—lift, thrust, drag, and gravity. Different paper airplane designs address these forces in different ways, making airplanes that are fast or slow, fly long or short distances, and fly straight or in circles.

What You Will Need:

- Printouts of paper airplane design instructions for your students (see Preparation, below)
- 2 or 3 sheets of paper per student
- Scissors
- Markers or colored pencils to decorate airplanes

Time required: 20-30 minutes

Preparation:

Print out 3 or 4 copies of the following paper airplane designs from http://www.funpaperairplanes.com/plane_downloads.html:

- **Arrow**
- **Classic dart**
- **Condor**
- **Canard**

Vocabulary:

- **LIFT**—*An upward force caused by high pressure below and low pressure above.*
- **THRUST**—*Energy that pushes an object forward.*
- **DRAG**—*Friction from the air that slows down an object as it moves.*
- **WEIGHT**—*The force on an object from the pull of gravity on it.*

Activity:

Pass out the airplane designs and paper to students. Have them make two or three paper airplanes and decorate them with markers. Test the designs by flying them all around the room.

Discussion

It is amazing to watch birds fly. Small birds like sparrows and chickadees dart through the air. Hawks and vultures slowly circle higher and higher. For most of human history, all people could do was look at birds and wish that we could fly, too.

ASK: How many of you would like to be able to fly?

Well, on December 7, 1903, the first successful airplane was built and flown by two brothers: Orville and Wilbur Wright. Ever since then, people have been making and improving airplanes to do a lot of different jobs: from carrying people and packages to fighting in wars to fighting fires.

Even though so many different airplanes do so many different types of jobs, they all have to balance four forces in order to take off, fly, and land safely. Your paper airplanes are affected by each of these forces as well, so let's look at them.

SHOW TOP DIAGRAM ON PAGE 4

The four forces acting on a plane are grouped into two pairs based on their effects.

Thrust and **drag** affect the forward motion of an airplane. *Thrust* is the force that is moving the plane forward. *Drag* is the force of the friction of the air, which slows down the plane. The amount of thrust depends on the power of the engines, and the amount of drag depends on the **surface area** of the plane (how much of the plane you can see when looking straight at it.

SHOW BOTTOM DIAGRAM ON PAGE 4

Remember how a small surface area helped the cylinder and cone fall faster than the flat paper a few weeks ago? The smaller the surface area, the less drag the airplane will experience. That means that the airplane needs less energy from thrust to move it forward. Reducing drag makes airplanes more efficient.

The other pair of forces are **weight** (pulling down) and **lift** (Pushing up). We can stand on a scale and it tells us how much we weigh in pounds. Our *weight* is a measure of our mass (how much matter we have in us) and the force of gravity acting on us. Things that weight a lot are harder to pick up. Airplane designers try to

reduce weight so they can also reduce the amount of thrust needed from energy sources like fuel. The energy from fuel in the engine produce the thrust. Thrust and lift work together to make an airplane fly. While drag works to slow the airplane and weight tries to pull it back to the ground.

Lift is the force that pushes an airplane up into the air. To make lift, airplane wings have a certain shape.

SHOW DIAGRAM ON PAGE 5

Notice that the top side of the airplane wing is curved, while the bottom is straight. If you stretched the top side straight, it would be longer than the bottom side. This is important because as the wing goes through the air, the air that gets split at the front of the wing has to meet at the back end of the wing.

To do that, the air that goes over the top of the wing must move faster than the air going under the wing (because it has to go a longer distance than the air under the wing).

This faster-moving air creates an area of low pressure above the wing. Low pressure pulls things towards itself. A vacuum cleaner works by creating an area of low pressure that pulls air and dirt up and inside.

The slower-moving air under the wing creates an area of high pressure, which pushes things away. So the low pressure above the wing pulls the wing up and the high pressure pushes the wing up. This is how an airplane wing creates lift.

The largest airplane ever built was the **Antonov An-225 *Mriya*.** You will not be surprised to know that it also has the largest wingspan of any aircraft placed in service, since to fly the heaviest weight you need the most lift, plus lots and lots of thrust! The *Myria* has transported a load weighing 559,580 pounds!

Whether it is the largest aircraft ever built or tiny drones whizzing around a park, all aircraft are affected by the same four forces: thrust, drag, weight, and lift.

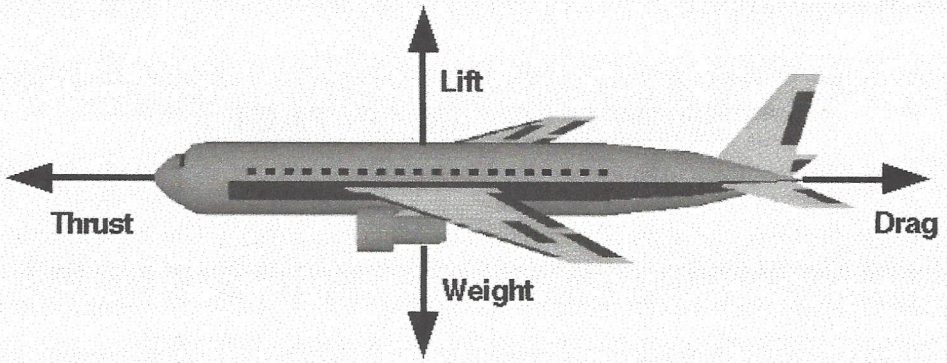
Your paper airplanes have all of these forces working on them, too:

- **THRUST** comes from your muscles when you throw the airplane.
- **DRAG** comes from the surface area of the paper that goes against the air.
- Your paper airplane has the **WEIGHT** of one piece of paper.
- The fold of the front of your airplane's wing creates **LIFT**. More lift can be made by making upward-angled flaps along the back of the tail.

Simplified Aircraft Motion

Unbalanced Forces

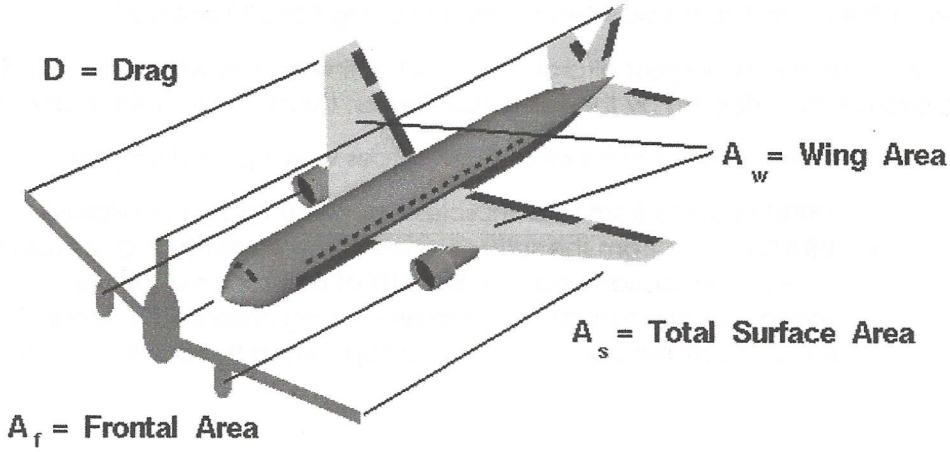
Glenn Research Center



Flight Condition	Effect
Lift > Weight	Plane Rises
Weight > Lift	Plane Falls
Drag > Thrust	Plane Slows
Thrust > Drag	Plane Accelerates

Size Effects on Drag

Glenn Research Center

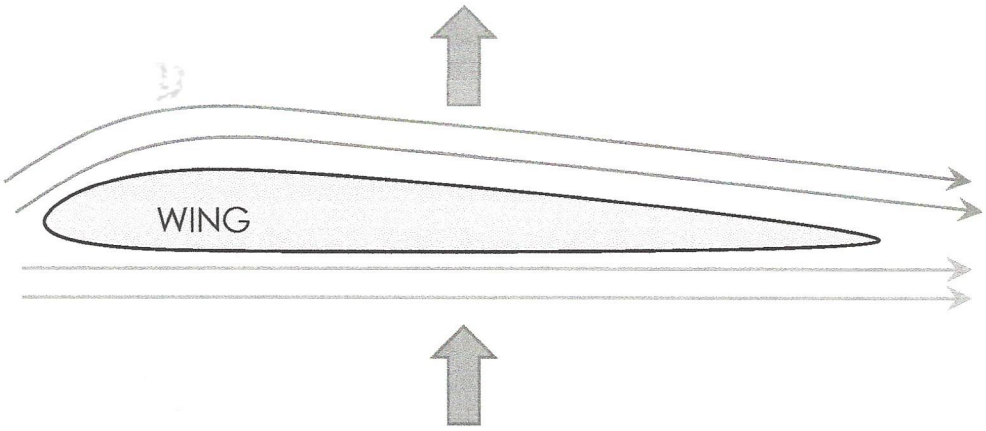


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HOW THE SHAPE OF A WING CREATES LIFT

The air that goes over the wing has to go further, because the top of the wing is bent.

This makes the air travel faster, creating low pressure above the wing. Low pressure pulls the wing up, like a vacuum cleaner.



The air that goes under the wing doesn't have as far to go, because the lower part of the wing is straight.

This makes the air travel slower than the air above the wing, creating high pressure below the wing. This pushes the wing upward, like a wind from underneath.

Natural Philosophy

Water: Displacement

Cycle 2, Week 21

Supplies/Set-Up

1. Big huge bowl or pot
2. Smaller bowl (that'll float like a boat in the big one)
3. Sand (or salt, sugar, rice, or beans)
4. Plastic ruler
5. Empty wine bottle & cork (or a bottle into which a cork will fit snugly; and make sure you haven't put a hole all the way through the cork with a corkscrew!)
6. Plenty of water

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Natural Philosophy

Lesson

1. The first thing God says about how he made the world is that it was full of **water**. Water has absolutely amazing properties, and those properties make everything you know and love about life and the world possible. Creationary physicist Dr. Russell Humphreys postulates that everything in the universe was made by God first out of water, and his predictions about the magnetic fields of other planets, based on that hypothesis, were proven true when we sent space probes to other planets like Uranus and Nepture. Regardless, we know for sure that water covers most of our planet, rains down upon our planet, makes up 60% of our own bodies, and is a huge part of our lives.

2. Today, we're going to learn about Displacement.

Bottle with Air & Bottle with Water Demonstration

1. Show empy bottle. Explain that this bottle isn't empty (like we learn about before!), but it is filled with... air!

2. What will happen if I try to push this cork into the bottle that is filled with air?

3. Push the cork into the bottle. If the bottle was filled with air, how was I able to put the cork in there? Two things can't be in the same place at the same time! (Answer: The air was *compressed*.)

4. Fill the bottle with water, all the way to the top. What will happen when we try to put the cork in this time?

5. Try to the push the cork into the bottle (it should *not* be able to go in).

6. Think of how easily and naturally air moves (forms) into areas of higher and lower pressure, as we learned last week.
    a. You can compress air really easily!
    b. Water doesn't compress like air; it takes a **lot** of force. Are you strong enough to compress water just this tiny little bit?

Natural Philosophy

Displacement Demonstration

1. So when we put something in water, it doesn't just go into the water; the water moves out of the way for it.

2. Use big bowl filled with water, and measure with ruler how deep the water is.

3. Add the "boat" floating on top; measure the depth of the water.

4. Add different amounts of sand, and measure water depth.

5. What we're measuring here is the **displacement** of the water—how much water we have *displaced* by adding this boat.

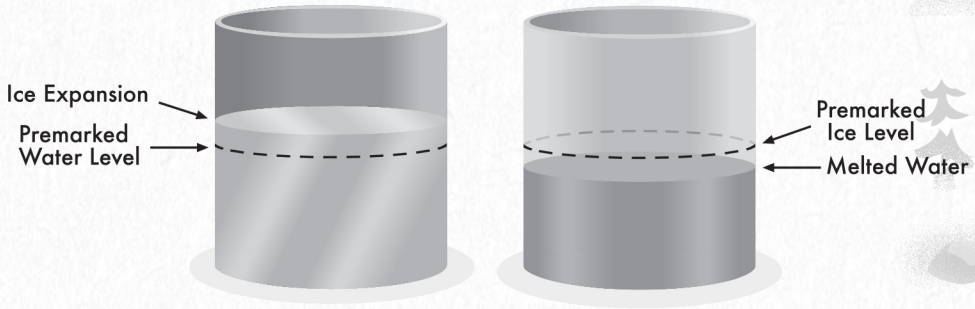
Day 4 Experiment
H2Ohhh!

DISCOVERING GOD'S GIFT OF WATER TO THE EARTH

EXPERIMENT 1

Materials

- ☐ Frozen ice container from previous day
- ☐ 2-liter bottles filled with water, 1 per table
- ☐ 2-liter bottles, nozzles and tops removed, 1 per table
- ☐ Ice cubes, enough to cover the bottom of each empty 2-liter bottle without nozzles and tops
- ☐ Frozen Lake Pictures (DVD-ROM), 1 per table
- ☐ 4 x 4-inch wax paper squares, 1 per child
- ☐ Toothpicks, 1 per child
- ☐ Eyedroppers, several per table



Pre-Prep

1. On Day 3 during class, fill a glass with water and then carefully place in the freezer. Let children watch as you fill it so they can see where the top of the water is and compare that to the level of the ice in the frozen container today. Mark where the level of water is. And then mark where the level of ice is.

Class Time Directions

Today, we're focusing on the Bible as a letter of love. In the Bible, we learn that God loves us so much He gave Jesus Christ as Savior of the world. God's one-of-a-kind gift is His Son, who can save us from our sins and give us eternal life when we repent of our sins and believe in Jesus.

The Bible also tells us about another unique gift of God. Read Genesis 1:1–2. **From the very beginning, God gave liquid water to the earth as a special gift. The surface of the earth is about 70% covered by water, and all living things contain water.**

Let's explore several qualities of God's wonderful gift of water. Let's think about the first unique quality. Water can be found in three different forms or phases, and all three of these phases can be found somewhere on the earth. What do we call water when it's a solid? Take responses—ice. **At your table, name two places you can find ice on the earth.** (Snow, glaciers, frozen tundra, frozen lakes, etc.) **Did anyone also say icebergs?**

What do we call water when it's a liquid? Take responses—water. **At your table, name two places you can find liquid water on the earth.** (Rivers, lakes, streams, etc.) **Did anyone also say plants?**

What do we call water when it's a gas? Take responses—steam or water vapor. **Again, at your table, name two places you can find steam on the earth.** (Geysers, hot springs, fog, clouds, etc.) **Did anyone also say your breath?**

There is another unique quality of water that God has created. Usually, any substance will contract and get smaller as it freezes, turning from a liquid to a solid. Water does just the opposite.

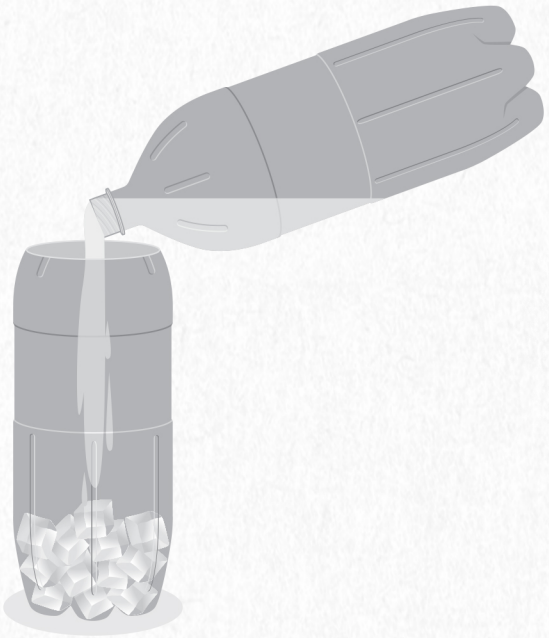
To show you this, let's examine the container of water we froze yesterday. Remember, we filled the glass to the rim. If you look closely, you will see the ice level is higher than the level we marked yesterday. Have a volunteer walk around to groups showing the frozen ice container. Mark where the ice level is and then allow it to melt during class and check the level again. **This demonstration shows that water expands when it freezes and takes up more space.**

Most substances contract and take up less space when they freeze. So this means that when water freezes it gets less dense rather than more dense. Most substances get more dense when they freeze. Density explains why something floats or sinks.

We are going to do a challenge with ice. At your table is a 2-liter bottle with ice at the bottom. You have another

2-liter bottle filled with water. Your challenge is to see if you can cover the ice cubes totally with water. Give time for the children to attempt the challenge. **You should have found you couldn't do it. No matter how much water you poured into the bottle with the ice cubes, the ice couldn't be completely covered. Ice will float and always extend above the surface of the water because it's less dense.**

Think about this idea. If water didn't expand and become less dense as it froze into ice, terrible things could happen on the earth. Ice would sink in lakes and oceans. It would crush plants and animals living on the bottom. As the water continued to freeze from the bottom up, other water plants and animals would also freeze and die. Fish and mammals would have shallower and shallower water in which to swim. Finally, they would get frozen into the ice as water eventually froze at the surface. The entire lake or river would be solid ice. Look at the sample pictures of what this might look like. Show Frozen Lake Pictures: pictures that show stages of a lake freezing from the bottom up. Give a minute for observation and discussion at tables. **Aren't we thankful to God that He created water to expand and float as it freezes?**



2-liter bottle with nozzle cut off and ice at the bottom

Water has many more unique qualities, such as the power of cohesion. Cohesion makes water molecules act like mini magnets. Water molecules are attracted to other water molecules and stick together.

Let's observe cohesion in action. Using your eyedroppers, put two small drops of water near each other on your piece of wax paper. Tap the wax paper to get the drops near each other. Observe what happens as the drops get closer and closer, almost touching each other. Allow time to explore and observe. **Now take your toothpick and try to break the big water drop apart. Share with others at your table what you observed.** Give a few more moments for them to attempt this. **Raise your hand if you saw your drops come together like a magnet was pulling them. You just observed water's property of cohesion that makes droplets stick together. It's a kind of electric attraction between the molecules of water.**

Today, we've talked about many examples where water is truly a unique substance. We've seen that water exists in all three phases on the earth—solid, liquid, and gas. We've seen that water expands when it freezes and becomes less dense. Finally, we've observed the power of cohesion that helps water molecules stick and flow together. Only God can create such a unique liquid and give it as a special gift to the earth!

Natural Philosophy

Three States of Matter

Cycle 2, Week 22

Supplies/Set-Up

1. Hot plate
2. Freezer—freeze some ice cubes ahead of time and have them ready for class
3. Tea light candle
4. Lighter
5. Paper plate
6. Optional: Answers in Genesis VBS Water Lesson

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Natural Philosophy

Lesson

1. There are three states of matter: solid, liquid, and gas.
    a. Solid—rocks, wood, metal, stone
    b. Liquid—water, oil
    c. Gas—air, helium (in balloons)

2. We're most familiar with the state a particular thing is in when it's at room temperature and at normal atmospheric pressure (that's normal air pressure here on earth!).

3. But under different conditions, things change into a different state. Examples:
    a. Rocks. What state are rocks? (Solid.) When they get really hot or under really high pressure (that means they get squeezed really hard), they melt!! They turn into liquid. Does anyone know what we call rocks when they're in the liquid state? (Lava.)
    b. Coconut oil. Does anyone use coconut oil?? In the summer, if your kitchen is warm, what does coconut oil look like? (Oil, a liquid!) But if the house is nice and cool, or in the grocery store, what does it look like? (Solid.) When it's *warmer*, it is a liquid; and when it's *cooler*, it is a solid.
    c. Nitrogen is a gas; our air is made up mostly of nitrogen. But when they cool it down to -320°F, it turns into a liquid, like water, but *crazy, dangerous* freezing cold. That's liquid nitrogen; doctors use that if you have a wart or some funny growth on your body; they put a little bit of liquid nitrogen on it, and it's so freezing cold that it kills whatever it touches! (Don't touch it with your healthy skin!!)
    d. And carbon dioxide is what you breathe out in your breath, but when we cool it down to -109°F, it freezes into dry ice!

Wax Demonstration

1. Wax. Light the candle

2. When wax is at room temperature, what state is it? (Solid.) What about when it gets heated up a bit? (Liquid.)

Three States of Matter Demonstration

1. Demonstrate the three states of matter by melting an ice cube (solid to liquid), and then boiling the water (liquid to gas). Explain!



Soak it up

Have you ever wondered how water gets from a tree's roots all the way up to the leaves?

God waters every tree in the world through a process called capillary (KA-puh-leh-ree) action. Trees have a special layer of cells called xylem (ZI-lem) between the bark and the wood. Xylem carries the water up the tree. Water molecules stick to one another (a process called cohesion) and stick to other things (a process called adhesion) because one part has a positive charge and the other has a negative charge—and opposites attract. The water molecules play leapfrog up the tree as they stick to the xylem cells and to one another, until they reach the leaves at the top.

This same process happens to liquids in a straw, ink in a pen, the tiniest blood vessels in our body, and many other things. You can even spot capillary action on paper towels. Paper towels are made of small plant fibers called cellulose. When you clean up your spilled juice, the liquid gets pulled up between the paper towel fibers by capillary action.

Let's do an experiment to see this process in action—and make something beautiful at the same time.



I'm **Roger Patterson**, the host of *Unlocking Science* on Answers TV. Let's have some fun as we investigate God's amazing creation.

Let's do it!

Rainbow Supplies

- 5 clear glasses filled with water
- Food coloring (red, yellow, and blue)
- Paper towels



Make the Rainbow

1. Place the glasses close to one another in a row or a circle. In the first glass, add yellow food coloring to the water; in the third glass, blue; and in the fifth glass, red. Leave the second and fourth glasses of water uncolored.
2. Fold the paper towels into thirds to make strips. They should be able to reach from the bottom of one glass to the next without the middle sticking up too high. You may have to snip the ends if they are too long.
3. Insert them into the glasses, connecting each glass with the one beside it.
4. After a few minutes, you should see the colored water travel up and down the paper towels. After a while, the water will have traveled the whole length of the paper towels, coloring the uncolored water and mixing to make new colors.

EXTRA FUN

» After the experiment, gently squeeze out the paper towels and let them dry on a baking sheet. You can use the tie-dyed towels for other crafts.

Color Combinations

As the water travels from glass to glass and the colors mix, notice what new colors are created.

Natural Philosophy

Water: Imbibition

Cycle 1, Week 23

Supplies/Set-Up

1. Sugar cubes
2. Food coloring
3. Plate/dish (clear pyrex is great, so everyone can see)
4. White carnation (or any white flower)
5. Skinny vase
6. Water-walking bug picture
7. Piece of cardboard or cheap envelope
8. Glass, filled to the top with water
9. Article: Soak It Up (*Kids Answers*, October–December, 2022)

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3. Today, we're going to learn about Imbibition.

Imbibition Demonstration #1

1. Briefly read/explain "Soak It Up", no need to read every detail, just basically explain, and begin the demonstration. (You'll explain what's going on in more detail during the rest of the class; let this demonstratio run during the rest of the class.)

Imbibition Demonstration #2

1. Teach about imbibition.

2. First, you have to know that everything that exists is made up of atoms. Atoms are so tiny that even with the most super powerful microscopes we have, we still can't see even the biggest atoms. They are mind-bogglingly tiny. But we have other ways of detecting them, other than seeing them visually, and there is a large and compelling body of evidence that, yes, indeed, everything that exists in the material world is built up out of atoms, kind of like legos.

3. *Draw diagram of atom on board. Say:* Atoms are kind of funny, because each one is like a little magnet, with a postive part, and a negative part, and the postive parts and negative parts are attracted to each other. The positive parts are called *protons*, and they are found in the center of the atom. The negative parts are called *electrons*, and they fly around center of the nucleus, kind of like the planets orbit the Sun, but wilder. *(Draw +'s and –'s in the right spots.)*

4. *Draw diagram of water molecule. Say:* The molecular structure of water is 1 oxygen atom and 2 hydrogen atoms; we abbreviate that by writing H_2O. So when you see water, it's thousands upon thousands upon thousands of little single molecules of 1 oxygen atom and 2 hydrogen atoms.

5. *Make some detail to your water molecule drawing. Say:* On the outside part of an oxygen atom, 6 little electrons fly around, and on the outside of a hydrogen atom, 1 little electon flies around. But when these three atoms join together, becoming H_2O, those 8 little electrons—6 from the oxygen, and 1 from each of the hydrogen atoms—fly around all three of the atoms, all together. When atoms join together into a little group like that, that's called a *molecule*. And the water molecule, again, is made up of how many atoms??? And what are they???

6. *Draw +'s and –'s in the right spots as you explain:* Something really wonderful happens with that molecule. What kinds of things are flying around the outside of the water molecule? (Electons.) And are they postive or negative? (Negative.) On the *inside* of the oxygen atom, there are 8 protons. What charge do they have? (Positive.) And on the inside of the hydrogen atoms, there is only 1 proton in each. So those electrons will not fly equally around the 3 atoms of the water molecule; they are more attracted to the 8 protons in the center of the oxygen atom than they are to the single proton in each of the hydrogen atoms.

7. This means that for every water molecule, the oxygen part of it has a slightly negative charge (because all of the electons, including the 2 extras from the 2 hydrogen atoms, are mostly flying around it); and both of the hydrogen atoms have a slightly positive charge (because their electrons are mostly *not* flying around them).

8. So each water molecule is attracted to a neighboring water molecule—the O part of one molecule is attracted to an H part of a neighboring one. It's not a strong enough bond to lock them together, but it's a very strong bond making water molecules all want to stick to each other. This is called the *Hydrogen bond*. And it is very powerful. And it causes a lot of the wonderful properties of water, that make so much of life possible.

9. Let's take plants. Plants don't have pumps (hearts) like we have, to make the nutrients flow through them; they get nutrients from their roots, *against gravity*, just because of the wonderful properties of water.

10. Plants have vessels inside of them, called xylem (ξυλον, meaning wood) and phloem (φλοιος, meaning bark). But how does the water flow up the vessels, without a heart pumping it? Because of those hydrogen bonds! The water molecules are attracted to the sides of the xylem, and the water molecules are attracted to each other. So, sticking to each other because of those hydrogen bonds, they creep up the vessels!! That's called capillary action, or **imbibition**.

11. We call things that form hydrogen bonds with water *hydrophilic*, from the Greek hydro- (water) and philic (loving)—water-loving.

12. Put some water in the pyrex dish, add food coloring. Make a tower of several sugar cubes, and place the tower (standing up) in the colored water. Watch imbibition in action!

Imbibition Demonstration #3

1. Fill vase with water; add food coloring to water, nice and dark.

2. Freshly trim the stem; put carnation in water. Leave it & look at it again next week (add more water and food coloring, if necessary, during the week). You might even see a change before everyone leaves at the end of the day today!

Hydrogen Bonding Demostration #1

1. Another effect of hydrogen bonding of is that you'll just *see* water sticking together. (Dip finger in water, and a drop will be hanging off of it.) Look at how much extra water came up with my finger, against gravity, just because all of these little molecules love to stick to the other molecules which like sticking to my finger!

2. This is why, when you having a leaky faucet, water gathers there at the spout, growing bigger and bigger, hanging against gravity, until the drop finally gets so big that the gravity wins and a whole drop falls.

Hydrogen Bonding: Surface Tension

1. And light things can walk on top of water, like certain bugs. They are so light, and the surface tension of water is so strong (that's the hydrogen bonds of the water molecules, at the surface, sticking together), that they can walk on top of the water. Do you see how he makes little dents in the water? Amazing!!

Hydrogen Bonding: Surface Tension Demonstration

1. Fill glass to the brim with water.

2. Ask: Do you think that this envelope is strong enough to hold all of this water in this glass?

3. Place the envelope over the top of the glass and carefully turn it over; then let go of the envelope. The envelope will hold all of the water in!!!

4. Say: What's going on here?! Is the envelope strong enough to hold up all of that water?! (No.) Here's what's happening: Paper is *hydrophilic,* so the water wants to stick to the cardboard, and wants to stick to itself, so it isn't that the envelope holds the water up, but the *water* holds the *envelope* up! The hydrogen bonding inside the glass, and air pressure outside, together, are stronger forces than gravity! The water stays in!!!

5. Finally, review "Soak It Up" demonstration!





Natural Philosophy

Water & Earth: Water Cycle & Erosion

Cycle 2, Week 24

Supplies/Set-Up

1. Plastic mixing bowl
2. Saran wrap
3. A mug
4. String
5. Water
6. Hot desk lamp (to shine down on everything, like the Sun)
7. Modeling clay
8. 3 plastic lunch trays
9. 2 cups of soil
10. 1 quart bowl filled with mixture of leaves, grass, and small twigs
11. Water
12. Water Cycle Diagram
13. Alternatively: Show *Moody Science Classics: Where the Waters Run* (available on youtube)

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Lesson

1. In the beginning God created the heaven and the earth. And the earth was without form and void, and darkness was upon the deep, and the Spirit of God moved upon the waters. **Genesis 1:1–2**

2. We've been learning about the three phases of matter: gas, liquid, and solid. The gas that we have the most of here on earth is air. We learned about how much air is above and all around us, didn't we?

3. We've been learning about many of the properties of water, that make it so amazing, and that make it so critical to life on earth.

4. Now we'll learn about how God supplies us with fresh water.

Water Cycle Demonstration

1. Since water is critical to all life on earth, and we need *fresh* water all the time, the Lord designed a water recycling system; we call it the Water Cycle. First, we're going to get a demonstration going, so we can watch what happens while we do other stuff.

2. Place the mug in the bottom of the bowl, and add water to the bowl, til it comes 2/3rds of the way up the outside of the mug.

3. Cover the bowl tightly with saran wrap and secure with string.

4. Shine the light on it, and watch water. Say: Let's let it sit and see what will happen.

5. In the meantime, let's look at a diagram of the Water Cycle. (Show diagram, explain.

6. Keep an eye on your Demonstration, watch for water to condensate on the saran wrap, and even to drop down into the mug! Explain how that's like the oceans, clouds, rain, and land.

7. Show Water Cycle Diagram.

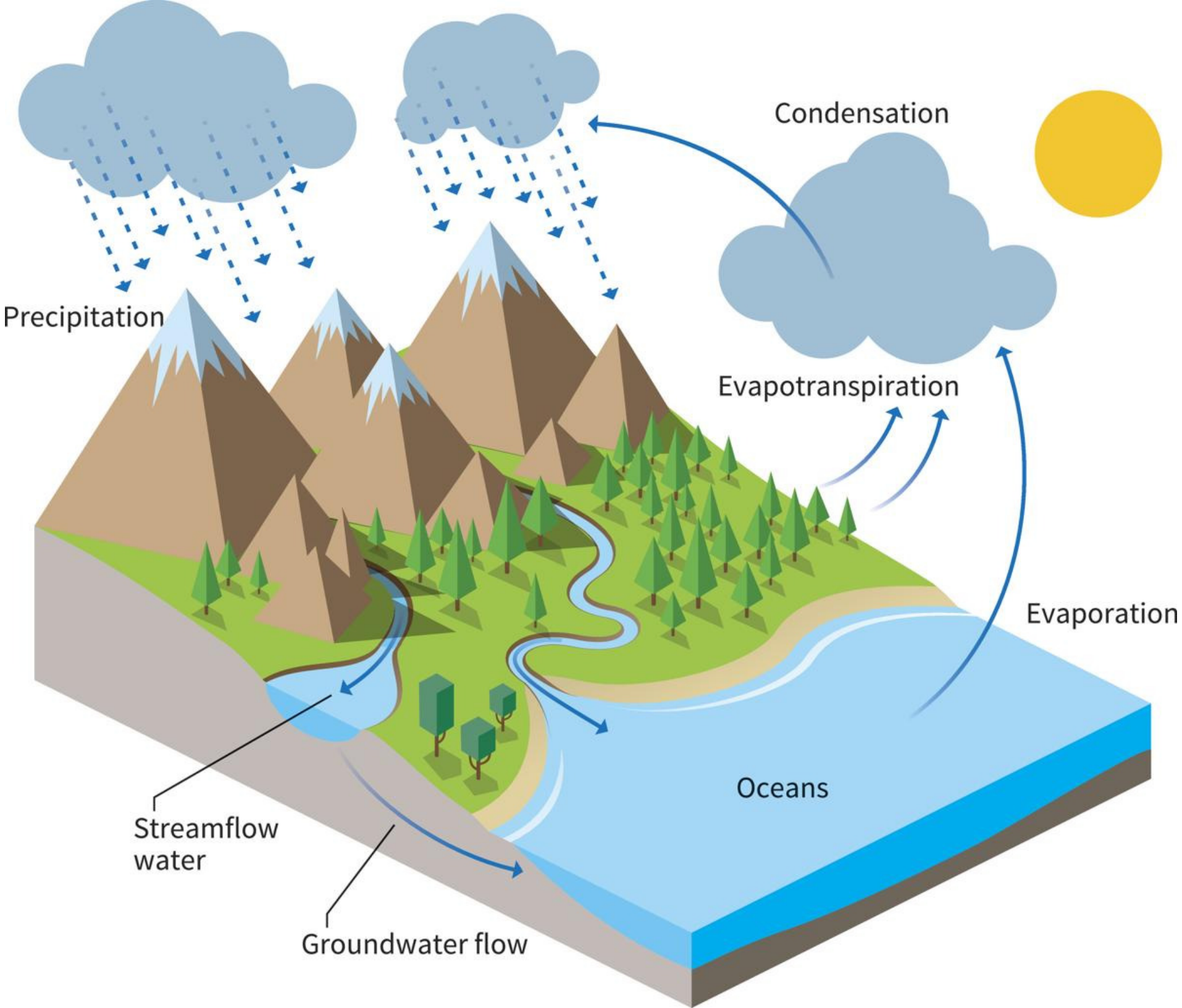
Natural Philosophy

Erosion Demonstration—Janet van Cleave's *Gooey, Slippery,...* #137

1. This term, as we've studied Earth Science, we've been looking at the main things the earth is made of—air, water, and earth itself. The earth is the ground—the rocks, dirt, sand, etc. The land. The Latin word for earth is *terra*, which we translate as *land*.

2. As water goes through the water the Water Cycle, it interacts with the earth.

3. If the earth were millions and billions of years old, did you know that all of the continents would be under water by now? Erosion would have caused all of the highest mountains, bit by tiny bit, to have been carried into the sea, after only 400 million years. The earth is constantly eroding!


Condensation
Precipitation
Evapotranspiration
Evaporation
Oceans
Streamflow
water
Groundwater flow